Estimating Plate-Lunch Demand:
A Bottom-Line Assessment of the Competitive School Food Environment

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Abstract

Direct regulation of school lunch content seems an intuitive approach for improving the nutrition of many American children. However, little is known about substitution patterns in response to such efforts, particular the likelihood that children and parents will turn to competitive foods outside the control of schools such as packed lunches. To our knowledge, no previous work documents if increasing the healthfulness of school lunches leads children to leave the school lunch line for potentially less nutritious options. To address this paucity of information we estimate the demand for school lunches as a function of calories provided and entrée protein source for a single elementary school. Our results suggest a highly inelastic response to a meal's calorie content and considerable sensitivity of demand to entrée protein source, suggesting that reductions in calorie content that may be possible under proposed changes to Federal regulation may enhance food service profits. In addition to using past records of lunch sales, we have launched a survey that explicitly explores the role of price, perceived palatability and perceived healthfulness on demand for school lunches. We discuss how this data will allow for the estimation of latent classes of decision makers that are shaped by household demographics, food and health attitudes and child involvement in the decision making process and how the data will help to decompose the drivers of demand for plate lunches in the district.

Motivation

School lunches play a pivotal role in the nutrition of U.S. children. Recognizing this, Federal policy guides the nutritional profile of foods offered as part of the National School Lunch Program (NSLP). Outside of the NSLP, other 'competitive' foods are often available to students, with estimates that 40% of students consume at least one competitive food each day (Fox et al. 2009). Recent policy efforts attempt to address competitive foods controlled by schools as part of a la carte offerings within school lunch rooms and as part of sales from stores and vending machines located in schools. At least 27 states have passed laws to regulate these school-controllable competitive foods while all schools receiving federal subsidies for school nutrition programs must have local wellness committees who address the nutritional profile of all foods controlled by school authorities (Guthrie, Newman and Ralston 2009).

While such direct regulation seems intuitive, little is known about the student and parent response to the alteration of school lunch menus or other school nutrition policies. Because children may not like all menu offerings, and because many school children can turn to competitive foods outside the domain of school regulation by packing a lunch or, in some districts, leaving campus for food, the school district could lose revenues from lunch substitution patterns arising from improved menu items with the improved nutrition going unsold or uneaten. Given the financial situations of many schools, districts put substantial pressure on food service divisions to maintain profitability (Wilde and Kennedy 2009). Furthermore, such a substitution away from school lunches to packed lunches or off-campus lunches may have counterproductive nutritional outcomes as research suggests that non-plate lunches are often less nutritious that school plate lunches (Condon et al. 2009; Hur, Burgess-Champoux and Reicks, 2011; see Schanzenback, 2009, for a result to the contrary).

We model NSLP plate-lunch demand among early elementary students in a single district in the Ohio to help the district understand demand for NLSP meals and predict revenues from these offerings. Paper records of elementary school plate-lunch demand were obtained from the Bexley, Ohio school district, an affluent public suburban school, for the years 2002 through 2009. We estimate plate lunch demand as a function calories, entrée protein source and weather. Fixed effects for day of the week, month and academic year are also included to account for weekly patterns of demand, seasonal demand shifters and alterations to school lunch prices, policies, total enrollments and record keeping, which occur each school year.

Previous work that directly focuses on school lunch demand dates from the 1980's and focuses largely on price sensitivity (Braley and Nelson 1975; Akin et al. 1983, Zucchino and Ranney 1990), a factor that is perfectly collinear with academic year effects in our model. Other more recent work focuses on modeling student perceptions of school food service operations (Meyer and Conklin 1998) or on student substitution patterns between foods of differing healthfulness offered within the school cafeteria environment (Grainger, Senauer and Runge 2007; Snelling, Korba and Burkey 2007; Hanks et al. 2012; Reicks et al. 2012). However, published empirical work that can be used to assess the trade-off between nutrition and profitability is limited (Sharma, Lambert and Conklin 2011).

We find that demand is positively affected by the calories available in the plate lunch, even when holding constant the protein source, though the demand elasticity in terms of calories in highly inelastic. At mean values, the model suggests that adding 80 calories to the meal would increase the number of lunches sold by 1%. The significant positive effect is not surprising, given that lunch prices are constant within an academic year regardless of entrée and calorie content. Given the fixed-price environment in which the plate-lunch demand is situated, this provides crucial information to school officials to assess the tradeoff between increasing costs via providing more calories per meal and increasing student demand. In short, it suggests that adding calories to a meal to induce additional demand would not be a profitable strategy given the inelastic response of demand to calories and that reductions in calories, which may be allowed under proposed changes to Federal regulations, would not harm sales revenues.

Furthermore, entrée protein source is highly significant ($p < 0.001$), with mixed-source protein entrees (e.g., hot dogs) being more popular than beef, chicken and vegetarian options, and fish being less popular than all other options. Strong day-of-the-week patterns also emerge, with Thursday and Friday being the most popular day for purchasing school plate lunch. Month and year fixed effects are also jointly significant and some weather effects emerge.

To understand the potential management latitude available to food service administrators, we estimate a more detailed model that includes more than 50 fixed effects for individual lunch items including the various main entrees, vegetables, fruits and other items that regularly appear in the data. Omitting all day, month, year and weather effects in this specification decreases the R2 of the model from 0.68 to 0.27, suggesting that variations in lunch menu offerings over the seven years have a moderate impact on daily plate lunch demand. However, it also suggests that key sources of variation in the demand for school lunches are due to weekly, seasonal and weather patterns and that year-to-year changes in food service and school environment have substantial impact on plate lunch sales.

We note that our approach is limited on several fronts. This approach fails to document if the food purchased is actually eaten. Hence, we are only able to wield our results to inform food service officials concerning the profitability of menu alterations with respect to entrees and caloric content. While profitability is an under-studied aspect of the school lunch interventions efforts discussed in the recent literature, we realize that integrating work such as ours with actual consumption data will be critical to make inferences about the nutritional implications of such alterations. Furthermore, we focus only on early elementary children in a single school. Clearly, more representative data would be needed to inform school officials in other districts. Given the recent spate of interest in behavioral interventions into improving children's nutritional outcomes, we believe our paper will stimulate significant discussion about how to translate such interventions in ways that school districts can afford.

Data & Model

Hand-written records of daily plate-lunch content and daily sales were obtained from food service officials at Bexley City Schools in Bexley, Ohio. Bexley is an affluent inner-suburb of Columbus, Ohio with a total population of 13,000, a median-family income of $83,000 and a homogeneous racial make-up (92% Caucasian). A substantial minority of Bexley residents are Jewish, which results in no offerings of pork as the main source of protein for any food service offerings. The records covered demand from first through third graders at one of the district's three elementary schools from 2002 through 2009. These grades are chosen because these students are not allowed to access a la carte offerings; they must choose the plate lunch menu, which is published well in advance, though they may substitute an alternative entrée (usually cheese pizza or a peanut butter and jelly sandwich) in place of the advertised main entrée.

Over these years the student population in these grades ranged from approximately 150 to 200 students while the number of students purchasing plate lunches averaged 48 (Table 1, first column), suggesting plate average daily plate-lunch uptake of less than one-third. For reference, the study by Hur, Burgess-Champoux and Reicks (2011) of fourth and fifth graders from two suburban elementary schools in Minneapolis revealed school lunch uptake of two-thirds, suggesting Bexley may be lower than national averages. Bexley allows students in these grades to go home for lunch (nearly all students live within a 15 minute walk of the school) or to bring a sack lunch from home.

A total of 744 days featured complete data; nearly complete coverage was available during the last two years of data (170+ days). Due to spotty physical records, early years feature substantially fewer observations (between 60 and 110 days per academic year). The missing records appear to occur idiosyncratically and we do not fear any systematic bias.

Each meal was coded for the protein source of the main entrée (beef, chicken, fish, mixed, which includes hot dogs and corn dogs, and non-meat entrees, which include cheese pizza and grilled cheese) and the total calories across all plate-lunch items. Caloric values for each lunch menu item were obtained from the United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference, Release 24. These caloric values were adjusted to the portion sizes served to the students as stated for that given day's school lunch record. The sum of all of the calories served for all listed items served was calculated to arrive at the total caloric content. For all lunches, an 8 oz serving of 2% milk was assumed since all school lunches include fluid milk as part of the meal.
Extensive dummy variables were also generated for individual entrée, fruit, vegetable, starch and other items. Daily weather variables, including minimum temperature in degrees Celsius and total precipitation from rain or snow in millimeters, were also included. To avoid correlation with monthly dummy variables, the minimum temperature variable is expressed as a deviation from the monthly average temperature observed in the data. Also, a dummy variable was created to indicate days that featured rain and maximum temperatures below 10 degrees Celsius. Price does not vary across offerings within the same year; hence it is not described or included in the model. Price differences, along with other lunch program changes that occur between school years, will be absorbed in the academic year fixed effects.

We model the number of meals purchased daily as a function of plate-lunch calories; entrée protein source; fixed effects for day-of-the-week, month and academic year; and weather variables. We also include dummy variables for two non-entrée items that revealed a large influence on demand in preliminary analysis – the serving of a roll and the serving of a particular processed fruit treat. We report both linear models and log-log models where the calories are the explanatory variable subject to transformation; both provide similar qualitative and quantitative results. We note that quadratic specifications of calories did not yield significant results in preliminary regressions and are not considered further. Robust standard errors are calculated (clustered) to account for correlation across observations from the same academic year. Both models yield a strong fit to the data, with R^2 values exceeding 0.60.

Results

We first consider and discuss variables under the control of food service managers. Higher calorie meals yielded higher daily sales with an elasticity of about 0.09 in the linear model (using an average daily sales of 48 and average daily calorie content of 688) and 0.06 in the log-log model. This is a highly inelastic response. To put this in perspective, for the linear model, an additional 77 calories added to a meal would increase sales by 1% (0.48 meals) while an additional 164 calories would sell one additional meal. Given meal prices ranged between 2 and 3 dollars during this era, and given an average of about 48 meals sold per day to this group, this means the food services staff would have to supply approximately 8700 more total calories to generate one additional sale yielding additional revenue of less than $3.00. Indeed, calorie reduction would seem the profitable adjustment, which might mean that proposed reductions in the minimum caloric levels of NSLP meals (Federal Register, 2011) could prove profitable for foodservice divisions.

The entrée protein source is also a significant driver of lunch demand with the dummy variables clearly achieving joint significance ($p < 0.001$). Fish, the omitted category, results in the lowest demand while the mixed category, which includes hot dogs and corn dogs, results in the highest demand. Demand for lunches with beef, chicken and vegetarian entrees (largely cheese pizza or grilled cheese entrees) are statistically similar, though significantly higher than fish and significantly lower than mixed protein entrees. The magnitudes of the effects are large. For example, in the linear model, substituting a mixed protein entrée in place of fish increases lunch demand by nearly 23 lunches, which translates to a 47% increase at the mean. It is not surprising that fish entrees were served in less than one percent of all meals. The addition of key side items, including a dinner roll or a popular processed fruit snack, also augmented lunch sales.

While the variables controlled by food service managers had large effects on demand, the bulk of the variation in the data is explained by items outside the control of the food service staff. For example, when only calories, entrée protein source and the two side-item dummies are included, the R^2 for the linear model drops to 0.05. We also explore an alternative specification in which the entrée protein source categorical variables is replaced with 50 detailed dummy variables for nearly all entrée, vegetable, fruit or other items that were offered more than a dozen times within the data set (detailed results are available but not displayed). This item-specific specification increases R^2 to 0.27, but the addition of the other variables (weather, day, month and year fixed effects) increases R^2 to 0.68. Academic year fixed effects had the largest explanatory value, with a trend towards greater demand in later years. Day-of-the-week effects were also significant, with demand increasing as the week progresses towards Friday. Weather also plays a minor role, with heavy precipitation increasing demand and unseasonably warm weather depressing demand.

We note that, within the item-specific specification, which provides detailed control for the various individual items offered on the plate lunch, the regression coefficient on calories declines by more than an order of magnitude and loses statistical significance. This suggests that substitutions across items drive lunch sales rather than simple manipulation of calories through, say portion size adjustment or augmentation of lunches with additional items. Put another way, it suggests that the source of the calories is the driver, and not merely more calories. Again, for foodservice managers, it suggests that downward adjustments of calories through smaller portions of existing popular items may have limited impacts on total lunch demand, though experimentation with different portion sizes would be necessary to confirm this result.

Results

	Summary Statistics	Linear Model	Log-Log Model
Dependent Variable: # Meals Sold	47.90 (16.05)		
Calories	688.46 (189.15)	0.006*** (0.002)	0.063*** (0.015)
<u>Protein Type</u>			
Fish (omitted)	0.4%	--	--
Chicken	22.8%	14.75*** (2.59)	0.26** (0.08)
Beef	24.0%	11.73*** (2.16)	0.22*** (0.060
Mixed (includes Hot Dogs)	22.6%	22.58*** (2.56)	0.42*** (0.06)
Vegetarian (includes Cheese Pizza)	30.2%	14.25*** (2.27)	0.24*** (0.07)
<u>Popular Additional Items</u>			
Roll	16.5%	9.08*** (1.31)	0.064*** (0.010)
Fruit by the Foot	0.4%	3.23*** (0.60)	0.160*** (0.026)
<u>Day of the Week</u>			
Monday (omitted)	20.3%	--	--
Tuesday	22.3%	2.89* (1.37)	0.059* (0.029)
Wednesday	21.5%	1.34 (0.82)	0.029 (0.017)
Thursday	20.5%	4.18*** (0.90)	0.094*** (0.025)
Friday	15.4%	5.44*** (1.43)	0.095** (0.032)
<u>Month</u>			
Jan (omitted)	11.5%	--	--
Feb	9.5%	1.14 (1.37)	0.034 (0.029)
Mar	10.5%	-0.23 (0.63)	-0.001 (0.011)
Apr	13.4%	-0.61 (0.96)	-0.001 (0.017)
May	11.0%	3.30 (2.61)	0.02 (0.054)
Jun	2.0%	5.84*** (1.59)	0.121*** (0.032)
Aug	3.0%	-7.89 (6.99)	-0.153 (0.139)
Sep	10.2%	-0.79 (3.99)	-0.003 (0.019)
Oct	11.9%	-1.19 (0.93)	-0.036 (0.019)
Nov	8.7%	-0.58 (1.28)	0.001 (0.027)
Dec	8.3%	2.61 (1.38)	0.059* (0.028)
<u>Year</u>			
2002-2003 (omitted)	9.9%	--	--
2003-2004	13.6%	7.98*** (0.57)	0.254*** (0.012)
2004-2005	14.6%	17.40*** (0.99)	0.479*** (0.017)
2005-2006	8.2%	12.21*** (1.33)	0.359*** (0.024)
2006-2007	9.1%	19.22*** (0.99)	0.516*** (0.015)
2007-2008	21.9%	26.48*** (0.91)	0.662*** (0.014)
2008-2009	22.7%	38.25*** (0.86)	0.858*** (0.015)
<u>Rain + Snow (in mm)</u>			
None (omitted)	59.1%	--	--
Trace – 5 cm	38.9%	0.29 (0.78)	-0.002 (0.021)
5 cm – 10 cm	1.6%	1.41 (2.00)	0.029 (0.047)
> 10 cm	0.4%	3.57** (1.03)	0.081** (0.025)
<u>Other Weather Variables</u>			
Temp – Monthly Ave Temp (°C)	-0.009 (5.14)	-0.14* (0.06)	-0.002 (0.001)
Cold Rain (rain>0 & max temp<10 °C)	13.8%	-1.19 (1.22)	-0.005 (0.024)
Intercept		3.89* (1.98)	2.534*** (0.110)
N	745	745	745
R^2		0.65	0.63

Conclusions

Understanding the foods and food sources that compete with the Federally subsidized plate lunch is critical for assessing proposed changes to Federal, state and local food and nutrition policies. Indeed, certain classes of competitive foods – those sold or controlled by schools – are increasingly addressed by policy at several levels. However, other classes of competitive foods outside the control of schools must also be considered when assessing proposed policies. Packed lunches and off-campus meal options represent key competition in many districts. Nationally, 6% of elementary schools and 28% of high schools allow students to leave campus at meal times (CDC 2006). While off-campus meal competition may be addressed in some districts via changes in school rules, prohibiting students from bringing their own lunches seems to be a more difficult policy to introduce and enforce (Eng and Hood, 2011). Hence, understanding the competition between plate and packed lunches represents an important domain for research.

Extant research is largely silent on potential competition between plate and packed lunch, though several studies do compare the nutritional profiles of plate versus packed lunches (Condon et al. 2009; Hur, Burgess-Champoux and Reicks, 2011) or compare obesity rates between students who predominantly each plate versus packed lunches (Schanzenback, 2009). The former studies find that the nutritional profile of packed lunches is inferior to the NSLP lunch sold by the school while the Schanzenback (2009) study finds that the health status of children who rely primarily upon packed lunches is actually superior to those students who rely primarily on school lunches. Hence, further work may be needed to clarify the nutritional and health ramifications of substitution between school and packed lunches.

There is increasing investigation of the substitution patterns between healthy and unhealthy foods conditional on students opting into the school lunch line (Grainger, Senauer and Runge 2007; Snelling, Korba and Burkey 2007; Hanks et al. 2012; Wansink, Just and Payne 2008). This work is critical as it provides guidance to school officials who hope to alter food service design or educational efforts to improve the healthfulness of the food that students choose and consume after they have opted into school-based sources of nutrition. To our knowledge, only the work of Sharma, Lambert and Conklin (2011) directly examines how policies aimed at improving the nutritional content of school-controlled competitive foods affects the perceived profitability of school food services division. However, to our knowledge, there is little focus on the extensive margin, i.e., on whether the alterations repel or attract students into school food service programs.

Understanding school food services' extensive margin requires understanding the often complex intra-household decision making process that governs a child's lunch choices. The role of children on household food purchase decisions varies considerably (Wilson and Wood 2004) and the considerations concerning lunch potentially include issues related to health, taste, cost, peer influences and logistics. In addition, unlike home-cooked or restaurant meals, where parents have direct supervision over foods chosen and consumed, lunches consumed at school are done so outside the direct supervision of parents. Hence, a parent-packed lunch allows for control over the items available for eating (or trading) by the child. Each of these dimensions may play a role in driving the sale of school plate lunch and the subsequent profits of school food service divisions and the nutrition of children.

We note that our approach is limited on several fronts. This approach fails to document if the food purchased is actually eaten. Hence, we are only able to wield our results to inform food service officials concerning the profitability of menu alterations with respect to entrees and caloric content. While profitability is an under-studied aspect of the school lunch interventions efforts discussed in the recent literature, we realize that integrating work such as ours with actual consumption data will be critical to make inferences about the nutritional implications of such alterations. Furthermore, we focus only on early elementary children in a single school. Clearly, more representative data would be needed to inform school officials in other districts. Given the recent spate of interest in behavioral interventions into improving children's nutritional outcomes, we believe our paper will stimulate significant discussion about how to translate such interventions in ways that school districts can afford.

References

Akin, J.S., D.K. Guilkey, B.M. Popkin and J.H. Wyckoff. 1983. The demand for school lunches: An analysis of individual participation in the school lunch program, Journal of Human Resources, 18(2):213-230.

Brayley, G.A. and P.E. Nelson. 1975. Effect of a controlled price increase on school lunch participation: Pittsburgh 1973. American Journal of Agricultural Economics, 57(1):90-96.

Centers for Disease Control and Prevention (CDC), National Center for Chronic Disease Prevention and Health Promotion, Division of Adolescent and School Health. 2006. Fact Sheet: Foods and Beverages Sold Outside of the School Meal Programs, 2000. Available online at: http://www.cdc.gov/healthyyouth/shpps/2006/factsheets/pdf/FS_FoodandBeverages_SHPPS2006.pdf

Condon, E.M., M.K. Crepinsek and M.K. Fox. 2009. School meals: Types of foods offered to and consumed by children at lunch and breakfast, Journal of the American Dietetic Association, 109:S67-S78.

Eng, M. and J. Hood. 2011. Chicago school bans some lunches brought from home, Chicago Tribune, April 11.

Federal Register. 2011. Nutrition standards in the national school lunch and school breakfast programs, Volume 76(9):2494-2570, January 13.

Fox, M.K., A. Gordon, R. Nogales, A. Wilson. 2009. Availability and consumption of competitive foods in US public schools, Journal of the American Dietetic Association, 109:S57-S66.

Grainger, C., B. Senauer and C.F. Runge. 2007. Nutritional improvements and student food choices in a school lunch program, Journal of Consumer Affairs, 41(2):265-284.

Guthrie, J., C. Newman and K. Ralston. 2009. USDA school meal programs face new challenges, Choices, 24(3):article 2, available online at: http://www.choicesmagazine.org/magazine/article.php?article=83

Hanks, A.S., D.R. Just, L.E. Smith and B. Wansink. In Press. Healthy convenience: Nudging students toward healthier choices in the lunchroom, Journal of Public Health.

Hur, I., T. Burgess-Champoux and M. Reicks. 2011. Higher quality intake from school lunch meals compared with bagged lunches, ICAN: Infant, Child & Adolescent Nutrition, 3(2):70-75.

Meyer, M.K. and M.T. Conklin. 1998. Variables affecting high school students' perceptions of school foodservice. Journal of the American Dietetic Association 98(12):1424-1431.

Reicks, M, J.P. Redden, T. Mann, E. Mykerezi and Z. Vickers. 2012. Photographs in lunch tray compartments and vegetable consumption among children in elementary school cafeterias, Journal of the American Medical Association, 307(8):784-785.

Schanzenbach, D.W. 2009. Do school lunches contribute to obesity? Journal of Human Resources, 44(3):684-709.

Sharma, A., C. Lambert and M. Conklin. 2011. The relationship of à la carte revenues to the implementation of school nutrition standards, Journal of Foodservice Business Research, 14(4):380-392.

Snelling, A. M., Korba, C. and Burkey, A. 2007. The national school lunch and competitive food offerings and purchasing behaviors of high school students. Journal of School Health, 77: 701–705.

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