School Breakfast and Lunch Costs: Are There Economies of Scale?

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Abstract:

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On a given school day, over 31 million lunches and 10.1 million breakfasts are served to children in participating American schools through the USDA National School Lunch and School Breakfast Programs. The United States Department of Agriculture reimburses schools for some or all of their costs. Reimbursement rates are based on an average meal cost, adjusted each year based on the national CPI for food away from home. There is no adjustment for school characteristics such as size, although there can be as much as a seven-fold difference in the number of meals served, from the smallest to largest schools. Yet, economists have shown that economies of scale exist in a variety of commercial and industrial settings. Thus, we use a multiproduct translog cost function to estimate the costs of school breakfasts and lunches. Results indicate substantial and persistent economies of scale across 21 locations for school breakfasts but few unexploited scale economies in school lunches.

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Over 31 million lunches and 10.1 million breakfasts were served each day to children in schools participating in the United States Department of Agriculture's (USDA) National School Lunch and School Breakfast Program (NSLP) and School Breakfast Program (SBP) in 2009 (Oliviera, 2010). The school food authorities (SFAs) that prepared and served these meals were required then and must still provide appealing, healthful meals within the USDA reimbursement rates. Separate reimbursement rates are established at a national level set for both NSLP lunches and breakfasts. The reimbursement rate varies depending on the household income of the child to whom the meal is served and the overall prevalence of needy children within a school, but is otherwise the same for each SFA, regardless of other differences in SFA characteristics and the number of lunches or breakfasts provided.

Policy-makers use the results of studies that used cost accounting methods to determine the costs of NSLP lunches and SBP breakfasts and the adequacy of reimbursement rates. The cost estimates are based on nationally representative school NSLP lunches and SBP breakfasts. The most recent cost study -- The School Lunch and Breakfast Cost Study (SLBCS-II) for the 2005-2006 school year -- estimated the full cost of an average lunch as $2.79 and estimated the full costs of an average breakfast as $1.81 (Bartlett, Glanz, and Logan, 2008). No adjustments were made for different SFA characteristics, such as the numbers of lunches or breakfasts served. Yet, SFAs vary tremendously in number of meals served, with larger SFAs serving up to seven times as many meals as smaller SFAs, and empirical economists have demonstrated that economies of scale exist in a variety of industrial and commercial settings.

The purpose of this paper is to examine how cost per lunch and cost per breakfast change across different geographic locations as the number of lunches and breakfasts change. Results have useful implications for policy, given that the adequacy of reimbursements to support provision of healthful, appealing meals is currently a topic of policy debate. Breakfast costs, in particular, are a subject of concern, as the USDA School Lunch and Breakfast Study II concluded that 64 percent of SFAs served breakfasts at costs that exceeded their reimbursements.

In previous research using econometric methods to account for various characteristics, Bartlett, Glanz, and Logan (2008) evaluated meal costs with a partial cost function but made several strong assumptions, such as costs per breakfast being a fixed fraction of costs per lunch, that cast doubts on their results. Ollinger, Ralston, and Guthrie (2011) used a single-product translog cost function to examine costs in 21 locations (three types of Metropolitan Statistical Areas (MSAs) in each of the seven Food Nutrition Service (FNS) regions). They found substantial cost variation across locations and economies of scale in the number of prepared meals but could not assess economies of scales in lunches and breakfasts separately.

This paper differs from Bartlett, Glanz, and Logan (2008) in that it used a translog cost function to evaluate costs per meal and it differs from Ollinger, Ralston, and Guthrie (2011) in that it uses a multi-product rather than single product translog cost function to obtain separate cost estimates for NSLP lunches and SBP breakfasts across 21 locations. Results suggest that there are substantial economies of scale that remain to be exploited in SBP breakfasts but that most scale economies have been exhausted in NSP school lunches. Results also show wide variations across locations. The paper proceeds as follows. First, we give a brief overview of the NSLP and SBP programs. Then, we present our model and describe the data. Next, we explain model selection and the estimation procedures and give results. This is followed by a discussion of economies of scale and a conclusion.

The National School Lunch Program

More than 42 million NSLP lunches and SBP breakfasts were served each day at a cost of more than $12 billion in 2009 (Oliviera, 2010). Under these programs, SFAs are expected to meet nutrition guidelines for the meals they serve. They are reimbursed for part or all of the meal costs by the Food and Nutrition Service (FNS), the agency that administers USDA's food assistance programs at the Federal level. Note, SFAs provide meals to local schools and often have the same boundaries as a school district, but they can be smaller than the district or be responsible for more than one district.

Reimbursement rates depend on whether the meal is a lunch or a breakfast and whether the student is certified to receive the meal for free or at reduced or full price. Students may be certified to receive the meals for free if household income is below 130 percent of the poverty level, or at a reduced price of no more than 40 cents for lunch and 30 cents for breakfast for households with income between 130 and 185 percent of poverty. For example, a student in a family of four with a household annual income below $28,665, which is 130 percent of $22,050 (the 2010 poverty level for a family of four), could be eligible to receive free meals.

The large volume of meals served means that differences of even a few cents in meal costs, meal prices, or meal reimbursements paid by USDA to SFAs can have a large impact on school, household, and USDA budgets. Reimbursement rates are the same for all SFAs except for adjustments for SFAs in Alaska or Hawaii or for individual schools located where most children receiving school meals live in low-income households. Schools receive an extra 2 cents per lunch if at least 60 percent of lunches served in the second preceding school year were reimbursed at the free or reduced-price rates. In the SBP, the bar is set lower and the additional reimbursement is higher: Schools that are designated as “severe need” receive an additional 24 cents for free and reduced-price breakfasts if 40 percent of lunches served in the second preceding school year were free or reduced price. Each year, reimbursement rates are updated based on the national average Consumer Price Index for all Urban Consumers for Food Away From Home

A Model of School Meal Costs

There are three types of commonly used total cost functions: the Cobb-Douglas, Constant Elasticity of Substitution (CES), and translog. Only the translog cost function allows for more than two inputs, places no a priori restrictions on substitution elasticities—i.e., the ratio at which inputs, such as capital and labor, substitute for each other—and is consistent with constraints typically assumed by economists (Berndt, 1991). In addition, this second-order Taylor expansion in log form is very general and permits a variety of possible production relationships, including returns to scale, optimal input shares that vary with the level of output and characteristics, and nonconstant elasticities of input demand. Different specifications allow for alternative ways in which characteristics can be combined to examine their impact on costs, which is important because it allows us to examine the diverse production practices followed by SFAs across the United States.

The translog cost function can be adapted for either single or multiple products. A single product cost function assumes that one product may or may not have variations. Product variations are accounted for by model characteristics. An important advantage of this approach over multiproduct cost functions is that it allows researchers to examine industries in which some plants produce multiple products and others produce one. The model accommodates multiple products by including variables in the model that account for differences in product qualities. Several researchers have used single-output cost functions with product quality variables. Allen and Liu (1995), for example, used a single product translog cost function in his study of trucking establishments and MacDonald, et al, (1999) and Ollinger, MacDonald, and Madison, (2000) examined the cattle, hog, and poultry slaughter industries.

A multiple-product (or multiproduct) cost function (Baumol, Panzar, and Willig, 1982) allows for two or more distinct products. In this model, different outputs enter the cost function separately. This approach has been widely used in a variety of settings, including hospital costs (Bilodeau, Cremieux,, and Ouellette, 2000), police departments

(Gyimeh-Brempong, 1987), Milk assembly costs (Gallagher, Thrain, and Schnitkey, 1993), childhood education (Powell and Cosgrove, 1992), and Federal Reserve payment processing (Adams, Bauer, and Sickles, 2004).

The school meal program includes three types of meals: breakfasts, lunches, and after-school snacks. SFAs may offer only one meal (e.g., lunches), all three meals, or any combination of two meals. School lunches are by far the most popular meal, with more than three times as many lunches served as breakfasts. Nevertheless, a substantial number of breakfasts are served and must be accounted for. After-school snacks are a much less popular item and are generally very low cost. These were dropped after they were shown to be insignificant to model fit.

We specify a multiproduct cost function (equation 1) with the number of breakfasts (BFAST) and the number of lunches (LUNCH) as outputs. The input prices are for food, labor, and supplies (P_{FOOD}, P_{LAB}, and P_{SUPPLY}). We also include dummy variables to account for whether the SFA reports capital costs (C_{cap}), SFA urbanicity (C_{SUBURB}, C_{RUR}, and C_{LUNCH}), and FNS region of the country ($C_{ATLANTIC}$, etc). There are also a number of control variables accounting for serving size ($C_{HIGH\_SCHOOL\_LO}$, $C_{HIGH\_SCHOOL\_HI}$), SFA options (C_{HEALTH}, $C_{FOOD\_SERVICE}$, and C_{FREE}) and meal value ($C_{VALUE\_LO,}$ $C_{VALUE\_HI,}$ and C_{VALUE_LO}). All variables are defined in table 1.

$$(1) \qquad \ln C_i = \alpha_0 + \sum_i \beta_i \ln P_i + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln P_i * \ln P_j + \gamma_L \ln LUNCH$$

$$+ \gamma_{LL}(\ln LUNCH)^2 + \sum_i \gamma_{Li} \ln LUNCH * \ln P_i + \omega_B \ln BFAST + \omega_{BB}(\ln BFAST)^2$$

$$+ \sum_i \omega_{Bi} \ln BFAST * \ln P_i + \sum_i \pi_{URi} C_{URBANICITY_i} + \sum_i \sum_j \sigma_{ij} C_{URBANICITY_i} * \ln P_j +$$

$$\sum_i \sigma_{Lu_I} C_{URBANICITY_i} * \ln LUNCH + \sum_i \sigma_{BU_I} C_{URBANICITY_i} * \ln BFAST + \sum_i \pi_i C_{REGION_i} +$$

$$\sum_i \sum_j \pi_{ij} C_{REGION_i} * \ln P_j + \sum_i \pi_{iL} C_{REGION} * \ln LUNCH + \sum_i \pi_{iB} C_{REGION} * \ln BFAST +$$

$$\delta_{cap} C_{cap} + \sum_i \delta_{capi_i} C_{cap} * \ln P_i + \delta_{capL} C_{cap} * \ln LUNCH + \delta_{capB} C_{cap} * \ln BFAST$$

$$+ \sum_i \psi_{HSi} C_{HIGH\_SCHOOL_i} + \sum_i \sum_j \psi_{HSij} C_{HIGH\_SCHOOL_i} * \ln P_j + \sum_i \psi_{HSLi} C_{HIGH\_SCHOOL} * \ln LUNCH$$

$$+ \sum_i \psi_{HSBi} C_{HIGH\_SCHOOL} * \ln BFAST + \sum_i \psi_{HSiK} C_{HIGH\_SCHOOL_i} * C_{cap}$$

$$+ \sum_i \psi_{HSiS} C_{HIGH\_SCHOOLi} * C_{SERVICE} + \psi_H C_{HEALTH} + \sum_i \psi_{Hi} C_{HEALTH_i} * \ln P_i$$

$$+ \psi_{HL} C_{HEALTH} * \ln LUNCH + \psi_{HB} C_{HEALTH} * \ln BFAST + \upsilon_S C_{SERVICE} + \sum_i \upsilon_{Si} C_{SERVICE} * \ln P_i$$

$$+ \sum_i \upsilon_{SL} C_{SERVICE} * \ln LUNCH + \sum_i \upsilon_{SB} C_{SERVICE} * \ln BFAST + \psi_F C_{FREE} + \sum_i \psi_{F_i} C_{FREE_i} * \ln P_i$$

$$+ \psi_{LM} C_{FREE} * \ln LUNCH + \psi_{BM} C_{FREE} * \ln BFAST + \sum_i \omega_i C_{Value_i} + \sum_i \sum_j w_{ij} \ln C_{Value_i} * \ln P_j$$

$$+ \sum_i \omega_{LV_{iI}} \ln C_{Value_i} * \ln LUNCH + \sum_i \omega_{BV_{iI}} \ln C_{Value_i} * \ln BFAST + \kappa_L C_{LACARTE}$$

$$+ \sum_i \kappa_{L_i} C_{LACARTE_i} * \ln P_i + \kappa_{LL} C_{LACARTE} * \ln LUNCH + \kappa_{LB} C_{LACARTE} * \ln BFAST + \varepsilon_i$$

where C_i is the total cost of labor, food, and supplies and the other variables are as defined in table 1.

The cost function can be estimated directly, but parameter estimates are often inefficient because of multicollinearity among explanatory variables. Gains in efficiency can be realized by estimating the factor demand equations (cost-share equations) jointly with the cost function. The equations are obtained from the derivatives of the total cost function with respect to each price (equation 2).

$$2)\quad \frac{\partial lnC}{\partial\, lnP_i} = \frac{P_i\, X_i}{C} = \beta_i + \sum_j \beta_{ij} \ln P_j \; + \gamma_{Li} \ln LUNCH \, + \omega_{BI} \, \ln BFAST + \sum_i \; \sum_j \; \sigma_{ij} C_{urbanicity_i}$$

$$+ \sum_i \; \sum_j \pi_{ij} C_{REGION_i} \; + \delta_i C_{cap} \; + \sum_i \psi_{HSi} C_{HIGH\_SCHOOL_i i} \; + \psi_{Hi} C_{HEALTH_i}$$

$$+ \upsilon_{Si} C_{SERVICE} \; + + \psi_{F_i} C_{FREE_i} \; + \sum_i \; w_{Vi} C_{VALUE_i} \; + \kappa_i C_{Lacarte}$$

All variables are normalized (i.e., divided by their mean values before estimation); thus, the first-order terms (the βs) can be interpreted as the estimated cost-share of factor i at mean values. The other coefficients show how characteristics affect costs and how the estimated factor shares change with changes in other prices, number of meals served, and characteristics. Price elasticities of factor demand can be derived from the coefficients and variables in the share equations.

Symmetry and homogeneity of degree one are imposed on the cost function in order to gain improvements in efficiency (Berndt, 1991). Symmetry means that the coefficients on all interaction terms with identical components are equal (that is, the coefficients β_{ij}=β_{ji}, γ_{iL} = γ_{iL}, $\omega_{Bj=}\omega_{Bj}$, $\sigma_{U,i}$ = $\sigma_{i,U}$, $\pi_{i,j}$ = $\pi_{ji,}$ $\delta_{cap,i}$=, $\delta_{i,cap}$, $\psi_{HS,i}$ = $\psi_{,i,HS}$, $\psi_{H,i}$ = $\psi_{,i,H}$, $\upsilon_{S,i}$ = $\upsilon_{S,i}$, $\psi_{F,i}$ = $\psi_{,i,F}$,$\varphi_{v,i}$=$\varphi_{i,v}$, and $\kappa_{L,j}$=$\kappa_{j.L}$. The omitted variables are not reported because they are implied.

Homogeneity of degree one means that if all inputs are doubled, then output (meals served) also doubles. Systems that are homogeneous of degree one have the following properties: $\sum\beta_i$=1, $\sum\gamma_{Li}$=0, $\sum\omega_{Bj=}$0, $\sum\sigma_{U,i}$=0, $\sum\pi_{i,j}$=0, $\sum\delta_{cap,i}$ =0, $\sum\psi_{HS,i}$ = 0, $\psi_{H,i}$=0, $\sum\upsilon_{S,i}$ =0, $\sum\psi_{F,i}$ =0, $\sum\varphi_{v,i}$=0 and $\sum\kappa_L$=0.

Data

Data are from a nationally representative sample of SFAs stratified by FNS region and conducted by Mathematica Policy Research (MPR) in the Spring of 2004 for the 2002-03 school-years (MPR, 2004) to support the SLBC-II study. Survey data were collected with three instruments: a one-page fax-back form, a brief telephone interview, and a 4-page self-administered survey on costs and revenues and related characteristics. The fax-back form requested general SFA characteristics, such as student enrollment; the telephone survey obtained information on the use of food service management companies and other non-numerical information; the self-administered cost and revenue file contains detailed information on 1,665 SFAs and contains detailed information on food, labor, and material costs. MPR also constructed a link file containing information on school district enrollment and demographic and wealth characteristics that was drawn from the National Center for Educational Statistics Common Core Data CCD (NCES, 2004) and from U.S. Census Bureau data.

Not all respondents replied to all questions. Complete and usable data were available from 1,432 respondents that serve lunches only or lunches and breakfasts. We dropped all observations of SFAs that did not serve breakfasts, giving a final dataset that included 1,282 observations.

The survey of SFAs was a nationally representative sample but it still requires the use of sample weights to account for differences in the probability of selection due to sample design, non-response, and ineligibility. These weights were provided by Mathematica Policy Research Inc.

There was no direct measure of meal value available for this study. However, there was an ample amount of data on meal costs and school and local economic characteristics. Using these data and the literature on food consumption, we created a model to estimate a measure of meal value based on the average price of a school meal.

Two measures of meal value were estimated: the probabilities of an SFA falling in the 90th percentile or higher of food prices (high value) and the probability of an SFA falling in the 10th or lower percentile of food prices. Estimation proceeded in the following way. First, we ranked the average price paid for a full-priced meal by each SFA from highest to lowest price. Then, we recognized that truly high-value meals exist at the 90th percentile or higher of all average prices paid for a school lunches and truly lower value meals occupy the 10th percentile or lower of all average prices of school lunches. For the higher value group, we set a dependent variable equal to one if it fell in 90th or higher percentile and zero otherwise, and, for the lower value group, we set the dependent variable equal to one if it fell in the 10th or lower percentile and zero otherwise. Next, relying on the literature on the economics of food consumption, we constructed a model of meal value. The variables and their definitions are given in appendix table A.1. Using a probit regression, we estimated the probabilities of an SFA serving low-value or high-value meals— i.e., falling in the 10th or lower percentile or falling in the 90th or higher percentile. We label the predicted probabilities of a meal price in the 10th or lower or 90th or higher percentile as C_{VALUE_LO} and C_{VALUE_HI}.

Estimation and Model Selection

The variable cost function (equation 1) is estimated jointly in a multivariate regression system with three factor demand equations (equation 2). Since the factor shares add to one, an equation must be dropped to avoid a singular covariance matrix. We dropped the supply share equation, meaning that the price of supplies and all of its interaction terms were dropped. Each equation in the system could be estimated by itself by ordinary least squares, but we used a nonlinear iterative, seemingly unrelated regression procedure to account for cross-equation correlation in the error terms.

The model described in equation (1) is quite general, so we used a Gallant-Jorgenson likelihood ratio test (a chi-Square test) to choose the specific model best able to explain school meal costs. Table 3 summarizes the model description, test models, and the relevant statistical information. In the first test (Model I versus Model II), a base model containing input prices and meals served is compared to the full model containing all variables. The full model is highly significant. The remainder of the table compares the full model to other models in which one variable was removed. In the last test, we evaluated the full model for homotheticity and found it to be non-homothetic. All variables in equation 1 were significant except for capital costs, worker health insurance, and whether the SFA offered free meals to all students. We retained all of these variables in the model because previous research (Ollinger, Ralston, and Guthrie, 2011) showed that these were important contributors to school meal costs.

Results of the Preferred Model

The final model includes variables for input prices, the number of lunches, the number of breakfasts, SFA location, whether the SFA reported capital costs, the number of high school students as a share of all SFA students (a proxy for meal size), the provision of health insurance, the use of a food management company, whether the SFAs serves free meals to all students, the sale of a la carte foods, and meal value. All dependent and explanatory variables are normalized by their sample means; thus, first-order coefficients can be interpreted as elasticities at their sample mean values.

Cost function estimates are given in table 4. The model R^2 is 0.9825. It is also important to examine the regularity conditions, particularly since the factor shares are highly skewed.

Diewert and Wales (1987) argue that the translog and other flexible functional forms can violate regularity. Overall, there were no violations of regularity since all cost share terms are positive. At the micro-level, supplies violated regularity in two percent of the observations; food and labor never violated regularity. These findings suggest that regularity conditions were generally met.

Table 6 compares the estimated costs to actual costs. It shows that the per meal cost estimate for MSAs within each region (location) is within 5 percent of actual cost in 14 of the 21 cases and the difference in costs between the two values exceeds 10 percent of actual costs in only 3 cases.

The reference SFA in table 4 is a southeast, urban SFA with no capital or health insurance costs and not serving a la carte foods or providing free meals to all students.

The parameter values for the first-order input price terms are input cost shares, food inputs (P_{FOOD}) account for about 60 percent of meal costs while labor (P_{LAB}) and supplies (P_{SUPPLY}) comprise about 34 and 6 percents of costs. The interaction terms show how estimates vary from the reference SFA value. For example, the coefficients on the interactions of C_{SUBURB} and C_{RURAL} with labor and food factor prices (P_{LAB} and P_{FOOD}) show how labor and food cost shares change in different urbanicities of the southeast. Interactions of rural and suburban and the labor and food input prices show that the food share is 7 percent lower (about 53 percent) and the labor share more than 6 percent higher (41 percent) in suburban and rural SFAs than in urban SFAs.

There are also sizeable difference in cost shares between the reference region (Southeast) and other regions. The Southwest had the greatest change in the labor share and the Midwest the largest change in the food share from the Southeast. Most regions had larger shares of labor and lower supply shares.

Now consider how cost shares change when the SFA offers health insurance. In the case of a southeastern SFA offering health insurance, the labor share rises from 33 to about 37 percent ($P_{LAB} + P_{LAB}*C_{HEALTH}$) and the food share drops to about 55 percent ($P_{FOOD} + P_{FOOD}*C_{HEALTH}$). Finally, if the southeastern SFA offered health insurance and was located in a suburban area, then the labor share would rise to about 43 percent ($P_{LAB} + P_{LAB}*C_{SUBURB} + P_{LAB}*C_{HEALTH}$) and the food share would drop to about 48 percent ($P_{FOOD} + P_{FOOD}*C_{SUBURB} + P_{FOOD}*C_{HEALTH}$). There are also substantial changes in cost shares for the use of food service management companies. Food and labor shares also change for different types of students served, a la carte food service, and meal value.

Table 6 gives the own-price elasticities and Allen and Morishima cross elasticities. The own-price factor demand elasticity shows how a given change in the price of factor j, such as food, affects demand for factor j – food.   Use of the same input should decline as its price rises. Table 6 shows that the own price elasticity labor and supplies is negative and of food is positive. The positive value for food was unexpected. It is small, however, and it can become negative for urbanicities other than an urban one and other SFA characteristics, such as whether workers receive health benefits.

The Allen cross elasticity indicates the degree of substitutability among inputs, i.e. how a change in the use of one input affects usage of a different input. The Morishima cross elasticity indicates how a change in the price of one input affects use of another input. Positive values for either of the cross elasticities indicate substitutability between inputs and negative values indicate that the inputs are complements. Table 6 shows that the signs on the coefficients of each of these elasticities are identical (where applicable).

The interaction term between lunches and breakfasts gives a measure of economies of scope in meal production. Table 4 shows that it is negative, suggesting that the cost of producing lunches drops as the number of breakfasts served increases and vice versa. A 10 percent increase in the number of NSLP lunches decreases the cost per breakfast by about one percent. Similarly, a 10 percent increase in the number of SBP breakfasts decreases lunch costs by about one percent at sample mean levels of output

Economies of scale

Economists have found that production systems exhibit increasing, constant, or decreasing economies of scale. Since school meal service involves the production of meals, the cost of production should be affected by the number of meals produced. The total differential of the translog cost function provides a measure of the response of short-run costs to a change in all outputs.

$$3) \quad d\ln C = \sum_j \partial \ln C / \partial \ln Y_j \, d\ln Y_i$$

Letting d $\ln Y_i$ equal 1 for both breakfasts and lunches and subtracting the expression from 1 provides a measure of short- run economies of scale. Larger numbers suggest greater economies of scale.

$$\begin{aligned}(4) \qquad scale = 1-(&\gamma_L+\gamma_{LL}(\ln LUNCH)+\sum_i \gamma_{Li}+\omega_B+\omega_{BB}(\ln BFAST)\\ &+\sum_i \omega_{Bi}P_i+\sum_i \sigma_{Lu_I}C_{URBANICITY_i}+\sum_i \sigma_{BU_I}C_{URBANICITY_i}+\sum_i \pi_{iL}C_{REGION}+\sum_i \pi_{iB}C_{REGION}\\ &+\delta_{capL}C_{cap}+\delta_{capB}C_{cap}+\sum_i \psi_{HSLi}C_{HIGH\_SCHOOL}+\sum_i \psi_{HSBi}C_{HIGH\_SCHOOL}\\ &+\psi_{HL}C_{HEALTH}+\psi_{HB}C_{HEALTH}+\sum_i \upsilon_{SL}C_{SERVICE}+\sum_i \upsilon_{SB}C_{SERVICE}+\psi_{LM}C_{FREE}\\ &+\psi_{BM}C_{FREE}+\sum_i \omega_{LV_{iI}}\ln C_{Value_i}+\sum_i \omega_{BV_{iI}}\ln C_{Value_i}+\kappa_{LL}C_{LACARTE}+\kappa_{LB}C_{LACARTE})\end{aligned}$$

Using sample mean data and setting all dummy variables to zero yields the following

$$(5) \qquad scale = 1-(\gamma_L+\omega_B)$$

The sum of the parameters on the NSLP lunch and SBP breakfast variables is less than one (0.96), suggesting increasing returns to scale at the sample-mean. Since the breakfast and lunch quadratic terms are positive, economies of scale diminish at output levels beyond the sample mean. Below, we examine how economies of scale affect breakfasts and lunches differently.

Economies of Scale in Breakfast Service

Our goal is to see how the cost of providing breakfasts changes with the number of SBP breakfasts served. One way to observe cost changes is to estimate the cost of breakfasts at various levels of output and then compare average costs at different output levels. However, the cost of NSLP breakfasts and lunches cannot both be directly estimated from equation one because there is one cost and two output variables. It is possible, however, to estimate the costs of SBP breakfasts over a range of SBP breakfast servings on the variable cost curve if the number of NSLP lunch servings does not change. This is not the average cost of a breakfast but only the average cost over range, such as the 100 breakfasts served over a range spanning from 501st to 600th breakfast.

We used the following procedure. First, we recognized that the difference between any two cost estimates at two different levels of meal service divided by the change in the number of meals served gives an average cost of a meal over a range of meal service, e.g. the 100 meals over the 501st to 600th breakfast. Next, we noted that, if the number of only one type of meal varies (SBP breakfasts), then the entire change in the number of meals served is due to an increase in the output of that type of meal (SBP breakfasts) and the entire change in costs over that range is due to an increase of one type of meal (SBP breakfasts). Thus, it is possible to estimate a cost per breakfast over a range of meal service as long as lunch servings are held constant. Note, there will be modest economies of scope over the range of meal service that will bias costs downward.

Equation 6 gives a more formal representation of how we propose to estimate costs per breakfast over a range of output. It shows the change in total costs divided by the change in total meals served over any two levels of meal service. The change in meals equals $MEALS_2$ -$MEALS_1$ = ($BFAST_2$+ $LUNCH_2$) - ($BFAST_1$+$LUNCH_1$)= ($BFAST_2$-$BFAST_1$)+ ($LUNCH_2$ -$LUNCH_1$. If $LUNCH_2$ equals $LUNCH_1$, the denominator equals the change in the number of breakfasts. We call this a range over $BFAST_2$ to $BFAST_1$. Similarly, the difference in total costs ($COST_2$-$COST_1$) should be due entirely to the change in the number of breakfasts served since the number of lunches did not change. Thus,

$$(6) \qquad BFAST_{CR} = \frac{COST_2 - COST_1}{(BFAST_2 - BFAST_1)}$$

where $BFAST_{CR}$ is the cost of breakfasts served over a range of breakfasts served with the number of lunches held constant.

To see how costs per breakfast vary across several ranges of breakfast service, we use equation (1) and the number of lunches served and other variables at their location-specific means to estimate costs at breakfast service levels: 50, 75, 100, 125, 150, and 200 percents of the location-specific mean breakfasts. Now, using these cost estimates, numbers of SBP breakfasts served, and equation 6, we compute the average costs over their corresponding service ranges: 50 to 75 percent, 75 to 100 percent, 100 to 125 percent, 125 to 150 percent, and 150 to 200 of the location-specific mean number of breakfasts. Note, the location-specific mean of SBP breakfast meals is the mean number of breakfasts served at that location during the survey year.

Estimates based on equation 6 (table 7) indicate that costs per breakfast dropped dramatically for SFAs in the 75 to 100 percent range of location-specific mean breakfasts (column 4) to SFAs in the 150 to 200 percent range (last column). The largest drop was $0.88 for the Southwest, suburban location and the smallest was $0.02 for the Mountain, suburban location. Only two locations had less than $0.10 decline and seven had more than a $0.50 declines.

The persistence of cost changes is also important since persistence indicates whether cost changes are likely to continue. The data in table 6 show that average costs dropped continuously from the 50 to 75 percent of location-specific mean range to the 150 to 200 percent of location-specific mean range in 14 of 21 cases. There was an increase in costs over the 50 to 75 percent of location-specific mean range to the 75 to 100 percent of location-specific mean range and then a persistent decline in the 4 remaining ranges and an increase in costs followed by a flat pattern over 2 ranges. Overall, the results of table 6 suggest that there are large economies of scale in breakfast service that still exist at twice the location-specific mean levels of breakfast service. The drop in costs and the persistent changes could have important implications for whether SFAs are able to offer breakfasts at a cost compatible with their financial capacity.

Economies of Scale in Lunch Service

We use the same method used for breakfasts to estimate how lunch costs change. We employ equation (1) to estimate costs over a range of lunch services. However, this time, we hold the number of breakfasts served constant and change the number of lunches. Since the number of breakfasts served is held constant, all costs are due to changes in the number of lunches served. Thus, the cost of a NSLP lunch over a range of output ($LUNCH_{CR}$) equals the change in total costs over the range divided by the change in total meals served over the range. The change in meals equals $MEALS_2$ -$MEALS_1$ = ($BFAST_2$+ $LUNCH_2$) - ($BFAST_1$+$LUNCH_1$)= ($BFAST_2$-$BFAST_1$)+ ($LUNCH_2$ - $LUNCH_1$). If $BFAST_2$ equals $BFAST_1$ in equation (7), then (1) the denominator equals $LUNCH_2$-$LUNCH_1$ and the difference in costs is due entirely to the change in the number of lunches served.

$$(7) \qquad LUNCH_{CR} = \frac{COST_2 - COST_1}{(LUNCH_2 - LUNCH_1)}$$

where $LUNCH_{CR}$ is the cost of NSLP lunches served over a range of lunches served with the number of SBP breakfasts held constant.

Table 8 gives cost estimates for ranges of NSLP lunches that, in a relative sense, match the ranges for the SBP breakfasts (table 7). The results are markedly different from breakfasts. Costs per lunch rose in 6 cases, were flat (less than $0.05 up or down) in 6 cases, and dropped in 9 cases from the 75 to 100 percent range of the mean-specific number of lunches served (column 4) to the 150 to 200 percent range (last column). The largest decline in costs was $0.15 and the biggest increase was $0.12.

Most SFAs exhibited continuing reductions in average costs per NSLP lunch over all ranges but the changes were not near as large as those for SBP breakfasts. Costs per lunch dropped in 12 cases but only 4 of these were more than $0.20 per lunch. The costs per lunch rose in 5 of the 21 locations and the increase was $0.10 or more per lunch in 4 of these cases. There was a mix of increases and decreases in 4 cases.

Discussion and Conclusion

This paper examined economies of scale in the NSLP breakfast and lunch programs. Results show that costs per SBP breakfast dropped in all locations as the numbers of breakfasts served rose and that costs continue to drop at twice the location-specific mean number of breakfasts. On average, the costs per breakfast served dropped from about $2.38 for each breakfast in the range of breakfast servings varying from one-half to three-fourths of the location-specific mean to about $1.87 for each breakfast in the range of breakfast servings varying from 1.5 to twice the location-specific mean. In contrast, costs per NSLP lunch dropped from about $2.70 per lunch in the range of lunch servings varying from one-half to three-fourths of the location-specific mean to $2.61 for each NSLP lunch in the range of lunch servings varying from 1.5 to twice the location-specific mean.

Overall, results suggest that increases in the number of breakfasts served will likely result in lower costs per meal but changes in the number of lunches served will have little impact on average costs. These results make sense. Serving and preparing meals is a production process, and production processes lend themselves to lower production costs at higher production volumes. Since the average number of breakfasts served is about one-third that of the average number of lunches served, it appears that breakfast costs have not yet reached a level of constant returns to scale. Lunches, on the other hand, exhibit very little change in costs as output grows, suggesting that the costs of additional lunch servings will remain flat.

Results have important implications for reimbursement policies. Most importantly, they show that economies of scale is an important contributor to costs per meal. To the SFA, this means that small levels of breakfast service may require substantial subsidies to meet their actual costs. This may explain why the SLBCS II found that many SFAs had breakfast costs that exceeded reimbursements. It also means that SFAs can lower the cost per breakfast by expanding breakfast service as much as possible. Since the number of breakfasts served is less than one-third that of the number of lunches served, there appears to be ample room for SFAs to expand service before reaching a point at which costs no longer drop. In contrast, increasing the number of lunches served will not likely have a substantial effect on total average cost because costs per lunch changed very little after the number of lunches served reached the mean level of service.

Currently, there is considerable public interest in expanding the School Breakfast Program, both in terms of the number of meals served at participating schools, and increasing the number of schools offering the program (Food Research and Action Center, http://frac.org/federal-foodnutrition-programs/school-breakfast-and-lunch/outreach/). Increasing the number of meals served at participating schools will likely help the program to cover its costs. However, if some schools are not currently participating because they perceive demand to be low, they may need to make special efforts to attract enough participants to make the program affordable.

Results also suggest that there are economies of scope in breakfast and lunch preparation. A one percent rise in the volume of lunches results in about a one percent drop in the cost of a breakfast and a one percent rise in the volume of breakfasts results in about a one percent drop in the cost of lunches. Thus, increased participation in either meal will help control costs of the overall school food program.

There are some limitations to our study. We used the SFA Characteristics Survey, which offers a large national sample of SFAs stratified by region and urbanicity. However, data limitations still posed challenges. In particular, food prices were not available, forcing us to use food expenditures per meal as a proxy. Fortunately, labor wage and benefits rates were available.

The survey-based estimates of per meal costs and the simulations do not directly assess the adequacy of a reimbursement rate for NSLP lunches or SBP breakfasts. Findings do not answer the question of whether the USDA reimbursement is sufficient to produce a nutritious meal because the data used in the study did not include information on which SFAs produced meals that met USDA nutrition standards. The findings also do not imply that higher cost SFAs are operating at a loss. Higher cost SFAs may also be obtaining higher revenues from such sources as higher meal prices charged to students paying full price for meals, increased sales of a la carte foods, or State or local subsidies to the SFA.

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Table 1. Descriptive statistics of important variables for estimation

SFA Characteristic	Percent
Urban	8
Suburban	38
Rural	54
Mid-Atlantic	9
Midwest	20
Mountain	17
Northeast	13
Southeast	10
Southwest	17
Western	14
High school students as a share of all students are less than 30 percent.	49
High school students as a share of all students are more than 70 percent.	2
SFA provides workers with health insurance	91
Food service management company provides some or all (1) workers, (2) food or supplies purchasing, or (3) food or supplies purchasing and labor.	14
More than 80 percent of schools in the SFA are designated as universal free lunch	7
Revenue from sales of a la carte items is more than $0.10 per meal	54
SFA follows traditional meal plan	60
SFA follows enhanced menu school meal plan	21
SFA reports some capital costs	59

SFA Costs and Meals

	Mean
Average wage + fringe benefits per hour per cafeteria worker.	$11.35
Food costs per meal	$1.17
Other costs per meal	$0.24
Food cost as a share of total meal costs	0.46
Labor cost as a share of total meal costs	0.47
Supply cost as a share of total meal costs	0.07
Number of NSLP lunches served per year.	0.423 million
Number of NSLP breakfasts served per year.	0.141 million

Table 2: Definitions of Cost Function Variables

Variable	**Definition**
P_{LAB}	Average wage of cafeteria staff times (one + fringe benefits as a share of wages and salaries and benefits)
P_{FOOD}	(Food Cost)/ (Number of reimbursable lunches and breakfasts served). Food cost equals purchased food plus donated commodities used plus State and Processor charges related to donated commodities plus food service management fees.
P_{SUPPLY}	(Non-Food Material Cost)/ (Number of reimbursable lunches and breakfasts served). Non-Food Material Cost = supplies and expendable equipment + utilities + other contracted/purchased services + other direct and indirect costs.
LUNCH	Number of reimbursable lunches served by the SFA
BFAST	Number or reimbursable breakfasts served by the SFA.
C_{CAP}	One if SFA had capital costs and zero otherwise.
Location	**Includes MSA and Region Variables**
C_{SUBURB}	One if Common Core data indicates that SFA is a suburban area. Zero otherwise.
C_{RUR}	One if Common Core data indicates that SFA is a rural area. Zero otherwise.
$C_{ATLANTIC}$	One if SFA located in FNS "Mid-Atlantic" region and zero otherwise.
$C_{MIDWEST}$	One if SFA located in FNS "Midwest" region and zero otherwise.
C_{MOUNT}	One if SFA located in FNS "Mountain" region and zero otherwise.
$C_{NORTHEAST}$	One if SFA located in FNS "Northeast" region and zero otherwise.
$C_{SOUTHWEST}$	One if SFA located in FNS "Southwest" region and zero otherwise.
C_{WEST}	One if SFA located in FNS "Western" region and zero otherwise.
Serving Size	
$C_{HIGH\_SCHOOL\_LO}$	One if the number of high school students enrolled in NSLP program as a share of all students (elementary, middle and high school) enrolled in the NSLP program is less than 30 percent. It is zero otherwise.[1]
$C_{HIGH\_SCHOOL\_HI}$	One if the number of high school students as a share of all students is more than 70 percent. It is zero otherwise.[2]
SFA Options	
C_{HEALTH}	One if SFA provides workers with health insurance and zero otherwise.
$C_{FOOD\_SERVICE}$	One if service management company provides some or all (1) workers, (2) food or supplies purchasing, or (3) food or supplies purchasing and labor. Zero otherwise.
C_{FREE}	One if more than 80 percent of schools in the SFA is designated as free lunch for all schools and zero otherwise.
Meal Value	
C_{VALUE_LO}	Probability that meal value fell in the 10 percentile or lower of the value distribution.
$C_{VALUE\ HI}$	Probability that meal value fell in the 90 percentile or higher of value distribution.
$C_{LACARTE}$	One if revenue from sales of a la carte items is more than \$0.10 per meal and zero otherwise. A la carte foods are assumed to be those indicated in response to questions asking for other student payments and food sales, such as a la carte foods.

[1] About 54 percent of all SFAs fall into this category. Number varies from 37.9 percent for the Midwest to 74.3 percent for the Southeast.

[2] About 2 percent of all SFAs fall into this category, ranging from 0 percent for the Southwest and 0.4 percent for the Southeast to 4 percent for the West.

Table 3: Gallant-Jorgenson Likelihood Ratio Test of School Meal Cost Functions

					-------Test Statistics[1]--------		
Model	Description	G-J statistic	Parameters Estimated	Test	Res tric- tions	Critical Chi-Square at 0.01 level	Model Chi-Square
I	Basic Three Input Price Cost Function, No Characteristics	4695	15	-	-	-	-
II	Full Reference Model, All Characteristics[2]	3152	106	II vs I	91	129	1543***
III	Removes location from II	3230	66	III vs II	40	68	78**
IV	Removes capital costs from reference model	3161	99	IV vs. II	7	20	9
V	Removes shares of high school students from II	3204	92	V vs. II	14	31	52***
VI	Removes health insurance for workers from II	3151	101	VI vs. II	5	17	-1
VII	Removes food service companies from II	3202	99	VII vs. II	7	19	50***
VIII	Removes free meals for all students from II	3159	101	VIII vs. II	5	17	7
IX	Removes high and low value meals from II	3194	94	IX vs. II	12	28	42***
X	Rénoves a' la carte revenues from II	3238	101	X vs. II	5	17	76***
XI	Removes the interaction of breakfasts and lunches with input prices	3176	102	XI vs. II	4	15	24***

***, **,* significant at the 0.01, 0.02, and 0.05 levels of confidence.
[1]Chi-square statistics are differences in G-J statistics between test and reference models. Restrictions are differences in the number of parameters between the two models
[2]The full model includes variables for input prices, output, and meal value and dummy variables for determining if the SFA had capital expenditures, schools served no breakfasts or schools that served breakfasts accounting for 33 percent or more of all meals, if ratios of high school students as shares of all students exceeded two different limits, a' la carte revenues exceeded $0.10 per meal, and SFA offered free meals to all.

Table 4: Translog Cost Function Estimates for School Meals, School Year 2002-03

Variable	Coefficient	t-statistic	Variable	Coefficient	t-statistic
Intercept	-0.208	-3.75	$P_{FOOD}*C_{HIGH\_SCHOOL\_HI}$	-0.014	-0.95
P_{LAB}	0.342^{***}	22.04	$P_{FOOD}*C_{HEALTH}$	-0.045^{***}	-5.76
P_{FOOD}	0.600^{***}	41.22	$P_{FOOD}*C_{FOOD\_SERVICE}$	0.052^{***}	8.02
P_{SUPPLY}	0.058^{***}	5.22	$P_{FOOD}* C_{FREE}$	-0.001	-0.10
LUNCH	0.729^{***}	19.16	$P_{FOOD}* C_{VALUE\_LO}$	0.003^{**}	2.66
BFAST	0.230^{***}	5.99	$P_{FOOD} * C_{VALUE\_HI}$	0.003	0.38
C_{SUBURB}	0.080^{***}	3.27	P_{SUPPLY}*LUNCH	0.001	0.33
C_{RUR}	0.098^{***}	3.48	P_{SUPPLY}*BFAST	-0.000	-0.03
$C_{ATLANTIC}$	-0.010	-0.33	$P_{SUPPLY}*C_{SUBURB}$	0.009	1.41
$C_{MIDWEST}$	-0.091^{**}	-2.88	$P_{SUPPLY}*C_{RUR}$	0.009	1.34
C_{MOUNT}	-0.093^{**}	-2.69	$P_{SUPPLY}*C_{ATLANTIC}$	-0.013^{*}	-1.67
$C_{NORTHEAST}$	-0.089^{*}	-2.39	$P_{SUPPLY}*C_{MIDWEST}$	-0.015^{**}	-2.19
$C_{SOUTHWEST}$	0.068	2.47	$P_{SUPPLY}*C_{MOUNT}$	-0.028^{***}	-3.82
C_{WEST}	-0.068^{**}	-2.37	$P_{SUPPLY}*C_{NORTHEAST}$	-0.032^{***}	-3.95
$C_{LACARTE}$	0.067^{***}	3.97	$P_{SUPPLY}*C_{SOUTHWEST}$	-0.027^{***}	-3.93
C_{CAP}	0.050**	2.42	$P_{SUPPLY}*C_{WEST}$	-0.006	-0.76
$C_{HIGH\_SCHOOL\_LO}$	0.017	0.76	$P_{SUPPLY}* C_{LACARTE}$	0.018^{***}	4.79
$C_{HIGH\_SCHOOL\_HI}$	0.019^{*}	1.70	$P_{SUPPLY}*C_{CAP}$	0.011^{***}	3.11
C_{HEALTH}	0.080^{**}	1.99	$P_{SUPPLY}* C_{HIGH\_SCHOOL\_LO}$	-0.005	-1.58
$C_{SERVICE}$	-0.067^{***}	-2.62	$P_{SUPPLY} * C_{HIGH\_SCHOOL\_HI}$	0.023^{***}	2.08
C_{FREE}	-0.016	-0.55	$P_{SUPPLY} *C_{HEALTH}$	0.012^{**}	2.15
C_{VALUE_LO}	-0.020^{***}	-3.93	$P_{SUPPLY}*C_{SERVICE}$	0.017^{***}	3.65
C_{VALUE_HI}	0.051	1.32	$P_{SUPPLY}*C_{FREE}$	0.015^{**}	2.20
$P_{LAB} * P_{LAB}$	0.133^{***}	16.25	$P_{SUPPLY}* C_{VALUE\_LO}$	-0.003^{***}	-3.59
$P_{FOOD} * P_{FOOD}$	0.168^{***}	33.28	$P_{SUPPLY}* C_{VALUE\_HI}$	-0.016^{***}	-2.98
$P_{SUPPLY}*P_{SUPPLY}$	0.069	-	LUNCH*BFAST	-0.113	-16.59
LUNCH*LUNCH	0.139^{***}	15.59	LUNCH $*C_{SUBURB}$	0.021	0.93
BFAST*BFAST	0.096^{***}	12.87	LUNCH $*C_{RURAL}$	0.014	0.61
$C_{VALUE\_LO} *C_{VALUE\_LO}$	-0.0003^{*}	-1.67	LUNCH $*C_{ATLANTIC}$	0.116^{***}	4.11
$C_{VALUE\_HI} *C_{VALUE\_HI}$	0.015^{*}	1.82	LUNCH$*C_{MIDWEST}$	0.103^{***}	4.36
$P_{LAB} * P_{FOOD}$	-0.116^{***}	-18.33	LUNCH$*C_{MOUNT}$	0.062^{**}	2.52
$P_{LAB} * P_{SUPPLY}$	-0.017^{***}	-3.13	LUNCH$*C_{NORTHEAST}$	0.066^{***}	2.69
P_{LAB} * LUNCH	0.0003	0.07	LUNCH$*C_{SOUTHWEST}$	0.044^{*}	1.68
P_{LAB} * BFAST	-0.006	-1.85	LUNCH$*C_{WEST}$	0.049^{*}	1.87
$P_{LAB} * C_{SUBURB}$	0.063^{***}	6.72	LUNCH $* C_{LACARTE}$	-0.041^{***}	-3.56
$P_{LAB} * C_{RUR}$	0.069^{***}	7.19	LUNCH $*C_{CAP}$	-0.031^{***}	-2.99
$P_{LAB} *C_{ATLANTIC}$	0.014	1.25	LUNCH$* C_{HIGH_SCHOOL_LO}$	-0.001	-0.99
$P_{LAB} *C_{MIDWEST}$	-0.006	-0.60	LUNCH$* C_{HIGH_SCHOOL_HI}$	0.020	0.45

P_{LAB} *C_{MOUNT}	0.017*	1.61	LUNCH*C_{HEALTH}	0.019**	1.99
P_{LAB} *$C_{NORTHEAST}$	0.018	1.55	LUNCH*$C_{SERVICE}$	0.010	0.78
P_{LAB} *$C_{SOUTHWEST}$	0.037***	3.78	LUNCH*C_{FREE}	0.017	0.83
P_{LAB} *C_{WEST}	0.012	1.15	LUNCH* C_{VALUE_LO}	0.004**	2.16
P_{LAB} * $C_{LACARTE}$	0.011**	2.20	LUNCH* C_{VALUE_HI}	-0.003	-0.26
P_{LAB} *C_{CAP}	-0.008*	-1.60	BFAST *C_{SUBURB}	-0.016	-0.71
P_{LAB} *$C_{HIGH\_SCHOOL\_LO}$	0.004	0.85	BFAST *C_{RURAL}	-0.001	-0.39
P_{LAB} *$C_{HIGH\_SCHOOL\_HI}$	-0.008	-0.54	BFAST *$C_{ATLANTIC}$	-0.079***	-2.95
P_{LAB} *C_{HEALTH}	0.032***	3.88	BFAST *$C_{MIDWEST}$	-0.079***	-3.40
P_{LAB} *$C_{FOOD\_SERVICE}$	-0.069***	-10.11	BFAST *C_{MOUNT}	-0.060**	-2.40
P_{LAB} * C_{FREE}	-0.013	-1.43	BFAST*$C_{NORTHEAST}$	-0.050**	-2.37
P_{LAB} * C_{VALUE_LO}	-0.000	0.06	BFAST *$C_{SOUTHWEST}$	-0.021*	-0.83
P_{LAB} * C_{VALUE_HI}	0.013*	1.72	BFAST *C_{WEST}	-0.044*	-1.64
P_{FOOD} * P_{SUPPLY}	-0.052***	-11.13	BFAST * $C_{LACARTE}$	0.034***	3.22
P_{FOOD} * LUNCH	-0.001	-0.32	BFAST *C_{CAP}	0.027***	2.74
P_{FOOD} * BFAST	0.007**	2.01	BFAST * $C_{HIGH\_SCHOOL\_LO}$	0.018**	1.99
P_{FOOD}*C_{SUBURB}	-0.072***	-8.16	BFAST * $C_{HIGH\_SCHOOL\_HI}$	0.015	0.39
P_{FOOD} *C_{RUR}	-0.078***	-8.60	BFAST *C_{HEALTH}	-0.013	-0.65
P_{FOOD} *$C_{ATLANTIC}$	-0.0017	-0.16	BFAST *$C_{SERVICE}$	-0.017	-1.38
P_{FOOD} *$C_{MIDWEST}$	0.022**	2.32	BFAST *C_{FREE}	-0.028	-1.52
P_{FOOD} *C_{MOUNT}	0.011	1.14	BFAST * C_{VALUE_LO}	-0.004*	0.83
P_{FOOD} *$C_{NORTHEAST}$	0.014	1.34	BFAST * C_{VALUE_HI}	-0.001	-0.05
P_{FOOD}*$C_{SOUTHWEST}$	-0.010	-1.08	C_{CAP}*$C_{HIGH\_SCHOOL\_LO}$	-0.016	-1.03
P_{FOOD} *C_{WEST}	-0.006	-0.68	C_{CAP}*$C_{HIGH\_SCHOOL\_HI}$	-0.059	-0.96
P_{FOOD} * $C_{LACARTE}$	-0.029***	-5.93	$C_{HIGH\_SCHOOL\_LO}$* $C_{FOOD\_SERVICE}$	0.006	0.28
P_{FOOD} *C_{CAP}	-0.003	-0.62	$C_{HIGH\_SCHOOL\_HI}$* $C_{FOOD\_SERVICE}$	-0.054	-0.94
P_{FOOD} *$C_{HIGH\_SCHOOL\_LO}$	0.001	0.28			

Notes: **, *** significant at the 0.05 and 0.001 levels.
--All variables are standardized at their means, so first-order coefficients can be interpreted as elasticities at the sample means. Dummy variable capture shifts due to various model attributes, such as region. Table 1 has all of the variable definitions
-- There were a total of 1,282 usable observations. The model R^2 was 0.9825.

Table 5: Own, Allen, and Morishima Elasticities

	--------Factor Price Variables-------		
	P_{LAB}	P_{FOOD}	P_{SUPPLY}
Estimated Factor Shares	.342	.600	.058
ε_{ii} (own factor price)	-0.283	0.217	-0.882
A_{ij} (Allen cross elasticities)			
P_{LAB}	-	0.463	0.483
P_{FOOD}	-	-	-0.614
P_{SUPPLY}	-	-	-
M_{ij} (Morishima cross elasticities)			
P_{LAB}	-	0.495	0.317
P_{FOOD}	0.001	-	-0.260
P_{SUPPLY}	1.109	0.60	-

Table 6: Comparison of Estimated and Actual Costs per Meal.[1]

Metropolitan Area	Mid-Atlantic	Midwest	Mountain	Northeast	Southeast	Southwest	West
	---region---						
	---estimated cost per meal in dollars---						
Rural	2.49	2.19	2.07	2.17	2.41	2.07	2.24
Suburban	3.13	3.26	2.61	2.97	2.65	2.60	2.77
Urban	2.53	2.75	2.62	2.97	2.51	2.37	3.03
	---actual cost per meal in dollars---						
Rural	2.54	2.37	2.43	2.50	2.65	2.14	2.54
Suburban	3.12	3.20	2.71	3.06	2.65	2.64	2.82
Urban	2.54	2.53	2.48	2.83	2.39	2.26	2.92

[1] Estimated costs are based on location-specific mean LaCarte revenues, meal value, and other characteristics and input prices were set at mean levels within each location, such as the rural Southwest. Meals equal the mean number of breakfasts and lunches served.

Table 7: The Cost of NSLP Breakfasts over selected ranges of breakfasts served.[1]

Location		Ranges of breakfasts in percentages of location-specific mean values.					Mean Breakfasts at Location
Region	Urbanicity	50 to 75	75 to 100	100 to 125	125 to 150	150 to 200	
		- dollars per breakfast over selected ranges of meals served					-Millions-
Mid-Atlantic	Urban	1.74	1.63	1.52	1.43	1.31	1.423
Mid-Atlantic	Suburban	2.30	2.35	2.28	2.18	2.04	0.294
Mid-Atlantic	Rural	2.19	2.02	1.87	1.74	1.60	0.153
Midwest	Urban	1.68	1.54	1.42	1.32	1.21	1.667
Midwest	Suburban	2.86	3.00	2.93	2.82	2.66	0.065
Midwest	Rural	2.56	2.40	2.23	2.09	1.93	0.048
Mountain	Urban	1.87	1.70	1.56	1.46	1.33	0.815
Mountain	Suburban	1.80	2.22	2.31	2.29	2.20	0.120
Mountain	Rural	1.95	2.34	2.40	2.37	2.27	0.039
Northeast	Urban	1.48	1.58	1.55	1.50	1.42	1.945
Northeast	Suburban	3.21	3.28	3.17	3.04	2.85	0.045
Northeast	Rural	3.24	2.93	2.69	2.51	2.30	0.033
Southeast	Urban	2.73	2.41	2.19	2.03	1.85	1.641
Southeast	Suburban	3.08	2.75	2.51	2.33	2.13	1.059
Southeast	Rural	2.92	2.58	2.34	2.17	1.98	0.235
Southwest	Urban	1.88	1.66	1.51	1.40	1.28	2.086
Southwest	Suburban	2.51	2.62	2.87	1.90	1.74	0.422
Southwest	Rural	2.26	2.00	1.82	1.68	1.54	0.122
West	Urban	1.98	1.77	1.63	1.52	1.39	1.818
West	Suburban	2.66	2.45	2.26	2.11	1.94	0.342
West	Rural	3.11	2.82	2.60	2.42	2.22	0.062
Mean		2.38	2.29	2.17	2.01	1.87	0.687

[1]Breakfast Cost Over a Range= ($Cost_2$-$Cost_1$)/ ($BFAST_2$-$BFAST_1$) where $BFAST_2$ = 75, 100, 125, 150, and 200 percent of the location-specific mean number of breakfasts served (columns 3, 4, 5, 6, and 7) and $BFAST_1$ = 50, 75, 100, 125, and 150 percent of the location-specific mean number of breakfasts served (columns 3, 4, 5, 6, and 7). $BFAST_2$ equals 75 percent of the location-specific mean number of breakfasts served and $BFAST_1$ is 50 percent of the location-specific mean value in column 3, etc. To estimate $Cost_2$ and $Cost_1$, we used the translog cost function and location-specific mean values for all variables except the number of breakfasts served. $BFAST_2$ and $BFAST_1$ were used to estimate $Cost_2$ and $Cost_1$.
Costs are valid only for breakfasts falling within each range. For example, Mid-Atlantic urban SFAs have a cost per breakfast of $1.74 over the range given by the 50 to 75 percent of location specific mean breakfasts and costs per breakfast of $1.63, $1.52, $1.43, and $1.31 over the 75-100, 100-125, 125-150, and 150-200 ranges.

Table 8: The Cost of NSLP lunches over selected ranges of lunches served.[1]

Location		Ranges of lunches in percentages of location-specific mean values					Mean Lunches at Location
Region	Metroploitan Area	50 to 75	75 to 100	100 to 125	125 to 150	150 to 200	
		-dollars per lunch served within a given ranges of output -					--Millions-
Mid-Atlantic	Urban	2.91	2.87	2.86	2.88	2.91	3.627
Mid-Atlantic	Suburban	3.31	3.31	3.34	3.38	3.45	1.364
Mid-Atlantic	Rural	2.80	2.74	2.72	2.71	2.73	0.450
Midwest	Urban	2.52	2.46	2.44	2.43	2.44	3.936
Midwest	Suburban	3.20	3.19	3.21	3.24	3.30	0.428
Midwest	Rural	2.72	2.67	2.64	2.64	2.65	0.185
Mountain	Urban	2.23	2.16	2.13	2.11	2.10	2.212
Mountain	Suburban	2.59	2.60	2.63	2.66	2.72	0.984
Mountain	Rural	2.60	2.60	2.63	2.66	2.72	0.159
Northeast	Urban	2.27	2.27	2.29	2.31	2.37	9.828
Northeast	Suburban	2.83	2.80	2.80	2.82	2.85	0.319
Northeast	Rural	2.77	2.67	2.62	2.60	2.58	0.123
Southeast	Urban	2.50	2.38	2.31	2.27	2.23	3.755
Southeast	Suburban	2.70	2.60	2.55	2.52	2.50	3.210
Southeast	Rural	2.50	2.37	2.30	2.25	2.20	0.549
Southwest	Urban	2.44	2.33	2.27	2.24	2.21	3.571
Southwest	Suburban	2.86	2.76	2.71	2.69	2.68	1.036
Southwest	Rural	2.57	2.45	2.38	2.34	2.30	0.232
West	Urban	2.48	2.41	2.38	2.37	2.37	4.640
West	Suburban	2.92	2.84	2.81	2.80	2.80	1.143
West	Rural	2.96	2.87	2.82	2.79	2.78	0.203
Mean							
Mean		2.70	2.64	2.61	2.60	2.61	2.00

[1]Lunch Cost Over a Range= $(Cost_2-Cost_1)/(LUNCH_2-LUNCH_1)$ where $LUNCH_2$ = 75, 100, 125, 150, and 200 percent of the location-specific mean number of lunches served (columns 3, 4, 5, 6, and 7) and $LUNCH_1$ = 50, 75, 100, 125, and 150 percent of the location-specific mean number of lunches served (columns 3, 4, 5, 6, and 7). $LUNCH_2$ equals 75 percent of the location-specific mean number of breakfasts served and $LUNCH_1$ is 50 percent of the location-specific mean value in column 3, etc. To estimate $Cost_2$ and $Cost_1$, we used the translog cost function and location-specific mean values for all variables except the number of lunches served. $LUNCH_2$ and $LUCH_1$ were used to estimate $Cost_2$ and $Cost_1$.
Costs are valid only for lunches falling within each range. For example, Mid-Atlantic urban SFAs have a cost per lunch of $2.91 over the range given by the 50 to 75 percent of location specific mean breakfasts and costs per lunch of $2.87, $2.86, $2.88, and $2.91 over the 75-100, 100-125, 125-150, and 150-200 ranges.

Table A.1: Probit estimates of low and high value meal indicators.

Variable	90^{th} or higher percentile	10^{th} or lower percentile		Definition
Intercept	-3.875^{***} (0.367)	2.224^{***} (0.377)		Intercept term.
INPUTS				
SH_COMMOD	0.619^{+} (0.402)	-1.882^{***} (0.402)		Cost of commodities as a share of all food costs. Food cost equals (purchased food + donated commodities used + State and Processor charges related to donated commodities)
SH_PURCH_FOOD	0.905^{***} (0.292)	-1.071^{***} (0.166)		Value of Purchased food divided by the value of all food
WAGE_WORKER	0.082^{***} (0.010)	0.048^{***} (0.012)		Average pay rate for a food service assistant.
DEMAND				
MEDIAN_INCOME	0.0105^{***} (0.0028)	-0.0491^{***} (0.0060)		Median family income in SFA in thousands.
POVERTY	3.735^{***} (0.358)	1.173^{**} (0.361)		Poverty level of the SFA.
MEDIAN_HOUSING_VAL	0.0042^{***} (0.005)	-0.0054^{***} (0.0010)		Median Housing value in SFA in thousands.
PART_FULL_STUD	-0.0011^{*} (0.0006)	0.0025^{***} (0.0006)		Students paying full price per meal as a share of all students not eligible to pay reduced or free rates.
SH_FREE_STUDENTS	-2.351^{***} (0.213)	0.951^{***} (0.187)		Students approved for free lunch as a share of all students.
SALARY_STUD	0.0012^{**} (0.0005)	0.0007^{+} (0.0004)		Salaries and wages divided by total number of enrolled students.
OTHER_UNSPECIFIED_FOOD	0.0035^{***} (0.0006)	0.0001 (0.0005)		Unspecified food payments as a share of all students.
STATE_REIM_PER_L	-0.0435 (0.057)	0.060^{**} (0.019)		Number of lunches reimbursed by the State as a share of all lunches served.
SCHOOL MEAL PROGRAM				
SH_SK_PREP_OFFSITE	0.864^{***} (0.072)	-0.745^{***} (0.101)		Schools preparing food offsite divided by the sum of schools preparing offsite plus schools preparing on-site plus schools preparing on and off-site.

AFTER_SCHOOL_SNACK	0.207*** (0.058)	-0.179** (0.057)		One if SFA offers after-school snack and zero otherwise.
SHARE_OTHER	-0.372 (0.393)	0.985*** (0.209)		Number of SFAs using school menus other than the typical school menus as a share of all SFAs using any school menu plan.
SCHOOL CHARACTERISTICS				
PCT_AT_ABOVE_PROF_MATH_4	-0.0099** (0.0043)	-0.039** (0.0045)		Percent of fourth grade students achieving at or above proficient level in math.
URBAN	-0.319** (0.099)	0.221** (0.090)		Common Core data indicates that SFA in an urban district. Zero otherwise.
RURAL	-0.236*** (0.052)	0.299+ (0.058)		Common Core data indicates that SFA in a rural district. Zero otherwise.
OBSERVATIONS	1,238	1,238		
LOG LIKELIHOOD	-2300	-2163		
CHANGE IN LOG LIKELIHOOD	1172***	672***		

Notes: **, *** significant at the 0.05 and 0.001 levels.
Standard errors in parentheses