CHILDHOOD MISNOURISHMENT, SCHOOL MEAL PROGRAMS AND ACADEMIC PERFORMANCE

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ABSTRACT

Both types of childhood misnourishment, overweight/obesity and underweight, are accompanied by serious health consequences and a heavy economic burden. In 2008, 19.6% of US children aged 6 to 11 and 18.1% of adolescents aged 12 to 19 were obese equating to 13 million children. Furthermore, in 2006, 2.7% of US children aged 6 to 11 and 3.9% of adolescents aged 12 to 19 were underweight translating to 2.4 million children. This dissertation contains three essays on the relationship between child weight, school meal program participation and academic performance. Chapter II examines how childrens' weight impacts their academic performance using a quantile analysis while controlling for potential simultaneity between weight and school outcomes. Results indicate that programs targeting child weight could potentially have positive spillover effects on academic performance leading to the question of what can be done to mitigate the problem. Since children consume one-third to one-half of their daily calories while in school each day, school level programs are natural policy instruments to tackle misnourishment. Specifically, the School Breakfast Program (SBP) and National School Lunch Program (NSLP) are two federally-funded programs providing meals to over 31.7 million children daily. Chapter III examines the impact that these programs have on child weight using a multiple simultaneous treatment analysis controlling for self-selection into the programs. Chapter IV then investigates whether these programs have spillover effects on academic performance through the mediator of child weight using structural equation modeling and multiple simultaneous equation methodologies. Each of these essays provides further insight to the relationship between child weight, school meal program participation and academic performance offering potential policy implications to tackle child misnourishment.

DEDICATION:

I dedicate this dissertation to my family.

To my mother,
who has supported me on every life endeaver with words of love and encouragment.

To my father,
who taught me to believe in myself and inspired me to strive for excellence.

To my sister,
who always finds room for laughter and has been a role model to me more than she could know.

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ATTRIBUTION

Wen You, PhD (Agricultural and Applied Economics) is currently an assistant professor at Virginia Tech and aided in the writing and research of this dissertation. She is co-author of Chapter II which has been accepted by the *Journal of Family and Economic Issues.* As my adviser, she also contributed editorial comments and was principal investigator of the grant supporting this research.

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Chapter I: Introduction

MOTIVATION

Two types of childhood misnourishment plague the United States and have far-reaching consequences on children: overweight and underweight. The term 'misnourishment' is used because it is usually a child's dietary and nutritional quality that causes problems of overweight and underweight in the United States as opposed to a lack of food. The one currently receiving the most attention is childhood overweight because of the dramatic increase that has occurred over the past three decades. However, the prevalence of childhood underweight is also of concern for such a developed country.

In 2008, 19.6 percent of children aged 6 to 11 were obese and 18.1 percent of adolescents aged 12 to 19[1] (Ogden et al. 2010)—approximately 13 million. In addition, overweight and obese children are more likely to become obese adults with about half of obese school-age children becoming obese adults (Serdula et al. 1993). According to the Centers for Disease Control and Prevention, obesity is associated with a multitude of chronic diseases including asthma, depression, hypertension, sleep apnea and Type 2 diabetes (CDC 2009). These not only reduce quality of life but also cause a substantial increase in medical expenditures. Direct costs of childhood obesity are estimated at over $14.3 billion annually, and the direct medical cost of obesity in adults is about $147 billion per year (Cawley 2010).

[1]A child is obese if his/her body mass index (BMI) is equal to or greater than the 95th percentile according to the CDC's BMI-for-Age weight status. A child is overweight if his/her BMI is between the 85th and 95th percentiles, and a child is underweight if his/her BMI is less than the 5th percentile.

Even with all of the attention focused on the childhood obesity epidemic, the childhood underweight prevelance rate remains a concern. Althouth the percentage of underweight US children aged 6 to 11 decreased from 3.9% in 1994 to 2.7% in 2006, the percentage of US underweight adolescents aged 12 to 19 remained about the same at 3.9% (Fryar and Ogden 2009). These percentages translate to 2.4 million underweight children and teenagers which are sizeable and should be of public concern as consequences of underweight can be serious. Underweight children are more likely to have lower intake and absorption of vital nutrients such as amino acids, vitamins and minerals which causes them to have a higher tendency toward weak immune systems and infections (Black et al. 2003). In addition, underweight is a risk factor for osteoporosis, even for younger individuals (Gjesdal 2008). However, to our knowledge, no studies have estimated the medical costs of childhood underweight.

Some research has linked childhood misnourishment to poor academic performance in school. A couple of studies have found underweight elementary school students, including kindergartners, to have lower test scores than their healthy weight counterparts (Karp et al. 2003; Wendt and Kinsey 2009). In addition, numerous studies (both correlation and causal) find overweight children to perform lower on reading and math assessments (Averett and Stifel 2010; Datar and Sturm 2006; Gable, Britt-Rankin, and Krull 2008; Gurley-Clavez and Higginbotham 2009; Sabia 2007; Shore et al. 2008). Research establishing links between childhood misnourishment and poor performance are discussed more in depth in each of the subsequent chapters, but the results are raising concerns among policymakers and warrant immediate attention.

Academic performance of children in the US is always a focus of administrations. The Department of Education was created in 1867 to aid states in establishing effective school systems, and Congress has remained an active player passing legislation such as the Second Morrill Act in 1890 supporting land-grand universities and the Elementary and Secondary Education Act (ESEA) in 1965 launching a comprehensive set of school system programs. In 2001, No Child Left Behind was enacted to hold schools and districts accountable for student performance, and the Obama administration initiated the Race to the Top-Early Learning Challenge Fund where grants are awarded to states to increase access to quality learning programs for vulnerable children. An estimated $1.1 trillion was spent on education at all levels for the 2009-2010 school year (US Dept of State 2010).

Congress has also played an integral role in school meal programs which are now being targeted as potential policy instruments to combat child overweight. Federal funding for school lunch programs began in the 1930s to combat child hunger, and the 1946 National School Lunch Act gave the program permanent status as the National School Lunch Program (NSLP) as well as necessary appropriations from Congress. In 1937, approximately 342,000 students received a school lunch; now over 31.7 million are served each day costing the government $10.8 billion in 2010. The School Breakfast Program (SBP) began as a pilot program for “nutritionally needy children” in 1966 and received permanent authorization in 1975. It currently serves over 11.6 million children daily costing $1.9 billion in 2010.

While both of these programs were intended to provide children with nutritionally adequate meals, recently they have garnered media attention for the unhealthy and energy dense content of their meals (e.g., Alderman 2010; Pear 2011). Research has found that much of the food served through the programs was of low nutritional quality (e.g., Briefel, Wilson and Gleason 2009; Cole and Fox 2008; Gordon et al. 2007) with a couple of studies finding that the meals have contributed to child overweight (e.g., Millimet, Tchernis and Husain 2010;

Schanzenbach 2009). While additional research is still needed to confirm results, findings such as these stimulated the USDA to release higher school meal standards in January 2012 which are the first changes in nutrition requirements to the programs since the 1995 School Meals Initiative. The negative media attention on the programs has also led to healthier school meal campaigns such as the Healthy, Hunger-Free Kids Act of 2010, *Chefs Move to Schools* and Small Farms/School Meals Initiative, all of which support SBP and NSLP. While all of these changes to the programs are being made, only a handful of studies have gone beyond correlation research in examining the impacts on child weight (Millimet, Tchernis and Husain 2010; Schanzenbach 2009), and even less research has examined impacts on academic performance.

OBJECTIVES AND INNOVATIVENESS

Due to the links found between child weight and academic performance as well as school meal program participation and child weight, further research on the relationship between all three is crucial for alleviating childhood misnourishment but also for improving US children's academic performance. Millimet, Tchernis and Husain (2010) specifically call for research on the impacts of school meal programs on additional cognitive and non-cognitive outcomes. This study investigates the impacts of child weight on academic performance and also explores the influences of school meal programs on both of these outcome measures using economic modeling and estimation techniques. We specifically choose to examine SBP and NSLP due to the realistic policy implications of affecting a large population of children and the tremendous benefits that can potentially emerge from successful policies executed through this avenue.

Much of the literature on this topic has been published in health, sociological and education journals utilizing fairly basic economic methodologies. Therefore, our first objective is to develop a more inclusive, economically motivated theoretical foundation that more accurately captures the relationship between child weight and academic performance. Averett and Stifel (2010) specifically point out that future research needs an investigation of the mechanisms behind this relationship. Therefore, our theoretical framework aids in identifying the pathways through which weight affects academic performance. Second, utilizing our theoretical model, we employ relatively complex estimation techniques that identify more of the non-spurious relationship which exists between child weight, school meal program participation and academic performance.

There are several gaps in the literature within this area of research. Some of these gaps include (a) no inclusive theoretical model of the relationship between child weight and academic performance that is dynamic in nature and incorporates home and school environments, (b) a need to handle endogeneity with better identification, (c) minimal research on underweight children, (d) a need for a more complete picture of child weight influences across the academic performance distribution, and (e) a need for an impact assessment of SBP and NSLP on non-cognitive and cognitive outcomes (Millimet, Tchernis and Husain 2010).

This study makes contributions toward several of these gaps. First, we develop a theoretical household production model that includes a child's cognitive production function that nests the child's weight production function to aid in capturing the effects of weight on performance. Both the child's home and school environments are modeled in the framework. This theoretical model contributes to the existing literature where a sound and inclusive underlying framework is absent. While many of the works in this area do not provide a theoretical basis for their empirical investigations, the ones that do are not dynamic in nature nor do they simultaneously capture child, home, and school characteristics—all of which provide distinct influences on weight and academic performance.

Second, we use a variety of estimation methods that are innovative in this area of research and aid in identifying non-spurious relationships. In Chapter II, we employ an instrumental variable quantile methodology that corrects for endogeneity in order to examine the effects of weight across the academic performance distribution. This particular estimation technique has not been used in this area of research and allows us to examine how weight impacts both lower and higher scoring students in addition to the average student. A Master's thesis uses the method to examine how class size affects student performance (Pereda-Fernandez 2010), and a similar method of instrumental variable quantile treatment effect is used in a working paper that examines the causal effect of education on weight (Brunello, Fabbri and Fort 2009). Chapter III examines the impacts of SBP and NSLP on child weight accounting for self-selection into programs and allowing for multiple simultaneous treatments since students have the option to participate in none, one or both programs. We specifically utilize Average Treatment Effect on the Treated and Difference-in-Difference methodologies in this essay. In Chapter IV we identify spillover effects of SBP and NSLP on academic performance through the medium of child weight. We use structural equation modeling to estimate selection equations, child choice equations as well as weight and cognitive production functions simultaneously.

A third contribution to the literature is that we examine childhood underweight in addition to childhood overweight. Studies on the academic performance of underweight children in the US are scarce (Karp et al. 2003; Oreopoulos et al. 2008; Wendt and Kinsey 2009) and focus only on particular groups, such as inner-city kindergartners (Karp et al. 2003). Also, the literature fails to examine impacts of school meal program participation on underweight children.

Last, there is also a need in the literature for more of an impact assessment of SBP and NSLP. While the primary aim of these programs is to provide children with nutritious meals, it is also important to consider the spillover effects that the programs have on academic performance. Our third and fourth chapters address the impacts of these school meal programs on weight and performance, respectively.

We begin by obtaining an overall picture of how children's weight status affects their academic performance across the entire academic performance distribution. From here, we are interested in potential policy instruments that can be used to improve this relationship. Because children spend a large portion of their waking hours in school and consume one-third to one-half of their calories while in school each day (Schanzenbach 2009), SBP and NSLP are realistic policy targets that could be used to influence child weight. This naturally leads to the fourth chapter which then examines the spillover effects of these programs on academic performance through the mediating factor of child weight.

DATA: EARLY CHILDHOOD LONGITUDINAL STUDY—KINDERGARTEN CLASS

This investigation employs the Early Childhood Longitudinal Study—Kindergarten Class (ECLS-K) dataset which was collected and provided by the National Center for Education and Statistics (NCES). It is a longitudinal study of a nationally representative cohort of 21,260 kindergartners beginning in the 1998 to 1999 school year and who are followed through eighth grade. The study collected data on children in over 1,000 different schools, as well as information on their families, teachers, and school facilities to examine early childhood experiences and the impact of numerous variables on early childhood development, learning, and early school performance. Seven waves of the study were administered—fall and spring of kindergarten and the springs of 1^{st}, 3^{rd}, 5^{th}, and 8^{th} grades. In addition, a survey was administered to a small subsample in the fall of 1^{st} grade to obtain information on the summer activities of children.

The dataset collected measures of children's physical health and growth, social and cognitive development, as well as emotional well-being along with information on family background and the educational quality of both the home and school environments. The data set is comprehensive and provides the information needed to conduct the entirety of the study. While most of the data is accessible from a public-use file, we also have access to a restricted-use data file that will be used in the third and fourth chapters when we examine free- and reduced-price meal recipients.

ECLS-K Sample Design

The ECLS-K implemented a multistage probability sample design with the primary sample units (PSUs) being geographic areas consisting of counties or groups of counties. Geographic areas had a probability of being selected proportional to their size with the basic PSU measure of size being the number of 5-year-olds; however, Asian and Pacific Islander children were oversampled.

Public and private schools offering kindergarten were then sampled within PSUs for the second-stage. Schools had a selection probability proportional to a weighted measure of size based on the number of kindergartners enrolled. As with the first-stage unit, the measure of size was constructed to take into account the oversampling of Asian and Pacific Islanders. The third-stage units were children within the sampled schools, and the target number of children sampled at any one school was 24. This sample of children was considered the base-year respondents. Children were considered a case if there was a complete child assessment or parent interview in either the fall or spring of kindergarten.

After the spring of kindergarten, the study freshened the sample with kindergarten programs that were in newly opened schools in the 1998-1999 school year and were not listed in the NCES Common Core of Data (CCD) and the NCES Private School Universe Survey (PSS) or schools that were in the CCD and PSS but did not appear to offer kindergarten programs the prior year which is where the original sample was drawn from. The probability was proportional to a weighted measure based on the number of kindergartners enrolled.

For children who changed schools between base-year kindergarten and spring first grade, a random 50 percent subsample were flagged to be followed for data collection. In selecting these students, the three primary strata were self-representing primary sampling units, non-self-representing primary sampling units that had been selected for fall-first grade subsample, and non-self-representing primary sampling units that had not been selected for fall-first grade. Within these strata, schools were grouped by original public, original private, freshened public, and freshened private. Within this, schools were stratified by whether the school participated in the base-year study and were then arranged in original selection order. Then equal probablity sampling methods were used to obtain the 50 percent sample. Basically, each base-year school had a 50 percent chance of its transfer children followed during the spring of first grade.

Survey Instruments

The data set has individual instruments and assessments for children, parents, teachers (general, math, reading, science, and special education), and school administrators in addition to data collected on the school facilities. Details of the data collection and instruments can be found in the *Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 User's Manual*.

Particularly significant for this research, the ECLS-K study collected anthropometric data in all seven rounds of the study. This data consists of the height (in inches to the nearest quarter-inch) and weight (in pounds to the nearest half-pound) of children. The height and weight measurements were recorded by the assessor using the Shorr Board and a Seca digital bathroom scale, respectively, and all children were measured twice to minimize measurement error.

In addition, at each data collection children were given individually administered math and English assessments. When the children entered third grade, they also were given science and social studies assessments. These assessments consisted of two-stages. In the first stage, children received a 12- to 20-item routing test. Performance on this assessment helped decide between several alternative second-stage tests. The second stage test contained questions with a level of difficulty indicated by the child's score on the routing test. Item response theory (IRT) scale scores were then computed since the children did not take the same tests. IRT scores represent estimates of the number of items students would have answered correctly if they had taken all 92 questions on the first- and second-stage reading forms and 64 questions on the mathematics forms. The IRT scores allow us to compare academic performance among students and over time.

Information on SBP and NSLP participation is also significant to this research and is readily available from parent, teacher, and school administrator surveys. Parents were asked if the school provides breakfast and lunch to students, if the child eats a school breakfast or lunch and how many per week, and if the child receives free- or reduced-price breakfasts or lunches.

Teachers were asked how many children in their class were eligible for free- or reduced-price breakfasts and lunches. School administrators were asked the percentage of free- and reduced-price lunch eligible students in the school, the actual number of students in the school who were eligible, and the number that participate in the programs.

Details on specific variables used in the estimation as well as summary statistics are discussed in detail for each paper within that particular chapter. The seventh wave of data, which was collected when the students were in 8^{th} grade (2006-2007 school year), was recently released in 2010; therefore, few studies have been conducted using the full breadth of the data. As a brief overview, some of the variables of interest with regard to child weight used in most of the models are the time spent watching television and participating in physical activity that makes the child sweat as well as purchases of school meals. Several of the home environment characteristics include parental involvement, household income, mother's education level, and frequency of family meals. School environment characteristics consist of variables such as the percentage of students on free- and reduced-price lunch, the size of the student body as well as experience and certification of the teacher. However, more detailed analysis of variables will be described in each chapter.

SUMMARY

This chapter presents the introduction and motivation for the examination of child weight, school meal program participation and academic performance. It explains the current gaps in the literature and how this research contributes to some of those gaps. Empirically, much of the literature does not lay the theoretical foundations to examine the mechanisms behind the relationship and thus only investigates correlations between child weight and academic performance. This study attempts to make contributions to the literature by developing a theoretical framework that nests a child's weight production function within his/her cognitive production function in order to explore the pathways in which child weight influences academic performance, particularly SBP and NSLP. The model also incorporates both home and school environment characteristics. In addition, innovative econometric methods are used in the analysis to correct for endogeneity and explore the dynamic relationship with this extensive longitudinal dataset.

The roadmap of this dissertation is as follows. To get an overall picture of how children's weight status affects their academic performance, Chapter II begins the investigation with an examination of this effect across the entire academic performance distribution. We do this through a quantile methodology that corrects for endogeneity that potentially exists in the cognitive production function through the presence of child weight as a regressor and correlations between the errors of the two models.

In order to identify additional factors that may be contributing to this relationship through school, Chapter III analyzes how the School Breakfast Program and National School Lunch Program impact child weight. We analyze this relationship through multiple simultaneous treatment effects and difference-in-difference approaches that take into consideration the issue of self-selection into the meal programs as well as the potential endogeneity.

This naturally leads to our investigation in Chapter IV which examines how SBP and NSLP influence academic performance through the mediating factor of child weight, particularly since an impact analysis of both of these programs on student performance has not yet been conducted. Chapter V summarizes findings and makes overall conclusions from the previous three chapters.

Chapter II: Academic Performance and Childhood Misnourishment: A Quantile Approach

Kristen Capogrossi and Wen You

ABSTRACT

This study assesses the impact of childhood BMI (underweight and overweight) on academic performance using data from the Early Childhood Longitudinal Study-Kindergarten class. The modeling framework is innovative in that it focuses primarily on (i) controlling for potential endogeneity of BMI on academic performance (as both may be driven by other household characteristics) and (ii) on examining marginal effects for the tails of the performance distribution (i.e., those lower performing students). We use Instrumental Variable Quantile Regression (IVQR) to address these two issues. We find that child BMI has differential impacts across the performance distribution: it affects lower performing students more and may contribute to the achievement gap.

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INTRODUCTION

Both types of childhood misnourishment, overweight/obesity and underweight, are accompanied by serious health consequences and a heavy economic burden. In 2008, 19.6% of US children aged 6 to 11 and 18.1% of US adolescents aged 12 to 19 were obese—this equates to approximately 13 million children (Ogden et al. 2010). Furthermore, overweight and obese children are more likely to become obese adults (Serdula et al. 1993). In addition, obesity is associated with a multitude of chronic diseases including asthma, depression, hypertension, sleep apnea and Type 2 diabetes (CDC 2010).

Even with all of the focus on the obesity epidemic, the childhood underweight prevelance rate remains a concern. Although the percentage of underweight US children aged 6 to 11 decreased from 3.9% in 1994 to 2.7% in 2006, the percentage of US underweight adolescents aged 12 to 19 remained the same at 3.9% (Fryar and Ogden 2009). These percentages translate to 2.4 million underweight children and teenagers in the US which is sizable and should be of public concern as consequences for underweight children are serious. These include lower intake and poor absorption of vital nutrients which cause higher tendency towards having weak immune systems and more frequent and serious infections (Black et al. 2003) which can have an impact on academic performance through increased absences and decreased study time quality.

There are several reasons why a child's weight may impact his/her academic performance. For instance, the stigmas of being overweight or underweight may negatively influence a child's self-esteem which may impact his/her performance (Falkner et al. 2001; Krukowski et al. 2009; Xie et al. 2006). On the other hand, academic performance could influence self-esteem (Rosenberg et al. 1989; Skaalvik and Hagtvet 1990) which could then influence weight either through the consumption of unhealthy foods (overweight) (Polivy, Heatherton and Herman 1988) or eating disorders (underweight) (French et al. 2001). Cho et al. (2009) find such a relationship for Korean adolescents; however, there has been little to no examination of causality in this direction for students in the US. In addition, conditions associated with overweight and underweight may cause children to miss more school (Datar and Sturm 2006; Schwimmer, Burwinkle and Vami 2003) or have lower levels of concentration resulting in poorer performance (Luder et al. 1998). Furthermore, other unobserved factors such as certain home and school environment characteristics may be influencing both weight and performance (i.e., the simultaneity problem) and causing spurious correlations rather than an actual causal relationship between weight and performance (Averett and Stifel 2010; Crosnoe and Muller 2004; Datar, Sturm and Magnabosco 2004).

Most of the work on the relationship between child weight and performance focuses on the effects of the "average" child; however, the average effect is limited in policy implication since it is more important to know whether and how weight impacts those students who are most in need (i.e., those at the lower end of the academic performance distribution). Such an analysis lends itself to quantile regression (QR) methodologies that are more robust to outliers (Koeneker and Bassett 1978) and allow for detailed analysis on the tails of the distribution. This is specifically important when the data exhibits long-tailed features which is common in academic achievement analysis (e.g., Betts and Grogger 2000; Eide and Showalter 1998; Levin 2001). Ignoring outliers and the long-tailed feature often results in skewed estimates that are not representative of the sample population. In the data section of our analysis, we show that the data used exhibits the long-tailed feature. In addition, minimal work in the area corrects for the simultaneity problem between child weight and academic performance. Disregarding potential endogeneity will result in biased estimates.

Therefore, this paper contributes to the literature by combining quantile regression methods with controlling for endogeneity using Instrumental Variable Quantile Regression (IVQR). To account for simultaneity, we develop a household production model with a nested production process: the child's weight outcome production process is nested within the child's cognitive production function. This theoretical framework provides much needed guidance in the selection of instruments and empirical model specification. Furthermore, our model considers the influence of home and school environments in the production process while examining both underweight and overweight children.

RELATED LITERATURE

Results from current literature on the relationship between child misnourishment (i.e., underweight and overweight) and academic performance are mixed. However, a majority of results have found that being either overweight or underweight lowers a child's academic performance. In addition, most of these studies have focused on the average effect and said nothing about the impact on those children who struggle academically. Only a couple of studies looked at underweight children. Wendt and Kinsey (2009) found that on average underweight students in elementary school scored lower on standardized tests compared to healthy weight students, particularly in math. Another study found that low weight-for-age urban kindergartners also had lower test scores (Karp et al. 2003).

Numerous studies examined associations between childhood overweight and academic performance. Multi-level modeling (i.e., nested or hierarchical modeling) was a frequent methodology used to control for the student-school nesting effect (e.g., Florence, Asbridge and Veugelers 2008; Gable, Britt-Rankin and Krull 2008). Results indicated that lower diet quality and overweight inhibited academic achievement. Other studies conducted multivariate analyses. Datar, Sturm and Magnabosco (2004) found no significant relationship between weight and performance once they accounted for socioeconomic differences, a result also supported by Li et al. (2008) and Judge and Jahns (2007). Datar and Sturm (2006) found that changing from healthy weight to overweight was a significant risk factor for poor achievement in girls but not boys.

Controlling the endogeneity caused by the simultaneous productions of child weight and academic performance is important in providing consistent estimates and meaningful insights for policy. Using indicators for whether the biological mother and father were obese as instruments, Sabia (2007) found a significant negative relationship between BMI and GPA for white females. Averett and Stifel (2010) employed theoretical modeling along with fixed effects and instrumental variable (IV) methods to address the endogeneity problem. They developed integrated health and cognitive production functions and found that the effects of weight on performance were more pronounced when models were subset by race and gender. Specifically, they found that overweight white boys had lower math and reading scores and overweight white girls had lower math scores. These two studies only examined the "mean" effect of weight on performance.

Recognizing the limitation of only studying the average student while leaving the endogeneity issue untreated, Eide, Showalter and Goldhaber (2010) and Nsiah and Joshi (2009) conducted quantile examinations of child weight on academic performance. Eide, Showalter and Goldhaber (2010) focused on a range of health conditions (e.g., weight, asthma, speech impairment, hearing/vision problems, and ADHD). Nsiah and Joshi (2009) focused on GPA outcomes using self-reported weight and height measures for both the students and parents.

As is evident, there is a need in the literature for studies that examine the students' weight impact on the entire academic performance distribution and properly account for the simultaneity feature of the weight and performance productions. This paper addresses these two needs by combining quantile regression with controlling for endogeneity using Instrumental Variable Quantile Regression (IVQR).

Understanding the effect of misnourishment on children's academic performance has timely policy relevance. This paper will contribute to policy targeting the education performance gap between white and minority students. According to a study by the 2003 Educational Testing Service (ETS), hunger and nutrition are listed as "core factors" that contribute to the achievement gap. Understanding whether or not students' weight worsens the gap is particularly pertinent since Hispanic and black children have a greater likelihood of being overweight and obese compared to white children (Federal Interagency 2010; Kimbro, Brooks-Gunn and McLanahan 2007). If weight negatively affects performance, policies targeting child nutrition and physical health should have positive spillover effects in helping narrow the achievement gap and should be considered in program evaluation.

For instance, the Kennedy Cluster Project examined the achievement gap in certain Montgomery County, Maryland schools. Findings spurred the expansion of the county's free summer lunch program for low-income and minority children as a way to help close the gap.

Furthermore, Congress introduced the Healthy Start Act to increase access to and participation in the School Breakfast Program (SBP) with the intent of improving both child nutrition and school performance (Indian Country 2010). These two programs share the same policy goal (i.e., improving children's academic performance), use the same policy instrument (i.e., through the improvement of the children's nutrition status) and have the same focus (i.e., targeting minority and disadvantaged children). However, there are no research findings to directly support the choice of policy instruments and focus. While we are examining child weight status as a measurement of misnourishment rather than nutrition directly, research has shown nutrition to affect weight status (e.g., Bowman and Vinyard 2004; Ledikwe et al. 2006). Therefore, our results will support policy targeting children's academic performance through nutrition.

This paper specifically seeks answers to three policy-relevant questions: 1. Does childhood misnourishment widen the achievement gap between white students and minority disadvantaged students (i.e., Hispanic and black)?; 2. Is the effect stronger for those students whose academic performance is among the lower end of the score distribution?; 3. How are the effect and the achievement gap changing through time? Answers to these questions will help the design and evaluation of policies through guiding/justifying the choice of policy instruments and sub-population focus. We find our answers to the three questions through examining students' academic performance inequalities *across* different weight classifications along with inequalities in student performance *within* specific weight classifications over time.

CONCEPTUAL FRAMEWORK

We utilize the two-stage Stackelberg model proposed by You and Davis (2010) which allows the interaction between parents and child while permitting the child to have some inputs to the household resource allocation decisions. The parents are modeled as the leader and the child is the follower. Several modifications are made to the model: a. We modify the framework to a unitary model since the data we have only contains household head information; b. We use and expand the child health production function to include time inputs, home environment and the child's previous weight status; c. We include the school environment in the child weight production function since school contexts are found to impact obesity (e.g., Crosnoe and Muller 2004); d. We add the child's cognitive production function to the model with the weight outcome as an input similar to Averett and Stifel's (2007) model; e. We include home and school characteristics in the cognitive production function to account for influences beyond the control of the child (Crosnoe and Muller 2004; Datar et al. 2004). This theoretical framework guides us in the selection of theoretically consistent instruments and provides theoretical guidance in coefficient interpretation (Keane 2010).

The Child's Optimization

By backward induction, we begin with the child's decision-making stage. First, we define the child's weight production function (***B***). The child makes choices regarding consumption goods affecting BMI $(\boldsymbol{x_B})$ such as food the child consumes. These consumption goods also affect utility as in Rosenzweig and Schultz (1983). The child also makes decisions on other consumption goods not affecting weight $(\boldsymbol{x_o})$ as well as on time spent in consuming all of these weight and non-weight goods $(\boldsymbol{t_X})$, time spent on exercise $(\boldsymbol{t_E})$, time spent on school work

$(\boldsymbol{t_{AP}})$ and time spent on other activities $(\boldsymbol{t_o})$. The child weight and academic performance production functions are as follows:

$$B = \boldsymbol{B}(\boldsymbol{x_B}, \boldsymbol{t_X}, \boldsymbol{t_E}; \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}) \quad (1)$$

$$AP = \boldsymbol{AP}(B, \boldsymbol{t_{AP}}; AP_{t-1}, \boldsymbol{K_h^{AP}}, \boldsymbol{K_s^{AP}}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \quad (2)$$

Both equations condition on the child's respective outcome in the previous period (B_{t-1}, AP_{t-1}), child characteristics $(\boldsymbol{\mu})$, as well as household $(\boldsymbol{K_h})$ and school $(\boldsymbol{K_s})$ environment characteristics affecting weight and performance, where $\boldsymbol{K_h} = (\boldsymbol{K_h^B}, \boldsymbol{K_h^{AP}})$ and $\boldsymbol{K_s} = (\boldsymbol{K_s^B}, \boldsymbol{K_s^{AP}})$. Examples for the household environment include parental employment status (e.g., Benson and Mokhtari 2011; Miller 2011) and parental involvement (e.g., You and Davis 2011), while examples for school characteristics include school size (e.g., Driscoll, Halcoussis and Svorny 2003) and teacher experience (e.g., Kane, Rockoff and Staiger 2008). The weight production function also conditions on inputs that do not augment child utility other than through effects on BMI $(\boldsymbol{I})$ (e.g., health insurance, health care) (Rosenzweig and Schultz 1983) and parental time spent in food preparation $(\boldsymbol{T_f})$ which reflects food quality and impacts the child's food choices. In addition, the cognitive production function is also conditioned on parental involvement with the child's school work $(\boldsymbol{T_{AP}})$.

The child's utility function depends on his/her academic performance (AP), weight (B), consumption of goods $(\boldsymbol{x_B}, \boldsymbol{x_o})$ and his/her time allocations $(\boldsymbol{t_X}, \boldsymbol{t_E}, \boldsymbol{t_{AP}}, \boldsymbol{t_o})$,

$$u = \boldsymbol{u}(AP, B, \boldsymbol{x_B}, \boldsymbol{x_o}, \boldsymbol{t_X}, \boldsymbol{t_E}, \boldsymbol{t_{AP}}, \boldsymbol{t_o}; \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}). \quad (3)$$

Utility is subject to the child's weight and cognitive production functions as well as a time constraint $\boldsymbol{t_X} + \boldsymbol{t_E} + \boldsymbol{t_{AP}} + \boldsymbol{t_o} = T$, where T is the total amount of time. Maximizing utility, the optimal choice set of the child is $(\boldsymbol{x_B^*}, \boldsymbol{x_o^*}, \boldsymbol{t_X^*}, \boldsymbol{t_E^*}, \boldsymbol{t_{AP}^*}, \boldsymbol{t_o^*}) = f(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu})$ which is a function of household and school environments as well as other exogenous variables. The following reduced form equations obtained from the child's choice set will be used later to acquire the final reduced forms from the parental stage:

$$B^* = \boldsymbol{B}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \quad (4)$$

$$AP^* = \boldsymbol{AP}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \quad (5)$$

$$u^* = \boldsymbol{u}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \quad (6)$$

The Parent's Optimization

The unitary model assumes that there is one parent (i.e., the household head) acting as the main decision-maker. The parent makes the decisions during the first stage of the game while taking into consideration the child's responses to his/her decisions. The parent's utility depends on the child's weight $(\boldsymbol{B^*})$, academic performance $(\boldsymbol{AP^*})$ and utility $(\boldsymbol{u^*})$ as well as the goods devoted to the child $(\boldsymbol{X_B}, \boldsymbol{X_o})$, market goods the parent consumes himself $(\boldsymbol{Z})$, household environment characteristics $(\boldsymbol{K_h})$, work environment characteristics $(\boldsymbol{K_w})$ (e.g., employment status, job satisfaction), the parent's characteristics $(\boldsymbol{\varphi})$ and parental time allocations to work, food preparation, the child's school work/activities and other residual activities $(\boldsymbol{T_w}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{T_o})$. The parent's utility function is

$$v = \boldsymbol{v}(\boldsymbol{Z}, \boldsymbol{T_w}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{T_o}, \boldsymbol{X_B}, \boldsymbol{X_o}, B^*, AP^*, u^*; \boldsymbol{K_h}, \boldsymbol{K_w}, \boldsymbol{\varphi}) \tag{7}$$

which is subject to the child's weight and cognitive production functions as well as the parent's time constraint $\boldsymbol{T_w} + \boldsymbol{T_f} + \boldsymbol{T_{AP}} + \boldsymbol{T_o} = T$ and budget constraint $\boldsymbol{p}(\boldsymbol{Z} + \boldsymbol{X_B} + \boldsymbol{X_o}) = Y$. In the budget, $\boldsymbol{p}$ is a price vector and Y is total household income. The optimal parental choices are then functions of the exogenous variables in the model:

$$(\boldsymbol{Z}^*, \boldsymbol{X}_{\boldsymbol{B}}^*, \boldsymbol{X}_{\boldsymbol{o}}^*, \boldsymbol{T}_{\boldsymbol{j}}^*) = f(\boldsymbol{p}, \boldsymbol{K_h}, \boldsymbol{K_w}, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{\varphi}, \boldsymbol{\mu}) \text{ where } j = w, f, AP, o \tag{8}$$

Substituting the parents' optimal input demand functions into the child's reduced form weight and cognitive production functions yields the final reduced form equations for the child:

$$B^{**} = \boldsymbol{B}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{9}$$

$$AP^{**} = \boldsymbol{AP}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{10}$$

The theoretical model presented above provides the key equation of interest: the child's cognitive production function (Equation 2). The model also provides theoretically consistent guidance in the selection of potential instruments from the parental input demand functions (Equation 8).

ESTIMATION STRATEGIES AND EMPIRICAL MODEL

Endogeneity

Endogeneity concerns arise due to the simultaneity of weight and cognitive outcome productions. Potential unobserved variables (to researchers) such as parental influences could affect both outcomes and result in biased, inconsistent estimates (Averett and Stifel 2010): unobserved poor parenting practices may contribute to both child misnourishment and poor academic performance rather than the misnourishment outcome itself being a cause of poor performance.

Equation 2 is the structural cognitive production function and is the key equation of interest for this paper. We do not have detailed time diary data of the parent and the child which prevent us from identifying the time input effect $(\boldsymbol{t_{AP}})$. However, we can still answer the key question of interest by estimating a partial reduced form of Equation 2 which contains only one potential endogenous variable in the right-hand-side of the equation: the child's weight outcome. The data set does provide frequency data of parental involvement with the child which is more reasonable to be grouped in the home environment exogenous variable category $(\boldsymbol{K_h^{AP}})$ of our model. This is because frequency data characterizes interests and captures a general pattern (StatSoft 2011) which in our case forms the dynamic of the home environment and is unlikely to change in the short term.

The extra exogenous arguments from the final reduced form of the child's weight production function (Equation 9) are used as instruments to identify the impact of child weight on cognitive outcomes. The available choice set for instruments include $(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi})$. The included exogenous variables in the structural *AP* function (Equation 2) are $(AP_{t-1}, \boldsymbol{K_h^{AP}}, \boldsymbol{K_s^{AP}}, \boldsymbol{\mu})$. Therefore, the identifying instruments are the child's health insurance/medical care (***I***), the child's weight from the previous period (B_{t-1}), household and school characteristics influencing child weight $(\boldsymbol{K_h^B}, \boldsymbol{K_s^B})$, parental work environment variables $(\boldsymbol{K}_w)$, parental characteristics (φ) and prices $(\boldsymbol{p})$.These instruments provide the basic candidate pool for our IV estimations. We employ two-stage least squares (2SLS) and IVQR methods along with regular OLS and QR.

Instrumental Variable Quantile Regression

We use Chernozhukov and Hansen's (2005) IVQR method to account for the endogeneity in quantile regression. This methodology is particularly suitable for this context because it allows us to examine the impacts of inputs on different quantiles of the output distribution with output being the child's academic performance and the input of interest being the endogenous variable of child weight. The method modifies the conditional quantile regression and uses a Structural Quantile Function (SQF) $S_{AP}(\tau \mid B, x)$ allowing us to identify quantile-specific covariate effects in an instrumental variable model where *B* is the endogenous variable, *x* are observed characteristics and τ refers to the τ-quantile of potential outcome *AP*. The estimated structural model is set up where the outcome *AP* can be related to its quantile function $q(B, x, \tau)$ as:

$$AP = q(B, x, U) \text{ where } U \sim \mathrm{U}(0,1). \qquad (11)$$

U is responsible for the heterogeneity of academic performance among students with the same observed characteristics *x* and weight outcome *B*. It can represent unobserved characteristics such as ability (Chernozhukov and Hansen 2005). We estimate every tenth quantile between the

5th and 35th percentiles and 65th and 95th percentiles as well as the median in each of the samples.[1]

Instrument Testing

Theory identifies the following categories as potential instruments: $(\boldsymbol{I}, B_{t-1}, \boldsymbol{K}_{\boldsymbol{w}}, \boldsymbol{K}_{\boldsymbol{h}}^{\boldsymbol{B}}, \boldsymbol{K}_{\boldsymbol{s}}^{\boldsymbol{B}}, \boldsymbol{p}, \boldsymbol{\varphi})$. In order to have model identification, the instrument(s) must be highly correlated with our endogenous variable of child weight and uncorrelated with unobserved factors contributing to academic performance.[2] Since we subset most of our models by race and gender, the only instrument to test statistically exogenous across all subsets is the child's previous BMI. Some issues may be raised as in Sabia (2007) that using the child's previous BMI does not satisfy the exclusion restriction if past child weight were used as a proxy for unobserved household characteristics associated with the child's academic performance.

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[1] All analyses in the paper not attempting to correct for endogeneity use sample weights which produce estimates that are representative of the population cohort of children who began kindergarten in 1998-1999. The sample weight used is C1_7FP0. When investigating causality without endogenous stratification using a structural approach with instrumental variables, sample weights are no longer necessary as long as the model is interpreted as correctly specified (Cameron and Trivedi 2005).

[2] Matching the data variables with the theory, we have: whether the child has health insurance (***I***), the child's BMI from the previous period (B_{t-1}), whether the parents are currently employed and work full time, $(\boldsymbol{K}_{\boldsymbol{w}})$ the prestige score of the parents' occupations $(\boldsymbol{K}_{\boldsymbol{w}})$, how many breakfasts and dinners the family eats together per week $(\boldsymbol{K}_{\boldsymbol{h}}^{\boldsymbol{B}})$, and how many school provided meals the child eats $(\boldsymbol{K}_{\boldsymbol{s}}^{\boldsymbol{B}})$. Because our theoretical model identifies several possible instruments and our data provides several variables in these suggested categories, we begin by using the C statistic (Hayashi 2000) to determine whether a subset of the model's overidentifying restrictions satisfies the exogeneity condition.

However, there are two main reasons supporting the use of child's previous BMI as an instrument: 1. The genetic component of BMI is stronger than household environment factors (Stunkard et al. 1986; Vogler et al. 1995) decreasing the probability of correlation between the child's previous weight and unobserved household characteristics associated with academic performance; 2. Several measures of parental involvement with the child that influence academic performance are controlled for making the child's lagged BMI an unnecessary proxy for unobserved household characteristics associated with academic performance. These variables include how involved the parent is with the school, how frequently the parent helps the child with homework, how frequently the parent is involved with the child's extracurricular activities and if the child has a consistent bedtime. We also control for child ability upon entering kindergarten which would capture household inputs to child performance prior to school.

Next, we use the F statistic, the Anderson canonical correlation likelihood ratio test and Cragg-Donald statistic as indicators of the strength of our instrument: the child's previous BMI. The child's BMI from the previous period proved strong for all subsets (p-values are all < 0.01). Testing for endogeneity within our model we use the control function version of the Hausman test. Ten of our 24 subsets rejected the null indicating that endogeneity may be present—7 of the subsets were for white students and 3 were for minority students; 5 were for males and 5 were for females. Therefore, we conduct 2SLS and IVQR to correct for endogeneity in our models using the child's previous BMI as the identifying instrument.[3]

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[3] We also present OLS results as suggested by Park and Davis (2001). QR results are not presented due to limited space but the results have similar patterns to IVQR except that child weight is less significant in IVQR results.

While using lagged BMI is plausible and is supported both theoretically and statistically, we recognize the potential weakness of the instrument; therefore, we follow the suggestions of the literature (e.g., Park and Davis 2001) and perform analysis with and without instrumenting.[4] Our findings are robust across methods which provide further credibility.

DATA AND SUMMARY STATISTICS

In estimation, we utilize data from the Early Childhood Longitudinal Study-Kindergarten Class (ECLS-K) which is a longitudinal study of a nationally representative cohort of 21,260 kindergartners beginning in the 1998-1999 school year and who are followed through 8th grade (2006-2007 school year. The study collected data on children in over 1,000 different schools, as well as on their families, teachers and school facilities to examine early childhood experiences, early childhood development and early school performance. Details of the data collection and instruments can be found in the *Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 User's Manual* (Tourangeau et al. 2009).

Academic Performance

Our interest is in how child weight influences academic performance (AP) over time across the distribution; therefore, the dependent variables of interest are math and reading IRT scale scores from 1st, 5th, and 8th grades allowing us to better understand how weight impacts performance as the child progresses through school. The use of IRT scale scores as performance

[4] Due to space limitation, the other results are available upon request

indicators are stronger measures than GPA or an individual state's standardized test scores which are used in much of the literature. The use of the ECLS-K assessments creates reliability and uniformity within the data since a two-stage cognitive assessment was used for all children in the study unlike standardized tests of varying difficulty depending on the state, and scores were not subjective such as GPAs determined by grades given by teachers.

The partial reduced form of the academic performance production function we estimate as discussed in our empirical model is as follows:

$$AP = \boldsymbol{AP}(B; AP_{t-1}, \boldsymbol{K}_{\boldsymbol{h}}^{\boldsymbol{AP}}, \boldsymbol{K}_{\boldsymbol{s}}^{\boldsymbol{AP}}, \boldsymbol{T}_{\boldsymbol{AP}}, \boldsymbol{\mu}) \tag{12}$$

For the measure of past performance, we include the IRT scale score from the previous data collection period. We also include a baseline IRT scale score that was administered when the child entered kindergarten in fall 1998-1999 to help control for the child's ability. Child characteristics include birth weight, gender, race/ethnicity, age, and the child's BMI upon entering kindergarten. In addition to running models with gender and race/ethnicity dummy variables, we subset by race (i.e., white and minority where minority refers to black and Hispanic students) and gender to discern the particular effects of weight on each of the target groups.

Child Weight

We first use BMI z-scores[5] as a continuous measure of child weight (B). We next subset models by dichotomous weight indicators to examine the heterogenous marginal impacts of child

[5] We report BMI z-scores which are the internationally accepted continuous measure of body mass index that are particularly useful in monitoring changes in weight. A BMI-for-age z-score

weight across weight categories (i.e., overweight/obese, healthy weight and underweight). These measures are more applicable for targeting policy.

We use a SAS program provided by the CDC for the calculation of child's BMI-for-age that uses a child's age in months, gender, height and weight to calculate BMI and BMI z-scores (CDC 2009). The program also provides outlier observations based on the World Health Organization's fixed exclusion ranges. These are observations with BMI values that are considered to be "biologically implausible values" (BIVs) (i.e., the BMI is either too low or too high to be realistic). We dropped 315 observations that were considered biologically implausible.

Exogenous Household and School Environment Variables

The theoretical model controls for household and school environment characteristics contributing to academic performance. Household environment characteristics include whether parents are married, the number of siblings, urban/rural, parental involvement in school, how frequently the parents help the child with homework, how frequently the parents are involved with their child's extracurricular activities, if the child has a consistent bedtime, and the number of times the child has changed schools. Household income is also included from the parent's budget constraint.

Family composition has been shown to have a significant effect on test scores in the literature (e.g., Arends-Kuenning and Duryea 2006; Dornbusch et al. 1991; Jeynes 2002).

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is the deviation of the value for a child from the mean value of the reference population divided by the standard deviation for the reference population (Cole et al. 2005).

Research also shows that parental involvement has a strong effect on a child's achievement that is not captured by family background variables (e.g., Englund et al. 2004; Houtenville and Conway 2008). Our indicator of parental involvement in school is on a scale from 0 to 7. Zero indicates no involvement with back-to-school nights, attending parent-teacher conferences or volunteering at the child's school. We also include two other variables for parental involvement: how frequently the parents help the child with homework (Tam and Chan 2010) and how frequently the parents are involved with their child's extracurricular activities. Baydar, Greek and Gritz (1999) find that working mothers spend less time in physical and interactive care as well as in passive supervision with their children where interactive care is considered time spent reading, playing, helping with homework, etc.. We also include a variable for whether a child has a consistent bedtime as an indicator of stability and rules within the household; however, this variable is only included for 1^{st} and 5^{th} grades because it is unavailable for 8^{th} grade. Variables such as household income and urban/rural area have also been found as household characteristics influencing a child's academic performance (e.g., Datar and Sturm 2006; Driscoll and Moore 1999; Hao 1995; Judge and Jahns 2007; Wendt and Kinsey 2009).

School environment variables include how many students are enrolled, whether the school is Title 1, the number of years a teacher has taught, and whether the teacher has a Master's degree. Literature shows that larger school sizes tend to have negative impacts on school performance compared to smaller school environments (e.g., Driscoll, Halcoussis and Svorny 2003; Lee and Smith 1995). The inclusion of a Title 1 school is determined by whether more than 40% of students qualify for free- and reduced-price lunch according to the Elementary and Secondary Education Act (ESEA). Studies have also found that teacher preparation and certification have a significant impact on student performance, particularly in mathematics (e.g., Kane, Rockoff and Staiger 2008; Wayne and Youngs 2003).

Whether the school is public or private could potentially cause a self-selection problem because children who attend private school are systematically different from those who attend public school (Witte 1992; Wrinkle, Stewart and Polinard 1999). In order to circumvent this problem, we focus our analysis on public school students only.

Summary Statistics

Table 1 gives selected summary statistics for the sample by grade and subject (i.e., math and reading).[6] The percentage of overweight and obese children in the sample increased from approximately 25% in 1st grade to 32% in 8th grade. The percentage of underweight students in the sample remained constant at 3%. Due to the small number of underweight observations, we are unable to subset by race and gender in our underweight models. Instead, we include race and gender dummy variables. We also group 1st and 3rd graders who are underweight as well as 5th and 8th graders to due to the sample size limitation.

Figure 1 depicts the heterogeneity of math and reading IRT scale scores in our sample. As students progress from 1st to 8th grade, the test score distribution is increasingly long-tailed and skewed. For instance, for math IRT scores the skewness statistics are 0.524, -0.723 and -1.007 for 1st, 5th and 8th grades, respectively, compared to the normal distribution's skewness of 0. For reading IRT scores the skewness numbers are 0.755, -0.536 and -1.120 for 1st, 5th and 8th

[6] We only included those variables that differed either across grade or subject area or were imperative to the analysis such as weight classification and race/ethnicity.

grades, respectively. A negative skewness occurs when the left tail is longer (i.e., a longer tail of lower performing students). This is one of the motivating factors behind the quantile analysis.

RESULTS

We ran a series of regressions including OLS, 2SLS, QR and IVQR. OLS, 2SLS and IVQR results are reported in Table 2 to Table 9. Table 2 to Table 5 present math and reading results using a continuous measure of BMI (i.e., BMI z-score) on the whole sample, and Table 6 to Table 9 are the subsamples of healthy weight children.[7] In answering the three questions posed in the introduction, the main conclusions of our analysis are as follows: 1. Results show that child weight may affect the achievement gap but significance varies by grade and demographics; 2. Weight has differential impacts across the academic performance distribution and impacts lower performing students more which may explain why some studies only examining the average child do not find weight to have a significant influence; and 3. Weight has a more significant impact on academic performance for those healthy weight students compared to those who are overweight/obese or underweight.

Using the total sample (i.e., no weight classification subsets), weight has differential impacts across the academic performance distribution with math results being more significant than reading results. For instance, for minority females in 1st grade, the impact of weight on math performance ranges from -2.57 to 1.75 across the distribution (Table 4) and for minority males in 8th grade, it ranges from -1.21 to 1.76 (Table 2). For reading scores, BMI has the most

[7] Overweight/obese and underweight results are not reported due to minimal significance and space. Results are available upon request.

significant impact on both 8^{th} grade males and females in the 5^{th} to 25^{th} quantiles negatively impacting minority females and positvely impacting white males and females. The difference in coefficient estimates of weight across the distribution supports the use of quantile methodologies when evaluating academic performance. In addition, weight becomes more significant as the child progresses through school with minimal significance in 1^{st} grade.

Examining the "average" child with OLS and 2SLS methods, child weight has a minimal significant effect on both math and reading scores for all subsets of students (i.e., minority, white, males, and females) in 1^{st}, 5^{th} and 8^{th} grades. Results from IVQR show evidence that child weight may influence the achievement gap: weight tends to positively affect white students, particularly at the lower end of the academic performance distribution for 8^{th} grade math and reading scores (5^{th}-35^{th} quantiles) with magnitudes ranging from an increase in scores of 1.04 points to 2.80 points (Table 2, Table 3 and Table 5). These results indicate that weight has a disproportional effect on lower performing students compared to the average student and that weight may actually increase the achievement gap (i.e., weight has a significant positive impact on white students while either a negative or insignificant impact on minority students).

Running models by weight classification gives more nuanced results compared to using the total sample. Weight has a larger mostly positive impact on the academic performance of students who are in the healthy BMI range as seen in Table 6 to Table 9 compared to those who are overweight/obese or underweight. These results support literature finding that child overweight is not a causal predictor of test scores (Averett and Stifel 2010; Datar, Sturm and Magnabosco 2004; Judge and Jahns 2007). This is predominantly evident with the math and reading scores of white males at the lower end of the performance distribution (5^{th} to 50^{th}

quantiles) which can be found in Table 6 and Table 7. Magnitudes on 8th grade white male math scores (Table 6) range from an increase of 1.79 points (50th quantile) to 5.57 points (5th quantile). Similar results can be seen for minority males and females of healthy weight at the higher end of the math and reading performance distributions (85th-95th quantiles). For instance, weight increases math scores by 9.56 points for minority males of healthy weight in 1st grade and by 6.98 points in 8th grade (95th quantiles). Our results cast doubt on the generalizability of results from existing studies that have focused on average effects. In terms of policy, this signifies that having children be in the healthy BMI range (i.e., decreasing the incidence of childhood overweight) could possibly lessen the achievement gap through the improvement of scores, especially since black and Hispanic students are more likely than white students to be overweight.

CONCLUSIONS AND POLICY IMPLICATIONS

Using a nationally representative sample of kindergartners followed through 8th grade, we examine the impacts of weight (underweight, healthy weight and overweight/obese) across the performance distribution. We modify You and Davis' (2010) theoretical model to incorporate cognitive production and derive instruments to conduct a more theoretically consistent study that accounts for simultaneity. This paper contributes to the literature by combining quantile regression methods with controlling for endogeneity using Instrumental Variable Quantile Regression (IVQR). Furthermore, our model considers the influence of home and school environments in the production process while examining both underweight and overweight children.

Our results cast doubt on the generalizability of results from existing studies that have focused on average effects. We find that the heterogeneous relationship between child weight and academic performance varies across the distribution having a larger significant impact on lower performing students; therefore, results on the "average" child do not present an accurate relationship between child weight and academic performance. In addition, weight has the most significant impact on those students in the healthy BMI range compared to those who are overweight/obese or underweight for both the minority and white students.

Results indicate that programs and policies targeting child weight could potentially have positive spillover effects on academic performance particularly if aimed at the lower performing and misnourished students. Policies should advocate maintaining a healthy weight and an active lifestyle as to include underweight children rather than only focusing on overweight/obese students. Since children spend a majority of their waking hours in school, school level policies are natural policy instruments that can potentially have far-reaching impacts.

Local Wellness Policies (LWPs) are one example which are required in districts that participate in the National School Lunch Program (NSLP) promoting healthy eating and an active lifestyle among students. Policies vary by district and the effects are relatively unknown; however, if certain strategies within the LWPs are found to be successful then they should be implemented throughout all districts. For instance, Bhatt (2009) finds that lengthening the amount of time that children eat lunch by ten minutes may help reduce childhood obesity. This could be a component of LWPs. In addition, Millimet, Tchernis and Husain (2010) and Bhattacharya, Currie and Haider (2006) find that SBP is influential in nutritional outcomes and in reducing childhood obesity; therefore, more regulation regarding school meals could positively impact child weight. Policies targeting childhood weight could have spillover effects into academic performance and potentially lessen the effects of the achievement gap.

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Table 1: Summary Statistics for Sample by Subject Area and Grade Level

		1st Grade		5th Grade		8th Grade	
Variable	Description	**Math**	**Reading**	**Math**	**Reading**	**Math**	**Reading**
Child							
Obese	=1 if child is obese	0.12	0.12	0.18	0.18	0.16	0.16
		(0.33)	(0.32)	(0.39)	(0.38)	(0.37)	(0.36)
Overweight	=1 if child is overweight	0.13	0.13	0.17	0.17	0.16	0.16
		(0.34)	(0.34)	(0.38)	(0.37)	(0.37)	(0.37)
Underweight	=1 if child is underweight	0.03	0.03	0.03	0.03	0.03	0.03
		(0.18)	(0.18)	(0.17)	(0.17)	(0.17)	(0.17)
BMI z-score		0.36	0.35	0.50	0.49	0.51	0.49
		(1.08)	(1.08)	(1.13)	(1.12)	(1.07)	(1.06)
CurrentTest Score	IRT test score	64.81	81.46	127.82	155.92	145.39	175.81
		(17.68)	(22.67)	(23.68)	(23.89)	(20.43)	(24.39)
Baseline	IRT test score upon entering kindergarten	27.44	36.24	27.39	36.17	27.84	36.55
		(9.02)	(9.68)	(8.97)	(9.64)	(9.24)	(9.94)
Female	=1 if child is female	0.49	0.50	0.50	0.50	0.50	0.51
		(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Black	=1 if child is black	0.09	0.09	0.08	0.09	0.07	0.08
		(0.28)	(0.29)	(0.28)	(0.28)	(0.26)	(0.27)
Hispanic	=1 if child is Hispanic	0.15	0.11	0.15	0.11	0.14	0.10
		(0.36)	(0.31)	(0.36)	(0.31)	(0.34)	(0.30)
Home Environment							
HelpHW	frequency parents help child with homework	2.80	2.78	1.75	1.95	1.14	1.24
		(1.01)	(1.01)	(1.22)	(1.18)	(1.16)	(1.06)
Income	household income on scale 1-9	5.01	5.14	5.30	5.42	5.67	5.79
		(2.09)	(2.05)	(2.14)	(2.10)	(2.03)	(1.99)
Involve	how involved the parent is in childs school on scale 1-7	4.85	4.91	4.89	4.94	2.93	2.98
		(1.56)	(1.53)	(1.50)	(1.48)	(1.81)	(1.81)
School Environment							
Enrollment	school enrollment ranked 1-5	3.55	3.51	3.47	3.43	4.04	4.01
		(1.05)	(1.05)	(0.99)	(0.99)	(1.04)	(1.04)
Title 1	=1 if school is Title 1	0.38	0.35	0.40	0.38	0.37	0.36
		(0.49)	(0.48)	(0.49)	(0.48)	(0.48)	(0.48)
N		3677	3496	3994	3792	3563	3407

Note: underweight, overweight and obese are calculated using the CDC's SAS program for Growth Charts: http://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm

Standard errors in parentheses

Table 2: Minority and White Male Math Scores - BMI z-scores

		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=1078**	-0.36	-1.17	0.29	1.61	1.39	0.51	1.28	1.17	2.05	2.93	4.14
		(0.94)	(1.51)	(0.98)	(1.13)	(1.24)	(1.24)	(1.41)	(1.53)	(1.90)	(2.16)	(3.06)
	White N=2187	-0.57	0.50	0.15	-0.03	0.51	-0.21	0.60	1.05	1.95	3.21*	5.91**
		(0.77)	(1.61)	(0.83)	(0.92)	(0.99)	(1.09)	(1.21)	(1.31)	(1.46)	(1.71)	(2.29)
5th Grade	**Minority N=745**	-0.04	-0.01	1.41	0.78	0.60	1.50	2.31**	1.23	1.32	1.05	0.33
		(1.04)	(1.23)	(0.86)	(1.00)	(1.04)	(1.06)	(1.13)	(1.15)	(1.12)	(1.20)	(1.14)
	White N=1700	-0.80	-0.58	-1.65**	-0.80	-0.80	-0.30	-0.30	-0.50	-0.65	-0.30	-1.45**
		(0.49)	(0.59)	(0.78)	(0.62)	(0.60)	(0.57)	(0.57)	(0.56)	(0.55)	(0.55)	(0.53)
8th Grade	**Minority N=491**	-0.56	0.40	-1.21	1.76	0.95	-0.31	-0.31	-0.13	-0.13	0.59	-0.22
		(0.82)	(1.10)	(1.63)	(1.17)	(1.20)	(1.12)	(1.11)	(1.14)	(1.23)	(1.26)	(1.05)
	White N=1376	0.72	2.02***	0.80	1.16**	1.20**	1.04*	0.76	0.60	0.48	0.16	0.04
		(0.52)	(0.59)	(0.72)	(0.56)	(0.54)	(0.52)	(0.51)	(0.50)	(0.49)	(0.46)	(0.41)

Note: robust standard errors in parentheses

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Table 3: Minority and White Male Reading Scores - BMI z-scores

		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=892**	1.11	2.50	-1.50	-1.33	-0.99	-1.33	-0.48	-0.82	-2.18	-2.52	-2.52
		(1.19)	(2.14)	(1.88)	(1.95)	(1.92)	(1.98)	(1.84)	(1.82)	(2.01)	(2.13)	(2.35)
	White N=2187	-0.55	-2.12	1.32	1.20	-0.24	-0.36	0.48	0.24	-0.36	-1.20	0.00
		(0.71)	(1.93)	(1.15)	(1.18)	(1.24)	(1.24)	(1.20)	(1.26)	(1.33)	(1.39)	(2.24)
5th Grade	**Minority N=606**	-1.40	-2.83**	-2.00*	-1.80	-1.40	-1.50	-1.10	-2.10*	-2.00	-3.30**	-2.40*
		(1.04)	(1.27)	(1.08)	(1.25)	(1.23)	(1.25)	(1.26)	(1.25)	(1.26)	(1.29)	(1.42)
	White N=1679	-0.50	0.11	-0.30	0.30	0.60	0.06	-0.42	-0.60	0.06	-0.42	-0.48
		(0.52)	(0.62)	(0.80)	(0.72)	(0.69)	(0.69)	(0.69)	(0.71)	(0.72)	(0.72)	(0.73)
8th Grade	**Minority N=379**	1.55	1.06	4.56	2.69	2.18	0.48	-0.03	0.48	-0.20	2.52	2.18
		(1.65)	(2.38)	(2.83)	(2.37)	(2.37)	(2.33)	(2.33)	(2.35)	(2.26)	(2.32)	(2.12)
	White N=1363	0.74	1.60	0.15	1.90**	1.48*	1.06	0.57	-0.69	-1.25*	-0.69	0.01
		(0.74)	(0.99)	(1.30)	(0.87)	(0.82)	(0.78)	(0.75)	(0.73)	(0.73)	(0.68)	(0.53)

Note: robust standard errors in parentheses

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Table 4: Minority and White Female Math Scores - BMI z-scores

		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=1076**	0.18	1.75	-0.77	0.76	0.40	-0.14	0.13	0.04	-0.59	-0.68	-2.57**
		(0.76)	(1.69)	(1.34)	(0.95)	(0.95)	(1.00)	(1.04)	(1.13)	(1.17)	(1.26)	(1.11)
	White N=2137	-0.74	-1.91	-0.75	-1.75	-1.25	0.25	0.00	0.25	0.50	1.50	0.25
		(0.75)	(1.25)	(2.68)	(2.72)	(2.68)	(2.57)	(2.65)	(2.77)	(2.98)	(3.68)	(4.54)
5th Grade	**Minority N=796**	-1.29	-0.53	-2.48*	-0.95	-1.31	-1.67	-1.22	-0.86	-0.95	-0.50	1.66
		(0.90)	(1.46)	(1.39)	(1.12)	(1.13)	(1.14)	(1.13)	(1.09)	(1.06)	(1.14)	(1.20)
	White N=1684	0.16	-1.05	0.25	-0.10	-0.30	-1.10*	-1.25*	-1.45**	-0.85	0.85	1.80**
		(0.56)	(0.89)	(0.88)	(0.63)	(0.65)	(0.65)	(0.65)	(0.67)	(0.75)	(0.89)	(0.81)
8th Grade	**Minority N=462**	-0.47	-0.75	-0.32	-1.76	-0.68	-2.60*	-1.16	0.04	-0.20	-1.52	-1.88
		(0.90)	(1.22)	(1.18)	(1.45)	(1.50)	(1.52)	(1.45)	(1.39)	(1.32)	(1.31)	(1.20)
	White N=1385	-0.15	0.82	-0.42	0.36	0.84	0.18	0.06	0.12	-0.12	-0.42	0.18
		(0.68)	(0.76)	(1.11)	(0.78)	(0.76)	(0.75)	(0.72)	(0.70)	(0.70)	(0.73)	(0.73)

Note: robust standard errors in parentheses

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Table 5: Minority and White Female Reading Scores - BMI z-scores

		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=904**	0.68	-0.13	1.44	0.84	1.68	1.08	0.84	1.20	-0.96	-0.12	0.36
		(1.35)	(2.36)	(1.26)	(1.51)	(1.27)	(1.32)	(1.43)	(1.34)	(1.47)	(1.34)	(1.84)
	White N=2136	-1.33	-0.50	-4.20	-1.64	-1.32	2.84	0.92	-4.84	0.28	1.24	1.88
		(0.89)	(1.66)	(5.26)	(3.74)	(3.90)	(4.61)	(4.36)	(3.89)	(3.63)	(4.13)	(5.26)
5th Grade	**Minority N=638**	-0.55	3.51*	3.04*	0.73	1.28	0.73	1.39	1.83	2.05*	2.49**	3.37***
		(1.45)	(1.98)	(1.75)	(1.65)	(1.39)	(1.41)	(1.31)	(1.23)	(1.18)	(1.12)	(1.16)
	White N=1676	0.42	0.25	-0.01	-1.13	-1.06	-0.43	-0.22	0.20	-0.50	0.13	0.06
		(0.71)	(0.94)	(0.82)	(0.72)	(0.70)	(0.71)	(0.74)	(0.75)	(0.76)	(0.83)	(0.92)
8th Grade	**Minority N=376**	-3.95**	-1.74	-6.20**	-1.60	-2.20	-0.40	-1.00	1.40	0.60	-1.00	-1.40
		(1.62)	(1.71)	(2.56)	(2.26)	(2.40)	(2.34)	(2.35)	(2.35)	(2.37)	(2.45)	(2.10)
	White N=1382	0.53	1.28	2.80*	1.68	1.20	-0.24	-0.32	-0.48	-0.16	-0.56	0.64
		(0.66)	(1.02)	(1.43)	(1.20)	(1.09)	(0.93)	(0.86)	(0.86)	(0.85)	(0.84)	(0.74)

Note: robust standard errors in parentheses
* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level
Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Table 6: Minority and White Male Math Scores - Healthy Weight

		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=712**	-2.28*	0.78	3.80**	1.64	0.20	-0.52	1.64	1.64	4.34	3.44	9.56**
		(1.24)	(2.41)	(1.64)	(1.81)	(1.89)	(1.98)	(2.27)	(2.42)	(2.93)	(3.27)	(4.13)
	White N=1600	-1.33	0.78	-1.56	-1.08	-0.92	-2.36	0.36	1.00	1.48	3.56	7.56**
		(0.97)	(2.41)	(1.35)	(1.55)	(1.74)	(1.90)	(2.14)	(2.12)	(2.22)	(2.55)	(2.90)
5th Grade	**Minority N=386**	2.05	-0.16	4.00	2.50	4.00	3.25	4.75	3.50	2.50	1.75	1.25
		(1.61)	(2.59)	(2.89)	(3.13)	(3.20)	(3.36)	(3.53)	(3.50)	(3.32)	(3.14)	(2.99)
	White N=1067	-0.74	0.93	-1.93	-1.38	-0.28	-0.28	0.49	0.05	-1.49	-0.39	-0.50
		(0.93)	(1.21)	(1.60)	(1.63)	(1.51)	(1.38)	(1.27)	(1.20)	(1.17)	(1.13)	(1.11)
8th Grade	**Minority N=259**	-0.49	8.12*	-2.01	1.76	3.50	0.02	-0.27	2.92	4.37	2.92	6.98*
		(1.81)	(4.29)	(3.41)	(3.72)	(4.15)	(4.06)	(3.99)	(3.68)	(3.63)	(3.40)	(3.99)
	White N=897	1.11	4.60***	5.57***	5.57***	4.58***	2.96**	1.79*	1.52	1.61	1.25	0.62
		(0.93)	(1.09)	(1.52)	(1.39)	(1.27)	(1.15)	(1.07)	(1.02)	(1.01)	(0.99)	(0.81)

Note: robust standard errors in parentheses

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Table 7: Minority and White Male Reading Scores - Healthy Weight

		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=600**	-0.26	0.23	-4.34	-3.56	-2.00	-1.22	-1.74	-1.48	-0.96	-1.22	-6.42
		(2.16)	(3.15)	(2.69)	(2.97)	(3.20)	(3.09)	(3.05)	(3.14)	(3.32)	(3.74)	(4.38)
	White N=1600	0.23	-2.53	-0.55	-0.55	-2.07	-1.69	1.54	1.54	0.78	-0.93	-2.45
		(1.25)	(3.57)	(2.03)	(2.35)	(2.31)	(2.28)	(2.15)	(2.14)	(2.21)	(2.35)	(3.39)
5th Grade	**Minority N=322**	1.04	-3.21	2.40	-0.60	1.20	0.00	1.20	0.90	0.90	0.00	-1.50
		(2.15)	(3.18)	(3.49)	(3.82)	(4.17)	(4.10)	(3.90)	(3.72)	(3.80)	(3.60)	(3.33)
	White N=1058	-1.65*	-0.08	0.36	1.56	0.00	-0.84	-0.96	-0.84	-0.12	0.36	0.00
		(0.94)	(1.28)	(1.81)	(1.74)	(1.64)	(1.58)	(1.58)	(1.52)	(1.48)	(1.52)	(1.42)
8th Grade	**Minority N=211**	1.13	-2.87	14.96*	12.16	16.08*	5.44	4.88	2.08	4.32	3.20	11.60*
		(3.48)	(8.43)	(8.56)	(8.91)	(8.66)	(7.58)	(7.27)	(7.09)	(6.98)	(6.37)	(6.47)
	White N=889	1.63	4.26**	5.80***	5.95**	4.60**	3.55*	0.85	-0.80	-1.70	-1.10	-0.05
		(1.12)	(1.79)	(2.06)	(2.15)	(1.96)	(1.82)	(1.67)	(1.59)	(1.55)	(1.40)	(1.05)

Note: robust standard errors in parentheses

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Table 8: Minority and White Female Math Scores - Healthy Weight

		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=700**	0.73	4.06	-0.88	-1.45	0.64	-0.69	-0.50	1.21	-0.12	-0.12	-1.45
		(1.22)	(3.77)	(2.54)	(2.96)	(2.64)	(2.85)	(2.76)	(2.42)	(2.68)	(2.79)	(2.84)
	White N=1566	-0.18	-2.07	-1.32	0.28	-3.08*	-1.80	-1.32	-1.64	-0.36	-0.04	-2.12
		(0.98)	(1.71)	(1.91)	(1.70)	(1.75)	(1.62)	(1.57)	(1.67)	(1.76)	(2.14)	(2.54)
5th Grade	**Minority N=422**	1.82	6.62*	-2.40	1.00	-1.40	-0.60	-0.60	0.40	-0.20	0.40	6.80**
		(1.41)	(3.34)	(3.74)	(2.94)	(2.80)	(2.76)	(2.68)	(2.53)	(2.44)	(2.45)	(3.19)
	White N=1101	-0.43	-2.63*	-2.15	-1.16	-0.61	-0.83	-1.60	-0.94	0.05	0.93	2.69*
		(0.94)	(1.37)	(2.17)	(1.49)	(1.45)	(1.41)	(1.36)	(1.36)	(1.39)	(1.53)	(1.54)
8th Grade	**Minority N=268**	-1.67	-2.77	-6.92*	-3.80	-2.84	-5.24*	-4.76	-0.44	-1.40	-5.72	-8.84**
		(1.73)	(2.78)	(2.00)	(2.34)	(2.58)	(2.85)	(3.05)	(3.08)	(2.98)	(3.71)	(4.10)
	White N=952	0.35	1.95	-1.76	-2.02	-0.07	0.45	-0.33	-0.20	-0.20	-0.85	-0.20
		(0.76)	(1.45)	(1.97)	(1.58)	(1.59)	(1.57)	(1.45)	(1.40)	(1.37)	(1.33)	(1.36)

Note: robust standard errors in parentheses

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Table 9: Minority and White Female Reading Scores - Healthy Weight

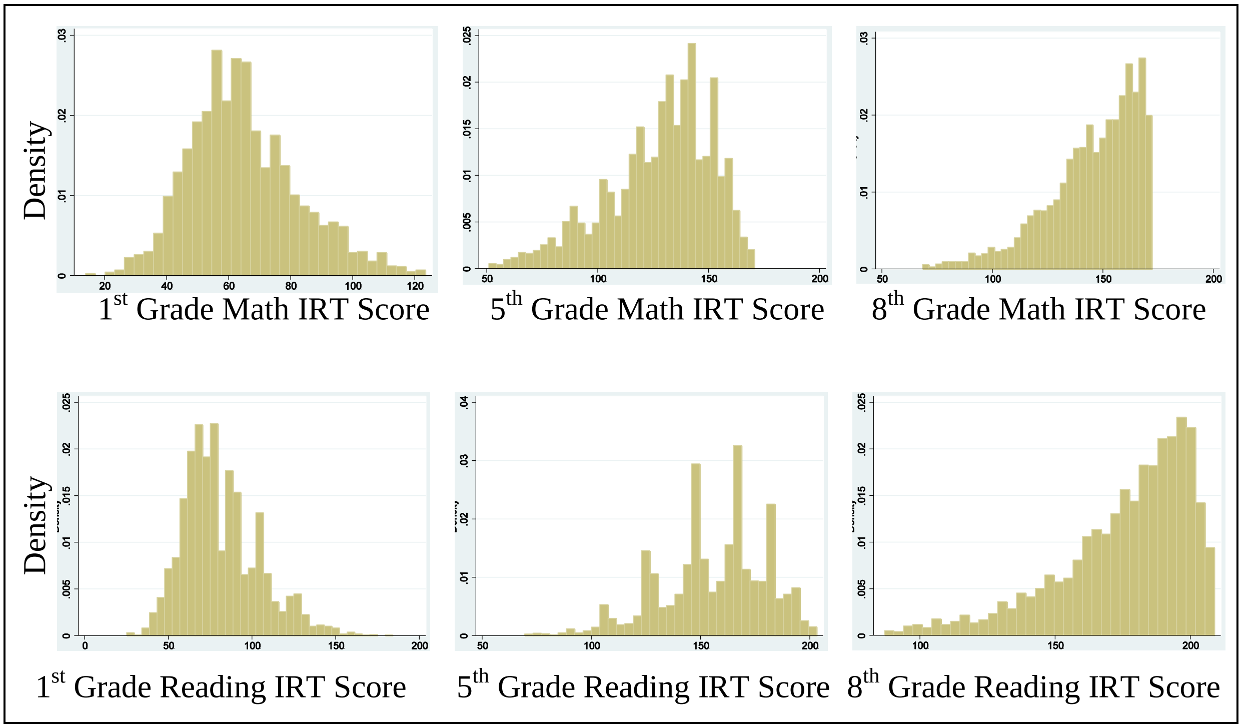
		Mean		IVQR								
		OLS	**2SLS**	**0.05**	**0.15**	**0.25**	**0.35**	**0.5**	**0.65**	**0.75**	**0.85**	**0.95**
1st Grade	**Minority N=588**	2.23	1.78	-2.08	1.00	2.40	1.84	2.96	1.84	0.16	1.56	10.24
		(1.89)	(5.16)	(3.23)	(3.39)	(3.10)	(3.12)	(3.01)	(3.20)	(3.37)	(3.38)	(6.81)
	White N=1565	-2.67**	0.58	-5.54*	-0.92	2.02	-0.29	-3.44	-1.13	-1.13	-0.92	3.49
		(1.16)	(2.70)	(3.07)	(2.45)	(2.51)	(2.45)	(2.36)	(2.16)	(2.06)	(2.07)	(2.86)
5th Grade	**Minority N=338**	0.33	5.71*	3.52	4.72	2.56	3.04	2.32	5.20*	4.48	5.44**	8.08***
		(1.93)	(3.18)	(3.09)	(2.90)	(2.88)	(2.91)	(2.81)	(2.85)	(2.74)	(2.59)	(2.64)
	White N=1097	-0.62	0.07	-0.24	-3.36**	-1.93	-0.76	0.02	0.15	-0.50	0.80	0.41
		(1.11)	(1.56)	(1.83)	(1.58)	(1.49)	(1.45)	(1.46)	(1.41)	(1.37)	(1.49)	(1.61)
8th Grade	**Minority N=218**	1.02	3.78	-2.46	-6.53*	0.13	-0.98	0.50	3.83	4.20	-3.20	-3.57
		(2.84)	(3.48)	(3.82)	(3.75)	(4.15)	(4.28)	(4.47)	(4.46)	(4.37)	(5.53)	(4.87)
	White N=939	2.13*	4.06**	0.31	4.39*	2.35	-0.20	0.99	1.67	1.33	1.67	2.18
		(1.09)	(2.00)	(3.12)	(2.47)	(2.29)	(1.90)	(1.80)	(1.78)	(1.78)	(1.76)	(1.44)

Note: robust standard errors in parentheses

* significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level

Explanatory variables include: BMI z-score, baseline BMI z-score, birth weight, age, baseline math score, previous math score, urbanicity, whether parents are married, number of siblings, household income, how involved the parent is in the child's school, how often the parent helps the child with homework, how often the child has changed schools, whether the child has a consistent bedtime, the number of students enrolled in the school, whether the school is Title 1, number of years the teacher has taught and whether the teacher has a Masters degree

Figure 1: Sample Distribution of 1st, 5th, and 8th Grade Math and Reading IRT Scale Scores



Chapter III: Do School Nutrition Programs Influence Child Weight? A Treatment Effect Analysis

ABSTRACT

Schools have significant influence on children's health making health interventions targeting schools more likely to succeed such as the School Breakfast Program (SBP) and National School Lunch Program (NSLP). A key question that this literature currently concentrates on is to what extent do SBP and/or NSLP directly contribute to the observed outcome of child weight? This study assesses the impact by analyzing multiple simultaneous treatments on weight as the child progresses from 1st to 8th grade while acknowledging self-selection into the programs. Specifically, we utilize Average Treatment Effect on the Treated (ATT) and Difference-in-Differences (DID) methodologies to address the issue. We find that participating in only NSLP decreases the probability of overweight; however, participating in both programs decreases the probability of healthy weight and increases the probability of overweight.

INTRODUCTION

Mainly due to the increase in the childhood obesity epidemic, public policy is increasingly targeting child weight. One of the most recognized programs is Michelle Obama's 'Let's Move' campaign proposing home, school and community interventions. Research has found school impacts on child health, particularly child weight, to be strong (e.g., Briefel, Wilson and Gleason 2009; Danielzik et al. 2005; James, Thomas and Kerr 2007; Muller et al. 2001; Story, Kaphingst and French 2006) making campaigns such as 'Let's Move' more likely to succeed. One of the key components of the 'Let's Move' campaign is healthier school meals through initiatives such as the Healthy, Hunger-Free Kids Act of 2010, *Chefs Move to Schools* and Small Farms/School Meals Initiative, all of which support the School Breakfast Program (SBP) and National School Lunch Program (NSLP).

The SBP and NSLP are two federally assisted school meal programs operating in public and nonprofit private schools designed to provide nutritionally balanced, low-cost or free meals to children in attendance each day. While administered at the federal level, the programs are directed by state agencies (usually departments of education) and are operated locally by school food authorities (SFAs) that are typically individual local education agencies. This allows for varying regulations and quality regarding school meals. However, as part of the Healthy, Hunger-Free Kids Act, the USDA raised nutrition standards of school meals in January 2012 for the first time in fifteen years which will be phased in through 2015.

As of 2009-2010, the SBP and NSLP covered over 101,000 schools (about 95% of all public and non-profit private schools in the US) with over 31.7 million children participating each day and nearly 20 million of these children receiving free- and reduced-price (FRP) meals

(USDA 2011). In addition to the large number of children served, research found that children consumed one-third to one-half of their daily calories and nutrients in school (Schanzenbach 2009), particularly those children in low-income communities. These children receive as much as 51% of their daily energy intake through SBP and NSLP (Briefel, Wilson and Gleason 2009). Therefore, policies supporting school meal programs are naturally promising tools that potentially impact a large number of children.

Most of the existing literature on SBP and NSLP examines the dietary quality of the food served, program accessibility, and connections between program participation and nutrient intake or child weight outcomes.[1] In addition to mixed results, most research has focused on correlations which may not reflect a causal relationship but merely the impacts of other characteristics that influence both child weight, program eligibility and the probability of choosing to participate in these programs. A causality investigation is essential: since these two programs are well established in terms of infrastructure, a strong positive causal impact between school meal programs and child weight could prompt effective policy implementation tools that will be easy to execute and have a large public health impact.

Some researchers have begun this investigation finding mixed results of program participation on child weight (Gundersen, Kreider and Pepper 2009; Millimet, Tchernis and Husain 2010; Schanzenbach 2009). However, these studies did not consider multiple simultaneous treatment effects nor did they examine longer-term program impacts. The School Nutrition Dietary Assessment III (Gordon et al. 2007) reported that 62% and 18% of students participated in NSLP and SBP, respectively. While the report did not mention the proportion of

[1] This literature will be elaborated on in the following sections.

students who participated in both programs, 25% of the students in our sample participated in both programs simultaneously at some point in elementary and/or middle school making multiple treatment analysis crucial.

A multiple overlapping treatment investigation of school meal programs is necessary since students have the option of participating in SBP and NSLP simultaneously. There are two main reasons motivating this type of analysis. First, impacts on child weight could vary depending on whether the child participates in one or both programs, and this effect is lost if programs are examined separately. For instance, the results of investigating one program could be overstated if program impacts mediate one another (i.e., SBP contributes to weight gain, but NSLP has an analogous or larger effect on weight loss or vice versa; therefore, only examining one program overstates the impacts on children who participate in both). Alternatively, the impacts could be understated if the effects of participation accumulate on one another (i.e., both SBP and NSLP contribute to weight loss; therefore, only looking at one program understates the impacts of the school meal programs for children who participate in both). Second, it is important to account for self-selection into multiple programs since research has found that students who participated in both programs had certain household and school characteristics driving them to participate in both compared to those who participated in only NSLP or neither program (Datar and Nicoisa 2009; Mirtcheva and Powell 2009; Reddan et al. 2002; Rosales and Jankowski 2002).

A key question that has been brought up in the literature that this paper concentrates on is, to what extent do SBP and NSLP contribute to the observed outcome of child weight? This research addresses the need for an impact analysis of two wide-reaching federal programs on child weight with the use of economic theory and econometric methods to identify the underlying mechanisms of this relationship. This research is innovative because we analyze multiple overlapping program treatment effects on child weight as the child progresses from 1st to 8th grade while acknowledging self-selection into SBP and NSLP. We utilize an interdisciplinary theoretical framework that considers the dynamic feature of a child's weight production function and, therefore, estimates both short-term and long-term effects on child weight (Capogrossi and You 2012).

Overall, the literature on multiple simultaneous treatments is minimal with Imbens (2000) and Lechner (2001) extending binary treatment effect analysis to multiple non-overlapping treatments. Cuong (2009) considers multiple overlapping treatments in a simulation analysis without providing an implementation tool. However, Bradley and Migali (2011) employ methodologies for studying multiple simultaneous treatments of two British school policies in addition to considering a multi-level setting. We utilize their Average Treatment Effect on the Treated methodology employing multiple overlapping treatments which is extremely applicable for school meal program analysis.

RELATED LITERATURE

Current literature examining school meals has mixed results with most having studied the dietary quality of the food served, program accessibility, and connections between program participation and children's nutrient intake and child weight outcomes. In addition, most research has focused on correlations which may not reflect a causal relationship but merely the impacts of other characteristics that influence both child weight, program eligibility and the likelihood of participating in these programs. This is the classic problem of non-random treatment cases where the data is either hard to obtain or full of observable and unobservable factors that simultaneously affect program participation and child weight.

Much research on SBP and NSLP focused on assessing the dietary and nutrient quality of school meals. Results from these studies are mixed. Cole and Fox (2008) found that NSLP participants consumed more calories on average than non-participants, 2343 versus 1989 calories. Furthermore, results from additional studies indicated that program participants consumed more of their calories at school from low-nutrient, energy-dense solid foods such as pizza (Briefel, Wilson and Gleason 2009; Gordon et al. 2007). However, in other research, Fox et al. (2010) found no significant differences in overall diet quality between participants and non-participants using the Healthy Eating Index (HEI). Further studies found positive correlations between school meal program participation and better nutrient intake of certain vitamins and minerals (e.g., Bhattacharya, Currie and Haider 2006; Gleason and Suitor 2003; Kennedy and Davis 1998).

Some literature has suggested a link between children/adolescents eating breakfast and lower BMI (Berkey et al. 2003; Niemeier 2006; Rampersaud et al. 2005) indicating that participation in SBP could aid in combatting the childhood obesity epidemic if healthy foods are provided. In the handful of studies specifically examining correlations between SBP and/or NSLP participation and child weight, results are also mixed. Some studies have shown no evidence of a relationship between NSLP and child weight (Gleason and Dodd 2009; Cole and Fox 2008). Other work has found NSLP participants more likely to be overweight (Fox et al. 2009; Hofferth and Curtin 2005), particularly low-income female participants (Hernandez, Francis and Doyle 2011). When examining SBP, Gleason and Dodd (2009) found that participation in SBP was associated with significantly lower BMI particularly among non-Hispanic, white students. Roy, Millimet and Tchernis (2010) examined associations between time use and families who participated in the Supplemental Nutrition Assistance Program (SNAP), SBP and NSLP as an effort to understand the mechanisms behind the relationship between assistance programs and child overweight. Their results suggested that participation in all three programs may benefit adolescent BMI.

There are several studies more in line with our research that examined whether school meal programs have a causal impact on child weight. Schanzenbach (2009) employed two methods: panel data to examine changes over time and the "fuzzy" regression discontinuity method. The author indirectly controlled for some non-random selection through the use of school-level fixed effects in her panel analysis. In addition, the RD methodology exploited exogenous characteristics of program selection based on income cut-offs and elicits a local average treatment effect. Both analyses indicated that by the end of 1st grade, NSLP participants were more likely to be overweight. However, self-selection into NSLP was not directly modeled, the focus of the panel data estimation was on short-term changes from kindergarten to 1st grade for ineligible FRP students, and Millimet, Tchernis and Husain (2010) pointed out that the RD method may only be valid for students near the income threshold.

Two other studies directly considered the selection process into SBP and NSLP in addition to program impacts on child weight. Millimet, Tchernis and Husain (2010) first assessed the relationship between meal program participation and child weight not directly accounting for any selection and then acknowledged the selection issue based on child weight trajectories from birth to kindergarten. Using school fixed effects, which accounted for some non-random selection, they found participation to be associated with higher BMI in 3rd grade. Specifically, there was a strong association between SBP participation and higher child weight for children who were in the "normal" BMI range in kindergarten as well as an association between NSLP participation and higher child weight for children who were "overweight" in kindergarten. In examining selection into the meal programs on the basis of weight growth prior to kindergarten, the authors found evidence of positive selection into SBP. In a sensitivity analysis, they found the positive associations from the original regressions to be sensitive to selection on unobservables; however, they were unable to obtain point estimates of the effects of participation with selection. Millimet, Tchernis and Husain (2010) then used propensity score matching (PSM) to estimate the average treatment effect (ATE) of SBP and NSLP individually. The authors found participation in either SBP or NSLP in kindergarten to be associated with greater child weight in 3rd grade. However, results were not robust to selection on unobservables when Rosenbaum bounds were obtained.

Focusing on FRP NSLP recipients who are 8-17 years-old, Gundersen, Kreider and Pepper (2009) applied partial identification bounding methods to ATE estimation to make inferences on the self-selected sample. Using the monotone instrumental variable assumption,[2] they found that FRP participants had better health outcomes than eligible non-participants.

As is evident, there are mixed results in the literature in terms of school meal program impacts on child weight indicating that a continuation of the analysis on SBP and NSLP is

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[2] This assumption is used instead of the standard independence assumption and states that certain observed covariates are known to be monotonically related to the latent response variable. Specifically, the authors assume that the latent probability of poor health is non-increasing with income.

necessary. We contribute to the literature by using our derived theoretical model of child weight to examine direct impacts of program participation while taking into account self-selection, multiple simultaneous treatments and school environment factors. In addition, prior results do not provide longer-term effects of program participation, so we examine program impacts on child weight through 8^{th} grade.

CONCEPTUAL FRAMEWORK

You and Davis (2010) establish a two-stage Stackelberg model that depicts the interaction between parents and a child while permitting the child to have some input to household resource allocation decisions. Their model considers a multi-person household where the husband and wife interact in the collective model framework weighting their individual utility and using their individual bargaining weights within the household which results in Pareto efficient resource allocation decisions. The parents are modeled as the leader and, therefore, make decisions taking into account the possible best responses of the child. The child is modeled as the follower and makes choices after observing parental decisions while knowing that his responses have influence on the observed parental allocations. Due to the unique problems this dissertation examines and the data set available, several changes are made to the You and Davis (2010) framework for the use of this study.

First, we modify the framework to a unitary model since the data we have only contains household head information. We recognize that this imposes restrictions on the parental decision process; however, because our interest is not on the impacts of parental time allocations with the child as in You and Davis (2010), this modification does not hinder our investigation. In addition, we expand the You and Davis (2010) child health production function to include consumption goods affecting weight and utility as well as goods affecting weight but not utility as discussed in Rosenzweig and Schultz (1983). We also include the school environment in our child weight production function since school contexts are found to impact obesity (e.g., Crosnoe and Muller 2004), and we have school characteristic data available.

These expansions of the child health production function make the model more appropriate for our problem of interest and capture additional influences on child weight allowing for a more thorough analysis. For example, including consumption goods affecting weight but not utility allows for impacts on child weight that may be beyond the control of the child such as the quality of medical care that the child receives. Furthermore, since children spend a majority of their waking hours in school, it is not surprising that research has found strong impacts of school influences on child health, particularly child weight (e.g., Briefel, Wilson and Gleason 2009; Danielzik et al. 2005; James, Thomas and Kerr 2007; Muller et al. 2001; Story, Kaphingst and French 2006). Therefore, the inclusion of school determinants in the weight production function is crucial.

This theoretical framework provides better guidance for the theoretical interpretation of our coefficients (Keane 2010). Keane (2010) argues that structural work has had a minimal presence in the literature recently, but that even experimentalist work is difficult to interpret without further structure and theoretical assumptions. Through the use of explicit assumptions, structural models aid in the understanding of the mechanisms driving the results and provide a concrete theoretical interpretation of coefficients.

The Child's Optimization

We use backward induction and begin with the child's decision-making stage. Given what is available, the child makes choices regarding the amount of goods consumed that affect both weight and utility as in Rosenzweig and Schultz (1983) (e.g., food and beverages that the child eats and drinks) $(\boldsymbol{x_B})$ in addition to the amount of other consumption goods not affecting weight $(\boldsymbol{x_o})$. The child also makes decisions regarding time spent in consuming all of these goods $(\boldsymbol{t_X})$, time spent on exercise $(\boldsymbol{t_E})$ and time spent on other activities $(\boldsymbol{t_o})$. The child weight production function is as follows:

$$B = \boldsymbol{B}(\boldsymbol{x_B}, \boldsymbol{t_E}, \boldsymbol{t_X}; SBP, NSLP, \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}) \quad (1)$$

Participation in the school meal programs $(SBP, NSLP)$ provides a given set of food choices for the child as well as contributes to a child's weight outcome (e.g., Briefel, Wilson and Gleason 2009; Cole and Fox 2008; Gordon et al. 2007). Since whether the child participates in one or both programs is a household head decision[3] (Gordon et al. 2007), the child's weight production function is conditional upon participation. In addition, parental time spent in food preparation $(\boldsymbol{T_f})$ reflects the quality of food at home since the child's food choices are restricted by the environment provided by the parents (e.g., Barlow and Dietz 1998; Oliveria et al. 1992), and children's food preferences are partly shaped by observing their parents' food selections (e.g., Harper and Sanders 1975; Cutting, Grimm-Thomas and Birch 1997). Due to our data

[3] Local Education Agencies (LEAs) must distribute information letters to the households of children attending school at the beginning of each school year. Letters must inform families about which school nutrition programs are offered and that meals may be available free or at reduced prices along with eligibility requirements for free- and reduced-price meals. While applications for free- and reduced-price meals may be accessed online, all LEAs must be able to provide households with paper applications, and the information letter must provide instructions on how to apply for free- and reduced-price meals. Students paying full-price for meals do not need to apply.

limitations, we utilize a frequency measure of time spent in home food preparation which captures a general pattern of the home environment that is unlikely to change in the short term. Therefore, the weight production function considers the quality of food that the child consumes both at home and school.

The child weight production function also conditions on the child's weight outcome in the previous period (B_{t-1}) as in Foster (1995) which captures some of the genetic effect on current child weight as well as unobserved environmental characteristics interacting with the genetic effect contributing to a child's past and current weight status. According to the CDC (2010), obesity ensues from the interaction between genetic variation and shifting environmental factors which is evident when members of a family living in the same environmental conditions have different weight outcomes. The production function also conditions on child characteristics $(\boldsymbol{\mu})$ which includes birth weight to capture the endowment health effect, as well as household $(\boldsymbol{K_h^B})$ and school $(\boldsymbol{K_s^B})$ environment characteristics affecting weight. The weight production function also conditions on weight inputs that do not augment child utility other than through effects on weight ($\boldsymbol{I}$) (e.g., health insurance, healthcare) (Rosenzweig and Schultz 1983).

The child's utility function depends on his/her weight (B), consumption of goods $(\boldsymbol{x_B}, \boldsymbol{x_o})$ and his/her time allocations $(\boldsymbol{t_X}, \boldsymbol{t_E}, \boldsymbol{t_o})$. It is conditional on school meal program participation $(SBP, NSLP)$. School meal program participation is included in the child's utility function since there is some evidence of stigmas attached to participation even though the choice to participate in the program is exogenous to the child. Much research shows a negative stigma attached to program participation (Bhatia, Jones and Reicker 2011; Mirtcheva and Powell 2009;

Saunders 2009; Pogash 2008). However, Lambert et al. (2002) finds that 79% of parents encourage participation in NSLP with favorable attitudes toward the program, and during childhood and adolecent years, children's attitudes often reflect those of their parents (Cobb 2001; Klausmeier and Ripple 1971) indicating potential positive notions about program participation. The child's utility function is as follows:

$$u = \boldsymbol{u}(B, \boldsymbol{x_B}, \boldsymbol{x_o}, \boldsymbol{t_X}, \boldsymbol{t_E}, \boldsymbol{t_o}; SBP, NSLP, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}) \tag{2}$$

Utility maximization is subject to the child's weight production function as well as a time constraint $\boldsymbol{t_X} + \boldsymbol{t_E} + \boldsymbol{t_o} = T$, where T is the total amount of time. The optimal choice set of the child is, therefore, $(\boldsymbol{x_B^*}, \boldsymbol{x_o^*}, \boldsymbol{t_X^*}, \boldsymbol{t_E^*}, \boldsymbol{t_o^*}) = f(SBP, NSLP, \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu})$ which is a function of parental choices, household and school environments as well as other exogenous variables. The reduced form equations obtained from the child's optimization stage will be used to acquire the final reduced forms from the parental stage. The following is the child's indirect health production function and the child's indirect utility function:

$$B^* = \boldsymbol{B}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}) \tag{3}$$

$$u^* = \boldsymbol{u}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}) \tag{4}$$

The Parent's Optimization

The unitary model assumes that there is one parent (i.e., the household head) acting as the main decision-maker. The household head makes the decisions during the first-stage of the game, including decisions on the child's school meal program participation, while taking into consideration the child's responses to his/her decisions. The household head's utility is affected directly by child's weight (B^*) and utility (u^*) as well as goods and foods purchased for the household that are available to the child $(\boldsymbol{X_B}, \boldsymbol{X_o})$, goods the household head consumes himself/herself $(\boldsymbol{Z})$, home and work environment characteristics $(\boldsymbol{K_h}, \boldsymbol{K_w})$, household head characteristics $(\boldsymbol{\varphi})$ and household head time allocations to work, food preparation and other residual activities $(\boldsymbol{T_w}, \boldsymbol{T_f}, \boldsymbol{T_o})$. Note that child participation in school meal programs enters the household head's utility indirectly through the child's weight (B^*) and the child's happiness level (i.e., utility (u^*)). The household head's utility function is

$$v = \boldsymbol{v}(\boldsymbol{Z}, \boldsymbol{T_w}, \boldsymbol{T_f}, \boldsymbol{T_o}, \boldsymbol{X_B}, \boldsymbol{X_o}, B^*, u^*; \boldsymbol{K_h}, \boldsymbol{K_w}, \boldsymbol{\varphi}) \tag{5}$$

which is subject to the child's weight production function as well as the household head's time constraint $\boldsymbol{T_w} + \boldsymbol{T_f} + \boldsymbol{T_o} = T$ and budget constraint $\boldsymbol{p}(\boldsymbol{Z} + \boldsymbol{X_B} + \boldsymbol{X_o}) = Y$. In the budget constraint, $\boldsymbol{p}$ are market prices associated with consumption goods and Y is total household income. The child's participation in the school meal programs enters the household head's utility function indirectly through B^* and u^*. The optimal household head choices are then functions of the exogenous variables in the model:

$$(SBP^*, NSLP^*, \boldsymbol{Z}^*, \boldsymbol{X_B^*}, \boldsymbol{X_o^*}, \boldsymbol{T_j^*}) = f(\boldsymbol{p}, \boldsymbol{K_h}, \boldsymbol{K_w}, \boldsymbol{K_s}, \boldsymbol{I}, B_{t-1}, \boldsymbol{\varphi}, \boldsymbol{\mu}) \text{ where } j = w, f, o \tag{6}$$

Substituting the household head's optimal input demand functions into the child's indirect weight production function yields the final reduced form equation for the child's weight outcome

$$B^{**} = \boldsymbol{B}(\boldsymbol{I}, B_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{7}$$

The theoretical model presented above provides the key equation of interest: the child's structural health outcome production function (Equation 1). The child's optimal choices from maximizing child utility in Equation 2 are functions of household and school characteristics outside of the child's control. Similarly, the household head's optimal choices (Equation 6) from maximizing household head utility in Equation 5 are functions of characteristics outside the household head's control. These optimal choices allow us to obtain the final reduced form of the child health outcome (Equation 7) where all explanatory variables are predetermined. Equation 6 also provides for instrument selection and model specification (Park and Davis 2001). This paper focuses on the estimation of Equation 1 with a particular interest on the impacts of *SBP* and *NSLP* on child weight.

ESTIMATION STRATEGIES

Self-Selection and Multiple Simultaneous Treatments

The two aforementioned studies (Millimet, Tchernis and Husain 2010; Gundersen, Kreider and Pepper 2009) utilize ATE in their estimations of school meal program effects on child weight. This technique examines the expected effects of school meal programs on a child's weight for a randomly selected student from the population through comparing the outcome effects of students who do and do not participate in the programs. Conditional on the covariates in the sample, ATE estimates: $\tau_{ATE} = \frac{1}{N}\sum_{i=1}^{N} E[Y_i(1) - Y_i(0) \mid X_i]$. This is the most relevant technique if the policy or program exposes every individual to the treatment or none at all (Imbens and Woolridge 2009). The ATE is focused on the average causal effect on the population which is difficult to identify from confounded observational data unless strong assumptions are made (Geneletti and Dawid 2011). One of these assumptions is referred to as the "no confounding" assumption by Geneletti and David (2011) or the conditional independence assumption which assumes that beyond covariates X there are no unobserved characteristics associated with both the treatment and the outcome. A second assumption is the joint distribution of the treatments and covariates (i.e., overlap assumption) where the support of the conditional distribution of X_i given no treatment $(T=0)$ overlaps completely with the conditional distribution of X_i given the individual participates in the treatment $(T=1)$ (Imbens 2004).

In terms of policy implications, ATE examines the effect of moving the entire population from one universal policy to a different universal policy. Heckman and Vytlacil (2007) give the example of moving from no Social Security to full-coverage for the entire population. He also notes that policy effects such as these would likely cause additional social interactions and general equilibrium impacts; however, ATE assumes away these potential effects.

In contrast, the Average Treatment Effect on the Treated (ATT) examines program effects on a well-defined population exposed to the treatment or effects of a voluntary program where individuals are not obligated to participate (Imbens and Woolridge 2009): $\tau_{ATT} = \frac{1}{N_1} \sum_{i|T_i=1} E[Y_i(1) - Y_i(0) | X_i]$. This is more relevant to our case: we are interested in the effect of participation on those children who choose to participate in SBP and/or NSLP where non-participation is always an option. We want to examine the expected effects of school meal programs on a child's weight who actually participates in one or more programs compared to if the same child had chosen not to participate and vice versa. If the program has a constant effect over all individuals, then ATE and ATT estimates would be identical. However, if heterogeneity is present, then estimates differ (Imbens and Woolridge 2009).

ATT actually considers two distinct effects together which calls for an analysis other than ATE: a treatment effect and a selection effect (Geneletti and Dawid 2011). This scenario is more appropriate for the examination of SBP and NSLP because while we are interested in the impact of SBP and NSLP on child weight (i.e., treatment effect), research has shown that certain children are more likely to participate in the programs based mainly on home environment factors (i.e., the selection effect) (e.g., Sampson et al. 1991; Dunifon and Kowaleski-Jones 2001; Mirtcheva and Powell 2009). Therefore, it is crucial that we allow for the combination of effects. To answer this question, we implement the Average Treatment Effect on the Treated for multiple simultaneous treatments, and to our knowledge, no one has examined school meal program impacts using ATT.

Self-selection concerns arise due to observable and unobservable characteristics that cause individuals to select themselves into a program. These characteristics make participating individuals systematically different from those who choose not participate (i.e., households participating in SBP and/or NSLP are likely to differ from non-participating households). If these characteristics are also related to child weight, coefficient estimates are biased due to non-random selection into the programs (Willis and Rosen 1979). Even modest amounts of positive selection can eliminate or reverse initial program impacts on child weight (Millimet, Tchernis and Husain 2010). We follow the same approach as Bradley and Migali (2011) where we account for potential selection bias by focusing on two-stage models combined with propensity score matching (PSM). The first stage models selection into one or more programs, and the second stage examines the impact of participation on child weight taking program selection into account.

Previous research examines the relationship between a single binary treatment (either SBP or NSLP) and child weight. However, accounting for multiple simultaneous treatments is important since many children consume both breakfast and lunch at school. In our analysis, 25% of the students in the sample participate in both programs simultaneously at some point in elementary and/or middle school. In addition, when we conduct the Wald test for combining program categories, we reject the null of collapsing categories at $p < 0.001$. It is also important from a policy perspective to analyze whether participation in both programs has a different or larger impact on child weight compared to single program participation or no program participation.

Minimal work in the evaluation literature considers multiple simultaneous treatments. Imbens (2000) and Lechner (2001) are two of the pioneers of multiple treatment analysis. They began the examination of multiple treatments by extending the Rosenbaum and Rubin (1983) binary treatment methodology that used propensity score matching to adjust for pre-treatment variables. However, Imbens (2000) and Lechner (2001) mainly focus on the assumptions and properties of a multiple treatment estimator and comparisons with binary treatments. Lechner (2002) contributes one of the first empirical applications of multiple treatments to the literature using mutually exclusive Swiss labor market policies. Cuong (2009) furthers the analysis in the area with a simulation that considers multiple overlapping policies using difference-in-differences but does not provide a tool for implementation. Bradley and Migali (2011) allow for overlapping treatments in a multi-level setting with a practical implementation technique to study the impacts of multiple program impacts on student achievement. This paper does not contribute to the multiple treatment literature methodologically but applies Bradley and Migali's (2011) techniques to child nutrition programs in the US.

Due to the overlapping nature of SBP and NSLP, we utilize the multinomial logistic model (MNL) which estimates the probability of the child participating in one, both or neither of the school meal programs (Lechner 2002). There are several reasons for using MNL as our selection equation: 1. The model assumes that program participation cannot be perfectly predicted from the provided independent variables (Dow and Endersby 2004); 2. We estimate the probability of program participation based on a fixed, stable group of options; 3. MNL almost always converges to a global optimum without requiring numerical integration; and 4. Multinomial probit models (MNP) are often weakly identified in application and may produce arbitrary parameter estimates (Dow and Endersby 2004).

One of the criticisms of MNL is the independence of irrelevant alternatives (IIA) assumption (Dow and Endersby 2004); however, this should not be a problem for our model. Theoretically, the IIA is most applicable when the choices are seen as substitutes. Since participating in two different meal programs is not a choice of substitutes (i.e., they are two different meals—breakfast and lunch), IIA should hold.

We test IIA between SBP and NSLP empirically using a Wald test for combining alternatives (i.e., whether any pair of outcome categories can be combined). We reject the null hypothesis that alternatives can be combined at $p<0.001$. We also test the assumption using seemingly unrelated regression estimation and testing cross-model hypotheses of equivalent coefficient estimates, and we fail to reject the null hypothesis that IIA holds.[4] From the MNL, we obtain the marginal probabilities of program participation:

$$P(MP_i = k \mid \boldsymbol{x_i}) = \frac{\exp(\boldsymbol{X'\beta_k})}{\sum_{k=0}^{K} \exp(\boldsymbol{X'\beta_k})} \quad i = 1\ldots \mathrm{N}, k = 0\ldots \mathrm{K} \tag{8}$$

MP represents the treatment status of school meal program participation from our theoretical model $MP = \{SBP, NSLP, both\}$ of the N students in the sample with K options of program choices (in our case K=no participation, SBP, NSLP, both). ***X*** includes student, home and school characteristics that may influence the probability of the treatment. For instance, participation in SBP and NSLP is found to be higher among boys and single-parent households (e.g., Dunifon and Kowaleski-Jones 2001; Datar and Nicosia 2009a; Mirtcheva and Powell 2009). Because SBP and NSLP are school-based policies, we include school characteristics such as the percentage of students eligible for free- and reduced-price lunch and urbanity which provide an indirect control for school differences.

For the two-stage models, we create the Inverse Mills Ratios from the MNL predicted probabilities according to Dubin and McFadden (1984) which are included as covariates in our regressions.

Average Treatment Effect on the Treated (ATT)

[4] In addition, Dow and Endersby (2004) note that IIA is a logical property rather than a statistical property; therefore, estimated MNL probabilities are consistent even when in violation of the assumption.

We utilize propensity score matching to calculate ATT. Propensity score matching is a method proposed by Rosenbaum and Rubin (1983) to reduce the bias in treatment effect analysis using observational data. It matches treated and untreated observations that are as similar as possible in an attempt to control for potential confounding factors. Imbens and Wooldridge (2009) note that the use of propensity score matching allows for 'interpretable treatment effects' as compared to merely controlling for potential confounding factors. This is because it mimics random assignment and addresses the issue of common support. If there is insufficient support between treated and non-treated groups, the robustness of results is questionable. Therefore, using PSM with strong support and binary outcome measures of child weight, we can interpret results as the mean effect of program participation compared with no participation or participation in both programs compared to one program. For instance, the mean effect of participating in NSLP compared to no participation is a higher/lower probability (i.e., positive/negative coefficient estimate) of being overweight for NSLP participants minus the probability of not being overweight when participating in the program if the binary outcome measure is child overweight.

For multiple simultaneous treatment ATT, we must also take into consideration the conditional probability of joining program *g* rather than program *j* (or joining program *j* rather than *g* or joining both programs) where the conditional probability of choosing to participate in program *g* rather than program *j* is as follows:

$$P^{g|j,g} = P^{g|j,g}(MP = g \mid X = x, MP \in \{j, g\} = \frac{P^{g}(x)}{P^{j}(x) + P^{g}(x)} \qquad (9)$$

and where $P^{g|j,g}$ is the estimated propensity score. In addition, $P^g(x) = P(MP = g \mid X = x)$ and $P^j(x) = P(MP = j \mid X = x)$. We obtain each of the conditional probabilities from the MNL model where only pre-treatment variables are used.[5] Cuong (2009) finds that controlling for simultaneous participation in multiple treatments (e.g., using MNL rather than a series of binary models) makes PSM more efficient with regard to the mean square error. We then match the propensity scores for the treated and untreated groups for estimation using caliper matching which is discussed further in the *Results* section.

Using the notation of Bradley and Migali (2011), the multiple treatment version of the ATT is

$$ATT^{j,g} = E(Y_{ij} - Y_{ig} \mid MP = j) = E(Y_{ij} \mid MP = j) - E(Y_{ig} \mid MP = j), \qquad (10)$$

where $ATT^{j,g}$ is the expected average program effect of program *j* relative to program *g* for students participating in program *j*. *MP* is the treatment status. Because both outcomes cannot be observed for the same student, we utilize the Conditional Independence Assumption (CIA) for identification (Imbens 2000; Lechner 2001). The CIA requires observation of the major variables jointly influencing selection into the program and outcomes for a given treatment. Although we assume CIA, ATT is often identifiable with much weaker assumptions than ATE (Geneletti and Dawid 2011). With this assumption, we actually estimate:

$$ATT^{j,g} = E(Y_{ij} \mid MP = j) + E_{P^{g|j,g}}[E(Y_{ig} \mid P^{g|j,g}(X), MP = g) \mid MP = j] \qquad (11)$$

[5] Pre-treatment variables in our case are from when the child entered kindergarten.

The conditional probability of policy *g* is taken from the PSM (Equation 9). We conduct our simultaneous multiple treatment analysis on the subset of children who participate in one or both meal programs over the entire treatment period (i.e., do not switch participation status). We create a categorical variable where students can fall into one of four treatment categories:

1. No program participation over the entire period (k=0)
2. SBP participation only over the entire period[6] (k=1)
3. NSLP participation only over the entire period (k=2)
4. SBP and NSLP participation over the entire period (k=3)

We only examine children who participate in one or both programs from 1st to 8th grade in order to examine the long-term effects of participation on weight outcomes. Most of the work conducted prior to this has focused on short-term impacts of program participation on weight (e.g., Millimet, Tchernis and Husain 2010; Schanzenbach 2009). In addition, if school meals impact students' weight, we would expect a larger effect for students who participate in the programs for longer periods, particularly multiple programs.

Difference-in-Differences

An alternative way to examine school meal program effects on child weight is to use difference-in-differences (DID) estimation controlling for multiple treatments through a two-stage model (Bradley and Migali 2011). This method is used to examine changes induced by a

[6] Due to the data limitation of an extremely small sample size of students who only participate in SBP, we are unable to actually estimate this particular treatment effect. There are no children in our data set who only participate in SBP during the entire period from 1st to 8th grades.

certain event such as a change in school meal program participation status. In addition to examining the effect of a treatment by comparing the outcomes of the treated group pre- and post-treatment, the method also considers the outcomes of a control group over the same pre- and post-treatment period. This inclusion accounts for trends over time. Using DID also controls for unobserved heterogeneity at the student level.

DID is often associated with natural or randomized experiments; however, Blundell and Costa Dias (2000) noted that the use of standard matching estimators (e.g., propensity score matching) in conjunction with DID can "improve the quality of non-experimental evaluation results significantly". Furthermore, Smith and Todd (2005) found the combination of matching estimators with DID to perform the best among several estimators they studied. They credited this to DID eliminating possible sources of temporarily invariant bias that could be present in the data. Therefore, DID is not limited to only natural and randomized experiments (Girma and Gorg 2006; Heckman, Ichimura and Todd 1997; Smith and Todd 2005).

Using individual-level panel data with a treatment variable, an example of our DID estimation is the following:

$$y_{it} = \alpha + \beta_1 T_{it} + \beta_2 MP_{it} + \beta_3 (T_{it} * MP_{it}) + \beta_4 \boldsymbol{X}_{it} + u_{it}, \quad t = 1, 2 \tag{12}$$

We include a time period dummy variable T_{it}, a binary program indicator MP_{it} where $MP = \{SBP, NSLP, both\}$, an interaction between the time period and program indicator and an unobservable error term u_{it} in addition to covariates $\boldsymbol{X}_{it}$. From this model, β_3 is our program treatment effect that takes into consideration trends over time for both participants and non-participants in absence of the treatment.

DATA SPECIFICATION AND SUMMARY STATISTICS

In estimation, we utilize data from the Early Childhood Longitudinal Study-Kindergarten Class (ECLS-K) which is a longitudinal study of a nationally representative cohort of 21,260 children beginning kindergarten in the 1998-1999 school year and who are followed through 8th grade in the 2006-2007 school year. Conducted by the National Center for Education and Statistics (NCES), the study collected data on children in over 1,000 different schools, as well as on their families, teachers and school facilities/characteristics at seven different points. Details of the data collection and instruments can be found in the *Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 User's Manual*[7] (Tourangeau et al. 2009), and further details regarding specific variables used in this analysis will be throughout this section.

It is important to note that our analysis on child weight focuses on different subsamples of the student population in order to get an overall picture of school meal program effects. For example, we analyze students by weight classification (obese, overweight, healthy weight, and underweight) as well as by urbanity (rural and urban). For all models we only examine students in schools who have the opportunity to participate in both SBP and NSLP. This avoids a potential selection issue on the decision of local education agencies (LEAs) regarding participation in either one or none of the meal programs. Examining children in our sample who have the opportunity to participate in both SBP and NSLP in 1st, 3rd, 5th and 8th grades, 88.8% of public schools offer both programs in 1st grade. In 3rd grade, 87.5% of public schools offer both

[7] More details of the data set are also found in Chapter 1 of the dissertation.

programs. In 5th grade, 87.4% of public schools offer both programs. In 8th grade, 86.9% of public schools offer both SBP and NSLP.

For our ATT analysis we want to better understand long-term impacts of the programs on child weight; therefore, we examine children who participate in either one or both meal programs throughout elementary and middle school (i.e., during all of the last four rounds of data collection: 1st, 3rd, 5th and 8th grades). To mitigate some of the impact household income may have on both participation and child weight, we also separate models by children who receive FRP meals and those who pay full-price for meals. By separating the models we are able to examine how the programs impact the weight of lower income-children compared to higher-income children. If the programs themselves have a significant influence on child weight, then the impacts should be similar for all participants whether they receive FRP or pay full-price.

It is important to note that for all of our ATT estimation no covariates are used in the analysis. Covariates are used in the selection equations, conditional probabilities and propensity score matching; therefore, all of the variables used in these estimations impact our ATT results; however, we are unable to directly control for additional covariates in the estimation. For our DID estimation, we conduct analysis with covariates to control for additional determinants to child weight, but we also conduct analysis without covariates as with ATT. If both of our DID results (with and without covariates) are similar, this lends further support to our ATT results that only indirectly control for other determinants to child weight.

Selection Equations

Because the household head makes the decision regarding the child's school meal program participation, our program participation selection equations are derived from the parent's optimization stage of the theoretical model where in Equation 6 we derived all of the household head's optimal choices. From Equation 6, we specifically obtain the household head's decision for SBP and NSLP participation:

$$(SBP^{*}, NSLP^{*}) = f(\boldsymbol{p}, \boldsymbol{K_h}, \boldsymbol{K}_w, \boldsymbol{K}_s, \boldsymbol{I}, B_{t-1}, \boldsymbol{\varphi}, \boldsymbol{\mu}) \tag{13}$$

Program participation decisions are functions of exogenous variables that influence household head decisions as can be seen in Equation 13. Literature has shown that participation in the programs varies by gender, age, and race/ethnicity of the child ($\boldsymbol{\mu}$), household characteristics such as socioeconomic status, single-parent status, food assistance program participation, region, and urbanity ($\boldsymbol{K_h}$), and the price of school meals ($\boldsymbol{p}$).

One of the first studies on NSLP participation found race, income and parental education to be the most significant predictors for students participating in free- or reduced-price lunch and that parental employment, urbanity and income were the crucial determinants of students paying full-price for lunch (Zucchino and Ranney 1990). Specifically, participation in SBP and NSLP was found to be higher among boys, students from rural districts, and students from minority (especially black), low income, less educated single-parent households (Devaney and Fraker 1989; Sampson et al. 1991; Dunifon and Kowaleski-Jones 2001; Datar and Nicosia 2009a; Mirtcheva and Powell 2009). Research has also shown that children attending schools with a higher proportion of its students eligible for free lunch were more likely to participate (Mirtcheva and Powell 2009) as were students from families who were Food Stamp recipients (Dunifon and Kowaleski-Jones 2001; Mirtcheva and Powell 2009). In addition, Datar and Nicosia (2009b) found that children whose mothers work were more likely to participate in NSLP but less likely to participate in SBP ($\boldsymbol{K_w}$). Other factors found to influence SBP participation have included the scheduling of school breakfast, bus and transportation issues, and length of time to eat ($\boldsymbol{K_s}$) (Reddan et al. 2002; Rosales and Jankowski 2002; Project Bread 2000).

Therefore, the following covariates are included in our multinomial logit selection equation: child's gender, child's race/ethnicity, household income, mother's education level, whether the mother works full-time, whether the parents are married, urbanity, Food Stamp recipient status and proportion of students in the school eligible for free lunch.[8]

Child Weight

Equation 1 is the structural child weight production function and is the key equation of interest for this paper. Child weight (*B*) was measured directly by the ECLS-K at each data collection point. We use a continuous measure (BMI z-score) as well as dichotomous quantifiers of child weight (i.e., obese, overweight, healthy weight and underweight) calculated according to

[8] The models are also robust in significance and magnitude when we include SBP length and whether SBP is offered in the classroom or cafeteria in the selection equations for 5th and 8th grades; however, these variables are not available in 1st grade, so we do not include them in the models for which we present results.

the CDC standards.[9] We dropped 320 observations that were considered biologically implausible.[10]

From the theoretical model (Equation 1), child weight depends on three child choice variables: consumption of goods that affect weight (x_B), time devoted to exercise (t_E) and other goods that affect health (t_X). Covariates for the weight production function controlling for exercise include how many minutes per day on average the child watched television (e.g., Francis, Lee and Birch 2003; Gortmaker et al. 1996; Hancox, Milne and Poulton 2004; Tremblay and Willms 2003), how many days per week on average the child participated in 20 minutes of physical activity that made him/her sweat and whether the child was involved in sports (Ara et al. 2004; Lioret et al. 2007; Tremblay and Willms 2003). These variables were all reported by the household head for the 1st, 3rd and 5th grade data collections and were reported by the child for the 8th grade. Two of our key independent variables of interest that depend on parental choice were participation in SBP and NSLP which were included as factors that have an impact on child weight since these meals contribute up to one-half of a child's daily calories (Schanzenbach 2009). Whether the child participated in the meal programs, whether the child received free- or reduced-price meals and how many school meals on average the child consumed per week were all reported by the household head.

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[9] We used a SAS program provided by the CDC for the calculation of child's BMI (CDC "Growth Chart Training" 2009). The SAS program contains indices of the anthropometric status of children from birth to 20-years-old based on the 2000 CDC growth charts. The program uses a child's age in months, gender, height and weight to calculate BMI and BMI z-scores.

[10] The SAS program provides outlier observations based on the World Health Organization's fixed exclusion ranges. These are children with BMIs that are considered to be "biologically implausible values" (BIVs) (CDC "Growth Chart Training" 2009) (ie. the BMI is either too low or too high to be realistic).

Child characteristics $(\boldsymbol{\mu})$ included gender, age, race/ethnicity (e.g., Dubois and Girard 2006; Gordon-Larsen et al. 2004; Kimbro, Brooks-Gunn and McLanahan 2007) and birth weight in ounces (e.g., Danielzik et al. 2004; Brooks-Gunn and McLanahan 2007) which were all variables reported by the household head. Inputs that affect child weight but not utility ($\boldsymbol{I}$) (Rosenzweig and Schultz 1983) included whether or not the child had health insurance (Haas et al. 2003) which was reported by the household head, and the child's weight status in the previous period was also accounted for (B_{t-1}) (Salsberry and Reagan 2005). Home environment characteristics $(\boldsymbol{K_h^B})$ that affect child weight consisted of the mother and father's education levels (e.g., Lumeng et al. 2006; Rose and Bodor 2006), the mother's employment status (e.g., Ruhm 2008; Anderson, Butcher and Levine 2003), whether the parents were married (e.g., Gable and Lutz 2000; Salsberry and Reagan 2005), household income (e.g., Dubois and Girard 2006; Haas et al. 2003), urbanity (city vs. suburb vs. rural) (e.g., Lutfiyya et al. 2007; McMurray et al. 1999), whether the household was food secure (Casey et al. 2006), and how many days per week the family ate breakfast and dinner together.[11] Literature has shown that family meals have the potential to enhance health and prevent unhealthy weight behaviors in youth (Neumark-Sztainer, et al. 2004; Eisenberg, et al. 2004; Videon and Manning 2003). These variables were all reported by the household head.[12]

The food security status of the child's household was assessed based on responses to 18 food security questions that measured a wide range of food insecurity and reduced food intake

[11] We also examine models including the number of SBP and/or NSLP meals the child consumed on average per week as covariates to which the models are robust.

[12] With ATT estimation, we were unable to control for covariates other than the variables used for propensity score matching from the selection equation. Therefore, these were all covariates used in DID estimation.

issues. Answers to these questions were combined into a scale using statistical methods based on the Rasch measurement model. Calculations of the household food security variables followed the standard methods described in *Guide to Measuring Household Food Security, Revised 2000* by the US Department of Agriculture (Tourangeau et al. 2009). In this analysis, we used a dummy variable for whether the household was food insecure that equalled one if the household was "food insecure without hunger" or "food insecure with hunger".[13]

Summary Statistics

Table 1 provides summary statistics for the sample by grade level and meal participation status in order to examine changes over time.[14] At any point in time over the data collection period, between 85% and 87% of our sample participated in one or both school meal programs. However, very few children participated in only SBP—about 1% of our sample. Therefore, we did not consider participation in only SBP in our analysis. Our sample follows the literature in that program participation is higher among boys, black and Hispanic students (particularly for students participating in both SBP and NSLP) and students from families with lower incomes and higher food insecurity. In addition, BMI z-scores are higher among program participants compared to non-participants. Specifically, the percentage of students who are overweight and obese is highest among those who participated in both SBP and NSLP. For instance, in 8th grade, 39% of the students who participated in both programs were overweight or obese

[13] There may be some concern regarding potential endogeneity between food security and child weight; however, none of the existing literature acknowledged this as a problem when examining the relationship between the two (Casey et al. 2006; Gundersen, Garasky and Lohman 2009; Gundersen et al. 2008; Jones et al. 2003).

[14] All analyses in the paper used sample weights which produced estimates that were representative of the population cohort of children who began kindergarten in 1998-1999. The sample weight used was C1_7FP0.

compared to 32% who participated in only NSLP and 27% who did not participate in either meal program. Similar trends exist for 1st, 3rd and 5th grades as can be seen in Table 1.

Furthermore, while the number of days that children participated in activities that made them sweat is around 4 days per week for elementary school students and 5.5 days per week for middle school students, students participating in meal programs watched more television on an average day compared to NSLP only participants and non-participants. For example, participants in both programs in 8th grade watched nearly 4 hours of television per day compared to 3 hours per day for NSLP only participants and 2.5 hours per day for non-participants.

RESULTS

Average Treatment Effect on the Treated

We examine students who participated in one or both programs at every data collection point to investigate the long-term relative impacts that SBP and NSLP have on child weight from 1st to 8th grade using ATT analysis. ATT answers the following question: among those children who participate in the program(s), what fraction is helped by the program(s) and what fraction is hurt (Aakvik, Heckman and Vytlacil 2005)? More specifically, we examine the average gain on the treated which is the probability of a certain weight outcome when participating in the program. In our model, a child receives the treatment if the household head decides that the child will participate in SBP, NSLP or both school meal programs. We estimate Equation 11 which is reproduced below:

$$ATT^{j,g} = E(Y_{ij} \mid MP = j) + E_{P^{g|j,g}}[E(Y_{ig} \mid P^{g|j,g}(X), MP = g) \mid MP = j]$$

This estimation technique allows us to examine the expected average program impact of program *j* relative to program *g* on child weight for students participating in program *j*. Two control groups are constructed for the analysis—one where students do not participate in either program while the treatment group is students who either participate in one or both programs. Another control is where students participating in both programs are compared to students participating in one program. More specifically, we examine the following program impacts on child weight who consistently consumed school meals from 1st to 8th grades: 1. Students who participated in only NSLP relative to no program participation; 2. Students who participated in both SBP and NSLP relative to no program participation; and 3. Students who participated in both SBP and NSLP relative to only NSLP participation.

In our sample of all students who have the option to participate in both of the meal programs at their respective schools, roughly 20% participated in only NSLP from 1st to 8th grades consistently throughout all four rounds of data collection while 17% participated in both the SBP and NSLP and less than 4% of students participated in neither program during the period.[15] The other 59% of students changed participation during the period which is examined through DID estimation.

Once we have obtained propensity scores for each student, the validity of results is dependent on the quality of matches between treatment and control groups based on observed characteristics of the two groups. The more characteristics used to match observations the higher the probability that the two groups are balanced with respect to all the characteristics relevant for

[15] We only examined children whose schools provided the option to participate in both SBP and NSLP from 1st to 8th grade for all models. If schools did not participate in either program or only NSLP, we did not include them in the analysis.

the outcome measure (child weight). There are several methods for matching treatment observations with control observations: Nearest Neighbor, Caliper and Radius Matching, Stratification Matching and Kernel Matching.

With nearest neighbor each observation in the control group is matched to a treatment case based on the closest propensity score. Once the observations are matched, then the difference between the outcome of the treated units and the control units is computed. The disadvantage to this method is that because all treated units are given a match, some of the matches are fairly poor (Becker and Ichino 2002). Caliper and radius matching uses a predefined tolerance level on the maximum propensity score distance (caliper/radius) between matches. Treated observations are matched with nearest neighbor control observations within that caliper to avoid poor matches. If the radius is set very small, then it is possible that some treated units are not matched because the neighborhood does not have any control units with a close enough propensity score (Becker and Ichino 2002).

The stratification method divides the range of variation of the propensity scores into strata, then treatment and control units are matched within each strata. On average, treated and control units within each strata have the same propensity score. Some suggest that five strata are enough to remove 95% of bias associated with covariates (Cochran and Chambers 1965). The disadvantage of stratification matching is that it discards observations in blocks where either treated or control units are missing (Becker and Ichino 2002). With kernel matching treated observations are matched with a weighted average of all controls where the weights are inversely proportional to the distance between the propensity score of the treated and control units with the closest control cases having the greatest weight (Becker and Ichino2002).

For our ATT analysis, we use caliper/radius matching with a radius of 0.01 with replacement. Replacement is where a control unit can be a best match for more than one treated unit. We also impose common support by dropping 2% of the treatment observations that have the lowest match with its control. Common support is the existence of substantial overlap between the characteristics of the treatment and control groups. For our first two sets of analyses, the treated group were those students who participated in either only NSLP or both meal programs from 1st to 8th grade. The control group were students who did not participate in any meal program throughout elementary and middle school. In the last set of analyses, the treated group were students who participated in both programs and the control were students who participated in only NSLP to obtain relative program effects.

We matched on the following characteristics from the kindergarten data collection round: gender, race/ethnicity, household income, mother's education, whether the mother works full-time, whether the parents are married, urbanity, whether the household has received Food Stamps within the last 12 months and the percent of children within the school eligible for free lunch. We used measures from when the child was in kindergarten because these are considered pre-treatment variables. Table 2 shows the common support between treatment and control observations for our sample by participation status and whether students receive free- and reduced-price meals or pay full-price. When matching participation to no participation, the number of treated observations off support is small: 0.5% to 3.7% of our sample. However, the number off support is larger when we match NSLP only participants to those students who participated in both programs—7.3% to 16.3% of our sample.

We also conducted a sensitivity analysis on the robustness of PSM estimates to selection on unobservables using Rosenbaum bounds. The propensity score constructs matched pairs that balance many observed covariates in a model absent random assignment. With random assignment, treatment and control groups are comparable with regard to the distribution of covariates; however, the propensity score does not balance unobserved covariates (Joffe and Rosenbaum 1999). Therefore, PSM needs robustness checks to determine the sensitivity of estimates to these unobserved covariates that are unaccounted for.

Rosenbaum bounds allow us to determine how strong the influence of unobservables must be on the selection process to weaken the results of the matching analysis (Becker and Caliendo 2007). This is crucial because if there are unobserved variables that influence program participation and child weight simultaneously, a hidden bias may exist to which matching estimators are not robust. It is important to note that this sensitivity analysis does not test the assumption of unconfoundedness (i.e., testing that no unobserved variables exist that influence selection into the meal programs). However, Rosenbaum bounds supply support on the degree to which the significance of results depends on this untestable assumption (Becker and Caliendo 2007). Rosenbaum's (2002) sensitivity analysis model says that matched subjects through PSM may differ in their probability of receiving the treatment by at most a factor of $\Gamma \geq 1$ to be robust where the probability that subject $j=1$ in pair *i* receives the treatment $Z_{i1}=1$ given that one subject in pair *i* receives the treatment $Z_{i1}+Z_{i2}=1$ is $\pi_{i1}/(\pi_{i1}+\pi_{i2})$ (Rosenbaum 2002). Therefore, Γ, which is the relative odds ratio of two observationally identical subjects receiving the treatment, is the following:

$$\Gamma \geq \frac{\Pr(Z_{i1}=1)}{\Pr(Z_{i2}=1)} = \frac{\pi_{i1}}{\pi_{i2}} = \frac{\pi_{i1}/(\pi_{i1}+\pi_{i2})}{\pi_{i2}/(\pi_{i1}+\pi_{i2})} \geq \frac{1}{\Gamma} \quad \text{for } i=1,\ldots,I. \tag{14}$$

When $\Gamma = 1$, then $\pi_{ij}/(\pi_{i1}+\pi_{i2}) = \frac{1}{2}$ for each *i*, *j*: the distribution of treatment is considered random and results do not exhibit hidden bias from selection on unobservables. As Γ increases, this indicates that unobservables play a more important role on selection (Rosenbaum 2002). Therefore, conducting a sensitivity analysis computes the range of possible inferences for several values of Γ providing the extent to which hidden biases of different amounts may change the conclusions of the analysis.

Specifically, we use the Mantel and Haenszel (1959) statistic because we have a binary outcome measure (i.e., underweight, healthy weight, overweight or obese). The test compares the number of successful subjects in the treatment group (i.e., where the outcome variable equals 1) with the number of successful non-participants from the control group (i.e., given the treatment effect is zero) (Becker and Caliendo 2007). From this testing, we are most interested in the significance of the upper-bound of Γ. The upper bound is the test statistic given that we have overestimated the treatment effect or that positive selection bias is present. For example, if the binary outcome measure is overweight=1, then positive selection bias occurs when those students most likely to participate in the program tend to be overweight even without participating and given that they have the same *x* vector as the individuals in the comparison group. For instance, $\Gamma = 3$ indicates that observationally identical children have different odds of program participation by a factor of three. This is considered a sensitive result which indicates potentially unreliable estimates.

Overall, we find long-term program impacts to be more significant for obese, overweight and healthy weight children but not underweight children. Long-term participation looks at those students who consistently participated in meal programs from 1st to 8th grades. Due to the small sample size of children only participating in SBP, we are unable to examine the impact of only SBP participation on child weight. As can be seen in Table 1, the number of students in our sample only participating in SBP ranges from 30 to 50 throughout the four rounds of data collection. The first two columns of Table 3 to Table 5 show the effect of only NSLP participation and participation in both SBP and NSLP compared to no program participation across weight classifications. Table 3 examines all participants whereas Table 4 and Table 5 look at FRP and full-price participants, respectively. The third column of Table 3 to Table 5 examines relative effects of participating in both meal programs compared to only participating in NSLP for these groups of students.

We begin by focusing on the first two columns of Table 3 to Table 5. When examining all participants (Table 3), we find that the ATT for only NSLP participants suggests a decrease in the probability of being overweight and obese compared to students who are not. It also suggests an increase in the probability of being in the healthy BMI range for students compared to those who are not of healthy weight. These results indicate that participation only in NSLP may decrease child overweight and obesity while encouraging healthy weight. However, results are not significant when we separate by FRP recipients (Table 4) and students paying full-price (Table 5).

When we consider the impact of participating in both SBP and NSLP compared to no participation, we find that multiple simultaneous program participation has somewhat of an opposite effect. For all participating students (Table 3) and FRP recipients (Table 4), participating in both SBP and NSLP compared to no participation decreases the probability of being healthy weight. In addition, for FRP recipients, there is an increase in the probability of being overweight and a decrease in the probability of being underweight. However, there appears to be no impacts on students paying full-price (Table 5). These results signal that either SBP has a negative impact on child weight (increasing overweight/obese and decreasing healthy weight), or there are other factors related to consuming breakfast at home versus school that impact child weight.

When examining the sensitivity of these ATT results to selection on unobservables, we find the results to be rather robust. Specifically, we find that the impacts of only NSLP participation compared to no participation on outcomes of overweight and obese as well as the impacts of multiple program participation compared to no participation on the outcome of healthy weight are insensitive to a bias that would triple the odds of program participation $(\Gamma = 3)$. We also find that the significance level on the bounds of only NSLP participation on healthy weight is insignificant when $1.3 \leq \Gamma \leq 1.9$ then becomes significant again which is common in some applications (Becker and Caliendo 2007). This implies that when $\Gamma > 1.9$, a significant negative treatment effect exists because we assume a large positive unobserved heterogeneity which turns the previously significant positive treatment effect into a negative one. Interpreting $\Gamma > 1.9$ indicates that observationally identical children in the healthy BMI range have different odds of only participating in NSLP by nearly a factor of two.

We also examine the relative effects of multiple program participation compared to single program participation (Tables 3 to Table 5). These findings support our previous results. We find that participating in both SBP and NSLP compared to only participating in NSLP increases the probability that the child is overweight or obese and decreases the probability that the child is of healthy weight when examining all participants (Table 3). We also find it increases the probability of being overweight and decreases the probability of being healthy weight and underweight for FRP students (Table 4). The result that participating in both programs compared to only NSLP decreases the probability of healthy weight is completely robust to the sensitivity analysis when examining all students. However, the increased probability of being obese and overweight for all students is insignificant when $1.6 \leq \Gamma \leq 2.4$ indicating a significant negative treatment effect when $\Gamma > 2.4$. Interpreting $\Gamma > 2.4$ indicates that observationally identical children who are overweight or obese have different odds of participating in both programs compared to only participating in NSLP by a factor of 2.4.

Results are completely robust for healthy weight outcomes for FRP recipients. However, several other results must be interpreted carefully as they are not extremely robust to the sensitivity analysis. For both of the significant overweight results for FRP, the bounding statistic reveals that our ATT results are likely overestimated: if the odds that the child participated in both programs compared to no program were 1.6 times higher, then our results would be sensitive to positive selection bias. While our results for full-price students are insignificant (Table 5), these results are robust to the sensitivity analysis.

When conducting OLS and school fixed effects regressions that examine associations between program participation and child weight, our results are similar those of the literature that find no impact of meal programs on child weight (Gleason and Dodd 2009; Cole and Fox 2008). For instance, we find no significant impact on weight for those children who always participate in only the lunch program or those who always participate in both programs. This is in contrast to our ATT estimates which find only participating in NSLP decreases the probability of being overweight and obese and increases the probability of a healthy BMI compared to no program participation when examining all participants (Table 3). In addition, ATT finds that participating in both SBP and NSLP compared to only NSLP increases the probability of being overweight and obese and decreases the probability of being healthy weight when examining all participants (Table 3) and FRP recipients (Table 4).

Difference-in-Differences Results

We also examine the impacts of school meal program participation on child weight through DID estimation which studies the impacts on students changing participation status. Table 6 shows the number of observations switching meal participation status from 1st to 5th grade and 1st to 8th grade. Overall, our DID results substantiate our ATT findings. Table 7 shows results of students who switch from only NSLP participation to no participation (or vice versa) and participation in both programs to no participation (or vice versa) on child weight outcomes for all students as well as FRP and full-price students. When examining all students, DID finds no significant impact of only NSLP participation when children switch participation status. This result is not contradictory to ATT results that find that participating in only NSLP from 1st to 8th grade decreases weight by the end of 8th grade. Instead, it indicates that the programs have more of an impact on those students who consistently participate than on those who participate intermittently. Table 7 also shows that switching participation for both SBP and

NSLP increases the probability of being overweight and decreases the probability of being underweight when examining all students.[16]

When examining students who receive in FRP meals, there is no impact of participating in only NSLP on child weight; however, participating in both SBP and NSLP increases the probability of overweight as can be seen in Table 7. When examining students paying full-price for meals, participating in only NSLP decreases the probability of overweight and increases the probability of underweight. However, there is no significant effect for full-price students participating in both programs.

Elementary School Results

The results discussed so far look at meal program impacts on child weight at the end of middle school (8th grade). Now, we examine results at the end of elementary school (5th grade) because this is a period of considerable transition for most children. Once children enter middle school they often have more food choices while at school. For instance, according to the CDC's 2006 School Health Policies and Programs Study, 32.7% of elementary schools had either vending machines, a school store, canteen or snack bar where students could purchase foods or beverages. However, 71.3% of middle school students had access to these competitive foods (CDC 2006). Therefore, we examine program impacts on child weight at the end of 5th grade using both ATT and DID methodologies.

[16] When looking at SBP participation (including those SBP participants who also participate in NSLP), the probability of overweight increases with participation and the probability of underweight decreases. However, most of these students also eat a school provided lunch, so it is not clear that the results are due solely to SBP. The sample size of SBP only participants is too small (ranging from 30-50 from 1st to 8th grades) to conduct an accurate analysis on these students.

Using ATT, we find no impact of meal participation on weight status for students at the end of 5th grade as can be seen in Table 8 to Table 10. This holds when looking at all students as well as when we separate models by FRP and full-price status. These results indicate that either much of the program impact on weight occurs in middle school or the ability to purchase competitive foods in addition to SBP and NSLP meals is impacting weight. Table 11 shows DID results for children switching participation status throughout elementary school. Participating in multiple programs indicates no impact of school meals on child weight. However, results for only NSLP participation show that for students paying full-price, participating decreases a child's BMI z-score as well as decreases the probability of being overweight which is similar to the 8th grade results. However, for FRP students, participating in only NSLP increases BMI z-scores as can be seen in Table 11.

Robustness Check for Food Quality Differences

Because the meal programs are directed by state agencies and are operated by local education agencies (LEAs), heterogeneous impacts could exist due to unobserved food quality differences regarding school meals. We examine the potential for unobserved food quality differences in three separate ways using DID estimation[17]: 1. Analyzing impacts on child weight controlling for food expenditures by LEA; 2. Examining impacts on child weight by sub-setting the sample based on the percentage of students eligible for free lunches; and 3. Examining impacts on child weight by dividing the sample based on region and urbanity. The amount of

[17] We did not use ATT because sample sizes were too small when models were subset by free lunch eligibility, region or urbanity.

food expenditures, the percentage of free-lunch eligible participants and the region/urbanity of the US in which the school is located could all be different factors that contribute to unobserved food quality differences in school meals. Each analysis is described in more detail below.

First, by linking the ECLS-K data to the Common Core of Data (CCD) by school ID, we are able to utilize expenditures on food services[18] by local education agency in our analysis. Revenue and expenditure data is submitted by state education agencies to the NCES on behalf of all LEAs in the state. Using LEA data is more appropriate than school-level data because meal programs are regulated at the district level and LEAs allocate funding. Controlling for average food expenditures per pupil provides an indicator of food quality since research shows that healthier food is more costly than nutrient dense food (Cade et al. 1999; Darmon, Briend and Drewnowski 2004; Drewnowski 2004; Drewnowski and Specter 2004; Kaufman et al. 1997; Stender et al. 1993). Therefore, we would expect programs to contribute less to childhood overweight and obesity within LEAs that spend more money on a per pupil basis for meal programs.

The CCD is a comprehensive, annual, national statistical database of all public elementary and secondary schools and school districts in the United States. It not only provides a listing of these schools within the US, but it also provides descriptive statistics on the schools as well as fiscal and non-fiscal data. We used the CCD's expenditures on food services variable and divide it by the CCD's school system enrollment variable since the data provides exact

[18] Expenditures on food services are described as "Gross expenditure for cafeteria operations to include the purchase of food but excluding the value of donated commodities and purchase of food service equipment (report equipment in Part III-4)".

enrollment.[19] We then included per pupil food expenditures as a covariate in our DID models in addition to the other covariates already included. Furthermore, we ran these models with the per pupil food expenditure variable in logs and in levels because of a potential scaling issue; however, the results for both models are the same. Table 12 and Table 13 show results for the impacts of meal program participation on child weight in 5th and 8th grades, respectively, including the log of per pupil food expenditures in the analysis. The results mimic those of Table 7 to Table 11 in significance and magnitude indicating that 5th and 8th grade results are robust to this specification. The only difference is that the 8th grade models with food expenditures have two coefficient estimates that are significant that were not significant in the original models: BMI z-score for only NSLP participation for the whole sample and underweight for multiple program participants for FRP students. In this specification, these estimates are significant at the 10% level.

Second, we examine schools based on the percentage of their students eligible for free lunches. The higher the proportion of free-lunch eligible children indicates a greater likelihood of a lower income school that may devote fewer resources to food services. The federal government declares schools with 40% or more free-lunch eligible students as Title 1. We examined schools in the following manner: those that had less than 25% of students eligible for free lunch, between 25% and 50% eligible, between 50% and 75% eligible and over 75% eligible. As can be seen in Table 14 and Table 15 which shows 5th and 8th grade results, respectively, DID results do not differ with regard to the percentage of students who qualify for

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[19] We dropped 40 outlier observations where per pupil food expenditures were larger than $2000 per student—10 observations in 1st grade, 0 observations in 3rd grade, 10 observations in 5th grade, and 20 observations in 8th grade. The mean of per pupil food expenditures for the sample was $333 and the median was $322. (Sample size numbers are rounded to the nearest 10 as per IES policy.)

free lunch. In 5^{th} grade (Table 14), there are no significant impacts on students who only participate in NSLP by percent of eligible students. For students who participate in both programs, participation increases BMI z-scores, increases the probability of being overweight and decreases the probability of being healthy weight for those students in schools where less than 25% of students qualify for free lunch. Our only significant result for 8^{th} grade (Table 15) is that for students who participate in both SBP and NSLP at schools where 25% to 50% of students are eligible for free lunch the probability of being underweight decreases.

Third, we examine schools by region (i.e., northeast, Midwest, south and west) as well as by rural and urban areas. We examine schools by region because the cuisine across the United States is diverse with each region having a distinct style that could influence the types of food served at school. For example, in the northeast, one-pot meals are popular such as baked beans, chowder and succotash compared to fried dishes in the South and Mexican influenced dishes in the West (Danforth, Feierabend and Chassman 1998; Kulkarni 2004; Smith 2004). With regard to rural and urban areas, research shows that children living in rural areas tend to have higher participation rates in school meal programs (Wauchope and Shattuck 2010) as well as higher rates of overweight and obesity (Datar, Sturm and Magnabosco 2004; McMurray et al. 1999; Wang and Beydoun 2007) which could be suggestive of the nutritional quality of foods consumed in rural areas.

When we examine results by region (Table 16 and Table 17) for 5^{th} grade, we find that participating in both SBP and NSLP increases child weight for those students in the Midwest (Table 16). Participation in only NSLP increases child weight for 8^{th} grade students in the South and West, as can be seen in Table 17, indicating that cuisine may play a factor in the nutritional quality of food served.

Examining DID results by urbanity (Table 18 and Table 19), 8th grade results (Table 19) indicate that participation in only NSLP increases BMI z-scores in rural areas. We also find that it decreases the probability of overweight and increases the probability of underweight in the suburbs. For students participating in both programs, participation increases the probability of overweight and decreases the probability of underweight in urban areas as well as decreases the probability of obesity and underweight in the suburbs.

CONCLUSIONS AND POLICY IMPLICATIONS

Using a nationally representative sample of kindergartners followed through 8th grade, we examine the impacts of school meal program participation (SBP and NSLP) on child weight. These two programs affect over 31.7 million children daily. We use Capogrossi and You's (2012) theoretical model incorporating program participation into the child weight production function to conduct a more theoretically consistent study. This paper contributes to the literature by conducting a multiple simultaneous treatment effect analysis while accounting for self-selection into the school meal programs. Specifically, we utilize ATT and DID methodologies for our treatment analysis to examine students who consistently participate in programs throughout school (ATT) as well as those students who switch participation status (DID). We also conduct analyses at the end of 5th and 8th grades since students often experience a large transition from elementary to middle school with regard to food and exercise choices.

From our analysis, we find long-term program impacts to be significant among all weight classifications. Specifically, ATT results show that participation in only NSLP compared to no participation decreases the probability of child overweight and obesity and increases the probability of healthy weight; however, participating in both SBP and NSLP decreases the probability of being healthy weight and increases the probability of being overweight and obese. Using DID we find no significant impact of only NSLP participation when children switch participation status, but it does find that switching participation in both SBP and NSLP increases the probability of being overweight and decreases the probability of being underweight when examining all students. In addition, for both ATT and DID there is minimal impact on child weight for students paying full-price for meals.

Results indicate that the school meal programs do have an impact on child weight, particularly in 8th grade. However, the parents, policy analysts and the media are not entirely correct when they criticize the meal programs for contributing to childhood obesity since we find that when students only participate in NSLP, participation decreases the probability of being overweight. Nevertheless, in January 2012 the USDA released new school nutrition standards to require healthier meals in schools that are to be phased in through 2015. These standards require less sodium and fat in meals and an increase in the amount of whole grains, fruits and vegetables that are served. While higher nutrition standards are good, one key facet that needs to be considered is how children will respond to healthier meals and whether they will consume the food. This problem can be overcome by continuing and expanding initiatives such as *Chefs Move to Schools* and Small Farms/School Meals Initiative. These programs support SBP and NSLP while encouraging students to eat healthier by having them take more of an interest in where food comes from and how it is prepared.

For instance, *Chefs Move to Schools* pairs chefs with schools in their communities with the task of collaboratively educating children about food and proper nutrition. They do this through cooking demonstrations, school gardens and other activities that focus on the importance of a balanced diet. The Small Farms/School Meals Initiative is a program that connects schools and local farms with the goal of serving healthy meals in school cafeterias, improving student nutrition and providing educational opportunities for students. Programs such as these are integral to providing nutritious school meals but also for helping to establish healthier life-long habits in our youth.

In addition, some research has shown links between nutrition, program participation and academic performance (Averett and Stifel 2010; Glewwe, Jacoby and King 2001; Meyers et al. 1989; Murphy et al. 1998). For instance, older research on SBP finds positive correlations between consuming a school breakfast and cognitive functioning (Meyers et al. 1989; Murphy et al. 1998). To our knowledge, no research examines the impacts of NSLP on student achievement. However, it is important to investigate whether the impacts of school meal programs extend beyond effects on child weight. Millimet, Tchernis and Husain (2010) specifically call for examining the impact of SBP and NSLP participation on other outcome measures including cognitive and non-cognitive skills. Although more research needs to be conducted, if these programs causally contribute to children's academic achievement through improvement of child weight (i.e., have positive spillover effects), stronger evidence will be available in showing the programs' effectiveness.

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Table 1: Summary Statistics for Sample by Grade and Meal Program Participation Status

		NSLP Only				SBP Only				SBP and NSLP				No Participation			
		1st	3rd	5th	8th	1st	3rd	5th	8th	1st	3rd	5th	8th	1st	3rd	5th	8th
Variable	**Description**																
Obese	=1 if child is obese	0.12	0.18	0.19	0.18	0.15	0.05	0.28	0.08	0.17	0.21	0.24	0.22	0.12	0.16	0.16	0.13
		(0.33)	(0.38)	(0.39)	(0.38)	(0.36)	(0.23)	(0.45)	(0.28)	(0.38)	(0.41)	(0.43)	(0.41)	(0.32)	(0.37)	(0.37)	(0.34)
Overweight	=1 if child is overweight	0.13	0.14	0.18	0.14	0.20	0.16	0.19	0.12	0.12	0.16	0.16	0.17	0.10	0.14	0.16	0.14
		(0.33)	(0.35)	(0.38)	(0.35)	(0.40)	(0.37)	(0.40)	(0.33)	(0.33)	(0.36)	(0.36)	(0.37)	(0.31)	(0.34)	(0.36)	(0.35)
Underweight	=1 if child is underweight	0.03	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.01	0.04	0.02	0.04	0.04
		(0.17)	(0.15)	(0.17)	(0.16)	(0.00)	(0.00)	(0.00)	(0.00)	(0.15)	(0.11)	(0.14)	(0.11)	(0.19)	(0.15)	(0.19)	(0.19)
Healthy Weight	=1 if child is healthy weight	0.66	0.60	0.55	0.58	0.59	0.73	0.47	0.72	0.61	0.54	0.51	0.49	0.65	0.61	0.59	0.59
		(0.48)	(0.49)	(0.50)	(0.49)	(0.50)	(0.45)	(0.51)	(0.46)	(0.49)	(0.50)	(0.50)	(0.50)	(0.48)	(0.49)	(0.49)	(0.49)
Current BMI	BMI z-score	0.39	0.55	0.58	0.59	0.73	0.35	0.71	0.60	0.56	0.70	0.75	0.78	0.35	0.46	0.48	0.40
		(1.07)	(1.08)	(1.12)	(1.08)	(0.79)	(0.90)	(1.14)	(0.70)	(1.12)	(1.10)	(1.11)	(1.06)	(1.08)	(1.09)	(1.11)	(1.12)
Previous BMI	BMI z-score in previous period	0.37	0.41	0.56	0.60	0.55	0.44	0.59	0.47	0.51	0.53	0.67	0.75	0.26	0.37	0.48	0.47
		(1.13)	(1.12)	(1.07)	(1.14)	(0.87)	(0.68)	(1.44)	(0.87)	(1.23)	(1.08)	(1.09)	(1.09)	(1.26)	(1.03)	(1.11)	(1.10)
Female	=1 if child is female	0.48	0.47	0.48	0.47	0.46	0.38	0.50	0.56	0.49	0.49	0.47	0.46	0.48	0.48	0.50	0.58
		(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.49)	(0.51)	(0.51)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.49)
Black	=1 if child is black	0.09	0.08	0.09	0.09	0.02	0.16	0.11	0.12	0.22	0.23	0.22	0.24	0.05	0.05	0.06	0.04
		(0.29)	(0.27)	(0.29)	(0.28)	(0.16)	(0.37)	(0.32)	(0.33)	(0.42)	(0.42)	(0.41)	(0.43)	(0.22)	(0.23)	(0.23)	(0.18)
Hispanic	=1 if child is Hispanic	0.17	0.17	0.18	0.17	0.39	0.19	0.22	0.08	0.28	0.28	0.28	0.30	0.11	0.12	0.11	0.12
		(0.38)	(0.38)	(0.38)	(0.37)	(0.49)	(0.40)	(0.42)	(0.28)	(0.45)	(0.45)	(0.45)	(0.46)	(0.31)	(0.32)	(0.32)	(0.32)
Rural	=1 if lives in rural area	0.31	0.32	0.34	0.36	0.15	0.32	0.21	0.32	0.39	0.38	0.38	0.37	0.23	0.21	0.20	0.23
		(0.46)	(0.47)	(0.47)	(0.48)	(0.36)	(0.47)	(0.41)	(0.48)	(0.49)	(0.49)	(0.49)	(0.48)	(0.42)	(0.40)	(0.40)	(0.42)
Urban	=1 if lives in urban area	0.34	0.34	0.32	0.29	0.50	0.35	0.47	0.41	0.34	0.35	0.35	0.37	0.36	0.36	0.37	0.30
		(0.47)	(0.47)	(0.47)	(0.45)	(0.51)	(0.49)	(0.51)	(0.50)	(0.48)	(0.48)	(0.48)	(0.48)	(0.48)	(0.48)	(0.48)	(0.46)
TV	minutes per day child watches	124.03	122.99	131.96	182.22	120.85	121.76	134.29	166.96	142.58	142.60	146.25	223.37	113.71	119.95	119.13	147.14
	TV	(72.29)	(71.95)	(70.01)	(173.97)	(67.51)	(75.37)	(89.65)	(109.98)	(91.63)	(89.25)	(83.13)	(208.10)	(66.37)	(78.55)	(70.61)	(132.27)
Active	days per week child participates	4.08	4.03	3.74	5.43	3.92	4.08	3.86	5.43	3.92	3.96	3.75	5.14	4.10	3.85	3.71	5.46
	in 20 minutes of activity (sweat	(2.26)	(1.96)	(1.79)	(1.70)	(2.43)	(1.75)	(1.59)	(1.73)	(2.47)	(2.14)	(2.07)	(1.86)	(2.22)	(1.90)	(1.75)	(1.67)
Household Income	on scale 1-9	4.84	5.15	5.19	5.44	4.30	4.85	5.11	5.17	3.06	3.30	3.49	3.64	5.77	5.92	6.18	6.31
		(1.92)	(1.92)	(1.96)	(1.94)	(2.01)	(1.67)	(1.97)	(1.99)	(1.68)	(1.71)	(1.84)	(1.86)	(1.69)	(1.66)	(1.71)	(1.80)
Mom Full-Time	=1 if mother works full-time	0.50	0.53	0.55	0.61	0.44	0.59	0.53	0.64	0.51	0.52	0.54	0.55	0.45	0.45	0.46	0.51
		(0.50)	(0.50)	(0.50)	(0.49)	(0.50)	(0.50)	(0.51)	(0.49)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Breakfasts	# of breakfasts eaten per week	4.61	4.34	3.76	3.28	3.22	3.65	3.14	1.60	3.13	2.85	2.55	2.43	4.94	4.73	3.92	3.65
	a family	(2.45)	(2.41)	(2.48)	(2.34)	(2.01)	(2.29)	(2.24)	(1.35)	(2.16)	(2.08)	(2.01)	(1.81)	(2.33)	(2.39)	(2.49)	(2.40)
Dinners	# of dinners eaten per week as	5.70	5.65	5.47	5.18	5.49	5.65	5.67	4.72	5.86	5.69	5.58	5.46	5.61	5.67	5.32	5.15
	a family	(1.73)	(1.71)	(1.75)	(1.75)	(2.04)	(1.55)	(1.62)	(2.41)	(1.74)	(1.73)	(1.78)	(1.79)	(1.73)	(1.63)	(1.73)	(1.70)
Food Insecure	=1 if family is food insecure	0.07	0.22	0.06	0.06	0.13	0.03	0.06	0.12	0.17	0.14	0.20	0.20	0.04	0.03	0.04	0.02
		(0.25)	(0.00)	(0.25)	(0.24)	(0.34)	(0.16)	(0.23)	(0.33)	(0.37)	(0.35)	(0.40)	(0.40)	(0.20)	(0.16)	(0.19)	(0.16)
N		1710	1710	1660	1770	40	40	40	30	1290	1340	1370	1260	520	460	480	480

Note: Standard errors in parentheses

Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 2: Common Support for ATT Between Treated and Control Groups by Participation Status

	NSLP Only to None								
Observations	**ALL**			**FRP**			**Full-Price**		
	Off Support	On Support	Total	Off Support	On Support	Total	Off Support	On Support	Total
Control	0	390	390	0	340	340	0	430	430
Treated	10	490	500	0	60	60	10	450	460
Total	10	880	890	0	400	400	10	880	890

	SBP and NSLP to None								
Observations	**ALL**			**FRP**			**Full-Price**		
	Off Support	On Support	Total	Off Support	On Support	Total	Off Support	On Support	Total
Control	0	570	570	0	130	130	0	560	560
Treated	10	320	330	20	260	280	10	320	330
Total	10	890	900	20	390	410	10	880	890

	SBP and NSLP to NSLP Only								
Observations	**ALL**			**FRP**			**Full-Price**		
	Off Support	On Support	Total	Off Support	On Support	Total	Off Support	On Support	Total
Control	0	570	570	0	130	130	0	560	560
Treated	80	250	330	70	210	280	70	260	330
Total	80	820	900	70	340	410	70	820	890

Note: Results are reported for radius/caliper matching of 0.01 trimming support at 2%

Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 3: ATT Results on Students who Always Participate in Meal Programs (8th Grade Outcome)

	a) Single and Multiple Treatment Effects Relative to No Participation		b) Multiple Treatment Effect Relative to Single Treatment Effect
	NSLP vs None	Both vs None	Both vs NSLP
Weight Outcome			
Healthy Weight	0.147	-0.103	-0.157
	(0.04)	(0.05)	(0.04)
t-value	4.217	-2.306	-4.168
Overweight/Obese	-0.104	0.053	0.122
	(0.03)	(0.04)	(0.04)
t-value	-3.107	1.26	3.36
Obese	-0.074	0.024	0.077
	(0.03)	(0.04)	(0.03)
t-value	-2.668	0.685	2.526
Underweight	0.006	-0.009	-0.011
	(0.01)	(0.01)	(1.18)
t-value	0.678	-0.743	-1.176
N	870	890	840

Notes : We examine relative impacts of single and multiple treatment effects with 8th grade weight status as the outcome variable.

a) Examine impacts on different child weight classifications of 1. Only NSLP participation compared to no participation; 2. SBP and NSLP participation compared to no participation

b) Examine impacts on different child weight classifications of SBP and NSLP participation compared to only NSLP participation.

Standard errors in parentheses; t-values below standard errors

Results are reported for radius/caliper matching of 0.01 trimming support at 2%

Results include all participating students: students paying full-price for meals and receiving FRP meals

Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 4: ATT Results on 8th Grade Child Weight for Free- and Reduced-Price Meal Participants

	a) Single and Multiple Treatment Effects Relative to No Participation		b) Multiple Treatment Effect Relative to Single Treatment Effect
	NSLP vs None	Both vs None	Both vs NSLP
Weight Outcome			
Healthy Weight	0.049	-0.12	-0.108
	(0.07)	(0.03)	(0.04)
t-value	0.747	-3.489	-3.053
Overweight/Obese	-0.103	0.084	0.073
	(0.06)	(0.03)	(0.03)
t-value	-1.762	2.498	2.13
Obese	-0.075	0.05	0.049
	(0.05)	(0.03)	(0.03)
t-value	-1.631	1.738	1.689
Underweight	-0.004	-0.022	-0.023
	(0.02)	(0.01)	(0.01)
t-value	-0.223	-2.853	-2.816
N	950	1530	1740

Notes : We examine relative impacts of single and multiple treatment effects with 8th grade weight status as the outcome variable.
a) Examine impacts on different child weight classifications of 1. Only NSLP participation compared to no participation; 2. SBP and NSLP participation compared to no participation
b) Examine impacts on different child weight classifications of SBP and NSLP participation compared to only NSLP participation.
Standard errors in parentheses; t-values below standard errors
Results are reported for radius/caliper matching of 0.01 trimming support at 2%
Results only include students receiving free- and reduced-price meals
Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 5: ATT Results on 8th Grade Child Weight for Students Paying Full-Price

	a) Single and Multiple Treatment Effects Relative to No Participation		b) Multiple Treatment Effect Relative to Single Treatment Effect
	NSLP vs None	**Both vs None**	**Both vs NSLP**
Weight Outcome			
Healthy Weight	0.056	-0.106	-0.109
	(0.05)	(0.06)	(0.06)
t-value	1.174	-1.909	-1.957
Overweight/Obese	-0.03	0.086	0.078
	(0.05)	(0.06)	(0.06)
t-value	-0.663	1.569	1.425
Obese	-0.007	0.025	0.02
	(0.04)	(0.04)	(0.04)
t-value	-0.176	0.55	0.44
Underweight	-0.015	-0.012	-0.007
	(0.01)	(0.01)	(0.01)
t-value	-1.15	-1.016	-0.555
N	820	870	860

Notes : We examine relative impacts of single and multiple treatment effects with 8th grade weight status as the outcome variable.

a) Examine impacts on different child weight classifications of 1. Only NSLP participation compared to no participation; 2. SBP and NSLP participation compared to no participation

b) Examine impacts on different child weight classifications of SBP and NSLP participation compared to only NSLP participation.

Standard errors in parentheses; t-values below standard errors

Results are reported for radius/caliper matching of 0.01 trimming support at 2%

Results only include students paying full-price for meals

Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 6: Number of Students Switching Participation Status in DID Sample

	Only NSLP Participation					
	Switch Status from 1st to 5th			Switch Status from 1st to 8th		
	All	**FRP**	**Full-Price**	**All**	**FRP**	**Full-Price**
No. of Students	3060	690	2370	3030	610	2430

	SBP and NSLP Participation					
	Switch Status from 1st to 5th			Switch Status from 1st to 8th		
	All	**FRP**	**Full-Price**	**All**	**FRP**	**Full-Price**
No. of Students	1480	1030	470	1310	880	440

Note: Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 7: DID Results on 8th Grade Child Weight for Free- and Reduced-Price and Full-Price Meal Students

	NSLP Only			SBP and NSLP		
	All	FRP	Full-Price	All	FRP	Full-Price
Weight Outcome						
BMI z-score	0.061	0.094	-0.029	0.023	0.046	-0.044
	(0.04)	(0.06)	(0.04)	(0.04)	(0.05)	(0.07)
Overweight/Obese	-0.013	0.04	-0.044**	0.04*	0.061**	-0.018
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)
Obese	0.014	-0.001	0.009	-0.003	0.006	-0.025
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)
Healthy Weight	-0.003	-0.028	0.028	-0.042	-0.05	0.005
	(0.02)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)
Underweight	0.012	0.002	0.02**	-0.023**	-0.022	-0.015
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)
N	5120	5430	4360	5380	5430	4360

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are given for all students combined as well as separated by students receiving free- and reduced-price meals and students paying full-price
Standard errors in parentheses
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure
Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 8: ATT Results on Students who Always Participate in Meal Programs (5th Grade Outcome)

	a) Single and Multiple Treatment Effects Relative to No Participation		b) Multiple Treatment Effect Relative to Single Treatment Effect
	NSLP vs None	Both vs None	Both vs NSLP
Weight Outcome			
Healthy Weight	0.086	-0.035	-0.102
	(0.04)	(0.05)	(0.04)
t-value	2.459	-0.787	-2.68
Overweight/Obese	-0.074	0.02	0.099
	(0.04)	(0.04)	(0.04)
t-value	-2.137	0.461	2.648
Obese	-0.083	0.04	0.096
	(0.03)	(0.04)	(0.03)
t-value	-2.838	1.097	2.967
Underweight	0.005	-0.003	-0.011
	(0.01)	(0.01)	(0.01)
t-value	0.459	-0.239	-1.138
N	870	890	840

Note: We examine relative impacts of single and multiple treatment effects with 5th grade weight status as the outcome variable.
a) Examine impacts on different child weight classifications of 1. Only NSLP participation compared to no participation; 2. SBP and NSLP participation compared to no participation
b) Examine impacts on different child weight classifications of SBP and NSLP participation compared to only NSLP participation.
Standard errors in parentheses; t-values below standard errors
Results are reported for radius/caliper matching of 0.01 trimming support at 2%
Results include students paying full-price for meals and receiving free- and reduced-price meals
Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 9: ATT Results on 5th Grade Child Weight for Free- and Reduced-Price Meal Participants

	a) Single and Multiple Treatment Effects Relative to No Participation		b) Multiple Treatment Effect Relative to Single Treatment Effect
	NSLP vs None	**Both vs None**	**Both vs NSLP**
Weight Outcome			
Healthy Weight	0.082	-0.073	-0.06
	(0.07)	(0.04)	(0.04)
t-value	1.252	-2.107	-1.683
Overweight/Obese	-0.106	0.068	0.05
	(0.06)	(0.03)	(0.04)
t-value	-1.717	2.004	1.432
Obese	-0.04	0.06	0.054
	(0.05)	(0.03)	(0.03)
t-value	-0.765	1.998	1.773
Underweight	-0.024	-0.01	-0.005
	(0.01)	(0.01)	(0.01)
t-value	-4.203	-1.027	-0.514
N	950	1530	1740

Note: We examine relative impacts of single and multiple treatment effects with 5th grade weight status as the outcome variable.
a) Examine impacts on different child weight classifications of 1. Only NSLP participation compared to no participation; 2. SBP and NSLP participation compared to no participation
b) Examine impacts on different child weight classifications of SBP and NSLP participation compared to only NSLP participation.
Standard errors in parentheses; t-values below standard errors
Results are reported for radius/caliper matching of 0.01 trimming support at 2%
Results only include students receiving free- and reduced-price meals
Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 10: ATT Results on 5th Grade Child Weight for Students Paying Full-Price

	a) Single and Multiple Treatment Effects Relative to No Participation		b) Multiple Treatment Effect Relative to Single Treatment Effect
	NSLP vs None	Both vs None	Both vs NSLP
Weight Outcome			
Healthy Weight	-0.027	-0.073	-0.071
	(0.05)	(0.04)	(0.04)
t-value	-0.552	-2.017	-1.96
Overweight/Obese	0.044	0.097	0.078
	(0.05)	(0.04)	(0.04)
t-value	0.935	2.699	2.181
Obese	0.006	0.119	0.083
	(0.04)	(0.03)	(0.03)
t-value	0.136	3.863	2.68
Underweight	-0.016	-0.029	-0.018
	(0.02)	(0.01)	(0.01)
t-value	-1.037	-2.957	-1.876
N	810	880	850

Note: We examine relative impacts of single and multiple treatment effects with 5th grade weight status as the outcome variable.

a) Examine impacts on different child weight classifications of 1. Only NSLP participation compared to no participation; 2. SBP and NSLP participation compared to no participation

b) Examine impacts on different child weight classifications of SBP and NSLP participation compared to only NSLP participation.

Standard errors in parentheses; t-values below standard errors

Results are reported for radius/caliper matching of 0.01 trimming support at 2%

Results only include students paying full-price for meals

Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 11: DID Results on 5th Grade Child Weight for Free- and Reduced-Price and Full-Price Meal Students

	NSLP Only			SBP and NSLP		
	All	**FRP**	**Full-Price**	**All**	**FRP**	**Full-Price**
Weight Outcome						
BMI z-score	0.005	0.127**	-0.092**	0.05	0.047	0.009
	(0.04)	0.055	0.039	(0.04)	0.047	0.064
Overweight/Obese	-0.005	0.063	-0.053**	0.03	0.034	0.003
	(0.02)	0.029	0.021	(0.02)	0.024	0.034
Obese	0.004	0.007	-0.007	0.007	0.006	0.001
	(0.02)	0.024	0.018	(0.02)	0.021	0.029
Healthy Weight	-0.012	-0.037	0.029	-0.026	-0.023	-0.009
	(0.02)	0.033	0.024	(0.03)	0.029	0.039
Underweight	0.007	-0.004	0.013	-0.014	-0.01	-0.014
	(0.01)	0.014	0.01	(0.01)	0.012	0.016
N	5640	5710	4560	5640	5700	4550

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are given for all students combined as well as separated by students receiving free- and reduced-price meals and students paying full-price
Standard errors in parentheses
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure
Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 12: DID Robustness Check on 5th Grade Child Weight including Per-Pupil Food Expenditures

	NSLP Only			SBP and NSLP		
	All	**FRP**	**Full-Price**	**All**	**FRP**	**Full-Price**
Weight Outcome						
BMI z-score	0.01	0.127**	-0.087**	0.046	0.041	0.01
	(0.04)	(0.06)	(0.04)	(0.04)	(0.05)	(0.07)
Overweight/Obese	-0.004	0.067**	-0.053**	0.026	0.029	0.004
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)
Obese	0.009	0.006	-0.001	0.002	-0.003	0.005
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Healthy Weight	-0.011	-0.039	0.032	-0.028	-0.026	-0.009
	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.04)
Underweight	0.006	-0.004	0.012	-0.014	-0.009	-0.014
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
N	5520	5590	4460	5520	5580	4460

Note:* significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are separated by students receiving free- and reduced-price meals and students paying full-price
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanicity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure and the log of per pupil food expenditures

Table 13: DID Robustness Check on 8th Grade Child Weight including Per-Pupil Food Expenditures

	NSLP Only			SBP and NSLP		
	All	**FRP**	**Full-Price**	**All**	**FRP**	**Full-Price**
Weight Outcome						
BMI z-score	0.065*	0.089	-0.024	0.02	0.043	-0.046
	(0.04)	(0.06)	(0.04)	(0.04)	(0.05)	(0.07)
Overweight/Obese	-0.007	0.044	-0.04*	0.035	0.055**	-0.021
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)
Obese	0.015	-0.001	0.011	-0.005	0.001	-0.021
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)
Healthy Weight	-0.007	-0.029	0.025	-0.041	-0.052	0.01
	(0.02)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)
Underweight	0.013	0.013	0.02**	-0.023**	-0.023*	-0.015
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
N	5310	5350	4290	5310	5350	4290

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are separated by students receiving free- and reduced-price meals and students paying full-price
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanicity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure and the log of per pupil food expenditures

Table 14: DID Robustness Check on 5th Grade Child Weight by Percentage of Students in School Eligible for Free Lunch

	NSLP Only				SBP and NSLP			
	Less Than 25%	**25% to 50%**	**50% to 75%**	**Over 75%**	**Less Than 25%**	**25% to 50%**	**50% to 75%**	**Over 75%**
Weight Outcome								
BMI z-score	-0.065	0.078	0.01	0.109	0.159**	0.068	0.006	-0.128
	(0.05)	(0.07)	(0.10)	(0.11)	(0.08)	(0.07)	(0.10)	(0.11)
Overweight/Obese	-0.017	0.022	-0.005	0.043	0.071*	0.019	0.014	-0.084
	(0.03)	(0.04)	(0.05)	(0.06)	(0.04)	(0.04)	(0.06)	(0.06)
Obese	0.003	0.021	-0.002	-0.02	0.025	0.001	-0.021	0.023
	(0.02)	(0.03)	(0.05)	(0.06)	(0.03)	(0.03)	(0.05)	(0.06)
Healthy Weight	-0.027	-0.014	-0.006	-0.004	-0.083*	-0.006	0.039	0.043
	(0.03)	(0.04)	(0.06)	(0.07)	(0.05)	(0.04)	(0.06)	(0.07)
Underweight	0.012	0.007	0.002	-0.006	-0.019	-0.022	-0.02	-0.004
	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)
N	2620	1730	710	580	2620	1730	710	580

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are for all participating students
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanicity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure

Table 15: DID Robustness Check on 8th Grade Child Weight by Percentage of Students in School Eligible for Free Lunch

	NSLP Only				SBP and NSLP			
	Less Than 25%	**25% to 50%**	**50% to 75%**	**Over 75%**	**Less Than 25%**	**25% to 50%**	**50% to 75%**	**Over 75%**
Weight Outcome								
BMI z-score	0.055	0.102	0.063	0.008	0.014	0.055	0.004	-0.018
	(0.06)	(0.07)	(0.11)	(0.14)	(0.08)	(0.08)	(0.12)	(0.14)
Overweight/Obese	-0.002	0.02	-0.03	-0.109	0.016	0.037	0.014	0.074
	(0.03)	(0.04)	(0.06)	(0.08)	(0.04)	(0.04)	(0.06)	(0.08)
Obese	0.012	0.035	-0.005	-0.041	0.008	-0.007	-0.008	0.002
	(0.02)	(0.03)	(0.05)	(0.07)	(0.03)	(0.03)	(0.05)	(0.07)
Healthy Weight	-0.043	-0.003	-0.002	0.148	-0.034	-0.027	0.044	-0.106
	(0.03)	(0.04)	(0.07)	(0.09)	(0.05)	(0.05)	(0.07)	(0.09)
Underweight	0.009	0.022	0.005	-0.003	-0.015	-0.032*	-0.033	-0.021
	(0.01)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)
N	2590	1720	640	420	2590	1720	640	420

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are for all participating students
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanicity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure

Table 16: DID Robustness Check on 5th Grade Child Weight by Region

	NSLP Only				SBP and NSLP			
	Northeast	**Midwest**	**South**	**West**	**Northeast**	**Midwest**	**South**	**West**
Weight Outcome								
BMI z-score	0.044	-0.074	-0.041	0.134	-0.082	0.176**	-0.020	0.021
	(0.09)	(0.07)	(0.06)	(0.09)	(0.12)	(0.07)	(0.06)	(0.10)
Overweight/Obese	-0.035	-0.024	0.003	0.029	-0.044	0.07*	-0.007	0.056
	(0.05)	(0.04)	(0.03)	(0.04)	(0.07)	(0.04)	(0.03)	(0.05)
Obese	-0.030	-0.017	0.010	0.034	0.008	0.028	-0.006	-0.002
	(0.04)	(0.03)	(0.03)	(0.04)	(0.06)	(0.04)	(0.03)	(0.04)
Healthy Weight	0.021	0.030	-0.017	-0.070	-0.024	-0.056	0.017	0.007
	(0.06)	(0.04)	(0.04)	(0.05)	(0.08)	(0.05)	(0.04)	(0.06)
Underweight	-0.03*	-0.008	0.028*	0.016	0.000	-0.011	-0.009	-0.036
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)
N	960	1470	1980	1130	960	1470	1980	1130

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are for all participating students
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanicity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure

Table 17: DID Robustness Check on 8th Grade Child Weight by Region

	NSLP Only				SBP and NSLP			
	Northeast	Midwest	South	West	Northeast	Midwest	South	West
Weight Outcome								
BMI z-score	0.110	-0.020	0.039	0.177*	-0.003	0.038	-0.011	0.027
	(0.08)	(0.07)	(0.06)	(0.10)	(0.12)	(0.08)	(0.07)	(0.11)
Overweight/Obese	-0.040	-0.055	0.024	-0.016	0.010	0.062	0.018	0.074
	(0.05)	(0.04)	(0.03)	(0.05)	(0.07)	(0.04)	(0.04)	(0.05)
Obese	-0.022	-0.047	0.061**	0.019	0.063	0.048	-0.054*	0.008
	(0.04)	(0.03)	(0.03)	(0.04)	(0.06)	(0.04)	(0.03)	(0.04)
Healthy Weight	-0.003	0.044	-0.023	0.006	-0.037	-0.069	-0.038	0.044
	(0.06)	(0.04)	(0.04)	(0.06)	(0.08)	(0.05)	(0.05)	(0.06)
Underweight	-0.004	0.009	0.034**	-0.015	-0.026	-0.005	-0.022	-0.041
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)
N	940	1490	1830	1050	940	1490	1830	1050

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are for all participating students
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, urbanicity, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure

Table 18: DID Robustness Check on 5th Grade Child Weight by Urbanity

	NSLP Only			SBP and NSLP		
	Urban	**Rural**	**Suburb**	**Urban**	**Rural**	**Suburb**
Weight Outcome						
BMI z-score	0.08	-0.02	-0.044	-0.011	0.126*	0.023
	(0.06)	(0.07)	(0.06)	(0.07)	(0.07)	(0.08)
Overweight/Obese	0.032	-0.018	-0.025	0.006	0.066*	0.008
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
Obese	0.005	-0.015	0.027	0.014	0.027	-0.039
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Healthy Weight	-0.006	0.011	-0.046	-0.024	-0.038	0.01
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
Underweight	-0.008	-0.006	0.036**	-0.013	-0.008	-0.029
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)
N	1820	1830	1990	1820	1830	1990

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are for all participating students
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure

Table 19: DID Robustness Check on 8th Grade Child Weight by Urbanity

	NSLP Only			SBP and NSLP		
	Urban	**Rural**	**Suburb**	**Urban**	**Rural**	**Suburb**
Weight Outcome						
BMI z-score	0.06	0.135**	0.004	0.113	-0.013	-0.093
	(0.07)	(0.07)	(0.06)	(0.08)	(0.07)	(0.08)
Overweight/Obese	-0.014	0.046	-0.058*	0.075*	0.026	-0.005
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)
Obese	0.015	0.016	0.02	-0.012	0.031	-0.065*
	0.03	0.03	0.026	(0.03)	(0.03)	(0.04)
Healthy Weight	0.036	-0.027	-0.024	-0.058	-0.054	0.033
	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)
Underweight	-0.003	-0.006	0.042***	-0.042**	0.014	-0.044**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
N	1640	1760	1980	1640	1760	1980

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Results are for all participating students
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy
Results include the following covariates: gender, race, age, birth weight, past BMI, minutes of TV watched per day, days per week the child participates in 20 minutes of activity where he/she sweats, mother's education level, father's education level, whether the mother works full-time, whether the parents are married, household income, number of breakfasts and dinners the family eats together, whether the child has health insurance, whether the household is food insecure

Chapter IV: Spillover Effects of SBP and NSLP on Academic Performance

ABSTRACT

The School Breakfast Program (SBP) and National School Lunch Program (NSLP) are two federally assisted school meal programs that currently serve over 31.7 million children each day. Most of the existing literature examines the nutritional quality of school meals with a handful studying the impacts on child weight. A couple of studies also examine whether SBP has impacts on academic performance, and, to our knowledge, no studies examine the direct or indirect effects of NSLP participation on performance. Using full-information maximum likelihood, we simultaneously estimate the child weight and academic performance production functions along with child choice equations and program participation equations to examine potential spillover effects of SBP and NSLP on academic performance through the mediator of child weight. Results do show spillover effects on 8th grade math and English scores with particularly large impacts on FRP eligible participants: negative impacts of NSLP participation and positive impacts of SBP participation on achievement.

INTRODUCTION

President Obama made education a priority in his 2011 State of the Union address declaring that "this is our generation's Sputnik moment" and that we need to "out-innovate, out-educate, and out-build the rest of the world." In his 2012 State of the Union address, he called for an end to teaching to the test and encouraged schools to educate children with more flexibility and passion. Academic performance and the quality of elementary and secondary education is always a focus of administrations. With such an emphasis on achievement, factors that impact standardized test scores are constantly a priority in order to improve and promote policy that will increase student performance.

Much research has been conducted examining different influences on a child's success in school from teacher quality (e.g., Aaronson, Barrow and Sander 2007; Rockoff 2004; Rothstein 2010) to parental involvement (e.g., Altschul 2011; Jeynes 2007; Keith and Keith 1993; Trivette and Anderson 1995) to school size (e.g., Driscoll, Halcoussis and Svorny 2003; Lee and Smith 1995). With the rise in childhood obesity, the impact of child weight on achievement has been of interest recently as well (e.g., Averett and Stifel 2010; Capogrossi and You 2012; Datar and Sturm 2006; Sabia 2007) with research finding mixed results. Other literature has specifically examined school program effects on academic performance which is crucial for policy analysis. For instance, most of the research in this area has focused on the impacts of after-school programs (e.g., Pierce, Bolt and Vandell 2010; Sheldon et al. 2010; Shernoff 2010) and tutoring programs (e.g., Ritter et al. 2009; Zimmer, Hamilton and Christina 2010).

However, there are two gaps in the literature that are of consequence: 1. Minimal research examines the impacts of the School Breakfast Program (SBP) and the National School

Lunch Program (NSLP) on student performance; and 2. Most of the aforementioned research examines direct impacts of determinants on student achievement. The first gap is of significance because the SBP and NSLP are two of the largest school programs in the US operating in approximately 95% of public and nonprofit private schools and serving over 31.7 million children daily. The second gap is important because all of the determinants above, particularly programs and policies, likely have indirect and direct impacts on achievement making it necessary to examine both. Indirect impacts are often referred to as spillover effects and can be positive or negative.

Much SBP and NSLP research has focused on the nutritional quality of school meals and the influences on child weight. Because research has found child weight to affect performance and the school meal programs to impact child weight, it is important to consider the spillover effects that these two programs may have on academic performance by testing the mediator effect of child weight. Millimet, Tchernis and Husain (2010) specifically call for examining the impact of SBP and NSLP participation on outcome measures other than child weight such as cognitive and non-cognitive skills.

The SBP and NSLP are two federally assisted school meal programs established in the 1930s with the intent of combatting child hunger in the US. The programs are designed to provide nutritionally balanced, low-cost or free meals to children in attendance each day with nearly 20 million program participants receiving free- and reduced-price (FRP) meals (USDA 2012). The costs of the programs are sizable to the government: as of FY 2010, SBP cost $2.9 billion, and NSLP cost $10.8 billion annually (USDA 2012). These programs are administered by the Food and Nutrition Service (FNS) and its regional offices at the federal level. At the state level, the programs are directed by state agencies that are usually departments of education. State agencies have the responsibility of overseeing federal reimbursements, providing technical assistance and monitoring program performance. At the local level, SBP and NSLP are operated by school food authorities (SFAs) that are usually individual local education agencies (i.e., school districts). SFAs that participate in school nutrition programs receive both cash reimbursements and agricultural commodities; the agricultural commodities are dispersed on an entitlement basis determined by the number of reimbursable meals served the previous school year.

Contrary to combatting hunger, the programs are currently garnering media attention from parents, teachers and policy analysts on whether the meals are contributing to childhood obesity. Some academic research supports this argument (Millimet, Tchernis and Husain 2010; Schanzenbach 2009). Therefore, for the first time in over fifteen years, the USDA unveiled higher nutrition requirements for school meals in January 2012 as part of the 2010 Healthy, Hunger-Free Kids Act. The legislation targets school breakfasts and lunches with specific limitations on the amount of saturated fat, trans fat and sodium present in each meal. Examples of additional changes include that milk must be 1% or lower, one cup of fruit must be offered at breakfast, a daily serving of fruits and vegetables must be offered at lunch and calorie minimums and maximums will be in place for each meal based on a child’s age.

Some educators and policy analysts are hoping that increases in nutrition standards will have positive spillover effects on academic performance. For example, Dr. Robert Ross, president and CEO of The California Endowment, offers awards for “Nutrition Innovators” believing that healthier school meals will help reduce childhood obesity and improve academic performance: "When schools are healthier, kids are healthier and more successful in school" (Okey 2011). Some studies have linked the consequences of child overweight and underweight to poorer academic performance (e.g., Averett and Stifel 2010; Capogrossi and You 2012; Karp et al. 2003; Sabia 2007). However, there is no research that we are aware of since the implementation of the 1995 School Meals Initiative (SMI) examining whether meals provided by SBP and NSLP impact academic performance. The SMI required school meals to have higher nutrition standards in accordance with the 1990 Dietary Guidelines for Americans. These SMI standards are what will be replaced by the new 2012 USDA requirements. Prior to the 1995 SMI, some small scale studies analyzed the impact of school breakfast programs on student achievement finding mixed results. These studies examined either SBP or universal school breakfast programs at two or three schools in one particular city (Cromer et al. 1990; Meyers et al. 1989; Murphy et al. 1998a).

The most comprehensive impact evaluation of the programs called for by the FNS has been the School Nutrition Dietary Assessment (SNDA) Study of which there have been three: 1991-1992, 1998-1999, and 2004-2005. SNDA-I confirmed that school meals were not consistent with Dietary Guidelines for Americans particularly for total fat and saturated fat levels (Dwyer 1995). SNDA-II found an increase in the percentage of schools offering lunches consistent with Dietary Guidelines with a statistically significant trend toward lower levels of fat and saturated fat and increased levels of carbohydrates relative to calorie content in these lunches. In addition, school breakfasts showed comparable improvements in relative fat and saturated fat content (USDA 2001). SNDA-III found that while lunches were lower in saturated fat than in SNDA-II, less than one-third of schools offered school lunches that met USDA recommendations for total fat and saturated fat. Two-third of schools, on the other hand, met recommendations for school breakfasts (Gordon et al. 2007). The FNS is currently collecting data for SNDA-IV.

It is evident that further investigation is needed on the impacts of school meal programs on outcomes other than nutritional quality. The FNS is currently calling for research on the cost of producing reimbursable school meals since the level of the federal reimbursement rate affects the ability of schools to serve nutritious meals as well as for research on state and local school meal program procurement practices (FNS 2010). In addition, when conducting a thorough program evaluation both positive and negative spillover effects need to be examined, and to our knowledge, no research examines spillover effects of SBP and NSLP.

This paper examines the relationship between school meal program participation and academic performance for elementary and middle school students. If these programs contribute to academic achievement through the mediating factor of child weight (i.e., positive spillover effects), more evidence will be available in showing the programs' effectiveness. Furthermore, these two programs are well established in terms of infrastructure stemming from the federal level to state, district and school levels which provide executable policy implementation tools with the potential for a large public health impact in addition to boosting student achievement. Most of the existing literature examines the nutritional quality of school meals with a handful studying the causal impacts on child weight. Other research examines the relationship between nutrition, weight and academic performance. We link the two areas by utilizing an interdisciplinary theoretical framework (Capogrossi and You 2012) to estimate both partial and total program impacts on children's weight and academic performance. Utilizing the Early Childhood Longitudinal Study—Kindergarten Class, this research employs structural equation modeling and simultaneous equation estimation while accounting for self-selection into the programs.

LITERATURE REVIEW

Most research examining SBP and NSLP has focused on the diet quality of school meals (e.g., Briefel, Wilson and Gleason 2009; Fox et al. 2010; Gordon et al. 2007; Hernandez, Francis and Doyle 2011) and found SBP and NSLP to have direct impacts on child nutrition and consequently child weight (e.g., Gundersen, Kreider and Pepper 2009; Millimet, Tchernis and Husain 2010; Schanzenbach 2009). Therefore, when examining whether SBP and NSLP have spillover effects on achievement, the first question to consider is whether child nutrition and weight actually affect student performance. Research, which is discussed below, supports that child nutrition and weight may have significant impacts on performance with some studies specifically examining the effects of breakfast consumption. This provides further motivation for examining whether participation in school meal programs has spillover effects on performance through the mediating factor of child weight.

We briefly review the literature linking child nutrition and weight to performance before discussing the studies specifically examining the impacts of breakfast consumption on achievement. Then we examine the existing research that links SBP participation with student performance, but to our knowledge, no studies examine achievement outcomes with regard to NSLP participation. In examining the impacts of SBP on achievement, Murphy et al. (1998a) did mention that one of the major justifications for both SBP and NSLP was the potential to reduce negative effects of chronic, intermittent under-nutrition in the US which could then influence achievement; however, the authors did not examine a potential joint effect of participating in both programs.

Child Nutrition and Weight on Performance

Much of the research focusing on nutrition and academic performance has examined children in developing countries; however, there has been some research examining the impacts on children of more developed countries. While most studies in this area lack theoretical foundations, Glewwe, Jacoby, and King (2001) made progress toward the causal relationship between nutrition and achievement utilizing a theoretical foundation built on a household decision-making model to conduct a structural production function analysis. Their model was unique in that they divided a child's life into three periods—the first two years of life, two years to the minimum age of primary school enrollment, and the primary school period. In their model, child nutrition during the second period influenced academic performance in the third period; however, current nutrition was not considered in their framework. Using the nutritional status of the older sibling in the first two years of life as an instrument for the nutritional status of the child of interest, the authors found that better nourished children performed better in school. Glewwe, Jacoby, and King's (2001) model was limited in that it lacked dynamics on the home and school environments of the children and provided no guidance to select instruments. Therefore, their research faced the weak instrument problem common to instrumental variable methods

Other research has found that food insufficiency or the limited availability of nutritionally adequate food decreased school attendance and negatively impacted achievement of US children.

For example, Alaimo, Olson and Frongillo (2001) conducted multivariate regression analyses controlling for confounding socioeconomic factors using 5,344 children ages 6 to 16 from the National Health and Nutrition Examination Survey III (NHANES III) to examine the impact of food insufficiency on academic performance, cognitive outcomes, school attendance and grade repetition. The authors found that food insufficiency was associated with lower math scores and likelier grade repetition (1.44 times as likely) but not associated with reading scores or cognitive outcomes. Murphy et al. (1998b) conducted parent-child interviews on 204 children in addition to collecting data from schools. They found that intermittent experiences of food insufficiency were associated with poor academic performance in low-income children.

Other research examined the impacts of specific vitamins and minerals on the achievement of children and adolescents in the US. For instance, some research found that iron deficiency was associated with lower achievement. Halterman et al. (2001) used 5,398 children ages 6 to 16 from NHANES III to examine associations between iron deficiency and standardized test scores. They found that average math scores were lower for children with iron deficiency (with and without anemia) compared to children with normal iron levels. In addition, they found that children with iron deficiency had more than twice the risk of scoring below average in math compared to children with normal iron levels. Another example found that iron deficient children who were provided iron supplements compared to those who were given a placebo improved significantly in memory recall tests (Bruner et al. 1996).

Another avenue of research examined the impacts of child weight on academic performance. Much of the literature looked at associations between the two finding mixed results (e.g., Florence, Asbridge and Veugelers 2008; Gable, Britt-Rankin and Krull 2008; Judge and Jahns 2007; Li et al. 2008); however, Sabia (2007) and Averett and Stifel (2010) took a more causal approach. These authors utilized both instrumental variables and fixed effects methods. Sabia (2007) attempted to control for the endogeneity caused by the simultaneous productions of child weight and academic performance by using indicators for whether the biological mother and father were obese as instruments. Utilizing the National Longitudinal Study of Adolescent Health, he found a significant negative relationship between BMI and GPA for white females. Specifically, his results showed that a difference of 50 to 60 pounds was associated with an 8% to 10% difference in standing in the GPA distribution.

While, Sabia (2007) did not substantiate his analysis with theoretical foundations, Averett and Stifel (2010) tried to identify causality between childhood overweight and academic performance utilizing integrated health and cognitive production functions. They used a historical measure of the mother's BMI as their instrument when conducting IV analysis. The authors found the impacts of weight on performance to be more pronounced when models were subset by race and gender. Specifically, overweight white girls had lower math scores, and overweight black boys and girls had lower reading scores. Overall, instrumental variable estimation is limited by the strength and validity of the instruments, and dynamic panel methods may still face weak instrument and endogeneity problems.

Breakfast Consumption on Achievement

Some research has also examined the effects of breakfast consumption on performance outcomes in children while not specifically focusing on school breakfast programs. In a review of the literature, Rampersaud et al. (2005) concluded that breakfast consumption may improve a child's cognitive function related to memory, test grades and school attendance although evidence is mixed. For instance, Wesnes et al. (2003) conducted an experiment on the breakfast habits of 29 children finding that those who ate a breakfast rich in complex carbohydrates had better attention and memory compared to those who consumed a glucose drink or no breakfast. On the other hand, Wyon et al. (1997) found no significant impact of breakfast consumption on reasoning in their experimental study of almost 200 children from 10 different classes at 5 different schools.

Mahoney et al. (2005) conducted two experimental studies each using 30 children (15 boys and 15 girls) to examine the relationships between breakfast consumption, breakfast composition and cognitive performance in middle-income elementary school children. They found that academic performance was enhanced by breakfast consumption especially on tasks that required complex visual memory. They also found that the composition of the breakfast (they examined oatmeal versus ready-to-eat cereal) may also influence children's performance on certain measures such as spatial memory, auditory attention and short-term memory.

Simeon and Grantham-McGregor (1989) and Pollitt et al. (1998) found the impacts of eating breakfast on cognitive tests to be more pronounced on students after a period of fasting as well as on children considered nutritionally-at-risk. Simeon and Grantham-McGregor (1989) examined three groups of 30 children (previously severely malnourished, stunted and non-stunted) and had them admitted to a metabolic ward twice after an overnight fast. Half the group received breakfast while the other half did not. The previously malnourished and stunted groups had lower test scores when they had no breakfast. Pollitt et al.'s (1998) reviews of three experiments on the effects of overnight and morning fasting examined attention and memory processes of 9-11 year-old children. Similar to Simeon and Grantham-McGregor (1989), the children were admitted to a research center where some were given breakfast prior to taking psychological tests that assessed memory recall and competence in discriminating visual stimuli. They found slower memory recall, increased errors and slower stimulus discrimination among students who did not consume breakfast.

Since several results have indicated a cognitive benefit from breakfast consumption, these further motivate analyses investigating school meal program participation, particularly SBP, impacts on academic performance. Especially for children who may not eat breakfast at home or those who may not consume a nutritionally adequate breakfast, the SBP could potentially provide both nutritional and cognitive benefits.

School Breakfast Programs on Achievement

Some older work has investigated the impact of school breakfast programs on student achievement. However, to our knowledge, there has been no research on SBP since the implementation of the 1995 SMI which increased nutrition standards of school meals. Two studies, Meyers et al. (1989) and Cromer et al. (1990), specifically examined the effects of SBP on achievement. Two additional studies, Murphy et al. (1998a) and Kleinman et al. (2002), examined the impacts of universal school breakfast programs.

Meyers et al. (1989) studied a group of low-income children grades 3 through 6 in six schools within a single school district in Lawrence, Massachusetts in the 1986-1987 school year. In 1986, about 70% of the children in the school system were considered low-income, so the study examined children who qualified to receive free- and reduced-price meals. The authors collected pre- and post-treatment test scores from the Massachusetts Comprehensive Tests of Basic Skills as well as data on absence and tardiness rates. They found that low-income participants had lower tardiness and absence rates and a larger increase in test scores on the 1987 total scale score compared to low-income children who did not participate. However, the internal validity of Meyers et al. (1989) is limited because children were not randomly assigned to the treatment and control groups (i.e., whether or not they participated in SBP), and there were initial differences in performance between participants and non-participants. Non-participants began with higher scores which may partially explain why SBP participants had a larger positive change in academic performance compared to non-participants.

Cromer et al. (1990) conducted a randomized experiment to examine cognitive outcomes (i.e., Peabody Picture Vocabulary, auditory-verbal learning, matching figure test, and a continuous performance test) on 18 students who received SBP and 16 students who were fed a low calorie breakfast one hour and four hours after each of the breakfasts were given. The authors found no impacts of SBP on short-term memory from any of the cognitive outcomes measured. In addition, the authors also gave these same cognitive tests to students after an overnight fast or one hour after receiving SBP to examine the impacts of blood glucose on cognitive functioning. Once again, the authors found no correlation between blood glucose and performance along with no differences in performance between students who did and did not receive breakfast. Although the study was randomized, the small sample may have led to insignificant results. In addition, the breakfast given to children was a donut, orange juice and chocolate milk; therefore, if breakfast composition has an impact on performance as results in Mahoney et al. (2005) indicated, the low nutritional quality of the breakfast could have affected results.

Murphy et al. (1998a) conducted in-depth interviews with parents and children as well as collected school record data and information on school breakfast participation. The study was conducted on 133 children in one Philadelphia public school and two Baltimore public schools prior to the execution of a universally free breakfast program (not SBP) and then again four months later. They found strong evidence that higher rates of school breakfast program participation were associated with improved student math grades in the four-month time span. Kleinman et al. (2002) examined the academic performance of 97 inner-city students before a universally free breakfast program was implemented and then again six months after the program had been in place. The authors found that when children decreased their nutritional risk by participating in a universally free breakfast program there was higher attendance as well as improvements in math scores compared to children who did not decrease their nutritional risk.

Each of these studies examining the relationship between school breakfast programs and academic performance is limited to correlation analysis in one geographic area with small sample sizes. No studies actually examined the pathway from SBP and NSLP participation to child weight to academic achievement. Because of mostly non-experimental designs (Cromer et al. (1990) was the exception), there is no guarantee that participants were similar to non-participants allowing for biased results from self-selection into the programs. Also, in the studies that examined participants across several schools, clustering was not taken into consideration. In addition, the existing work examined different types of breakfast programs (i.e., universally free breakfast programs and SBP) serving specific student populations (i.e., low-income, inner-city, FRP); therefore, more general impacts of SBP on achievement are unknown.

Another limitation is that the studies specifically examining SBP were conducted prior to the 1995 SMI, and no studies examined the potential joint effect of SBP and NSLP participation on achievement. Therefore, the impacts on performance of both programs in their current form are unknown. Furthermore, all of the existing studies mentioned examined direct impacts of participation on performance rather than indirect or spillover effects. Because the impact of program participation on performance is likely through a mediator such as child nutrition and/or child weight rather than a direct influence, a study investigating the effects on performance through these underlying mechanisms is crucial. Without examining the mechanisms using a strong theoretical framework, many different models may be consistent with the same data: the problem of identification (Heckman 2000). In this case, results are not identifying the causal effects of the programs on performance. All of these shortcomings indicate a need for continued investigation on the spillover effects from both SBP and NSLP on achievement.

Particularly, there is a need for identifying the mechanism underlying the relationship between school meal program participation, child weight and academic performance. There are several potential pathways linking the three. For instance, program participation could have a direct impact on achievement if the act of participating mentally prepares the child for the school day ahead. Or participation could have an effect on performance if the nutrients consumed from the meals have an impact on concentration and memory thereby affecting performance (Rampersaud et al. 2005; Wesnes et al. 2003). Another theory is that participating in the school meal programs could impact child weight (Millimet, Tchernis and Husain 2010; Schanzenbach 2009) with child weight impacting performance (Averett and Stifel 2010; Capogrossi and You 2012; Sabia 2007). Or program participation could impact child weight, and the stigmas of being overweight or underweight could negatively influence a child's self-esteem which may impact his/her performance (Falkner et al. 2001; Krukowski et al. 2009; Xie et al. 2006).

Furthermore, participating in SBP and/or NSLP could impact self-esteem due to stigmas attached with participation (Bhatia, Jones and Reicker 2011; Mirtcheva and Powell 2009; Saunders 2009; Pogash 2008) which could then influence performance. Or the impacts on self-esteem from program participation could impact child weight either through the consumption of unhealthy foods (overweight) (Polivy, Heatherton and Herman 1988) or eating disorders (underweight) (French et al. 2001), and child weight could subsequently impact academic performance (Averett and Stifel 2010; Sabia 2007). Finally, the relationship between the three could be the result of spurious correlations rather than an actual causal relationship.

Therefore, the focus of this investigation is to examine the pathway from SBP and NSLP participation to children's academic achievement via children's weight outcomes using structural equation modeling. This allows us to simultaneously estimate our equations of interest and tease out the spillover effects of program participation on achievement.

CONCEPTUAL FRAMEWORK

You and Davis (2010) establish a two-stage Stackelberg model that depicts the interaction between parents and a child while permitting the child to have some input to household resource allocation decisions. Their model considers a multi-person household where the husband and wife interact in the collective model framework weighting their individual utility and using their individual bargaining weights within the household which results in Pareto efficient resource allocation decisions. The parents are modeled as the leader and, therefore, make decisions taking into account the possible best responses of the child. The child is modeled as the follower and makes choices after observing parental decisions while knowing that his responses have an influence on the observed parental allocations. Due to the unique problems this dissertation examines and the data set available, several changes are made to the You and Davis (2010) framework for the use of this study.

First, we modify the framework to a unitary model since the data we have only contains household head information. We recognize that this imposes restrictions on the parental decision process; however, because our interest is not on the impacts of parental time allocations with the child as in You and Davis (2010), this modification does not hinder our investigation. Second, we expand the You and Davis (2010) child health production function to include consumption goods affecting weight and utility as well as goods affecting weight but not utility as discussed in Rosenzweig and Schultz (1983). We also include the school environment in our child weight production function since school contexts are found to impact obesity (e.g., Crosnoe and Muller 2004), and we have school characteristic data available. Third, we incorporate the child's cognitive production function in the model with the child's weight outcome as a direct input similar to Averett and Stifel's (2007) model. Additionally, we include home and school environment characteristics in the cognitive production function to account for influences beyond the control of the child (e.g., Crosnoe and Muller 2004; Datar et al. 2004).

These modifications and expansions to the theoretical framework make the model more appropriate for our problem of interest and capture more influences on child weight and academic performance which allows for a more thorough analysis. For example, including consumption goods affecting weight but not utility allows for impacts on child weight that may be beyond the control of the child such as the quality of medical care that the child receives. Furthermore, since children spend a majority of their waking hours in school, it is not surprising that research has found strong impacts of school influences on child health, particularly child weight (e.g., Briefel, Wilson and Gleason 2009; Danielzik et al. 2005; James, Thomas and Kerr 2007; Muller et al. 2001; Story, Kaphingst and French 2006). Therefore, the inclusion of school determinants in the weight production function is crucial. Additionally, research has shown strong associations between child weight and performance (e.g., Datar and Sturm 2006; Florence, Asbridge and Veugelers 2008; Gable, Britt-Rankin and Krull 2008) with some studies supporting more of a causal relationship (Averett and Stifel 2010; Sabia 2007). This provides further motivation for nesting the child weight production function within the cognitive production function.

This theoretical framework provides better guidance for the theoretical interpretation of coefficients (Keane 2010). Keane (2010) argued that structural work has had a minimal presence in the literature recently, but that even experimentalist work is difficult to interpret without further structure and theoretical assumptions. Through the use of explicit assumptions, structural models aid in the understanding of the mechanisms driving the results and provide a concrete theoretical interpretation of coefficients.

The Child's Optimization

We use backward induction and begin with the child's decision-making stage. Given what is available, the child makes choices regarding the amount of goods consumed that affect both weight and utility as in Rosenzweig and Schultz (1983) (e.g., food and beverages that the child eats and drinks) $(\boldsymbol{x_B})$ in addition to the amount of other consumption goods not affecting weight $(\boldsymbol{x_o})$. The child also makes decisions regarding time spent in consuming all of these goods $(\boldsymbol{t_X})$, time spent on exercise $(\boldsymbol{t_E})$, time spent on school work $(\boldsymbol{t_{AP}})$ and time spent on other activities $(\boldsymbol{t_o})$. From these decisions, the child's weight and cognitive production functions are as follows:

$$B = \boldsymbol{B}(\boldsymbol{x_B}, \boldsymbol{t_E}, \boldsymbol{t_X}; SBP, NSLP, \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}) \tag{1}$$

$$AP = \boldsymbol{AP}(B, \boldsymbol{t_{AP}}; AP_{t-1}, \boldsymbol{K_h^{AP}}, \boldsymbol{K_s^{AP}}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \tag{2}$$

Participation in the school meal programs $(SBP, NSLP)$ provides a given set of food choices for the child as well as contributes to a child's weight outcome (e.g., Briefel, Wilson and Gleason 2009; Cole and Fox 2008; Gordon et al. 2007). Since whether the child participates in one or both programs is a household head decision[1] (Gordon et al. 2007), the child's weight production function is conditional upon participation. In addition, parental time spent in food preparation $(\boldsymbol{T_f})$ reflects the quality of food at home since the child's food choices are restricted by the environment provided by the parents (e.g., Barlow and Dietz 1998; Oliveria et al. 1992), and children's food preferences are partly shaped by observing their parents' food selections (e.g., Harper and Sanders 1975; Cutting, Grimm-Thomas and Birch 1997). Due to our data

[1] Local Education Agencies (LEAs) must distribute information letters to the households of children attending school at the beginning of each school year. Letters must inform families about which school nutrition programs are offered and that meals may be available free or at reduced prices along with eligibility requirements for free- and reduced-price meals. While applications for free- and reduced-price meals may be accessed online, all LEAs must be able to provide households with paper applications, and the information letter must provide instructions on how to apply for free- and reduced-price meals. Students paying full-price for meals do not need to apply.

limitations, we utilize a frequency measure of time spent in home food preparation which captures a general pattern of the home environment that is unlikely to change in the short term. Therefore, the weight production function considers the quality of food that the child consumes both at home and school.

Both equations condition on the child's respective outcome in the previous period (B_{t-1}, AP_{t-1}), child characteristics $(\boldsymbol{\mu})$, as well as household $(\boldsymbol{K_h})$ and school (K_s) environment characteristics affecting weight and performance, where $\boldsymbol{K_h} = (\boldsymbol{K_h^B}, \boldsymbol{K_h^{AP}})$ and $\boldsymbol{K_s} = (\boldsymbol{K_s^B}, \boldsymbol{K_s^{AP}})$. The child's weight outcome in the previous period (B_{t-1}) (Foster 1995) captures some of the genetic effect on current child weight as well as unobserved environmental characteristics interacting with the genetic effect contributing to a child's past and current weight status. According to the CDC (2010), obesity ensues from the interaction between genetic variation and shifting environmental factors which is evident when members of a family living in the same environmental conditions have different weight outcomes. In addition, conditioning on child characteristics $(\boldsymbol{\mu})$ includes birth weight to capture the endowment health effect. Examples for the household environment include parental employment status (e.g., Benson and Mokhtari 2011; Miller 2011) and parental involvement (e.g., You and Davis 2011), while examples for school characteristics include school size (e.g., Driscoll, Halcoussis and Svorny 2003) and teacher experience (e.g., Kane, Rockoff and Staiger 2008).

The weight production function also conditions on weight inputs that do not augment child utility other than through effects on weight (***I***) (e.g., health insurance, healthcare) (Rosenzweig and Schultz 1983). Additionally, the academic performance production function conditions on parental involvement with the child's school work $(\boldsymbol{T_{AP}})$ which has been found to impact achievement (e.g., Baydar, Greek and Gritz 1999; Tam and Chan 2010). For instance, Keith and Keith (1993) found that parental involvement in students' academic lives impacts 8th grade achievement. This result partly stems from more homework completed by students with more involved parents. Altschul (2011) found a similar result for Mexican American students whose parents were involved with the student at home, and Trivette and Anderson (1995) found effects to be age-specific with parental involvement affecting the achievement of elementary students more than middle school students.

The child's utility function depends on his/her weight (B), academic performance (AP), consumption of goods $(\boldsymbol{x_B}, \boldsymbol{x_o})$ and his/her time allocations $(\boldsymbol{t_X}, \boldsymbol{t_E}, \boldsymbol{t_{AP}}, \boldsymbol{t_o})$. It is conditional on school meal program participation $(SBP, NSLP)$. It is also included in the child's utility function since there is some evidence of stigmas attached to participation even though the choice to participate is exogenous to the child. Much research has shown a negative stigma attached to program participation (Bhatia, Jones and Reicker 2011; Mirtcheva and Powell 2009; Saunders 2009; Pogash 2008). However, Lambert et al. (2002) found that 79% of parents encouraged participation in NSLP with favorable attitudes toward the program, and during childhood and adolecent years, children's attitudes often reflect those of their parents (Cobb 2001; Klausmeier and Ripple 1971) indicating potential positive notions about program participation. The child's utility function is as follows:

$$u = \boldsymbol{u}(B, AP, \boldsymbol{x_B}, \boldsymbol{x_o}, \boldsymbol{t_X}, \boldsymbol{t_E}, \boldsymbol{t_{AP}}, \boldsymbol{t_o}; SBP, NSLP, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}). \quad (3)$$

Utility maximization is subject to the child's weight and cognitive production functions as well as a time constraint $\boldsymbol{t_X} + \boldsymbol{t_E} + \boldsymbol{t_{AP}} + \boldsymbol{t_o} = T$, where *T* is the total amount of time. Maximizing utility, the optimal choice set of the child is $(\boldsymbol{x_B^*}, \boldsymbol{x_o^*}, \boldsymbol{t_X^*}, \boldsymbol{t_E^*}, \boldsymbol{t_{AP}^*}, \boldsymbol{t_o^*}) = f(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu})$ which is a function of parental choices, household and school environments as well as other exogenous variables. The reduced form equations obtained from the child's choice set will be used to acquire the final reduced forms from the parental stage:

$$B^* = \boldsymbol{B}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \quad (4)$$

$$AP^* = \boldsymbol{AP}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \quad (5)$$

$$u^* = \boldsymbol{u}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \quad (6)$$

The Parent's Optimization

The unitary model assumes that there is one parent (i.e., the household head) acting as the main decision-maker. The household head makes the decisions during the first stage of the game, including decisions on meal program participation, while taking into consideration the child's responses to his/her decisions. The household head's utility is affected directly by his/her child's weight (B^*), academic performance (AP^*) and utility (u^*) as well as goods and foods purchased for the household that are available to the child $(\boldsymbol{X_B}, \boldsymbol{X_o})$, goods the household head consumes himself/herself $(\boldsymbol{Z})$, home and work environment characteristics $(\boldsymbol{K_h}, \boldsymbol{K_w})$, household head characteristics $(\boldsymbol{\varphi})$ and household head time allocations to work, food preparation, the child's school work and other residual activities $(\boldsymbol{T_w}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{T_o})$. Child participation in school meal programs enters the household head's utility indirectly through the child's weight (B^*) and the child's happiness level (i.e., utility (u^*)). The household head's utility function is

$$v = \boldsymbol{v}(\boldsymbol{Z}, \boldsymbol{T_w}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{T_o}, \boldsymbol{X_B}, \boldsymbol{X_o}, B^*, AP^*, u^*; \boldsymbol{K_h}, \boldsymbol{K_w}, \boldsymbol{\varphi}) \tag{7}$$

which is subject to the child's weight and cognitive production functions as well as the household head's time constraint $\boldsymbol{T_w} + \boldsymbol{T_f} + \boldsymbol{T_{AP}} + \boldsymbol{T_o} = T$ and budget constraint $\boldsymbol{p}(\boldsymbol{Z} + \boldsymbol{X_B} + \boldsymbol{X_o}) = Y$. In the budget constraint, $\boldsymbol{p}$ are market prices associated with consumption goods and Y is total household income. The optimal household head choices are then functions of the exogenous variables in the model:

$$(SBP^*, NSLP^*, \boldsymbol{Z}^*, \boldsymbol{X_B^*}, \boldsymbol{X_o^*}, \boldsymbol{T_j^*}) = f(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \text{ where } j = w, f, AP, o \tag{8}$$

Substituting the household head's optimal input demand functions into the child's indirect weight and cognitive production functions yields the final reduced form equations for the child's weight and cognitive outcomes

$$B^{**} = \boldsymbol{B}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{9}$$

$$AP^{**} = \boldsymbol{AP}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{10}$$

The theoretical model presented above provides the key equations of interest: the child's weight production function (Equation 1) and cognitive production function (Equation 2). The child's optimal choices from maximizing child utility in Equation 3 are functions of household and school environment characteristics outside of the child's control. Similarly, the household head optimal choices (Equation 8) from maximizing household head utility in Equation 7 are functions of characteristics outside the household head's control. These optimal choices allow us to obtain the final indirect child weight production function (Equation 9) and indirect cognitive production function (Equation 10) where all explanatory variables are predetermined. Equation 8 also provides for instrument selection and model specification (Park and Davis 2001). This paper focuses on the simultaneous estimation of Equations 1 and 2 with a particular interest on the spillover effects of *SBP* and *NSLP* on academic performance through the mediating factor of child weight.

ESTIMATION STRATEGIES AND EMPIRICAL MODEL

Structural Equation Modeling and Path Analysis

Most of the literature in the area focuses on reduced form estimation; however, a structural analysis is needed for more intuitive results and to determine whether program participation has spillover effects on academic performance particularly due to the simultaneity between the child weight and cognitive production functions. A crucial difference between the two types of models is the information that is assumed known by the modeler: complete information with structural models versus incomplete information with reduced form models (Jarrow and Protter 2004). Simply estimating a reduced form model will not present a clear picture of the relationship between meal program participation and academic performance. Reduced form provides total effects, but does not separate direct and indirect effects. In addition, since reduced form models rely solely on exogenous factors, the impact of endogenous variables is ignored.

Structural equation modeling (SEM) is a large sample technique that uses an equation system to test causal relationships between both manifest and latent variables by examining the variances and covariances of these variables. McFadden (1999) describes these systems as being modeled in terms of numerous agent behaviors where the behaviors reach harmony at the equilibrium. While SEM is more rooted in theory, it provides a notation for specifying the empirical economic applications of structural models and simultaneous equation models. The covariance is the core statistic of SEM; therefore, by utilizing SEM we can examine patterns of covariance among observed variables of our structural model in addition to explaining as much of the model's variance as possible (Kline 2011). The models often include variables that are not well defined (e.g., attitudes, intelligence) and take into account potential measurement error in observed independent and dependent variables (Raykov and Marcoulides 2006). The explicit representation of measurement error in SEM diagrams as latent variables to be estimated given the entirety of the model and the data is a special feature of the methodology. This is in contrast to traditional regression analysis that does not consider potential measurement error in independent variables. Measurement error can be related either to observed variables or to factors that are specified as dependent variables both of which provide more accuracy to the analysis (Kline 2011).

Structural models rooted in SEM aim to estimate the underlying mechanisms or parameters of a relationship compared to reduced form models. Burtless (1995) as well as Heckman and Smith (1995) compared reduced form models to testing a "black box" since results cannot be used to infer effects of similar but non-identical models. The basic assumption of both types of models is that the researcher is able to show the outcome process as well as the relationship between the outcome process and the process of selection into the program being evaluated using both available data and economic theory (Heckman and Smith 1995). In terms of policy, reduced form models do not help answer questions of "why" such as understanding why a program fails or produces certain results. Structural models aid in uncovering these parameters of interest; however, identification of these structural parameters of interest requires knowledge of the full joint distribution (Heckman and Smith 1995). Estimating several structural models or reduced form models at the same time because of underlying relationships or correlations between errors is often called simultaneous equation estimation.

Utilizing SEM as a basis for constructing structural and simultaneous equation models is advantageous for several reasons. First, it provides more efficiency and less information deficiency since the method allows for all possible information among equations to be considered including correlation among error terms.[2] Second, SEM permits endogeneity in its right-hand side variables, and often there is one structural equation for each of the endogenous variables in the model (Raykov and Marcoulides 2006). Third, it provides the ability to predict and evaluate the effects of additional economic policies (Heckman 2000). Fourth, it allows for the examination of both direct and indirect effects of all variables in the model.

Direct effects are the impacts that go directly from one variable to another variable. Indirect effects are often called mediators where the effects between two variables are influenced by additional intervening variables. Total effects are obtained by combining direct and indirect effects and provide the results of a simultaneous change in all inputs from a change in a single

[2] There are several cases when there will be no efficiency gain from a system of equations compared to OLS: 1. All of the equations have the same set of covariates and there are no cross-equation restrictions in the model; 2. No cross-equation error correlation exists in the system; and 3. Covariates in one block of equations are a subset of the covariates in the other equations of the system. When any of these situations exist, estimating a system of equations simultaneously is unnecessary.

exogenous variable (Raykov and Marcoulides 2006). The ability to identify both partial (i.e., direct and indirect effects) and total effects is significant because it allows us to answer different research or policy questions. This is important since policymakers often have several targets of interest (You and Davis 2010) such as program participation's influence on child weight and its consequential influence on academic performance.

There are several types of structural equation models (Kline 2011): path analysis models, confirmatory factor analysis models, structural regression models, and latent change models. This investigation utilizes path analysis which is the backbone of SEM (Raykov and Marcoulides 2006). Path analysis tests theoretical relationships and estimates the effects among variables once a model has been specified (Schumacker and Lomax 1996). While path analysis evaluates structural models using only observed variables, the error terms of these models are usually represented as latent variables (Kline 2011).

Figure 1 depicts the path diagram of the system of equations derived from our theoretical model that is used for the empirical analysis. The terminal endogenous variable is academic performance (*AP*) which is directly influenced (the solid arrows) by child weight (*B*) and other variables impacting academic performance ($\boldsymbol{X_{AP}}$) where ($\boldsymbol{X_{AP}}$) is a matrix consisting of $\boldsymbol{X_{AP}} = \{B, \boldsymbol{t_{AP}}, AP_{t-1}, \boldsymbol{K_h^{AP}}, \boldsymbol{K_s^{AP}}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}\}$ from the cognitive production function of the theoretical model. Examples of these variables include past performance in school, school environment characteristics (e.g., school enrollment, teacher experience) and household environment characteristics (e.g., parental involvement, how frequently the child studies or does homework). There are indirect effects on (*AP*) from ($\boldsymbol{X_B}$) and ($\boldsymbol{X_{MP}}$) through the mediator variable of child weight (*B*). ($\boldsymbol{X_B}$) are determinants of current child weight as derived from the theoretical model

$\boldsymbol{X}_B = \{\boldsymbol{x_B}, \boldsymbol{t_E}, \boldsymbol{t_X}, SBP, NSLP, \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}\}$, and (***MP***) is school meal program participation $\boldsymbol{MP} = \{SBP, NSLP\}$ where ($\boldsymbol{X_{MP}}$) are determinants of participation. Examples of child weight factors include how often the child exercises, time spent watching television and parental employment status, and examples of determinants of program participation are household income and whether the parents are married. The child weight (*B*) mediator variable transfers some of the causal effects of exogenous preceding variables ($\boldsymbol{X_B}$, $\boldsymbol{X_{MP}}$) onto succeeding variables (*AP*).

The error terms are located in circles because they are considered latent variables and represent the unmeasured/omitted causes of the endogenous variables as well as measurement error (Kline 2011). The dashed arrows depict the contemporaneous correlation among the three equations—the unobserved characteristics that influence meal program participation, child weight and academic performance. The model shows the complexity of interdependencies between meal program participation, child weight and academic performance lending further support to our systems approach.

Full-Information Maximum Likelihood

Full-information maximum likelihood (FIML) is a system method frequently used for the estimation of SEM where all parameters in all equations are estimated simultaneously. This utilizes all of the information in the model through the joint estimation of the child weight and academic performance production functions along with the selection equations and incorporates correlation in unobservables across the equations for each individual. This method assumes that the equation errors are jointly normally distributed which is a frequent assumption in the literature and finds parameter estimates that maximize the likelihood of observing the available data if one were to collect data from the same population again (Raykov and Marcoulides 2006). FIML is an iterative procedure that improves the overall fit of the model until convergence to a stable solution is achieved (Kline 2011). When using FIML with path models, coefficient estimates are interpreted the same as in multiple regression analysis. Our system of equations derived from the theoretical model is as follows:

$$SBP^{*} = \boldsymbol{SBP}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{11}$$

$$NSLP^{*} = \boldsymbol{NSLP}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{12}$$

$$B = \boldsymbol{B}(\boldsymbol{x_B}, \boldsymbol{t_E}, \boldsymbol{t_x}; SBP, NSLP, \boldsymbol{I}, B_{t-1}, \boldsymbol{K_h^B}, \boldsymbol{K_s^B}, \boldsymbol{T_f}, \boldsymbol{\mu}) \tag{1}$$

$$AP = \boldsymbol{AP}(B, \boldsymbol{t_{AP}}; AP_{t-1}, \boldsymbol{K_h^{AP}}, \boldsymbol{K_s^{AP}}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \tag{2}$$

$$\boldsymbol{x_B^*} = \boldsymbol{x_B}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \tag{13}$$

$$\boldsymbol{t_E^*} = \boldsymbol{t_E}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \tag{14}$$

$$\boldsymbol{t_x^*} = \boldsymbol{t_x}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \tag{15}$$

$$t_{AP}^{*} = \boldsymbol{t_{AP}}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{T_f}, \boldsymbol{T_{AP}}, \boldsymbol{\mu}) \tag{16}$$

We estimate two selection equations as modeled in the path diagram $\boldsymbol{MP} = \{SBP, NSLP\}$: SBP and NSLP participation (Equation 11 and Equation 12). These are modeled simultaneously each taking the value of 1 if the child participates in the program since children can participate in neither, one or both programs. The determinants of each of the selection equations are variables that impact a household head’s decision for a child’s participation such as past participation status (Hernandez, Francis and Doyle 2011), certain home and school environment characteristics (e.g., urbanity, percentage of students at school eligible for FRP), household income, as well as parent and child characteristics (e.g., parental education, child's gender and age).[3] Past participation is also an indicator of parent and child satisfaction with the meal programs which influences participation (Gordon et al. 2007; Lambert, Conklin and Johnson 2002). Recognizing the importance of possible program self-selection influences the way economic data is interpreted and the effectiveness of the social policy being examined (Heckman 2001).

Equation 1 and Equation 2 are the child's weight and academic performance production functions, respectively, as derived in the theoretical model. The outcome measures of the production functions are discussed in more detail in the following section. Equation 13 to Equation 16 are the child's optimal choices of consumption goods affecting weight and utility (x_B), time spent on these goods $(\boldsymbol{t}_x)$, time spent on exercise $(\boldsymbol{t}_E)$ and time spent on school work $(\boldsymbol{t}_{AP})$. These choices are endogenous to the weight and cognitive production functions since they are determined within the system; therefore, they are modeled explicitly.

This system of equations will allow us to examine the possible spillover effects of meal program participation on academic performance through the medium of child weight. Stacking the observations for each child gives us the following model:

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[3] The selection equations contain the same variables except for past participation in NSLP is only in the NSLP selection equation, past participation in SBP is only in the SBP selection equation and the additional dummy variable of length of school breakfast is in the SBP selection equation (e.g., Gordon et al. 2007). For instance, in Gordon et al. (2007) most students indicated that the length of time to eat lunch is adequate; however, since school breakfasts are offered prior to the start of the school day rather than as part of the school day (like NSLP), the amount of time students have to eat a school breakfast varies for reasons such as school start time and student transportation (i.e., bus schedules) that impact participation decisions.

$$
\begin{bmatrix} SBP_i \\ NSLP_i \\ B_i \\ AP \\ \boldsymbol{x}_{\boldsymbol{B},i} \\ \boldsymbol{t}_{\boldsymbol{E},i} \\ \boldsymbol{t}_{\boldsymbol{x},i} \\ \boldsymbol{t}_{\boldsymbol{AP},i} \end{bmatrix} = \begin{bmatrix} X_{SBP,i} \\ X_{NSLP,i} \\ X_{B,i} \\ X_{AP,i} \\ X_{x_B,i} \\ X_{t_E,i} \\ X_{t_x,i} \\ X_{t_{AP},i} \end{bmatrix} \mathrm{B} + \begin{bmatrix} \omega_{SBP,i} \\ \omega_{NSLP,i} \\ \omega_{B,i} \\ \omega_{AP,i} \\ \omega_{x_B,i} \\ \omega_{t_E,i} \\ \omega_{t_x,i} \\ \omega_{t_{AP},i} \end{bmatrix} = \boldsymbol{XB} + \boldsymbol{\Omega} \tag{17}
$$

Estimated simultaneously, coefficient estimates in each equation are allowed to have different values, and interactions between equations enter the model explicitly through the Ω matrix. This system of equations allows us to examine the direct impacts of program participation on child weight which are the effects arising from the set framework of the program: providing students with nutritious meals. We only directly model child inputs to the system and not parental time inputs because parental decisions are exogenous to the child, and the frequency data available in the ECLS-K more readily captures a pattern that is not easily changed in the short-term. We also are able to study the indirect effects of program participation which are auxiliary impacts that go beyond the scope of the programs' objectives: spillover effects of program participation on academic performance.

Theoretical Identification of the System

A structural model is identified if there is enough information available to determine a unique optimal value for each parameter in the model. Technically, for a system of equations to be identified, there must be at least zero degrees of freedom (Kline 2011). If this condition is not met, the model is underidentified. For underidentified models, it is not possible to find unique estimates for all parameters. If a unique solution exists (zero degrees of freedom), the model is considered just-identified. Finally, a system may have fewer free parameters than observations in which the model is overidentified. In this case, restrictions are implemented that lead to a unique solution.

The order and rank conditions are used to determine whether a system is identified. The order condition, which is necessary but not sufficient, states that the number of excluded exogenous variables in an equation (*k*) must equal or exceed the number of endogenous variables in the equation (*m*) minus 1 (Kline 2011): $k \geq m - 1$. The rank condition, which is sufficient, asks whether there is enough independent information in the matrix to determine a unique solution: $\rho(A) \geq m - 1$, where *A* is the matrix of coefficients of the equations.

Due to data availability, the system we estimate only contains six of the theoretical equations $(SBP, NSLP, B, AP, \boldsymbol{t}_{\boldsymbol{E}}^{*}, \boldsymbol{t}_{\boldsymbol{AP}}^{*})$; therefore, we examine the identification of this modified system.

The order condition is satisfied for Equation 11 to Equation 16 because they consist of all exogenous variables. We examine the order condition for the weight and cognitive production functions, respectively. For the weight production function there is one included endogenous variable (*m*): $(\boldsymbol{t}_{\boldsymbol{E}})$; and there are at least seven excluded exogenous variables (*k*) $(AP_{t-1}, \boldsymbol{K}_{\boldsymbol{h}}^{\boldsymbol{AP}}, \boldsymbol{K}_{\boldsymbol{s}}^{\boldsymbol{AP}}, \boldsymbol{K}_{\boldsymbol{w}}, \boldsymbol{T}_{\boldsymbol{AP}}, \boldsymbol{p}, \boldsymbol{\varphi})$ since $(\boldsymbol{K}_{\boldsymbol{h}}^{\boldsymbol{AP}}, \boldsymbol{K}_{\boldsymbol{s}}^{\boldsymbol{AP}}, \boldsymbol{K}_{\boldsymbol{w}}, \boldsymbol{T}_{\boldsymbol{AP}}, \boldsymbol{p}, \boldsymbol{\varphi})$ are vectors and likely contain more than one variable. Therefore, the weight production function is overidentified: $7 \geq 0$. For the cognitive production function, there are two included endogenous variables (*m*): $(B, \boldsymbol{t}_{\boldsymbol{AP}})$; and there are at least seven excluded exogenous variables (*k*) $(B_{t-1}, \boldsymbol{K}_{\boldsymbol{h}}^{\boldsymbol{B}}, \boldsymbol{K}_{\boldsymbol{s}}^{\boldsymbol{B}}, \boldsymbol{K}_{\boldsymbol{w}}, \boldsymbol{T}_{\boldsymbol{f}}, \boldsymbol{p}, \boldsymbol{\varphi})$ since

$(\boldsymbol{K}_{\boldsymbol{h}}^{B}, \boldsymbol{K}_{\boldsymbol{s}}^{B}, \boldsymbol{K}_{w}, \boldsymbol{T}_{f}, \boldsymbol{p}, \boldsymbol{\varphi})$ are vectors and likely contain more than one variable. Therefore, the cognitive production function is also overidentified: $7 \geq 1$. The order condition is met for our structural model.

Since there are three endogenous child choice variables in the system, the rank condition is satisfied if $\rho(R_j\theta) \geq 2$ where $j = B, AP$. For both the child weight and cognitive production functions, the ranks are at most 5; therefore, both of the production functions pass the rank condition. Because both order and rank conditions are satisfied, the theoretical system is identified.

DATA SPECIFICATION AND SUMMARY STATISTICS

We utilize data from the Early Childhood Longitudinal Study-Kindergarten Class (ECLS-K). This is a nationally representative cohort of 21,260 children who began kindergarten in 1998-1999 and who are followed through 8th grade. The study collected data on children in over 1,000 different schools, as well as on their families, teachers and school facilities/characteristics. Details of the data collection and instruments can be found in the *Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 User's Manual* (Tourangeau et al. 2009).

Child Weight Production Function

While a variety of measures could be used to represent child weight (*B*), in this research we use the continuous measure of BMI z-score as the output of the weight production function.

This measure is calculated using CDC standards.[4] BMI z-scores are the internationally accepted continuous measure of body mass index for children that are particularly useful in monitoring changes in weight. A BMI-for-age z-score is the deviation of the value for a child from the mean value of a reference population divided by the standard deviation for the reference population. We drop 320 observations that are considered biologically implausible.[5]

Covariates for the weight production function controlling for exercise $(\boldsymbol{t_E})$ include how many minutes per day the child watches television and how many days per week, on average, the child participates in 20 minutes of physical activity that makes him/her sweat. Television watching and the frequency of physical activity is modeled directly in our system of equations to capture potential endogeneity (Agee et al. 2010; Chou 2008). We also include participation in SBP and NSLP as factors that impact child weight since these meals can contribute to one-half of a child's daily calories (Schanzenbach 2009).

Child characteristics $(\boldsymbol{\mu})$ include gender, age, race/ethnicity and birth weight in ounces. The child's weight status in the previous period is also accounted for (B_{t-1}). Home environment characteristics $(\boldsymbol{K_h^B})$ that affect child weight consist of mother and father's education levels, the mother's employment status, whether the parents are married, household income, urbanity (city vs. suburb vs. rural), whether the child is involved in sports and how many days a week the

[4] We use a SAS program provided by the CDC for the calculation of child's BMI (CDC "Growth Chart Training" 2009). The SAS program contains indices of the anthropometric status of children from birth to 20-years-old based on the 2000 CDC growth charts. The program uses a child's age in months, gender, height and weight to calculate BMI.

[5] The program provides outlier observations based on the World Health Organization's fixed exclusion ranges. These are observations with BMIs that are considered to be "biologically implausible values" (BIVs) (CDC "Growth Chart Training" 2009) (ie. the BMI is either too low or too high to be realistic).

family eats breakfast and dinner together. Whether the child participates in a sport is likely to capture the habits of the child which will not change in the short-run; therefore, this variable is treated as exogenous rather than modeled independently. Literature shows that family meals have the potential to enhance health and prevent unhealthy weight behaviors in youth (Eisenberg, et al. 2004; Neumark-Sztainer, et al. 2004; Videon and Manning 2003). A school environment characteristic $(\boldsymbol{K}_s^B)$ we capture other than school meal program participation is the percentage of students in the child's school who are overweight since peer effects are known to influence a child's eating habits and weight status (e.g., Oliver and Thelen 1996; Salvy et al. 2007).

Academic Performance Production Function

Our main interest in this study is how school meal program participation influences academic performance (*AP*) through the mediating factor of child weight. We use math and English IRT scale scores to capture a child's achievement compared to other children in the sample using an unbiased measure. The IRT scores allow us to compare scores between children in the sample and over time which is a stronger measure than GPA or individual states' standardized test scores. The use of the ECLS-K assessments creates reliability and uniformity within the data whereas each state requires a different standardized test of its students ranging in level of difficulty. In addition, GPA depends on the difficulty of classes as well as the teacher and school assigning grades.

As derived in the theoretical model, student performance depends on child BMI (*B*), the child's time input into school $(\boldsymbol{t}_{AP})$, past academic performance (AP_{t-1}), household $(\boldsymbol{K}_h^{AP})$ and school $(\boldsymbol{K}_s^{AP})$ environment characteristics, parental time inputs $(\boldsymbol{T_{AP}})$ as well as child characteristics $(\boldsymbol{\mu})$.

As time input factors to school work $(\boldsymbol{t_{AP}})$, we include how frequently, on average, the child does homework at home per week (on a scale of 0 to 4). Because this variable is endogenous, we model it explicitly in the system. In addition to including the child's IRT scale score from the previous period (AP_{t-1}), we also include a baseline IRT score for either math or English in all models that was administered when the child entered kindergarten in fall 1998-1999. This variable controls for a child's ability prior to school entry that contributes to a child's academic success and helps capture the child's motivation.

Household environment characteristics $(\boldsymbol{K}_h^{AP})$ controlled for in the model include whether parents are married, the number of siblings, urbanity and whether the parents have rules for watching television. Household income is also included from the parent's budget constraint in the optimization problem. Family composition has been shown to have a significant effect on test scores in the literature (e.g., Arends-Kuenning and Duryea 2006; Dornbusch et al. 1991; Jeynes 2002). Variables such as urbanity and household income have also been found to influence a child's academic performance (e.g., Datar and Sturm 2006; Judge and Jahns 2007; Wendt and Kinsey 2009). We include whether the parents have rules for television watching as an indicator of household stability and rules within the household.

School environment characteristics $(\boldsymbol{K}_s^{AP})$ include how many students are enrolled, whether the school is Title 1, the number of years a teacher has taught, and whether the teacher has a Master's degree. The inclusion of a Title 1 school is determined by whether more than

40% of students qualify for free- and reduced-price lunch according to the Elementary and Secondary Education Act (ESEA). Literature shows that larger school enrollment tends to have negative impacts on school performance compared to smaller school environments (e.g., Driscoll, Halcoussis and Svorny 2003; Lee and Smith 1995). Studies have also found that teacher preparation and certification have a significant impact on student performance, particularly in mathematics (e.g., Kane, Rockoff and Staiger 2008; Wayne and Youngs 2003).

Parental time inputs to a child's academic performance $(\boldsymbol{T_{AP}})$ include measures of parental involvement in school and how frequently the parents help the child with homework. Research has found that parental involvement has a strong effect on a child's achievement that is not captured by family background variables (e.g., Englund et al. 2004; Houtenville and Conway 2008). Our indicator of parental involvement in school is on a scale from 0 to 7. Zero indicates no involvement with back-to-school nights, attending parent-teacher conferences or volunteering at the child's school. Finally, child characteristics $(\boldsymbol{\mu})$ include gender, age, race/ethnicity and birth weight in ounces.

Selection Equation Variables

Because the household head makes the decision regarding whether the child participates in the school meal programs, the selection equations are derived from the parent's optimization stage of the theoretical model and are reproduced below from our system of equations:

$$SBP^* = \boldsymbol{SBP}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{11}$$

$$NSLP^* = \boldsymbol{NSLP}(\boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K_h}, \boldsymbol{K_s}, \boldsymbol{K_w}, \boldsymbol{p}, \boldsymbol{\mu}, \boldsymbol{\varphi}) \tag{12}$$

Program participation decisions are functions of exogenous variables that influence household head decisions as can be seen in Equation 11 and Equation 12. The following covariates are included in our prediction of both meal program participation equations: child characteristics $(\boldsymbol{\mu})$ of gender, age, race/ethnicity, and whether the child participated in the program in the previous year; child weight from the previous period (B_{t-1}); academic performance from the previous period (AP_{t-1}); household income $(\boldsymbol{p})$; mother and father's education levels $(\boldsymbol{\varphi})$; whether the child has health insurance $(\boldsymbol{I})$; whether the mother works full-time $(\boldsymbol{K_w})$; household characteristics $(\boldsymbol{K_h})$ of single-parent household, urbanity, Food Stamp recipient status; and proportion of students in school eligible for free lunch $(\boldsymbol{K_s})$. When we model selection into SBP, we also include the length of time allotted for school breakfast $(\boldsymbol{K_s})$ as discussed earlier.[6]

One of the first studies on NSLP participation found race, income, and parental education to be the most significant predictors for students participating in free- or reduced-price lunch and that employment, urbanicity, and income were the crucial determinants of students paying full-price for lunch (Zucchino and Ranney 1990). Specifically, participation in SBP and NSLP has been found to be higher among boys, students from rural districts, and students from minority (especially black), low income-to-poverty ratio, less educated and single-parent households (Devaney and Fraker 1989; Sampson et al. 1991; Dunifon and Kowaleski-Jones 2001; Datar and Nicosia 2009a; Mirtcheva and Powell 2009). Research has also shown that children attending

[6] We looked into where breakfast was served (e.g., classroom, cafeteria, other), but the variation within the variable was too small to include in the model. For most students, breakfast is served in the school cafeteria.

schools with a higher proportion of its students eligible for free lunch were more likely to participate (Mirtcheva and Powell 2009) as were students from families who are Food Stamp recipients (Dunifon and Kowaleski-Jones 2001; Mirtcheva and Powell 2009). There may be some concern regarding potential endogeneity between being Food Stamp recipients and school meal program participants; however, the existing literature that considered participation between the three programs did not acknowledge this as a problem (Dunifon and Kowaleski-Jones 2001; Mirtcheva and Powell 2009). Furthermore, including Food Stamp participation status acts as an indicator for supplementary income that the family can spend on food in addition to their household income.

Furthermore, Datar and Nicosia (2009b) found that children whose mothers work were more likely to participate in NSLP but less likely to participate in SBP ($\boldsymbol{K_w}$). Other factors found to influence SBP participation include the scheduling of school breakfast, bus and transportation issues, and length of time to eat ($\boldsymbol{K_s}$) (Gordon et al. 2007; Reddan et al. 2002; Rosales and Jankowski 2002).

Child Choice Variables

We also estimate three child choice equations in our system: average minutes of television watched daily $(\boldsymbol{t_E})$, how many days per week, on average, the child participates in 20 minutes of physical activity that makes him/her sweat $(\boldsymbol{t_E})$, and how frequently the child does homework $(\boldsymbol{t_{AP}})$. These three variables are derived from the following two theoretical equations:

$$\boldsymbol{t}_{\boldsymbol{E}}^{*} = \boldsymbol{t}_{\boldsymbol{E}}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K}_{\boldsymbol{h}}, \boldsymbol{K}_{\boldsymbol{s}}, \boldsymbol{T}_{\boldsymbol{f}}, \boldsymbol{T}_{\boldsymbol{AP}}, \boldsymbol{\mu}) \tag{28}$$

$$\boldsymbol{t}_{AP}^{*} = \boldsymbol{t}_{AP}(SBP, NSLP, \boldsymbol{I}, B_{t-1}, AP_{t-1}, \boldsymbol{K}_{\boldsymbol{h}}, \boldsymbol{K}_{\boldsymbol{s}}, \boldsymbol{T}_{\boldsymbol{f}}, \boldsymbol{T}_{\boldsymbol{AP}}, \boldsymbol{\mu}) \tag{30}$$

Therefore, covariates included in the two $(\boldsymbol{t}_{\boldsymbol{E}})$ equations include: the child's gender, race/ethnicity and age $(\boldsymbol{\mu})$, meal program participation status $(SBP, NSLP)$, child weight from the previous period (B_{t-1}), the child's IRT scale score from the previous period (AP_{t-1}), mother's education level, whether the parents are married, household income, urbanity, whether there are rules regarding the amount of television watched per week, and if the child participates in a sport $(\boldsymbol{K}_{\boldsymbol{h}})$, how often the child has Physical Education class at school $(\boldsymbol{K}_{s})$, how many breakfasts and dinners the family eats together on average per week $(\boldsymbol{T}_{\boldsymbol{f}})$, how frequently the parent helps the child with homework $(\boldsymbol{T}_{\boldsymbol{AP}})$.

Covariates included in the child's time input to school $(\boldsymbol{t}_{\boldsymbol{AP}})$ include: the child's gender, race/ethnicity and age $(\boldsymbol{\mu})$, meal program participation status $(SBP, NSLP)$, child weight from the previous period (B_{t-1}), the child's IRT scale score from the previous period (AP_{t-1}), household income, whether the parents are married, mother's education level, whether there are rules regarding the amount of television watched per week and if there is a place set aside at home for the child to do homework $(\boldsymbol{K}_{\boldsymbol{h}})$, how involved the parent is with the school, how many breakfasts and dinners the family eats together on average per week $(\boldsymbol{T}_{\boldsymbol{f}})$ and how frequently the parent helps the child with homework $(\boldsymbol{T}_{\boldsymbol{AP}})$.

Empirical Identification of the System

Although the theoretical system of equations is identified, we need to verify that the empirical system estimated is identified as well. In our system, we have four endogenous variables from the following three theoretical equations: $(B, \boldsymbol{t_E}, \boldsymbol{t_{AP}})$. These are represented by child BMI z-scores, how many minutes of television the child watches, frequency of physical activity and frequency of doing homework. There are 17 excluded exogenous variables in the weight production function making the equation overidentified. There are also 17 excluded exogenous variables in the cognitive production making it overidentified as well. Therefore, both empirical equations fulfill the order condition. Since there are four endogenous child choice variables in the system, the rank condition is satisfied if $\rho(R_j\theta) \geq 3$ where $j = B, AP$. For both the child weight and cognitive production functions, the ranks are at most 6; therefore, both of the production functions pass the rank condition. Because both order and rank conditions are satisfied, the theoretical system is identified.

Summary Statistics

Table 1 and Table 2 provide summary statistics for the selected sample by meal participation status and eligibility for free- and reduced-price meals for 5^{th} and 8^{th} grade students, respectively.[7] We group students by whether or not they are FRP eligible in order to examine the effects of participation on students who are similar to one another and compare program effects across the six groups (FRP eligible/non-eligible; SBP participants, NSLP participants, non-participants).

[7] All analyses in the paper use sample weights which produce estimates that are representative of the population cohort of children who began kindergarten in 1998-1999. The sample weight used is C1_7FP0.

BMI z-scores and the percentage of overweight and obese are higher among FRP eligible students in 5th and 8th grades. Among students who are not eligible for FRP, BMI z-scores and the percentage of overweight and obese are higher among program participants compared to non-participants. However, among eligible FRP students, BMI z-scores and the percentage of overweight and obese are higher among non-participants compared to participants. Furthermore, among all participants, child weight is higher among SBP participants compared to NSLP participants.

A higher proportion of female, black and Hispanic students participate in SBP and NSLP when they are eligible for FRP compared to non-eligible students. Eligible students who are also on Food Stamps are more likely to participate in SBP as are students (eligible and non-eligible) who attend Title 1 schools.

While the number of days that children participate in activities that make them sweat is a little under 4 for 5th graders and around 5.5 for all 8th graders, 8th grade students participating in SBP and NSLP watch more television on an average day compared to non-participants. Math and English scores are also highest among non-eligible students as well as higher among non-participants compared to participants.

RESULTS

We examine the spillover effects of school meal program participation on academic performance estimating the weight production function, the cognitive production function, two selection equations and three child choice variables simultaneously through a structural equation system.[8] All results are clustered at the school level since children attending the same school will consume the same SBP and NSLP meals and are influenced by the same school environment.[9] Because of clustering, we do not expect differences in overall school quality, meal programs or physical activity at the school level to be driving our findings.

We also examine outcome measures at the end of 5th and 8th grades because the transition between elementary and middle school is quite large both socially and academically for most children. Not to mention, research has found school meal program participation to be highest in elementary school compared to middle and high school (Gordon et al. 2007). Furthermore, once children enter middle school they often have more food choices other than SBP and NSLP. According to the CDC's 2006 School Health Policies and Programs Study, 32.7% of elementary schools had either vending machines, a school store, canteen or snack bar where students could purchase foods or beverages. However, 71.3% of middle school students had access to these competitive foods (CDC 2006). Therefore, examining program impacts on elementary school students is very appropriate for our analysis.

Using a system of equations, we have the ability to ask several questions: 1. What are key determinants of program participation? 2. What are the direct impacts of program participation on child BMI? 3. What are the indirect impacts of program participation on academic performance? 4. What are other key determinants of child weight and academic performance? We study these questions in two different ways: 1. For all participating students

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[8] Results are nearly identical when we do not include the three child choice variables in the system but consider them all exogenous covariates.

[9] Results are also robust when we cluster by teacher rather than school to control for teacher-level effects on academic performance.

combined as well as separately for FRP students and students paying full-price; and 2. By FRP eligibility and participation status. Examining both of these ways allows us to compare results with the literature as well as provide further insights to program participation impacts by examining children who are more similar in terms of socioeconomic status.

SBP and NSLP Determinants

First, in examining key determinants of program participation in both elementary and middle school by only participation status, our results support those of the literature as can be seen in Table 3 and Table 4 which show SBP and NSLP determinants, respectively, for 5th and 8th grades.[10] We find race/ethnicity (particularly Hispanic), household income, father's education, urbanity and past program participation to be the most significant indicators of current participation across programs in both elementary and middle school. For example, there is a negative relationship between participation and income as well as with father's education as in Dunifon and Kowaleski-Jones (2001). Similar to Datar and Nicosia (2009b), elementary students who have mothers working full-time are more likely to participate in the programs; however, this impact does not carry over to 8th grade. In addition, children attending elementary schools with a higher proportion of its students eligible for free lunch are more likely to participate as in Mirtcheva and Powell (2009), although the magnitude of this effect was miniscule. For elementary school students receiving FRP, household participation in the Food Stamp program is a determining factor just as in Dunifon and Kowaleski-Jones (2001) and

[10] Results are similar when we model both math and English IRT scale scores but we present the math results in Table 3 and Table 4.

Mirtcheva and Powell (2009). Additionally, mainly for elementary school students, age and the length of time allotted for school breakfast is a significant predictor of SBP participation as in Gordon et al. (2007) and Reddan et al. (2002); however, the magnitude of the coefficient estimates are extremely small. While urbanity is a significant predictor for all participating students, full-price students living in urban areas are less likely to participate in SBP.

In imposing and testing restrictions of equality across parameters from different equations, we find several interesting results. For example, we test whether household income has equivalent impacts on student participation in SBP and NSLP finding that household income has a different impact on the propensity to participate across programs. This holds for students paying full-price for meals and for students receiving FRP meals. However, a child's race and gender do not impact the decision to participate in SBP and NSLP differently. In addition, whether the child's mother works full-time and whether the family is on Food Stamps has a differential impact on program participation, particularly for FRP recipients.

However, once we compare children by FRP eligibility status, there is somewhat of a different story to tell as can be seen in Table 5 and Table 6. Income, Food Stamp participation and the percentage of FRP eligible students at the school are not nearly as crucial in determining participation. Race (particularly Hispanic) is only a significant determinant for 8^{th} grade NSLP participation. Whether a child's mother works full-time is only significant for non-eligible students. Past program participation is now the most important determining factor once children are compared to others of similar income.

Child BMI Determinants

Next, we examine the direct impacts of program participation on child BMI and find minimal significance in 8th grade as can be seen in Table 7 to Table 16. In Table 7 to Table 12 we examine students based only on participation status while Table 13 to Table 16 show results by FRP eligibility along with participation status. Results indicate that participating in SBP tends to increase child weight (Tables: 7, 8, 10, 13, 15): participating in the program increases a child's BMI z-score by approximately 0.34 to 0.49 points when examining all participants which is equivalent to about a 5.4% to 7.8% change in BMI z-score. For FRP participants, SBP participation increases BMI z-scores by 0.77 points (Table 8). However, we only see direct effects of NSLP participation when we examine children by eligibility (Table 13 and Table 15). For FRP eligible students participating in NSLP decreases BMI z-scores by 0.87 points in the math model (0.77 points in the English model) which is equivalent to approximately a 14% change (12% change) in BMI z-score. There are no significant impacts for non-eligible students (Table 14 and Table 16). These results support the analysis of the previous chapter in this dissertation as well as the results of Gundersen, Kreider and Pepper (2009) who found that NSLP participation reduces obesity of FRP students. A child's weight in the previous period, gender and living in an urban area are other factors that have a direct impact on current 8th grade weight.

Additionally, we found no significant indirect impacts of program participation on child weight for 8th grade students when only examining by participation status. However, once we examine children by FRP eligibility status as well as participation, we do find some indirect effects of program participation on child weight of FRP eligible students through other mediating factors controlled for in the analysis (Table 13 and Table 15): television viewing, physical activity level and homework frequency. The indirect effect of program participation through these factors increases BMI z-scores albeit by a small magnitude.

For 5th grade, we also find that participating in SBP tends to increase child weight as can be seen in Table 17, Table 20 and Table 22, although the magnitude is not as large: participating in the program increases a child's BMI z-score by approximately 0.16 points in the math model (0.22 points in the English model). However, in 5th grade, the impact is particularly seen on students paying full-price for breakfast in the English model where participation increases BMI z-scores by 0.63 points (Table 22).

In addition, there is a small indirect impact of NSLP participation on child weight where participation decreases BMI z-scores for FRP participants and increases BMI z-scores for students paying full-price (Table 18, Table 19 and Table 21); however, the magnitude of the impact is small. For elementary school students, past BMI, TV viewing and activity level are the most significant predictors of current BMI. However, no direct or indirect impacts of program participation are seen on child BMI when we separate by FRP eligibility status (Table 23 to Table 26). This indicates that socioeconomic status may be driving the other 5th grade results. Past BMI, urbanity, TV viewing and physical activity level are the most significant predictors of a child's BMI z-score in these models.

In addition, while previous research has shown that children in rural areas are more likely to be overweight as well as more likely to participate in school meal programs, we find that living in a rural/urban environment has different impacts on program participation and child BMI: living in a city versus rural environment contributes to the propensity to participate in school meal programs differently than it contributes to a child's BMI.

Academic Performance Determinants

Results indicate that there are spillover effects from program participation on 8th grade scores through the medium of child weight. Table 7 and Table 8 show large positive indirect effects of SBP participation on math scores, particularly for FRP recipients when we only examine by participation status. On the other hand, Table 10 and Table 12 show smaller negative indirect impacts of NSLP participation on English scores, particularly for students paying full-price in addition to small positive impacts of SBP on English scores.

When we examine results by both FRP eligibility and participation status in Table 13 to Table 16, we find a much larger negative indirect impact of NSLP participation on math and English scores for FRP eligible students as well as a positive indirect impact of SBP participation on both math and English scores (Table 13 to Table 15). The SBP results support research that finds breakfast consumption to have a positive impact on cognitive abilities (e.g., Mahoney et al. 2005; Rampersaud et al. 2005; Wesnes et al. 2003). There are similar indirect impacts but of smaller magnitude on 8th grade English scores of non-eligible students.

The sign of the spillover effects (i.e., positive/negative) on academic performance is rather unexpected. Because four of the six equations estimated in the system included program participation, the effect of program participation on performance could be the result of a combination of spillover effects from the following equations: television watching, frequency of physical activity, frequency of homework and child weight. The effects of program participation on these endogenous mediators could be the driving our findings.

Additionally, current child weight tends to have a positive direct impact on performance, and attending a Title 1 school has a large negative impact on both math and English scores (Table 7 to Table 16). Attending a Title 1 school has a large negative significant impact on performance which may contribute to the increasing disparities between high- and low-income schools. This could also be evidence of a lack of resources available to students in Title 1 schools. Either of these implications is important for policy. Furthermore, household income has a positive impact on English scores. Baseline and past performance are positively significant indicating that early success in school is crucial to continued success.

As a robustness check, we include a measure of a child's self-esteem in the academic performance equation, since research shows a child's self-esteem influences his/her academic performance (Krukowski et al. 2009; Xie et al. 2006; Falkner et al. 2001). The previous results discussed hold although higher self-esteem is positively significant for English performance outcomes.

Results for 5th grade IRT scores are found in Table 17 to Table 26, where Table 17 to Table 22 are by participation status only, and Table 23 to Table 26 are by FRP eligibility as well as participation status. For 5th grade, there are only two small spillover effects of program participation on performance: 1. For full-price SBP participants on English scores (Table 22); and 2. For non-eligible NSLP participants on English scores (Table 26). For elementary school students, past and baseline performance along with household income are the most significant indicators of achievement. Because there is no self-esteem measure for 5th grade children, we did not examine the impacts of self-esteem on performance for these models.

Conduit of Self-Esteem

Another hypothesis is that both self-esteem and child weight impact academic performance in addition to weight influencing self-esteem. For example, the stigmas of being overweight or underweight may negatively influence a child's self-esteem which may impact his/her performance (Krukowski et al. 2009; Xie et al. 2006; Falkner et al. 2001). From the theoretical model, self-esteem is considered a child characteristic $(\boldsymbol{\mu})$. Therefore, child weight can impact achievement through two conduits: 1. A direct impact on academic performance (through (B) in the AP production function); and 2. An indirect impact on *AP* through child self-esteem (through $(\boldsymbol{\mu})$ in the AP production function).

In this theory, a perceived social stigma associated with school meal program participation also may negatively influence a child's self-esteem (Kennedy and Davis 1998; Mirtcheva and Powell 2009). Ponza et al. (1999) suggested that because SBP participants were likely to be low-income, reduced participation in the program may have been due to a social stigma attached to participation. Therefore, program participation could also impact achievement through two conduits: 1. An indirect impact on performance through self-esteem (through $(\boldsymbol{\mu})$ in the AP production function); and 2. An indirect impact on performance through child weight (through (B) in the AP production function). This path diagram is depicted in Figure 2, and estimation results are in Table 27 to Table 30.

When we examine this conduit[11] by participation status only, there are minimal impacts of program participation on self-esteem.[12] We find a positive direct impact of NSLP participation on self-esteem as well as a positive indirect impact of SBP participation on self-esteem in the English model (Table 28). However, these impacts do not spill over into academic performance. In the math model (Table 27), SBP has a positive indirect impact on math scores; however, this impact is not a direct spillover effect from either child weight or self-esteem. We also find that a child's perception of whether he/she is overweight or underweight has a direct negative impact on self-esteem for students who are FRP recipients and those who pay full-price in both math and English models (Table 27 and Table 28). Furthermore, there are negative indirect impacts of a child's weight perception on English performance in addition to large negative direct impacts of self-esteem on English scores as can be seen in Table 28.

When we examine by FRP eligibility, we find positive direct and indirect impacts of NSLP participation on child self-esteem for FRP eligible students when examining math achievement as can be seen in Table 29. We also find negative indirect impacts of SBP participation on self-esteem for these same children. However, these program impacts do not spill over to performance, and there are no impacts on the self-esteem or performance of non-eligible participants (Table 29). As for English performance, self-esteem does have a large

[11] We include program participation as a determinant of child weight. We include child weight and program participation as determinants of self-esteem. We include child weight and self-esteem as determinants of academic performance.

[12] In these models, a child's self-esteem is dependent on the following variables: BMI z-score, the child's perceptions of his/her weight status (e.g., think himself/herself is overweight, underweight), participation in school meal programs (SBP and NSLP), gender, race, age, past academic performance (math and English), how important grades are to the child's parent(s), if the child attends a religious service frequently with his/her parent, mother's education level, household income, how often the child changed schools, parental time spent with the child, how important friends opinions are to the child and how confident the child is in his/her academic abilities (Hughes and Demo 1989; Rosenberg and Pearlin 1978).

positive direct impact on English test scores of non-eligible students (Table 30). For FRP eligible, NSLP participation has a positive direct impact on self-esteem and a negative indirect impact on self-esteem through child weight (Table 30). Once again, program participation effects do not spill over to academic performance, and we find that a child's perception of whether he/she is overweight or underweight has a direct negative impact on self-esteem (Table 29 and Table 30) with some indirect impacts on English performance as can be seen in Table 30.

CONCLUSIONS AND POLICY IMPLICATIONS

Using the ECLS-K's nationally representative sample of kindergartners followed through 8^{th} grade, we examine the impacts of participation in SBP and NSLP on 5^{th} and 8^{th} grade math and English test scores. We use Capogrossi and You's (2012) theoretical model incorporating meal program participation into the child's weight production function to examine direct and indirect impacts on performance by estimating a structural model with sound theoretical underpinnings. This paper contributes to the literature by focusing on the spillover effects of two federally funded school meal programs using structural equation modeling and full-information likelihood analysis while accounting for self-selection into the programs and possible endogeneity of children's choices. Previous research has either examined correlations or used instrumental variable and dynamic panel methods which are limited by the strength and validity of the instruments (instrumental variable) and endogeneity problems (dynamic panel). In addition, most research has failed to consider self-selection into the programs. Through structural equation modeling, we simultaneously estimate seven equations: two take into account self-selection, three model the child's choices and two equations of interest. These help tease out the spillover effects of program participation on achievement.

We find minimal evidence that school meal program participation has indirect impacts on academic performance in elementary school when participation levels are highest. However, results do show spillover effects on 8^{th} grade math and English scores with particularly large impacts on FRP eligible participants: negative impacts of NSLP participation and positive impacts of SBP participation on achievement. When we examine the influence of program participation through the conduit of self-esteem, we do find that participation in SBP has a negative indirect impact on a child's self-esteem and NSLP participation has a positive direct and indirect impact on self-esteem for FRP eligible students in 8^{th} grade, but these impacts do not spill over into academic performance.

Evidence indicates that school meal programs have far reaching impacts on participants. Not only do programs influence weight and self-esteem but they also indirectly impact student achievement. NSLP participation reduces child weight and increases self-esteem, and SBP participation has positive indirect impacts on test scores. These results bolster the effectiveness of two far-reaching federal programs. The concerning factors are that SBP participation increases child weight and NSLP participation has negative indirect effects on performance. Therefore, in terms of policy, it is crucial to reverse these negative impacts to make the programs more effective. Increasing the nutritional value of SBP meals will likely aid in reducing the negative impacts of this program on child weight; and since NSLP's impacts on performance are through the mediator of child weight, reducing the incidence of overweight through healthier NSLP meals will potentially reverse this effect as well.

Additionally, the programs largely have a significant impact on FRP eligible students who are often the most in need of both nutritional and academic assistance. Therefore, the positive impacts SBP and NSLP have on these children are irreplaceable. Furthermore, if the negative impacts can be mitigated, then the programs will have an even larger impact on these low-income students. A report to Congress entitled *Foods Sold in Competition with USDA School Meal Programs* (2001) found that children may perceive school meals to be primarily for poor children which may reduce the willingness of low-income children to accept FRP meals. Because FRP eligible children are the ones most impacted, more creative advertising that focuses on making participation trendy and enticing should increase participation and decrease negative associations with the programs. This would then increase the benefits of the programs particularly for the FRP eligible. For instance, states with the most restrictive competitive food policies (e.g., Georgia, West Virginia, Louisiana, Mississippi) have school meal program participation rates higher than the national average making SBP and NSLP seem more inclusive. Policies like this could have large benefits for the programs and participants.

Overall, the programs continue to have an integral nutritional impact on each one of their 31.7 million daily participants. Our findings provide further motivation for campaigns and initiatives to continue their calls for healthier school meals. Healthier meals may also entice more parents to have their children participate in the programs. The USDA's higher nutrition requirements for school meals that were unveiled in January 2012 are a start, and Michelle Obama's 'Let's Move' campaign is also in support of the meal programs. This campaign not only emphasizes healthier meals but also increases nutrition education by having children cook with chefs and visit local farms to learn more about what they are eating. While the programs do have positive impacts on child health and performance, it is important for policymakers to concentrate on resolving the existing problems with the programs to make them even more effective.

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Table 1: Summary Statistics for 5th Grade Students by Meal Program Participation Status and Eligibility for Free- and Reduced-Price Meals

Variables	Description	SBP Participants		NSLP Particpants		Non-Participants	
		FRP Eligible N=390	Non-Eligible N=270	FRP Eligible N=770	Non-Eligible N=1600	FRP Eligible N=60	Non-Eligible N=660
BMI z-score	internationally accepted measure of	0.74	0.71	0.69	0.49	0.81	0.25
	BMI for children	(1.18)	(1.07)	(1.19)	(1.10)	(0.97)	(1.06)
Obese	=1 if child is obese	0.26	0.23	0.24	0.17	0.22	0.11
		(0.44)	(0.42)	(0.43)	(0.38)	(0.42)	(0.31)
Overweight	=1 if child is overweight/obese	0.18	0.19	0.20	0.17	0.25	0.14
		(0.38)	(0.40)	(0.40)	(0.37)	(0.44)	(0.34)
Underweight	=1 if child is underweight	0.03	0.00	0.03	0.03	0.02	0.04
		(0.16)	(0.06)	(0.16)	(0.16)	(0.13)	(0.19)
Female	=1 if child is female	0.51	0.44	0.51	0.47	0.54	0.54
		(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Black	=1 if child is black	0.12	0.07	0.08	0.03	0.05	0.02
		(0.32)	(0.26)	(0.27)	(0.18)	(0.22)	(0.14)
Hispanic	=1 if child is Hispanic	0.36	0.16	0.32	0.08	0.15	0.07
		(0.48)	(0.37)	(0.47)	(0.28)	(0.36)	(0.26)
Rural	=1 if child lives in rural area	0.38	0.45	0.35	0.34	0.20	0.13
		(0.49)	(0.50)	(0.48)	(0.47)	(0.41)	(0.33)
City	=1 if child lives in urban area	0.40	0.25	0.39	0.23	0.31	0.27
		(0.49)	(0.43)	(0.49)	(0.42)	(0.46)	(0.44)
Married	=1 if parents are married	0.76	0.84	0.79	0.90	0.88	0.95
		(0.43)	(0.37)	(0.40)	(0.30)	(0.33)	(0.22)
Income	household income on scale 1-9	3.31	5.36	3.69	6.14	5.20	6.85
		(1.51)	(1.90)	(1.63)	(1.70)	(1.84)	(1.42)
Food Stamps	=1 if family participated in FS in	0.22	0.07	0.17	0.02	0.03	0.01
	last 12 months	(0.41)	(0.26)	(0.38)	(0.14)	(0.18)	(0.08)
Mom Full-Time	=1 if mother works full-time	0.50	0.69	0.50	0.57	0.42	0.40
		(0.50)	(0.46)	(0.50)	(0.50)	(0.50)	(0.49)
Math IRT	8th grade math IRT scale score	114.66	125.20	119.40	131.95	127.84	137.12
		(23.85)	(22.36)	(24.73)	(21.11)	(26.13)	(19.13)
English IRT	8th grade English IRT scale score	138.22	149.41	144.15	159.16	149.51	164.69
		(25.85)	(24.85)	(26.09)	(22.74)	(25.55)	(19.68)
Baseline Math	math IRT score upon entering	22.19	26.42	23.73	29.01	28.31	30.70
	kindergarten	(6.81)	(7.82)	(7.80)	(8.97)	(8.44)	(9.16)
Baseline English	English IRT score upon entering	31.44	35.02	33.06	37.32	36.83	39.12
	kindergarten	(6.27)	(7.71)	(7.92)	(10.21)	(8.86)	(10.08)
SBP - 3rd Grade	participated in SBP in previous period	0.67	0.51	0.44	0.14	0.05	0.02
		(0.47)	(0.50)	(0.50)	(0.35)	(0.22)	(0.15)
NSLP - 3rd Grade	participated in NSLP in previous	0.93	0.90	0.92	0.84	0.47	0.41
	period	(0.25)	(0.30)	(0.28)	(0.37)	(0.50)	(0.49)
TV	minutes per day child watches TV	138.73	142.67	137.07	123.91	140.27	109.36
		(74.22)	(80.83)	(77.01)	(67.99)	(86.33)	(62.72)
Active	days per week child participates	3.74	3.92	3.78	3.83	3.85	3.72
	in 20 minutes of activity (sweats)	(2.05)	(1.87)	(1.95)	(1.73)	(1.93)	(1.72)
Freq HW	how often child does homework	3.33	3.32	3.37	3.34	3.51	3.47
	scale 0-4	(0.80)	(0.74)	(0.75)	(0.72)	(0.70)	(0.65)
% Free Lunch Eligible	percent of students in school eligible	0.53	0.39	0.48	0.26	0.37	0.18
	for free lunch	(0.26)	(0.24)	(0.27)	(0.21)	(0.26)	(0.17)
Title 1 School	=1 if school is Title 1	0.73	0.54	0.64	0.30	0.49	0.15
		(0.45)	(0.50)	(0.48)	(0.46)	(0.50)	(0.36)

Note: Students are eligible for free- and reduced-price meals if a family's household income is 185% of the federal poverty line
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 2: Summary Statistics for 8th Grade Students by Meal Program Participation Status and Eligibility for Free- and Reduced-Price Meals

Variables	Description	SBP Participants		NSLP Particpants		Non-Participants	
		FRP Eligible N=270	Non-Eligible N=170	FRP Eligible N=690	Non-Eligible N=1360	FRP Eligible N=90	Non-Eligible N=570
BMI z-score	internationally accepted measure of	0.72	0.55	0.65	0.41	0.74	0.32
	BMI for children	(1.07)	(1.00)	(1.05)	(1.05)	(1.20)	(1.01)
Obese	=1 if child is obese	0.23	0.16	0.20	0.13	0.29	0.10
		(0.42)	(0.37)	(0.40)	(0.34)	(0.46)	(0.30)
Overweight	=1 if child is overweight/obese	0.19	0.18	0.18	0.15	0.18	0.13
		(0.39)	(0.39)	(0.38)	(0.36)	(0.39)	(0.34)
Underweight	=1 if child is underweight	0.01	0.01	0.02	0.03	0.04	0.04
		(0.12)	(0.08)	(0.15)	(0.18)	(0.20)	(0.18)
Female	=1 if child is female	0.53	0.37	0.51	0.44	0.60	0.57
		(0.50)	(0.48)	(0.50)	(0.50)	(0.49)	(0.50)
Black	=1 if child is black	0.11	0.05	0.07	0.04	0.02	0.01
		(0.31)	(0.23)	(0.25)	(0.18)	(0.15)	(0.10)
Hispanic	=1 if child is Hispanic	0.44	0.15	0.30	0.08	0.24	0.05
		(0.50)	(0.36)	(0.46)	(0.27)	(0.43)	(0.22)
Rural	=1 if child lives in rural area	0.34	0.38	0.38	0.30	0.22	0.16
		(0.48)	(0.49)	(0.49)	(0.46)	(0.41)	(0.37)
City	=1 if child lives in urban area	0.42	0.28	0.33	0.24	0.26	0.18
		(0.49)	(0.45)	(0.47)	(0.43)	(0.44)	(0.38)
Married	=1 if parents are married	0.77	0.82	0.81	0.87	0.89	0.91
		(0.42)	(0.38)	(0.39)	(0.33)	(0.31)	(0.28)
Income	household income on scale 1-9	3.84	5.83	4.32	6.49	5.30	7.08
		(1.58)	(1.75)	(1.66)	(1.56)	(1.65)	(1.38)
Food Stamps	=1 if family participated in FS in	0.22	0.07	0.15	0.02	0.02	0.01
	last 12 months	(0.41)	(0.25)	(0.35)	(0.14)	(0.15)	(0.10)
Mom Full-Time	=1 if mother works full-time	0.57	0.69	0.55	0.61	0.53	0.48
		(0.50)	(0.47)	(0.50)	(0.49)	(0.50)	(0.50)
Math IRT	8th grade math IRT scale score	136.20	146.04	139.32	150.07	144.07	153.76
		(22.54)	(18.74)	(22.04)	(17.12)	(21.45)	(15.72)
English IRT	8th grade English IRT scale score	159.04	171.08	165.78	179.00	176.32	186.47
		(27.93)	(25.47)	(26.78)	(21.71)	(25.73)	(17.47)
Baseline Math	math IRT score upon entering	22.78	28.00	24.68	29.83	25.78	31.10
	kindergarten	(7.14)	(8.80)	(8.17)	(9.18)	(9.15)	(9.71)
Baseline English	English IRT score upon entering	31.94	35.29	33.69	37.87	36.34	39.54
	kindergarten	(6.42)	(8.38)	(7.68)	(10.36)	(11.06)	(10.94)
SBP - 5th Grade	participated in SBP in previous period	0.69	0.54	0.41	0.13	0.20	0.04
		(0.46)	(0.50)	(0.49)	(0.34)	(0.41)	(0.19)
NSLP - 5th Grade	participated in NSLP in previous	0.96	0.89	0.92	0.80	0.62	0.42
	period	(0.20)	(0.32)	(0.27)	(0.40)	(0.49)	(0.49)
TV	minutes per day child watches TV	204.93	188.17	192.09	153.89	167.74	134.55
		(190.44)	(157.92)	(178.80)	(135.76)	(126.53)	(127.07)
Active	days per week child participates	5.17	5.57	5.34	5.56	5.27	5.51
	in 20 minutes of activity (sweats)	(1.86)	(1.77)	(1.77)	(1.60)	(1.75)	(1.60)
Freq HW	how often child does homework	3.19	3.08	3.18	3.29	3.56	3.57
	scale 0-4	(0.80)	(0.77)	(0.79)	(0.75)	(0.56)	(0.59)
% Free Lunch Eligible	percent of students in school eligible	0.46	0.32	0.39	0.25	0.33	0.18
	for free lunch	(0.24)	(0.19)	(0.23)	(0.18)	(0.23)	(0.18)
Title 1 School	=1 if school is Title 1	0.68	0.43	0.55	0.28	0.44	0.14
		(0.47)	(0.50)	(0.50)	(0.45)	(0.50)	(0.35)

Note: Students are eligible for free- and reduced-price meals if a family's household income is 185% of the federal poverty line
Standard errors in parentheses
Unweighted sample sizes are rounded to the nearest 10 as per IES policy

Table 3: SBP Determinants for 5th and 8th Grade Students by Participation Status

	5th Grade			***8th Grade***		
	All Students	**FRP**	**Full-Price**	**All Students**	**FRP**	**Full-Price**
Hispanic	0.08**	0.07**	0.01	0.16**	0.26***	-0.06*
	(0.04)	(0.03)	(0.03)	(0.07)	(0.08)	(0.04)
Age	0.003*	0.003**	-0.0003	-0.01**	-0.01**	-0.00003
	(0.002)	(0.001)	(0.001)	(0.01)	(0.01)	(0.002)
Father's Ed	0.001	0.01*	-0.01	-0.04	-0.03	-0.02
	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.01)
Income	-0.02**	-0.04***	0.02***	-0.04*	-0.05**	0.01
	(0.01)	(0.01)	(0.01)	(0.02)	(0.03)	(0.01)
Food Stamps	0.07	0.13**	-0.06**	0.26*	0.34**	-0.02
	(0.06)	(0.06)	(0.03)	(0.14)	(0.13)	(0.07)
Mom Full-Time	0.04**	0.01	0.03**	0.01	0.4	-0.02
	(0.02)	(0.02)	(0.01)	(0.05)	(0.04)	(0.03)
Rural	0.09***	0.02	0.07***	-0.18**	-0.17**	0.02
	(0.03)	(0.03)	(0.02)	(0.07)	(0.07)	(0.02)
City	0.02	0.06**	-0.03**	-0.18***	-0.18***	0.01
	(0.03)	(0.03)	(0.01)	(0.06)	(0.07)	(0.02)
Past SBP	0.45***	0.26***	0.16***	0.39***	0.17*	0.13*
	(0.04)	(0.04)	(0.03)	(0.12)	(0.09)	(0.08)
% FRP	0.001	0.001*	-0.0003	0.002	0.002	0.001
	(0.001)	(0.001)	(0.0003)	(0.002)	(0.002)	(0.0004)
SBP Length	0.001*	-0.001	0.002***	0.003	0.001	-0.001
	(0.001)	(0.001)	(0.0004)	(0.002)	(0.002)	(0.001)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Shows results from the system examining math IRT scale scores as the dependent variable

Table 4: NSLP Determinants for 5th and 8th Grade Students by Participation Status

	5th Grade			*8th Grade*		
	All Students	**FRP**	**Full-Price**	**All Students**	**FRP**	**Full-Price**
Hispanic	-0.01	0.11***	-0.13***	0.22**	0.31***	-0.09
	(0.03)	(0.03)	(0.04)	(0.10)	(0.08)	(0.12)
Father's Ed	-0.01	-0.01	0.001	-0.07**	0.03	-0.09***
	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.03)
Income	-0.02***	-0.10***	0.07***	-0.02	-0.14***	0.11***
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)
Food Stamps	-0.03	0.14***	-0.17***	0.10	0.10	-0.03
	(0.04)	(0.04)	(0.04)	(0.11)	(0.10)	(0.18)
Mom Full-Time	0.06**	-0.05**	0.10***	0.03	-0.04	0.08
	(0.02)	(0.02)	(0.03)	(0.05)	(0.05)	(0.07)
Rural	0.09***	-0.02	0.11***	-0.12*	-0.19***	0.08
	(0.02)	(0.03)	(0.04)	(0.07)	(0.06)	(0.10)
City	0.004	0.03	-0.02	-0.17	-0.06	-0.10
	(0.03)	(0.03)	(0.03)	(0.11)	(0.08)	(0.13)
Past NSLP	0.42***	0.06***	0.35***	0.42***	0.07	0.28***
	(0.03)	(0.02)	(0.03)	(0.08)	(0.06)	(0.10)
% FRP	0.001*	0.003***	-0.001***	-0.001	0.0005	-0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Shows results from the system examining math IRT scale scores as the dependent variable

Table 5: SBP Determinants for 5th and 8th Grade Participants by FRP Eligibility

	5th Grade		*8th Grade*	
	FRP Eligible	**Non-Eligible**	**FRP Eligible**	**Non-Eligible**
Hispanic	0.07	0.06	0.10	0.04
	(0.07)	(0.04)	(0.14)	(0.04)
Age	0.01**	-0.00004	-0.03	-0.001
	(0.02)	(0.002)	(0.02)	(0.002)
Father's Ed	0.01	-0.01	-0.08	-0.004
	(0.03)	(0.01)	(0.07)	(0.03)
Income	-0.04***	-0.002	-0.06	-0.02
	(0.01)	(0.01)	(0.05)	(0.01)
Food Stamps	0.002	0.17*	0.05	0.36*
	(0.07)	(0.10)	(0.18)	(0.20)
Mom Full-Time	0.02	-0.05**	0.11	-0.06*
	(0.04)	(0.02)	(0.11)	(0.03)
Rural	-0.16***	0.05*	-0.35**	0.02
	(0.06)	(0.03)	(0.14)	(0.03)
City	0.07	0.01	-0.37**	0.01
	(0.06)	(0.03)	(0.17)	(0.03)
Past SBP	0.42***	0.45***	0.34***	0.53***
	(0.05)	(0.05)	(0.12)	(0.17)
% FRP	-0.001	0.002***	0.002	0.0002
	(0.001)	(0.001)	(0.003)	(0.001)
SBP Length	0.003	0.0002	0.01**	-0.002
	(0.001)	(0.001)	(0.003)	(0.002)

Note: * significant at 10% level

** significant at 5% level

*** significant at 1% level

Shows results from the system examining math IRT scale scores as the dependent variable

Table 6: NSLP Determinants for 5th and 8th Grade Participants by FRP Eligibility

	5th Grade		*8th Grade*	
	FRP Eligible	**Non-Eligible**	**FRP Eligible**	**Non-Eligible**
Hispanic	0.01	-0.05	0.37***	0.26***
	(0.02)	(0.05)	(0.11)	(0.09)
Father's Ed	-0.01	0.004	-0.03	-0.07***
	(0.01)	(0.01)	(0.06)	(0.03)
Income	-0.01*	-0.02	-0.03	-0.05
	(0.01)	(0.01)	(0.03)	(0.03)
Food Stamps	0.001	-0.12	0.21*	-0.78***
	(0.03)	(0.13)	(0.11)	(0.21)
Mom Full-Time	0.02	0.06**	0.07	-0.05
	(0.02)	(0.03)	(0.07)	(0.06)
Rural	0.04*	0.12***	-0.02	-0.21**
	(0.02)	(0.03)	(0.08)	(0.08)
City	0.03	-0.02	-0.20**	-0.13
	(0.03)	(0.03)	(0.09)	(0.17)
Past NSLP	0.29***	0.44***	0.50***	0.54***
	(0.07)	(0.03)	(0.15)	(0.09)
% FRP	-0.0001	0.002**	-0.003*	0.004
	(0.0003)	(0.001)	(0.002)	(0.003)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Shows results from the system examining math IRT scale scores as the dependent variable

Table 7: Direct, Indirect and Total Effects for All Participants on 8th Grade BMI and Math IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
All Participants						
NSLP	-0.02	--	-0.001	-1.13	-0.02	-1.13
	(0.17)		(0.004)	(0.73)	(0.17)	(0.73)
SBP	0.34*	--	0.004	2.04**	0.35*	2.04**
	(0.21)		0.01	(0.97)	(0.21)	(0.97)
BMIZ	--	2.66**	--	--	--	2.66**
		(1.04)				(1.04)
Past BMIZ	0.82***	--	0.0002	2.37***	0.82***	2.37***
	(0.04)		(0.01)	(0.86)	(0.03)	(0.86)
TV	0.0001	--	--	0.0003	0.0001	0.0003
	(0.0002)			(0.0004)	(0.0002)	(0.0004)
Phys Activity	-0.01	--	--	-0.03	-0.01	-0.03
	(0.02)			(0.05)	(0.02)	(0.05)
Female	0.13**	1.32	0.02	1.80**	0.15***	3.11
	(0.06)	(1.97)	(0.03)	0.79	(0.06)	(2.09)
Rural	-0.02	6.01	-0.06	-0.30	-0.09	5.71
	(0.05)	(3.73)	0.05	(0.27)	(0.06)	(3.80)
Urban	0.22***	3.52	-0.06	0.41	0.16**	3.93
	(0.08)	(4.18)	(0.05)	(0.31)	(0.07)	(4.15)
HH Income	-0.02	1.24	-0.02	0.06	-0.03	1.29
	(0.03)	(0.76)	(0.01)	(0.23)	(0.02)	(0.83)
Past AP	--	0.53***	-0.00001	0.01	-0.00001	0.54***
		(0.07)	(0.001)	(0.01)	(0.001)	(0.07)
Baseline AP	--	0.27*	--	--	--	0.27*
		(0.15)				(0.15)
TT1	--	-8.95**	--	--	--	-8.95**
		(4.32)				(4.32)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are for all students who participate in the programs (FRP and full-price)

Table 8: Direct, Indirect and Total Effects for FRP Participants on 8th Grade BMI and Math IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
FRP Participants						
NSLP	-0.97	--	-0.004	-2.62	-0.97	-2.62
	(1.25)		(0.01)	(3.38)	(1.25)	(3.38)
SBP	0.77*	--	0.01	3.23**	0.77*	3.23**
	(0.44)		(0.01)	(1.52)	(0.44)	(1.52)
BMIZ	--	2.65**	--	--	--	2.65**
		(1.03)				(1.03)
Past BMIZ	0.86***	--	-0.04	2.32***	0.82***	2.32***
	(0.06)		(0.05)	(0.85)	(0.03)	(0.85)
TV	0.0001	--	--	0.0002	0.0001	0.0002
	(0.0002)			(0.001)	(0.0002)	(0.001)
Phys Activity	-0.01	--	--	-0.03	-0.01	-0.03
	(0.02)			(0.05)	(0.02)	(0.05)
Female	0.12*	1.47	0.06	1.71**	0.18**	3.18
	(0.07)	(1.98)	(0.06)	(0.79)	(0.07)	(2.09)
Rural	-0.13	5.76	0.04	-0.43	-0.09*	5.32
	(0.20)	(3.57)	(0.21)	(0.28)	(0.05)	(3.64)
Urban	0.24*	3.55	-0.08	0.19	0.15**	3.74
	(0.13)	(4.21)	(0.11)	(0.29)	(0.07)	(4.25)
HH Income	-0.12	1..13	0.09	0.11	-0.03	1.23
	(0.18)	(0.78)	(0.17)	(0.22)	(0.03)	(0.85)
Past AP	--	0.52***	0.001	0.02	0.001	0.54***
		(0.06)	(0.002)	(0.01)	(0.002)	(0.06)
Baseline AP	--	0.28*	--	--	--	0.28*
		(0.16)				(0.16)
TT1	--	-9.64**	--	--	--	-9.64**
		(4.40)				(4.40)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students receiving FRP meals

Table 9: Direct, Indirect and Total Effects for Full-Price Participants on 8th Grade BMI and Math IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
Full-Price Participants						
NSLP	-0.10	--	-0.0003	-1.30	-0.10	-1.30
	(0.30)		(0.01)	(0.90)	(0.30)	(0.90)
SBP	1.25	--	-0.004	3.16	1.24	3.16
	(1.41)		(0.01)	(3.97)	(1.41)	(3.97)
BMIZ	--	2.65**	--	--	--	2.65**
		(1.03)				(1.03)
Past BMIZ	0.82***	--	0.01	2.42***	0.83***	2.42***
	(0.04)		(0.02)	(0.87)	(0.03)	(0.87)
TV	0.0002	--	--	0.001	0.0002	0.001
	(0.0002)			(0.0004)	(0.0002)	(0.0004)
Phys Activity	-0.01	--	--	-0.03	-0.01	-0.03
	(0.02)			(0.05)	(0.02)	(0.05)
Female	0.13**	1.47	0.03	1.68**	0.16**	3.00
	(0.06)	(1.98)	(0.03)	(0.76)	(0.06)	(2.11)
Rural	-0.10	5.76	0.02	-0.31	-0.09	4.95
	(0.10)	(3.57)	(0.05)	(0.20)	(0.07)	(3.74)
Urban	0.14*	3.55	0.01	0.51*	0.16**	3.55
	(0.08)	(4.21)	(0.04)	(0.29)	(0.07)	(4.14)
HH Income	-0.05	1.13	-0.01	-0.04	-0.05*	1.13
	(0.05)	(0.78)	(0.04)	(0.23)	(0.02)	(0.86)
Past AP	--	0.52***	0.0004	0.01	0.0004	0.54***
		(0.06)	(0.002)	(0.01)	(0.002)	(0.07)
Baseline AP	--	0.28*	--	--	--	0.28*
		(0.16)				(0.16)
TT1	--	-9.46**	--	--	--	-9.46**
		(4.40)				(4.40)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students paying full-price for meals

Table 10: Direct, Indirect and Total Effects for All Participants on 8th Grade BMI and English IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
All Participants						
NSLP	-0.01	--	0.001	-0.73**	-0.01	-0.73**
	(0.14)		(0.004)	(0.34)	(0.14)	(0.34)
SBP	0.39*	--	0.001	0.88**	0.40*	0.88**
	(0.23)		(0.01)	(0.44)	(0.23)	(0.44)
BMIZ	--	-0.38	--	--	--	-0.38
		(1.36)				(1.36)
Past BMIZ	0.83***	--	-0.01	-0.29	0.82***	-0.29
	(0.03)		(0.01)	(1.13)	(0.03)	(1.13)
TV	0.0001	--	--	-0.00004	0.0001	-0.00004
	(0.0002)			(0.0001)	(0.0002)	(0.0001)
Phys Activity	0.01	--	--	-0.002	0.01	-0.002
	(0.02)			(0.01)	(0.02)	(0.01)
Female	0.07	3.60	0.02	0.38	0.09	3.96
	(0.07)	(2.99)	(0.03)	(0.38)	(0.07)	(2.94)
Rural	-0.05	15.43***	-0.05	0.01	-0.10	15.61***
	(0.05)	(5.11)	(0.04)	(0.23)	(0.06)	(5.20)
Urban	0.12	8.50	-0.02	0.06	0.10	8.59
	(0.08)	(5.28)	(0.04)	(0.23)	(0.07)	(5.25)
HH Income	-0.01	1.73*	-0.02	0.07	-0.02	1.93**
	(0.03)	(0.93)	(0.01)	(0.15)	(0.02)	(0.97)
Past AP	--	0.64***	-0.001	0.002	-0.001	0.64***
		(0.08)	(0.001)	(0.01)	(0.001)	v
Baseline AP	--	0.28*	--	--	--	0.28*
		(0.15)				(0.15)
TT1	--	-11.25**	--	--	--	-11.25**
		(5.70)				(5.70)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are for all students who participate in the programs (FRP and full-price)

Table 11: Direct, Indirect and Total Effects for FRP Participants on 8th Grade BMI and English IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
FRP Participants						
NSLP	0.36	--	0.001	-0.01	0.36	-0.01
	(1.15)		(0.004)	(0.82)	(1.15)	(0.82)
SBP	0.50	--	-0.003	0.65	0.49	0.65
	(0.45)		(0.004)	(0.59)	(0.45)	(0.59)
BMIZ	--	-0.57	--	--	--	-0.57
		(1.38)				(1.38)
Past BMIZ	0.81***	--	0.003	-0.44	0.82***	-0.44
	(0.06)		(0.05)	(1.13)	(0.03)	(1.13)
TV	0.00004	--	--	-0.00002	0.00004	-0.00002
	(0.0002)			(0.0001)	(0.0002)	(0.0001)
Phys Activity	0.01	--	--	-0.003	0.01	-0.003
	(0.01)			(0.01)	(0.01)	(0.01)
Female	0.09	3.55	0.01	0.28	0.11	3.84
	(0.09)	(3.02)	(0.04)	(0.34)	(0.07)	(2.97)
Rural	0.03	13.59***	-0.12	-0.11	-0.09	13.61**
	(0.14)	(4.73)	(0.13)	(0.22)	(0.05)	(4.80)
Urban	0.14	7.78	-0.04	-0.14	0.10	7.67
	(0.10)	(5.19)	(0.06)	(0.15)	(0.08)	(5.18)
HH Income	0.07	1.60*	-0.08	0.09	-0.01	1.80*
	(0.16)	(0.92)	(0.15)	(0.13)	(0.03)	(0.94)
Past AP	--	0.66***	-0.001	0.001	-0.001	0.67***
		(0.07)	(0.001)	(0.01)	(0.001)	(0.07)
Baseline AP	--	0.25*	--	--	--	0.25*
		(0.15)				(0.15)
TT1	--	-10.78*	--	--	--	-10.78*
		(5.69)				(5.69)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students receiving FRP meals

Table 12: Direct, Indirect and Total Effects for Full-Price Participants on 8th Grade BMI and English IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
Full-Price Participants						
NSLP	-0.13	--	-0.001	-0.79**	-0.13	-0.79**
	(0.25)		(0.006)	(0.31)	(0.25)	(0.31)
SBP	0.47	--	0.01	0.08	0.48	0.08
	(0.75)		(0.01)	(0.46)	(0.75)	(0.46)
BMIZ	--	-0.32	--	--	--	-0.32
		(1.37)				(1.37)
Past BMIZ	0.84***	--	-0.002	-0.20	0.83***	-0.20
	(0.03)		(0.01)	(1.16)	(0.03)	(1.16)
TV	0.0002	--	--	-0.0001	0.0002	-0.0001
	(0.0002)			(0.0001)	(0.0002)	(0.0001)
Phys Activity	-0.00001	--	--	0.00001	-0.00001	0.00001
	(0.02)			(0.01)	(0.02)	(0.01)
Female	0.08	3.57	0.02	0.38	0.10	3.94
	(0.07)	(2.99)	(0.02)	(0.38)	(0.07)	(2.94)
Rural	-0.09	15.36***	0.002	0.03	-0.09	15.39***
	(0.09)	(5.09)	(0.03)	(0.17)	(0.07)	(5.11)
Urban	0.04	8.37	0.04	0.16	0.09	8.53
	(0.08)	(5.31)	(0.06)	(0.23)	(0.08)	(5.26)
HH Income	-0.03	1.71*	-0.01	0.03	-0.05**	1.74*
	(0.04)	(0.94)	(0.03)	(0.18)	(0.02)	(0.98)
Past AP	--	0.65***	-0.0005	0.0002	-0.0005	0.65***
		(0.08)	(0.001)	(0.01)	(0.001)	(0.08)
Baseline AP	--	0.28*	--	--	--	0.28*
		(0.15)				(0.15)
TT1	--	-11.16**	--	--	--	-11.16**
		(5.57)				(5.57)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students paying full-price for meals

Table 13: Direct, Indirect and Total Effects on 8th Grade BMI and Math IRT Scores for FRP Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
FRP Eligible						
NSLP	-0.87**	--	0.08**	-7.14***	-0.79**	-7.14***
	(0.37)		(0.04)	(2.14)	(0.38)	(2.14)
SBP	0.49*	--	0.05*	3.32**	0.54*	3.32**
	(0.28)		(0.03)	(1.37)	(0.29)	(1.37)
BMIZ	--	2.22	--	--	--	2.22
		(1.93)				(1.93)
Past BMIZ	0.84***	--	-0.07	1.65	0.78***	1.65
	(0.07)		(0.06)	(1.58)	(0.05)	(1.58)
TV	0.0003*	--	--	0.001*	0.0003*	0.001*
	(0.0002)			(0.0003)	(0.0002)	(0.0003)
Phys Activity	-0.06**	--	--	-0.14**	-0.06**	-0.14**
	(0.03)			(0.07)	(0.03)	(0.07)
Female	0.21**	2.50	0.11	4.01**	0.32***	6.51**
	(0.09)	(2.83)	(0.09)	2.00	(0.11)	(3.13)
Rural	-0.08	10.02*	-0.24*	-1.32	-0.32**	8.70
	(0.14)	(5.86)	0.14	(1.02)	(0.13)	(6.16)
Urban	0.09	2.93	-0.06	0.37	0.03	3.30
	(0.16)	(5.83)	(0.19)	(0.92)	(0.12)	(5.83)
HH Income	-0.08	0.40	-0.02	-1.01	-0.10***	-0.62
	(0.05)	(1.21)	(0.05)	(0.66)	(0.03)	(1.27)
Past AP	--	0.51***	-0.002	0.03	-0.002	0.54***
		(0.10)	(0.003)	(0.04)	(0.003)	(0.09)
Baseline AP	--	0.05	--	--	--	0.05
		(0.25)				(0.25)
TT1	--	-14.97***	--	--	--	-14.97***
		(5.52)				(5.52)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students eligible for FRP meals

Table 14: Direct, Indirect and Total Effects on 8th Grade BMI and Math IRT Scores for Non-Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
Non-Eligible						
NSLP	-0.10	--	0.002	-0.60	-0.10	-0.60
	(0.18)		(0.003)	(0.54)	(0.18)	(0.54)
SBP	0.12	--	-0.003	0.61	0.11	0.61
	(0.19)		(0.005)	(0.61)	(0.19)	(0.61)
BMIZ	--	2.77**	--	--	--	2.77**
		(1.35)				(1.35)
Past BMIZ	0.83***	--	0.0001	2.32**	0.83***	2.32**
	(0.04)		(0.01)	(1.14)	(0.03)	(1.14)
TV	-0.0001	--	--	-0.0003	-0.0001	-0.0003
	(0.0004)			(0.001)	(0.0004)	(0.001)
Phys Activity	-0.003	--	--	-0.010	-0.003	-0.010
	(0.03)			(0.07)	(0.03)	(0.07)
Female	-0.01	-1.78	0.02	-0.06	0.01	-1.85
	(0.09)	(2.91)	(0.03)	(0.31)	(0.07)	(2.97)
Rural	-0.08	-0.29	0.02	-0.09	-0.06	-0.38
	(0.09)	(2.30)	(0.05)	(0.35)	(0.10)	(2.33)
Urban	0.16	-1.47	0.01	0.51	0.17	-0.95
	(0.11)	(3.60)	(0.03)	(0.32)	(0.11)	(3.69)
HH Income	0.03	2.34***	0.003	0.27	0.04	2.61***
	(0.04)	(0.89)	(0.01)	(0.28)	(0.03)	(0.86)
Past AP	--	0.62***	0.0004	0.01	0.0004	0.63***
		(0.06)	(0.0006)	(0.01)	(0.001)	(0.06)
Baseline AP	--	(0.09)	--	--	--	(0.09)
		(0.17)				(0.17)
TT1	--	-2.89	--	--	--	-2.89
		(2.63)				(2.63)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students non-eligible for FRP status

Table 15: Direct, Indirect and Total Effects on 8th Grade BMI and English IRT Scores for FRP Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
FRP Eligible						
NSLP	-0.77*	--	0.11***	-5.81***	-0.66*	-5.81***
	(0.40)		(0.04)	(2.21)	(0.39)	(2.21)
SBP	0.41*	--	0.003	2.30*	0.41*	2.30*
	(0.23)		(0.03)	(1.31)	(0.24)	(1.31)
BMIZ	--	3.80*	--	--	--	3.80*
		(2.12)				(2.12)
Past BMIZ	0.87***	--	-0.09	2.75	0.78***	2.75
	(0.05)		(0.05)	(1.68)	(0.05)	(1.68)
TV	0.0003**	--	--	0.001**	0.0003**	0.001**
	(0.0001)			(0.001)	(0.0001)	(0.001)
Phys Activity	-0.07**	--	--	-0.25**	-0.07**	-0.25**
	(0.03)			(0.11)	(0.03)	(0.11)
Female	0.16	-3.02	0.10	3.65*	0.26***	0.63
	(0.11)	(5.45)	(0.08)	2.03	(0.10)	(4.90)
Rural	-0.23	33.88***	-0.16	-1.63	-0.39**	32.26***
	(0.14)	(7.58)	0.13	(1.12)	(0.16)	(7.54)
Urban	-0.22	12.95	0.09	0.42	-0.12	13.37
	(0.24)	(11.72)	(0.21)	(1.14)	(0.14)	(12.08)
HH Income	-0.06	1.76	-0.01	-1.08*	-0.07*	0.68
	(0.05)	(1.37)	(0.05)	(0.57)	(0.04)	(1.44)
Past AP	--	0.71***	-0.01***	-0.06	-0.01***	0.65***
		(0.12)	(0.003)	(0.04)	(0.003)	(0.12)
Baseline AP	--	0.05	--	--	--	0.05
		(0.16)				(0.16)
TT1	--	-25.12***	--	--	--	-25.12***
		(6.55)				(6.55)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students eligible for FRP meals

Table 16: Direct, Indirect and Total Effects on 8th Grade BMI and English IRT Scores for FRP Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	English IRT	BMI	English IRT	BMI	English IRT
Non-Eligible						
NSLP	-0.14	--	0.0005	-0.74*	-0.14	-0.74*
	(0.14)		(0.002)	(0.38)	(0.14)	(0.38)
SBP	-0.03	--	-0.0003	0.65*	-0.03	0.65*
	(0.22)		(0.003)	(0.39)	(0.22)	(0.39)
BMIZ	--	-0.64	--	--	--	-0.64
		(1.49)				(1.49)
Past BMIZ	0.84***	--	-0.01	-0.50	0.83***	-0.50
	(0.04)		(0.01)	(1.24)	(0.03)	(1.24)
TV	-0.0001	--	--	0.0001	-0.0001	0.0001
	(0.0004)			(0.0002)	(0.0004)	(0.0002)
Phys Activity	-0.001	--	--	0.001	-0.001	0.001
	(0.03)			(0.02)	(0.03)	(0.02)
Female	-0.02	2.47	0.01	-0.22	-0.01	2.24
	(0.09)	(2.12)	(0.03)	(0.41)	(0.07)	(2.13)
Rural	-0.10	5.54	0.03	0.25	-0.07	5.79
	(0.09)	(3.50)	(0.04)	(0.18)	(0.09)	(3.54)
Urban	0.15	2.82	0.01	-0.01	0.17*	2.82
	(0.11)	(3.24)	(0.03)	(0.30)	(0.10)	(3.34)
HH Income	0.02	1.65*	0.01	0.34	0.03	1.99**
	(0.04)	(0.97)	(0.01)	(0.27)	(0.04)	(0.94)
Past AP	--	0.65***	0.0006	0.01	0.0006	0.67***
		(0.08)	(0.0008)	(0.01)	(0.0008)	(0.07)
Baseline AP	--	0.29**	--	--	--	0.29**
		(0.14)				(0.14)
TT1	--	1.10	--	--	--	1.10
		(3.26)				(3.26)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students non-eligible for FRP status

Table 17: Direct, Indirect and Total Effects for All Participants on 5th Grade BMI and Math IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
All Participants						
NSLP	-0.12	--	0.001	-0.002	-0.12	-0.002
	(0.10)		(0.003)	(0.05)	(0.10)	(0.05)
SBP	0.16*	--	-0.002	-0.06	0.16*	-0.06
	(0.09)		(0.01)	(0.04)	(0.09)	(0.04)
BMIZ	--	-0.35	--	--	--	-0.35
		(0.35)				(0.35)
Past BMIZ	0.85***	--	0.01*	-0.29	0.85***	-0.29
	(0.04)		(0.004)	(0.30)	(0.04)	(0.30)
TV	0.001***	--	--	-0.0002	0.001***	-0.0002
	(0.0003)			(0.0001)	(0.0003)	(0.0001)
Phys Activity	-0.01*	--	--	0.01*	-0.01*	0.01*
	(0.01)			(0.003)	(0.01)	(0.003)
Female	0.02	-0.68	0.004	0.04	0.02	-0.64
	(0.03)	(0.77)	(0.01)	(0.05)	(0.03)	(0.77)
Rural	-0.05	1.91	-0.004	0.02	-0.06	1.92
	(0.07)	(1.52)	(0.01)	(0.03)	(0.07)	(1.52)
Urban	-0.05	0.15	0.003	0.02	-0.05	0.16
	(0.05)	(0.92)	(0.01)	(0.03)	(0.05)	(0.91)
HH Income	-0.01	0.61**	-0.004	0.02	-0.01	0.63**
	(0.01)	(0.27)	(0.004)	(0.01)	(0.01)	(0.27)
Past AP	--	0.78***	-0.00003	0.001	-0.00003	0.79***
		(0.02)	(0.0002)	(0.001)	(0.0002)	(0.02)
Baseline AP	--	0.23***	--	--	--	0.23***
		(0.05)				(0.05)
TT1	--	0.53	--	--	--	0.53
		(1.05)				(1.05)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are for all students who participate in the programs (FRP and full-price)

Table 18: Direct, Indirect and Total Effects for FRP Participants on 5th Grade BMI and Math IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	Math IRT	BMI	Math IRT	BMI	Math IRT
FRP Participants						
NSLP	-0.08	--	-0.02**	0.03	-0.10	0.03
	(0.28)		(0.01)	(0.10)	(0.28)	(0.10)
SBP	0.16	--	0.01	-0.06	0.17	-0.06
	(0.22)		(0.01)	(0.08)	(0.22)	(0.08)
BMIZ	--	-0.35	--	--	--	-0.35
		(0.35)				(0.35)
Past BMIZ	0.85***	--	0.01*	-0.29	0.85***	-0.29
	(0.04)		(0.003)	(0.30)	(0.04)	(0.30)
TV	0.001**	--	--	-0.0003**	0.001**	-0.0003**
	(0.0003)			(0.0001)	(0.0003)	(0.0001)
Phys Activity	-0.01*	--	--	0.01*	-0.01*	0.01*
	(0.01)			(0.003)	(0.01)	(0.003)
Female	0.02	-0.68	-0.0003	0.04	0.02	-0.64
	(0.03)	(0.77)	(0.01)	(0.05)	(0.03)	(0.77)
Rural	-0.06	1.91	-0.002	0.02	-0.06	1.93
	(0.06)	(1.51)	(0.01)	(0.03)	(0.06)	(1.51)
Urban	-0.05	0.15	0.01	0.02	-0.05	0.16
	(0.05)	(0.92)	(0.01)	(0.03)	(0.05)	(0.91)
HH Income	-0.01	0.61**	-0.003	0.02	-0.01	0.63**
	(0.03)	(0.27)	(0.02)	(0.01)	(0.01)	(0.27)
Past AP	--	0.78***	-0.00003	0.001	-0.00003	0.78***
		(0.02)	(0.0002)	(0.001)	(0.0002)	(0.02)
Baseline AP	--	0.23***	--	--	--	0.23***
		(0.05)				(0.05)
TT1	--	0.54	--	--	--	0.54
		(1.05)				(1.05)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students receiving FRP meals

Table 19: Direct, Indirect and Total Effects for Full-Price Participants on 5th Grade BMI and Math IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
Full-Price Participants						
NSLP	-0.15	--	0.01**	0.05	-0.15	0.05
	(0.11)		(0.003)	(0.04)	(0.11)	(0.04)
SBP	0.56	--	-0.01	-0.20	0.55	-0.20
	(0.36)		(0.01)	(0.13)	(0.36)	(0.13)
BMIZ	--	-0.36	--	--	--	-0.36
		(0.35)				(0.35)
Past BMIZ	0.85***	--	0.01	-0.30	0.85***	-0.30
	(0.04)		(0.01)	(0.30)	(0.04)	(0.30)
TV	0.001***	--	--	-0.0002***	0.001***	-0.0002***
	(0.0003)			(0.0001)	(0.0003)	(0.0001)
Phys Activity	-0.02*	--	--	0.01*	-0.02*	0.01*
	(0.01)			(0.003)	(0.01)	(0.003)
Female	0.01	-0.69	0.01	0.04	0.02	-0.65
	(0.03)	(0.77)	(0.01)	(0.05)	(0.03)	(0.77)
Rural	-0.08	1.86	0.02	0.02	-0.07	1.88
	(0.09)	(1.51)	(0.03)	(0.04)	(0.07)	(1.51)
Urban	-0.04	0.15	-0.02	0.02	-0.05	0.17
	(0.04)	(0.91)	(0.02)	(0.03)	(0.05)	(0.91)
HH Income	-0.01	0.60**	-0.001	0.02	-0.01	0.62**
	(0.02)	(0.27)	(0.01)	(0.01)	(0.01)	(0.27)
Past AP	--	0.78***	-0.0001	0.001	-0.0001	0.78***
		(0.02)	(0.0002)	(0.001)	(0.0002)	(0.02)
Baseline AP	--	0.23***	--	--	--	0.23***
		(0.05)				(0.05)
TT1	--	0.53	--	--	--	0.53
		(1.05)				(1.05)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students paying full-price for meals

Table 20: Direct, Indirect and Total Effects for All Participants on 5th Grade BMI and English IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
All Participants						
NSLP	-0.11	--	0.0002	-0.03	-0.11	-0.03
	(0.11)		(0.004)	(0.03)	(0.11)	(0.03)
SBP	0.22***	--	-0.001	-0.01	0.22***	-0.01
	(0.09)		(0.01)	(0.03)	(0.09)	(0.03)
BMIZ	--	-0.09	--	--	--	-0.09
		(0.40)				(0.40)
Past BMIZ	0.85***	--	0.01	-0.07	0.86***	-0.07
	(0.04)		(0.004)	(0.34)	(0.04)	(0.34)
TV	0.001**	--	--	-0.0001**	0.001**	-0.0001**
	(0.0003)			(0.00002)	(0.0003)	(0.00002)
Phys Activity	-0.02*	--	--	0.001*	-0.02*	0.001*
	(0.01)			(0.001)	(0.01)	(0.001)
Female	0.03	-0.50	0.004	0.04	0.04	-0.46
	(0.04)	(0.71)	(0.01)	(0.06)	(0.04)	(0.72)
Rural	-0.07	0.91	0.001	0.004	-0.07	0.91
	(0.08)	(1.03)	(0.02)	(0.03)	(0.07)	(1.03)
Urban	-0.04	-0.17	0.01	0.003	-0.03	-0.17
	(0.05)	(0.96)	(0.01)	(0.01)	(0.05)	(0.96)
HH Income	-0.01	0.65***	-0.004	0.01	-0.01	0.66***
	(0.01)	(0.24)	(0.004)	(0.02)	(0.01)	0.24
Past AP	--	0.70***	-0.0002	0.00002	-0.0002	0.70***
		(0.02)	(0.0002)	(0.0001)	(0.0002)	(0.02)
Baseline AP	--	0.13***	--	--	--	0.13***
		(0.04)				(0.04)
TT1	--	-0.64	--	--	--	-0.64
		(0.85)				(0.85)

Note: * significant at 10% level

** significant at 5% level

*** significant at 1% level

Standard errors in parentheses

Results are for all students who participate in the programs (FRP and full-price)

Table 21: Direct, Indirect and Total Effects for FRP Participants on 5th Grade BMI and English IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	English IRT	BMI	English IRT	BMI	English IRT
FRP Participants						
NSLP	-0.10	--	-0.02**	0.01	-0.120	0.01
	(0.33)		(0.01)	(0.02)	(0.33)	(0.02)
SBP	0.23	--	0.01	-0.02	0.24	-0.02
	(0.28)		(0.01)	(0.02)	(0.28)	(0.02)
BMIZ	--	-0.07	--	--	--	-0.07
		(0.40)				(0.40)
Past BMIZ	0.85***	--	0.01	-0.06	0.86***	-0.06
	(0.04)		(0.004)	(0.34)	(0.04)	(0.34)
TV	0.001**	--	--	-0.0001**	0.001**	-0.0001**
	(0.0003)			(0.00002)	(0.0003)	(0.00002)
Phys Activity	-0.02*	--	--	0.001*	-0.02*	0.001*
	(0.01)			(0.001)	(0.01)	(0.001)
Female	0.04	-0.50	-0.001	0.04	0.03	-0.46
	(0.03)	(0.71)	(0.01)	(0.06)	(0.03)	(0.72)
Rural	-0.07	0.88	-0.001	0.01	-0.07	0.89
	(0.06)	(1.03)	(0.02)	(0.03)	(0.07)	(1.03)
Urban	-0.04	-0.17	0.01	0.002	-0.03	-0.17
	(0.05)	(0.96)	(0.01)	(0.01)	(0.05)	(0.96)
HH Income	-0.01	0.65***	-0.003	0.01	-0.02	0.66***
	(0.03)	(0.24)	(0.03)	(0.02)	(0.01)	(0.24)
Past AP	--	0.70***	-0.0002	0.00001	-0.0002	0.70***
		(0.02)	(0.0002)	(0.0001)	(0.0002)	(0.02)
Baseline AP	--	0.14***	--	--	--	0.14***
		(0.04)				(0.04)
TT1	--	-0.64	--	--	--	-0.64
		(0.85)				(0.85)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students receiving FRP meals

Table 22: Direct, Indirect and Total Effects for Full-Price Participants on 5th Grade BMI and English IRT Scores

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
Full-Price Participants						
NSLP	-0.15	--	0.01**	0.01	-0.14	0.01
	(0.11)		(0.003)	(0.01)	(0.11)	(0.01)
SBP	0.63**	--	-0.01	-0.05*	0.62*	-0.05*
	(0.33)		(0.01)	(0.03)	(0.33)	(0.03)
BMIZ	--	-0.09	--	--	--	-0.09
		(0.40)				(0.40)
Past BMIZ	0.85***	--	0.01	-0.07	0.86***	-0.07
	(0.05)		(0.01)	(0.34)	(0.04)	(0.34)
TV	0.001**	--	--	-0.0001**	0.001**	-0.0001**
	(0.0003)			(0.00002)	(0.0003)	(0.00002)
Phys Activity	-0.02**	--	--	0.001**	-0.02**	0.001**
	(0.01)			(0.001)	(0.01)	(0.001)
Female	0.02	-0.49	0.02	0.04	0.04	-0.45
	(0.04)	(0.71)	(0.01)	(0.06)	(0.04)	(0.72)
Rural	-0.09	0.91	0.02	0.01	-0.08	0.91
	(0.09)	(1.03)	(0.03)	(0.03)	(0.07)	(1.03)
Urban	-0.02	-0.16	-0.02	0.003	-0.04	-0.16
	(0.04)	(0.96)	(0.02)	(0.02)	(0.05)	(0.96)
HH Income	-0.01	0.64***	0.001	0.01	-0.01	0.65***
	(0.02)	(0.24)	(0.01)	(0.02)	(0.01)	(0.24)
Past AP	--	0.70***	-0.0003	0.00002	-0.0003	0.70***
		(0.02)	(0.0002)	(0.0001)	(0.0002)	(0.02)
Baseline AP	--	0.13***	--	--	--	0.13***
		(0.04)				(0.04)
TT1	--	-0.69	--	--	--	-0.69
		(0.85)				(0.85)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students paying full-price for meals

Table 23: Direct, Indirect and Total Effects on 5th Grade BMI and Math IRT Scores for FRP Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
FRP Eligible						
NSLP	0.09	--	0.003	0.11	0.10	0.11
	(0.36)		(0.01)	(0.28)	(0.36)	(0.28)
SBP	0.09	--	0.001	0.10	0.09	0.10
	(0.14)		(0.01)	(0.11)	(0.14)	(0.11)
BMIZ	--	0.78	--	--	--	0.78
		(0.71)				(0.71)
Past BMIZ	0.80***	--	0.001	0.61	0.81***	0.61
	(0.07)		(0.01)	(0.56)	(0.07)	(0.56)
TV	0.001*	--	--	0.001*	0.001*	0.001*
	(0.0004)			(0.0004)	(0.0004)	(0.0004)
Phys Activity	-0.01	--	--	-0.01	-0.01	-0.01
	(0.01)			(0.01)	(0.01)	(0.01)
Female	0.07	-0.27	0.11	0.01	0.08	-0.26
	(0.07)	(1.19)	(0.01)	0.13	(0.07)	(1.19)
Rural	-0.16**	1.38	0.02	-0.10	-0.14*	1.28
	(0.08)	(2.16)	(0.03)	(0.13)	(0.08)	(2.12)
Urban	-0.14*	1.15	0.01	-0.09	-0.13	1.05
	(0.07)	(1.71)	(0.02)	(0.11)	(0.08)	(1.70)
HH Income	0.02	0.49	-0.01	-0.001	0.01	0.48
	(0.02)	(0.42)	(0.01)	(0.03)	(0.02)	(0.42)
Past AP	--	0.91***	-0.0001	-0.001	-0.0001	0.91***
		(0.03)	(0.0002)	(0.002)	(0.0002)	(0.03)
Baseline AP	--	0.09	--	--	--	0.09
		(0.10)				(0.10)
TT1	--	-0.96	--	--	--	-0.96
		(1.43)				(1.43)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students eligible for FRP meals

Table 24: Direct, Indirect and Total Effects on 5th Grade BMI and Math IRT Scores for Non-Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**Math IRT**	**BMI**	**Math IRT**	**BMI**	**Math IRT**
Non-Eligible						
NSLP	-0.13	--	0.001	0.04	-0.13	0.04
	(0.11)		(0.004)	(0.10)	(0.11)	(0.10)
SBP	0.23	--	-0.01	-0.11	0.23	-0.11
	(0.15)		(0.01)	(0.12)	(0.15)	(0.12)
BMIZ	--	-0.75**	--	--	--	-0.75**
		(0.37)				(0.37)
Past BMIZ	0.88***	--	0.002	-0.67**	0.88***	-0.67**
	(0.03)		(0.01)	(0.33)	(0.03)	(0.33)
TV	0.001*	--	--	-0.001**	0.001*	-0.001**
	(0.0003)			(0.0002)	(0.0003)	(0.0002)
Phys Activity	-0.02**	--	--	0.02**	-0.02**	0.02**
	(0.01)			(0.01)	(0.01)	(0.01)
Female	-0.01	-1.08	0.01	0.02	0.002	-1.05
	(0.04)	(0.94)	(0.01)	(0.05)	(0.04)	(0.94)
Rural	0.02	2.35	-0.02	-0.01	0.01	2.34
	(0.08)	(1.59)	(0.02)	(0.05)	(0.07)	(1.59)
Urban	-0.002	-0.23	0.002	0.001	0.0003	-0.23
	(0.05)	(0.93)	(0.01)	(0.04)	(0.05)	(0.93)
HH Income	-0.01	0.35	-0.001	0.02	-0.01	0.36
	(0.01)	(0.33)	(0.003)	(0.02)	(0.01)	(0.33)
Past AP	--	0.72***	0.00004	0.0002	0.00004	0.72***
		(0.02)	(0.0002)	(0.001)	(0.0002)	(0.02)
Baseline AP	--	0.27***	--	--	--	0.27***
		(0.06)				(0.06)
TT1	--	1.00	--	--	--	1.00
		(1.20)				(1.20)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students non-eligible for FRP status

Table 25: Direct, Indirect and Total Effects on 5th Grade BMI and English IRT Scores for FRP Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
FRP Eligible						
NSLP	0.14	--	0.003	-0.19	0.14	-0.19
	(0.37)		(0.01)	(0.30)	(0.37)	(0.30)
SBP	0.17	--	0.010	-0.16	0.18	-0.16
	(0.12)		(0.01)	(0.11)	(0.12)	(0.11)
BMIZ	--	-0.83	--	--	--	-0.83
		(0.74)				(0.74)
Past BMIZ	0.82***	--	0.01	-0.66	0.82***	-0.66
	(0.08)		(0.01)	(0.62)	(0.08)	(0.62)
TV	0.001*	--	--	-0.001*	0.001*	-0.001*
	(0.001)			(0.0004)	(0.001)	(0.0004)
Phys Activity	-0.01	--	--	0.01	-0.01	0.01
	(0.01)			(0.01)	(0.01)	(0.01)
Female	0.14	2.33*	0.004	-0.05	0.14	2.28*
	(0.08)	(1.36)	(0.02)	0.21	(0.08)	(1.36)
Rural	-0.21**	1.53	0.04	0.14	-0.17**	1.67
	(0.08)	(1.79)	0.03	(0.13)	(0.08)	(1.79)
Urban	-0.12*	-0.15	0.03	0.08	-0.10	-0.08
	(0.07)	(1.83)	(0.02)	(0.09)	(0.08)	(1.81)
HH Income	0.03	0.96**	-0.01	0.0005	0.02	0.96*
	(0.02)	(0.48)	(0.01)	(0.04)	(0.02)	(0.49)
Past AP	--	0.72***	-0.0004	0.0004	-0.0004	0.72***
		(0.03)	(0.0004)	(0.0005)	(0.0004)	(0.03)
Baseline AP	--	0.17	--	--	--	0.17
		(0.10)				(0.10)
TT1	--	0.57	--	--	--	0.57
		(1.40)				(1.40)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students eligible for FRP meals

Table 26: Direct, Indirect and Total Effects on 5th Grade BMI and English IRT Scores for Non-Eligible Students

	Direct Effects		Indirect Effects		Total Effects	
	BMI	**English IRT**	**BMI**	**English IRT**	**BMI**	**English IRT**
Non-Eligible						
NSLP	-0.14	--	-0.0001	-0.05*	0.14	-0.05*
	(0.12)		(0.004)	(0.03)	(0.12)	(0.03)
SBP	0.22	--	-0.01	0.08	0.22	0.08
	(0.16)		(0.01)	(0.05)	(0.16)	(0.05)
BMIZ	--	0.26	--	--	--	0.26
		(0.46)				(0.46)
Past BMIZ	0.88***	--	0.0001	0.23	0.88***	0.23
	(0.03)		(0.01)	(0.40)	(0.03)	(0.40)
TV	0.001*	--	--	0.0002*	0.001*	0.0002*
	(0.0003)			(0.0001)	(0.0003)	(0.0001)
Phys Activity	-0.02**	--	--	-0.01**	-0.02**	-0.01**
	(0.01)			(0.003)	(0.01)	(0.003)
Female	-0.01	-1.50*	0.01	0.01	0.004	-1.49*
	(0.04)	(0.83)	(0.01)	(0.03)	(0.04)	(0.83)
Rural	0.03	0.47	-0.02	0.00	0.02	0.47
	(0.08)	(1.12)	(0.02)	(0.02)	(0.07)	(1.11)
Urban	-0.002	0.09	0.0006	-0.0001	-0.002	0.09
	(0.05)	(1.08)	(0.01)	(0.01)	(0.05)	(1.08)
HH Income	-0.01	0.18	-0.0009	0.002	-0.01	0.19
	(0.01)	(0.30)	(0.003)	(0.01)	(0.01)	(0.29)
Past AP	--	0.68***	-0.00002	0.00001	-0.00002	0.68***
		(0.02)	(0.0001)	(0.00005)	(0.0001)	(0.02)
Baseline AP	--	0.15**	--	--	--	0.15**
		(0.04)				(0.04)
TT1	--	-1.12	--	--	--	-1.12
		(0.96)				(0.96)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are only for students non-eligible for FRP status

Table 27: Direct, Indirect and Total Effects on 8th Grade BMI, Self-Esteem and Math IRT Scores by Participation Status

	Direct Effects			Indirect Effects			Total Effects		
	BMIZ	**Self-Esteem**	**Math IRT**	**BMIZ**	**Self-Esteem**	**Math IRT**	**BMIZ**	**Self-Esteem**	**Math IRT**
All Participants									
NSLP	0.003	0.14	--	0.0001	-0.0001	-0.98	0.003	0.14	-0.98
	(0.17)	(0.09)		(0.004)	(0.01)	(0.83)	(0.17)	(0.09)	(0.83)
SBP	0.34	-0.09	--	0.003	-0.01	2.22**	0.34	-0.10	2.22**
	(0.21)	(0.15)		(0.01)	(0.01)	(1.09)	(0.21)	(0.15)	(1.09)
BMIZ	--	-0.03	3.42***	--	--	-0.04	--	-0.03	3.38***
		(0.07)	(0.97)			(0.10)		(0.07)	(0.98)
Perceive UW	--	-0.21	--	--	--	-0.29	--	-0.21	-0.29
		(0.13)				(0.59)		(0.13)	(0.59)
Perceive OW	--	-0.34**	--	--	--	-0.48	--	-0.34**	-0.48
		(0.17)				(0.76)		(0.17)	(0.76)
Self-Esteem	--	--	1.39	--	--	--	--	--	1.39
			(2.49)						(2.49)
FRP Participants									
NSLP	-1.20	0.14	--	-0.002	0.03	-4.30	-1.20	0.16	-4.30
	(1.05)	(0.17)		(0.01)	(0.02)	(3.47)	(1.05)	(0.18)	(3.47)
SBP	0.85*	-0.15	--	0.01	-0.02*	4.23**	0.86*	-0.17	4.23**
	(0.49)	(0.19)		(0.01)	(0.01)	(1.99)	(0.49)	(0.20)	(1.99)
BMIZ	--	-0.02	3.36***	--	--	-0.03	--	-0.02	3.33***
		(0.07)	(0.97)			(0.09)		(0.07)	(0.99)
Perceive UW	--	-0.20	--	--	--	-0.24	--	-0.20	-0.24
		(0.13)				(0.50)		(0.13)	(0.50)
Perceive OW	--	-0.35**	--	--	--	-0.43	--	-0.35**	-0.43
		(0.17)				(0.76)		(0.17)	(0.76)
Self-Esteem	--	--	1.24	--	--	--	--	--	1.24
			(2.32)						(2.32)
Full-Price Participants									
NSLP	-0.05	0.08	--	0.00003	0.001	-1.09	-0.05	0.08	-1.09
	(0.27)	(0.09)		(0.01)	(0.004)	(1.04)	(0.27)	(0.09)	(1.04)
SBP	1.21	-0.04	--	-0.01	-0.02	3.78	1.21	-0.05	3.78
	(1.39)	(0.26)		(0.01)	(0.02)	(4.76)	(1.39)	(0.27)	(4.76)
BMIZ	--	-0.02	3.39***	--	--	-0.02	--	-0.02	3.37***
		(0.07)	(0.96)			(0.07)		(0.07)	(0.97)
Perceive UW	--	-0.19	--	--	--	-0.19	--	-0.19	-0.19
		(0.12)				(0.50)		(0.12)	(0.50)
Perceive OW	--	-0.36**	--	--	--	-0.36	--	-0.36**	-0.36
		(0.16)				(0.82)		(0.16)	(0.82)
Self-Esteem	--	--	0.99	--	--	--	--	--	0.99
			(2.39)						(2.39)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are separated by participation status

Table 28: Direct, Indirect and Total Effects on 8th Grade BMI, Self-Esteem and English IRT Scores by Participation Status

	Direct Effects			Indirect Effects			Total Effects		
	BMI	**Self-Esteem**	**English IRT**	**BMI**	**Self-Esteem**	**English IRT**	**BMI**	**Self-Esteem**	**English IRT**
All Participants									
NSLP	-0.02	0.17**	--	0.001	-0.0001	0.90	-0.02	0.17**	0.90
	(0.14)	(0.08)		(0.003)	(0.001)	(1.03)	(0.14)	(0.08)	(1.03)
SBP	0.38*	-0.16	--	0.002	0.001*	0.14	0.38*	-0.16	0.14
	(0.22)	(0.17)		(0.01)	(0.001)	(1.37)	(0.22)	(0.17)	(1.37)
BMIZ	--	0.004	1.74	--	--	0.04	--	0.004	1.780
		(0.07)	(1.31)			(0.69)		(0.07)	(1.45)
Perceive UW	--	-0.24*	--	--	--	-2.44*	--	-0.24*	-2.44*
		(0.13)				(1.36)		(0.13)	(1.36)
Perceive OW	--	-0.44***	--	--	--	-4.53***	--	-0.44***	-4.53***
		(0.13)				(1.71)		(0.13)	(1.71)
Self-Esteem	--	--	10.35***	--	--	--	--	--	10.35***
			(2.36)						(2.36)
FRP Participants									
NSLP	0.002	0.20	--	0.001	0.00001	2.25	0.002	0.20	2.25
	(1.43)	(0.17)		(0.004)	(0.01)	(2.97)	(1.43)	(0.17)	(2.97)
SBP	0.58	-0.27	--	0.0001	0.004	-0.80	0.58	-0.27	-0.80
	(0.55)	(0.23)		(0.004)	(0.003)	(2.33)	(0.55)	(0.23)	(2.33)
BMIZ	--	0.01	1.82	--	--	0.07	--	0.01	1.89
		(0.07)	(1.33)			(0.79)		(0.07)	(1.46)
Perceive UW	--	-0.22*	--	--	--	-2.53*	--	-0.22*	-2.53*
		(0.13)				(1.47)		(0.13)	(1.47)
Perceive OW	--	-0.44***	--	--	--	-4.94***	--	-0.44***	-4.94***
		(0.14)				(2.06)		(0.14)	(2.06)
Self-Esteem	--	--	11.35***	--	--	--	--	--	11.35***
			(2.33)						(2.33)
Full-Price Participants									
NSLP	-0.18	0.08	--	0.002	0.01	1.57	-0.18	0.10	1.57
	(0.25)	(0.10)		(0.01)	(0.01)	(2.04)	(0.25)	(0.10)	(2.04)
SBP	0.54	-0.14	--	-0.01	-0.03	-2.22	0.53	-0.17	-2.22
	(0.84)	(0.33)		(0.01)	(0.05)	(6.24)	(0.85)	(0.35)	(6.24)
BMIZ	--	-0.06	2.33	--	--	-1.16	--	-0.06	1.17
		(0.08)	(3.01)			(1.71)		(0.08)	(2.33)
Perceive UW	--	-0.33**	--	--	--	-6.60	--	-0.33**	-6.60
		(0.14)				(5.67)		(0.14)	(5.67)
Perceive OW	--	-0.30	--	--	--	-6.08**	--	-0.30	-6.08**
		(0.21)				(3.02)		(0.21)	(3.02)
Self-Esteem	--	--	20.19	--	--	--	--	--	20.19
			(17.17)						(17.17)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are separated by participation status

Table 29: Direct, Indirect and Total Effects on 8th Grade BMI, Self-Esteem and Math IRT Scores by FRP Eligibility

	Direct Effects			Indirect Effects			Total Effects		
	BMIZ	**Self-Esteem**	**Math IRT**	**BMIZ**	**Self-Esteem**	**Math IRT**	**BMIZ**	**Self-Esteem**	**Math IRT**
FRP Eligible									
NSLP	-0.98**	0.56**	--	0.09**	0.03**	-4.04	-0.90**	0.59**	-4.04
	(0.42)	(0.28)		(0.04)	(0.01)	(2.59)	(0.42)	(0.28)	(2.59)
SBP	0.72**	-0.23	--	0.05*	-0.03**	2.48	0.77**	-0.25	2.48
	(0.35)	(0.29)		(0.03)	(0.01)	(1.78)	(0.35)	(0.28)	(1.78)
BMIZ	--	0.05	1.92	--	--	-0.16	--	-0.03	1.76
		(0.11)	(9.05)			(0.94)		(0.19)	(8.76)
Perceive UW	--	-0.66	--	--	--	-3.28	--	-0.66	-3.28
		(0.76)				(17.34)		(0.76)	(17.34)
Perceive OW	--	-0.28	--	--	--	-1.39	--	-0.28	-1.39
		(0.49)				(4.56)		(0.49)	(4.56)
Self-Esteem	--	--	4.95	--	--	--	--	--	4.95
			(20.72)						(20.72)
Non-Eligible									
NSLP	-0.16	0.04	--	0.003	-0.01	-0.63	-0.16	0.03	-0.63
	(0.19)	(0.11)		(0.01)	(0.01)	(0.52)	(0.19)	(0.11)	(0.52)
SBP	0.12	0.11	--	-0.01	0.01	0.17	0.11	0.11	0.17
	(0.20)	(0.14)		(0.01)	(0.01)	(0.54)	(0.20)	(0.14)	(0.54)
BMIZ	--	0.05	2.69*	--	--	-0.10	--	0.05	2.60*
		(0.07)	(1.46)			(0.15)		(0.07)	(1.42)
Perceive UW	--	-0.01	--	--	--	0.02	--	-0.01	0.02
		(0.15)				(0.28)		(0.15)	(0.28)
Perceive OW	--	-0.34**	--	--	--	0.69	--	-0.34**	0.69
		(0.14)				(1.46)		(0.14)	(1.46)
Self-Esteem	--	--	-2.02	--	--	--	--	--	-2.02
			(4.17)						(4.17)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are separated by whether or not students are eligible for FRP meals

Table 30: Direct, Indirect and Total Effects on 8th Grade BMI, Self-Esteem and English IRT Scores by FRP Eligibility

	Direct Effects			Indirect Effects			Total Effects		
	BMI	**Self-Esteem**	**English IRT**	**BMI**	**Self-Esteem**	**English IRT**	**BMI**	**Self-Esteem**	**English IRT**
FRP Eligible									
NSLP	-1.10**	0.53*	--	0.10***	-0.24*	-2.39	-1.00*	0.29	-2.39
	(0.54)	(0.30)		(0.03)	(0.13)	(7.02)	(0.54)	(0.29)	(7.02)
SBP	0.22	-0.65	--	-0.001	0.05	-8.80	0.22	-0.60	-8.80
	(0.24)	(0.57)		(0.03)	(0.06)	(9.24)	(0.25)	(0.55)	(9.24)
BMIZ	--	0.24	7.66*	--	--	4.11	--	0.24	11.77***
		(0.22)	(4.33)			(3.85)		(0.22)	(4.04)
Perceive UW	--	-0.29	--	--	--	-5.11	--	-0.29	-5.11
		(0.28)				(3.90)		(0.28)	(3.90)
Perceive OW	--	-0.98**	--	--	--	-17.09*	--	-0.98**	-17.09*
		(0.45)				(9.82)		(0.45)	(9.82)
Self-Esteem	--	--	17.42	--	--	--	--	--	17.42
			(11.35)						(11.35)
Non-Eligible									
NSLP	-0.19	0.10	--	0.001	0.001	0.55	-0.19	0.10	0.55
	(0.16)	(0.09)		(0.01)	(0.0004)	(1.37)	(0.16)	(0.09)	(1.37)
SBP	-0.11	0.02	--	-0.01	0.0003	0.75	-0.12	0.02	0.75
	(0.21)	(0.13)		(0.01)	(0.001)	(2.20)	(0.21)	(0.13)	(2.20)
BMIZ	--	-0.002	0.55	--	--	-0.04	--	-0.002	0.51
		(0.07)	(1.43)			(1.10)		(0.07)	(1.52)
Perceive UW	--	-0.16	--	--	--	-2.50	--	-0.16	-2.50
		(0.15)				(2.55)		(0.15)	(2.55)
Perceive OW	--	-0.33**	--	--	--	-5.09**	--	-0.33**	-5.09**
		(0.14)				(2.06)		(0.14)	(2.06)
Self-Esteem	--	--	15.32***	--	--	--	--	--	15.32***
			(4.98)						(4.98)

Note: * significant at 10% level
** significant at 5% level
*** significant at 1% level
Standard errors in parentheses
Results are separated by whether or not students are eligible for FRP meals

Figure 1:Path Diagram of Meal Program Participation, Child Weight and Academic Performance

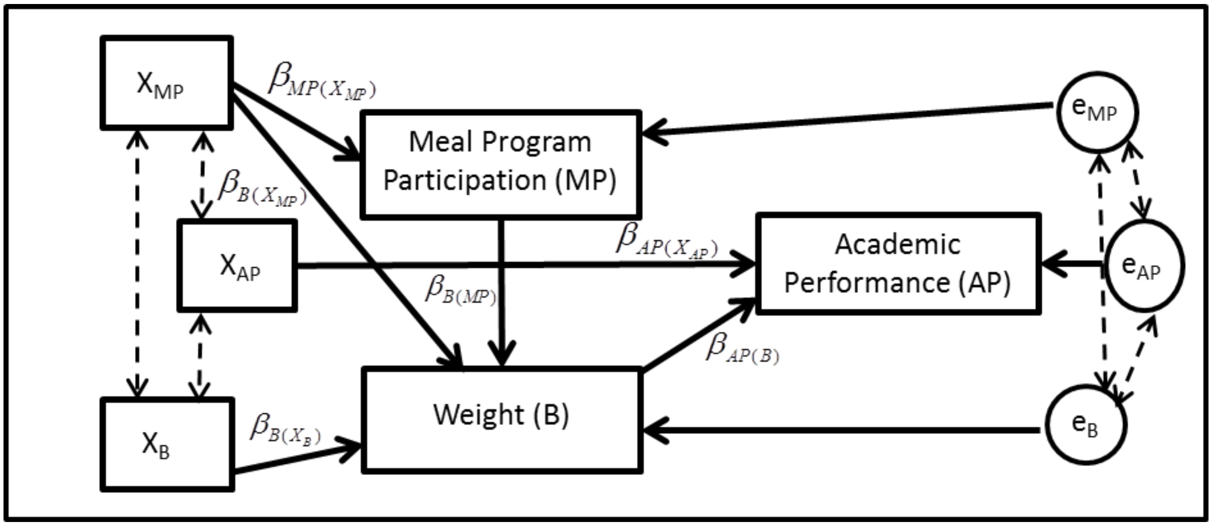
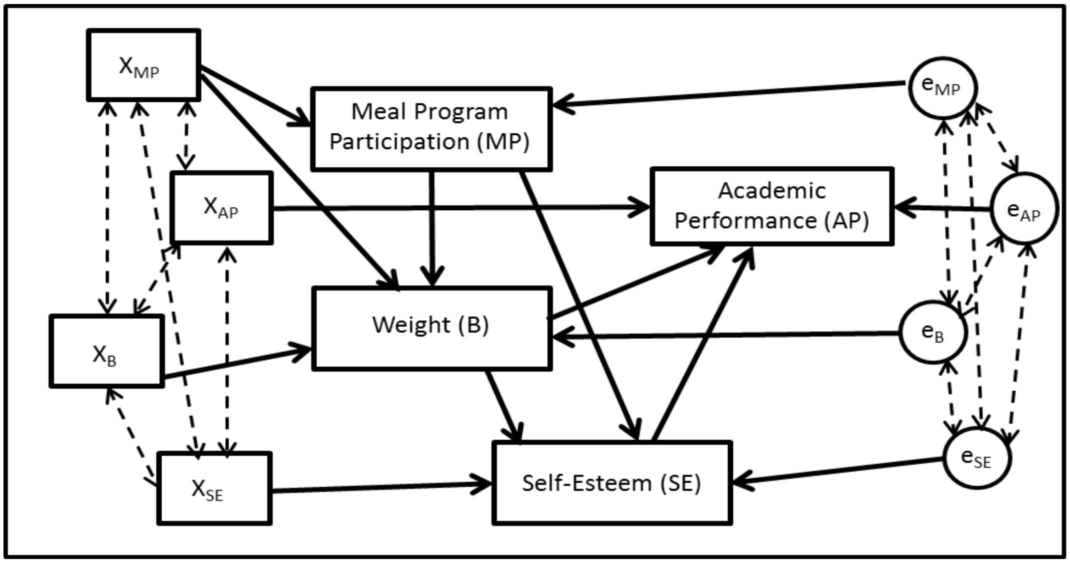


Figure 2: Path Diagram of Meal Program Participation, Child Weight, Self-Esteem and Academic Performance



Chapter V: Conclusion

With over 15.5 million children affected by misnourishment (either underweight or overweight) in the US, it is important to understand the health and non-health consequences impacting these children. Research has found links between child weight and academic performance as well as school meal program participation and child weight. However, further research on the relationship between all three is crucial not only to better inform policymakers of potential avenues for alleviating childhood misnourishment but also for improving US children's academic performance. This study investigates the impacts of child weight on academic performance and also explores the influences of school meal programs on both child weight and academic performance using economic modeling and estimation techniques. The entirety of this dissertation utilizes data from the Early Childhood Longitudinal Study-Kindergarten Class while Chapter III also employs the Common Core of Data in robustness checks.

Chapter II of this dissertation examines how childrens' BMI z-scores in addition to their specific weight classifications (underweight, overweight and healthy weight) impact their academic performance. This essay uses a quantile analysis while controlling for potential simultaneity between weight and school outcomes (as both may be driven by other household characteristics). A quantile methodology is key to examining marginal effects for the tails of the performance distribution (i.e., those lower performing students). We find that child BMI has differential impacts across the performance distribution: it affects lower performing students and children in the healthy BMI range more and may contribute to the achievement gap. These results indicate that programs targeting child weight could potentially have positive spillover effects on academic performance.

Because children consume one-third to one-half of their daily calories while in school each day and 31.7 million children participate in the School Breakfast Program (SBP) and the National School Lunch Program (NSLP) daily, school nutrition programs are natural policy instruments to tackle misnourishment. Chapter III examines whether SBP and NSLP impact child weight using a multiple simultaneous treatment analysis controlling for self-selection into the programs. Specifically, Average Treatment Effect on the Treated (ATT) and Difference-in-Differences (DID) methodologies are used. We find that while participating only in NSLP decreases the probability of children being overweight, participating in both SBP and NSLP increases the likelihood of being overweight and decreases the likelihood of being underweight, particularly for students receiving free- and reduced-price meals. These results lend further support to policies requiring higher nutritional quality of school meals such as the new USDA nutrition standards released in January 2012 as well as initiatives encouraging children to eat healthier meals such as *Chefs Move to Schools* and the Small Farms/School Meals Initiative.

Next, Chapter IV answers Millimet, Tchernis and Husain's (2010) call for research on the impacts of school meal programs on additional cognitive and non-cognitive outcomes by examining spillover effects of SBP and NSLP on math and English achievement through the mediator of child weight. We investigate program impacts using structural equation modeling and simultaneous equation methodologies. Using full-information maximum likelihood, we simultaneously estimate the child weight and academic performance production functions along with child choice equations and program participation equations to examine potential spillover effects of SBP and NSLP on academic performance through the mediator of child weight. We find that spillover effects do exist, particularly when examining children by free- and reduced-price eligibility status. These results encourage participation in the meal programs in addition to consuming nutritious meals.

In conclusion, this dissertation contributes to the literature in several ways. First, it develops a more inclusive theoretical framework modeling the dynamic relationship between child weight and academic performance. This framework provides strong theoretical support for our empirical investigations throughout the dissertation. In addition, we handle potential endogeneity through a variety of estimation methods while accounting for self-selection into the school meal programs: instrumental variable quantile regression, treatment effect methodologies and simultaneous equations. We also consider how SBP and NSLP impact underweight children in addition to how being underweight impacts achievement. Finally, there is a need in the literature for more thorough impact assessment of SBP and NSLP; Chapter III and Chapter IV address the impacts of these school meal programs on weight and performance, respectively. Overall, this dissertation finds strong links between child weight, school meal program participation and academic performance and encourages further research in this area.

APPENDIX A – Copyright Permission Approval

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