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THE CHILD CARE INDUSTRY: COST
FUNCTIONS, EFFICIENCY, AND QUALITY

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ABSTRACT

Using a newly compiled data set, this paper provides insights into the characteristics of the child care industry. First, there is no difference in average quality of the services produced between nonprofit and for-profit centers. This indicates that nonprofit status cannot be taken as a signal of higher quality. Second, the hypothesis of relative inefficiency of nonprofit centers with respect to for-profits is unfounded. On the other hand, centers that receive public money, either from the state or federal government, that is tied to higher standards, have variable costs that are 19 percent higher than other centers.

Child care workers with 13 to 15 years of education and workers with 16 and more years of education are substitutes. Both of these groups are complements to workers with 12 and less years of education. 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 hours of children served brings about only an 8.5 percent increase in costs in the long-run. There is no evidence of economies of scope. Serving various age groups jointly is not more efficient than serving them separately, although the issue is less clear in the case of preschoolers and school aged children.

The cost of increasing the quality of an average center from mediocre to good is between 12-16 cents per child-hour.

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I. Introduction

The increase in female labor force participation since World War II is one of the most significant changes in the Unites States labor market. Over the last two decades, this increase has been especially pronounced for married women with children. One of the consequences of this change has been the reallocation of child care and child-rearing tasks. Since the mid-1970s, it has become increasingly common for children from all segments of society to be cared for by persons other than their parents (Blau and Hotz, 1992). The U.S. Department of Commerce reported that families with employed women spent an estimated $21 billion on child care in 1988, and women in poverty pay approximately 21 percent of their family income for child care (U.S. Department of Commerce, 1992). Proposed welfare reforms are expected to further increase female labor force participation and the demand for market based child care.

Another important development in the U.S. labor market during the last decade is the increase in wage and income inequality (Levy and Murnane 1992, Murphy and Welsch 1992, Mocan 1995a). Inequality in wages and earnings increased significantly even within narrowly defined groups, suggesting that the growing demand for more skilled workers and the rise in the returns to skill are the main reasons for the increase in wage inequality (Burtless 1990, Moffitt 1990, Cutler and Katz 1991, Juhn, Murphy and Pierce 1993).

There is growing evidence linking 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 et al., 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, it is critical to develop an understanding of the functioning of child care industry. First, it is documented by professionals in early care

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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 et al., 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; i.e. 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 taking 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 child care industry, 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 exists 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.

Mukarjee 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

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nonprofit centers and conclude that the observed higher costs for nonprofit centers result from different input and output choices, and not from differences in the method of operation.

Preston (1993) estimates an average cost function using data from a national survey conducted in 1976-1977. Using a sample of 2703 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. Mukarjee and Witte (1993), and Preston (1993) also acknowledge the heterogeneous nature of the output, and 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 important ways, and provides new insights into the cost and production structure of the child care industry. 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-around care. Unlike other data sets currently available that are based upon telephone surveys (e.g the data of the Affordibility Study Team at Wellesley College, used by Mukarjee and Witte 1993), or questionnaires mailed to the centers (e.g. 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

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

and center structural and process quality. 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 to 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, etc.) can be created using micro data.

Another improvement over existing data sets is the detailed measurement of donations. Because donations are received more heavily by nonprofit centers, failure to account for the value of donations would create an inaccurate picture as to 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 into the cost function as explanatory variables. These center characteristics, known as "structural quality measures" in early childhood education literature, are "inputs" into the production of center's "process quality". Classroom 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

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[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 their job title.*

served, the age groups that are served. The center's process quality is also affected by the quality of 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 demonstrates the bias that is generated by attempting to control quality using improper proxies.

The data contain information on actual hours of service provided for various age groups of children. Thus, a multi-product 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 industry. Other contributions are the calculation of the cost of an increase in center quality, and 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 design and the measurement of variables. Section V presents the empirical results, and Section VI is the conclusion.

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[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 (1994) and Mocan, Morris and Helburn (1995)*

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III. Empirical Implementation

The analyses are based upon the estimation of cost functions for child care centers. While the production function and the cost function are dual in theory, estimates of the stochastic forms need not be dual to each other. With a cost function one needs only to assume that firms are minimizing costs, while estimation of a production function requires the underlying, more stringent assumption of profit maximization (Hamermesh and Grant 1979). Given the existence of nonprofit firms in this industry, estimation of a cost function has more relevance. Second, in our context, estimation of a cost function has stronger statistical power. This is because the cost function is based upon the exogeneity of input prices, while the production function assumes that the quantity of inputs is exogenous. Given that our unit of observation is the firm, it is more reasonable to assume the exogeneity of wages rather than the exogeneity of quantity of labor hired.[4]

The paper estimates short-run cost functions. Long-run cost functions are also important, but estimating a long-run cost function with these data may be problematic. Estimation of a long-run cost function would indicate that centers were in their long-run equilibrium. If this is not the case, i.e. if centers are off their expansion paths, the assumption of cost minimization is violated. This would imply misspecification of the long-run cost function and biased parameter estimates (Vita 1990, Nelson 1985). For child care centers, capital is not so much toys and equipment, as it is the physical plant.[5] Unlike machinery, however, the expansion or contraction of the physical plant may be

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[4] *The possibility of wage endogeneity is explored later in the paper.*

[5] *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 8 percent.*

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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.[6] 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.[7]

It should be noted that although a short-run cost function is estimated, following previous work (Noulas, Ray and Miller 1990, Callan and Santerre 1990, Vita 1990), inferences about long-run economies of scale and scope are reported as discussed below.

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

(1) 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, which is fixed in the short-run, and q is the level of quality produced.

To estimate the cost function in equation (1), a translog functional form is employed. Translog cost functions have enjoyed wide-spread 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), cost

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[6] *The same argument is made for electric power industry (Nelson 1985), hospital costs (Cowing and Holtmann 1983), and costs for school districts (Callan and Santarre 1990).*

[7] *If the user cost of capital is the same among narrowly defined groups of centers, then estimating a cost finction with controls for auspice types and without capital may resolve this problem.*

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functions pertaining to electricity and gas production (Betancourt and Edwards 1987), as well as cost functions for child care centers (Powell and Cosgrove 1992) and the nursing home industry (Gertler and Waldman 1992). A translog function is a second-order Taylor series approximation to an unknown, underlying, twice-differentiable function (Christensen, Jorgensen, and Lau, 1973). It does not impose any restrictions on elasticities of substitution among inputs and allows returns to scale change with respect to output. The empirical counterpart of equation (1) is the following translog cost function:

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

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 years or less formal education, wages for staff with 13-15 years of education, and wages for staff with 16 and more years of education.

Some studies used the number of full time equivalent children as the measure of output (e.g. 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 before- and after-school services for school-aged 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_a) 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 cost function should be linearly

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homogenous in input prices, and the cross-coefficients must be symmetric. These imply the following restrictions on Equation (2).

$\Sigma\alpha_i=1$, $\Sigma_j\gamma_{ij}=0$ for all i, $\Sigma\delta_i=0$, $\Sigma\Omega_i=0$, and $\Sigma\mu_{ik}=0$ for all k;

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

Using Shephard's Lemma, optimal demand for the ith input is obtained by differentiating the cost function with respect to the price of the ith input (P_i) which yields:

(3) $\partial lnC/\partial lnP_i=(\partial C/\partial P_i)(P_i/C)=P_iX_i/C$,

where X_i is the optimal level of input i. Thus, P_iX_i/C is the share of the input i in total variable cost. Letting S_i denote the cost share of input i, and differentiating the cost function depicted in (2) with respect to P_i yields the following structure for the cost shares:

(4) $S_i=\alpha_i+\Sigma\gamma_{ij}lnP_j+\Sigma\delta_i lnK+\Sigma\mu_{ik}lnY_k+\Omega_i lnq$.

The cost equation is estimated jointly with the system of share equations depicted in (4). To avoid singularity in the error covariance matrix, one of the share equations is deleted and the model is estimated using non-linear methods subject to the restrictions imposed above. The explanatory variables are normalized by dividing each variable by its mean before taking the natural logs (Callan and Santerre 1990, Vita 1990).[8]

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 into the analysis (Caves et al. 1980, p. 478). Following Caves et al. (1980) Vita (1990), and Callan and Santerre (1990), the Box-Cox transformation

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[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). Furthermore, normalization of the explanatory variables generates the convenience that the first-order parameters are elasticities when evaluated at the means.*

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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.

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 all 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.

TVC is total variable cost of the center during the fiscal year 1991-1992. 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.

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-

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[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.*

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 non-profit) and similar center size, (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 and 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 less 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*

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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 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 that 50 percent of its revenue from public grants public fees and USDA reimbursement. Also included are the 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 child care process were employed by trained observers to assess the quality of the operation.[10] 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, which has a seven point scale, with a range from inadequate (1) to minimal (3), good (5) and excellent (7).

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[10] *See the Appendix for the details.*

Quality has dimensions that include parents' preferences concerning 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 impact 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 zero. For-profit centers serve more child-hours for infant-toddler and school aged children. There is no statically 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, which may be attributable to relatively lax regulations in North Carolina in comparison to other states in the sample. The mean values of variable costs 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 and more years of education are higher in

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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.[11]

V. Empirical Results

Functional form

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 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 and performing a likelihood ratio

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[11] *See Frank and Salkever (1994) for an analysis of nonprofit sector quality in the health sector.*

test.[12] The calculated Chi-square was 12.93 with 9 degrees of freedom. Therefore the hypothesis of homotheticity is not rejected. The calculated Chi-square under the hypothesis of Cobb-Douglas form was 109.57 with 21 degrees of freedom, leading to the rejection of the Cobb-Douglas functional form. The results below are based upon the general form depicted in Equation (2).

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 zero. The coefficient demonstrates that if the quality index increases by 10%, this brings a 4.0% increase in total variable costs.[13] Research on child development used the same quality index and demonstrated the positive impact of process quality on children's language, pre-math skills, and social and cognitive development. The mean value of the quality index 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% increase in quality implies a 10 percent increase in total

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[12] *The test statistic is $N[ln|\Omega_r|-ln|\Omega_u|]$, where Ω_r and Ω_u are the determinants of the residual variance-covariance matrix of the restricted and the unrestricted systems, respectively. It is distributed χ^2 with degrees of freedom equal to the number of restrictions.*

[13] *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.*

variable costs for the average center. The average total variable costs for centers is $225,406. This implies that an increase 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.

Alternative functional forms for quality

It should be noted that Equation (2) treats both quantity and quality as two attributes of output that are determined jointly. 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 lnq and lnq^2, if one assumes that center quality is determined exogenously, or fixed in the short-run (This specification is used by Mocan 1995b). To investigate the results under this specification, quality is entered without the interaction terms. It is found that an increase of 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 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 these three alternative specifications generate a range of 12-16 cents per child per hour as the cost of increasing center quality from average to good.

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The effect of center attributes

Table 3 shows that the coefficient of the profit dummy (ω_1) is not significantly different from zero; neither is the coefficient of the dummy for national chains. The sum of the PROFIT and NATIONAL CHAIN coefficients were not significantly different from zero either. The model is also estimated by including the profit dummy only (i.e without NATIONAL CHAIN, PUBSUPP, PUBAUSP and SPECREG). The profit dummy was not significantly different from zero. The model reported in Table 3 is re-estimated by including interaction terms between PROFIT and state dummies. The results remained intact, suggesting that there are no efficiency differences between nonprofit centers 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 0.18, and significantly different from zero. 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 19 percent higher than their non-publicly owned or operated, or publicly supported nonprofit counterparts.[14] SPECREG was robustly significant in all specifications, possibly reflecting expended and costly services in these centers.

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 into cost equations as a control for quality (Powell & Cosgrove 1992, Mukerjee & 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

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

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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 into 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 (e.g. staff-child ratio, group size, average education, experience and tenure of staff, etc.) 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 1994; Mocan, Morris and Helburn 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 (Powell and Cosgrove 1992) is estimated, where the staff-child ratio, the group size of children, center staff turnover, average education, experience and tenure of staff members, the percent children who are infants and 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 A-1 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 9 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.

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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.[15] 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 A-2 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 value of 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 PROF, SPECREG, PUBAUSP, PUBSUPP, NATIONAL CHAIN, and state dummies. The predicted wages are used to calculate the center weighted averages. Employing these new wage measures did not alter the results.

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[15] *I thank David M. Blau for this insight.*

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Economies of scope and scale

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

(6) $\quad C(Y_1,Y_2) < \{C(Y_1,0)+C(0,Y_2)\}$,

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 (6) 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

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

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

Equation (7) indicates that for long-run economies of scope to exist between outputs Y_i and Y_j, an increase in Y_j should decrease long-run marginal cost of Y_i. Note that

(8) $\quad C^{LR}_{ij} = \partial^2 C^{LR}/\partial Y_i \partial Y_j = C^{SR}_{ij} + C^{SR}_{iK}(\partial K^*/\partial Y_j)$

where $C^{SR}_{iK} = \partial^2 C^{SR}/\partial Y_i \partial K$, 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 $C^{SR}_{iK} < 0$ and $C^{SR}_{ij} < 0$.

In our context, if $\pi_k \pi_r + \xi_{kr} < 0$ this implies that $C^{SR}_{ij} < 0$ (Vita 1990, Gyimah-Brempong 1987, Murray and White 1983). The presence of scope economies is tested among infant-toddlers, preschoolers and kindergarten-school aged children by calculating $\pi_k \pi_r + \xi_{kr}$ for three possible combinations. Estimated $\pi_1 \pi_2 + \xi_{12}$ was 0.04174 with a

standard error of 0.0206[16] This means that the 95% confidence interval is (0.001, 0.082), indicating no economies of scope between infant-toddlers and preschoolers. The 95% confidence interval for $\pi_1\pi_3 + \xi_{13}$ is (0.006, 0.039), which does not give support to the hypothesis of scope economies between infant-toddlers and school aged children. The 95% confidence interval for scope economies between preschooler and school aged children is (-0.032, 0.024). Because it includes both the negative and positive regions, the inference is not conclusive, but nevertheless, the interval does not enable us to reject the hypothesis of no economies of scope. These results display no evidence indicating that serving various age groups jointly is more efficient than serving them separately.

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

(9)   LSCE = $(1 - \partial \ln C / \partial \ln K) / \Sigma (\partial \ln C / \partial \ln Y)$ =

$[1 - (\beta_1 + \beta_2 \ln K + \Sigma \delta_i \ln P_i + \Sigma \phi_k \ln K + \tau_3 \ln q)]$ /

$\{\Sigma \pi_k + \Sigma \Sigma \xi_{kr} Y_r + \Sigma \Sigma \mu \ln P_i + \Sigma \phi_k \ln K + \Sigma \psi_k \ln q\}$.

When LSCE > 1, there are scale economies. That is, a proportional increase in the hours of infant-toddlers, preschoolers and school aged children brings about a proportionately smaller increase in total variable cost. When LSCE < 1, there are decreasing returns to scale, because an increase in the number of children served generates a proportionately larger increase in costs.

When mean-scaled data are used, the last four terms in the numerator and denominator of equation (9) are equal to zero. Therefore the measure of long-run scale economies reduces to $LSCE = (1 - \beta_1) / \Sigma \pi_k$.

The long-run scale economies obtained from Table 3 is 1.22   [(1-0.205) / (0.26+0.30+0.09)], which reveals that a 10% increase in total hours of operation is associated with 8.2% increase in total variable costs for an average center in the long-

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[16] *The variance of $\pi_1\pi_2 + \xi_{12}$ is equal to $\pi_2^2 Var(\pi_1) + \pi_1^2 Var(\pi_2) + Var(\xi_{12})$*
$+ 2\pi_1\pi_2 Cov(\pi_1\pi_2) + 2\pi_2 Cov(\pi_1\xi_{12}) + 2\pi_1 Cov(\pi_2\xi_{12})$.

run. The 95% confidence interval was (1.02, 1.41), which translates into 7.1 to 9.8 percent increase in costs following a 10% increase in output, demonstrating long-run scale economies.

There is significant variation in the length of 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 results indicate that an increase in this size would be associated with a decrease in average variable costs, keeping center quality constant.

Labor-labor Substitution and Wage Elasticities of Labor Demand

The Allen Elasticity of Substitution, σ_{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, $\sigma_{ij} = (\gamma_{ij}/\alpha_i \alpha_j) + 1$ $i \neq j$.

The first panel of Table 5 presents the elasticities of substitution between three labor categories. The results indicate that centers can very easily substitute workers with 13-15 years of education for workers with 16 and more years of education. On the other hand, workers with 12 years or less of education and the ones with 16+ years of education are complements in production. The same is true for workers with the least education and workers with 13 to 15 years of education. This result may imply that the least educated workers are supervised by workers with higher levels of education. This is an interesting result and it underlines the importance of classifying labor by education. The classification of labor by title (e.g. teachers, teacher aides, etc.) 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

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generates a more lucid picture of substitution elasticities.[17]

The differences in the elasticities of substitution across 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 $lnY = f(g(lnL_1, lnL_2), lnL_3)$, 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 7.82 for separability of L_1 and L_2 from L_3. It was 5.85 for separability of L_1 and L_3 from L_2, and 0.90 for separability of L_2 and L_3 from L_1, where L_1 stands for workers with 12 years or less education, L_2 stands for workers with 13-15 years of education, and L_3 is workers with 16+ years of education. Thus, workers with 12 or less years of schooling and the ones with 13 to 15 years of schooling are not separable from workers with 16 and more years of education. Similarly, workers with the least education and with highest education are not separable from the group with 13-15 years of education. On the other hand, workers with 13-15 years of education and workers with 16+ years of education are separable from the ones with 12 and less years of education. This suggests that disaggregating labor by title will lead to incorrect inferences about the elasticities of substitution, if there is overlap in distribution of education among categories.

The second panel of Table 5 reports the estimated constant-output (short-run) labor demand elasticity (η) for three labor categories. It can be shown that $\eta_i = (\gamma_{ii} + \alpha_i^2 - \alpha_i)/\alpha_i$,

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[17] *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).*

where α_i is the estimated share of the ith input in total variable cost. The estimated own price elasticity for workers with less than 12 years of education is positive which is contradictory to economic theory. This result, however, is due to the large second order coefficient γ_{11}. The variance of the elasticity is calculated, which is then used to test the hypothesis that the elasticity is equal to zero. The variance of η_1 is equal to

$$(1/\alpha_1)^2 \mathrm{Var}(\gamma_{11}) + [1-(\gamma_{11}/\alpha_1{}^2)]^2 \mathrm{Var}(\alpha_1) + 2\mathrm{Cov}(\gamma_{11},\alpha_1)(1/\alpha_1)[1-(\gamma_{11}/\alpha_1{}^2)].$$

The calculated t-statistic under the null hypothesis of perfectly inelastic labor demand for workers with education less than 12 years is 0.53. Thus, we could not reject the hypothesis that labor demand for these workers is perfectly inelastic in the short-run. This means that in the short-run, centers would not reduce their demand for these workers in the face of a wage increase. This result is intuitive because given that the level of operation is constant in the short-run, centers may not have much flexibility in terms of reducing the labor usage, if state-mandated staff-child ratio requirements are binding. For a given number of children, centers have to employ a minimum number of adults (teachers and aides) dictated by state regulations. Thus, small increases in the wages paid to low educated workers will not generate a reduction in center's demand for these workers as long as the increase in the wage rate is not large enough to exceed the level paid to those workers with higher education. The demand elasticity for workers with 13-15 years of education is -0.44, and the one for worker with 16+ years of education is -0.33, indicating that centers do not have much flexibility in the short-run to adjust their labor usage in the presence of wage increases.[18]

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[18] *As Hamermesh and Grant (1979) indicate, estimation of own-price elasticities may be biased towards zero in the absence of capital, because the substitution toward capital following a wage increase is not accounted for. However, as described earlier, 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 make it difficult to switch to a more capital intensive technology following an increase in the wage rates. Because*
(continued...)

VI. Conclusion

Research in child development has demonstrated a direct association between the quality of child care and children's social and cognitive developments, and academic achievements (Ramey and Campbell 1991). Similarly, the links between academic achievements and labor market success, and cognitive skills and wages have been documented in the economics literature (Murnane, Willett and Levy 1995). The growing wage inequality in the United States, and the relationship between quality of child care, cognitive skills and labor market success make it crucial to investigate the way the child care industry functions. The issue is important, especially because the average quality of center-based child care provided in the United States is below the level that is considered good by professionals in early child care and education (Whitebook et al., 1990), and because the demand for child care is increasing rapidly.

There exists a strong folklore in the child care industry as to the behavior of for-profit and nonprofit centers along these lines. Nonprofit centers are accused of "shirking"; i.e. producing child care services at higher costs than their for-profit counterparts. For-profit centers, on the other hand, are being blamed for "cheating"; i.e. producing lower quality, and therefore taking advantage of the consumers who cannot have perfect information about the quality of services purchased. Anecdotal and some scattered empirical evidence are cited to support both of these positions. However, there has been only a few economic studies to shed light on these claims, and they suffer from various data limitations. Similarly, in many cases data limitations prevented previous

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[18](...continued)
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).

research from providing credible information on production technology, elasticities of substitution and economies of scope in the industry.

This paper uses a new data set which is constructed through visits to child care centers and which contains extraordinary detail on center characteristics, workers and children. Quality is measured by an 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 industry. First, there is no difference in average quality of the services produced between nonprofit and for-profit centers. This result is important because it demonstrates that on the average, the hypothesis of for-profit centers taking advantage of the information asymmetry on quality is incorrect, and 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 there is no efficiency difference between for-profit and nonprofit centers in terms of producing child care services, keeping quality constant. However, 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. 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 19 percent higher than their non-publicly owned or operated, or publicly supported nonprofit counterparts.

Classification of labor into three categories by education reveals that the labor sub-categories should not be combined into one group, and doing so may lead to incorrect inferences about the substitution possibility among inputs. Child care workers with 13 to 15 years of education and workers with 16 and more years of education are substitutes. On the other hand, both of these groups are complements to workers with

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12 and less years of education.   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 hours of children served brings about only an 8.5 percent increase in costs in the long-run. There is no evidence of economies of scope. Serving various age groups jointly is not more efficient than serving them separately, although the issue is less clear in the case of preschoolers and school age children.

Estimation results show that the cost of increasing the quality of an average center from mediocre to good is between 12-16 cents per child-hour.

Table 1
Descriptive Statistics

Variable	Definition	Profit (N=200)	Non-Profit (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 years or less formal education ($/hour).	5.64 (1.13)	5.86 (1.30)	5.75 (1.22)
WAGE2	Center weighted average wages for staff with 13-15 years of education ($/hour).	6.26* (1.41)	6.83* (1.96)	6.54 (1.72)
WAGE3	Center weighted average wages for staff with 16 and more years of 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	The annual hours of service provided for preschoolers.	92,031 (75,534)	88,303 (70,377)	90,186 (72,959)
SCHOOLAGE	The annual hours of care provided for kindergarten-school age children.	22,453* (33,430)	12,718* (20,221)	17,635 (28,083)

	(Table 1 concluded)			
PROFIT	Dummy variable (=1) if the center is for-profit, (=0) otherwise.	----	----	0.505 (0.501)
NATIONAL CHAIN	Dummy variable (=1) if the center is a part of a for-profit national chain, (=0) otherwise.	0.240 (0.428)	----	0.121 (0.327)
SPECREG	Dummy variable (=1) if the center receives public money, (=0) otherwise.	----	0.143 (0.351)	0.071 (0.257)
PUBAUSP	Dummy variable (=1) if the center is owned and operated by public agencies, (=0) otherwise.	----	0.138 (0.346)	0.068 (0.252)
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 (0.196)	0.194 (0.396)	0.116 (0.321)
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, weighed by enrollments at the appropriate age levels.	3.87* (0.85)	4.15* (0.83)	4.01 (0.85)

The numbers in each cell are the means. The values in parenthesis are the standard deviations. (*) indicates that the means between for-profit and nonprofit centers are different at the 5% level.

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

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

a: The first number in each cell is the mean. The number in the parenthesis is the standard deviation. (*) indicates that the corresponding means between for-profit and nonprofit centers are significantly different from each other.

Table 3
Short-run Translog Cost Function Regression[a]

Variable Name I	Parameter II	Coefficient III	t-Statistic IV
Constant	α_0	12.486*	256.628
Wage1	α_1	0.221*	17.190
Wage2	α_2	0.371*	22.700
Wage3	α_3	0.221*	15.940
Infant-toddler	π_1	0.263*	8.981
Preschool	π_2	0.298*	7.045
Schoolage	π_3	0.095*	4.188
Infant * Preschool	ξ_{12}	-0.037*	-2.849
Infant * Schoolage	ξ_{13}	-0.002	-0.956
Preschool * Schoolage	ξ_{23}	-0.032*	-2.948
Infant-toddler^2	ξ_{11}	0.082*	5.555
Preschool^2	ξ_{22}	0.147*	4.460
Schoolage^2	ξ_{33}	0.032*	3.210
Wage1^2	γ_{11}	0.202*	3.639
Wage2^2	γ_{22}	0.069	0.865
Wage3^2	γ_{33}	0.102*	1.960
Wage1 * Wage2	γ_{12}	-0.092	-1.742

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(Table 3 continued)			
Wage1 * Wage3	γ_{13}	-0.110*	-2.915
Wage2 * Wage3	γ_{23}	0.083	1.571
Space	β_1	0.205*	4.687
Space^2	β_2	-0.007	-0.147
Wage1 * Space	δ_1	0.010	0.747
Wage2 * Space	δ_2	-0.013	-0.698
Wage3 * Space	δ_3	0.017	1.106
Wage1 * Infant-toddler	μ_{11}	0.015*	3.090
Wage1 * Preschool	μ_{12}	-0.015	-1.385
Wage1 * Schoolage	μ_{13}	-0.001	-0.145
Wage2 * Infant-toddler	μ_{21}	-0.007	-1.406
Wage2 * Preschool	μ_{22}	0.022	1.633
Wage2 * Schoolage	μ_{23}	-0.004	-0.902
Wage3 * Infant-toddler	μ_{31}	-0.006	-1.346
Wage3 * Preschool	μ_{32}	-0.007	-0.645
Wage3 * Schoolage	μ_{33}	0.002	0.470
Space * Infant-toddler	Φ_1	0.002	0.171
Space * Preschool	Φ_2	-0.087*	-2.534
Space * Schoolage	Φ_3	0.017	1.528

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(Table 3 concluded)			
Quality	r_1	0.400*	3.584
Quality^2	r_2	0.616	1.444
Quality * Space	r_3	-0.007	-0.067
Quality * Wage1	Ω_1	-0.212*	-5.237
Quality * Wage2	Ω_2	0.035	0.677
Quality * Wage3	Ω_3	0.228*	5.192
Quality * Infant-toddler	ψ_1	0.011	0.377
Quality * Preschool	ψ_2	0.028	0.386
Quality * Schoolage	ψ_3	-0.022	-0.756
Profit	ω_1	-0.041	-1.198
Specreg	ω_2	0.181*	2.810
Pubsupp	ω_3	0.081	1.576
Public Auspice	ω_4	0.036	0.585
National Chain	ω_5	-0.021	-0.407
California	ω_6	-0.197*	-4.496
Colorado	ω_7	-0.130*	-3.085
North Carolina	ω_8	-0.298*	-6.426
Box-Cox Parameter	λ	0.206	4.196

* Statistically significant at the 5 percent level. N=396.

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Table 4
Translog Short-run Cost Functions with Structural Quality*

Variable I	Parameter II	Coefficient III	t-Statistic IV
Constant	α_0	12.737*	146.441
Wage1	α_1	0.210*	21.173
Wage2	α_2	0.381*	31.296
Wage3	α_3	0.225*	20.364
Infant-toddler	π_1	0.219*	5.929
Preschool	π_2	0.364*	7.871
Schoolage	π_3	0.090*	4.896
Infant * Preschool	ξ_{12}	-0.118*	-4.102
Infant * Schoolage	ξ_{13}	-0.007	-0.706
Preschool * Schoolage	ξ_{23}	-0.064*	-3.916
Infant-toddler^2	ξ_{11}	0.003	0.127
Preschool^2	ξ_{22}	-0.077	-1.568
Schoolage^2	ξ_{33}	-0.005	-0.610
Wage1^2	γ_{11}	0.218*	3.932
Wage2^2	γ_{22}	0.109	1.329
Wage3^2	γ_{33}	0.116*	2.288
Wage1 * Wage2	γ_{12}	-0.112*	-2.068

(Table 4 continued)			
Wage1 * Wage3	γ_{13}	-0.108*	-2.902
Wage2 * Wage3	γ_{23}	0.083	1.571
Space	β_1	0.243*	6.679
Space^2	β_2	-0.023	-0.897
Wage1 * Space	δ_1	0.010	0.607
Wage2 * Space	δ_2	-0.030	-1.533
Wage3 * Space	δ_3	0.033	1.851
Wage1 * Infant-toddler	μ_{11}	0.041*	4.929
Wage1 * Preschool	μ_{12}	-0.023	-1.564
Wage1 * Schoolage	μ_{13}	0.001	0.123
Wage2 * Infant-toddler	μ_{21}	-0.013	-1.217
Wage2 * Preschool	μ_{22}	0.052*	2.793
Wage2 * Schoolage	μ_{23}	-0.006	-0.682
Wage3 * Infant-toddler	μ_{31}	-0.023*	-2.573
Wage3 * Preschool	μ_{32}	-0.027	-1.611
Wage3 * Schoolage	μ_{33}	-0.002	-0.251
Space * Infant-toddler	Φ_1	0.044	1.648
Space * Preschool	Φ_2	-0.031	-0.662
Space * Schoolage	Φ_3	0.041	1.756

(Table 4 concluded)			
Staff-Child Ratio		0.025	1.166
Group Size		-0.041	-1.479
Turnover		-0.008	-0.625
Education		-0.100*	-5.697
Experience		-0.035	-1.742
Tenure		-0.034	-1.536
% Infants		0.004	0.112
Center Age		0.010	0.542
Profit	ω_1	-0.092*	-2.639
Specreg	ω_2	0.271*	3.985
Pubsupp	ω_3	0.033	0.630
Public Auspice	ω_4	0.094	1.530
National Chain	ω_5	-0.020	-0.387
California	ω_6	-0.174*	-3.930
Colorado	ω_7	-0.163*	-3.749
North Carolina	ω_8	-0.357*	-7.714
Box-Cox Parameter	λ	0.703*	10.263

* Statistically significant at the 5 percent level. N=384.

Table 5

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)	
Workers with education ≤ 12 years (1) & Workers with education 13-15 years (2)	-0.12
Workers with education ≤ 12 years (1) & Workers with education 16+ years (3)	-1.26
Workers with education 13-15 years (2) & Workers with education 16+ years (3)	2.02
Constant output labor demand elasticities (η)	
Workers with education ≤ 12 years (1)	0.13
Workers with education 13-15 years (2)	-0.44
Workers with education 16+ years (3)	-0.33

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APPENDIX

A total of 228 infant/toddler classrooms and 521 preschool classrooms were observed to collect information about 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 enter served both age groups. No school age 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 used two well-established global observation 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 similar instrument designed to assess center rooms 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, test of interrater reliability at each site and between sites were very high.[19]

Observers counted classroom staffing ratios and group size five different times throughout the day. They also used the Observations of Activities in Preschool instrument (Palacios and Lera 1991) periodically throughout the day to document the teacher's role in activities, how children were grouped, and the from of expression used during the activity. Finally, they used the UCLA Early Childhood Observation Form

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[19] *The details can be found in "Cost, Quality and Child Outcomes in Child Care Centers," Technical Report; Center for Research on Economic and Social Policy, University of Colorado at Denver.*

(Stipek, Daniels, Galuzzo and Milburn, 1992) to differentiate between didactic, structured, and child-centered programs based on five scales: child initiation, academic emphasis, performance pressure, discipline and negative evaluation.

Classroom process describes aspects of the overall quality of the services received by children. More specifically, classroom process refers to the way that children are cared for, such as the amount of warmth a caregiver shows for a child, or the emotional tone that is present in the classroom. The activities that are available for children to engage in, and the learning opportunities that are present, are also aspects of classroom process.

To create a single score to represent classroom process quality, a process quality index was created using principal component techniques. Principal components analyses were performed including both the factor and the total scores from most of the measures of process quality (ECERS, ITERS, Caregiver Interaction Scale, and Adult Involvement Scale). The Peer Play Scale was not included because it was viewed as a measure of child outcomes rather than child care quality. The UCLA Early Childhood Observation Form and the Observation of Activities in Preschool measures were not included because they were not used in infant/toddler classrooms. The principal components analyses were conducted separately for the infant/toddler and preschool data. In both infant/toddler and preschool classrooms, high correlations were observed between the factor scores for each process quality measure and the total scores for each process quality measure. These high correlations indicated that process quality could be indexed by a single score. Thus, the final process index includes the total scores from the ECERS, ITERS, Caregiver Interaction Scale, and Adult 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 percent of center FTE children in the given age-group.

Table A-1
Center Structural Characteristics

Variables	For-profit (N=200)	Nonprofit (N=196)
Weighted mean staff-child ratio during mid-morning inside activities.	0.16* (0.12)	0.21* (0.16)
Weighted mean group size	12.71 (8.28)	12.72 (5.90)
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)
Percent Infants	0.25* (0.23)	0.18* (0.23)
Age of the Center (in years)	10.31* (8.31)	16.12* (14.66)

The first value in each cell is the mean. The number in parenthesis is the standard deviation. (*) indicates that the means between for-profit and nonprofit centers are different at the 5% level.

A-3

Table A-2
Translog Cost Functions for centers that employ all three labor categories

VARIABLE	PARAMETER	COEFFICIENT	t-STATISTIC
Constant	α_0	12.600*	199.490
Wage1	α_1	0.234*	17.740
Wage2	α_2	0.335*	21.969
Wage3	α_3	0.243*	17.619
Infant-toddler	π_1	0.330*	8.910
Preschool	π_2	0.254*	4.957
Schoolage	π_3	0.100*	3.273
Infant*Preschool	ξ_{12}	-0.001	-0.058
Infant*Schoolage	ξ_{13}	0.000	0.029
Preschool*Schoolage	ξ_{23}	0.000	-0.059
Infant-toddler^2	ξ_{11}	0.002	0.058
Preschool^2	ξ_{22}	0.002	0.058
Schoolage^2	ξ_{33}	0.001	0.058
Wage1^2	γ_{11}	0.213*	3.555
Wage2^2	γ_{22}	0.273*	3.367
Wage3^2	γ_{33}	0.089	1.715
Wage1*Wage2	γ_{12}	-0.251*	-4.588
Wage1*Wage3	γ_{13}	-0.015	-0.363
Wage2*Wage3	γ_{23}	0.038	0.751
Space	β_1	0.172*	3.178
Space^2	β_2	0.062	1.270
Wage1*Space	δ_1	0.006	0.486

A-4

(Table A-2 continued)			
Wage2*Space	δ_2	0.007	0.460
Wage3*Space	δ_3	-0.018	-1.369
Wage1*Infant-toddler	μ_{11}	0.000	0.058
Wage1*Preschool	μ_{12}	0.000	-0.058
Wage1*Schoolage	μ_{13}	0.000	-0.058
Wage2*Infant-toddler	μ_{21}	0.000	-0.057
Wage2*Preschool	μ_{22}	0.000	-0.052
Wage2*Schoolage	μ_{23}	0.000	-0.058
Wage3*Infant-toddler	μ_{31}	0.000	-0.058
Wage3*Preschool	μ_{32}	0.000	0.058
Wage3*Schoolage	μ_{33}	0.000	0.058
Space*Infant-toddler	Φ_1	0.000	0.059
Space*Preschool	Φ_2	-0.001	-0.057
Space*Schoolage	Φ_3	0.000	0.055
Quality	τ_1	0.415*	2.907
Quality^2	τ_2	0.536	0.850
Quality*Space	τ_3	0.055	0.425
Quality*Wage1	Ω_1	-0.178*	-3.985
Quality*Wage2	Ω_2	0.066	1.289
Quality*Wage3	Ω_3	0.131*	2.796
Quality*Infant-toddlers	ψ_1	0.001	0.057
Quality*Preschool	ψ_2	0.003	0.058
Quality*Schoolage	ψ_3	-0.001	-0.058

A-5

(Table A-2 concluded)			
Profit	ω_1	-0.010	-0.245
Specreg	ω_2	0.110	1.359
Pubsupp	ω_3	0.077	0.956
Pubausp	ω_4	0.036	0.467
National Chain	ω_5	-0.123*	-2.189
California	ω_6	-0.107	-1.840
Colorado	ω_7	-0.068	-1.408
North Carolina	ω_8	-0.153*	-2.598
Box-Cox Parameter	λ	0.003	0.058

* Statistically significant at the 5 percent level. N=225.