Household Choices and Child Development: Gender Roles and Outcomes

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Abstract

The growth in labor market participation and attachment among women with young children has raised concerns about the potential negative impact of the mother's absence from home on child outcomes. Recent data show that mother's time with children's has in fact declined in the last decade, while the indicators of children cognitive and non cognitive outcomes have worsened. The goal of our research is to estimate a model of the cognitive development process of children as an outcome of a production technology nested within a reasonably standard model of life cycle behavior, in which parents face partially endogenous constraint sets that evolve over time. The model is able to capture a number of possible feedbacks between the child quality and employment processes in the household, which we hope will be able to shed some light on dynamic relationships observed in the raw data and the possible impacts of labor market shocks on the welfare of children.

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1 Introduction

Economic theory does not predict clear effects regarding the impact of maternal employment on the welfare of children. While family income is necessary to provide for the sustainability of the household, there are opportunity costs associated with time supplied to the labor market beyond the lost leisure of the parents. As discussed below, numerous studies have demonstrated a positive relationship between time spent with their parents and the quality of a child's outcomes, measured on any of several dimensions. This tradeoff can be viewed quite simply if we think of the household as an enterprise with a complicated set of preferences, outputs, and constraints. From a societal perspective, perhaps the most important output of the household is the number and "quality" of children it produces. On the quality dimension, it is helpful to think of there being a production technology, in which some initial endowment of child quality, given at birth say, is augmented over time by inputs of time contributed by parents, siblings, other relatives, paid child-care workers, teachers, etc., and various types of goods purchased as inputs to the development process, such as private schooling, toys, books, sporting goods, etc. Given the household's objectives, its mode of decision-making, and the constraints it is confronted with over tiime, the household makes a sequence of time allocation, consumption, and investment decisions at each stage of the child development process. Forgetting about the possibility of borrowing and saving for the moment, the more income the household has at a point in time, the more can be spent on child investment goods. Holding other inputs fixed, including initial endowments, which improves child outcomes. By the same token, decreasing time with the child, holding other inputs fixed, leads to worse child quality outcomes. How does the household properly balance these trade-offs?

It is useful to compare and contrast the situation that prevails in the standard profit-maximizing firm. In this case, firm behavior is decomposed into a (1) cost-minimization problem, which yields a function that provides the minimum cost required to produce any level of output, and (2) a profit-maximization problem in which the cost function is considered predetermined. The solution of these two sequential problems yields the profit-maximizing output quantity and the demand for the factors of production. This is all reasonably straightforward.

In the case of child quality, we face a number of additional challenges, some of them nicely detailed by Todd and Wolpin (2004). The production process is truly dynamic in the case of child quality, with input decisions from years past influencing current investment choices and child quality levels. Unlike the case of the firm, whose objective is to choose output levels so as to maximize profits, the objectives of the parents are not defined only with respect to the quality, or the quantity, of their children. Their utility levels also are determined by their leisure, their consumption of adult private goods, and public goods that affect the welfare of all members of the household. In other words, their sole objective is not to maximize child quality given the resources available to them.

The preferences of profit-maximizing firms are defined strictly in terms of profit levels, and not as a function of their level of factor utilization. The same assumption is most probably not reasonable when applied to child quality production. Parental time with the child, which augments child quality outcomes, may also be yield positive (or negative) utility to the parent supplying the time to the child. This is like a problem of joint production, in which the household can be viewed as producing a number of 'goods' simultaneously, the welfare of each adult member and the quality of the child. Inputs into these various production processes often have a 'public' feature, in that the same input may impact the output levels of several of the household outputs simultaneously. This means that if we look at the child quality investment process in isolation, we may obtain a very misleading impression of the productivity of the observed inputs in the child quality production process. For example, the fact that a mother spends a great deal of her time with her child may indicate that her time inputs are extremely valuable in augmenting child quality, but such an observation would also be consistent with a state of the world in which the mother gained a large amount of satisfaction interacting with her child, even if the direct impact of her interaction on the quality level of the child was minimal.

Our focus is on the estimation of child outcome technologies, or production functions, that include as arguments a relatively large number of (observable) factors, and functions characterizing the dynamic evolution of the budget constraint of the household. Given the arguments we have just presented, we feel that it is necessary to model the household decision-making process in a relatively complete way if we are to uncover the characteristics of the child quality production technology. Our model utilizes a reasonably standard model of life cycle behavior, in which parents face partially endogenous constraint sets that evolve over time.The PSID-CDS gives us a vast amount of useful information, but only at one or two points in time. The keys to being able to use such limited (in a dynamic sense) information to estimate a growth model are (1) assuming time-invariance of the functions and processes describing the households' objectives and constraints and (2) the use of simulation-based estimation techniques that allow us to "fill in" the huge numbers of gaps we face in our data on the development process at the household level.

Our estimates allow us to consider impact of changes in the time inputs of mothers and fathers on the child development process. Of course, both of these processes are endogenous within the model, so that any changes in the relationship between them must be produced by changes in the wage processes, and prices of the consumption and investment goods. The model is able to capture a number of possible feedbacks between the child quality and employment processes in the household, which we hope will be able to shed some light on dynamic relationships observed in the raw data and the possible impacts of labor market shocks on the welfare of children.

There exists a large empirical literature on the relationship between household characteristics, parental employment patterns, and child outcomes, and in Section 2 we provide a brief survey. Section 3 contains a simple example that is meant to illustrate the workings of the more complex model we take to the data without all of the added generality required for that task. In Section 4 we present the model, and Section 5 discusses estimation issues and the data utilized. We also present descriptive empirical analyses in this section. Section 6 contains the model estimates, as well as a few relevant policy simulations. Section 7 concludes.

2 Parental Time Inputs and Child Outcomes

A large number of studies have assessed the effect of parental time on children's cognitive development. Most studies have used parents' employment as a proxy for time with the children. These studies report evidence that, while the loss of parental time with the children has a negative effect on the child's well-being (e.g. socio-emotional adjustment and cognitive outcomes), it is also the case that the additional labor income has positive implications for expenditures on goods consumed by the child (Brooks-Gunn, Han and Waldfoge 2001, Ermisch and Francesconi 2005, Bernal 2008). It remains mostly unclear however which effect prevails, since the existing literature provides conflicting conclusions. There is wide variation in reported empirical estimates, even for studies based on the same data set. Estimates range from parental employment being detrimental (Baydar and Brooks-Gunn,1991; Desai et. al., 1989), to its having no effect (Blau and Grossberg, 1992) to its being beneficial (Vandell and Ramanan, 1992). Reasons for the diversity of these results may include the wide range of specifications that are estimated, as well as the common limitation of failing to control for potential biases that may arise due to the endogeneity of parental time as well as on the type of inputs considered.

Most studies limit their attention to mother's inputs. The literature on the effects of maternal time on child cognitive outcomes is extensive. Some studies focused on the timing of the process showing that there are deleterious effects associated with employment during children's first year but that the influence of maternal employment after the first year is more ambigous (Baydar and Brooks-Gunn, 1991; Harvey, 1991; Brooks-Gunn, Han and Waldfogel, 2002; Ruhm, 2004).

Many studies also demonstrate that the influence of maternal employment differs by the economic and demographic characteristics of mothers and families, suggesting that maternal employment may be more harmful for children from advantaged backgrounds—children from wealthier families, non-Hispanic white children and children from intact families. Desai, Chase-Lansdale and Michael (1989) find that maternal employment only negatively influences children from higher income families but not children from middle or low income families (1989), while Waldfogel, Han and Brooks-Gunn f(2002) find a persistent negative effect mother's employment on cognitive tests for non-Hispanic white children but not for African American or Hispanic children.

Very few studies insofar have used direct measures of parents-child time to examine the relationship between parental investments and children's cognitive development. time Time diary data show suggest that women entry into the labor force is associated with behavioral changes in time use that make employment status a poor proxy for maternal involvement. Booth et al (2002) analyze time diaries administered to mothers from the NICHD Study of Early Child Care and find that the amount of time mothers spend with their young children is not significantly correlated with measures of cognitive skills. Huston and Aronson (2005) find that mother involvement even relates negatively to children language skills. Their studies however limit their analyses to the first two years of life and do not take into account children's initial endowments. More recently Hsin (2008) using Child Development Supplement of the PSID investigates the effect of maternal involvement during pre-school years on children's cognitive outcomes controlling for characteristics of children that may bias estimates of maternal time. For example, children may also differ in their initial endowments such as innate cognitive ability, health and physical development. Mothers may respond to observed difficulties faced by children by spending more time with children with learning. She finds a positive and persistent effect of the time mothers spend with children on children's language development, but only among children who spend time with verbally skilled mothers.

However while mother's time is a crucial input in the production process of children outcomes, father's time may be equally productive especially in some stages in children life and that has increased overtime partly off-setting the decline in mother's time (Gauthier, Smeeding and Furstember, 2004)..Studies considering father's time show that fathers care for infants is no better or worse than other types of arrangements (Averett et al (2005) and the amount of time a father spends with children is affected by the gender composition (Lundberg et al 2006, Mammen 2005) but that there is a long term benefit of paternal involvement on children achievement and behavior (Yeung, Hill and Duncan,1999, Haveman and Wolfe 1995).

Other reasons for the diversity of the results are methodological and are associated with the model specification. Bernal (2008) estimates a dynamic model of mothers' choices to control for potential biases that may arise as a result of the fact that women that work/use child care may be systematically different from women who do not work/do not use child care and the child's cognitive ability itself may influence the mother's decisions. Todd and Wolpin (2003), estimate a production function that is consistent with theoretical notions that child development is a cumulative process depending on the history of family and school inputs and on heritable endowments.Their estimating framework allows for unobserved endowment effects, potentially endogenous input choices, and for the cumulative effects of children investments. Their results show that both contemporaneous and lagged inputs matter in the production of current achievement and that it is important to allow for unobserved child-specific endowment effects and endogeneity of inputs.

Recent surveys (Heckman and Masterov, 2007) have shown that children's cognitive and noncognitive outcomes are largely determined early in life. Inputs applied by families as well as other environmental factors, during the early childhood years and culminating in adolescence in the form of "crystallized" cognitive abilities, attitudes, and social skills play a very important role. Cunha and Heckman (2007) analyse children cognitive and non cognitive outcomes in a model of skill formation They estimate a dynamic factor model to solve the problem of endogeneity of inputs and multiplicity of inputs relative to instruments. They find that early environments play a large role in shaping later outcomes. and children cognitive and non-cognitive outcomes are largely determined early in life; moreover, the benefits of early investments appear to be greater than their costs relatively to investments in later childhood stages

3 A Simple Example

In order to illustrate the workings of the model, we present a very stylized example in which there are three periods, in only two of them does the household actually face a decision. There is no uncertainty, and utility functions have a simple form. We assume that in each of three periods, parents have utility defined over their consumption and child quality. Household income is known in advance in all periods, y_1, y_2, and y_3. In each of the first two periods, parents make a decision of how much of their income in period t, y_t, $t = 1, 2$, to devote to investments in the child. The investment expenditures in period t are denoted i_t. Households are not allowed to save or borrow, so that in period t, $y_t = c_t + i_t$. When defining the value of the parents' decision problem, in period 3 we only consider the utility value associated with the child's final "quality state," k_3, which is a function of the child's initial quality endowment and the investments made in her during periods 1 and 2. We write the value of the parents' problem as of the onset of period 1 as

$$\begin{aligned} V_1(y_1, y_2, k_1) &= \max_{i_1, i_2} \ln(y_1 - i_1) + \gamma_1 k_1 \\ &\quad + \beta(\ln(y_2 - i_2) + \gamma_2 k_2(k_1, i_1)) \\ &\quad + \beta^2 \gamma_3 k_3(k_2, i_2), \end{aligned}$$

where k_t is child quality in stage t, $\beta \in (0, 1]$ is the discount factor, and γ_t is the preference weight on child quality in stage t.

Parents choose one level of monetary investment in each of the first two periods of child development. The production technology is given by

$$k_{t+1} = k_t^{\varphi_t} i_t^{1-\varphi_t}, \ t = 1, 2.$$

The child's quality endowment in period 1, k_1, is an initial condition of the child quality process. We note that

$$\begin{aligned} k_2 &= k_1^{\varphi_1} i_1^{1-\varphi_1} \\ k_3 &= k_2^{\varphi_2} i_2^{1-\varphi_2} \\ \Rightarrow k_3 &= (k_1^{\varphi_1} i_1^{1-\varphi_1})^{\varphi_2} i_2^{1-\varphi_2} \\ &= k_1^{\varphi_1 \varphi_2} i_1^{(1-\varphi_1)\varphi_2} i_2^{1-\varphi_2} \end{aligned}$$

The final (period 3) child quality can be written as another constant returns to scale Cobb-Douglas production function, where the inputs are the child's endowment and first and second period investment.There are a few points to note about the relationship between the parental valuation of child quality and the returns to investment at various stages in the child development process:

1. If parents only value the final child quality level, so that

$$\gamma_1 = \gamma_2 = 0 \text{ and } \gamma_3 = 1 \text{ (say)},$$

   the discount factor is set to 1 in all periods, and parental income is constant in the first two periods ($\bar{y} = y_1 = y_2$), then the parents' problem becomes

$$V_1 = \max_{i_1, i_2} \ln(\bar{y} - i_1) + \ln(\bar{y} - i_2) + k_3(k_1, i_1, i_2).$$

   In this case, the opportunity cost of investment is the same in all periods, which implies that

$$i_1^* > i_2^*$$

   if and only if

$$2 - \varphi_1 > \varphi_2$$

2. If we continue to assume no discounting and constant income in all periods, but allow for parents to derive utility from their child's quality level in all periods, the picture changes. Now the value of the problem is

$$V_1 = \max_{i_1, i_2} \ln(\bar{y} - i_1) + \gamma_1 k_1 + \ln(\bar{y} - i_2) + \gamma_2 k_2(k_1, i_1) + \gamma_3 k_3(k_1, i_1, i_2). \quad (1)$$

   Since we have added a component to parental utility that is only a function of period 1 investment, it is clear that the amount of investment in the first period in this case will exceed the amount of investment in the first specification, given the same production parameters (this statement relies on there not being corner solutions in either specification).

3. Parents often have lower levels of income when their children are young than when they are older. For most households, then, it makes sense to assume that $y_1 < y_2$. In this case, due to higher costs of investment in terms of foregone consumption in early years, parents may invest

comparatively less in their children even when early investments are more productive than later ones. This effect would be mitigated or eliminated if we allowed lending and borrowing against certain income, but there is some evidence, however controversial, that the ability to borrow for the purpose of human capital investment is limited.

Thus, there are a number of factors at work producing differential child quality investment by age, even in this highly-stylized, deterministic model. The first-order effects are due to the nature of the child quality production function itself. In our case, we have assumed a production function that allows investments at different points in time to be substituted for one another in a fairly flexible manner. Of course, if we assumed a linear production technology, substitutability in investment would have been unlimited, while a fixed coefficients production technology would have made the case for the necessity of early investment stronger.

Second, the age-income profile of the parents matters to child investment, especially when capital markets are "perfectly imperfect," as they are in this example. This effect may be especially pronounced when parents have more than one child, though we have no explicitly considered this eventuality in our example.

Third, the preferences of the parents may matter greatly in the age-pattern of investment. While not as potentially measurable as income processes or production technologies, the manner in which parents relate to and value child quality as the child works through various development phases may have a large impact on the pattern of investment. For example, a father who enjoys participating in organized sports activities with his son or daughter may spend a large proportion of his time with the child during this period of the child's life, while spending less time with the child during periods when the child's and parent's interests diverge.

We have conducted a small numerical example to illustrate the impact of certain changes in the investment environment on investment levels and child outcomes, and the results are presented in the accompanying table. In the baseline environment, we set $y_1 = y_2 = 200$. The "law of motion" for child quality has $\varphi_1 = \varphi_2 = 0.5$. The weights on child quality in parental preferences, γ_t, are set to 0.1 in all three periods, and the initial child quality endowment, k_1, is set to 50. The discount factor, β, is set to 0.8.

Baseline Values:
$y_1 = 200$, $y_2 = 200$, $\gamma_1 = \gamma_2 = \gamma_3 = 0.1$,
$\beta = 0.8$, $\phi_1 = \phi_2 = 0.5$, $k_1 = 50$

Changes from Baseline	i_1	i_2	k_1	k_2	k_3
-	170.014	166.413	50	92.199	123.867
$k_1 = 60$	172.041	167.861	60	101.600	130.593
$\gamma_1 = \gamma_2 = 0$	129.585	164.284	50	80.494	114.995
$\phi_2 = 0.7$	171.723	143.433	50	92.662	105.639
$\phi_2 = 0.7$, $y_1 = y_2 = 100$	79.658	59.855	50	63.110	62.115
$\phi_2 = 0.7$, $y_1 = 50$, $y_2 = 150$	37.191	83.715	50	43.123	52.618
$\phi_2 = 0.7$, $y_1 = 100$, $y_2 = 300$	82.145	205.743	50	64.088	90.937
$\phi_2 = 0.7$, $y_1 = 300$, $y_2 = 100$	261.478	70.346	50	114.341	98.836

At the baseline values, investment is slightly greater in period 1 than in period 2, and their is strong growth in child quality over the three periods, culminating in a value of 123.867. In the second row of the table, we look at the response to an increase in the endowment of 10 quality points. The increase in the endowment makes further investment have a higher rate of return, which is reflected in the small increases in the investment levels in each of the first two periods. Coupled with the higher endowment, this generates substantial increases in child quality in all periods. This gives us some indication that this simple model may be capable of generating investment behavior that exacerbates initial differences in child ability.

In the third line, we change the baseline so that parents only value ultimate (period 3) child quality. This results in a large drop in period 1 investment, with period 2 investment roughly the same as in the baseline. There is a precipitous drop in quality at all ages.

We next change the baseline to reflect a decreasing impact of parental investment in child quality. Keeping $\varphi_1 = 0.5$, we set $\varphi_2 = 0.7$ (so that the coefficient associated with i_2 drops to 0.3. In this case, we see a slight increase in period 1 investment and a dramatic decrease in period 2 investment. In period 3, there is a large decline in child quality.

The next line of the table keeps the production structure, but decreases parental income to 100 in each period. This leads to over a 50 percent decline in investment compared to the line above it, and large decreases in child quality at all ages. The following line keeps the production structure as is, but reallocates parental income so the $y_1 = 50$ and $y_2 = 150$. The income shift results in much more dramatic declines in investment in child quality. This line, and the following two lines of the table, indicate how the "misalignment" of investment incentives and available income by age can worsen child quality outcomes. We see this as a particular problem for very young children, where public investment is minimal. In periods where money and time investments in the child may have the highest returns, parental resources are often severely lacking.

4 Model

This section develops the model that is the basis of our empirical estimation. We extend the simple model analyzed above in several dimensions by allowing for i) multiple parental inputs into child development, including mother's and father's time and child specific goods expenditures, ii) a more general production technology where the marginal productivity of parental time, child goods, and previous child quality varies as the child ages, iii) distinct labor supply choices for mother's and fathers, iv) distinct household preferences for parental leisure, consumption, and child quality, iv) heterogeneity in the child's initial human capital, and v) a wage process where the evolution of future wage offers are uncertain.

4.1 Timing and Preferences

The household makes decisions in each period of a child's life, where the child's age is indexed by t. For simplicity, we assume that the family has only one child. Parents make investments in child quality from the first period of the child's life $t = 1$ to period $t = T$. At this "terminal" point (from the perspective of the parents' investment in the child), the child has reached adulthood and adult outcomes depend (in part) on the level of child quality obtained at this point.

In each period, the household makes five choices: hours of work for each parent h_{1t} (mother) and h_{2t} (father), time spent in child care for each parent τ_{1t} (mother) and τ_{2t} (father), and expenditures on "child" goods e_t. Flow utility for the household is a function of each parent's hours of leisure, l_{1t} for the mother and l_{2t} for the father, joint private consumption of the parents c_t, and the level of their child's quality k_t. We assume a Cobb-Douglas form for preferences and restrict the preference parameters to be stable over time:

$$u(l_{1t}, l_{2t}, c_t, k_t) = l_{1t}^{\alpha_1} l_{2t}^{\alpha_2} c_t^{\alpha_3} k_t^{1-\alpha_1-\alpha_2-\alpha_3}$$

4.2 Child Quality Production

Next period child quality is produced by the current level of child quality k_t, parental time and expenditures. We assume a Cobb-Douglas form for the child quality technology:

$$k_{t+1} = k_t^{\delta_t} \tau_{1t}^{\zeta_{it}} \tau_{2t}^{\zeta_{2t}} e_t^{\zeta_{3t}}$$

While the Cobb-Douglas form restricts the substitution possibilities, we allow the productivities of the various inputs to vary over the age of the chld. This allows us to capture the important insights in the economics and child development literatures that the marginal productivity of inputs varies over the stages of child devlopment. Note that we assume that the evolution of child quality is deterministic. An extension of the model is to assume there are stochastic shocks to child quality production, though given the data available to us, the assumption that the process is deterministic is not overly restrictive.

Below we discuss the mapping between the child quality that enters the household utility function and observable measures of child quality available in specific data. In general, there may be one or more measures of k_t available to researchers, which measure k_t with some error.

4.3 Wage Offers

Conceptually it is straightforward to allow for time-varying wage offers to both parents, but we found very limited evidence of large year-to-year movements in wage rates in our sample. Partially this is a consequence of our solution method, in which we first discretize the distribution of wages to construct a small number of wage "states." To speed up the solution to the dynamic programming problem, we restricted the wage state space to be small, meaning that each wage state contains a fairly large interval of wage observations. Given the size of the interval, it is not surprising to find low transition rates between wage states over a relatively small portion of the life cycle. As a result, we are treating the wages of mothers and fathers as fixed over the child investment period, so that

$$w_{jt} = w_{j1},\ t = 2, ..., T;\ j = 1, 2.$$

4.4 Dynamic Program

Given wage offers and the current level of child quality, parents optimally choose their labor supply and child inputs to maximize expected lifetime discounted utility. The value function for the household at period t is then

$$V_t(S_t) = \max_{h_{1t},\tau_{1t},h_{2t},\tau_{2t},e_t} u(l_{1t}, l_{2t}, c_t, k_t) + \beta V_{t+1}(S_{t+1}).$$

where the vector of state variables S_t consist of the current level of child quality k_t and the (fixed) wage offers: $S_t = [k_t, w_{11}, w_{21}]$. $\beta \in [0, 1]$ is the discount rate. By assuming no child quality shocks and constant wages, we assume the child quality process is deterministic. While this assumption obviously is problematic, by allowing heterogeneity in primitive parameters, such as the child quality production function, we can produce stochastic outcomes from the distribution of primitive parameters.

The constraints on the maximization problem consist of a time constraint for each parent and a budget constraint for the household. Given a time endowment of TT hours for each parent, each parent $j = 1, 2$ faces the following time constraint

$$TT = l_{jt} + h_{jt} + \tau_{jt}$$

With no borrowing, saving, or non-labor income, the household budget constraint equates total labor income with parental consumption and child expenditures:

$$c_t + e_t = w_{1t}h_{1t} + w_{2t}h_{2t}.$$

4.5 Terminal Value

Parent's investments in child quality are limited to the first T period's of the child's life. At the terminal point, $t = T$, the continuation value is given by $V_{T+1}(S_{T+1}) = V_{T+1}(k_{T+1})$, which represents the value of the child's quality to herself as she begins her own adult life. We parameterize this terminal value as $V_{T+1}(k_{T+1}) = \frac{\psi k_{T+1}}{1-\beta}$. We think of k_{T+1} are representing an initial condition for the child's lifetime maximization problem. While we do not employ an explicit overlapping generations framework, the k_{T+1} would be expected to be related to the wages the child will receive as an adult, their education level, etc., all variables which are included in our analysis of the parents problem. The factor $(1 - \beta)^{-1}$ is included to scale the child quality into something similar to a present value, and the ψ is to be treated as a free parameter, which can be estimated subject to restrictions on the child quality production function.

4.6 Initial Conditions

The remaining element necessary to close the model is a specification of the initial conditions at the time of the birth of the child. Initial conditions consist of initial child quality and wages for the parents: $S_1 = [k_1, w_{11}, w_{21}]$. We treat these initial conditions as unobserved but with a distribution that depends on observed household characteristics, including mother's and father's age and mother's and father's education. Initial wage offers are defined as the wage offers the parents receive at time $t = 1$, which is the period at the birth of the child. Parents could be of many different ages at the birth of this child.

5 Estimation

The family data we have available consist of a sample households with observed characteristics X and includes children interviewed at various ages indexed by t. The observed household characteristics include parental variables, such as education and ages of parents at the birth of the child, and child variables such as birth weight. We observe for each mother and father in the household, hours worked, hours spent with children, expenditures on children and a measure of child quality for a sample of child's ages, indexed t: $[h_{1t}, \tau_{1t}, h_{2t}, \tau_{2t}, k_t]$. We also have four test score measures for each child at the age they are interviewed: $y_{1t}, \ldots, y_{4t}$. In addition to this data, we also have data on an overlapping sample of adults that provides information on the timing of the births of their children, if any, and longitudinal data on labor supply and wages for those who worked.

5.1 Empirical Specification

Periods are in years and the assumed planning horizon is age 14, $T = 14$. Parents may continue to make child investments after this point but we do not explicitly model these investments and rely on our terminal period specification to capture the utility value of these investments. The discount rate for the household is fixed at $\beta = 0.95$.

The joint wage offer distribution is assumed to be discrete with support $w_{1t}^{J_1}, \ldots, w_{1t}^{J_1}$ for mother's wage offers and $w_{2t}^{J_2}, \ldots, w_{2t}^{J_2}$ for father's wage offers. As mentioned above, we assume that wage offers are time invariant in our current specification of the model. The probability masses for the inital wage distribution is given by $pr(w_{11} = w_1^{j_1}, w_{21} = w_2^{j_2}|X)$. Allowing for dependence between mother's and father's wages is meant to capture assortive marriage patterns on wages. We estimate initial wages conditional on observed household characteristics X using a multinomial logit model.

The log of initial child quality is assumed to be given by

$$\ln k_1 = X'\beta_{k_1} + \phi$$

where $\phi \sim N(0, \sigma^2_{k_1})$. The ϕ component is unobservable. Hence, initial child quality is assumed to have some unobservable dimensions.

For our initial estimation we assume child quality is measured without error by a particular test score in our PSID data. Extensions to include measurement error and multiple measures of child quality are discussed below.

5.2 Model Simulation

Denote the full set of model parameters θ. We use the following algorithm to generate simulated data given θ and the vector of household characteristics X.

1. Given an observed (X, t) and θ, we draw initial conditions $S_1 = [w_{11}, w_{21}, k_1]$ from the distribution of unobserved initial child quality and the estimated distribution of initial wage offers. Note that the initial conditions distribution depends only on household characteristics X, not on the age at which the child is interviewed t.

2. Given the t and S_1 draw, generate data for this household type. Generating a simulated observation consists of solving the model forward from the initial conditions S_1 to the age of the child t.

Repeating Steps 1-2 R times yields a data set with R total observations for each sample household. A sample household is essential a vector X from the point of view of the simulations.

5.3 Estimation

We use the method of simulated moments to form an estimator of the parameters θ. The moments we use include average child quality at each child age, average hours of work for mothers and fathers at each age, and average child care hours for mothers and fathers at each age. We also match regression parameter estimates from several "reduced form" regressions of log child quality on previous child quality, parental time, and parental education (Tables 3-5).

6 Data

We utilize data from the Panel Study of Income Dynamics (PSID) and its two waves of Child Development Supplements (CDS-I e CD-II)). The PSID is a longitudinal study that began in 1968 with a nationally representative sample of about 5,000 American families, with an oversample of black, low-income families. In 1997, the PSID began collecting data on a random sample of the PSID families that have children under the age of 13 in a Child Development Supplement (CDS-I). Data were collected for up to two children per family. The CDS collects information on child development and family dynamics, including parent-child relationships, home environment, indicators of children's health, cognitive achievements, social-emotional development and time use, among other variables. The entire CDS sample size in 1997 is approximately 3,500 children residing in 2,400 households. A follow-up study with these children and families was conducted in 2002 and 2003 (CDS-II). These children were between the ages of 8-18 in 2003. No new children were added to the study.

An important addition in CDS-II is a set of detailed questions about childhood consumption.These questions concern the amount of money the family and others outside of the family unit pay for various aspects of consumption for the target child over the past 12 months. These items include tuition, tutoring programs, lessons and sports. There are also a set of questions concerning the expenditures the family or others outside the family unit make for all the children within the household. These includes toys or presents, vacation, school supplies, food and clothes or shoes. There is also information on health care, childcare and related care expenses.

Starting in 1997, children's time diaries were collected along with detailed assessments of children's cognitive development. Children's cognitive skills are conceived broadly to include language skills, literacy and problem-solving skills and are measured with the Woodcock Johnson Achievement Test-Revised (Woodcock and Johnson 1989). Children under the age of 6 received only Letter-Word Identification and Applied Problem subscales. Children aged 6 and above received Letter-Word and Passage Comprehension subtests as well as Applied Problems and Calculation subtests in 1997. However, in 2002, the Calculation subsets were not administered to the children. All children received also the memory for Digit Span test to assess child's short term memory. All test measures are reported either as raw scores or age standardized with a mean of 100. We will use the three test available for children of all ages in both waves: the letter-word, the applied problem and the digit span test.

7 Empirical Results

We are interested in households in which both biological parents were present in both waves (976 households). Most of the variables we use in the model are collected from the primary caregiver of a child and for the head and wife of the household. Therefore, our sample consists of children who (1) have valid test scores in either wave of the Child Development Supplements, (2) have the mother as the primary caregiver of the target child (95% of the entire CDS sample) and (3) are sons or daughters of the head of the household.(93.8 percent of the original CDS sample). Table 1 reports descriptive statistics of our selected sample.

Table 1: **Descriptive statistics**

	1997		**2002**	
Variable	**Mean**	**(Std. Dev.)**	**Mean**	**(Std. Dev.)**
Child's age			12.446	(2.848)
Father's age			42.653	(6.266)
Mother's age			40.278	(5.565)
Father's education			13.291	(2.762)
Mother's education			13.328	(2.597)
Children Expenditures			67.661	(54.875)
Targeted child expenditures			29.204	(147.258)
Father time (alone)	5.629	(8.555)	4.245	(7.259)
Mother time (alone)	22.332	(16.976)	13.019	(12.647)
Parents time with the child together	21.112	(13.213)	20.328	(16.666)
Applied problem raw score	25.812	(11.309)	40.176	(6.850)
Letter_ word raw score	29.294	(16.37)	47.157	(6.305)
Digit raw score	11.271	(5.145)	16.156	(4.311)

Parents average age is 42 for fathers and 40 for mothers while the years of schooling are quite similar. Children total expenditures are quite small about 68$ and the expenditures for the target child are 29.2$. Father'time is 5.6 hours a week and in 1997 and 4.2 in 2002. Mothers time is about four times as much in 1997 and three times as much in 2002. The parents' time together is did not change much between the two years. All the test scores increase between 1997 and 2002. Figure 1-2 show the pattern of mothers and fathers time with the child. Mother' s time is greater than father's and declines with the age the child, while fathers' time does not change with child age and child's gender. Figure 3 and 4 show parents' hours of work.

Fathers hours of work are higher than mothers' during the period.

Table 2 reports estimates of the impacts of parental time on the child test scores. We include mother's and fathers time spent alone with the child as well as the time they spend together with the child, the previous test score (1997) and the expenditures on the children.(I specification). To take into account parents' characteristics we add In the second specification, yan interaction term between parents' time and their schooling (a dummy variable indicating whether the schooling years were greater than 16).

The results of column 1, 3, 5 reports the coefficients of the first specification. The coefficient of the previous test score is always statistically significant capturing also previous parental investments. Parental time impact is not always statistically different from zero and vary across test scores. Mother's time is more statistically significant than father's time for Letter Word as well as for Applied Problem. Father's time is never significant except for Digit score

The test scores Letter word and Applied Problem appear to be more sensitive to parental time and expenditure than Digit. For the third test score Digit, the past score appears to be the most important determinant while parental time as well as expenditures are less important,which is consistent with the nature of the test (more based on memorization). Expenditures for children are statistically significant and positive for the letter word score and the applied problem score but not for the digit score.

In the second specification we include also parental education We include a dummy variables for education greater than 16 years of completed schooling.and interact the mother and father educational dummies with time with the child. When including parental education, fathers' education remains not significant, while mother's time becomes significant only for Digit. The coefficient of time together remains positive and significant for letter word. The interaction between mother time and education is positive and significant for all test scores while the interaction between father time and education is not.

Table 2: Log test scores regression (OLS) All children

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Letter-word		Applied problem		Digit	
k_{t-1}	.124***	.120***	.158***	.147***	.242***	.232***
	(.018)	(.0184)	(.013)	(0.014)	(.009)	(.009)
Child's age	-.006	-.004	.003	.005	-.007	-.005
	(.004)	(.004)	(.005)	(.004)	(.004)	(.004)
τ_f	.003	.006	.004	.005	.003*	-.011
	(.005)	(.030)	(.003)	(.003)	(.001)	(.010)
τ_m	.004*	.001	.004*	.006	0.01	-.013*
	(002)	(.003)	(.002)	(.004)	(.004)	(.002)
τ	.008**	.008**	.008*	.007	.001	-.002*
	(.001)	(.003)	(.004)	(.004)	(.001)	(.001)
e	.002***	.002**	.005**	.004**	.003	.002
	(001)	(.0001)	(.0001)	(.001)	(.002)	(.002)
$\tau_f * s_f$		.004		.020		.029
		(.004)		(.013)		(.023)
$\tau_m * s_m$		.014**		.031**		.021**
		(.003)		(.006)		(.003)
Constant	3.495***	3.0732***	3.068***	3.111***	2.345***	2.408***
	(0.0596)	(0.0557)	(0.0852)	(0.0933)	(0.0934)	(0.100)
Observations	760	760	760	760	760	760
R^2	0.398	0.428	0.209	0.227	0.212	0.233

Table 3 and 4 report the coefficients for boys and girls separately.Table 3 reports that in the first specification, mother's time coefficients are never significant while father time is significant for applied problem and digit score.Time together is always positive and significant except for digit. Expenditures are always significant

In the second specification (Column 2, 4, 6) the coefficients do not change much and father's time, parental time together and expenditures remain positive and significant except for digit. Mother's time is negative fro Digit. Also for boys, the impact of the interaction of mother's time with education is always positive and significant.for all test scores The impact of father's time interacted with education is significant only for Applied problem.

Table 3: Log test scores regression (OLS) boys

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Letter-word		Applied problem		Digit	
k_{t-1}	.118*	.111**	.185***	.172***	.209***	.201***
	(.028)	(.020)	(.016)	(.015)	(.022)	(.009)
Child's age	-.007	-.005	.-004*	-.005	-.007	-.006
	(.007)	(.008)	(.001)	(.006)	(.008)	(.004)
τ_f	.001	.002	.003*	.014*	.004*	-.001
	(.003)	(.008)	(.001)	(.003)	(.002)	(.003)
τ_m	.003	.004	.001	-.009	.008	-.017*
	(005)	(.006)	(.004)	(.005)	(.010)	(.008)
τ	.008**	.007*	.011*	.009*	.003	.005
	(.001)	(.002)	(.005)	(.003)	(.014)	(.003)
e	.003*	.002**	.005**	.003***	.006*	.004
	(001)	(.0001)	(.001)	(.001)	(.003)	(.003)
$\tau_f *s_f$		.002		.025*		.012
		(.005)		(.010)		(.008)
$\tau_m * s_m$		.019**		.029**		.022**
		(.002)		(.005)		(.005)
Constant	3.495***	3.0732***	3.068***	3.111***	2.345***	2.408***
	(0.0596)	(0.0557)	(0.0852)	(0.0933)	(0.0934)	(0.100)
Observations	355	355	355	357	355	357
R^2	0.398	0.428	0.537	0.227	0.212	0.233

Table 4 reports the estimates for girls. In the first specification both mother's and father's time are significant only for applied problem while time together is significant only for Letter Word. Expenditure are always positive and significant. In the second specification only father time for Applied problem remains significant while the interaction between father's time and high education is significant only for letter word and mother's interaction term is significant for all test scores as for boys.

Table 4: Log test scores regression (OLS) Girls

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Letter-word		Applied problem		Digit	
k_{t-1}	.129**	.127***	.128*	.117*	.292**	.283***
	(.010)	(.010)	(.050)	(0.048)	(.032)	(.043)
Child's age	-.005**	-.004**	.011	.013	-.009*	-.009*
	(.002)	(.001)	(.011)	(.014)	(.003)	(.004)
τ_f	.009	.006	.006*	.002*	.003	-.023
	(.008)	(.008)	(.003)	(.001)	(.004)	(.019)
τ_m	.007	.007	.008**	.002	.001	-.009
	(005)	(.006)	(.001)	(.0018)	(.021)	(.019)
τ	.008**	.008**	.005	.004	.002	-.002
	(.001)	(.002)	(.004)	(.004)	(.004)	(.004)
e	.002*	.002*	.004*	.004*	.002*	.002
	(001)	(.0001)	(.001)	(.001)	(.001)	(.001)
$\tau_f * s_f$		.004*		.006		.048
		(.002)		(.012)		(.044)
$\tau_m * s_m$		.011**		.033**		.022**
		(.002)		(.004)		(.008)
Constant	3.495***	3.0732***	3.068***	3.111***	2.345***	2.408***
	(0.0596)	(0.0557)	(0.0852)	(0.0933)	(0.0934)	(0.100)
Observations	405	405	405	405	405	405
R^2	0.453	0.428	0.209	0.209	0.212	0.249

These results are coherent with some of the previous results presented above (Lundberg 2005)

Overall, we can say that time together appears to be an important predictor of children test scores, while mother and father time has a greater variability across scores and specifications. The impact of mother's and father's time are quite coherent with gender roles' differences. Father's time appears to be more important for boys, and for applied problem. Mother's time is on average more significant across specifications. More educated mothers's time has a significant and positive impact across gender and scores (Hsin 2008).

8 Further Empirical Work

While these regression results are interesting when taken at face value, and are somewhat similar to those obtained from previous empirical analyses of child quality production, our model suggests that they be interpreted with caution. As is well-known from the production function estimation literature, production function parameter estimates are generally biased and inconsistent when account is not taken of the endogeneity of input utilization levels. Our dynamic model produces dynamic factor utilization functions that can be used in "solving" this simultaneity problem under the assumed structure of the model.

As mentioned briefly above, an key interest of ours is in examining the extent of the simultaneity problem in the OLS estimates of the production function that are reported above. In creating a list of sample characteristics to fit in order to identify the underlying behavior parameters characterizing preferences, the production technology, and the initial condition distributions of (initial) child quality and spousal wages, we will include some of the OLS regression function estimates in Tables 3-5 in addition to more standard univariate and bivariate relationships from the data (e.g., mean child quality level by age, standard deviation of child quality by age, correlation of spousal wages for working spouses, etc.). This gives the structural estimation exercise an "Indirect Inference" flavour, where the OLS regression functions are viewed as the auxilliary functions in defining the estimator. In this way, we establish a more or less direct mapping between the OLS regression parameter estimates and the underlying primitive parameters (and exogenous distributions of family characteristics) that generate them. We expect to find significant differences between the OLS estimates of the production function parameter estimates and those generated from the MSM estimator, and we are currently in the process of estimating the model.

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Appendix: Model Solution

The following describes the model solution by backwards recursion.

Step 1: Calculate the expectation of the value function at period T. The state variables entering period T are $S_{T-1} = [k_{T-1}, w_{1,T-1}, w_{2,T-1}]$. We first form a grid over the child quality state variables.

The solution to the period T optimization problem then consists of two parts: i) Given a point on child quality grid (a k_{T-1}), and a point in the discrete distribution of mother's and father's wages (a $w_{1,T}$ and $w_{2,T}$ pair), we draw R η_T draws from log normal distribution. ii) For each η_T draw, η_{Tr}, we calculate the maximized value of utility $u_T^*(k_{T-1}, w_{1,T}, w_{2,T}, \eta_{Tr})$:

$$u_T^*(k_{T-1}, w_{1,T}, w_{2,T}, \eta_{Tr}) = \max_{h_{1T}, \tau_{1T}, h_{2T}, \tau_{2T}, e_T} u(l_{1T}, l_{2T}, c_T, k_T) + \beta EV(T+1, S_T)$$

s.t. [constraints from above]

where $V(T+1, S_T) = \frac{k_T^{\phi}}{1-\beta}$ by assumption of the finite horizon,

$$k_T = k_{T-1}^{\delta_T} \tau_{1T}^{\gamma_{1T}} \tau_{2T}^{\gamma_{2T}} e_T^{\gamma_{3T}} \eta_{Tr}$$

Note that k_{T-1} is the value from the child quality grid.

We can then calculate the expectation of the value function at each k_{T-1} grid point as

$$EV(T, S_{T-1}) = \frac{1}{R} \sum_{r=1}^{R} \sum_{j_1, j_2} q_{j_1, j_2} u_T^*(k_{T-1}, w_{1,T}, w_{2,T}, \eta_{Tr})$$

Step 2: We then move backward to period $T-1$. The state variables entering this period are $S_{T-2} = [k_{T-2}, w_{1,T-2}, w_{2,T-2}]$. We repeat as above using the calculation of the expectation of the value function from Step 1.

Given that the value function was evaluated for only a grid of points on the continuous k_{T-1} child quality distribution, we approximate the solution to $EV(T-1, S_{T-1})$ using the following interpolation method. We estimate a linear regression of $EV(T-1, S_{T-1})$ on a linear function of grid points K_{T-1} at each $w_{1,T-2}, w_{2,T-2}$ point. The interpolated values are then

$$\tilde{E}V(T-1, S_{T-1}) = \hat{\varphi}_0 + \hat{\varphi}_1 k_{T-1}$$

where $\hat{\varphi}_0$ are the OLS estimates $\hat{\varphi}_1$.