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Location, School Characteristics, and the Cost of School Meals

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The U.S. Department of Agriculture reimburses schools for meals provided to students participating in the National School Lunch and School Breakfast Programs. Reimbursement amounts are based on national average estimated costs of meal production. Food prices, however, vary across the United States, suggesting regional cost differences. This paper uses a quality-adjusted translog variable-cost function to show how costs per meal vary across twenty-one U.S. locations. The average deviation from national average cost is about $0.38 per meal; the average cost deviation attributed to input prices is $0.17 and the scale effect is $0.135.

Key words: National School Lunch Program, School Breakfast Program, school food service costs per meal, school meals

Introduction

In fiscal year 2009, the USDA Food and Nutrition Service (FNS) provided about 42 million lunches and breakfasts to schoolchildren participating in the National School Lunch Program (NSLP) and School Breakfast Program (SBP) (Oliveira, 2010). The USDA reimburses local school food authorities (SFAs) that administer these programs for part or all of their meal costs. Reimbursement rates are based on per meal cost estimates made by the USDA at a national level. With the exception of Alaska and Hawaii, these estimates are identical across the United States. USDA cost analyses do not account for regional cost differences. However, a food-price index developed for the Missouri Economic Research and Information Center (MERIC) indicates that food prices vary from state to state. In 2005, index values ranged from 0.892 in Texas to 1.187 in Connecticut.

This paper examines the effect of geographic location and SFA characteristics on the cost of providing a school meal. The two main issues are how large differences in food-service costs per meal are among geographic locations after accounting for nongeographic factors and how input prices, the number of meals served, and SFA characteristics contribute to cost differences. We examine twenty-one geographic locations with different types of metropolitan areas—urban, suburban, and rural—covering each of the seven regions (Mid-Atlantic, Midwest, Mountain Plains, Northeast, Southeast, Southwest, and West) administered by the FNS.

We use a quality-adjusted translog cost function developed by Gertler and Waldman (1992) and extended by Antle (2000) and data from 1,359 SFAs participating in the School Food Authority Characteristics Survey (SFACS) to estimate the costs of producing and serving NSLP and SBP meals. Besides input prices and the number of meals served, variables included in the model account for the proportion of meals that are lunches, variation in meal quality, and other characteristics. After estimating the model, we examine the individual contributions of input prices (wage and benefit

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rates, food prices, and supply prices), number of meals served, and regional SFA characteristics to regional differences in cost per meal.

This is the first theoretically grounded approach to examine the cost of providing school meals through USDA meal programs across all U.S. geographic locations. A 1993 analysis by the U.S. Government Accountability Office using 1987–88 and 1988–89 data provided no conclusive evidence that regional cost differences exist (U.S. General Accounting Office, 1993). Bartlett, Glantz, and Logan (2008) reported that cost per meal is negatively associated with urban locations but did not vary among regions. This econometric analysis assumes that breakfast costs are a fixed fraction of the cost of a lunch, yet other studies (Hilleren, 2007; Sackin, 2008) show that costs per breakfast vary with the number of breakfasts served and service style (for example, in the classroom). This study also deducts the costs of non-USDA foods prepared by SFA staff from total average costs, even though these foods use the same inputs as those used for USDA meals.

The FNS has supported several nationally representative NSLP and SBP cost studies that use accounting methods to obtain estimates of costs per NSLP lunch and SBP breakfast at the national level. The most recent of these, the School Lunch and Breakfast Cost Study (SLBCS-II), was completed by Abt Associates using data for the 2005–06 school year. SLBCS-II estimated the weighted average cost of a meal for a "typical" SFA to be \$2.36 for a lunch and \$1.92 for a breakfast. The study found that about 2.9% of SFAs had costs per lunch below \$1.40 and more than 12% had per lunch costs of \$3.00 or more but did not determine why costs varied.

School Food Authority Behavior

SFAs are nonprofit organizations that provide NSLP and SBP meals to eligible students while meeting USDA nutritional guidelines and balancing revenues with costs. SFAs encourage participation by students not eligible for USDA meals. The SLBC-II (Bartlett, Glantz, and Logan, 2008) indicates that many SFAs may not be able to cover all of their meal preparation costs, suggesting a strong incentive to minimize these costs.

SFAs serve three types of students: full-price students for whom SFAs receive a small subsidy from the USDA, reduced-price students for whom SFAs are reimbursed for the cost of the meal minus a co-payment of \$0.40 per NSLP lunch and \$0.30 per SBP breakfast,[1] and free-lunch students for whom SFAs are reimbursed for the full cost of an NSLP lunch or SBP breakfast. Meal reimbursement rates are based on a nationally representative meal-cost estimate made by the USDA that is updated annually. Reimbursement rates are not adjusted for geographic differences within the lower forty-eight states; separate rates are estimated for Alaska and Hawaii.

A Model with Quality Adjustments

Unlike Bartlett, Glantz, and Logan (2008), who use a partial cost function, we use a total cost function. Total costs functions include Cobb-Douglas, Constant Elasticity of Substitution (CES), and translog cost functions. We use a translog cost function because it places no *a priori* restrictions on substitution elasticities and is consistent with typical constraints (Berndt, 1991). It is also relatively general and permits a variety of possible production relationships, including returns to scale, optimal input shares that vary with the level of output and other characteristics, and nonconstant elasticities of input demand. In addition, a translog cost function can account for diverse SFA practices by allowing alternative ways in which attributes can be specified.

The USDA school meal program offers two main types of meals: SBP breakfasts and NSLP lunches. The USDA also offers a small after-school snack. SFAs may provide any combination of these products. NSLP lunches are the most costly and serve the most students, but a substantial number of breakfasts are also served. Both types of meals must therefore be considered. All SFAs

[1] Reimbursement rates are established by Congress and change over time. These rates were for 2003.

Table 1. Model Variables and Descriptive Statistics, 2002–03 School Year

Variables	National Average across SFAs
Cost per meal and input price measures:	
Cost per meal (total annual food-service cost divided by total reimbursable lunches and breakfasts served),	$2.77
Price of Labor (mean wage plus fringe benefits per hour per cafeteria worker)	$11.74
Price of Food (Price Index based on author's estimates)	$0.97
Price of Supplies (MERIC Price Index for products excluding food, energy, transportation, housing, and medical costs.)	$0.25
Geography:	
Urban	13%
Suburban	48%
Rural	39%
Food and Nutrition Service Region	
Mid-Atlantic	12%
Midwest	19%
Mountain Plains	15%
Northeast	10%
Southeast	16%
Southwest	14%
West	14%
SFA Characteristics:	
Meals served per year, national average across SFAs	913,000
Percentage of SFAs serving no breakfasts	10%
NSLP lunches as share of all USDA meals.	80%
Percentage of revenues from USDA meals.	81%
Average NSLP lunch price	$1.57
Percentage of SFAs comprised of less than 30% elementary schools	1.9%
Percentage of SFAs comprised of more than 70% elementary schools.	54.1%
Percentage of SFAs using a traditional menu	48.4%
Percentage of SFA provides food-service workers with health insurance	93.5%
Percentage of SFAs with food-service management companies providing some inputs	15.7%

Notes: School Food Authority Characteristics Survey, Mathematica Policy Research, Inc. (2004), and analysis by the Economic Research Service, USDA.

in our sample offer NSLP lunches and 90% serve breakfasts (table 1). After-school snacks are a low-cost, much less utilized item. Snacks are omitted from the analysis presented here because in estimation models they appeared to play no role in determining meal costs.

Either a multiproduct or single-product cost function could have been used. A multiproduct cost function would have allowed us to include both breakfasts and lunches directly in the model, but estimation would have been challenging. Translog cost functions are estimated in log form; since 10% of SFAs serve no breakfasts, the variable measuring breakfast would take on zero values for those SFAs, and zero values cannot be defined in log form. Small valuing (replacing zeros with small positive values prior to estimation) and Box-Cox transformations have been used to estimate multiproduct cost functions in the presence of zero outputs. Each of these approaches has its drawbacks (Weninger, 2003). Weninger (2003) introduced a model that improves the small-valuing method, but that model lacks flexibility and generality (Triebs et al., 2011).

A more direct way of dealing with different (but similar) outputs is to use a single-product cost function with USDA meals defined as the single product and equal to the sum of NSLP lunches and SBP breakfasts for each SFA during the 2002–2003 school year. Within this framework, meal types, meal quality, and other characteristics are included as independent variables. Breakfasts in general represent a relatively small share of total meals served, accounting for less than one in three meals in 80% of all SFAs and less than one in five meals in more than 50% of all SFAs.

Economists have used single-product translog cost functions with exogenous product characteristics to describe variations of one product in many different situations. For example, the variable ton-miles has been used for hauling freight in trucking (Allen and Liu, 1995) and railroads (Caves et al., 1985) and passenger-miles has been used for airlines (Baltagi, Griffin, and Rich, 1995). MacDonald and Ollinger (2000); Ollinger, MacDonald, and Madison (2005); and MacDonald and Ollinger (2005) use product output shares as characteristics for meat and poultry. Our model must account not only for differences in observed exogenous meal characteristics but also for unobserved meal quality. Meal quality—meal tastiness, meal presentation, and other attributes that cannot be directly measured—varies across SFAs. For example, some SFAs offer salad bars and multiple entrée choices, while others serve only a limited choice of fruits and vegetables and a single entrée option (Gordon et al., 2007).

As nonprofit organizations, SFAs are expected to meet operating costs (Ralston et al., 2008). Hence, SFAs jointly determine costs and meal quality by adjusting quality to match their financial resources. If revenues are sufficient, SFAs may improve quality to encourage greater meal participation rates. Conversely, if costs are too high, they may reduce quality. Poppendieck (2010) cites one school food-service director who indicated that cost pressures prevented him from offering as many salads and fresh foods compared to those offered at more affluent SFAs.

Braeutigam and Pauly (1986) note that failure to account for quality in cost function analyses may result in omitted-variables bias. Subsequent cost analyses (Gertler and Waldman, 1992; Antle, 2000; Hughes and Mester, 1993; Blau and Mocan, 2002) have accounted for product quality in nursing home care, meat and poultry food safety, banking, and hospital care. This paper most closely tracks Gertler and Waldman (1992) and Antle (2000) because meal quality is not directly observed.

A Quality-Adjusted Cost Function

Following Gertler and Waldman (1992) and Antle (2000), we specify a quality-adjusted variable-cost function with no fixed factor:

$$C(\boldsymbol{w}, m, \boldsymbol{t}, q, \boldsymbol{o}, k) = VC(\boldsymbol{w}, m, \boldsymbol{t}, q, \boldsymbol{o}, \boldsymbol{z}), \tag{1}$$

where $\boldsymbol{w}$ is defined as a vector of factor prices, m is the number of meals prepared, $\boldsymbol{t}$ is a vector of variables describing the types of meals offered, q is meal quality, $\boldsymbol{o}$ is a vector of other meal qualities, k is a fixed factor, and $\boldsymbol{z}$ is a vector of SFA characteristics.

We do not include a fixed factor in the model, because SFAs view themselves as food-service organizations with very limited use of capital services. School districts provide the eating and cooking facilities while SFAs prepare and serve meals. SFAs pay no rental fees to school districts, and about one-third of SFAs do not report any use of capital services. SFAs that do report the use of capital services indicate that these costs are less than 2% of total costs.

School Food Authorities produce meals for students who pay full- or reduced-price or get meals for free. The total number of meals served is:

$$M = M_{FP} + M_R + M_{FR}, \tag{2}$$

where M is the total number of meals produced, M_{FP} is the number of full price meals produced, M_R is the number of reduced-price meals, and M_{FR} is the number of free meals. The number of meals served is always less than the total number of students since some students will be absent from school and others will carry a lunch from home.

SFAs are free to produce food of any level of quality so long as they meet USDA nutrient standards established for the SBP and NSLP, serve meals to all students eligible for a USDA meal, and balance revenues with costs. Within these constraints, SFAs minimize costs and encourage meal participation, which increases revenues, by providing the highest meal quality possible. Meal quality is the same for all students regardless of whether they purchase a meal or get a subsidized meal. In the absence of adequate meal quality, more students bring meals from home or buy food elsewhere.

Following Antle's (2000) implementation of Rosen's (1974) model of a competitive industry with product differentiation, we specify the demand for full price meals as $M_{FP} = M_{FP}(P, Q, \boldsymbol{O}, \boldsymbol{D})$ and the demand for free meals as $M_{FR} = M_{FR}(Q, \boldsymbol{O}, \boldsymbol{D})$, where P is the price of full price meals, Q is meal quality, $\boldsymbol{O}$ is a vector of other qualities, and $\boldsymbol{D}$ is a vector of demand variables. Two demand variables are market size (captured by total student enrollment) and the share of students eligible for subsidized meals.

Other qualities are serving size and the type of menu plan used. High school students receive bigger meals and are served different types of products than elementary school students (Gordon et al., 2007). The type of menu plan SFAs use may also affect food and meal-preparation choices and costs. SFAs can choose from four menu options to meet USDA nutritional guidelines: traditional food-based, enhanced food-based, nutrient-based, and other. Enhanced food-based menus and nutrient-based menus were introduced as part of the School Meals Initiative in the 1990s. All SFAs had previously been required to use a menu offering traditional food-based meals.

The demand for reduced-price meals must account for the small co-payment made by buyers. Moore, Hulsey, and Ponza (2009) found that this co-payment of about \$0.40 per meal has a small effect on meal participation. Thus, $M_R = M_R(X, Q, \boldsymbol{O}, \boldsymbol{D})$, where X is the reduced-price co-payment. This co-payment does not vary nationwide, except for Hawaii and Alaska. Total meal demand can now be written as:

$$M^D = M_{FP}(P, Q, \boldsymbol{O}, \boldsymbol{D}) + M_R(X, Q, \boldsymbol{O}, \boldsymbol{D}) + M_{FR}(Q, \boldsymbol{O}, \boldsymbol{D}), \tag{3}$$

and:

$$M^D = M^D(P, X, Q, \boldsymbol{O}, \boldsymbol{D}). \tag{4}$$

A key insight of Rosen (1974) is that product prices, qualities, and quantities demanded and supplied are jointly determined. Keeping this in mind and following Antle (2000), we specify market supply as a function of the average price of a meal, the subsidy paid for each eligible student (S), meal quality, other quality, and a vector of factor prices ($\boldsymbol{W}$):

$$M^S = S(P, S, Q, \boldsymbol{O}, \boldsymbol{W}). \tag{5}$$

We equate supply and demand and solve for meal quality, giving:

$$Q = F(P, S, X, \boldsymbol{O}, \boldsymbol{D}, \boldsymbol{W}). \tag{6}$$

Now, we substitute the value of Q into the cost function:

$$c(\boldsymbol{w}, y, \boldsymbol{t}, q, \boldsymbol{o}, \boldsymbol{z}) = C(\boldsymbol{w}, y, \boldsymbol{t}, F(p, o, \boldsymbol{D}, \boldsymbol{W}), \boldsymbol{o}, \boldsymbol{z}). \tag{7}$$

All variables in the cost function in equation (6) are observed. The USDA subsidy and the co-payment made by students eligible for reduced-price meals are identical across the United States and have therefore been dropped in the empirical analysis since they exhibit no variation among observations. Output price and demand variables vary across SFAs and can be used to identify the cost function.

The Empirical Specification

We specify a translog cost-function model of school meal costs in which C_i is the cost of school meals in SFA i and P_i represents prices for labor (P_{LAB}), food (P_{FOOD}), and nonfood supplies (P_{SUPPLY}). The variable *MEALS* measures the total number of USDA-reimbursable SBP breakfasts and NSLP lunches. Other variables are types of meals (T), other quality variables (O), characteristics (Z), and $C_{QUALITY}$, a measure of meal quality:

$$
\begin{aligned}
(8)\qquad \ln C_i = {} & \alpha 0 + \sum_i \beta_i \ln P_i + \frac{1}{2}\sum_i \sum_j \beta_{i,j} \ln P_i \times \ln P_j + \gamma_M \ln MEALS + \\
& \frac{1}{2}\gamma_{M,M}(\ln MEALS)^2 + \sum_i \gamma_{M,i} \ln MEALS \times \ln P_i + \sum_h \lambda_h \ln T_{h_i} + \\
& \sum_h \sum_j \lambda_{h,j} \ln T_h \times \ln P_j + \sum_h \lambda_{hM} \ln T_h \times \ln MEALS + \frac{1}{2}\sum_h \sum_g \lambda_{h,g} \ln T_{h_i} \times \ln T_g + \\
& \sum_k \omega_{k_i} O_k + \sum_k \sum_j \omega_{k,j} O_{k_i} \times \ln P_j + \sum_k \omega_{k_i M} O_k \times \ln MEALS + \sum_l \pi_{l_i} Z_{l_i} + \\
& \sum_l \sum_j \pi_{l,j} Z_{l_i} \times \ln P_j + \sum_l \pi_{l_i M} Z_{l_i} \times \ln MEALS + \\
& \sum_l \sum_h \pi_{l,h} Z_{l_i} \times \ln T_h + \delta_Q \ln C_{QUALITY} + \delta_{Q,Q} \times (\ln C_{QUALITY})^2 + \\
& \sum_j \delta_{Qj} \times \ln C_{QUALITY} \times \ln P_j + \delta_{Q,M} \ln C_{QUALITY} \ln MEALS + \varepsilon.
\end{aligned}
$$

Types of meals (T) include the number of NSLP lunches as a share of all USDA meals (C_{SH_LUNCH}) and a variable accounting for the cost of producing à la carte foods ($C_{LACARTE}$). Other qualities (O) include variables accounting for meal serving size ($C_{HIGH\_SCHOOL\_LO}$ and $C_{HIGH\_SCHOOL\_HI}$) and menu option (C_{TRAD_MENU}). SFA characteristics include variables indicating SFAs offering health care to cafeteria workers (C_{HEALTH}) and SFAs that outsource some tasks, which range from administrative assistance to the provision of meals to food-service organizations ($C_{FOOD\_SERVICE}$). Other SFA characteristics include location indicator variables for urban, suburban, and rural areas (C_{SUBURB} and C_{RURAL}) and the FNS Region of the SFA ($C_{ATLANTIC}$, $C_{MIDWEST}$, $C_{MOUNTAIN}$, $C_{NORTHEAST}$, $C_{SOUTHWEST}$, and C_{WEST}).

Gains in efficiency can be realized by estimating input demand equations (cost-share equations) jointly with the cost function, obtained by applying Shepard's lemma to the cost function:

$$
\begin{aligned}
(9)\qquad \frac{\partial \ln C}{\partial \ln P_i} = \frac{P_i X_i}{C} = {} & \beta_1 + \sum_j \beta_{i,j} \ln P_j + \gamma_{M,P_i} \ln M + \sum_h \lambda_{h,j} \ln T_h + \\
& \sum_k \omega_{k,j_i} O_k + \sum_j \pi_{l,j} Z_l + \delta_{Q,P_i} \ln C_{QUALITY_i}.
\end{aligned}
$$

All variables are normalized by dividing by their mean values before estimation. Thus, first-order terms (the βs) can be interpreted as the estimated cost shares at mean values. SFAs located in urban areas in the Southeast region serve as the reference location.

Symmetry and homogeneity of degree one are imposed on the cost function, increasing efficiency and reducing the number of parameters to be estimated (Berndt, 1991). Symmetry implies that $\beta_{ij} = \beta_{ji}$, $\gamma_{Mi} = \gamma_{iM}$, $\lambda_{h,j} = \lambda_{j,h}$, $\omega_{j,k} = \omega_{k,j}$, $\pi_{l,j} = \pi_{j,l}$, and $\delta_{Q,i} = \delta_{i,Q}$. Translog cost functions are symmetric, continuous, monotonic in input prices and outputs, concave in input prices, and linearly homogeneous in input prices, with the following properties: $\sum \beta_i = 1$, $\sum \beta_{i,j} = 0$, $\sum \gamma_{Mi} = 0$, $\sum \lambda_{h,j} = 0$, $\sum \omega_{k,j} = 0$, $\sum \pi_{l,j} = 0$, and $\sum \delta_{Q,i} = 0$.

Meal quality is jointly determined with costs. It is affected by other meal qualities (O), demand variables (D), and input prices (P_i). Demand variables are excluded from the cost function and identify meal quality:

$$C_{QUALITY_i} = \delta_0 + \sum_k \sigma_k O_k + \sum_d \rho_r D_r + \sum_i \omega_{P_i} \ln(P_i). \tag{10}$$

The O and P_i variables have already been discussed. Demand variables (D) include the share of free and reduced-price meals served ($C_{FREE\_REDUCED}$), student enrollment ($C_{ENROLLMENT}$), median income of the SFA (C_{INCOME}), education achievement ($C_{EDUCATION}$), the student-teacher ratio ($C_{STUDENT\_TEACHER}$), and housing values (C_{HOUSE}).

Variable Definitions

Table 2 includes variable definitions. The variables wage, food, supply prices, NSLP lunch share, à la carte, and meal quality require more discussion.

Worker wages are a weighted average of the wages and fringe benefits of a typical allocation of kitchen staff. Pannell-Martin (1999) indicates that typical SFA staffing includes three cooks, twenty-two assistants, and four supervisors. Wage data (for example, assistant_wage and cost_fringe_benefits) were determined from the survey for each individual SFA.

We do not have a direct measure of food prices. Hence, an index of food prices is constructed using the Quarterly Food-At-Home Price Database (QFAHPD) reported by the Economic Research Service (ERS) and the food menu plans and purchases of the schools surveyed in the School Nutrition and Dietary Assessment (SNDA-III). The QFAHPD is based on Homescan data and reports price indexes for fifty-two food categories covering thirty-five market areas across the United States between 1999 and 2006. SNDA-III is available from the FNS and includes the types and amounts of foods used by 398 schools participating in USDA school meal programs in the 2004–2005 school year.

To create the food price index, we first identified the amount of each food consumed by all schools participating nationwide in SNDA-III during the 2004–2005 school year. Using prices from the QFAHPD, we multiplied the price of each food item in each marketing area by the number of pounds of each item used by all schools nationwide to obtain a dollar estimation of the cost of each food item in that marketing area. The dollar values of all food items in a given market area are then summed to obtain a dollar value of the nationally representative mix and amount of food consumed in schools in each market. In each of the thirty-five market areas, price indexes specific to each area are available for the foods used in school meals. Differences in values across market areas are therefore attributed only to these price differences. Using these estimates, we created an index of food prices used by SFAs by dividing the value of food in each marketing area by the average value of food for all SFAs across all market areas.

The dataset does not include the QFAHPD market area but does include a state identifier. Thus, market areas from the QFAHPD were mapped into states and merged into our dataset. The MERIC food price index is an available alternative to the index constructed using the QFAHPD price data. However, we prefer the index based on the QFAHPD and food menus because the food items are those typically purchased by schools, whereas MERIC measures food items representative of purchases by all consumers. We do use the MERIC data to check the validity of our reported results and find results from the two approaches to be consistent.

No data were available on the price of supplies. As an instrument for the price of supplies, we use a general price index reported by MERIC for each state, which excludes food, housing, utilities, health care, and transportation costs.

USDA school meals include NSLP lunches and SBP breakfasts. These meal types must be distinguished from each other because the SLBCS-II indicates that breakfasts are less costly to produce. The variable NSLP lunches served as a share of all meals (C_{SH_LUNCH}) is used to account

Table 2. Definitions of Cost Function Variables

Variable	Definition
Cost	Total wage and fringe benefit, food, including donated food, and supply costs
P_{LAB}	$P_{LAB} = Mean\_wage + Mean\_benefits$, where $Mean\_wage = \frac{22}{29} \times assistant\_wage + \frac{3}{29} \times cook\_wage + \frac{4}{29} supervisor\_wage, Mean\_benefits = Mean\_wage \times \left[\frac{SFA\_fringe\_benefits}{SFA\_wages + SFA\_fringe\_benefits}\right]$.
P_{FOOD}	$P_{FOOD,j} = \frac{V_j}{Mean\_V}$ and $V_j = \sum_i P_{i,j} \times Q_i$, where $P_{FOOD,j}$ is a price index of food for a typical USDA meal in market area j; Q_i is the total pounds of food item i purchased by all SFAs nationwide, as given by SNDA-III; $P_{i,j}$ is the price of food item i in market area j and comes from the QFAHPD; V_j is the value of all food purchased nationwide based on prices from one market area j of the QFAHPD; $Mean\_V$ is the mean value of V_j by all SFAs across all market areas of the QFAHPD. Differences in $P_{FOOD,j}$ are due to the influence of prices only since the mix and amount of food used was identical across market areas.
P_{SUPPLY}	Index price for general merchandise purchases for each state including cleaning material and other general merchandise. Excludes food, housing, utilities, health care, and transportation and is provided by MERIC.
$MEALS$	Number of reimbursable SBP breakfasts and NSLP lunches served by the SFA
SFA Characteristics	
C_{SH_LUNCH}	1 minus the number of breakfasts as a share of all USDA meals.
$C_{LACARTE}$	1 minus à la carte revenues as a share of SFA meal revenues.
$C_{HIGH\_SCHOOL\_LO}$	1 if the number of high school students enrolled in NSLP as a share of all elementary, middle, and high school students in NSLP is less than 30%; 0 otherwise.
$C_{HIGH\_SCHOOL\_HI}$	1 if high school students as a share of students in NSLP is more than 70%; 0 otherwise.
C_{TRAD_MENU}	1 if the SFA uses a traditional menu plan; 0 otherwise.
C_{HEALTH}	1 if SFA provides workers with health insurance; 0 otherwise.
$C_{FOOD\_SERVICE}$	1 if service management company provides some or all (1) workers, (2) food or supplies purchasing, or (3) food or supplies purchasing and labor; 0 otherwise.
$C_{QUALITY}$	Measure of meal quality as determined in the model.
Location	Includes Region and Urbanicity Variables
C_{SUBURB}	1 if Common Core Data indicate that SFA is in a suburban area; 0 otherwise.
C_{RUR}	1 if Common Core Data indicate that SFA is in a rural area; 0 otherwise.
$C_{ATLANTIC}$	1 if SFA located in FNS “Mid-Atlantic” region; 0 otherwise.
$C_{MIDWEST}$	1 if SFA located in FNS “Midwest” region; 0 otherwise.
C_{MOUNT}	1 if SFA located in FNS “Mountain Plains” region; 0 otherwise.
$C_{NORTHEAST}$	1 if SFA located in FNS “Northeast” region; 0 otherwise.
$C_{SOUTHWEST}$	1 if SFA located in FNS “Southwest” region; 0 otherwise.
C_{WEST}	1 if SFA located in FNS “West” region; 0 otherwise.

for differences in meal service. We use this approach because, as discussed above, some SFAs do not serve breakfasts and log functions are undefined at zero. Since all SFAs serve some NSLP lunches, C_{SH_LUNCH} is always positive and less than or equal to one.

À la carte foods are costly to produce and must also be accounted for. These are generally snacks that supplement a USDA meal or a meal brought from home but can constitute an entire meal in themselves. We account for à la carte foods by defining $C_{LACARTE}$ as one minus the value of à la carte revenues as a share of all meal revenues. This form of the variable is positive even if an SFA does not sell à la carte foods (no school sells only à la carte foods).

Meal quality is affected by other attributes, input prices, and demand variables. Other attributes—meal serving size and the meal menu planning option—and input prices have already been discussed. Two demand variables—the share of students eligible for free or reduced-price USDA meals ($C_{FREE\_REDUCED}$) and student enrollment ($C_{ENROLLMENT}$)—affect meal demand and quality but do not affect costs directly. Meal quality may also be affected by income, education, and, to a lesser extent, wealth in the areas served by an SFA (Drewnowski and Darmon, 2005; Patrick and Nicklas, 2005; Beydoun and Wang, 2008). The variables C_{INCOME}, $C_{EDUCATION}$, $C_{STUDENT\_TEACHER}$, and C_{HOUSE} are used in equation (9) to account for other demand effects. These six demand variables are omitted from the cost function but included in the meal quality equation. They therefore identify the cost function through exclusion restrictions.

Data

The data were obtained from a nationally representative survey of SFAs stratified by FNS region that was conducted by Mathematica Policy Research (MPR) for the 2002–03 school years (Mathematica Policy Research, Inc., 2004). MPR used three survey instruments: a one-page fax-back form, a brief telephone interview, and a four-page self-administered survey on costs, 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 qualitative information; and the self-administered cost and revenue file contained detailed information on food, labor, and material costs for 1,665 SFAs. MPR also constructed a link file containing school district and demographic information drawn from the National Center for Educational Statistics Common Core Data (National Center for Education Statistics, 2004) and from U.S. Census Bureau data. Some respondents did not reply to all questions. Complete and usable data were available for 1,359 respondents serving only NSLP lunches or NSLP lunches and SBP breakfasts. MPR asserts that the survey data reflect the population of local public SFAs in the fifty states and the District of Columbia.[2] To obtain representative results we used weights provided by MPR to account for differences in the probability of selection associated with sample design, nonresponse, and ineligibility.

Estimation, Model Selection, and Evaluation

We estimate a translog cost function in order to evaluate the sources of cost differences among twenty-one locations in seven regions, as designated by the FNS, and three types of metropolitan areas (urban, suburban, and rural).

Estimation Procedures and Model Selection

The model selection procedures used in this study are as follows. The variable cost function is estimated jointly with three cost-share equations and a meal-quality equation. Since cost-share equations sum to one, the share equation for supplies is omitted. We use a weighted iterative three-stage least squares regression procedure in the analysis because meal quality is jointly determined with costs. We use sampling weights to account for survey design, as discussed above. Among the $\ln T_{h_i} \times \ln T_g$ expressions from equation (8), only the interaction of the meal type with itself is retained, and among the $Z_{l_i} \times \ln T_h$ expressions only the interactions between the share of lunches and location variables are retained.

Diewert and Wales (1987) note that translog functional forms violate regularity if coefficients for input prices are nonpositive and if an estimated cost share for an observation is less than zero. The results in table 4 indicate that all estimated coefficients on input prices are positive. Cost shares at each observation are greater than zero in all cases.[3]

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[2] Memo dated August 6, 2004, from John Hall and Yuhong Zheng of MPR to Pat McKinney of FNS entitled "Weighting the NSLP Sampling Frame."

[3] Cost shares at each observation are not reported here but are available on request from the authors.

Table 3. Model Selection Tests for School Meal Cost Functions

Model	Description	Parameters Estimated	Test Statistics			
			Test	Restrictions	Critical Chi-Square at 0.01 level	Model Chi-Square
I	Translog Input Prices and Output	9	-	-	-	-
II	Reference Model[a]	84	II vs I	75	106	854***
III	Removes NSLP lunches as a share of all meals	71	III vs II	13	28	66***
IV	Removes 'à la carte' variable	79	IV vs II	5	15	190***
V	Removes shares of high school students from II	76	V vs II	8	20	26***
VI	Removes use of traditional menus from II	80	VI vs II	4	13	0
VII	Removes health care for workers from II	80	VII vs II	4	13	12**
VIII	Removes foodservice companies from II	80	VIII vs II	4	13	78***
IX	Removes location variables (urbanicities and region) from II	44	IX vs II	40	64	188**
X	Removes meal quality from II	79	X vs II	5	15	22***
XI	Imposes homotheticity on II	82	XI vs II	2	9	40***

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level.
[a]The reference model includes input prices, number of meals, the share of USDA meals that are NSLP lunches, revenues from USDA meals as share of all revenues, SFAs with a large share of high school students, SFAs with a small share of high school students, use of traditional menus, provision of health care, use foodservice companies, location, and meal quality.

We used a likelihood ratio test to assess model fit. A likelihood ratio test is preferable to single-variable statistical significance because translog cost functions have many interaction terms, making single variables poor measures of contributions to model fit. Table 3 presents test results for each of the independent variables by model number, model description, number of parameters in the restricted model, test comparison, number of restrictions, critical chi-square, and model chi-square values. For each model test, we compare the fit of a restricted model (a model in which at least one variable is left out of the reference model) to the fit of the reference model. The reference model includes all variables shown in table 2 and equation (8). If the chi-square statistic exceeds the critical value, then the restricted model is rejected in favor of the reference model.

We first compare a nine-parameter model that accounts for input prices and meals served (Model I) with the reference model containing eighty-four parameters (Model II). As shown in table 3, there are seventy-five restrictions and a chi-square of 854, which exceeds the critical chi-square statistic of 110. Next, we compare the reference model with a seventy-one-parameter model that excludes the variable share of NSLP lunches. The seventy-one-parameter model is rejected in favor of the reference model (the value of the chi-square statistic is 66). In subsequent tests, each independent variable, except prices and meals, is removed from the reference model to create a restricted model that is compared against the reference model. Every independent variable is statistically significant except the use of traditional menus and health insurance. We retain the variable for traditional menus because it is an important policy variable and include health insurance because it appears to affect the labor and food input cost shares in some models. Several other variables, including whether the SFA participated in the school snack program and whether the SFA used a central cooking facility, cooked offsite, or served free meals to all students were excluded from the final model because evidence of statistically significant effects was lacking.

Table 4. Translog Variable Cost Function Estimates of School Meals, School Year 2002–03

Variable	Coeff.	Std. Err.	Variable	Coeff.	Std. Err.
Intercept	0.044	0.07	$P_{FOOD} \times C_{HIGH\_SCHOOL\_HI}$	0.012	0.016
P_{LAB}	0.443^{***}	0.014	$P_{FOOD} \times C_{HEALTH}$	-0.037^{***}	0.009
P_{FOOD}	0.445^{***}	0.014	$P_{FOOD} \times C_{FOOD\_SERVICE}$	0.047^{***}	0.006
P_{SUPPLY}	0.112^{***}	0.009	$P_{FOOD} \times C_{TRAD\_MEN}$	0.017^{***}	0.005
$MEALS$	0.938^{***}	0.031	$P_{FOOD} \times C_{QUALITY}$	0.012	0.019
C_{SH_LUNCH}	0.776^{***}	0.159	$P_{FOOD} \times C_{SUBURB}$	0.005	0.008
$C_{LACARTE}$	-0.038^{***}	0.038	$P_{FOOD} \times C_{RUR}$	-0.009	0.009
$C_{HIGH\_SCHOOL\_LO}$	0.017	0.021	$P_{FOOD} \times C_{ATLANTIC}$	0.015^{*}	0.009
$C_{HIGH\_SCHOOL\_HI}$	0.297^{***}	0.102	$P_{FOOD} \times C_{MIDWEST}$	0.031^{***}	0.009
C_{TRAD_MENU}	-0.002	0.019	$P_{FOOD} \times C_{MOUNT}$	0.024^{***}	0.009
C_{HEALTH}	0.140^{***}	0.056	$P_{FOOD} \times C_{NORTHEAST}$	0.006	0.010
$C_{SERVICE}$	0.021	0.024	$P_{FOOD} \times C_{SOUTHWEST}$	-0.001	0.008
$C_{QUALITY}$	0.870^{***}	0.104	$P_{FOOD} \times C_{WEST}$	0.009	0.009
C_{SUBURB}	-0.031	0.032	$P_{SUPPLY} \times MEALS$	0.008^{***}	0.001
C_{RUR}	-0.076^{**}	0.035	$P_{SUPPLY} \times C_{SH\_LUNCH}$	-0.008	0.008
$C_{ATLANTIC}$	-0.113^{***}	0.034	$P_{SUPPLY} \times C_{LACARTE}$	-0.006^{**}	0.003
$C_{MIDWEST}$	-0.152^{***}	0.043	$P_{SUPPLY} \times C_{HIGH\_SCHOOL\_LO}$	-0.002	0.003
C_{MOUNT}	-0.127^{***}	0.030	$P_{SUPPLY} \times C_{HIGH\_SCHOOL\_HI}$	0.002	0.020
$C_{NORTHEAST}$	-0.177^{***}	0.031	$P_{SUPPLY} \times C_{TRAD\_MEN}$	$0.006**$	0.003
$C_{SOUTHWEST}$	0.011	0.030	$P_{SUPPLY} \times C_{HEALTH}$	-0.004	0.006
C_{WEST}	-0.264^{***}	0.034	$P_{SUPPLY} \times C_{SERVICE}$	0.007^{*}	0.004
$C_{LAB} \times P_{LAB}$	0.039^{***}	0.005	$P_{SUPPLY} \times C_{QUALITY}$	-0.074^{***}	0.013
$P_{FOOD} \times P_{FOOD}$	0.032^{**}	0.014	$P_{SUPPLY} \times C_{SUBURB}$	0.004	0.005
$P_{SUPPLY} \times P_{SUPPLY}$	-0.093^{***}	0.018	$P_{SUPPLY} \times C_{RUR}$	-0.003	0.006
$MEALS \times MEALS$	0.005^{*}	0.003	$P_{SUPPLY} \times C_{ATLANTIC}$	-0.026^{***}	0.006
$C_{SH_LUNCH} \times C_{SH\_LUNCH}$	0.132^{***}	0.033	$P_{SUPPLY} \times C_{MIDWEST}$	-0.018^{***}	0.006
$C_{LACARTE} \times C_{LACARTE}$	-0.090^{***}	0.009	$P_{SUPPLY} \times C_{MOUNT}$	-0.018^{***}	0.006
$C_{QUALITY} \times C_{QUALITY}$	0.585^{***}	0.186	$P_{SUPPLY} \times C_{NORTHEAST}$	-0.018^{***}	0.007
$P_{LAB} \times P_{FOOD}$	-0.082^{***}	0.011	$P_{SUPPLY} \times C_{SOUTHWEST}$	-0.024^{***}	0.006
$P_{LAB} \times P_{SUPPLY}$	0.043^{***}	0.008	$P_{SUPPLY} \times C_{WEST}$	-0.001	0.006
$P_{LAB} \times MEALS$	-0.005^{***}	0.002	$MEALS \times C_{SH\_LUNCH}$	0.024	0.035
$P_{LAB} \times C_{SH\_LUNCH}$	-0.005	0.012	$MEALS \times C_{LACARTE}$	0.007	0.009
$P_{LAB} \times C_{LACARTE}$	0.005	0.004	$MEALS \times C_{HIGH\_SCHOOL\_LO}$	0.006	0.010
$P_{LAB} \times C_{HIGH\_SCHOOL\_LO}$	-0.001	0.005	$MEALS \times C_{HIGH\_SCHOOL\_HI}$	0.074^{*}	0.037
$P_{LAB} \times C_{HIGH\_SCHOOL\_HI}$	-0.014	0.016	$MEALS \times C_{TRAD\_MEN}$	0.006	0.008
$P_{LAB} \times C_{TRAD\_MEN}$	-0.010^{***}	0.005	$MEALS \times C_{HEALTH}$	0.032^{*}	0.019
$P_{LAB} \times C_{SUBURB}$	-0.009	0.008	$MEALS \times C_{SERVICE}$	-0.006	0.013
$P_{LAB} \times C_{HEALTH}$	0.041^{***}	0.009	$MEALS \times C_{QUALITY}$	-0.078	0.060
$P_{LAB} \times C_{FOOD\_SERVICE}$	-0.054^{***}	0.006	$MEALS \times C_{SUBURB}$	-0.008	0.020
$P_{LAB} \times C_{QUALITY}$	0.062^{***}	0.019	$MEALS \times C_{RURAL}$	-0.043^{**}	0.021
$P_{LAB} \times C_{RUR}$	0.013	0.009	$MEALS \times C_{ATLANTIC}$	-0.003	0.021
$P_{LAB} \times C_{ATLANTIC}$	0.012	0.009	$MEALS \times C_{MIDWEST}$	0.005	0.020
$P_{LAB} \times C_{MIDWEST}$	-0.012	0.009	$MEALS \times C_{MOUNT}$	-0.012	0.019
$P_{LAB} \times C_{MOUNT}$	-0.006	0.009	$MEALS \times C_{NORTHEAST}$	0.004	0.022
$P_{LAB} \times C_{NORTHEAST}$	0.011	0.010	$MEALS \times C_{SOUTHWEST}$	-0.014	0.017
$P_{LAB} \times C_{SOUTHWEST}$	0.025^{***}	0.008	$MEALS \times C_{WEST}$	-0.016	0.018
$P_{LAB} \times C_{WEST}$	-0.009	0.009	$C_{SH\_LUNCH} \times C_{ATLANTIC}$	0.055	0.194
$P_{FOOD} \times P_{SUPPLY}$	0.050^{***}	0.014	$C_{SH\_LUNCH} \times C_{MIDWEST}$	-0.153	0.166
$P_{FOOD} \times MEALS$	-0.003^{*}	0.002	$C_{SH\_LUNCH} \times C_{MOUNT}$	-0.117	0.153
$P_{FOOD} \times C_{SH\_LUNCH}$	0.013	0.013	$C_{SH\_LUNCH} \times C_{NORTHEAST}$	-0.330^{*}	0.190
$P_{FOOD} \times C_{LACARTE}$	0.000	0.004	$C_{SH\_LUNCH} \times C_{SOUTHWEST}$	0.170	0.143
$P_{FOOD} \times C_{HIGH\_SCHOOL\_LO}$	0.003	0.73	$C_{SH\_LUNCH} \times C_{WEST}$	-0.229	0.172

(continued on next page. . .)

Table 4. – continued from previous page

Variable	Coeff.	Std. Err.
Quality Function		
Intercept	0.00	0.00
$C_{HIGH\_SCHOOL\_LO}$	−0.011	0.009
$C_{HIGH\_SCHOOL\_HI}$	0.123***	0.038
C_{TRAD_MENU}	0.006	0.010
$C_{FREE\_REDUCED}$	−0.042***	0.011
$C_{ENROLLMENT}$	0.007*	0.004
C_{INCOME}	0.183	0.041
$C_{EDUCATION}$	0.171***	0.027
$C_{STUDENT\_TEACHER}$	0.129***	0.027
C_{HOUSE}	0.074***	0.021
P_{LAB}	−0.049**	0.021
P_{FOOD}	−0.028	0.076
P_{SUPPLY}	−0.359***	0.096

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level. All variables are standardized at their means, so first-order coefficients can be interpreted as elasticities at the sample means. Dummy variable capture shifts in costs. There were 1,359 observations taken from the SFA Characteristics Survey of 2002-2003 on the costs of producing school meals at the School Food Authority level. The model R^2 was 0.9817.
Source: School Food Authority Characteristics Survey and ERS Analysis.

A cost function is homothetic if it is separable in input prices and output. To test this proposition, we exclude interaction terms for input prices and number of meals ($P_i \times MEALS$) from the model in equation (8) and compare it to the reference model. We reject homotheticity with a likelihood test (chi-square = 38) and conclude the model is nonhomothetic.

Evaluating Model Coefficients and Elasticities

Table 4 presents estimated coefficients for the best fitting model. Coefficients for the first-order input-price terms provide estimates of the share of costs devoted to labor (P_{LAB}), food (P_{FOOD}), and supplies (P_{SUPPLY}). Food inputs account for about 44.5% of per meal costs and labor and supplies comprise about 44.3% and 11.2% of costs. These cost shares apply to the reference category, which consists of urban SFAs in the Southeast that do not provide health care to food-service staff, do not contract with foodservice companies, serve an average number of elementary and high school students, prepare average quality meals, and serve an average value of à la carte foods and an average number of NSLP lunches. This is an atypical case.

The interactions of input prices with characteristics variables show how cost shares change as those characteristics change. The interaction of input prices with the regional dummy variables indicate that the food share of cost is 1–3% higher in the Mid-Atlantic, Midwest, Mountain Plains, and West regions; the labor share of costs is 1–3% higher in the Mid-Atlantic, Northeast, and Southwest regions; and the supply share of costs is lower in all other regions. These results are broadly consistent with national cost estimates provided by the SLBCS-II, which indicate that the food cost share of a meal was 46%, the labor cost share was about 44%, and the supply cost share was about 10%.

The characteristics of an SFA also have a strong influence on the food and labor cost shares. If the SFA offers health insurance, then the labor cost share increases by about 4% and the food cost share drops by about 4%. However, an SFA's food share rises by about 5% and its labor share drops by more than 5% if it uses a service management company.

Price elasticities at mean values indicate the responsiveness of demand to price changes. Input price elasticities (table 5) are negative and take on plausible values in all cases. They imply that a 10% price increase in labor, food, and supplies leads to declines in demand of 4.79%, 4.47%, and 20.9%. Allen elasticities of substitution indicate the degree to which a given percentage change in factor k can substitute for a percentage change in factor j. Allen elasticities (table 5) indicate that

Table 5. Mean Input Shares and Elasticities for the 2002–03 School Year

Shares/Elasticities	Input Price Variables		
	P_{LAB}	P_{FOOD}	P_{SUPPLY}
Mean Input Shares	0.47	0.45	0.08
ε_{ii} (own input price)	-0.479^{***}	-0.447^{***}	-2.082^{***}
	(0.0007)	(0.0008)	(0.019)
Allen elasticities of substitution			
P_{LAB}	-0.95^{***}	0.617^{***}	1.203^{***}
	(0.0036)	(0.0004)	(0.0002)
P_{FOOD}	-	-1.06^{***}	1.24^{***}
		(0.0038)	(0.0002)
P_{SUPPLY}	-	-	-26.02^{***}
			(2.65)

Notes: All values are calculated using mean 1992 data values and parameters from table 4. The own-price input demand elasticities are calculated holding output and other factors constant, while the elasticities of substitution are calculated using Allen's formula. See MacDonald et al. (1999) for equations. Standards errors based on standard errors for individual observations.
Source: School Food Authority Characteristics Survey and ERS Analysis.

the largest degree of substitutability is between supplies and food; the smallest is between labor and food. Price and Allen elasticities at the observation level and their mean values are similar to those in table 5.[4]

Evaluating Economies of Scale, Quality, Types of Meals, and Other Variables and Costs

Economies of scale are important in evaluating the cost of school meal production because size varies considerably. Twenty-five SFAs produce more than 10 million meals per year, but 350 produce fewer than 150,000 meals per year. Thus, even modest economies of scale can mean large differences in costs per meal.

The derivative of the cost function with respect to size yields the elasticity of total cost with respect to the number of meals served and can be used to evaluate economies of scale (MacDonald and Ollinger, 2000). Values smaller than one imply that economies of scale exist. The coefficient on the first-order *MEALS* term in table 4 implies that there are economies of scale at sample mean values and at the reference location (urban SFAs in the Southeast). Scale economies change at alternative points. The coefficients on all location and meals interaction terms (e.g., $MEALS \times C_{SUBURB}$ and $MEALS \times C_{SOUTHWEST}$) are negative except for the interactions of *MEALS* and the Midwest and Northeast regions. These signs imply larger economies of scale for suburban and rural SFAs than for urban SFAs and larger economies of scale for SFAs in the Mid-Atlantic, Mountain Plains, Southwest, and West than for SFAs in the Southeast. The coefficient on $MEALS \times MEALS$ (table 4) is positive, suggesting economies of scale moderate as SFA size increases. The cost elasticity equals one at about ten times the sample mean.

Results for the estimated meal-quality equation are as expected and consistent with those reported by Gertler and Waldman (1992). The three cost variables are negative, which is expected because increases in input prices raise the marginal cost of meal quality. Of the demand variables, income, education, the student-teacher ratio, housing values, and enrollment are estimated to have positive effects on meal quality. The proportion of students eligible for free or reduced-price meals has a negative impact on meal quality. This result is consistent with the hypothesis that these students have a higher opportunity cost of purchasing meals not subsidized by the USDA.

[4] Available from the authors on request.

Costs per meal change substantially as meal quality varies from its mean value. Using the reference model, sample mean values, and defining all dummy variables as zero, we examine costs at the sample mean, both 25% below the sample mean and 25% above the sample mean. Under these conditions, the estimated cost per meal is about \$2.51 at the mean value for meal quality, \$2.15 at meal quality levels that are 25% below the sample mean, and \$3.28 at meal quality levels that are 25% above the sample mean values.

Three other quality variables—SFAs with either a high or low share of high school students and use of traditional menus—had a modest effect on costs. Only five of the fifteen variables were significant. The results also indicate that the use of food-service companies reduces the labor share of costs and raises the food share of costs. Additionally, health benefits raise the labor share of costs. Signs on all of these results are consistent with expectations.

SFAs serve SBP breakfasts, NSLP lunches, and à la carte foods as part of their meal service. The SLBCS-II indicates that breakfasts are less costly to produce than NSLP lunches, and our results are consistent with this finding. Both the first- and second-order NSLP lunch share coefficients are significant and positive. Costs per meal at NSLP lunch shares at 25% below the sample mean are about \$2.12. They are \$3.14 for SFAs with NSLP lunch shares 25% above the sample mean. In these simulations, values for all dummy variables are set equal to zero and values for other variables are set equal to their sample means.

À la carte foods are mainly snacks or foods that complement a meal and add to the cost per meal. The negative signs on the coefficients for the first- and second-order à la carte terms indicate that costs drop as USDA meal revenues as a share of all revenues increase (that is, SFAs serve proportionately more USDA meals than snacks). Using sample mean values and equation (8), the cost per meal rises to \$2.91 per meal as $C_{LACARTE}$ decreases to 25% below the sample mean and cost per meal drops to \$2.38 per meal as $C_{LACARTE}$ increases to 25% above the sample mean.

School Meal Costs and SFA Location

The top panel of table 6 shows costs per meal based on either location-specific average values for the relevant variables or national average values for the relevant variables for the twenty-one locations. The per meal costs in rows entitled location are estimated using equation (8), the coefficients of table 4, and location-specific mean values. The national average meal cost of \$2.36 is obtained using equation (8), the coefficients in table 4, and national average values (including those for location).

The bottom panel of table 6 shows the difference in costs for each of the twenty-one cost pairs shown in the top panel. A positive value indicates that the estimated cost per meal at specific locations is higher than the estimated national average cost of the meal. Using location-specific values, costs per meal range from \$0.81 below the national average for urban Southwest SFAs to \$0.67 above the national average for suburban West and Midwest SFAs. Costs per meal using location-specific information are higher than the costs per meal using national values in eight locations in the West and rural and suburban locations in the Midwest and Northeast. Costs using location-specific values are lower than costs using national values in thirteen cases—all locations in the Mountain Plains, Southeast, Southwest, and six of the seven urban locations.

Information in table 7 shows how costs change as the value of one independent variable changes from the national value to the location-specific value. There are five change variables: three input prices, meals served, and all SFA characteristics. We compute the contributions of each of the five change variables to the meal cost differences shown in the bottom panel of table 6 as follows. First, we used equation (8), the coefficients in table 4, and national mean values to calculate the baseline cost per meal for each location. These costs match those in the top panel of table 6 in the rows entitled nation. Then, we compute an adjusted cost using the same criteria for all variables except for one change variable. This change variable (one of three input prices, meal servings, or all SFA characteristics) is assigned the location-specific mean value(s). The contribution of one change

Table 6. Estimated Cost per Meal Using Location-Specific Prices and Characteristics versus Cost per Meal Using National Prices and Characteristics for the 2002–03 School Year

		FNS region						
Urbanicity	**Prices/ Characteristics**	**Mid-Atlantic**	**Midwest**	**Mtn Plains**	**Northeast**	**Southeast**	**Southwest**	**West**
		Dollars per Meal						
Rural	Location	2.31	2.56	2.16	2.62	2.08	2.04	2.57
	Nation	2.32	2.23	2.30	2.18	2.60	2.64	2.00
Suburban	Location	3.09	2.97	2.32	2.82	2.29	2.35	2.75
	Nation	2.42	2.33	2.39	2.27	2.71	2.74	2.08
Urban	Location	2.28	2.39	2.31	2.33	2.30	2.02	2.35
	Nation	2.50	2.40	2.46	2.34	2.80	2.83	2.15
Meal Cost Difference[a]		*Dollars per Meal*						
Rural		−0.01	0.33	−0.14	0.44	−0.52	−0.60	0.57
Suburban		0.67	0.64	−0.07	0.55	−0.42	−0.39	0.67
Urban		−0.22	−0.01	−0.15	−0.01	−0.50	−0.81	0.20

Notes: Location is defined as one urbanicity paired with one FNS region (e.g., rural Midwest). Location costs based on equation (8), coefficients of table 4 and location-specific mean values for all independent variables. National costs based on equation (8), coefficients of table 4, and national mean values for the independent variables.
[a] Estimated cost per meal at the location minus estimated cost per meal at the national level.
Source: School Food Authority Characteristics Survey, Mathematica Policy Research, Inc. (2004), and analysis by the Economic Research Service, USDA.

variable to the difference in meal cost is then obtained by subtracting the baseline meal cost from the adjusted meal cost.[5]

Columns "a" to "c" and columns "e" and "f" of table 7 show the contributions of each of the three input prices, meals, and characteristics to meal cost differences shown in the bottom panel of table 6 and also in column "h" of table 7. A positive value indicates that the location-specific change in cost due to the "change variable" is greater than the cost of using the corresponding national mean value. Number of meal servings is the biggest contributor to costs in six of twenty-one cases; the average value of the contribution was $0.136 per meal. SFA characteristics were the largest contributor to costs in nine cases and accounted for about $0.237 in cost differences, and all prices were the biggest contributor to costs in seven cases, accounting for $0.17 per meal in cost differences. Prices and SFA characteristics contributed equal amounts in one case. The combined contribution of meals and prices to meal cost differences was about $0.221. Labor is the biggest cost contributor of the input prices in sixteen cases and food is the biggest contributor in five cases.

The ranges of cost effects are also important. Per meal cost differences associated with input prices range from location-specific costs per meal that are $0.33 above (urban and suburban West) to $0.30 below (suburban Southeast and rural Southwest) national average costs per meal. For meals, per meal costs at the location level vary from $0.39 higher (rural West) to $0.18 lower (rural Mid-Atlantic) than costs obtained using national values. The combined total of cost differences due to all input prices and meals served ranges from $0.60 above (rural West) to $0.37 below (suburban Southeast) the costs obtained using national values. Column "h" of table 7 shows the total impact of all change variables, including all characteristics and the three input prices and meals. Per meal

[5] The costs per meal given in the top panel of table 6 in the rows entitled "location" were computed by setting all five change variables to their location-specific values.

Table 7. The Contribution of Input Prices, Meals Served, and Characteristics to Differences in Cost per Meal for the 2002–03 School Year[a]

		Input Prices[b]				Attributes			
		Food Price[b]	Labor Price[b]	Supply Price[b]	Total Price	Meals Served[b]	Character-istics[b,c]	Price+ Meals	Price+ Attri.
		(a)	(b)	(c)	(a+b+c)	(e)	(f)	(d+e)	(f+g)
Region	Urbanicity				(d)			(g)	(h)
Mid-Atlantic	Rural	0.01	0.04[d]	0.00	0.05	−0.18[e]	0.12	−0.13	−0.01
	Suburban	0.08[d]	0.07	0.00	0.15	0.03	0.49[e]	0.18	0.67
	Urban	0.12	0.18[d]	0.01	0.31	−0.05	−0.48[e]	0.26	−0.22
Midwest	Rural	−0.07	0.08[d]	−0.01	0.00	0.34[e]	−0.01	0.34	0.33
	Suburban	−0.06	0.12[d]	−0.01	0.05	0.16	0.49[e]	0.21	0.70[f]
	Urban	−0.02	0.13[d]	−0.01	0.10[e]	−0.05	−0.06	0.05	−0.01
Mountain Plains	Rural	−0.04	−0.16[d]	0.00	−0.20	0.34[e]	−0.33	0.14	−0.19[f]
	Suburban	−0.02	−0.09[d]	0.00	−0.11[e]	0.05	−0.01	−0.06	−0.07
	Urban	−0.01	−0.04[d]	0.00	−0.05	−0.06[e]	−0.04	−0.11	−0.15
Northeast	Rural	0.04[d]	0.01	0.02	0.07	0.34[e]	0.03	0.41	0.44
	Suburban	0.10*d*	0.05	0.03	0.18	0.13	0.27[e]	0.31	0.58[f]
	Urban	−0.12[d]	−0.06	−0.04	−0.22[e]	0.03	0.18	−0.19	−0.01
Southeast	Rural	−0.01	−0.13[d]	−0.01	−0.15	0.08	−0.45[e]	−0.07	−0.52
	Suburban	−0.28[d]	−0.01	−0.01	−0.30[e]	−0.07	−0.05	−0.37	−0.42
	Urban	−0.02	−0.04[d]	0.00	−0.06	−0.05	−0.39[e]	−0.11	−0.50
Southwest	Rural	−0.02	−0.28[d]	0.00	−0.30	0.22	−0.54[e]	−0.08	−0.62[f]
	Suburban	0.0	−0.21[d]	−0.01	−0.22[e]	−0.01	−0.16	−0.23	−0.39
	Urban	0.00	−0.13[d]	−0.01	−0.14	−0.10	−0.53[e]	−0.24	−0.77[f]
West	Rural	0.04	0.17[d]	0.00	0.21	0.39[e]	−0.00	0.60	0.60[f]
	Suburban	0.13	0.21[d]	−0.01	0.33[e]	0.05	0.33[e]	0.38	0.71[f]
	Urban	0.12	0.20[d]	0.01	0.33[e]	−0.13	0.00	0.20	0.20
	Mean absolute difference	0.063	0.115	0.01	0.169	0.136	0.237	0.221	0.386

Notes: [a]Cost difference is costs per meal based on equation (8), coefficients in table 4, and location-specific mean values for independent variables minus cost per meal using equation (8), coefficients of table 4, and national values for the independent variables.
[b]Meal cost difference equals the costs based on equation 8, coefficients of table 4, one change variable (price of food, labor, or supplies, meals served, or all characteristics) equal to its location-specific value, and other nonchange, independent variables equal to national mean values minus cost per meal based on equation (8), coefficients of table 4, and national values for all independent variables.
[c]Characteristics is the combined effect of meal quality, share of NSLP lunches served, "à la carte" foods, traditional menus, share of SFA with large or small shares of high school students, the use of service management companies, and the provision of health care for workers.
[d]The price contributing the most to location-specific meal cost differences.
[e]Denotes which of prices, meals served, or characteristics contribute the most to meal cost differences.
[f]The values differ from bottom panel of table 6 because all interaction terms involving two or more different independent and continuous variables are not included in the computations since one is always defined at its national mean, which in log form is zero. Source: School Food Authority Characteristics Survey, Mathematica Policy Research, Inc. (2004), and Analysis by the Economic Research Service, USDA.

costs range from \$0.70 above (suburban Midwest) to \$0.77 below (urban Southwest) costs using national values.

The sums of the individual impacts of the five change variables do not always equal the meal cost differences shown in table 6. Interaction terms from equation (8) that include two different variables (for example, prices of food and labor) will always have at least one variable equal to their national mean since there is only one change variable. Since the national mean equals one and the log of one is zero, the interaction term always equals zero.

Conclusion

We use a quality-adjusted translog cost function to examine differences in costs of producing USDA school meals in twenty-one U.S. locations. The methodology follows an approach pioneered by Gertler and Waldman (1992) and extended by Antle (2000); it is the first cost-function-based approach to examine the cost of providing school meals. The methodology allows us to account for the effects and characteristics of meal quality as well several SFA characteristics and geographic locations. The methodology differs from Gertler and Waldman (1992) and Antle (2000) in that we use a weighted three-stage least squares econometric approach.

The purposes of this paper were to estimate costs per school meal across twenty-one geographic locations and measure the individual contributions of input prices, the number of meals served, and SFA characteristics to differences from the national average cost per meal. Results show that the cost per USDA meal varied from $2.02 per in urban SFAs in the Southwest to $3.09 per USDA meal in suburban SFAs in the Mid-Atlantic. Differences in the estimated cost per meal at different locations are substantial, ranging from $0.81 below to $0.67 above the costs obtained using national average prices.

The main drivers of these cost differences varied by location and included differences in input prices (largest effect in seven locations), SFA characteristics (nine locations), and economies of scale (six locations). SFA characteristics and the combined effect of input prices and number of meals served contributed equally to differences in meal costs from the national average (about $0.23 per meal). The total average difference from the national average cost per meal due to characteristics, prices, and meals was about $0.38 per meal, or about 15% of the average cost of a meal.

This study provides information on two important issues associated with USDA school meal reimbursement policy—the size of differences in per meal cost across U.S. locations and the source of those cost differences. Cost differences due to food, labor, and supply prices and SFA size (scale) are potentially most relevant to reimbursement policy because the USDA reimburses SFAs using national average variable costs. Our results show that costs vary, on average, by about $0.22 from the national average cost per mean, suggesting that some SFAs may be overcompensated and others undercompensated for their actual costs.

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