Quality-Adjusted Cost Functions for Child-Care Centers

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In 1990, there were 27.6 million U.S. households with children under age 13, and in these households there were 47.7 million children. The primary child-care arrangement for 6.2 million of these children was center-based day care. Although most nonworking mothers care for their children themselves, nearly one out of every three nonworking mothers relies on center-based programs for 3–4-year-old children (Sandra Hofferth et al., 1991). 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).

The average quality of center-based care provided in the United States is below the level that is considered good by professionals in early care and education (e.g., Marcy Whitebook et al., 1990). On the other hand, 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 (Irving Lazar and Richard Darlington, 1982) and to improve the academic outcomes of children (Craig Ramey and Frances Campbell, 1991). It is therefore critical to develop an understanding of the determinants of cost of child care and of the relationship between cost and quality, especially because of the current legislative climate in the United States. Both the Welfare Reform Act and the Child Care and Development Block Grant, which is up for re-authorization, will have far-reaching consequences for the child-care market.

Using an extensive data base that has recently been constructed from 399 child-care centers in California, Colorado, Connecticut, and North Carolina, this paper investigates two important issues: (i) Is there an efficiency difference between for-profit and nonprofit centers? More precisely, do nonprofit centers produce the same output at similar costs as their for-profit counterparts, or do they waste resources? (ii) How much would it cost to increase the quality of care from average to good (as defined by education experts)?

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, providing full-time year-round care. The centers were visited during the spring of 1993. Comprehensive financial data, as well as detailed data on structural and process quality of the center and classrooms were collected. This data set has a number of significant advantages over existing data sets used by previous studies. Two of these advantages, which are particularly relevant for this paper, are the extraordinary detail pertaining to the cost structures of the centers and the ability to

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control the quality of the operation by a quality index, which has been widely used in the early-childhood education literature.

I. Empirical Implementation

Although the objectives of the nonprofit child-care centers may differ from those of for-profit centers, under cost minimization and competitive input prices, the short-run cost functions for child-care centers can be described by the following translog functional form.

$$\begin{aligned}(1)\quad \ln C = {} & \alpha_0 + \Sigma\alpha_i(\ln P_i) + \beta_1(\ln K) \\ & + (1/2)\beta_2(\ln K)^2 \\ & + (1/2)\Sigma\Sigma\gamma_{ij}(\ln P_i \ln P_j) \\ & + \Sigma\delta_i(\ln P_i \ln K) \\ & + \Sigma\lambda_k(\ln Y_k) + (1/2)\Sigma\Sigma\xi_{kr}(\ln Y_k \ln Y_r) \\ & + \Sigma\Sigma\mu_{ik}(\ln P_i \ln Y_k) + \Sigma\phi_k(\ln Y_k \ln K) \\ & + \eta_1(\ln q) + \eta_2(\ln q)^2 + \Sigma\omega_n D_n + u_i\end{aligned}$$

where C is the total variable cost, P_i and P_j denote the prices of the ith and jth inputs, respectively, Y_r and Y_k stand for the amounts of the rth and kth output, and K is the amount of physical space, which is fixed in the short run; ln stands for the natural logarithm, u is the error term, and q represents the quality level of the service provided. The inclusion of the quality index q in equation (1) allows for the control of the variation in costs due to quality differentials between otherwise similar centers. Similarly, a vector of dummy variables ($\mathbf{D}_n$), representing center attributes is included to capture efficiency differentials due to center characteristics. They are defined in the next section.

To be consistent with economic theory, the cost function should be linearly homogenous in input prices, and the cross-coefficients must be symmetric. These imply the following restrictions on Equation (1): $\Sigma\alpha_i = 1$, $\Sigma_j\gamma_{ij}$ for all i, $\Sigma\delta_i = 0$, and $\Sigma_i\mu_{ik} = 0$ 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:

$$\begin{aligned}(2)\quad \partial \ln C/\partial \ln P_i &= (\partial C/\partial P_i)(P_i/C) \\ &= P_i X_i / C\end{aligned}$$

where X_i is the optimal level of input i. Thus, $P_i X_i / C$ 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 (1) with respect to P_i yields the following structure for the cost shares:

$$\begin{aligned}(3)\quad S_i = {} & \alpha_i + \Sigma\gamma_{ij}\ln P_j + \Sigma\delta_i \ln K \\ & + \Sigma\mu_{ik}\ln Y_k .\end{aligned}$$

The cost equation is estimated jointly with the system of share equations depicted in (3). To avoid singularity in the error covariance matrix, one of the share equations is deleted, and the model is estimated using Zellner's iterative procedure subject to the restrictions imposed above.

II. Measurement of the Variables

The data set includes information on 399 child-care centers. The dependent variable (C) is the total variable cost of the center during the fiscal year 1991–1992. It is the sum of wages, nonwage benefits, staff education costs, subcontracting costs, food costs, maintenance, and other operating expenses. Since nonprofit centers generally receive donations from various sources, the value of donations in the form of food, services, supplies and volunteers are added to the total variable costs. To the extent that the centers can alter the hours of service provided by the centers' directors, the salaries of the directors are also part of the total variable costs. For those directors who did not report a wage or salary, the salaries are imputed and added to the total variable costs.[1]

[1]The details can be found in Mocan (1995).

INFANT-TODD is an output measure, defined as the total hours of service provided for infant-toddlers at the center during the fiscal year 1991–1992. Similarly, PRESCHOOL and SCHOOLAGE represent the annual hours of care provided for preschoolers and kindergarten–school-age children, respectively. These are the output variables, depicted by Y in equations (1) and (3). WAGE1 is the average wage rate of teachers at the center, weighted by teacher hours. Similarly, WAGE2 and WAGE3 stand for the average teacher-aide and teacher-director weighted wages, respectively. These variables represent the prices of variable inputs (P). SPACE is the square footage of the inside space used by children, which is the measure of physical capital (K).

The model includes eight controls for center characteristics ($\mathbf{D}_n$) in equation (1). PROFIT is a dichotomous variable, which takes the value of 1 if the center is for-profit, and 0 if it is nonprofit. CHAIN is also a dichotomous variable, indicating whether the center is part of a for-profit national chain. PUBREGUL 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 the enrollment constitutes special-needs children, special publicly funded preschool programs, 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 some combination of 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.

In each center two classrooms were randomly selected: one with older children (30 months and older) and one with the younger groups. In each classroom well-established global measures of child-care process were employed by trained observers to assess the quality of the operation. They include the Early Childhood Environmental Rating Scale (ECERS) (Thelma Harms and Richard Clifford, 1980), its infant-toddler version (ITERS) (Thelma Harms et al., 1990), the ARNETT scale of teacher sensitivity (Jeffrey Arnett, 1989), the Stipek Classroom Observation Measure (Deborah Stipek, 1993), and the Teacher Involvement Scale (Carollee Howes and Phyliss Stewart, 1987). To create a single score to represent classroom process quality, an index was created using principal-components techniques. The center-level quality index (QUALITY) is the average classroom quality, weighted by enrollments at the appropriate age levels.

TABLE 1—ESTIMATED TRANSLOG COST FUNCTION FOR CHILD-CARE CENTERS

Variable	Parameter	Coefficient	Standard error
Constant	α_0	12.468**	0.048
INFANT-TODD	λ_1	10.270**	0.032
PRESCHOOL	λ_2	0.241**	0.038
SCHOOLAGE	λ_3	0.146**	0.024
WAGE1	α_1	0.434**	0.013
WAGE2	α_2	0.238**	0.011
WAGE3	α_3	0.328**	0.008
SPACE	β_1	0.219**	0.041
QUALITY	η_1	0.321**	0.078
PROFIT	ω_1	−0.006	0.033
CHAIN	ω_2	−0.035	0.050
PUBREGUL	ω_3	0.169**	0.062
PUBSUPP	ω_4	0.031	0.049
PUBAUSP	ω_5	0.015	0.059
CALIFORNIA	ω_6	−0.108**	0.042
COLORADO	ω_7	−0.009	0.040
NORTH CAROLINA	ω_8	−0.132**	0.044
N:	399		
Adjusted R^2:	0.78		

**Statistically significant at the 1-percent level.

III. Results

The explanatory variables are normalized by dividing each variable by its mean before taking the natural logs. Table 1 reports the estimated model using the whole sample. For brevity, the second-order parameters

are not reported. The first-order parameters (λ_1, λ_2, λ_3, α_1, α_2, and α_3) are positive and highly significant as suggested by theory, indicating that increases in production levels and the wage rates bring about increases in total variable cost.

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 CHAIN coefficients is not significantly different from zero either. On the other hand, the coefficient of PUBREGUL (ω_3) is 0.169, and significantly different from zero. This indicates that centers that receive public money, either from the state or federal government, which is tied to higher standards have variable costs that are 18-percent higher than their nonpublicly owned or operated, or publicly supported, nonprofit counterparts (see Peter Kennedy [1981], on the interpretation of the dummy variable). The model is also estimated by including the profit dummy only (i.e., without CHAIN, PUBSUPP, PUBAUSP, and PUBREGUL). The profit dummy was not significantly different from zero. Both versions of the model were reestimated using volunteer hours as a fixed input, which involves additional cross terms between volunteer hours, wages, and outputs. The results were very similar to the ones reported in Table 1. Similarly, treating directors as a fixed input and subtracting their salaries from the total variable cost did not alter the results. The hypothesis of no structural difference between nonprofit and for-profit centers could not be rejected either, after estimating the cost functions separately for both categories and applying a standard Chow test (the F value was 0.38, with a marginal significance level of 0.99). The model reported in Table 1 was also reestimated by including interaction terms between PROFIT and state dummies. The results remained intact.

The findings indicate that for-profit centers are not distinguishable from nonprofit centers. However, those nonprofit centers that receive state or federal money, which is tied to higher standards, have higher costs than other types of centers. There is no evidence of efficiency differences across various types of providers within a given state either. These results are in contrast to earlier studies which used much less detailed data and concluded that nonprofit child-care centers were relatively inefficient (e.g., Swati Mukerjee et al. 1990; Irene Powell and James Cosgrove, 1992).

The sample mean of the quality index of the centers scaled to the ECERS instrument is 4.0, with a standard deviation of 0.85. Previous research that presented the link between quality of care and child outcomes employed the same quality index, which ranges from 1 to 7. The indication is that a score of 3.0 reflects "minimal" quality, whereas a 5.0 or above represents "good" quality. This means that the average center in our sample must increase its quality by 25 percent to achieve good quality. Using the estimated coefficient of the quality index (η_1), this brings about an 8-percent increase in total variable costs for the average center. The mean value of the total variable costs for centers is $224,899. 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 $18,048 per year. Given that the average center provides a total of 137,017 hours of service to infant-toddlers, preschoolers, and kindergarden–school-age children in a year, it would cost an additional 13 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.

IV. Conclusions

Using a newly compiled data set, this paper estimates multiproduct translog cost functions for 399 child-care centers from California, Colorado, Connecticut, and North Carolina. Quality of child care is controlled by a quality index, based on various center characteristics, which has been shown to be positively related to child outcomes by previous research. Nonprofit centers that receive public money, either from the state or federal government (which is tied to

higher standards) have total variable costs that are 18-percent higher than other centers, keeping quality of services constant. No statistically significant differences between general categories of for-profit and nonprofit centers are detected. Furthermore, various types of nonprofit centers (publicly supported, publicly operated, etc.) are not distinguishable from their for-profit counterparts (whether they are independently owned and operated or part of a national chain).

These results indicate that, with the exception of a particular segment of the nonprofit sector, there are no efficiency differences between for-profit and nonprofit sectors in terms of producing child-care services. In agreement with previous studies, the data show that the average quality of center-based child care is between "minimal" and "good," and it costs 13 cents per hour per child to increase this average quality to the level considered developmentally appropriate by child-care experts.

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