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Food Insecurity and Standardized Test Scores

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Abstract: This paper aims to explore the impact of food insecurity on students' standardized test scores by using a state-level panel data from the US from 2005-2012. While estimating this relationship, we also address the endogeneity bias of food insecurity in the math-SAT score regression by relying on a dynamic panel specific system GMM estimator. We find that food insecurity is a significant factor in determining the average math-SAT score. An increase in food insecurity lowers the students' Math-SAT scores. Although, a few studies using small micro-level survey data have found evidence to link food insecurity to children's learning outcomes, this is the first study to find this link using a macro level panel data for the US states, indicating that the problem of food insecurity is much more pervasive than what the small-scale studies have indicated so far, and needs to be dealt with in a more effective way through public policies, if the US has to succeed in the twenty-first century.
Keywords: Food Insecurity, Learning Outcomes, SAT, System GMM, US

JEL Classifications: H75, I00

1. Introduction

Food insecurity generally implies that a household lacks consistent access to adequate food at times during the year due to budgetary and other resource constraints. In 2013, 49.1 million Americans lived in food insecure households, including 33.3 million adults, and 15.8 million children. In 2013, 14 percent of households (17.5 million households) were food insecure. In 2013, 6 percent of households (6.8 million households) experienced very low food security. [1]

The proportion of households suffering from food insecurity is much larger in other parts of the world. [2] Growing up in a food insecure home poses many hardships and challenges for children. The direct impact of food insecurity is on the nutritional intake of household members including children, who need adequate supplies of essential nutrients to grow and function. Several studies have linked nutritional inadequacy to cognitive impairment and performance of students on the standardized tests (see for example Cook et al, 2004; Jyoti et al, 2005; Olson, 1999).

With food insecurity becoming a significant part of the environment in the United States, it has started to pose serious challenges to the educational growth expectations. Schools serving in the areas with high populations of food insecurity are too often faced with the dilemma of whether or not to schedule long periods of breaks, in fear that the students who rely heavily on meals provided by the schools, will go malnourished for this extended period of time. The obvious severity of the issue must certainly have an impact on each child plagued by food insecurity.

In this paper, we aim to explore the relationship between food insecurity and student performance on standardized tests by using a panel data of the US states from 2005-12. This study is unique in the sense that no other study, to the best of our knowledge, has examined this relationship using a macro level panel data for the US states. Additionally, this study also addresses the endogeneity bias of food insecurity in the student performance on standardized test regression. This is important; because, there are state level time variant and invariant variables, which we don't observe in the data, but they are likely to influence both student performance and food insecurity, causing the standard pooled Ordinary Least Squares (OLS) estimates to be biased. The source of endogeneity might also be due to the systematic measurement errors, which persist over time, and are likely to be correlated with our variable of interest, food insecurity.

The result of this paper suggests that food insecurity lowers student performance on the standardized tests, as measured by the Scholastic Aptitude Test (SAT) mathematics scores. In the light of this result, we discuss some policy implications.

The rest of the paper is organized as follows. Next section briefly discusses the relevant literature. Section 3 lays out the empirical strategy. Section 4 describes the data and summary statistics. Section 5 presents the result. Section 6 discusses the implications of the findings, and section 7 concludes the paper.

2. Background literature

Bhattacharya et al (2004) using data from the National Health and Nutrition Examination Survey find no association between food insecurity and nutritional outcomes of school going children. However, for non-elderly adults, they find a significant relationship.

Cook et al (2004) using multisite retrospective cohort study with cross-sectional surveys at urban medical centers in 5 states and Washington DC, from August 1998–December 2001, find that food insecurity and health outcomes are related. According to this study food insecurity can have dire effects on the health of children and infants. Children living in food insecure households are more likely to be hospitalized and suffer from illnesses frequently than children who are food secure. Along with physical health problems, food insecurity also impacts the psychological health of children.

Studies have found that food insecurity can cause increased stress, worry, depression, and deprivation. These effects of food insecurity could easily translate into factors that impact the educational performance of students. Jyoti et al (2005) study the socioeconomic effects of food insecurity, the impact of food insecurity on educational progress, social skills, and various health factors using a longitudinal data. They find that students living in food insecure households had a smaller increase in standardized test scores than students living in food secure households. The study also found that food insecurity impacted social skill outcomes for young boys only. Whereas food insecurity's effect on BMI and weight were significant for girls only. The study also assessed the increase in standardized test scores for students transitioning to either a food insecure or food secure household. Their findings suggest that students transitioning to a food insecure household had a 3.21 point smaller increase in standardized test scores. They also find that when transitioning from food insecurity to food security, both boys and girls, experienced an increase in social skills.

Connell et al (2005) using qualitative data analyze the effect of food insecurity experiences by children on their nutritional, physical, and mental health.

Olson (1999) studies the consequences of food insecurity and finds that it impacts both physical and mental health of children. This study also finds that the physical impairment brought on by food insecurity contributes to a reduction in learning and productivity for both children and adults. This impairment includes fatigue and illness related to the malnutrition brought on by food deprivation. The findings of this study also suggest that these mental and physical problems brought on by food insecurity had larger social implications, one of them being a decrease in learning and productivity.

Alaimo et al (2001) examine the role of food insufficiency in cognitive, academic, and psychological outcomes of US children and teenagers ranging in age from 6-11 and 12-16 years by using data from the Third National Health and Nutrition Examination Survey (NHANES III). Their findings suggest that food insufficient children in the 6-11 years age-group were more likely to have lower arithmetic scores, repeat a grade, seen a psychologist, and difficulty in getting along with other children. While the food insufficient teenagers were more likely to have seen a psychologist, suspended from school, difficulty in getting along with other children.
We are not aware of any study that follows our methodology and relies on the state level aggregated data to analyze the impact of food insecurity on standardized test scores.

3. Econometric Strategy

The impact of food insecurity on student learning outcomes could be estimated by the following equation:

$$y_{it} = \beta_0 + \beta_1 foodinsecurity_{it} + \beta_2 x_{it} + u_{it} \quad (1)$$

where y_{it} is a measure of student learning outcomes in the i^{th} state in the t^{th} time period. The term $foodinsecurity_{it}$ is a measure of food insecurity in the i^{th} state in the t^{th} time period. The term x_{it} is a set of other controls influencing student learning outcomes in the i^{th} state in the t^{th} time period. The term u_{it} is the idiosyncratic error term, which contains state-specific time variant and invariant unobserved variables that influence student learning outcomes. The term β_1 is the coefficient of interest, whereas, β_2 is a vector of coefficients associated with other controls driving student learning outcomes.

Estimating equation (1) by using the standard pooled OLS estimator may yield biased estimates for β_1 , the coefficient of the variable of interest, food insecurity, due to correlation with the omitted variables in equation (1). There are state level time variant and invariant determinants of student learning outcomes that we do not observe, and therefore are unable to control for in our regression, which might be correlated with our variable of interest, food insecurity. If such is the case, then teasing out the causal effect of food insecurity on student learning outcomes is not reliable. There is an additional source of endogeneity bias in our estimation, and that is due to the measurement error. The measurement of food insecurity might have a systemic bias, as it relies on self-reported survey data, and therefore, this systemic component might be present in the error term and correlated with food insecurity over time, which can bias the estimate of the coefficient of food insecurity.

This endogeneity bias can be mitigated by relying on the instrumental variables estimation technique. However, finding an instrument at the aggregate level that is correlated with food insecurity, but not correlated with the unobserved variables in the error term, is difficult, and therefore we do not resort to this approach. The use of panel data affords us some advantages in tackling the endogeneity bias, which a purely cross-sectional data will not permit. We can take advantage of the fixed effects estimator, which differences out the state level time-invariant unobserved determinants that are correlated with food insecurity, and in so doing, removes a potential source of endogeneity. Although the fixed effects estimator is an improvement over the standard pooled OLS estimator, it fails to remove all sources of endogeneity, and therefore the estimate of the coefficient of food insecurity is likely to remain biased.

However, to fully control for all potential sources of endogeneity, we can resort to the difference GMM estimator as proposed by Arellano and Bond (1991) for the dynamic panel data. Under this estimation technique, the lag of the dependent variable is used as an additional regressor in equation (1). The use of dynamic model specification is imperative because the student learning outcomes at the state level are likely to persist over time. In other words, better and poorer performing states persist over time, and performance in the past can be a good predictor of the performance in the future.

In the difference GMM estimator, the lagged values of the endogenous variables are used as instruments under the assumption that past values are correlated with the current values, but they are not correlated with the contemporaneous errors. We rely on a modified version of the difference GMM estimator called the system GMM estimator. This derives two equations from the original equation, one in the levels and the other in the first differences. The benefit of relying on this is that it provides additional instruments, and estimates are usually more efficient than under the difference GMM estimator (see, for example, Cardenas & Sharma, 2011; Dutt et al, 2009; Fajnzylber et al, 2002; Sharma, 2015).

Thus, we estimate the following modified equation for system GMM estimation:

$$\Delta y_{it} = \propto_0 \Delta y_{i,t-1} + \propto_1 \Delta foodinsecurity_{i,t} + \propto_2 \Delta x_{it} + \Delta u_{it} \quad (2)$$

where Δ represents the first difference and $y_{i,t-1}$ is the measure of student learning outcomes in the previous year.

4. Data and Summary Statistics

The dependent variable in this study is a measure of student learning outcomes. This study uses the mean scores on the mathematics section of the Scholastic Aptitude Test (SAT) of college-bound high school seniors for each state from 2005-2012 as a measure of student learning outcomes. Mathematics score is chosen as a measure of learning outcomes because quantitative skill acquisition has received a lot of attention and funding from the policy makers under various initiatives in the US in recent times, as students in the US have lagged their counterparts in other advanced economies in terms of quantitative skill formation. Quantitative skills have been associated with earnings, employment, and productivity boosts in several studies, and therefore, it is crucial for the American competitiveness in the twenty-first century (see, for example, Rivera-Batiz, 1992 and Carbonaro, 2007). The average Math-SAT score across all states over 2005-12 was 539.89 with a maximum of 617 in Illinois in 2010 and 2012, and a minimum of 457 in Delaware in 2012.

We use the percentage of food insecure households that have children under the age of eighteen years, as a measure of food insecurity in our analysis, which serves as the variable of interest. This variable accounts for all households that have children under the age of eighteen that were food insecure at some point over the course of a year. The variable has been adjusted by the Census Bureau to account for any sampling errors caused by the collection of data at the state level. Each yearly figure represents a three-year moving average of the data. The data is available for all fifty states from the years 2005 to 2012. This variable ranges from 9 percent in 2005 in New Hampshire to 30 percent in 2011 in Arizona. The mean value for all states over the period of 2005-12 was 19 percent.

The other plausible determinants of student learning outcomes include measures such as poverty rate, per capita state GDP, per pupil government spending on education, proportion of single parent households, proportion of children abusing drugs, proportion of whites, number of males and females, state unemployment rate, hourly wage, proportion of population with high school diploma, and proportion of population with college degrees.

Poverty is hypothesized to have an adverse impact on math SAT scores in line with the findings of other studies on learning outcomes and poverty (see for example Howley & Bickell, 2000). Poverty rate data for each state is sourced from various surveys of the United States Census Bureau. This variable measures the percentage of under eighteen years of age population who live in families that fall below the one hundred and fifty percent of the federal poverty level in a given state during a year. This particular level of poverty was chosen because it closely mirrors the poverty level required for students to receive assistance from the national school lunch program. The data for this variable is available for all fifty states from the years 2005 to 2012. It ranges from 15 percent in 2007 in New Hampshire to 48 percent in 2012 in Mississippi. The mean value for all states over the 2005-12 period was 29.8 percent.

The prevalence of single parent households is continuing to grow according to the Kids Count organization. Presumably, the lack of support and dual incomes of two parents could create a disadvantage for students. This variable is measured by the percentage of these households at the state level. The single parent household variable is hypothesized to have an adverse impact on Math-SAT score. This hypothesis is in line with the findings of other studies that point towards a detrimental effect of single parent household on child learning outcomes (see, for example Krein & Beller, 1988). The data is obtained from the United States census bureau, and it ranges from 18 percent in 2008 in Utah to 49 percent in 2012 in Mississippi. The mean value of single parent households was 32 percent across all states during 2005-12.

The per capita GDP is a proxy for income in student homes and is hypothesized to have a positive effect on Math-SAT scores, as it correlates with the resources available to students in the realms of schooling, extra-curricular activities, and overall support. It may also reflect the parental education and home environment (see, for example Blau, 1999; Brooks-Gunn & Duncan, 1997; Davis-Kean, 2005). The per capita GDP data is obtained from the Bureau of Economic Analysis and is expressed in 2009 dollars. The per capita GDP ranges from 30,988 dollars in 2011 in Mississippi to 72,281 dollars in 2012 in Alaska. The mean per capita GDP across all states over 2005-2012 was 46,806.68 dollars.

The percentage of whites in the population is included to control for racial diversity, as it can affect the outcomes of student performance (see, for example Terenzini et al, 2001). This variable represents only the white population under the age of fifteen in every state. The data for this variable is obtained from the United States Census Bureau for all fifty states and represents years 2005 to 2012. The variable ranges from 13 percent in 2010 in Hawaii to 93 percent in 2005 in Vermont. The mean value for all states was 63 percent.

The use of alcohol and drugs can impact the brain function of a person, especially adolescents. This variable measures the number of students who have reported being dependent on or abusing illicit drugs in the past. These illicit drugs include marijuana, cocaine, heroin, hallucinogens, inhalants, or prescription drugs used non-medically. The data was collected by the Substance Abuse and Mental Health Services Administration. Dependence and abuse were defined by the Diagnostic and Statistical Manual of Mental Disorders. Each data point is recorded as a two-year average to account for sampling errors. The data covers all fifty states over the years 2005 to 2012. This variable ranges from a minimum of 5 percent of children in 2008 in Tennessee to 14 percent in 2005 in Montana. The mean value of adolescents who abused drugs is 7 percent.

The United States department of education spent 140.9 billion dollars on education related expenses in 2014. Along with the national government expenditures, states may supplement with more spending. The per-pupil educational expenditures for each state vary based on the differences in spending. If governments are spending more per pupil, one would hypothesize that student performance would reflect positively, as students have access to more qualified teachers and availability of resources conducive to learning (see, for example Elliott, 1998). This variable is measured in dollar amounts per student for all fifty states for the years 2005-2012. It was collected by the National Center for Education statistics. Per pupil expenditure ranges from 5,463 dollars in Utah to 19,534 dollars in 2011 in Wyoming. The mean value was 10,882 dollars.

The variable 'Higher Education' measures the percentage of total population 25 years and over with a Bachelor's degree or higher. This data is obtained from the Decennial Census and the Current Population Survey (CPS) on educational attainment collected by the United States Census Bureau (USCB). This variable is included to proxy for the inducement or encouragement factor since a greater percentage of the population with higher education is likely to induce more high school seniors to choose to go to college, and thereby aim to do well on the standardized tests. The mean of this variable across all states over 2005-12 was 27.25% with a minimum of 15.1% in 2005 in West Virginia and a maximum of 39.5% in 2012 in Massachusetts.

The variable 'High School Graduates' measures the number of public high school graduates in thousands in each state. The data for this variable is obtained from the Digest of Education Statistics and Projections of Education Statistics by the U.S. National Center for Education Statistics. This variable is hypothesized to be associated with student performance, although the direction of association remains uncertain. The mean of this variable across all states over the period 2005-12 was 58,150 with a minimum of 5,140 in 2012 in Wyoming and a maximum of 383,638 in 2010 in California.

The variable 'Unemployment' measures the percentage of total non-institutional population 16 years and over that is unemployed. The mean unemployment rate across all states over 2005-12 was 6.4% with a minimum of 2.4% in 2006 in Hawaii and a maximum of 14.9% in 2010 in Nevada. This variable is included to control for the labor market conditions.

The variable 'Hourly Wage' measures the hourly wage for all occupations and these figures have been obtained from the Occupational Employment Statistics program of the BLS. The mean hourly wage across all states over 2005-12 was $19.49 with a minimum of $13.99 in 2005 in Mississippi and a maximum of $26.73 in 2012 in Massachusetts. This variable is also included to control for the labor market conditions.

We also control for Men and women. The data consists of civilian non-institutional males and females, and have been obtained from the Bureau of labor statistics' Geographic Profile of Employment and Unemployment.

5. Results

Table 2 presents the estimation results. Column 1 shows the estimations of the pooled OLS, Column 2 of the fixed effects, and column 3 of the system GMM. Robust standard errors are presented in the parentheses. The coefficient of food insecurity under the OLS estimation is negative and statistically significant at the 5% level, implying that an increase in the proportion of food insecure households is negatively associated with the Math-SAT score. However, when the state level time-invariant unobserved determinants of Math-SAT scores are differenced out under the fixed effects estimation, the coefficient of food insecurity while still remaining negative in sign, becomes statistically insignificant at the conventional levels. This estimator, however, is not able to remove all sources of endogeneity for the reasons discussed earlier. According to the system GMM estimation result, which aims to control for all potential sources of endogeneity, the coefficient of food insecurity remains negative and increases in magnitude, and also becomes statistically significant at the 1% level. Comparing the OLS estimate with the system GMM estimate, we can say that the unobserved state-level determinants of average Math-SAT scores were driving the coefficient of food insecurity up, but once these unobserved determinants are controlled for under the system GMM, the coefficient of food insecurity has a more pronounced adverse impact on the Math-SAT scores. Thus, in the light of the above discussion, we can conclude that food insecurity adversely impacts student learning outcomes, as measured by the performance on the Math-SAT standardized examination.

The above conclusion is robust to the inclusion of time trend, quadratic time trend, and median household incomes. These results will be provided upon request.

According to the system GMM estimation, the other statistically significant determinants of Math-SAT scores are: the one-period lagged Math-SAT score, poverty rate, unemployment rate, and white population.

The Math-SAT score in the previous year is positively associated with the Math-SAT score in the current year, suggesting that at the state level student performance persists over time and there is an inbuilt inertia in the system that propels performance. More research is needed to examine the causes of this inertia.

Poverty is negatively associated with Math-SAT score, implying that an increase in the percentage of households with children below eighteen years of age and who fall below the one hundred and fifty percent of the federal poverty line results in a decline in the Math-SAT scores.

The labor market conditions also have bearings on the Math-SAT scores, as evidenced by the unemployment rate. An increase in the unemployment rate has a positive influence on the Math-SAT scores. This result might be due to the fact that students see a higher unemployment rate as a signal to study harder so that they can pursue higher education and later on able to secure jobs.

Finally, an increase in the proportion of white population is negatively associated with the Math-SAT score, suggesting that a reduction in racial diversity has a negative influence on the Math-SAT scores at the state level.

6. Discussion

In the light of the results of this paper, we can safely say that even though the government has created several programs to supplement the nutrition of both children and adults, it is likely that these programs are not enough. These programs, including the Supplemental Nutrition Assistance Program and the National School Lunch Program, perhaps need to be reevaluated in an attempt to be more effective.

As the United States continues to be among the lower ranks of the OECD countries in terms of math, science, and reading skills of fifteen-year-old children (PISA rankings) [3], perhaps it's time to acknowledge that the country must first address the physiological needs of its population. The educational ranking leaves the United States government and population in angst, but if it is truly the desire of the country to improve its education, leaders must look outside the box. When children are concerned about when and if they will receive their next meal, and suffering physically and mentally from the malnutrition caused by food insecurity, it seems unfair to expect these young minds to sincerely focus on the long, tedious exams that are created to test their intelligence. One must improve the foundation of the child environment before it can expect the young minds to understand, apply, and utilize the countless pieces of knowledge in the way that the educators expect them to.

7. Conclusions

Food insecurity is a vexing issue affecting all of the humanity including the richest countries. So, it is no surprise that food insecurity has received substantial attention in the US as well. Food insecurity has been shown to have adverse impacts on growing children in terms of mental development, social well-being, among others. A few micro level studies have linked food insecurity to student performance on the standardized tests, and have found mixed evidence.

This study explores this issue using a macro-level data of the US states from 2005-12 and finds that food insecurity adversely affects the Math-SAT scores of students. This finding is robust to the endogeneity bias of food insecurity in the student performance regression, as a dynamic panel data specific system GMM estimator has been used to control for endogeneity bias.

The findings of this study call into question the current government led food assistance program's effectiveness in dealing with food insecurity and hunger, especially among children.

Endnotes

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Table 1: Summary Statistics

Variable	Mean	S.D.	Min	Max
Math-SAT	539.8997	39.78662	457	617
Food insecurity	.194725	.0427023	.09	.3
Poverty	.29795	.0689506	.15	.48
Single Parent	.32435	.0516793	.18	.49
White	.63515	.1708257	.13	.93
Drug Abuse	.0763143	.0126157	.05	.14
Educational Expenditure	10911.44	2539.507	5463	19534
Higher Education	27.257	4.824005	15.1	39.5
High School Graduates	58.1506	65.75002	5.14	383.63
GDP per capita	46806.68	8615.223	30988	72281
Unemployment	6.43575	2.374393	2.4	14.9
Hourly Wage	19.38405	2.644734	13.99	26.73
Men	2265.713	2496.157	198	14341
Women	2417.585	2634.9	201	15007

Table 2: Dependent Variable – Math-SAT Score

Variables	(1) OLS	(2) Fixed Effects	(3) System GMM
Food insecurity	-1.478**	-0.535	-2.013***
	(0.695)	(0.507)	(0.700)
Educational expenditure	-0.00124	0.000821	0.00175
	(0.000758)	(0.00110)	(0.00218)
Drug abuse	-0.713	0.280	-0.0227
	(0.783)	(0.466)	(0.520)
Single parent	-1.759***	-0.536	-1.286
	(0.612)	(1.083)	(1.278)
poverty	2.331***	-0.147	-1.637**
	(0.558)	(0.802)	(0.806)
GDP per capita	0.000607*	0.000395	0.00162
	(0.000316)	(0.000664)	(0.00107)
Hourly wage	-2.606***	-0.810***	0.230
	(0.982)	(0.247)	(0.525)
Unemployment	-0.0389	-0.397	1.849*
	(1.009)	(0.766)	(1.052)
Higher education	0.353	-0.0457	-1.741
	(0.548)	(1.267)	(2.383)
High school graduates	0.878***	-0.0356	-0.387
	(0.160)	(0.109)	(0.313)
white	0.448***	-1.979	-3.685**
	(0.122)	(1.211)	(1.562)
men	-0.00521	0.0235	0.0565
	(0.0234)	(0.0482)	(0.0470)
women	-0.0181	-0.0329	-0.0551
	(0.0202)	(0.0465)	(0.0410)
Lag Math-SAT			-0.371***
			(0.0550)
Constant	563.5***	716.3***	
	(36.41)	(100.5)	
Observations	398	398	297
R-squared	0.276	0.033	
Number of state		50	50

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1