The Supply of Quality in Child Care Centers

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Abstract

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We use data from a sample of day care centers to estimate the relationships between cost and the quality of the child care service provided, and between revenue and quality. We use a measure of child care quality derived from an instrument designed by developmental psychologists. This measure of quality has been found to be positively associated with child development outcomes. Taking the estimated cost-quality and revenue-quality relationships as given, we then estimate the objective functions of the firms and compute the supply function for quality. The results indicate that (1) the estimated cost function is inconsistent with the implications of cost-minimization; (2) for-profit firms operate at a positive level of marginal cost, but non-profit firms operate at zero marginal cost; (3) revenue is positively but weakly associated with quality in most cases; and (4) the supply of quality is inelastic, with point estimates of the supply elasticity of approximately zero for both for-profit and non-profit firms. Implications of the results for child care policy are discussed.

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1. Introduction

Developmental psychologists assert that the cognitive, social, and emotional development of children is enhanced by exposure to high-quality child care and is harmed by exposure to low-quality care (Hayes, Palmer, and Zaslow, 1990). The quality of child care services in the U.S. is thought to be mediocre on average, particularly in comparison to the quality of care provided in other developed countries (Whitebook, Howes and Phillips, 1990; Mocan, 1997; Bergman, 1996). There is considerable interest among policy makers in finding ways to increase the quality of child care in the U.S. For example, the Federal Child Care Development Block Grant stipulated that a portion of funds appropriated under the grant be set aside for "quality-improving" activities. However, using government policy instruments to accomplish this goal will be difficult without understanding the behavior of firms supplying day care services, the "technology" of day care, and the resulting relationships among quality, cost, and the price of care.[1] Until recently, little was known about these important issues in the child care market. Mocan (1995, 1997) provided the first analysis of the cost-quality relationship for day care centers with results that are useful for public policy, including an estimate of the cost of increasing quality. We build on Mocan's analysis by extending his approach to estimating the cost function for day care centers, and by

[1]Day care centers accounted for 30 percent of all primary child care arrangements for preschool children of employed mothers in 1993 (Casper, 1997). In-home babysitters and family day care providers constituted 21 percent of arrangements, but there is much less information available about such providers. Relatives, including the father and the mother (while working) accounted for the remaining child care for preschool children of employed mothers.

estimating the supply function for quality. Our results provide a basis for analyzing the impact of alternative forms of government subsidies and regulations intended to improve child care quality.

An important issue in conducting such an analysis is the appropriate definition of child care quality. Several previous analyses of the cost-quality relationship in day care centers included variables such as the child-staff ratio, group size, and the average education of the staff as proxies for quality in the cost function (Preston, 1993; Mukerjee and Witte, 1993; Powell and Cosgrove, 1992). However, these variables are more appropriately thought of as inputs to the production of quality, and as such do not belong in the cost function.[2] In other contexts, the quality of child care purchased by a family has been treated as exogenous (Ribar, 1995), as equivalent to the family's expenditure on child care (Michalopoulos, Robins, and Garfinkel, 1992), as an unobserved variable proxied by the mode of care (Leibowitz, Waite, and Witsberger, 1988), or as an unobserved choice variable (Blau and Robins, 1988; Connelly, 1992). In this paper we take a different approach. Developmental psychologists define the quality of child care by the developmental appropriateness of the interactions between the provider and the child, and the environment, curriculum, materials, and activities to which children are exposed. Psychologists have designed instruments to measure the quality of child care defined in this way. For example, teaching staff can be rated by observers on aspects of care such as how sensitive they are to children, whether they encourage children to engage in activities, and use positive guidance

[2]Another problem with treating these variables as proxies for quality is that they do not appear to be closely related to either the quality of care or child development (Blau, 1997; Blau, in press). See Gertler and Waldman (1992) for an analysis of the cost function for nursing homes that treats quality as an unobserved choice variable of the firm.

techniques. As measured by these instruments, child care quality has a positive effect on child development. This is not surprising, because child care quality is *defined* by provider behavior and environments that have been determined through research and practice to foster child development (Love, Schochet, and Meckstroth, 1996).

We believe that the concept of child care quality developed by psychologists is the appropriate one for our purposes. Arguments for government intervention in the child care market are often based on the externalities generated by exposing children to high quality care (Council of Economic Advisors, 1997; Robins, 1991; Hayes, Palmer, and Zaslow, 1990).[3] It makes sense, therefore, to use a measure of quality that is known to be correlated with child development when analyzing the supply of quality in child care.

[3]Other common arguments for intervention in the child care market are that parents are unaware of the benefits of high-quality care or lack the ability to discern the quality of care.

We use a measure of child care quality derived from an instrument designed by developmental psychologists. This instrument was used to rate the quality of care provided in a stratified random sample of 400 day care centers in four states. Detailed data on costs, inputs, prices, and other key variables were collected for the same centers. We use these data to estimate the cost function[4] and the market price-quality locus facing day care centers. These two functions are the constraints faced by day care centers in their efforts to achieve their objectives. Taking these estimated constraints as given, we then estimate the objective functions of the firms in our sample. We assume that firms care about profit and quality, and we estimate the relative weights attached to these two variables, using variation across firms in the constraint functions they face to identify these weights. This variation arises from variation in geographical location of the firms, both across and within states, and from variation in the estimated technology across for-profit and non-profit firms. We allow for-profit and non-profit firms to have different relative weights on profit and quality, and we specify and estimate additional constraints on the profit that can be earned by non-profit centers as a result of their non-profit legal status. We use the estimated constraint and objective functions to simulate the supply of quality and the response of firms to alternative subsidies and regulations intended to increase the quality of child care.

The main findings are that (1) the estimated cost function is inconsistent with the implications of cost-minimization; (2) for-profit firms operate at a positive level of marginal cost,

[4]We improve upon previous analyses of day care center cost functions in several ways. First, we allow for the possibility that input prices and the quantity and quality of services are endogenous in the cost function as a result of unobserved heterogeneity across centers. Second, we account for the fact that care is provided in groups and that the number of groups is a discrete choice variable of the center. Third, we explicitly account for corner solutions for inputs. Fourth, we specify a cost function that does not hold the quantity of capital fixed, which allows us to

but non-profit firms operate at zero marginal cost; (3) revenue is positively but weakly associated with quality in most cases; and (4) the supply of quality is inelastic, with point estimates of the supply elasticity of approximately zero for both for-profit and non-profit firms.

In the following sections of the paper we specify a model of day care center behavior, describe our econometric methods, discuss the data, and present the results. The final section concludes with a discussion of the implications of the results.

2. A Model of Day Care Center Behavior

A. Technology and Cost

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determine the long run response of centers to changes in input prices.

We classify the care provided in day care centers according to the ages of children served, because the "technology" of day care is likely to differ across age groups. There are three types of rooms in a day care center: (1) infant-toddler, (2) preschool, and (3) kindergarten-school age.[5] There are T types of teaching staff categorized by skill, as measured by education and training. The production function for quality in rooms of type i in center j is

$$Q_{ij} = Q^{i}(N_{ij1},...,N_{ijT}, H_{ij}, g_{ij}, R_{j}, M_{ij}, \mu_{j}, \xi_{ij}, \varepsilon_{Qij}) \qquad (1)$$

where Q_{ij} is the quality of care provided in a room of type i (i=1, 2, 3) in center j, N_{ijk} is the weekly number of staff-hours of type k employed per room, H_{ij} is the number of hours per week spent by children in rooms of type i in center j, g_{ij} is the number of children cared for in a room of type i (group size), R_j is a vector of center characteristics taken as given by the firm (e.g., whether the firm is for-profit or non-profit), M_{ij} is a vector of room-type-specific child and family characteristics, μ_j is a center-specific error component, ξ_{ij} is a room-type-and-center-specific error component, and ε_{Qij} is an idiosyncratic room-center error. The values of μ_j, ξ_{ij}, and ε_{Qij} are assumed to be known to the firm when input decisions are made. Group size $g_{ij} = K_{ij}/G_{ij}$, where K_{ij} is the number of children of type i enrolled in center j, and G_{ij} is the number of groups (rooms) for children of age group i in center j.

[5] Infants and toddlers include children ages 0-29 months, preschoolers 30-59 months, and kindergarten-school ages 60+ months.

All rooms of a given type in a center are assumed to have the same configuration (group size and number of staff by type), but configurations can differ across the three types of rooms. We ignore the fact that there actually is variation in configuration of rooms within room types, because we have no way to account for such variation in the empirical analysis.[6] The hourly cost of employing a worker of skill level k, denoted W_{jk}, is the same across rooms, and is taken as given by the firm. The quality production function depicted by (1) may have different parameters for the three types of rooms. Restricting the technology to be the same across room types yields a more parsimonious model, and is testable.

Both for-profit and non-profit firms are assumed to be cost minimizers. The firm chooses the weekly number of hours of each type of staff (the N's) and the number of groups to which the K_{ij} children will be assigned (G_{ij}, or equivalently, group size g_{ij}) to minimize cost subject to the production constraint, given values of H_{ij}, K_{ij}, R_j, M_{ij}, μ_j, ξ_{ij}, ε_{Qij}, and a given level of quality for each room-type. We treat the quantity of output (child-hours of care and numbers of children: H and K) and the family and child characteristics (M) as determined by choices made by consumers, given the price and quality set by the firm.[7] The firm's problem is to

$$\text{Min } \_ \;= \sum^{3} [\sum^{T} N_{ijk}W_{jk}G_{ij} + f(K_{ij})] + \sum^{3} G_{ij}\lambda_{ij}[Q_{ij} - Q^{i}(N_{ij1},...,N_{ijT}, H_{ij}, g_{ij}, R_j, M_{ij}, \mu_j, \xi_{ij}, \varepsilon_{Qij})] \qquad (2)$$

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[6]We observe quality in at most two rooms per center. We observe the configuration of all rooms in the center, but without observations on the quality of each room we cannot account for variation in room configuration within room types.

[7]In the empirical analysis we allow for the possibility that H, K, Q, and W are endogenous as a result of unobserved heterogeneity. Another set of constraints that a firm might face in minimizing cost is state regulations governing the maximum allowable group size, the minimum allowable staff-child ratio, and the qualifications of the staff. It is straightforward to incorporate such regulations in the model, but we do not do so here because regulations do not appear to be binding constraints on the firms in our sample. We discuss this below.

N_{ijk}, G_{ij} i=1 k=1 i=1

where $f(K_{ij})$ is non-personnel cost. The first term of (2) is the total cost of providing care for the $K_j = K_{1j} + K_{2j} + K_{3j}$ children who enroll at the center. This consists of the cost of staffing G_{ij} groups of type i with N_{ijk} staff hours of type k, k=1,...T, i = 1, 2, 3; and the associated non-personnel cost, $f(K_{ij})$. The second term is the production constraint for the G_{ij} rooms of type i in center j. Because of the assumption of identical room configurations for a given room type, the constraint is the same for each room of a given type; hence there are G_{ij} identical constraints for room-type i. We treat non-personnel cost as a deterministic function of the number of children served for practical reasons: we have little information on input prices other than staff compensation.

Because G_{ij} is an integer, the problem is solved in two stages: first, choose the optimal values of N_{ijk} for a given value of G_{ij}; then choose the optimal value of G_{ij}. The first-order condition for N_{ijk} for a given value of G_{ij} is

$$W_{jk}G_{ij} = \lambda_{ij}[\partial Q^i(\ )/\partial N_{ijk}] \qquad \text{if } N_{ijk} > 0 \text{ if at the optimum.} \qquad (3)$$

The first-order conditions for the full interior solution for rooms of type i (in which $N_{ijk} > 0$ for all of the T teacher types) can be solved jointly with the production function for conditional input demand functions for the N's and the cost function for room-type i:

$$C_{ij} = C^i(W_{j1},..., W_{jT}, H_{ij}, Q_{ij}, R_j, M_{ij}, G_{ij}, K_{ij}, \mu_j, \xi_{ij}) \qquad (4)$$

$$N_{ijk} = N^{ik}(W_{j1},..., W_{jT}, H_{ij}, Q_{ij}, R_j, M_{ij}, G_{ij}, K_{ij}, \mu_j, \xi_{ij})$$

(5)

These functions have standard properties: the cost function is homogenous of degree one in the W's; the input demand functions are homogeneous of degree zero in the W's and satisfy symmetry conditions; and the input demand functions are the first partial derivatives of the cost function with respect to input prices. We test the estimated cost and input demand functions for these properties.

A firm may choose a corner solution in which it does not use staff of some type k in rooms of type i. Functions similar to (4) and (5) can be derived for all possible combinations of corner solutions for the N_{ijk}. Imposing and testing the conditions for such functions to be consistent with cost-minimizing behavior would have to be done separately for every combination of corner solutions, which means estimating a separate set of cost and input demand functions for all of the observed combinations of corner solutions. If T is even moderately large then the number of parameters would be far too large, and there are insufficient numbers of cases in the data with any given corner solution.[8]

Instead, we estimate the cost function and input demands corresponding to the full interior solution, imposing and testing the restrictions implied by cost-minimization, and include in the analysis all firms, whether or not they chose the full interior solution. We do, however, account for self-selection of firms by whether they use particular types of staff. An appropriate method of accounting for self-selection would recognize that the corner solution that has the lowest cost for room-type i is the one chosen by the firm: $Pr(l(i)=1) = Pr(C_{ijl(i)} < C_{ijm}\ \forall\ m \neq l(i))$, where $l(i)=1$ if the l'th corner solution is chosen for rooms of type i, and a corner solution is characterized by the

[8]An alternative approach is to parameterize the production function and solve explicitly for the cost-minimizing input demands and cost function. In this case the same underlying set of production parameters would enter the input demands and cost function for every combination of corner solutions. The restrictions would automatically be satisfied for every combination of corner solutions since the input demands and cost function would be derived under the *assumption* of cost-minimization. This is unfortunately much too complex to be feasible with many staff types.

particular combination of staff types used. Estimating a multinomial choice model of this type would require estimating the parameters of the cost function separately for every corner solution, and this is infeasible as noted above. As an alternative, we specify functions that determine whether each individual staff type is used:

$$D_{ijk}=1 \text{ iff } D^{ik}(W_{j1},..., W_{jT}, H_{ij}, Q_{ij}, R_j, M_{ij}, G_{ij}, K_{ij}, \mu_j, \xi_{ij}, \varepsilon_{Dijk}) > 0 \quad k=1,...,T \qquad (6)$$

where $D_{ijk}=1$ if staff of type k are used in rooms of type i, and $D_{ijk}=0$ otherwise. These functions are approximations to the true functions determining whether it is optimal to use any type-k staff. One approach to parameterizing these functions is to assume that they contain the same parameters as the N_{ijk} demand functions in (5): this would be a tobit-like specification. Alternatively, they can be freely parameterized, estimated as probits, and the "tobit" restrictions can be tested.[9]

The above analysis is repeated for each feasible value of G_{ij}, and the solution corresponding to the value of G_{ij} that yields the lowest total cost is optimal. Hence the optimal value of G_{ij}, G^*_{ij}, satisfies

$$C^i(..., G^*_{ij}, ...) < C^i(..., G'_{ij}, ...) \quad \forall\, G'_{ij} \neq G^*_{ij}, \qquad (7)$$

This is a structural equation for G and contains the same parameters as the cost function. An alternative approach that we pursue in the empirical analysis is to specify a non-structural ordered model for G that includes the same arguments as in (4) and (5), but without restricting the parameters to be the same as those in (4). This model is specified below.

[9] This approximation approach to the corner solution problem requires that firms that do not use a given staff type in a particular type of room nevertheless must be included in the cost function with values for all of the W's. Firms that do not use a particular type of staff are assigned the average compensation of other firms in their state that employ the staff type.

B. Price Determination

Following the literature on demand for differentiated products (Rosen 1974), and its application to child care (Blau and Hagy, 1998; Hagy, 1998; Walker, 1992), we assume that there exists an equilibrium price-quality locus in firm *j*'s market:

$$P_j = P(Q_j, X_m), \tag{8}$$

where Q_j is the firm's average level of quality, and X_m represents factors that shift the locus, such as the size and characteristics of the market *m* in which the firm is located. By choosing the level of quality to provide, a firm determines the price it will be able to charge per hour of care, P_j. By choosing a day care center, parents determine the price they pay per hour of care. Firms and consumers are assumed to take $P(Q_j, X_m)$ as given: it is determined by market supply and demand, not by the actions of any individual firm or consumer.

C. Quality Supply

We follow Lakdawalla and Philipson (1998), and assume an objective function of the form $U(Q_j, \pi(Q_j))$, where π represents the firm's profit.[10] If $U_Q \neq 0$ the firm is said to have "profit-deviating" preferences. A center with for-profit legal status could have profit-deviating preferences or could be a profit-maximizer ($U_Q = 0$). The same is true for a center with non-profit status. A for-profit center chooses Q to maximize $U(Q, \pi(Q))$ subject only to the $\pi(Q)$ constraint, while a non-profit center chooses Q to maximize $U(Q, \pi(Q))$ subject to $\pi=\pi(Q)$ and $\pi_l \leq \pi \leq \pi_u$, where π_l is the minimum level of profit needed to survive in the long run (which could

[10] Lakdawalla and Philipson (1998) use output instead of quality. Quality seems the more natural variable to use here. See Hansmann (1996), Weisbrod (1998), and Rose-Ackerman (1996) for discussion of general issues in analysis of the behavior of non-profit firms.

be negative), and π_u is the legal upper limit on the profit that can be earned by a non-profit center. As noted above, cost-minimization is assumed in both cases. The first-order condition (FOC) for a for-profit center is

$$U_Q(Q_j) + U_\pi(Q_j)(MR(Q_j) - MC(Q_j)) = 0, \qquad (9)$$

where MR is marginal revenue and MC is marginal cost. If the constraint $\pi_l \leq \pi \leq \pi_u$ is not binding, then (9) also characterizes the behavior of a non-profit center. If $\pi \leq \pi_u$ is binding, then the FOC is $\pi(Q_j) \equiv R(Q_j) - C(Q_j) = \pi_u$, where R is revenue and C is cost. If $\pi_l \leq \pi$ is binding, then the FOC is $\pi(Q_j) \equiv R(Q_j) - C(Q_j) = \pi_l$.

3. Empirical Implementation

A. Cost and Input Demand Functions

We specify a translog cost function, as in many other analyses of service industries (e.g. Mocan, 1997; Gertler and Waldman, 1992; Gagne, 1990). Conditional on G_{ij}, the cost function is specified as:

$$\begin{aligned} lnC_{ij} &= \beta_{0i} + \Sigma_k\beta_{ik}lnW_{jk} + \beta_{Gi}lnG_{ij} + \beta_{Qi}lnQ_{ij} + \beta_{Ki}lnK_{ij} + \beta_{Hi}lnH_{ij} + \beta_{Ri}R_j + \beta_{Mi}M_{ij} \\ &+ \tfrac{1}{2}\Sigma_k\Sigma_m\gamma_{ikm}\, lnW_{jk}lnW_{jm} + \Sigma_k\gamma_{Gik}lnW_{jk}lnG_{ij} + \Sigma_k\gamma_{Qik}lnW_{jk}lnQ_{ij} + \Sigma_k\gamma_{Rik}lnW_{jk}R_j + \\ &\Sigma_k\gamma_{Mik}lnW_{jk}M_{ij} + \Sigma_k\gamma_{Kik}lnW_{jk}lnK_{ij} + \Sigma_k\gamma_{Hik}lnW_{jk}lnH_{ij} + \gamma_{GQi}lnG_{ij}lnQ_{ij} + \tfrac{1}{2}\gamma_{Qi}(lnQ_{ij})^2 + \\ &\tfrac{1}{2}\gamma_{Ki}(lnK_{ij})^2 + \tfrac{1}{2}\gamma_{Hi}(lnH_{ij})^2 + \tfrac{1}{2}\gamma_{Gi}(lnG_{ij})^2 + \gamma_{RQi}R_jlnQ_{ij} + \gamma_{MQi}M_{ij}lnQ_{ij} + \gamma_{KQ}lnK_{ij}lnQ_{ij} + \mu_j + \\ &\xi_{ij}, \qquad (10) \end{aligned}$$

where C_{ij} is total cost for rooms of type i in center j. The corresponding cost share equation, given that an input is used, is

$$S_{ijk} = \beta_{ik} + \Sigma_m\gamma_{ikm}lnW_{jm} + \gamma_{Gik}lnG_{ij} + \gamma_{Qik}lnQ_{ij} + \gamma_{Rik}R_j + \gamma_{Mik}M_{ij} + \gamma_{Kik}lnK_{ij} + \gamma_{Hik}lnH_{ij} +$$

$\rho_{\mu Sik}\mu_j + \rho_{\xi Sik}\xi_{ij} + \varepsilon_{Sijk}$, (11)

where S_{ijk} is the share of the firm's total cost accounted for by staff of type k in rooms of type i, $\rho_{\mu Sik}$ and $\rho_{\xi Sik}$ are factor loadings introduced to allow flexibility in the error correlation structure, and ε_{Sijk} is a disturbance. The testable restrictions implied by cost-minimization are:

$$\sum_{k=1}^{T}\beta_{ik} = 1; \qquad \sum_{k=1}^{T}\gamma_{ikm} = 0 \ \forall\ m; \qquad \gamma_{ikm} = \gamma_{imk} \ \ \forall\ m \neq k$$

and that the parameters of the cost share equations are in fact the same as the corresponding parameters in the cost function. We assume that total cost is observed with error: $C_j = \Sigma_i C_{ij} + \varepsilon_{cj}$, where C_j is observed cost and ε_{cj} is measurement error. Note that we observe the center's total cost (C_j) but not the breakdown of cost by room type (C_{ij}).

The ordered model for the number of groups of type i has the form

$$G_{ij} = n \ \text{ iff } \ \kappa_n \geq G^i(W_{j1},..., W_{jT}, H_{ij}, Q_{ij}, R_j, M_{ij}, G_{ij}, K_{ij}, \mu_j, \xi_{ij}) + \varepsilon_{Gij} > \kappa_{n-1},\ n=1,...,G^{max}$$

(12)

where the κ's are parameters to be estimated ($\kappa_0 \equiv -\infty$, and $\kappa_{Gmax} \equiv \infty$).

B. Quality, Wages, Numbers and Hours of Children, and Any Rooms of Type i

The unobserved factors that affect cost and input demand will also affect the production of quality. To account for this potential endogeneity, we specify a reduced form equation for the logarithm of quality. We also specify reduced form equations for the logarithms of H, K, and W in order to account for the possibility that these variables are affected by the same unobserved heterogeneity as cost, and we specify a reduced form model to explain whether the center has any rooms of type i.

$$LnQ_{ij} = \delta_{01} + \delta_{11}M_{ij} + \delta_{21}R_j + \delta_{31}Z_j + \rho_{\mu W}\mu_j + \rho_{\xi W}\xi_{ij} + \varepsilon_{Qij} \quad (13)$$

$$LnH_{ij} = \delta_{02} + \delta_{12}M_{ij} + \delta_{22}R_j + \delta_{32}Z_j + \rho_{\mu Q}\mu_j + \rho_{\xi Q}\xi_{ij} + \varepsilon_{Hij} \quad (14)$$

$$LnK_{ij} = \delta_{03} + \delta_{13}M_{ij} + \delta_{23}R_j + \delta_{33}Z_j + \rho_{\mu K}\mu_j + \rho_{\xi K}\xi_{ij} + \varepsilon_{Kij} \quad (15)$$

$$LnW_{jk} = \delta_{04} + \delta_{14}M_{ij} + \delta_{24}R_j + \delta_{34}Z_j + \rho_{\mu H}\mu_j + \rho_{\xi H}\xi_{ij} + \varepsilon_{Wjk} \quad (16)$$

$$Pr(G_{ij}>0) = Pr(I_{Gij} \equiv \delta_{05} + \delta_{15}M_{ij} + \delta_{25}R_j + \delta_{35}Z_j + \rho_{\mu G}\mu_j + \rho_{\xi G}\xi_{ij} > -\varepsilon_{Gaij}) \quad (17)$$

where Z is a vector of identifying instruments to be specified below. By including μ_j and ξ_{ij} we allow for the possibility that unobserved center-specific and room-specific factors associated with productivity also affect wages etc. Note that the parameters of these auxiliary equations are not allowed to vary by room type or staff type. This restriction is imposed in order to avoid an excessively large number of parameters.

C. Error Structure

Following Mroz (1999), we assume that μ_j and ξ_{ij} are independent random effects with discrete distributions:

$$Pr(\mu_j = \mu_h) = \tau_h, \; h=1,...,A; \qquad Pr(\xi_{ij} = \xi_{in}) = \nu_{in}, \; n=1,...,B, \quad i = 1,2,3$$

where $\Sigma_h\tau_h=1$, $\Sigma_n\nu_{in}=1$, μ_h and ξ_{in} are points of support of the distributions, and τ_h and ν_{in} are probability weights. The τ's, ν's, μ's and ξ's are parameters to be estimated. H and A are specified a priori and the model is estimated for alternative values of H and A. This specification allows the outcomes across rooms in a given center to be correlated, allows outcomes within rooms to be correlated as well, conditional on the center-specific factor, and does not impose normality on the random effects. See Blau and Hagy (1998) and Hu (1999) for empirical applications of this discrete factor approach. The disturbances ε_{Cj}, ε_{Sijk}, ε_{Wjk}, ε_{Qij}, ε_{Kij}, ε_{Hij}, ε_{Dijk}, and ε_{Gaij} are assumed to be independently normally distributed with mean zero and standard deviations σ_C, σ_{Sk}, σ_W, σ_Q, σ_K, σ_H, 1, and 1, respectively. These are restricted to not depend on i in order to avoid a large number of σ's. The disturbance ε_{Gij} is assumed to follow the extreme value distribution, yielding an ordered logit model for G_{ij}. The likelihood function is derived in Appendix A.

D. Price Function

The empirical counterpart to the price equation is a double-log model:

$$LnP_j = \theta X_m + \omega lnQ_j + \eta I_j + u_j, \qquad (18)$$

where X_m is a vector of characteristics of the market *m* in which center j is located, I_j is the proportion of infant-toddlers among center j's children, θ, ω, and η are parameters, and u_j is a disturbance. In the estimation we specify X_m by zipcode dummies: the intercept of the price function is allowed to vary freely across zipcodes, which are assumed to constitute the relevant markets. The quality parameter ω is restricted to be the same across zip codes within a state, but is allowed to vary across states. The dependent variable is the logarithm of the average fee of the center. It is a weighted average of infant-toddler and preschool fees, weighted by the proportion of infant-toddlers and preschoolers. Thus, we include the proportion of infant-toddlers as an explanatory variable. This equation is estimated independently of the cost and other functions. It is possible to estimate it jointly with the other equations, but it contains a large number of parameters, making joint estimation burdensome. Experimentation with the equation suggested that conditional on the zipcode fixed effects unobserved heterogeneity is not a problem, so we estimate it by OLS.

E. Center Behavior and Quality Supply

We adopt a Cobb-Douglas specification of the objective function:

$$U(Q, \pi(Q)) = (Q_j)^{\alpha}(\pi_j)^{1-\alpha} \quad (19)$$

where α is allowed to differ between for-profit and non-profit firms. Profit maximization implies $\alpha = 0$. The FOC for a for-profit center implies

$$(MC(Q) - MR(Q)) = \alpha\pi/(1-\alpha)Q + \varepsilon_p \quad (20)$$

where

$$\text{Revenue} = R = \Sigma_i K_{ij} H_{ij} P_j = \exp\{\theta X_m + \omega \ln Q_j + \eta I_j + u_j\}\Sigma_i K_{ij} H_{ij}$$

$$MR = \partial R/\partial Q = \omega R_j/Q_j$$

$$MC = [\partial lnC/\partial lnQ]C(Q)/Q = [\beta_{Qi} + \Sigma_k \gamma_{Qik} lnW_{ijk} + \gamma_{GQi} lnG_{ij} + \gamma_{Qi} lnQ_{ij} + \gamma_{RQi} R_j + \gamma_{MQi} M_{ij} + \gamma_{KQ} lnK_{ij}]C_j/Q_j$$

and ε_p is measurement error in MC-MR. Equation (20) is a nonlinear implicit equation for the optimal Q.

A non-profit center for which the constraint $\pi_l \leq \pi \leq \pi_u$ is not binding has a FOC of the same form as (20),

$$(MC(Q) - MR(Q)) = \alpha\pi/(1-\alpha)Q + \varepsilon_n \quad (21)$$

where ε_n is measurement error. A non-profit center that would have chosen $\pi > \pi_u$ in the absence of a constraint will be forced to set Q so that $\pi(Q) = R(Q) - C(Q) = \pi_u$. We assume that π_u is known to the firm but unobserved by us. It can therefore be treated as a disturbance. Similarly, a firm that hits the $\pi_l \leq \pi$ constraint will be forced to set $\pi = \pi_l$, and we treat π_l as observed by the firm but unknown to us. This results in a switching regression model with unknown regime. We do not know whether any particular non-profit center is in the unconstrained regime ($\pi_l < \pi < \pi_u$) or one of the constrained regimes ($\pi = \pi_u$ or $\pi = \pi_l$). The model governing the choice of Q in the unconstrained regime is equation (21), and in the constrained regimes is $R(Q) - C(Q) = \pi_u$ or $R(Q) - C(Q) = \pi_l$, which are implicit equations for Q. Suppose that $\varepsilon_n \sim N(0, \sigma_n^2)$, $\pi_u \sim N(\mu_u, \varsigma_u^2)$, and $\pi_l \sim N(\mu_l, \varsigma_l^2)$. The probability that a center is constrained by π_l is $\lambda_l = Pr(\pi_l > \pi^*)$, where π^* is the unconstrained level of profit, which is the solution to (21):

$$\lambda_l = Pr(\pi_l > \pi^*) = Pr(\pi_l > (MC(Q^*) - MR(Q^*))(1-\alpha)Q^*/\alpha)$$

where Q* is the unconstrained choice for Q, which is found by solving (19) numerically. The probability that a center is constrained by π_u is

$$\lambda_u = Pr(\pi_u < \pi^*) = Pr((MC(Q^*) - MR(Q^*))(1-\alpha)Q^*/\alpha > \pi_u)$$

Taking the parameters of the cost and fee equations as given, the likelihood function contribution for a non-profit child care center is

$$L = [\phi((R[Q^*] - C[Q^*]-\mu_l)/\varsigma_l)/\varsigma_l]^{\lambda l}[\phi((R[Q^*] - C[Q^*]-\mu_u)/\varsigma_u)/\varsigma_u]^{\lambda u}[\phi(\varepsilon_n/\sigma_n)/\sigma_n]^{1-\lambda l-\lambda u}$$

The parameters to be estimated are α, σ_n, μ_l, μ_u, ς_l, and ς_u. We restrict α to the unit interval. Testing the hypothesis of profit-maximization involves a restriction on α and is straightforward. We can incorporate for-profits and non-profits in the same analysis and explicitly test whether the parameters of their objective functions differ. The likelihood contribution for a for-profit center is $L=\phi(\varepsilon_p/\sigma_p)/\sigma_p$, where σ_p is the standard deviation of ε_p, and ε_p is assumed to be normally distributed with zero mean.[11]

F. Quality Supply

With estimates of α, μ_u, μ_l and the parameters of the cost and fee equations, we solve

[11] Alternatively, (20) could be estimated by nonlinear least squares for the for-profit sample. We estimate the firm objective function parameters separately from the cost and price equations in order to avoid contaminating the cost and price estimates by a misspecified objective

numerically for the quality supply function, $Q = Q^*(\theta, W_1,..., W_T, K, H, R, M)$, which provides a picture of how quality supplied varies with the determinants of price and cost. The quality supply function for non-profits accounts for the different regimes by weighting by the estimated values of the λ's.

G. Identification

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function, since we are least confident about the latter.

The cost function contains five potentially endogenous regressors: the number of groups, quality, wages, child-hours, and child enrollment (G, Q, W, H, K)[12]. Our identification strategy assumes that location within a state (state dummies are included in the cost function in R_j), as defined by a center's zip code, is uncorrelated with technology, but is correlated with these potentially endogenous regressors. There are on average 1.6 centers per zip code in the data. One way to operationalize this is to include zip code dummies as instruments (the Z's) in the equations for G, Q, W, H, and K. This would add a very large number of parameters to the model, so we follow a different approach. We estimate a set of regressions of center characteristics on zip code dummies and construct from each regression a linear combination of the zip code dummies given by the regression coefficients. We use these linear combinations (i.e., the center's zipcode coefficient in each regression) as the identifying instruments, along with the zipcode-level unemployment rate.

4. Data

[12]It is possible that some of the child and family characteristics in M_{ij} and some of the center characteristics in R_j are endogenous as well. We ignore this possibility because of the very large number of parameters that would have to be estimated if models for M_{ij} and R_j were added.

We use data collected from day care centers in California, Colorado, Connecticut, and North Carolina as part of the Cost, Quality, and Outcomes (CQO) Study. A random sample of approximately 50 for-profit and 50 non-profit day care centers providing full-time year-round care was selected from specified regions within each state.[13] Interviewers visited each center in the Spring of 1993 and gathered detailed information on costs, revenues, donations, quality, and human capital characteristics and wages of every worker. In addition to information collected from interviewing the center director, two rooms at each center were randomly chosen to be observed: one preschool and one infant-toddler room if the center served both age groups.[14] Trained observers visited each center for one day to observe the rooms. They recorded the group size and the number of staff in each of the selected rooms five different times during the morning. The Early Childhood Environmental Rating Scale (ECERS) and the Infant-Toddler Environmental Rating Scale (ITERS) were used to measure the quality of care provided in the selected rooms. These instruments contain around 30 items characterizing personal care routines, furnishings, language-reasoning experience, fine and gross motor activities, creative activities, and social development. Each item is scored on a seven point scale with a score of one representing inadequate and a score of seven representing excellent. These are widely used instruments, and

[13]The regions were Los Angeles County; the Colorado Springs, Denver, Boulder, Fort Collins, Greeley area; the Hartford-New Haven area; and the "Triad" area of Winston-Salem, Greensboro, and Burlington.

[14]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. No school age or kindergarten classrooms were observed.

have good psychometric properties.[15] In essence, they formalize the notions of quality that a well-educated parent might look for when visiting a center: the nature of the interactions between staff and children; the developmental appropriateness of the materials, toys, playground equipment, and activities; and the hygiene and food preparation practices of the center. Appendix B provides a list of items and examples of instructions to the observers on how to score items. A principal component analysis was use to create a summary quality index for each room, also scaled from one to seven. We use the first principal component in the analysis.

[15] See Harms and Clifford (1980, 1986) for details. Several other instruments were used as well, but we focus on the ECERS and ITERS as our measure of quality. Interrater reliability at each site and between sites was very high for all instruments used.

The descriptive statistics shown in Table 1 indicate that infant-toddler rooms have significantly lower quality than preschool rooms, and that average quality in preschool rooms is 4.3, which corresponds to a description of somewhere between "minimal" and "good." Table 2 shows that average center quality is higher in non-profit centers; this is due largely to a pronounced difference between the quality of for-profit and non-profit centers in North Carolina.[16]

Cost is the sum of annual wage and salary expenditure, nonwage benefits, staff education costs, subcontracting costs, food costs, other operating expenses, the estimated value of in-kind donations (food, volunteer services, and supplies), overhead, insurance, and occupancy costs (rent or mortgage, utilities, repair and maintenance). For centers that use donated space the annual rental value of the space is calculated and treated as occupancy cost. For those centers that receive financial help with rent, the discount they receive on rent is added to occupancy costs. Since our aim is to estimate a long run cost function in which all inputs are treated as variable, we include all costs. Annual cost is divided by 52 to obtain a measure of weekly total cost that is used in the estimation. The center director provided information on the total number of children enrolled in the center by age, average hours per child by age, and the number of rooms by age. As shown in Table 2, average weekly cost per child is 14 percent higher in non-profit centers. Average cost per unit of quality is lower in non-profit centers, but average cost per child per unit of quality is higher.

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[16] Additional descriptive information by state and profit status can be found in Mocan (1997) and Helburn (1995).

The center director provided a roster of all workers in the center, including data on the hourly wage or annual salary, hours of work per week, years of experience, tenure at the center, training, age, race, gender, the age group of children served and the worker's job title. After considerable experimentation, we decided to classify staff into four categories (T=4) by years of formal education: high school dropout, high school graduate, some college, and college graduate. The survey contains detailed information on the specific type and source of child-development-related training of each staff member. In preliminary analyses we found that this additional training information was for the most part redundant once staff were categorized by years of schooling. We also found that worker productivity differed by job title (teacher versus aide) and by job tenure (less than one year versus one or more years) within education categories. Therefore, we attempted to estimate models with more than four staff types, but the very large number of parameters in such models made it impossible to achieve convergence in most cases. Conditional on education, title, and tenure, we found no differences in staff productivity by age, race, or total years of child care experience in our preliminary analysis. Table 1 shows descriptive statistics on staff hours and cost share by staff-type and room-type. Table 2 shows average hourly compensation by staff type. Compensation consists of average hourly earnings plus estimated average fringe benefits per hour.[17] Compensation rises with education, but not by as much as in other jobs held by women (Blau, 1992; Mocan and Viola, 1997). Non-profit centers pay

[17]Wages are averaged over all staff with a given level of education.The center's total expenditure on fringe benefits is divided by total staff hours to measure the average hourly value of fringe benefits.

substantially higher wages than for-profits.

Two measures of group size are shown in Table 1. "Enrolled group size" is derived from a roster of all the rooms in the center listing the number of children enrolled in each room and their age group. "Observed group size" is the average of five measures of group size recorded during the morning observation period for the two rooms observed. Observed group size is less than enrolled group size because some children are absent on any given day and because children are sometimes reshuffled among groups during the day. In order to derive a measure of the number of groups from observed group size, we would have to divide total enrollment (by age group) by observed group size and round it to obtain an integer. And this cannot be done for the oldest groups since no rooms were observed for this group. Instead we use the direct measure of the number of groups derived from the roster of rooms. This is an integer by construction and is available for all three age groups.

Table 1 shows descriptive statistics on the room-specific family characteristics of the enrolled children (M_{ij}). These were collected in a survey instrument distributed to the parents of children in the observed rooms. Since no Kindergarten-School-age rooms were observed, we assign the center averages to those rooms. We use only three of the many variables available in this survey: family income, marital status, and the percent of families in which at least one parent has graduated from college**.** Table 2 describes the center-specific fixed inputs included in the analysis (R_j). These include state dummies, indicators of for-profit status; whether the center receives public money tied to meeting higher than normal standards (pubregul);[18] whether the

[18]This group includes Head Start programs, centers where 20 percent or more of the enrollment constitute special needs children, special preschool programs sponsored by the State or

center receives more than half its revenue from public grants, public fees and USDA reimbursement (pubsub); whether the center is part of a for-profit national chain; whether the center has a religious affiliation; the center's age, and the percent of children who are white.

Federal Department of Education, and other special programs in Connecticut and California.

The variables Z_1-Z_4 are the linear combinations of zipcode dummies that, along with the local unemployment rate, are used as identifying instruments. These are the regression coefficients on zipcode dummies in models of the log fee, whether the center offers extended hours, whether the center offers a bilingual program, and the percent of staff who are white.[19]

5. Results

A. Specification Tests

- We rejected all of the implications of cost minimization, including symmetry of the input demand functions, adding up restrictions on the cost function and input demand functions, and the hypothesis that the parameters of the input demand functions are equal to the equivalent cost function parameters. These conclusions hold regardless of other aspects of the specification.
- We rejected the hypothesis that the parameters of the cost function are the same for non-profit and for-profit firms. This was true for every specification we examined.
- We rejected the hypothesis that the parameters of the cost function are the same for the

[19]As noted in section 2, we ignore state regulations on group size, staff-child ratio, and staff qualifications in both the theory and the empirical analysis. If regulations affected the behavior of centers, then we would expect to find many centers with a group size and/or staff-child ratio at or close to the regulation. However, the great bulk of firms substantially exceed the regulations (i.e. they have a group size smaller than the regulated maximum, and a staff-child ratio higher than the regulated minimum), suggesting that the regulations are not binding. Those firms that do not exceed the regulation are often well below it (or above, in the case of group size). This suggests that not only are the regulations not binding, but they are not strictly enforced either. Regulations and observed choices are positively correlated across states, but it is not obvious that this represents cause and effect, particularly in view of the apparent lack of enforcement of the regulations. Evidence to support these assertions is presented in an ongoing analysis of the reasons for the apparent lack of impact of regulations. See Blau (1993), Chipty and Witte (1998) Gormley (1991), Hotz and Kilburn (1998), Howes et al. (1998), and Phillips, Lande, and Goldberg (1990) for analyses of the impact of regulations.

three types of rooms, again regardless of other aspects of the specification.

· We estimated models with up to four points of support in the distribution of unobserved center-specific heterogeneity (μ), and found that three points of support yielded a large improvement in the likelihood compared with two points (and two points was a big improvement over one), while four points did not improve the likelihood compared to three points. We then estimated specifications with unobserved room-type-specific heterogeneity (ξ) in addition to center-specific heterogeneity. We could not reject the hypothesis that there was no room-specific heterogeneity.

Rejection of the implications of cost-minimization means that we cannot interpret our cost function parameters in terms of the underlying technology of production of quality. Nevertheless, we can derive estimates of the marginal cost of quality from the parameters of the cost function, and use them to derive the quality supply function. In doing so, we recognize that the fact that cost-minimization is rejected by our estimates means that we cannot interpret the resulting supply function as a conventional one that reflects cost-minimizing behavior.

The main reason for estimating the input demand functions jointly with the cost function is to improve the precision of the cost function estimates by imposing the cross-equation restrictions implied by cost-minimization. Having rejected these restrictions, there is no reason to estimate the input demand functions since we do not use them in the quality supply analysis, so we drop them in order to reduce the number of parameters estimated. Even with this reduction in the number of parameters, there are so many parameters in the cost function specification with room-type-specific parameters that we were unable to achieve convergence of such a specification allowing for unobserved heterogeneity. Therefore, we use a specification with parameters that are independent of room-type, but that are allowed to differ by legal status (for-profit versus non-profit).

B. Cost Function Estimates

Table 3 presents selected cost function parameter estimates, with and without unobserved firm-specific heterogeneity. The parameters shown in Table 3 are those needed to compute marginal cost; the other cost function parameters are given in Appendix C. The specifications shown in Table 3 omit many interactions between *ln*Q and other variables, including $(ln Q)^2$. The coefficients on these terms were generally insignificantly different from zero, and including them caused substantial collinearity in the cost function. The cost function for non-profit firms was especially sensitive to the inclusion of many quality interactions, and the final specification is very parsimonious in *ln*Q.

The marginal cost of quality in for-profit firms is decreasing in the number of groups (G) and increasing in the number of children (K), with parameters that are opposite in sign and close in absolute value. Since group size g = K/G, proportionate increases in K and G that leave group size unchanged also leave cost slightly lower. The marginal cost of quality is higher in Colorado and North Carolina than in California (the omitted category) and Connecticut. This suggests one reason why quality is lower on average in Colorado and North Carolina: quality costs more to produce in those states. The marginal cost of quality is higher in for-profit firms that serve a higher proportion of white children and in firms that receive a substantial amount of revenue from public subsidies, and is lower in firms that are part of a national chain. The latter result could indicate that there are economies of scale in some aspects of quality production. The marginal cost of quality is higher in for-profit firms that serve higher-income families and families in which the parents are not married. Marginal cost is significantly higher in infant-toddler rooms than in preschool rooms and kindergarten-school age rooms (the latter is the omitted category). Allowing for unobserved heterogeneity made a big difference in some of the parameters estimates.

In non-profit firms, proportionate increases in G and K leave the marginal cost of producing quality unchanged, as in for-profit firms. The only coefficients for non-profit firms that are significantly different from zero indicate that cost is lower for firms that receive substantial public subsidies, unlike in the for-profit case, and cost rises with the age of the firm.

Some of the implications of these estimates are shown in Table 4, which presents marginal cost and the elasticity of cost with respect to quality, overall and by state, evaluated at each firm's observed level of quality and averaged over firms. On average, marginal cost is positive and significantly different from zero in for-profit firms, but is close to zero in non-profits. The hypothesis that marginal cost is zero is not rejected overall and in each state for non-profits. The average elasticity of cost with respect to quality is .37 for for-profits, and .01 for non-profits. Figure 1 illustrates how marginal cost varies with the level of quality, based on simulations that set each firm's quality to the same level, holding everything else fixed, with the results averaged across firms. Marginal cost is positive at all levels of quality for for-profits, and rises with the level of quality. Marginal cost is negative at low levels of quality for non-profits, and rises with the level of quality. Marginal cost was either close to zero or negative for non-profits in all of the specifications we estimated.

C. Price Function Estimates

Linear regression estimates of the slope coefficients from the log(average hourly fee) function with zipcode fixed effects are presented in Table 5. The hypothesis that the slope coefficients are the same across states is soundly rejected. The results indicate that Connecticut is the only state in which the market rewards higher-quality care with a significantly higher price, with an elasticity of .31. The price-quality elasticity in the other states is .05-.06. Fees are significantly higher for infants and toddlers in Colorado and Connecticut, but not in California and North Carolina. Table 4 shows the average level of marginal revenue evaluated at the observed level of quality in each center. Marginal revenue is positive but has large standard errors in all states and for both types of firms. Figure 3 shows how marginal revenue varies with quality. Marginal revenue declines with quality but remains positive at all levels of quality (this is an implication of the functional form of the price equation together with a positive coefficient on *ln*Q in the price function). Marginal cost and marginal revenue intersect at a low level of quality for for-profits, suggesting that profit-maximization will be consistent with the data for for-profits, since their observed level of quality is on average low. Marginal cost and marginal revenue do not intersect for non-profits, although the large standard errors on both MC and MR for non-profits suggest that the 95 percent confidence intervals would include many points of intersection.

Interpreting these functions as market price-quality loci, they do not directly reveal anything about preferences or technology, but they are nevertheless quite suggestive. If the marginal cost of producing quality was zero, this could explain why the market price-quality elasticity is so low in three of the four states in our sample. This hypothesis is consistent with the data for non-profits in all four states, and for for-profits in California but not the other states. The alternative explanation is that parents are unwilling to pay more for higher-quality child care, at least when quality is measured by the developmental appropriateness of the care. We have no other source of data with which to check this conjecture, so it must be regarded as provisional. It is however consistent with the findings of Blau and Hagy (1998), who report that the income elasticity of demand for quality-related attributes of child care, including group size, staff-child ratio, and trained providers, is very small.

D. Objective Function Estimates

Table 6 presents estimates of the relative weight on quality in the objective function of firms, along with related parameter estimates. The relative weight on quality is estimated to be zero in all specifications. In order to restrict the parameter to the unit interval, it was specified as a logit, $\alpha = e^{\tau}/(1+e^{\tau})$, with τ as the parameter estimated. In every case, τ was estimated to be a large negative number, often with a very large standard error. When the restriction α=0 was imposed, it was never rejected, and the other parameter estimates were not affected at all. An explicit test of the hypothesis of profit-maximization does not reject it for for-profits, and rejects it at the 10 percent level but not the 5 percent level for non-profits. The point estimate of the upper bound on profit for non-profits is $65 per week, but fewer than two percent of the non-profit firms in the sample are estimated to be constrained by the upper bound.[20]

E. The Supply of Quality

[20]An alternative hypothesis that we examined for the objective function of non-profits is quality-maximization subject to the minimum-profit constraint. We attempted to impose and estimate this specification, but the likelihood function became unbounded: the estimated standard deviation of the lower bound on profit approached zero (as did the mean of the lower bound).

Since price is determined by the firm's choice of quality, we cannot compute a conventional supply function. Instead, we simulate supply behavior by varying the intercept of the supply function (θ), and solving for each firm's profit-maximizing choice of quality for alternative values of θ. We then average over firms (as well as integrating over the estimated heterogeneity distribution). This can be thought of as measuring how a firm would respond to an exogenous change in the intercept of the price-quality relationship in its market. It can also be thought of as the effect of an unconditional (on quality) subsidy per hour of care provided. To provide a price metric that is understandable and can be used to compute a supply elasticity, the value of θ underlying each point in the simulation is converted to a value of P evaluated at the observed average level of quality in the sample.[21]

[21]We argued above that our model is consistent with the quantity of services (K and H) and characteristics of the families served (M) being determined by consumers in response to the price and quality offered by the firm. However, we do not allow K, H, and M to respond to changes in θ in these simulations. We estimated regression models of the functions that determine how K, H, and M respond to price and quality, and found little evidence of any response. We are not confident that these models are well-identified in any case. The simulations should be interpreted with this point in mind.

The simulated quality supply function is shown in the upper panel of Table 7 by state and overall, separately for for-profits and non-profits. The results indicate that the simulated level of quality is quite high compared to the actual levels observed in the data. Quality supply is not monotonic with respect to the intercept of the price function, and is very inelastic.[22] The largest elasticity is .036 for non-profits in Connecticut, and the average price elasticity of supply is very close to zero for for-profits and non-profits. This suggests that it will be difficult to use across-the-board price subsidies to achieve improvements in quality. The levels of the quality supply simulations shown in Table 7 are too high and should not be taken seriously, but the slopes and elasticities are the magnitudes of interest and there is no obvious reason why they would be biased. It is possible to examine the impact of subsidies that are tied to the firm's level of quality, by simulating the effect of altering the slope of the price-quality function, for example. However, a subsidy of this sort is impractical because government agencies cannot readily observe a firm's level of quality.

A wage subsidy might be a more practical alternative to a price subsidy. The middle panel of Table 7 shows the simulated impact on quality of setting wages for the four types of teachers at alternative levels, holding other things constant. The results are again rather discouraging. Higher wages are associated with a higher level of quality supplied by for-profits in each state.[23] A

[22]The lack of monotonicity appears to be due to the form of the price function. An increase in the intercept of the log price function (θ) raises the intercept of the MR function and steepens its slope. For a fixed MC function these have offsetting effects on the profit-maximizing level of quality, and there is no obvious reason why one effect would always dominate the other.

[23]In principle, higher wages should raise MC and reduce the profit-maximizing level of quality. However, the estimated cost function fails to satisfy the properties associated with cost-minimization, so there is no guarantee that higher wages will increase marginal cost in practice.

subsidy that *reduces* the effective wage rate to firms would therefore cause a reduction in the level of quality supplied. Higher wages are associated with a lower level of quality supplied by non-profits on average, but the effect is very small.[24] [25]

An alternative to subsidies that could be considered as a policy to raise quality is to enforce and tighten state regulations. The lower panel of Table 7 presents simulation results for alternative group size regulations. The first line of the lower panel shows the average profit-maximizing level of quality based on the assumption under which the model was estimated, i.e. that regulations are not binding or enforced. The second line show the simulated impact of perfect enforcement of existing regulations in each state. This causes only small increases in quality, which is not surprising in view of the fact that most firms exceed the regulations anyway (see Figure 1). The third line shows the impact of setting the regulations in each state equal to Connecticut's regulations, which are the most stringent of the four states, and enforcing them perfectly. This increases quality by a modest amount in for-profits in California and Colorado, but not at all in non-profits. The last two rows show the effects of tightening the group size

[24]We also simulated changes in the wage rates of each teacher type holding the wages of the other types fixed. The results were similar to those shown in the table but generally smaller in magnitude.

[25]We computed simulations for the non-profits under the assumption of quality-maximization subject to a breakeven constraint (a lower bound on profit of zero). This yielded a quality supply elasticity of .002 with respect to price and .01 with respect to wages.

regulations by two children per group, using the uniform application of Connecticut's regulations (row 3) as a starting point. The effects are moderately large in a couple of cases but small when averaged across states.

6. Conclusions

One of the stated goals of federal child care policy and of many state child care policies is to improve the quality of child care. This paper analyzes the behavior of suppliers of child care and reports results that are not encouraging from a policy perspective. Policies that would be relatively straightforward to implement, such as across-the-board price and wage subsidies and more stringent group size regulations, would have negligible impacts on the average level of child care quality according to the results presented here. Such policies are reasonably straightforward because they do not impose heavy information requirements for implementation and enforcement. Alternative policies that might be more successful would have to be targeted at centers that are willing to maintain a given level of quality or achieve a specified amount of quality improvement, but measuring quality is costly for government monitoring agencies. More easily observed indicators such as group size, staff-child ratio, and the level of staff training are unlikely to be good proxies for the measures of quality that actually matter for child development (Blau, 1997, 1999, in press).

We regard these conclusions as provisional. This is the first paper to analyze the quality supply behavior of day care centers, and we hope that other studies will be conducted to determine how robust our results are. It is somewhat disconcerting that our cost function estimates are inconsistent with the implications of cost-minimization, and it is important to determine if this is a robust finding. It is not without precedent in the cost function literature (for example, see Berndt and Christensen, 1974; Borjas, 1986; and Nadiri and Rosen, 1973, among others). Given this finding, it is perhaps not surprising that the “technology” of quality production appears to differ by the legal status of the firms. This could be another indication that the cost functions we have estimated do not conform to the predictions of economic theory. It is hard to imagine why the technology would differ by legal status if all relevant variables are well-measured.

Our findings on the revenue side are somewhat easier to rationalize and are consistent with results from other studies: most parents appear unwilling to spend significantly more on child care in order to obtain higher quality care. It is not obvious why parents behave this way, but one can speculate that many parents do not know how to distinguish low-quality from high-quality care, or are unaware of the benefits to children of high-quality care. Alternatively, parents may have the goal of making their children happy, which could require substituting expenditures on current child-related consumption for “investment” in high-quality child care.

Our results for the objective function of firms seem reasonable for for-profit firms but are somewhat puzzling for non-profits. We would not have guessed a priori that profit-maximization would be a good characterization of the goal of non-profit child care providers. It is likely that this result is driven by the fact that marginal cost and marginal revenue are both low for non-profits, and we put little stock in it. But we have not been able to find an alternative characterization of the behavior of non-profits that is more plausible.

If child care quality is well-measured by the construct we use here, which we believe is the case; and if child care quality as so measured has beneficial effects on child development, which also seems plausible to us; then current child care policy is most likely ineffective at encouraging improvement in the quality of care provided. An alternative policy would be to “nationalize” the child care industry: i.e., treat child care the way K-12 education is currently treated by providing free or low cost care of reasonably high quality to all children at public expense. This is in fact what most Western European countries already do to a greater or lesser extent. This is a radical idea in the U.S. context, and we do not suggest it here in order to advocate it, but rather to spur discussion. Based on our results, it is hard to imagine other policies that would be able to significantly raise the quality of care in the U.S.

Appendix A

If a given center does not have rooms of a particular type, then we leave out the terms for that room type from the likelihood function. We observe C_j, (but not C_{ij}) D_{ijk}, Q_{ij}, (i=1,2 only; we assume Q_{3j} = average observed center quality), S_{ijk}, g_{ij}, G_{ij}, H_{ij}, R_j, M_{ij}, K_{ij}, and W_{jk}. The log likelihood function for a sample of J centers is (conditioning on R and M is implicit)

$$\ln L = \sum_{j=1}^{J} \ln L_j.$$

$$L_j = \sum_{h=1}^{A} \tau_h L_j(\mu_h).$$

$$L_j(\mu_h) = \Pr(C_j, D_{ijk}, Q_{ij}, S_{ijk}, H_{ij}, G_{ij}, W_{jk}, K_{ij}\ \forall\ i, k \mid \mu_h)$$

$$= \sum_{n1=1}^{B} \sum_{n2=1}^{B} \sum_{n3=1}^{B} \nu_{1n1}\nu_{2n2}\nu_{3n3}\Pr(C_j, D_{ijk}, Q_{ij}, S_{ijk}, H_{ij}, G_{ij}, W_{jk}\ \forall\ i, k \mid \mu_h, \xi_{1n1}, \xi_{2n2}, \xi_{3n3}).$$

$$\Pr(C_j, D_{ijk}, Q_{ij}, S_{ijk}, K_{ij}, H_{ij}, G_{ij}, W_{jk}\ \forall\ i, k \mid \mu_h, \xi_{1n1}, \xi_{2n2}, \xi_{3n3})$$

$$= \Pr(C_j \mid G_{ij}, Q_{ij}, K_{ij}, H_{ij}, W_{jk}\ \forall\ i, k; \mu_h, \xi_{1n1}, \xi_{2n2}, \xi_{3n3})$$

$$*\Pr(S_{ijk}, D_{ijk}\ \forall\ i, k \mid G_{ij}, Q_{ij}, K_{ij}, H_{ij}, W_{jk}\ \forall\ i, k; \mu_h, \xi_{1n1}, \xi_{2n2}, \xi_{3n3})$$

$$*\Pr(G_{ij}, Q_{ij}, K_{ij}, H_{ij}, W_{jk}\ \forall\ i, k \mid \mu_h, \xi_{1n1}, \xi_{2n2}, \xi_{3n3})$$

S_{ijk} and D_{ijk} are jointly determined if the tobit assumption holds; otherwise they are conditionally independent. G_{ij} and C_j are conditionally independent in the case of a non-structural ordered model for G_{ij}, which is the approach we adopt here. The first line after the equality can be written

$$\Pr(C_j \mid G_{ij}, Q_{ij}, K_{ij}, H_{ij}, W_{jk}\ \forall\ i, k; \mu_h, \xi_{1n1}, \xi_{2n2}, \xi_{3n3})$$

$$= \Pr([\Sigma^3_{i=1}\exp\{\ln C_{ij}\}] + \varepsilon_{cj} \mid G_{ij}, Q_{ij}, K_{ij}, H_{ij}, W_{jk}\ \forall\ i, k; \mu_h, \xi_{1n1}, \xi_{2n2}, \xi_{3n3})])$$

$$= \phi(\varepsilon_{Cj}/\sigma_C)/\sigma_C.$$

If we do not make the tobit assumption then we let the parameters determining D_{ijk} be different than those of the S_{ijk} demand equation. This yields for the second line above

$$\Pr(S_{ijk}, D_{ijk}\ \forall\ i, k \mid G_{ij}, Q_{ij}, K_{ij}, H_{ij}, W_{jk}\ \forall\ i, k; \mu_h, \xi_{n1}, \xi_{n2}, \xi_{n3}, \tau_m)$$

$$= \prod_{i=1}^{3} \prod_{k=1}^{T} [\phi(\varepsilon_{Sijk}/\sigma_{Sk})/\sigma_{Nk}]^{Dijk}[\Phi(D^*_{ijk})]^{Dijk}[1-\Phi(D^*_{ijk})]^{1-Dijk}$$

where $D^*_{ijk} = \beta_{Dik} + \Sigma_m\gamma_{Dikm}\mathit{ln}W_{ijm} + \gamma_{DGik}\mathit{ln}G_{ij} + \gamma_{DQik}\mathit{ln}Q_{ij} + \gamma_{DRik}R_j + \gamma_{DMik}M_{ij} + \gamma_{DKik}\mathit{ln}K_{jj} +$

$\gamma_{DHik}\mathit{ln}H_{jj} + \rho_{\mu Dik}\mu_j + \rho_{\xi Dik}\xi_{ij}$

is our parameterization of equation (6). Finally,

$$\Pr(Q_{ij}, G_{ij}, K_{ij}, H_{ij}, W_{jk}\ \forall\ i, k \mid \mu_h, \xi_{n1}, \xi_{n2}, \xi_{n3})$$

$$= \prod_{i=1}^{3} \prod_{k=1}^{T}([\phi(\varepsilon_{Wjk}/\sigma_W)/\sigma_W]^{Dijk})(\Pr(G_{ij}))^{I(Gij>0)}(\Phi(I_{Gij})^{I(Gij>0)}(1-\Phi(I_{Gij}))^{1-I(Gij>0)})$$

$$*[\phi(\varepsilon_{Kij}/\sigma_K)/\sigma_K][\phi(\varepsilon_{Hij}/\sigma_H)/\sigma_H][\prod_{i=1}^{2}\phi(\varepsilon_{Qij}/\sigma_Q)/\sigma_Q]$$

where

$G_{ij} = n$ iff $\kappa_n \geq G^i(W_{j1},..., W_{jT}, H_{ij}, Q_{ij}, R_j, M_{ij}, G_{ij}, K_{ij}, \mu_j, \xi_{ij}, \varepsilon_{Gij}) > \kappa_{n-1}$, $n=1,...,G^{max}$

$I(G_{ij}>0) = 1$ if $G_{ij}>0$ and $I(G_{ij}>0) = 0$ if $G_{ij}=0$; and

$\Pr(G_{ij}) = 1/(1 + \exp\{G^i\})$ if $G_{ij} = 1$

$\Pr(G_{ij}) = [\exp\{G^i + \kappa_{n-1}\}/(1 + \exp\{G^i + \kappa_{n-1}\})] - [\exp\{G^i + \kappa_n\}/(1 + \exp\{G^i + \kappa_n\})]$

if $G_{ij} = n$, $n=2,...,G^{max} - 1$

$\Pr(G_{ij}) = [\exp\{G^i + \kappa_{Gmax-1}\}/(1 + \exp\{G^i + \kappa_{Gmax-1}\})]$ if $G_{ij} = G^{max}$

where G^i is the function defined in equation (12) in the text.

Appendix B

The ECERS items are listed below. The ITERS items are similar, although not always identical. See Harms and Clifford (1980, 1990) for details.

Greeting/Departing
Meals/Snacks
Nap/Rest
Diapering/Toileting
Understanding Language
Using Language
Reasoning
Informal Language
Supervision - Fine Motor
Supervision - Gross Motor
Music/Movement Activities
Schedule of Creative Activities
Free Play

Furnishing for learning
Furnishing for Relaxation
Room Arrangement
Fine Motor Activities
Art Activities
Block Activities
Sand and Water Activities
Dramatic Play
Space to be Alone
Cultural Awareness Activities
Group Time
Tone of Interactions

Examples of instructions to raters include the following.

Item	Inadequate 1	2	Minimal 3	4	5	Good 6	Excellent 7
Understanding Language	Few materials present and little use of materials to help children understand language (e.g. no scheduled daily story time).		Some materials present, but not regularly available or used for language development.		Many materials available for free choice and supervised use. At least one planned activity daily.		Everything in 5 plus teacher provides good language model throughout the day (e.g. gives clear directions, uses words exactly in descriptions).
Art Activities	Few art materials available; regimented use of materials (e.g. mostly teacher-directed).		Some materials available for free choice but major emphasis on projects that are like an example shown.		Individual expression and free choice encouraged with art materials. Few projects that are like an example shown.		Variety of materials available for free choice. Attempt to relate art activities to other experiences.

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Table 1: Room-Level Descriptive Statistics

	Infant-Toddler	Preschool	Kind.-School
Use any teaching staff with			
Educ<12	.19	.14	.13
Educ=12	.88	.75	.60
Educ=13-15	.76	.80	.75
Educ=16+	.64	.76	.69
Staff Hours per week per room (if >0)			
Educ<12	13.6 (10.5)	10.3 (10.2)	10.7 (7.4)
Educ=12	46.1 (28.6)	29.7 (24.2)	24.4 (20.5)
Educ=13-15	35.7 (24.4)	31.0 (24.5)	29.5 (22.8)
Educ=16+	27.8 (23.9)	33.7 (31.7)	39.5 (31.2)
Staff Cost Share (if >0)			
Educ<12	.018 (.021)	.016 (.018)	.018 (.019)
Educ=12	.071 (.060)	.053 (.053)	.040 (.040)
Educ=13-15	.054 (.047)	.063 (.071)	.047 (.042)
Educ=16+	.053 (.054)	.089 (.115)	.079 (.071)
No. of children enrolled (if >0)	22.4 (14.5)	41.8 (32.7)	26.9 (20.5)
Hours per day per FT child	8.8 (1.0)	8.7 (1.1)	4.9 (1.6)
Number of groups	2.3 (1.2)	2.8 (1.9)	1.6 (0.8)
Enrolled Group Size	9.9 (3.7)	15.8 (7.8)	17.0 (9.2)
Observed group Size	8.1 (3.2)	15.1 (6.1)	
Quality	3.4 (1.0)	4.3 (1.0)	
Family Characteristics			
Annual Income ($000)	54.6 (19.4)	53.3 (26.8)	
Married	.77 (.26)	.68 (.28)	
At least one parent att. college	.49 (.30)	.42 (.29)	

No. of centers with any rooms	226	363	210
Number of rooms observed	155	474	

Table 2: Descriptive Statistics on Center-Level Variables

	All	For-profit	Non-profit
Total Weekly Cost	5,533 (3765)	5672 (3530)	5394 (3991)
Total Full Time Equivalent (FTE) Enrollment	69.8 (47.6)	78.1 (52.6)	61.5 (40.5)
Average Weekly Cost per FTE Child	88.7 (40.8)	82.9 (38.1)	94.5 (42.6)
Average Center Quality	4.0 (0.8)	3.8 (0.8)	4.2 (0.8)
California	4.3 (0.8)	4.1 (0.7)	4.4 (0.8)
Colorado	3.9 (0.7)	3.8 (0.6)	4.0 (0.8)
Connecticut	4.3 (0.8)	4.3 (0.8)	4.4 (0.8)
North Carolina	3.6 (0.9)	3.2 (0.7)	4.0 (0.8)
Total Cost/Quality	1413 (946)	1513 (942)	1313 (942)
Average Cost per Child/Quality	22.3 (9.6)	21.7 (8.8)	23.0 (10.4)
Average Teaching Staff Compensation/hour			
Educ<12	7.39 (3.13)	6.86 (2.01)	7.91 (3.71)
Educ=12	7.94 (3.65)	7.30 (2.37)	8.58 (4.37)
Educ=13-15	8.88 (4.53)	8.19 (3.64)	9.57 (4.83)
Educ=16+	10.81 (5.79)	9.46 (4.46)	12.16 (6.38)
For-profit	.50 (.50)	1.00 (0)	0 (0)
Percent of Children White	67 (32)	75 (24)	59 (34)
Meets higher standards (pubregul)	.07 (.25)	0	.14 (.34)
>50% of revenue from subsidies (pubsub)	.12 (.32)	.04 (.19)	.19 (.40)
Church-sponsored	.19 (.40)	0	.39 (.49)
National Chain	.13 (.33)	.25 (.44)	0
Center Age (years)	13.3 (12.3)	10.6 (8.3)	16.1 (14.6)
Local Unemployment rate, 1992	7.0 (2.1)	6.7 (1.8)	7.3 (2.3)

Zip code dummies from:			
Z_1: log fee equation	.18 (.28)	.20 (.24)	.15 (.31)
Z_2: part-day extended care equation	.05 (.41)	.14 (.41)	-.04 (.40)
Z_3: bilingual program equation	-.12 (.28)	-.13 (.26)	-.11 (.29)
Z_4: percent of white staff equation	.05 (.32)	.10 (.31)	.00 (.32)
Average Hourly Fee	2.06 (.84)	2.16 (.73)	1.97 (.94)
Number of Centers	370	185	185

Table 3: Selected Cost Function Parameter Estimates

	For-profit		Non-profit	
	No heterogeneity	Heterogeneity	No Heterogeneity	Heterogeneity
LnQ	-1.72 (.78)*	-1.40 (.55)**	.65 (.59)	.69 (.58)
LnQ*lnG	.20 (.25)	-39 (.19)**	-.38 (.32)	-.42 (.31)
LnQ*lnK	-.28 (.21)	.31 (.15)**	.35 (.29)	.40 (.28)
LnQ*CO	.50 (.34)	.69 (.26)**		
LnQ*CT	.14 (.29)	.23 (.24)		
LnQ*NC	.36 (.37)	.77 (.27)**		
LnQ*White	1.11 (.31)**	.96 (.23)**		
LnQ*Pubsub	.76 (.35)**	.56 (.26)**	-.49 (.23)**	-.52 (.23)**
LnQ*Chain	-.51 (.19)**	-.70 (.14)**		
LnQ*Years in operation	.48 (1.19)	.61 (.85)	1.54 (.61)**	1.54 (.64)**
LnQ*Parents College	.72 (.33)**	-.23 (.27)		
LnQ*Parent Income	.47 (.63)	2.22 (.51)**		
LnQ*Parents Married	-.68 (.43)	-.36 (.33)**		
LnQ*IT room	.31 (.50)	.92 (.40)**		
LnQ*PS room	.54 (.56)	.27 (.43)**		
Ln L	-684.8	-519.9	-906.4	-716.6
No. of parameters	233	243	180	190

Notes: See Appendix Table C-1 for the other parameter estimates from the models with heterogeneity. * and ** indicate significantly different from zero at the 10 percent and five percent levels, respectively.

Table 4
Estimates of Marginal Cost, Marginal Revenue, and Elasticity of Cost with Respect to Quality

	For-profit	Non-profit
All		
Marginal Cost	481 (115)	31 (160)
Marginal Revenue	301 (251)	270 (202)
Elasticity of Cost wrt Quality	.37 (.06)	.01 (.11)
California		
Marginal Cost	223 (315)	106 (185)
Marginal Revenue	356 (767)	215 (458)
Elasticity of Cost wrt Quality	.22 (.16)	.05 (.11)
Colorado		
Marginal Cost	499 (187)	-19 (154)
Marginal Revenue	201 (466)	219 (524)
Elasticity of Cost wrt Quality	.39 (.13)	.004 (.11)
Connecticut		
Marginal Cost	677 (147)	50 (186)
Marginal Revenue	537 (391)	570 (427)
Elasticity of Cost wrt Quality	.55 (.11)	-.03 (.13)
North Carolina		
Marginal Cost	549 (242)	-8 (184)
Marginal Revenue	127 (194)	104 (158)
Elasticity of Cost wrt Quality	.34 (.10)	.01 (.11)

Notes: Standard errors (in parentheses) are derived by taking 1,000 random draws from the joint distribution of all the parameters, computing the variable of interest (e.g. average marginal cost), and using the standard deviation of the resulting distribution.

Table 5
Linear Regression Estimates of the Ln(Average Hourly Fee) Model

	Ln(Quality)	Proportion infant-toddler services	Adjusted R^2	No. of zipcodes	No. of observations
California	.06 (.21)	.25 (.20)	.38	71	99
Colorado	.05 (.20)	.45 (.12)**	.14	56	100
Connecticut	.31 (.16)*	.42 (.13)**	.34	54	99
North Carolina	.06 (.11)	.11 (.14)	.05	45	98
All	.16 (.08)**	.37 (.07)**	.60	226	396

Notes: Each model included zipcode dummies in addition to the variables shown in the table. Test-statistic for the hypothesis that the slope coefficients are the same in each state is 6.03 ~ $F(6, 159)$. The hypothesis is rejected at the 1 percent level of significance.

Table 6
Maximum Likelihood Estimates of Parameters of the Firm Objective Function and Constraints

	For-Profit		Non-Profit		
	Uncon-strained	Assuming profit-max.	Uncon-strained	α=0	Assuming profit-max.
τ	-34.5 (405,882)		-10.42 (4.83)**		
Relative weight on quality, $\alpha = e^{\tau}/(1+e^{\tau})$	0	0	0	0	0
Ln(SD of measurement error/1000)	-1.20 (.07)**	-1.20 (.01)**	-1.32 (.05)**	-1.32 (.0002)**	-1.33 (.05)**
Implied SD of measurement error	301	301	267	267	264
Upper Bound on Profit			65 (50)	65 (1)	64 (63)
Ln(SD of Upper Bound/1000)			-2.07 (.47)**	-2.07 (.07)**	-2.07 (.43)**
Implied SD of Upper Bound			126	126	126
Lower Bound on Profit			-50 (49)	-50 (56)	
Ln(SD of Lower Bound/1000)			-2.14 (.50)**	-2.14 (.05)**	
Implied SD of Lower Bound			118	118	
Percent of Firms at the upper bound			1.6%	1.6	1.6%
Percent of firms at the lower bound			10.3%	10.3	0
Ln Likelihood	-40.1	-40.1	-10.42	-10.42	-13.88

Table 7: Simulated Supply of Quality

	For-profit					Non-profit				
Price	All	CA	CO	CT	NC	All	CA	CO	CT	NC
1.00	6.11	6.08	6.83	5.30	6.16	6.75	6.74	6.92	6.59	6.74
1.13	6.29	6.49	6.65	5.56	6.40	6.86	6.83	6.91	7	6.71
1.28	5.82	5.75	6.41	5.22	5.86	6.81	6.89	6.84	6.69	6.79
1.45	6.08	6.07	6.82	5.21	6.15	6.80	6.82	6.73	6.86	6.77
1.63	6.17	6.16	6.80	5.40	5.24	6.81	6.86	6.90	6.86	6.65
1.85	6.23	6.50	6.68	5.22	6.42	6.71	6.78	6.74	6.61	6.71
2.09	6.19	6.50	6.69	5.05	6.43	6.88	6.90	6.84	7	6.78
2.36	6.13	6.14	6.83	5.28	6.21	6.83	6.82	6.74	6.87	6.88
2.66	6.21	6.40	6.76	5.23	6.34	6.86	6.93	6.84	7	6.67
3.01	6.16	6.17	6.79	5.38	6.23	6.78	6.73	6.89	6.86	6.66
Elas.	.007	.013	-.005	.013	.010	.004	-.001	-.005	.036	-.011
Wage Simulations										
11	6.02	5.77	6.85	5.08	6.32	6.59	6.58	6.77	6.39	6.59
13	5.63	5.75	6.22	4.79	5.70	6.84	6.68	6.96	6.70	6.99
15	5.35	6.21	5.33	4.84	4.95	6.85	6.74	6.94	6.75	6.96
17	5.79	6.12	5.40	5.81	5.82	6.82	6.72	6.93	6.75	6.89
19	6.45	6.02	6.38	6.72	6.72	6.77	6.57	6.91	6.70	6.90
21	6.71	6.00	6.94	6.98	6.96	6.74	6.58	6.83	6.71	6.85
23	6.72	5.93	7	7	7	6.72	6.65	6.77	6.68	6.76
25	6.60	5.47	7	7	7	6.60	6.49	6.64	6.62	6.63
27	6.76	6.06	7	7	7	6.69	6.73	6.68	6.62	6.71
29	6.87	6.52	7	7	7	6.65	6.74	6.64	6.60	6.63
Elas.	.18	.16	.10	.32	.16	-.006	.028	-.037	.01	-.023
Regulations										
1	6.16	6.17	6.79	5.38	6.23	6.64	6.65	6.87	6.61	6.43
2	6.23	6.32	6.73	5.59	6.22	6.64	6.57	6.87	6.61	6.51
3	6.27	6.32	6.82	5.66	6.22	6.63	6.57	6.89	6.62	6.47
4	6.39	6.47	6.92	5.85	6.27	6.68	6.80	6.92	6.47	6.50

5	6.50	6.53	6.81	5.94	6.67	6.65	6.80	6.95	6.35	6.48

Notes to Table 7: The ECERS/ITERS quality scale has a minimum value of 1 and a maximum of 7. These bounds were imposed when solving for the optimal level of quality. The wage simulations vary the wages of all four teacher types jointly. The wage rates shown in the table are for college graduates. The wages of college attendees in the simulations are $2 less than for college graduates, and so forth for the other groups. The elasticities are the average arc elasticities from one simulated value to the next, averaged over the simulations. See the text for interpretation of the regulation simulations.

Appendix C

Table C-1
Additional Coefficient Estimates from the Cost Function and Auxiliary Equations

Interactions between teacher wages and other variables

	For-Profit Firms				Non-Profit Firms			
	Ln(W(1))	Ln(W(2))	Ln(W(3))	Ln(W(4))	Ln(W(1))	Ln(W(2))	Ln(W(3))	Ln(W(4))
Intercept	1.8413	5.2716	3.7573	-0.0364	-1.0322	3.8715	-0.4472	-0.5395
	(2.0760)	(3.0494)	(3.0274)	(1.6482)	(1.6185)	(1.5685)	(1.6270)	(1.0804)
Ln(K)	-1.0450	-0.1913	0.7402	-0.0233	-0.2143	0.9481	-0.6151	-.0282
	(0.3312)	(0.3422)	(0.2637)	(0.1872)	(.4869)	(.4118)	(.4825)	(.3332)
Ln(H)	2.6870	2.2561	0.4472	-2.8164	-1.5163	0.7750	-0.2206	-0.3388
	(1.1765)	(1.1322)	(1.3202)	(0.7671)	(1.3983)	(1.3225)	(1.2850)	(.9632)
Ln(G)	0.5287	-0.3431	0.8302	-0.5877	0.1663	-1.0904	0.5689	0.1724
	(0.4258)	(0.3836)	(0.3439)	(0.2947)	(.5271)	(.4478)	(.4668)	(.3064)
Ln(W(1))	-2.8278	1.3025	-2.6518	1.2120	-0.5886	0.8227	-1.0723	0.8443
	(2.7791)	(1.3801)	(1.1349)	(1.0035)	(2.2233)	(1.4189)	(1.1675)	(0.8155)
Ln(W(2))	1.3025	-3.1635	1.1496	0.5108	0.8227	-2.0946	0.9718	-0.3229
	(1.3801)	(1.2358)	(0.7375)	(0.5767)	(1.4189)	(1.0828)	(1.0543)	(.7523)
Ln(W(3))	-2.6518	1.1496	1.8648	-1.1961	-1.0723	0.9718	-.4695	0.2737
	(1.1349)	(0.7375)	(0.7115)	(0.7046)	(1.1675)	(1.0543)	(0.9069)	(.7453)
Ln(W(4))	1.2120	0.5108	-1.1961	-0.6444	0.8443	-0.3229	0.2737	-0.5548
	(1.0035)	(0.5767)	(0.7046)	(0.3398)	(0.8155)	(.7523)	(.7453)	(.5456)
CO	-5.1725	2.2371	-0.1852	-0.1742				
	(0.7145)	(0.5554)	(0.5735)	(0.3185)				
CT	-3.2908	0.8423	0.9796	-0.2537				
	(0.4848)	(0.3474)	(0.3497)	(0.2847)				
NC	-4.0581	1.1093	0.2095	-0.7724				
	(0.7606)	(0.5049)	(0.5643)	(0.2802)				
White	2.2718	-1.8318	-0.7025	0.4708				
	(0.6907)	(0.5333)	(0.4214)	(0.3656)				
Pubsub	-8.2292	3.7210	-3.8506	1.6496				
	(2.1535)	(1.1336)	(0.6836)	(0.5334)				
Chain	1.7431	-0.8943	-0.8812	0.3971				
	(0.3762)	(0.3362)	(0.2842)	(0.1937)				
Center age	2.2741	-2.2499	0.3482	0.6726				
	(1.9614)	(1.1472)	(1.2278)	(0.9117)				
College	1.1144	2.5492	-1.3113	-1.7999				
	(0.7027)	(0.7048)	(0.5698)	(0.3840)				
Income	-1.7484	1.2190	-0.4554	-0.0812				
	(1.0643)	(1.0018)	(0.9711)	(0.3173)				
Married	4.1504	-6.2773	0.2636	1.3783				
	(0.9654)	(0.8849)	(0.6792)	(0.4787)				
IT Room	-0.4107	-1.6851	0.2504	-0.3888				
	(2.0677)	(1.2875)	(1.3749)	(0.7709)				
PS Room	0.8685	-0.4891	-1.8394	-0.2507				
	(2.1869)	(1.1881)	(1.2392)	(0.6648)				

Main effects

	For-Profit		Non-Profit	
CO	4.7916	(1.1970)	-0.0223	(.0834)
CT	3.0622	(0.7737)	0.1869	(.1002)
NC	5.1718	(1.2377)	-0.0738	(.0759)
White	-1.5896	(0.6052)	-.04723	(.0783)
Pubregul			0.1825	(.0754)
Pubsub	10.5015	(3.5952)	0.7267	(.3255)
Church			-0.1424	(.0534)
Chain	0.4297	(0.3314)		
Center age	-2.5645	(1.7325)	-2.0370	(.9390)
College	-0.1036	(0.7013)	-0.0385	(.1044)
Income	-0.9516	(1.0368)	0.1953	(.1357)
Married	1.4292	(0.7321)	0.0168	(.1125)
IT Room	4.4409	(1.5363)	0.1684	(.2369)
PS Room	4.0452	(1.7652)	0.0592	(.2324)
Intercept	-3.9137	(2.7581)	5.1307	(1.1706)

Ln(K)	1.4065 (0.4007)	-0.0767 (.4657)
$(Ln(K))^2$	0.0949 (0.0372)	0.0156 (.0623)
Ln(H)	-6.0153 (1.3240)	1.8667 (1.0995)
$(Ln(H))^2$	-0.6916 (0.2165)	-2.8395 (.8693)
Ln(K)*Ln(H)	-0.6076 (0.2544)	
Ln(K)*Ln(G)	-0.0225 (0.0606)	
Ln(H)*Ln(G)	0.4907 (0.2948)	
Ln(G)	-0.2193 (0.4963)	0.9356 (.5674)
$(Ln(G))^2$		1.0953 (.0681)
σ_c	0.0897 (0.0619)	.2275 (.0570)

Ordered logit coefficients

INTERCEPT	13.5573 (2.9780)	6.2024 (2.2292)
Ln(K)	3.9097 (0.2664)	5.1341 (.3586)
Ln(H)	-0.7645 (0.6650)	1.9554 (.7636)
Ln(W(1))	-0.6280 (1.1120)	-.3099 (.9597)
Ln(W(2))	-2.0658 (0.9324)	0.1784 (1.0048)
Ln(W(3))	-0.9459 (0.8111)	-.1102 (.8645)
Ln(W(4))	-0.1658 (0.5018)	.9433 (.7131)
CO	-2.4363 (0.6757)	.0769 (.4516)
CT	-0.3402 (0.4741)	.2360 (.6198)
NC	-1.7929 (0.6176)	-.7040 (.4321)
White	0.5496 (0.6362)	.4665 (.5277)
Pubregul		-.1114 (.4528)
Pubsub	-0.3922 (0.7613)	-.0046 (.4489)
Church		1.1576 (.3057)
Chain	-0.2962 (0.2774)	
Center age	0.4445 (1.0229)	-1.0213 (.9281)
College	0.3079 (0.4609)	.1740 (.6020)
Income	-1.2362 (0.7859)	.1416 (.8283)
Married	0.9394 (0.6166)	-.3701 (.6584)
IT Room	3.6100 (0.5663)	1.8273 (.5806)
PS Room	2.1015 (0.5259)	.0423 (.5229)
RHO	2.2489 (0.6078)	-5.9921 (3.7996)

CUTOFFS (κ's)

1	10.3900 (0.0748)	3.0468 (.0840)
2	8.1554 (0.1010)	0.9164 (.1173)
3	6.8225 (0.1848)	-.6858 (.1802)
4	5.7909 (0.2596)	-1.3969 (.3445)
5	4.4753 (0.3742)	-1.8279 (.5117)
6	3.3007 (0.7441)	-2.5318 (.4395)
7	3.3007 (1.0303)	-3.4681 (.4793)
8	3.3007 (1.0303)	-4.1423 (.9769)
9	2.5088 (0.9913)	-4.6345 (.9983)
10	2.5088 (1.0298)	-5.5098 (.9985)

Auxiliary Equations

	For-profit					Non-profit				
	Ln(W)	G>0	Ln(Q)	Ln(K)	Ln(H)	Ln(W)	G>0	Ln(Q)	Ln(K)	Ln(H)
Intercept	2.440	-1.843	1.283	-0.957	-0.732	2.126	-1.506	1.546	-1.883	-.825
	(0.053)	(0.958)	(0.114)	(0.000)	(0.000)	(.067)	(.874)	(.086)	(.000)	(.000)
College	0.036	0.071	0.157	0.142	0.022	.066	.476	.118	-.186	.002
	(0.023)	(0.732)	(0.052)	(0.145)	(0.034)	(.043)	(.556)	(.058)	(.156)	(.045)
Income	0.078	-0.330	-0.004	-0.142	0.019	-.002	-.526	.182	.363	-.025
	(0.034)	(0.781)	(0.070)	(0.206)	(0.050)	(.068)	(.817)	(.080)	(.237)	(.069)
Married	-0.077	0.041	0.066	-0.045	0.035	.101	.384	-.032	.253	.073
	(0.029)	(0.857)	(0.061)	(0.164)	(0.039)	(.051)	(.612)	(.060)	(.167)	(.048)
IT	-0.023	0.286	-0.194	-0.109	0.651	-.028	.164	-.189	-.011	.592
	(0.013)	(0.307)	(0.031)	(0.084)	(0.021)	(.024)	(.234)	(.036)	(.097)	(.025)
PS	-0.016	3.590		0.408	0.631	-.002	4.515		.514	.583
	(0.012)	(0.556)		(0.077)	(0.020)	(.020)	(.587)		(.082)	(.021)
CO	-0.460	2.052	-0.103	-0.394	0.037	-.263	.696	-.073	.107	.087
	(0.030)	(0.563)	(0.058)	(0.163)	(0.040)	(.036)	(.486)	(.050)	(.138)	(.037)
CT	-0.152	1.573	-0.059	-0.880	-0.019	.263	.705	-.069	-.187	.019
	(0.029)	(0.528)	(0.053)	(0.150)	(0.038)	(.041)	(.553)	(.054)	(.152)	(.041)

NC	-0.394	2.372	-0.313	-0.212	-0.052	-.085	.735	-.024	.292	-.056
	(0.029)	(0.638)	(0.053)	(0.150)	(0.036)	(.037)	(.451)	(.047)	(.126)	(.034)
White	-0.024	0.950	0.046	-0.156	-0.036	-.058	.696	-.122	-.154	.017
	(0.033)	(0.805)	(0.066)	(0.187)	(0.045)	(.040)	(.527)	(.054)	(.141)	(.039)
Pubregul						.138	-.364	.128	.343	-.008
						(.034)	(.394)	(.046)	(.115)	(.031)
Pubsub	-0.371	1.003	-0.208	-0.560	-0.050	-.109	.443	-.125	-.323	-.004
	(0.039)	(0.985)	(0.084)	(0.196)	(0.046)	(.029)	(.368)	(.043)	(.106)	(.028)
Church						-.121	-.027	-.123	-.082	.029
						(.022)	(.269)	(.031)	(.076)	(.020)
Chain	0.021	2.362	0.115	0.180	0.047					
	(0.015)	(0.579)	(0.032)	(0.081)	(0.020)					
Cen. age	0.050	-0.893	-0.312	-0.550	-0.118	.267	.973	.126	1.060	.066
	(0.087)	(1.013)	(0.164)	(0.470)	(0.116)	(.058)	(.944)	(.087)	(.225)	(.065)
Z(1)	0.088	-1.693	0.003	0.416	-0.112	.312	-1.197	.057	-.320	-.164
	(0.038)	(0.880)	(0.077)	(0.208)	(0.053)	(.042)	(.659)	(.063)	(.165)	(.045)
Z(2)	-0.010	0.069	0.006	-0.015	-0.001	.011	.017	-.006	-.004	.001
	(0.004)	(0.097)	(0.009)	(0.025)	(0.006)	(.005)	(.071)	(.008)	(.019)	(.005)
Z(3)	0.030	1.026	0.050	0.029	0.015	-.087	.400	-.038	.106	-.012
	(0.023)	(0.492)	(0.039)	(0.114)	(0.028)	(.027)	(.328)	(.039)	(.095)	(.026)
Z(4)	0.002	-0.455	-0.077	0.080	-0.034	.138	.256	-.001	-.055	-.025
	(0.027)	(0.766)	(0.055)	(0.147)	(0.036)	(.038)	(.470)	(.051)	(.135)	(.038)
Z(5)	0.069	-0.114	0.119	0.116	-0.057	.057	-.465	.154	.203	.014
	(0.033)	(0.799)	(0.060)	(0.165)	(0.040)	(.038)	(.509)	(.056)	(.144)	(.040)
RHO	0.507	-0.652	0.154	0.095	0.045	2.436	-3.170	.816	1.227	-.209
	(0.037)	(0.386)	(0.040)	(0.097)	(0.030)	(1.011)	(1.552)	(.371)	(.541)	(.129)
SIGMA	0.169		0.213	0.653	0.180	.205		.200	.574	.166
	(0.022)		(0.043)	(0.033)	(0.033)	(.025)		(.045)	(.037)	(.037)

Heterogeneity Coefficients: For-profit

	A_h	π_h	B_h	μ_h
MASS POINT 1	1.1501	0.4268	0.0000	-0.4536
	(0.2657)			
MASS POINT 2	1.1761	0.4381	-0.2213	-0.0500
	(0.2631)		(0.0838)	
MASS POINT 3	0.0000	0.1351	1.0000	0.4536

Scale 0.907 (.064)

Heterogeneity Coefficients: Non-profit

MASS POINT 1	0.2900	.2621	.0000	-.1447
	(.2444)			
MASS POINT 2	1.0162	.5418	-.1740	-.0126
	(.2224)		(.0980)	
MASS POINT 3	.0000	.1961	1.0000	.1447

Scale 0.289 (0.122)

Note: $\pi_h = \exp\{A_h\}/\Sigma_i \exp\{A_i\}$. $\mu_h = Scale*(\exp\{B_h\}/(1+\exp\{B_i\}) - .5)$