Cost Functions, Efficiency, and Quality in Day Care Centers

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ABSTRACT

Using a new data set, this paper finds that there is no quality difference between nonprofit and for-profit day care centers, and with the exception of one segment of the nonprofit sector, there is no efficiency difference. The cost of increasing the quality from mediocre to good is between 12 and 16 cents per child-hour.

Centers have inelastic demand for workers. Child care workers with 13 to 15 years of education and workers with more than 16 years of education are substitutes; workers with more than 16 years of education are complements to workers with 12 or fewer years of education. There are economies of scale and scope in production.

I. Introduction

Day care centers accounted for almost one-quarter of all child care arrangements in the United States in 1991 (Casper, Hawkins, and O'Connell

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1994). Enrollment in full-time child care increased from 900,000 children in the mid-1970s to 3.9 million in 1990 (Kisker and Maynard 1991). The increase in the demand for center-based child care services is coincident with the rise in the number of working mothers with small children. Between 1975 and 1993, the number of working mothers with children under 6 almost doubled, exceeding 8.7 million (Goodman 1995). Recent welfare reforms are expected to further increase female labor force participation and the demand for market-based child care.

Growing evidence links the quality of childhood care and education to child development. High-quality child care programs have been shown to reduce the likelihood of enrolling in special education programs (Lazar and Darlington 1982) and to improve the academic outcomes of children (Ramey and Campbell 1991). Also, recent studies demonstrate the relationship between schooling, cognitive skills, and labor market success (Murnane, Willett, and Levy 1995; Coleman 1993; Angrist and Krueger 1991).

Given the path from the quality of child care to child outcomes and children's future labor market achievement, and the detrimental impact of child care costs on the labor force participation of mothers with young children (Blau and Robins 1988; Ribar 1992), it is critical to develop an understanding of the functioning of the child care industry. First, it is documented by professionals in early care and education that the average quality of center-based care provided in the United States is below the level that is considered developmentally appropriate (Whitebook, Howes, and Phillips 1990). This study confirms that finding, and estimates the costs associated with an increase in quality. Second, there exists a long-standing controversy in the child care industry about the performances of nonprofit and for-profit centers. Nonprofit centers are accused of being inefficient; namely, receiving various donations from public and private agencies, but wasting those resources by producing child care services at higher costs than their for-profit counterparts. For-profit centers, on the other hand, are said to have lower quality and therefore take advantage of the consumers who cannot have perfect information about the quality of services purchased. This paper shows that both of these claims are incorrect. The paper also estimates demand elasticities of various types of labor, and investigates the existence of economies of scale and scope in center-based child care services, which are important pieces of information if decisions about the type and scale of production are to be made to reduce costs.

II. Background, Data, and Improvements over Previous Work

As Walker (1991) states, there exist only a handful of studies that investigate the supply side of the child care market. Powell and Cosgrove (1992) estimate a translog cost function using data from 182 child care centers accredited by the National Association for the Education of Young Children in 1989. They find that for-profit centers have costs that are 9 percent lower than their nonprofit counterparts. They also detect economies of scale in production. Powell and

Cosgrove control for center quality by adding the child/staff ratio, the group size of children, staff turnover, experience, and education to the cost equation and report significant relationships between these center characteristics and costs.

Mukerjee and Witte (1993) estimate a homothetic CES cost function for centers from the state of Massachusetts with data from 35 for-profit and 46 nonprofit centers. They report that the parameters of the cost function do not differ between for-profit and nonprofit centers and conclude that the observed higher costs for nonprofit centers result from different input and output choices, and not from differences in method of operation.

Preston (1993) estimates an average cost function using data from a national survey conducted in 1976–77. Using a sample of 2,703 observations she finds that the production functions of nonprofit and for-profit centers are similar. She reports that nonprofit centers offer costlier services than for-profit centers and nonprofit centers provide higher-quality services if federally regulated. Mukerjee and Witte (1993) and Preston (1993) also acknowledge the heterogeneous nature of the output, and they control quality by including variables similar to the ones used by Powell and Cosgrove (1992).

This paper improves upon previous studies in a number of ways, and provides new insights into the cost and production structure of child care centers. First, it uses a new data set obtained from child care centers in California, Colorado, Connecticut, and North Carolina.[1] The data are based upon a stratified random sample of approximately 100 day care centers from each participating state, with equal representation of for-profit and nonprofit programs, which provide full-time year-round care. Unlike other data sets currently available that are based upon telephone surveys (for example, the data of the Affordability Study Team at Wellesley College, used by Mukerjee and Witte 1993), or questionnaires mailed to the centers (for example, the GAO data set used by Powell and Cosgrove 1992), the data of this study are obtained by actual visits to the centers during the spring of 1993. Data collectors obtained in-depth financial information on center costs, amounts and sources of revenue, and amounts and sources of donations through on-site interviews and reviews of center records with center administrators or owners. Also, two observers visited each center for one day to gather data on classroom and center structural and process quality (defined below). As a result, the extraordinary detail of the data allows for control of center quality and the measurement of variables with more precision than was possible before. For example, many previous studies constructed the average wage rate of the center by dividing the wage bill by hours of labor. In this study information was collected on all workers in every center.[2] Consequently, center average wages for various labor categories (by title, by education, and so on) can be created

1. The data are compiled with the collaboration of economists, psychologists, and child development experts from University of Colorado at Denver, Yale University, the University of North Carolina at Chapel Hill, and UCLA.

2. More specifically, for every worker, the data set contains information on hourly wage or annual salary, hours of work per week, years of experience, tenure at the center, age, race, gender, the age group of children served, and job titles.

using microdata. Another improvement over existing data sets is the detailed measurement of donations. Because nonprofit centers receive more donations than do for-profit centers, failure to account for the value of donations would create an inaccurate picture of the relative costs of nonprofit centers. The data set contains information on line-item donations such as food, equipment, facilities, insurance, and supplies. It also contains information about individual volunteers, including the hours donated by each volunteer, and the job performed at the center.

One other main aspect of this data set is the ability to distinguish between center structural and process quality. Although previous studies acknowledged the heterogeneity of the output produced, they lacked a good control of center quality. As a result, they attempted to control center quality by including various center characteristics such as staff-child ratio, staff education, and experience in the cost function as explanatory variables. These center characteristics are known as "structural quality measures" in early childhood education literature. They are inputs into the production of the center's "process quality." Center process quality is influenced by classroom structures such as teacher education, teacher experience, and the number of children per teacher, as well as by center structural characteristics such as the number of children served and the age groups that are served. The center's process quality is also affected by the quality of the child care environment, specific aspects of teacher-child interactions, and the style of teaching.[3]

This paper employs the index of process quality to control for heterogeneity in output. This index is widely used in early childhood literature and has been shown to be positively related to children's social and cognitive developments. Later in the paper it is shown that the use of structural quality measures (such as the staff-child ratio) in a cost function is troublesome because of theoretical and statistical reasons. The paper also demonstrates the bias that is generated by attempting to control for quality using improper proxies.

The data contain information on actual hours of service provided for various age groups of children. Thus, a multiproduct cost function is estimated, where the services for infant-toddlers, preschoolers, and kindergarten-school age children are distinguished. As a result, this paper provides, for the first time, information on economies of scope in child care centers. Other contributions are the calculation of the cost of an increase in center quality and the economies of scale in production. Aspects of production technology, such as homotheticity and the separability of inputs, and the efficiency comparison between nonprofit and for-profit centers are also reported. Finally, this is the first paper to report elasticities of substitution among three labor categories and the corresponding labor demand elasticities.

Section III describes the model estimated. Section IV explains the sample

3. See the appendix for a description of structural and process quality instruments. A detailed discussion of the relationship between process and structural quality can be found in Blau (1997) and Mocan et al. (1995).

design and the measurement of variables. Section V presents the empirical results, and Section VI is the conclusion.

III. Empirical Implementation

The analyses are based upon the estimation of short-run cost functions for child care centers. Long-run cost functions are also important, but estimating a long-run cost function with these data may be problematic. For child care centers, capital is not so much toys and equipment, as it is the physical plant.[4] Unlike machinery, however, the expansion or contraction of the physical plant may be difficult. This is particularly the case if centers are using donated space. For example, if space is not easily divisible, then centers which receive donated space may be driven to use above-optimum physical capital. Thus, given the nature of capital in this industry, it may be difficult to obtain information about long-run equilibrium with these data.[5] The second difficulty with estimating a long-run cost function involves the price of capital. A long-run cost function would treat capital as a variable input, and this necessitates the inclusion of the cost of capital as an explanatory variable, which is not available for centers that use partially or completely donated space.[6]

The short-run quality-adjusted cost function for child care centers can be expressed as

$$(1)\quad TVC = f(P, Y, K, q),$$

where TVC is the total variable cost, P is the vector of prices, Y denotes the vector of the quantity of outputs, K stands for capital, and q is the level of quality produced.[7]

To estimate the cost function in Equation 1, a translog functional form is employed. Translog cost functions have enjoyed widespread applications which include estimation of hospital cost functions (Vita 1990), cost of producing public safety (Gyimah-Brempong 1987), cost functions for the trucking industry (Gagne 1990), and cost functions pertaining to electricity and gas production (Betancourt and Edwards 1987), as well as cost functions for child care centers (Powell and

4. In our data set children's program supplies and equipment are reported as part of the operating costs. Some other components of the operating costs are office supplies, maintenance supplies, depreciation on equipment, transportation and travel, telephone, postage, licensing and fees, marketing, advertising, and public relations. The ratio of operating costs to total costs was 0.08.

5. The same argument is made for the electric power industry (Nelson 1985), hospital costs (Cowing and Holtmann 1983), and costs for school districts (Callan and Santerre 1990).

6. If the user cost of capital is the same among narrowly defined groups of centers, then estimating a cost function with controls for auspice types but without capital may resolve this problem.

7. The cost function depicted in Equation 1 can be called a restricted cost function, which corresponds to the minimization of the costs of variable inputs conditional on the level of the remaining quasi-fixed factor (physical capital in our case) (for example Halvorsen and Smith 1986; Caves, Christensen, and Swanson 1981).

Cosgrove 1992) and the nursing home industry (Gertler and Waldman 1992). The empirical counterpart of Equation 1 is

$$\text{(2)}\quad \ln TVC = \alpha_0 + \Sigma\alpha_i(\ln P_i) + \beta_1(\ln K) + (\beta_2/2)(\ln K)^2$$
$$+ (1/2)\Sigma\Sigma\gamma_{ij}(\ln P_i \ln P_j) + \Sigma\delta_i(\ln P_i \ln K) + \Sigma\pi_k(\ln Y_k)$$
$$+ (1/2)\Sigma\Sigma\xi_{kr}(\ln Y_k \ln Y_r) + \Sigma\Sigma\mu_{ik}(\ln P_i \ln Y_k)$$
$$+ \Sigma\phi_k(\ln Y_k \ln K) + \tau_1(\ln q) + (\tau_2/2)(\ln q)^2 + \tau_3(\ln K \ln q)$$
$$+ \Sigma\psi_k(\ln Y_k \ln q) + \Sigma\Omega_i(\ln P_i \ln q) + \Sigma\omega_n D_n + \mu_n,$$

where TVC is total variable cost. P_i and P_j are prices of the ith and jth inputs, respectively. They are the wages for teaching staff with 12 or fewer years of formal education, wages for staff with 13–15 years of education, and wages for staff with 16 or more years of education.

Some studies used the number of full-time-equivalent children as the measure of output (for example, Powell and Cosgrove 1992; Preston 1993). This is problematic, because the definition of full-time equivalent is not the same across centers. There is significant variation in the length of a full-time day across centers and across age groups. Thus, a more reliable measure of output is the actual hours of service provided. In this analysis output is classified into three categories: hours of infant-toddler services, hours of preschool services, and hours of kindergarten and before- and after-school services for school-age children. Y_r and Y_k represent the amounts of the rth and kth output. K stands for the amount of physical space, which is fixed in the short run; q is the process quality of the center. A vector of dummy variables (D_n) representing center attributes is included to capture efficiency differentials due to center characteristics. The variables are defined in detail in the data section below.

To be consistent with economic theory, the cross-coefficients must be symmetric and the cost function should be linearly homogenous in input prices. These imply the following restrictions on Equation 2:

$$\text{(3)}\quad \gamma_{ij} = \gamma_{ji} \text{ for all } i \text{ and } j, \text{ and } \xi_{kr} = \xi_{rk} \text{ for all } k \text{ and } r.$$

$$\text{(4)}\quad \Sigma\alpha_i = 1, \Sigma_j\gamma_{ij} = 0 \text{ for all } i, \Sigma\delta_i = 0, \Sigma\Omega_i = 0, \text{ and } \Sigma_i\mu_{ik} = 0 \text{ for all } k.$$

The cost equation is estimated jointly with the system of share equations. To avoid singularity in the error covariance matrix, one of the share equations is deleted and the model is estimated using nonlinear methods by imposing the symmetry restrictions depicted in (3) above. Restrictions in (4) are used for a specification test. The explanatory variables are normalized by dividing each variable by its mean before taking the natural logs (Callan and Santerre 1990; Vita 1990).[8]

8. Because the translog cost function is a second-order approximation to an arbitrary cost function, its ability to represent the firm's technology is more robust at the point of approximation, which is the sample mean. Translog and other flexible functional forms may perform poorly for data points far from the approximation point (Vita 1990; Caves and Christensen 1980; Wales 1977). Normalization of the explanatory variables generates the convenience that the first-order parameters are elasticities when evaluated at the means.

Not all centers in the sample serve all three age groups. However, to obtain global information on the production function, it is necessary that the centers with zero output levels be included in the analysis (Caves, Christensen, and Tretheway 1980). Following Caves et al. (1980), Vita (1990), and Callan and Santerre (1990), the Box-Cox transformation is applied to the output variables, where $\ln Y_i$ is replaced with $(Y_i^{\lambda} - 1)/\lambda$, and the Box-Cox parameter λ is estimated jointly with other coefficients of the system.

A. Economies of Scope and Scale

Economies of scope exist if there are complementarities between groups of outputs, and hence it is cheaper to produce them jointly rather than separately. Assume there are two categories of output: infant-toddlers, and older children. Following Gyimah-Brempong (1987), Murray and White (1983), and Denny and Pinto (1978), economies of scope exist, if

$$(5)\quad C(Y_1, Y_2) < C(Y_1, 0) + C(0, Y_2),$$

where Y_1 stands for the hours of service provided for infant-toddlers, and Y_2 is the hours of older children served. If the condition in (5) holds, the cost of serving infant-toddlers and older children jointly is less than the sum of the costs of serving them separately. In the long run, a sufficient condition for the existence of scope economies between two outputs i and j is

$$(6)\quad C_{ij}^{LR} = \partial^2 C^{LR}/\partial Y_i \partial Y_j < 0 \; i \neq j \text{ for all } Y,$$

where C^{LR} is the long-run cost function.

Equation 6 indicates that for long-run economies of scope to exist between outputs Y_i and Y_j, an increase in Y_j should decrease the long-run marginal cost of Y_i. Note that

$$(7)\quad C_{ij}^{LR} = \partial^2 C^{LR}/\partial Y_i \partial Y_j = C_{ij}^{SR} + C_{ik}^{SR}(\partial K^*/\partial Y_j),$$

where $C_{ik}^{SR} = \partial^2 C^{SR}/\partial Y_i \partial K$, C^{SR} stands for the short-run cost function, and K^* is the long-run equilibrium value of K. If K is normal, $\partial K^*/\partial Y_j > 0$, and a sufficient condition for long-run scope economies is $C_{ik}^{SR} < 0$ and $C_{ij}^{SR} < 0$. In our context, if $\pi_k \pi_r + \xi_{kr} < 0$ this implies that $C_{ij}^{SR} < 0$, and also implies the presence of scope economies between Y_k and Y_r(Vita 1990; Gyimah-Brempong 1987; Murray and White 1983).

As Vita (1990) and Nelson (1985) outline, in the absence of the price of capital, long-run scale economies (*LSCE*) can be calculated as

$$\begin{aligned}(8)\quad LSCE &= (1 - \partial \ln C/\partial \ln K)/\Sigma(\partial \ln C/\partial \ln Y) \\ &= [1 - (\beta_1 + \beta_2 \ln K + \Sigma\delta_i \ln P_i + \Sigma\phi_k \ln K + \tau_3 \ln q)]/ \\ &\quad [\Sigma\pi_k + \Sigma\Sigma\xi_{kr} Y_r + \Sigma\Sigma_i \mu \ln P_i + \Sigma\phi_k \ln K + \Sigma\psi_k \ln q].\end{aligned}$$

The second term in the numerator is the difference between the long-run and the short-run scale economies, and it accounts for the cost adjustment due to a change in capital.

When $LSCE > 1$, there are scale economies. That is, a proportional increase in the hours of infant-toddlers, preschoolers, and school-age children brings about a proportionately smaller increase in total variable cost. When mean-scaled data are used, the last four terms in the numerator and denominator of Equation 8 are equal to 0, and the measure of scale economies reduces to $LSCE = (1 - \beta_1)/\Sigma\pi_k$.

B. Labor–Labor Substitution and Wage Elasticities of Labor Demand

The estimated parameters of the cost function can also be used to calculate the elasticities of substitution among labor categories, as well as the labor demand elasticities. The Allen Elasticity of Substitution, $\sigma_{ij}\, i \neq j$, measures the effect on relative factor inputs of a change in the relative factor prices, holding constant output and other factor prices. Two factors are called *p*-complements (*p*-substitutes), if $\sigma_{ij} < 0(>0)$. For our translog cost function, $\sigma_{ij} = (\gamma_{ij}/\alpha_i\alpha_j) + 1,\ i \neq j$. Similarly, the constant-output (short-run) labor demand elasticity for the *i*th labor category can be calculated as $\eta_i = (\gamma_{ii} + \alpha_i^2 - \alpha_i)/\alpha_i$, where α_i is the estimated share of the *i*th input in total variable cost.

IV. Sample Design and the Measurement of Variables

Data were collected through visits during the spring of 1993 to approximately 50 randomly chosen for-profit centers and 50 nonprofit centers in each of four states: California, Colorado, Connecticut, and North Carolina.[9] Only state-licensed child care centers offering services at least 30 hours per week and 11 months per year were included. The centers had to be in operation at least one full fiscal year immediately prior to data collection, and the majority of children had to attend at least 30 hours and five days per week in order to be included.[10]

TVC is total variable cost of the center during fiscal year 1991–92. It is the sum of annual wage and salary expenditures, nonwage benefits, staff education costs, subcontracting costs, food costs, other operating expenses, and the estimated value of in-kind donations (food, volunteer services, and supplies). The value of donations is included to make the total variable costs of different centers comparable to each other. The value of volunteer services is calculated by multiplying the volunteer hours by the wage rate of the paid labor doing similar work.

9. The Los Angeles county in California, the Front Range region in Colorado (Colorado Springs, Denver, Fort Collins), the Hartford–New Haven corridor in Connecticut, and the Piedmont Triad area in North Carolina (Greensboro, Winston-Salem, and High Point) are sampled.

10. The response rates ranged from 41 percent in North Carolina centers to 68 percent in Colorado and Connecticut centers. In Colorado, Connecticut, and North Carolina there was no statistically significant difference between participants and nonparticipants with respect to such characteristics as the legal capacity of the center, age of the center, profit status (nonprofit or for-profit), enrollment, and the type of children served (namely serving infants, toddlers, preschoolers, and school-age children). In California, the participation rate was higher for nonprofit centers, and participating centers had larger legal capacity and enrollment, and a higher propensity to serve infants. (Details can be found in Cryer et al. 1995).

To the extent that the centers can alter the hours of work provided by the center's director(s), the salaries of the directors are also part of the total variable costs. Some for-profit centers are owned and operated by individuals who are also the directors of the center. For those owner-directors who did not report a wage or salary, the salaries are imputed and added to the total variable costs. Missing salaries of owner-directors are imputed by multiplying their hours by the highest wage at the center plus 23 percent, which is the mean premium a director receives above the highest-wage of the center. To check the sensitivity, missing salaries were also imputed by (i) assigning the average salary of administrative directors in the same state, same sector (profit or nonprofit), and similar center size, and (ii) by multiplying the highest wage at the center with the hours worked by the owner-director. The results were insensitive to the method. The overhead costs, facilities cost, and insurance costs are considered fixed costs. The overall sensitivity of the results to changes in the ingredients of TVC is discussed in the results section.

Each member of the teaching staff is classified into one of the three categories: staff with less than or equal to 12 years of formal education, staff with 13–15 years of education, and staff with 16 or more years of education. Workers who have special training and certificate degrees are promoted to the next category. For example, workers who have 12 or fewer years of education but who have CDA training are promoted to the second level. Workers with an education of 13–15 years and who have a Registered Nurse degree are promoted to the third category. For each group, center average wages (*WAGE1, WAGE2, WAGE3*) are calculated using individual wages, weighted by hours of work. For centers which do not have any staff in a particular category, the mean wage for that state is substituted. Infant-toddler output (*INFANT-TODDLER*) is the total annual hours of service the center provided for infant-toddlers in the fiscal year. *PRESCHOOL* is the annual hours of service provided for preschoolers, and *SCHOOLAGE* stands for the annual hours of care provided for kindergarten-school age children. Centers that are observably identical in every respect (including quality) may have different costs in the presence of different, unobservable center characteristics. Because of these concerns, in Equation (2), D_n stands for the variables that capture the efficiency differential due to the structure in which the center operates. In this group of variables there is profit status (*PROFIT*), which takes the value of 1 if the center is for-profit, and 0 if it is nonprofit. *NATIONAL CHAIN* is also a dichotomous variable, indicating whether the center is part of a for-profit national chain. *SPECREG* is 1 if the center receives public money, either from the state or federal government, tied to higher standards (above and beyond normal licensing regulations), and 0 otherwise. This group includes Head Start centers, centers where 20 percent or more of their enrollment constitute special-needs children, special preschool programs sponsored by the state or federal Department of Education, and other special programs in Connecticut and California.

PUBAUSP is set to 1 for centers that are owned and operated by public agencies. Examples include public colleges, hospitals, and city departments of family services. *PUBSUPP* is another dichotomous variable which takes the value of 1 if the center is not publicly owned or operated, but receives more than

50 percent of its revenue from public grants, public fees, and USDA reimbursement. Also included are state dummies which aim to capture state-specific unobservables such as variations in regulatory environment. *SPACE* is the square footage of the inside space used by children, which is the measure of physical capital (K). It is obtained from the records of the center. In cases where it was not available, the observers measured the square footage of the center.

In each center two classrooms were randomly selected: one from the older children (30 months and older) and one from the younger groups. In each room well-established global measures of the child care process were employed by trained observers to assess the quality of the operation.[11] To create a single score to represent classroom process quality, an index was created using principal components techniques. The center-level process quality (*QUALITY*) is the average classroom quality, weighted by enrollments at the appropriate age levels. This is the same quality index that has been widely used in child development literature. It has a seven-point scale, with a range from inadequate (1) to minimal (3), good (5), and excellent (7).

Quality has dimensions that include parents' preferences concerning the child care arrangement, such as whether the provider shares the same religion and values of the parents (Blau 1991). These aspects of child care, which create utility for parents, are expected to have an impact on the demand for child care. This implies that a particular consumer's perception (or assessment) of quality of a given center may diverge from the child care experts' evaluation, as represented by our quality index. Nevertheless, the process quality index employed in this paper is the best measure to control for heterogeneity in output, and it is well suited for our task, because the investigation pertains to the supply of child care.

The descriptive statistics are presented in Table 1. In the full sample, nonprofit centers pay higher wages to workers than for-profit centers in each education category, although the difference for workers with less than 13 years of schooling is not significantly different from 0. For-profit centers serve more child-hours for infant-toddler and school-age children. There is no statistically significant difference in the mean values of total variable costs, preschool hours produced, and the space used between the two sectors.

The sample average of the quality index is 4.01, reflecting mediocre quality of care. The average quality of for-profit centers is lower than that of nonprofits. The difference, however, is due to the quality difference between the two sectors in North Carolina. Table 2 presents the descriptive statistics of quality, total variable costs, and wages, by state and profit status. There is no significant difference in quality between for-profit and nonprofit centers in California, Colorado, and Connecticut. North Carolina for-profit centers have significantly lower average quality than their nonprofit counterparts.[12] The mean values of variable costs

11. See the appendix for the details.

12. There is a consensus among child care professionals that this outcome is attributable to relatively lax regulations in North Carolina in comparison to other states. This assessment, however, is not entirely correct. For example, a comparison of the required staff-child ratios and group sizes between California and North Carolina reveals that in California the state-mandated minimum staff-child ratios are 1:4 for infants, 1:12 for preschoolers, and 1:14 for school-age children (California Department of Social Services

do not differ by profit status within a given state. The wages of the least-educated workers do not differ by profit status, except in Colorado, where nonprofit centers pay more than for-profit centers. Wages of workers with 16 or more years of education are higher in nonprofit centers in all four states. The same is true for workers with 13 to 15 years of education, with the exception of California, where no significant difference is present. In short, Tables 1 and 2 demonstrate that with the exception of North Carolina, average quality is the same between for-profit and nonprofit centers, nonprofits pay higher wages to educated workers, for-profits produce more child-hours of service, and the total variable costs are not noticeably different between sectors.

The equality of average center quality between for-profit and nonprofit centers is important. Child care is an example of a trust good, where the quality of the product is important to the buyers, but difficult for them to assess accurately (Weisbrod 1988). Because trusting the provider is important, consumers would need indications or signals of quality to help in their choice of provider. Tables 1 and 2 show that nonprofit status should not be considered as a "trust signal" for quality in the child care market.[13]

V. Empirical Results

A. *Specification Test and Functional Form*

The cost function presented in Equation 2 is estimated jointly with the corresponding share equations, by imposing the symmetry condition depicted in (3). To be consistent with economic theory, the conditions presented by (4) must also hold. The validity of the model is tested by imposing the restrictions in (4) and performing a likelihood ratio test. The calculated chi-squared was 11.89 with nine degrees of freedom, indicating that the model satisfied the conditions presented by (4). The estimated cost function can be used to test hypotheses about specific functional forms. For example, if $\mu_{ik} = 0$ for all i and k in Equation 2, this means that the production is homothetic, and output is separable from input prices. If $\mu_{ik} = 0$ for all i and k, $\gamma_{ij} = 0$ for all i and j, and $\xi_{kr} = 0$ for all k and r, this implies that the elasticities of substitution between inputs are equal to 1. In this

1996). In North Carolina, the staff-child ratios are 1:5 for children aged 0 to 12 months, 1:6 for children 12 to 24 months, 1:10 for children 2 to 3 years, and 1:15 for 3–4 year olds. The staff-child ratio is 1:15 for children 4 to 5 years old if the center is small, and 1:20 if the center is medium or large. The ratio is 1:25 for children 5 years and older (North Carolina Department of Human Services 1996). Thus, although the required staff-child ratio is smaller in North Carolina for older children, it is not much different from the requirements in California for younger children. Furthermore, the second major regulation, the group size of children, is drastically different between the two states in favor of North Carolina. While maximum group size ranges from 10 to 25 in North Carolina, there is no maximum group size regulation in California. In short, it is not the case that North Carolina has more laxed regulations than California. It may, however, be the case that North Carolina regulations are difficult to enforce and comply with because of their complicated nature (namely, trying to impose staff-child ratios and group sizes for every age group and separately for small and medium and large centers).

13. See Frank and Salkever (1994) for an analysis of nonprofit sector quality in the health sector.

Table 1
Descriptive Statistics[a]

Variable	Definition	Profit (N = 200)	Nonprofit (N = 196)	All (N = 396)
TVC	Total variable cost (the sum of wage and salary expenditures, nonwage benefits, staff education costs, subcontracting costs, food costs, other operating expenses, and the estimated value of in-kind donations and owner-director salaries)	218,953 (138,035)	231,990 (171,826)	225,406 (155,618)
WAGE1	Center-weighted average wages for staff with 12 or fewer years of formal education ($/hour).	5.64 (1.13)	5.86 (1.30)	5.75 (1.22)
WAGE2	Center-weighted average wages for staff with 12–15 years of formal education ($/hour).	6.26* (1.41)	6.83* (1.96)	6.54 (1.72)
WAGE3	Center-weighted average wages for staff with 16 or more years of formal education ($/hour).	6.95* (1.65)	8.11* (2.83)	7.53 (2.38)
INFANT-TODDLER	Total annual hours of service the center provided for infant-toddlers in fiscal year.	34,877* (32,814)	23,827* (39,237)	29,408 (36,511)
PRESCHOOL	Total annual hours of service the center provided for preschooler in fiscal year.	92,031 (75,534)	88,303 (70,377)	90,186 (72,959)

SCHOOLAGE	Total annual hours of service the center provided for kindergarten- or school-age children in fiscal year.	22,453* (33,430)	12,718* (20,221)	17,635 (28,083)
PROFIT	Dummy variable (= 1) if center is for profit, (= 0) otherwise.	—	—	0.505 (0.50)
NATIONAL CHAIN	Dummy variable (= 1) if center is part of a for-profit national chain, (= 0) otherwise.	0.240 (0.43)	—	0.121 (0.33)
SPECREG	Dummy variable (= 1) if center receives public money, (= 0) otherwise.	—	0.143 (0.35)	0.071 (0.26)
PUBAUSP	Dummy variable (= 1) if center is owned and operated by public agencies, (= 0) otherwise.	—	0.138 (0.35)	0.068 (0.25)
PUBSUPP	Dummy variable (= 1) if the center is not publicly owned or operated, but receives more than 50 percent of its revenue from public grants, fees, and USDA reimbursement, (= 0) otherwise.	0.040 (0.20)	0.194 (0.40)	0.116 (0.32)
SPACE	The square footage of the inside space used by children.	4,703 (3,383)	5,098 (4,687)	4,898 (4,081)
QUALITY	The average classroom process quality, weighted by enrollments at the appropriate age levels.	3.87 (0.85)	4.15 (0.83)	4.01 (0.85)

a. The numbers in the cells are the means. The numbers in parentheses are standard deviations. (*) indicate that the means between for-profit and nonprofit centers are different at the 5 percent level or better.

Table 2
Descriptive Statistics by State and Profit Status[a]

Variable	Center Type	California	Colorado	Connecticut	North Carolina
TVC	For-profit	273,582	215,675	202,748	185,226
		(201,970)	(93,158)	(112,664)	(106,593)
	Nonprofit	240,389	207,029	250,433	230,800
		(163,689)	(157,781)	(160,526)	(204,329)
QUALITY	For-profit	4.15	3.80	4.35	3.18*
		(0.75)	(0.61)	(0.83)	(0.72)
	Nonprofit	4.35	3.93	4.32	3.98*
		(0.87)	(0.77)	(0.82)	(0.79)
WAGE1	For-profit	6.25	4.93*	6.38	5.01
		(1.38)	(0.55)	(0.94)	(0.56)
	Nonprofit	6.27	5.26*	6.75	5.17
		(1.46)	(0.98)	(1.24)	(0.65)
WAGE2	For-profit	7.58	5.40*	6.88*	5.19*
		(1.85)	(0.49)	(1.03)	(0.47)
	Nonprofit	7.81	6.11*	7.85*	5.53*
		(2.17)	(1.41)	(1.96)	(0.84)
WAGE3	For-profit	8.37*	5.87*	7.84*	5.74*
		(1.47)	(0.90)	(1.52)	(0.54)
	Nonprofit	9.56*	6.76*	9.89*	6.24*
		(2.66)	(1.74)	(3.21)	(1.16)
		n(for-pr) = 49	n(for-pr) = 50	n(for-pr) = 51	n(for-pr) = 50
		n(nonpr) = 50	n(nonpr) = 50	n(nonpr) = 48	n(nonpr) = 48

a. The first number in each cell is the mean. The numbers in parentheses are standard deviations. (*) indicates the corresponding means between for-proft and nonprofit centers are significantly different from each other at the 5 percent level or better.

case, the cost function corresponds to a Cobb-Douglas production function. The hypothesis of homotheticity is tested by imposing the restriction $\mu_{ik} = 0$ on the cost function. The calculated chi-squared was 35.32 with nine degrees of freedom, leading to the rejection of the hypothesis of homotheticity. The calculated chi-squared under the hypothesis of Cobb-Douglas form was 117.04 with 21 degrees of freedom, rejecting the Cobb-Douglas functional form. The results below are based upon the estimation of the general form depicted by Equation 2 under symmetry restrictions (3).

B. Cost of Increasing Quality

The estimated parameters of the short-run cost function are reported in Table 3. The first-order parameters of prices and quantities (α_1, α_2, α_3, π_1, π_2, π_3,) are positive and significant as suggested by theory, indicating that increases in production levels and the wage rates bring about increases in total variable cost. There exists a positive relation between total variable cost and quality. The first-order parameter of the quality index (τ_1) is positive and significant, which indicates, as expected, that an increase in quality is associated with an increase in total variable costs. The second-order term of quality (τ_2) is not statistically different from 0. The estimated quality coefficients demonstrate that if the quality index increases by 10 percent, this brings a 4.0 percent increase in total variable costs.[14] Research on child development used the same quality index and demonstrated the positive impact of process quality on children's language, premath skills, and social and cognitive development. The mean value of the quality index in the sample is 4.0, which represents mediocre quality. This means that the average center in our sample must increase its quality by 25 percent to achieve the level of quality considered "developmentally appropriate" by child care experts. Using the estimated coefficient of the quality index (τ_1), a 25 percent increase in quality implies a 10 percent increase in total variable costs for the average center. The average total variable costs for centers is \$225,406. This implies that an increase in the quality level of an average center to the level considered good by education experts would be associated with an additional cost of \$22,540 per year. Given that the average center provides a total of 137,228 hours of service to infant-toddlers, preschoolers, and kindergarten-school age children in a year, it would cost an additional 16 cents per hour per child to produce good quality for an average center, keeping constant the space, the hours of service provided, and the wages paid to staff.

C. Alternative Functional Forms for Quality

It should be noted that Equation 2 treats quality as an attribute which is determined jointly with output. Thus, the model gives the centers the flexibility of increasing or decreasing the level of quality as a response to variation in wages. The cost function will include only $\ln q$ and $(\ln q)^2$, if one assumes that center quality is determined exogenously, or fixed in the short run (this specification is used by Mocan 1995). To investigate the results under this specification, quality is entered without the interaction terms. It is found that an increase in quality from average to good would cost an additional 13 cents per hour per child. Alternatively, a more flexible method of controlling for quality in this framework is to include a series of dummy variables. Inclusion of four dummy variables for quality intervals 0–2.5, 2.5–3.5, 4.5–5.5, and 5.5 and above (3.5–4.5 being the control group) revealed that centers that operate at the quality range of 4.5–5.5 have

14. The interaction terms between QUALITY and other variables drop out in evaluating the impact of a change in quality on TVC if they are evaluated at the means.

Table 3
Short-Run Translog Cost Function Regression

Variable I	Parameter II	Coefficient III	*t*-statistic IV
Constant	α_0	12.511*	273.325
WAGE1	α_1	0.205*	21.232
WAGE2	α_2	0.384*	31.348
WAGE3	α_3	0.181	1.897
INFANT-TODDLER	π_1	0.240*	12.895
PRESCHOOL	π_2	0.346*	8.123
SCHOOLAGE	π_3	0.082*	5.046
*INFANT * PRESCHOOL*	ξ_{12}	−0.136*	−4.822
*INFANT * SCHOOLAGE*	ξ_{13}	−0.010	−0.926
*PRESCHOOL * SCHOOLAGE*	ξ_{23}	−0.065*	−4.160
INFANT-TODDLER^2	ξ_{11}	0.017	0.677
PRESCHOOL^2	ξ_{22}	−0.054	−1.080
SCHOOLAGE^2	ξ_{33}	−0.009	−0.885
WAGE1^2	γ_{11}	0.145*	2.478
WAGE2^2	γ_{22}	0.096	1.210
WAGE3^2	γ_{33}	0.144	0.466
*WAGE1 * WAGE2*	γ_{12}	−0.074	−1.394
*WAGE1 * WAGE3*	γ_{13}	−0.156*	−3.689
*WAGE2 * WAGE3*	γ_{23}	0.136*	2.344
SPACE	β_1	0.243*	6.756
SPACE^2	β_2	−0.043	−0.854
*WAGE1 * SPACE*	δ_1	0.012	0.762
*WAGE2 * SPACE*	δ_2	−0.027	−1.368
*WAGE3 * SPACE*	δ_3	0.180	1.711
*WAGE1 * INFANT-TODDLER*	μ_{11}	0.033*	4.057
*WAGE1 * PRESCHOOL*	μ_{12}	−0.028*	−1.959
*WAGE1 * SCHOOLAGE*	μ_{13}	−0.002	−0.341
*WAGE2 * INFANT-TODDLER*	μ_{21}	−0.009	−0.833
*WAGE2 * PRESCHOOL*	μ_{22}	0.054*	2.962
*WAGE2 * SCHOOLAGE*	μ_{23}	−0.006	−0.624
*WAGE3 *INFANT-TODDLER*	μ_{31}	−0.025	−0.416
*WAGE3 * PRESCHOOL*	μ_{32}	−0.213*	−2.045
*WAGE3 * SCHOOLAGE*	μ_{33}	0.015	0.294
*SPACE * INFANT-TODDLER*	Φ_1	0.030	1.124
*SPACE * PRESCHOOL*	Φ_2	−0.031	−0.681
*SPACE * SCHOOLAGE*	Φ_3	0.049*	2.010
QUALITY	τ_1	0.400*	4.336
QUALITY^2	τ_2	0.671	1.521
*QUALITY * SPACE*	τ_3	0.048	0.396
*QUALITY * WAGE1*	Ω_1	−0.188*	−4.581

Table 3 (*Continued*)

Variable I	Parameter II	Coefficient III	*t*-statistic IV
*QUALITY * WAGE2*	Ω_2	0.010	0.199
*QUALITY * WAGE3*	Ω_3	0.352	1.105
*QUALITY * INFANT-TODDLER*	ψ_1	0.024	0.342
*QUALITY * PRESCHOOL*	ψ_2	−0.022	−0.182
*QUALITY * SCHOOLAGE*	ψ_3	−0.077	−1.130
PROFIT	ω_1	−0.043	−1.260
SPECREG	ω_2	0.224*	3.439
PUBSUPP	ω_3	0.062	1.221
PUBAUSP	ω_4	0.058	0.844
NATIONAL CHAIN	ω_5	−0.037	−0.731
CALIFORNIA	ω_6	−0.171*	−3.935
COLORADO	ω_7	−0.134*	−2.766
NORTH CAROLINA	ω_8	−0.323*	−5.979
LAMBDA	λ	0.667*	10.070

* Statistically significant at 5 percent level or better.

costs that are 7.5 percent higher than the ones that operate in the quality range of 3.5–4.5, which is associated with an additional 12 cents per child per hour. Therefore, the original specification and these two alternative specifications generate a range of 12–16 cents per child per hour as the cost of increasing center quality from average to good.

D. The Effect of Center Attributes

Table 3 shows that the coefficient of the profit dummy (ω_1) is not significantly different from 0; neither is the coefficient of the dummy for national chains. The sum of the *PROFIT* and *NATIONAL CHAIN* coefficients is not significantly different from 0 either. The model is also estimated by including the profit dummy only (namely, without *NATIONAL CHAIN, PUBSUPP, PUBAUSP, and SPECREG*). The coefficient of the profit dummy was not significantly different from 0. The model reported in Table 3 is reestimated by including interaction terms between *PROFIT* and state dummies. The results remained intact, suggesting that there are no efficiency differences between nonprofit and for-profit centers that are part of a national chain, and between nonprofit centers and non-chain for-profits. On the other hand, the coefficient of *SPECREG* (ω_2) is 0.224 and significantly different from 0. This indicates that centers that receive public money, either from the state or federal government, that is tied to higher standards have variable costs that are 25 percent higher than their nonpublicly owned or operated, or publicly supported, nonprofit counterparts.[15] *SPECREG* was robustly significant in all specifications, possibly reflecting expended and costly services in these centers.

E. Comparison with Previous Research

Previous research on efficiency differences between for-profit and nonprofit centers lacked a good proxy for center quality. As a result, researchers included the ratio of teaching staff to full-time-equivalent children in cost equations as a control for quality (Powell and Cosgrove 1992; Mukerjee and Witte 1993; Preston 1993). This is problematic because the cost function already controls for the number of children served. Thus, including the ratio of teaching staff to children is analogous to adding the labor input (teaching staff) as an explanatory variable to the cost function. By the nature of the cost function, the amount of labor used is an endogenous variable and should not be included as an independent variable in the cost function. Furthermore, even though the staff-child ratio is a determinant of center process quality, it captures only one dimension of center quality. In fact, there is evidence indicating that various structural quality indicators (for example, staff-child ratio, group size, average education, experience and tenure of staff) explain only half of the variation in center process quality, and unobservable center characteristics are responsible for the remainder of the variation in quality across centers (Blau 1997; Mocan et al. 1995). This implies that staff-child ratio, included as a proxy for quality, would be measured with error. This may yield biased parameter estimates if the component of the process quality not explained by staff-child ratio is correlated with the right-hand-side variables of the cost equation.

To investigate the sensitivity of the results to this measurement error and specification problem, a cost equation similar to the ones employed by previous studies is estimated (for example, Powell and Cosgrove 1992), where the staff-child ratio, the group size of children, center staff turnover, average education, experience, and tenure of staff members, the proportion of children who are infants, and the age of the center are included as proxies for center quality. The variables are weighted by child-hours or by staff-hours, where appropriate. The descriptive statistics of these variables are reported in Table A1 of the appendix. The results are reported in Table 4. Although the main results remain the same, the coefficient of the profit dummy (ω_1) becomes negative and significant in agreement with Powell and Cosgrove (1992). According to Table 4, for-profit centers have 6.5 percent lower costs with respect to nonprofits, all else being equal. This result underscores the importance of controlling center quality carefully. Due to the unavailability of data, previous work relied on imprecise proxies of center quality, which resulted in biased estimates and inaccurate representation of production technology.

15. Note that the percentage impact of the profit status on total variable cost is $\exp\{\omega_2 - \frac{1}{2}\mathrm{Var}(\omega_2)\} - 1$, where $\mathrm{Var}(\omega_2)$ is the variance of ω_2 (Kennedy 1981).

Table 4
Translog Short-Run Function with Structural Quality (n = 310)

Variable I	Parameter II	Coefficient III	*t*-statistic IV
Constant	α_0	12.682*	121.812
WAGE1	α_1	0.192*	18.089
WAGE2	α_2	0.399*	28.819
WAGE3	α_3	0.227*	17.450
INFANT-TODDLER	π_1	0.181*	4.505
PRESCHOOL	π_2	0.327*	5.370
SCHOOLAGE	π_3	0.067*	3.341
*INFANT *PRESCHOOL*	ξ_{12}	−0.116*	−3.197
*INFANT * SCHOOLAGE*	ξ_{13}	−0.016	−1.486
*PRESCHOOL * SCHOOLAGE*	ξ_{23}	−0.056*	−3.008
INFANT-TODDLER^2	ξ_{11}	−0.008	−0.358
PRESCHOOL^2	ξ_{22}	−0.024	−0.378
SCHOOLAGE^2	ξ_{33}	0.001	0.056
WAGE1^2	γ_{11}	0.116	1.888
WAGE2^2	γ_{22}	0.159	1.881
WAGE3^2	γ_{33}	0.106	0.316
*WAGE1 * WAGE2*	γ_{12}	−0.095	−1.667
*WAGE1 * WAGE3*	γ_{13}	−0.181*	−4.234
*WAGE2 * WAGE3*	γ_{23}	0.117	1.923
SPACE	β_1	0.310*	6.858
SPACE^2	β_2	0.006	0.179
*WAGE1 * SPACE*	δ_1	0.013	0.755
*WAGE2 * SPACE*	δ_2	−0.052*	−2.295
*WAGE3 * SPACE*	δ_3	0.137	1.215
*WAGE1 * INFANT-TODDLER*	μ_{11}	0.027*	3.478
*WAGE1 * PRESCHOOL*	μ_{12}	−0.026	−1.662
*WAGE1 * SCHOOLAGE*	μ_{13}	0.005	0.719
*WAGE2 * INFANT-TODDLER*	μ_{21}	0.003	0.318
*WAGE2 * PRESCHOOL*	μ_{22}	0.062*	2.931
*WAGE2 * SCHOOLAGE*	μ_{23}	−0.008	−0.763
*WAGE3 * INFANT-TODDLER*	μ_{31}	−0.058	−1.000
*WAGE3 * PRESCHOOL*	μ_{32}	−0.188	−1.819
*WAGE3 * SCHOOLAGE*	μ_{33}	−0.025	−0.439
*SPACE * INFANT-TODDLER*	ϕ_1	0.067*	2.320
*SPACE * PRESCHOOL*	ϕ_2	−0.077	−1.291
*SPACE * SCHOOLAGE*	ϕ_3	0.030	1.178
Staff-child ratio		0.124*	3.045
Group size		−0.028	−0.827
Turnover		−0.013	−0.880
Education		−0.139*	−7.112

Table 4 (*Continued*)

Variable I	Parameter II	Coefficient III	*t*-statistic IV
Experience		−0.023	−1.044
Tenure		−0.043	−1.690
Proportion of infants		−0.027	−0.681
Center age		0.010	0.492
PROFIT	ω_1	−0.065	−1.648
SPECREG	ω_2	0.263*	3.506
PRESUPP	ω_3	0.022	0.347
PUBAUSP	ω_4	0.070	0.942
NATIONAL CHAIN	ω_5	−0.020	−0.315
CALIFORNIA	ω_6	−0.161*	−3.378
COLORADO	ω_7	−0.182*	−3.542
NORTH CAROLINA	ω_8	−0.336*	−6.010
BOX-COX PARAMETER	λ	0.659*	8.234

* Statistically significant at the 5 percent level or better.

F. Sensitivity of the Results to Alternative Specifications

For centers that do not employ a particular group of workers, the state average wage is used. These centers, however, may react differently to marginal price changes than the firms which are at an interior optimum.[16] To investigate the sensitivity of the results, the cost function is estimated with centers that use all three types of labor. The results, which are reported in Table A2 of the appendix, are essentially the same as the ones reported in Table 3.

The cost function is estimated using the volunteer hours as a fixed instead of a variable input. This involved subtracting the variable in-kind volunteer donations from total variable cost on the left-hand side of the equation and then including volunteer hours on the right-hand side. This can be justified if centers, in their long-range planning, can accurately forecast the number of volunteers hours to be received, and if they plan their operation by taking into account this factor. Using volunteer hours as a fixed input of production involves additional cross terms between volunteer hours, wages, and outputs. The results (not reported in the interest of space) were very similar to the ones reported in Table 3. Similarly, treating directors as a fixed input and subtracting their salaries from the total variable cost did not alter the results.

To control for possible endogeneity of wages paid to staff, a wage equation is estimated using 4,877 observations of workers where the logarithm of wages is regressed on age, age squared, education, experience, tenure, center characteristics such as *PROFIT, SPECREG, PUBAUSP, PUBSUPP, NATIONAL CHAIN,*

16. I thank David M. Blau for this insight.

and state dummies. The predicted wages are used to calculate the center-weighted averages. Employing these new wage measures did not alter the results.

G. Economies of Scale and Scope

According to the estimated coefficients reported in Table 3, the calculated measure of scale economies $[(1 - \beta_1)/\Sigma\pi_k]$ is 1.13, which reveals that a 10 percent increase in total hours of operation is associated with an 8.8 percent increase in total variable costs for an average center in the long run. The 90 percent confidence interval for the measure of scale economies is (1.00, 1.26), which translates into a 7.9 to 10 percent increase in costs in the long run, following a 10 percent increase in output.

There is significant variation in the length of a full-time day across centers and among the age groups. Therefore, it is difficult to compare the number of full-time-equivalent children among centers. Given this caveat, the average center size is 67 full-time-equivalent children. The economies of scale result indicates that an increase in this size would be associated with a decrease in average variable costs, keeping center quality constant.

The presence of scope economies is tested among infant-toddlers, preschoolers, and kindergarten-school age children by calculating $\pi_k\pi_r + \xi_{kr}$ for three possible combinations. The estimated value of $\pi_1\pi_2 + \xi_{12}$ was -0.053 with a standard error of 0.03.[17] This means that the 90 percent confidence interval is $(-0.103, -0.004)$, and suggests economies of scope between infant-toddlers and preschoolers. $\pi_1\pi_3 + \xi_{13}$ is equal to 0.020 and its 90 percent confidence interval is (0.004, 0.037), which does not give support to the hypothesis of scope economies between infant-toddlers and school-age children. $\pi_2\pi_3 + \xi_{23}$ is -0.037 with a 90 percent confidence interval of $(-0.070, -0.004)$. Thus, there is evidence for scope economies between preschoolers and school-age children. These results imply that serving infant-toddlers and preschoolers jointly is more efficient than serving them separately. The same is true for preschoolers and school-age children. However, serving infant-toddlers and school-age children jointly is no more cost-efficient than serving them separately.

Table 5 presents the distribution of centers with respect to the age groups they are serving. The table indicates that centers, by and large, take advantage of the existing scope economies and avoid the output combinations that do not provide economies of scope. For example, only 2 percent of the centers serve just infant-toddlers. There is no center in the sample that serves only kindergarten-schoolage children. Similarly, no center serves infant-toddlers and kindergarten-school age children jointly. On the other hand, 21 percent of all centers serve infant-toddlers and preschoolers jointly, and another 21 percent serve preschoolers and kindergarten-school age children jointly. Table 5 also shows that 35 percent of all California centers serve only preschoolers. Our results show that adding infant-toddlers or preschoolers to those operations would be more cost-efficient than their current structure.

17. The variance of $\pi_1\pi_2 + \xi_{12}$ is equal to $\pi_2^2\mathrm{Var}(\pi_1) + \pi_1^2\mathrm{Var}(\pi_2) + \mathrm{Var}(\xi_{12}) + 2\pi_1\pi_2\mathrm{Cov}(\pi_1\pi_2) + 2\pi_2\mathrm{Cov}(\pi_1\xi_{12}) + 2\pi_1\mathrm{Cov}(\pi_2\xi_{12})$.

Table 5
Distribution of the Age Groups Served

Children Served	California (n = 99)	Colorado (n = 100)	Connecticut (n = 99)	North Carolina (n = 98)	All Centers (n = 396)
Only infant-toddlers (1)	2%	2%	3%	2%	2%
Only preschoolers (2)	35%	13%	14%	9%	17%
Only kindergarten-school age children (3)	0%	0%	0%	0%	0%
Infant-toddler (1) & Preschoolers (2)	16%	14%	28%	27%	21%
Infant-toddlers (1) & Kindergarten-school age (3)	0%	0%	0%	0%	0%
Preschoolers (2) & Kindergarten-school age (3)	28%	26%	22%	7%	21%
Infant-toddlers (1) & Preschoolers (2) & Kindergarten-school age (3)	18%	45%	32%	54%	37%

H. Labor–Labor Substitution and Wage Elasticities of Labor Demand

The second column of Table 6 presents the elasticities of substitution between three labor categories. The results indicate that the elasticity of substitution between workers with the least education and workers with 13 to 15 years of education is very small. On the other hand, centers can very easily substitute workers with 13–15 years of education for workers with 16 or more years of education. Workers with 12 years or fewer of education and the ones with 16 or more years of education are complements in production. This result may imply that the least-educated workers are supervised by workers with the highest level of education. This is an interesting result and it underlines the importance of classifying labor by education. The classification of labor by title (for example, teachers, teacher aides) may not be reliable, because the skill embodied in each group categorized by title may differ greatly across centers. This is because the designation of titles may be arbitrary (a teacher at one center may have the title of assistant teacher at another center). The classification of labor by education, on the other hand, creates more homogeneous categories of labor and generates a more lucid picture of substitution elasticities.[18]

The differences in the elasticities of substitution across the three labor categories suggests that these inputs are not separable. Separability among inputs is equivalent to having the marginal rates of substitution in each separated group be independent of the amount of factors outside the group (Hamermesh and Grant 1979). For example, separability of labor inputs L_1 and L_2 from the third category of labor, L_3, means that $\ln Y = f(g(\ln L_1, \ln L_2), \ln L_3)$, where Y stands for output. A sufficient condition for separability in this case is $\sigma_{13} = \sigma_{23}$, which implies $\alpha_1 = \alpha_2\gamma_{13}/\gamma_{23}$ (Hamermesh and Grant 1979; Denny and Fuss 1977). Separability among inputs is formally tested by imposing the condition above and performing a likelihood ratio test. The likelihood ratio statistic with one degree of freedom was 13.40 for separability of L_1 and L_2 from L_3. It was 8.20 for separability of L_1 and L_3 from L_2, and 3.42 for separability of L_2 and L_3 from L_1, where L_1 stands for workers with 12 or fewer years of education, L_2 stands for workers with 13–15 years of education, and L_3 stands for workers with 16 or more years of education. Thus, workers with 12 or fewer years of schooling and the ones with 13 to 15 years of schooling are not separable from workers with 16 or more years of education. Similarly, workers with the least education and those with the highest education are not separable from the group with 13–15 years of education. On the other hand, there is evidence that workers with 13–15 years of education and workers with 16 or more years of education are separable from the ones with 12 or fewer years of education. This suggests that disaggregating labor by title may lead to incorrect inferences about the elasticities of substitution, if there is overlap in the distribution of education among categories.

The second panel of Table 6 reports the estimated constant-output (short-run) labor demand elasticity (η) for the three labor categories. The estimated own-price elasticity for workers with 12 or fewer years of education is -0.09. The demand

18. For example Powell and Cosgrove (1992) found that teachers and aides are substitutes to each other, although their cost function included a third input (using their Table 2).

Table 6
Substitution and Labor Demand Elasticities

	Elasticities of Substitution between Inputs $\sigma_{ij} = (\gamma_{ij}/\alpha_i\alpha_j) + 1$ ($\sigma_{ij} > 0 \Rightarrow i,j$ substitutes)	Constant-Output Labor Demand Elasticities (η)
Workers with education ≤ 12 years (1) & workers with education 13–15 years (2)	0.06	—
Workers with education ≤ 12 years (1)& workers with education 16+ years (3)	−3.20	—
Workers with education 13–15 years (2) & workers with education 16+ years (3)	2.96	—
Workers with education ≤ 12 years (1)	—	−0.09
Workers with education 13–15 years (2)	—	−0.37
Workers with education 16+ years (3)	—	−0.02

elasticity for workers with 13–15 years of education is −0.37, and it is −0.02 for workers with 16 or more years of education, indicating that centers do not have much flexibility in the short run to adjust their labor usage in the presence of wage increases.[19]

VI. Conclusion

This paper uses a new data set which is constructed through visits to approximately 200 randomly chosen for-profit day care centers and 200 nonprofit centers in California, Colorado, Connecticut, and North Carolina. In addition to detailed information on center characteristics, workers and children, the data set contains a quality index, which has been widely used in child development literature and which has been shown to be positively related to child outcomes. The paper provides a number of important insights into the characteristics of the child care centers. First, descriptive evidence shows that there is no difference in quality of the services produced between nonprofit and for-profit centers. This result is important because it demonstrates that the hypothesis of for-profit centers taking advantage of the information asymmetry on quality is incorrect, and it indicates that nonprofit status cannot be taken as a signal of higher quality.

The results also show that the hypothesis of relative inefficiency of nonprofit centers (the shirking hypothesis) is unfounded. Estimation of translog cost functions reveal that, keeping quality constant, there is no efficiency difference between for-profit and nonprofit centers in terms of producing child care services, with one exception: centers associated with one segment of the nonprofit sector (centers that receive public money, either from the state or federal government, that is tied to higher standards) have variable costs that are 25 percent higher than their non-publicly-owned or -operated, or publicly supported, nonprofit counterparts. The paper shows that if center quality is approximated by inaccurate measures, such as staff-child ratios, erroneous results emerge as to the relative efficiency of the two sectors. The cost of increasing the quality of an average center from mediocre to good is between 12–16 cents per child-hour, which translates into between \$243 and \$324 per child per year.

Classification of labor into three categories by education reveals that child care workers with 13 to 15 years of education and workers with 16 and more years of education are substitutes. Workers with 16 and more years of education are

19. As Hamermesh and Grant (1979) indicate, estimation of own-price elasticities may be biased towards 0 in the absence of capital, because the substitution toward capital following a wage increase is not accounted for. As described earlier, however, capital in this industry is the physical plant, which is difficult to expand or contract, at least in the short run. Similarly, the state-mandated staff-child ratios may make it difficult to switch to a more capital-intensive technology following an increase in the wage rates. Because of these reasons, the reported wage elasticities can be regarded as accurate. The inclusion of the price of capital has its own problems. If the measurement error in the price of capital is larger than that of the wage rates, the inclusion of the price of capital may create more harm than good, because the elasticities of substitution and the price elasticities can be very sensitive to the noise in the price of capital (Berndt 1976; Hamermesh and Grant 1979).

complements to workers with 12 or fewer years of education. The elasticity of substitution between workers with 13 to 15 years of education and the ones with 12 or fewer of education is virtually zero. Centers have inelastic demand for workers.

There are economies of scale in production. Controlling for the level of quality of services, a 10 percent increase in the hours of children served brings about only an 8.8 percent increase in costs. There is also evidence for economies of scope. Serving infant-toddlers and preschoolers jointly is more efficient than serving them separately. The same is true for preschoolers and school-age children, but not for infant-toddlers and school-age children.

Appendix 1

The Quality Index

Two hundred twenty-eight infant-toddler classrooms and 521 preschool classrooms were observed to collect information on structural and process quality. Infant-toddler rooms were defined as those where the majority of children were less than two-and-a-half years old. Preschool classrooms were defined as those where the majority of children were at least two-and-a-half years old, but not yet in kindergarten. At each center, two classrooms were randomly chosen: one preschool and one infant-toddler room if the center served both age groups. No primary school or kindergarten classrooms were observed.

In each state, pairs of observers, who were trained in a week-long intensive program, visited each center for one day (from 8:30 a.m. to 3:00 p.m.) to observe the classrooms. They counted classroom staff-child ratios and group sizes five different times throughout the day. They used two instruments to comprehensively assess the day-to-day quality of care provided for children: the Early Childhood Environmental Rating Scale (ECERS) (Harms and Clifford 1980), and its infant-toddler version, the Infant-Toddler Environmental Rating Scale (ITERS) (Harms, Cryer, and Clifford 1990). The ECERS is a 37-item scale organized under seven categories: personal care routines, furnishings and display for children, language-reasoning experience, fine and gross motor activities, creative activities, social development, and adult needs. Each item is scored on a seven-point scale from inadequate to excellent. The ITERS is a comparable instrument designed to assess the quality of care for children from birth to 30 months of age.

In addition, observers used two instruments designed specifically to measure teacher involvement: the Caregiver Interaction Scale (Arnett 1989), which measures the lead teacher's sensitivity, harshness, degree of attachment, and permissiveness; and the Teacher Involvement Scale (Howes and Stewart 1987), which measures the amount and quality of teacher-child interactions. For all four instruments, tests of interrater reliability at each site and between sites were very high.[20]

20. The details can be found in *Cost, Quality, and Child Outcomes in Child Care Centers: Technical Report*, 1995, Center for Research on Economic and Social Policy, University of Colorado at Denver.

Principal component analyses were performed to create a classroom-level process quality index. It includes the total scores from the ECERS, ITERS, Caregiver Interaction Scale, and Teacher Involvement Scale. Separate indices were also computed for infant-toddler and preschool classrooms. The index was scaled to a seven-point scale (similar to the ECERS and ITERS) with a range from 1 (inadequate), to 3 (minimal), to 5 (good), and to 7 (excellent). Each center's process quality index is a weighted average of room-level indices, weighted by the percentage of center FTE children in the given age group.

Table A1
Center Structural Characteristics[a]

Variables	For-profit (n = 200)	Nonprofit (n = 196)
Weighted mean staff-child ratio during mid-morning inside activities[b]	0.17* (0.08)	0.20* (0.10)
Weighted mean group size[b]	12.95 (7.48)	13.53 (5.77)
Rate of staff turnover	45.58* (44.41)	30.02* (36.28)
Weighted average age of teaching staff	31.56* (5.44)	35.08* (6.26)
Weighted average prior child care experience of teaching staff (in years)	2.87* (2.30)	3.65* (2.47)
Percent teaching staff with 16 and more years of education	0.26 (0.26)	0.30 (0.23)
Weighted average tenure of teaching staff (in months)	31.64* (28.84)	48.31* (35.46)
Proportion of infants	0.25* (0.23)	0.18* (0.23)
Age of the center (in years)	10.31* (8.31)	16.12* (14.66)

a. The first value in each cell is the mean. The numbers in parentheses are standard deviations. (*) indicates that the means between for-profit and nonprofit centers are different at the 5 percent level.
b. The sample size for this variable is 157 for-profit centers and 168 for nonprofit centers.

Table A2

Translog Cost Functions for Centers that Employ All Three Labor Categories (n = 225)

Variable	Parameter	Coefficient	t-statistic
Constant	α_0	12.534*	206.612
WAGE1	α_1	0.238*	25.427
WAGE2	α_2	0.346*	32.223
WAGE3	α_3	0.120	1.013
INFANT-TODDLER	π_1	0.278*	11.917
PRESCHOOL	π_2	0.373*	7.264
SCHOOLAGE	π_3	0.074*	3.593
*INFANT * PRESCHOOL*	ξ_{12}	−0.178*	−4.443
*INFANT * SCHOOLAGE*	ξ_{13}	0.009	0.466
*PRESCHOOL * SCHOOLAGE*	ξ_{23}	−0.043	−1.770
*INFANT * TODDLER*^{2}	ξ_{11}	0.039	1.108
PRESCHOOL	ξ_{22}	−0.125	−1.621
SCHOOLAGE	ξ_{33}	0.001	0.065
WAGE1^2	γ_{11}	0.216*	3.469
WAGE2^2	γ_{22}	0.298*	3.685
WAGE3^2	γ_{33}	0.363	0.906
*WAGE1 * WAGE2*	γ_{12}	−0.253*	−4.574
*WAGE1 * WAGE3*	γ_{13}	−0.011	−0.251
*WAGE2 * WAGE3*	γ_{23}	0.040	0.740
SPACE	β_1	0.158*	3.789
SPACE^2	β_2	0.075	1.213
*WAGE1 * SPACE*	δ_1	0.018	1.148
*WAGE2 * SPACE*	δ_2	−0.012	−0.627
*WAGE3 * SPACE*	δ_3	−0.184	−1.270
*WAGE1 * INFANT-TODDLER*	μ_{11}	0.010	1.151
*WAGE1 * PRESCHOOL*	μ_{12}	−0.0234	−1.612
*WAGE1 * SCHOOLAGE*	μ_{13}	−0.008	−1.004
*WAGE2 * INFANT-TODDLER*	μ_{21}	0.003	0.277
*WAGE2 * PRESCHOOL*	μ_{22}	0.033*	1.990
*WAGE2 * SCHOOLAGE*	μ_{23}	−0.007	−0.683
*WAGE3 * INFANT-TODDLER*	μ_{31}	0.107	1.228
*WAGE3 * PRESCHOOL*	μ_{32}	0.004	0.030
*WAGE3 * SCHOOLAGE*	μ_{33}	0.128	1.469
*SPACE * INFANT-TODDLER*	ϕ_1	0.004	0.092
*SPACE * PRESCHOOL*	ϕ_2	−0.045	−0.664
*SPACE * SCHOOLAGE*	ϕ_3	0.005	0.137
QUALITY	τ_1	0.415*	3.741
QUALITY^2	τ_2	0.762	1.128
*QUALITY * SPACE*	τ_3	0.182*	25.777
*QUALITY * WAGE1*	Ω_1	−0.174*	−3.831

Table A2 (*continued*)

Variable	Parameter	Coefficient	*t*-statistic
*QUALITY * WAGE2*	Ω_2	0.074	1.424
*QUALITY * WAGE3*	Ω_3	0.115	0.274
*QUALITY * INFANT TODDLERS*	ψ_1	−0.000	−0.002
*QUALITY * PRESCHOOL*	ψ_2	−0.201	−1.124
*QUALITY * SCHOOLAGE*	ψ_3	−0.152	−1.432
PROFIT	ω_1	0.016	0.376
SPECREG	ω_2	0.186*	2.070
PRESUPP	ω_3	0.066	0.772
PUBAUSP	ω_4	0.122	1.392
NATIONAL CHAIN	ω_5	−0.114*	−2.001
CALIFORNIA	ω_6	−0.126*	−2.115
COLORADO	ω_7	−0.085	−1.483
NORTH CAROLINA	ω_8	−0.221*	−3.119
Box-Cox parameter	λ	0.714	7.835

* Statistically significant at the 5 percent level.

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