Maternal Time, Child Care and Child Cognitive Development: The Case of Single Mothers

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Abstract

This paper evaluates the effects of home inputs on children's cognitive development using the sample of single mothers in the National Longitudinal Survey of Youth (NLSY). Of course, an important selection problem arises when trying to assess the impact of maternal time and income on children's development. To deal with this, we take advantage of (plausibly) exogenous variation in employment and child care choices of single mothers generated by the differences in welfare regulations across states and over time. This approach is motivated by the fact that the Welfare Reform of 1996, as well as earlier State level changes adopted under Section 1115 Welfare Waivers, generated substantial increases in work and child care use. Thus, we construct a comprehensive set of welfare policy variables at the individual and State level, and use them as instrumental variables in order to estimate child cognitive ability production functions.

The results indicate that the effect of child care use is negative, significant and rather sizeable. In particular an additional year of child care use is associated with a reduction of 2.8% in test scores. However, this general finding masks important differences across types of child care and across child age ranges. Formal child care (i.e., pre-school, formal center based care) does not have any adverse effect on cognitive outcomes, nor does formal or informal care in the first year. Only non-formal types of child care lead to significant reductions in child's achievement, in particular, if used after the first year after childbirth. Finally, the effect of household income since the birth of the child is statistically insignificant, given controls for mother's education. This is consistent with a view that permanent income is significant in determining children's achievement while transitory income is not.

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1. Introduction

The effect of parental time inputs and child care (as well as child care quality) on children's development has been widely analyzed, especially in the psychology and sociology literature. Economists have also realized the importance of this question. For many years we have been trying to understand the determinants of individuals' labor market performance, in particular, wages. In spite of the vast research in this area, there is still a large component of wages that we have not been able to explain. Furthermore, recent studies[2] have concluded that once people reach a certain age, around 16-18 years old, most of what determines their later labor market performance has already been determined. In other words, a set of unobserved (to the researcher) characteristics that determine a significant portion of wages, educational attainment or other career outcomes are already present by age 16. These unobserved characteristics have often been called the individual's "cognitive ability" or "skill endowment". But their determinants remain largely a black box.

Extensive research has shown that children's early achievements are strong predictors of a variety of outcomes later in life: the high achievers are more likely to have higher educational attainment and higher earnings; and less likely to have out-of-wedlock births, be on welfare or participate in crime. For this reason, the issue of what determines ability of individuals at early stages of life is critical for the design of public policy aimed at improving labor market outcomes. However, the question of what determines children's cognitive achievement remains unresolved.[3]

A major challenge to estimating the determinants of achievement is that the data available are often deficient. For example, data on inherited ability is often unavailable, which creates problems of endogeneity and self-selection that are difficult to address. In fact, the main reason for the diversity of results in previous literature may well be the common limitation of failing to control for potential biases that may arise as a result of one or both of the following facts: (1) Women that work/use child care may be systematically different from women that do not work/do not use child care; (2) The child's cognitive ability itself may influence the mother's decisions of whether to work or not and/or place the child in daycare.

Women are heterogeneous in both the constraints they face and their tastes. Likewise, children are heterogeneous in their cognitive ability endowments. Some of these characteristics are unobserved by the researcher. Mothers' decisions of whether or not to work and whether or not to use child care will depend on these unobserved characteristics of both mothers and children.

[2] See Keane and Wolpin (1997, 2001) and Cameron and Heckman (1998).
[3] In Section 2 we discuss in detail the fact that results from previous literature are inconclusive at best.

To make the selection problem clear, we lay out an example in each of the two cases. In the case of (1), for example, a woman with higher skills is more likely to have a child with high cognitive ability and also more likely to work/use child care. Then, a statistical analysis would spuriously attribute the effect of the woman's higher skills to employment (child care use), and the estimated effects of maternal employment (child care) on child's cognitive outcomes would be upwardly biased. In the case of (2), mothers of low ability endowment children may choose to compensate them by spending more time with them, in which case mothers are more likely to work (use child care) if they have high ability children. Again, the estimated effect of maternal employment (child care) on child's cognitive outcomes would be upwardly biased. Clearly, these sample selection issues make evaluation of the effects of women's decisions on child outcomes very difficult.

In this paper, we estimate a child's cognitive ability production function for single mothers in the NLSY. We focus on single mothers because recent important changes in welfare rules, generated by welfare waivers and the Temporary Aid to Needy Families (TANF) program, along with increased day care subsidy spending, through the Child Care Development Fund (CCDF), have led to dramatic and plausibly exogenous variation in work incentives, child care prices and child care availability for this group. These policy changes have generated substantial increases in employment and child care use among single mothers.

Between 1993 and 1996, 43 States were granted "Section 1115" Welfare Waivers which allowed them to adopt innovative approaches to welfare reform. Many of the policies and concepts included in state waivers were later incorporated into "The Personal Responsibility and Work Opportunity Reconciliation Act" (PRWORA) of 1996. PRWORA changed the welfare system into one requiring work in exchange for time-limited assistance. It created the Temporary Assistance for Needy Families (TANF) program, which replaced the Aid to Families with Dependent Children (AFDC), and created the Child Care and Development Fund (CCDF). Under TANF and the CCDF, States operate their own programs, so a great deal of heterogeneity in work incentives and day care subsidy programs across states has emerged.

The main changes in the welfare system under both Section 1115 Waivers and TANF that are relevant for our exercise could be grouped into the following categories: termination and work requirement time limits, earnings disregard, child care assistance and child support enforcement. States differ greatly in terms of the rules they have adopted in each of these dimensions. Thus, we construct an extensive set of State and individual-specific welfare rules variables, and use these as

instrumental variables in the estimation of the cognitive ability production function. Most of the leverage for identification comes from comparing behavior and child outcomes of women who had children between 1990 and 2000, so they were impacted by welfare waivers and TANF, with women whose children were born earlier, since these two groups are subject to very different welfare rules.

The study of the case of single mothers extends earlier work by Bernal (2003), who estimated the effects of parental time inputs on children of married women in the NLSY. A key motivation of this work is to see whether her results on the importance of maternal time inputs generalize from married to single mothers. Second, the study of single mothers is of special interest, given the huge welfare policy changes that have substantially altered their work decisions in recent years.

The main results indicate that the effect of child care use on children's achievement is negative, significant and rather sizeable. In particular, one additional year of child use is associated with a reduction of approximately 2.8% in test scores (depending slightly on the particular specification of the cognitive ability production function). This corresponds to 0.14 standard deviations, so it is a substantial effect.

However, this general finding masks important differences across types of child care and across child age ranges. Formal child care (i.e., pre-school, formal center based care) does not have any adverse effect on cognitive outcomes, nor does formal or informal care in the first year after the birth of the child. Only non-formal types of child care lead to significant reductions in child's achievement, in particular, if used after the first year after childbirth. In particular, an additional year of informal child care use is associated with a reduction of 3.5% in test scores. The estimated effect for formal care is actually positive, but insignificant.

In addition, the estimated effect of household income since the birth of the child is quantitatively small, and statistically insignificant, given controls for mother's education. This is consistent with a view that permanent income is significant in determining parental investment in children, and hence the children's achievement, while transitory income is not.[4] Mother's education is highly significant in the child's cognitive ability production function, but we make no attempt to disentangle the extent to which this reflects genetic transmission of maternal ability to the child vs. the impact of maternal permanent income on investment in children.

This paper is organized as follows. In section 2 we present a brief review of the relevant

[4] This finding is reminiscent of the findings by Keane and Wolpin (2001) and Cameron and Heckman (1998) to the effect that transitory fluctuations in parental income have little effect on college attendance decisions by youth.

literature. In Section 3 we discuss our identification strategy, and in particular, the way in which welfare rules are expected to affect employment and child care choices of mothers. In addition we discuss specifically how we constructed the welfare variables used in the analysis. In Section 4 we present the theoretical framework. In Section 5 we talk about the data and the sample used in this paper. Section 6 presents the estimation results and finally Section 7 concludes.

2. Literature Review

2.1. The Effect of Maternal Employment and Child Care on Children's Cognitive Outcomes

A number of prior studies have used NLSY data to assess the effect of maternal employment and child care use on children's cognitive development, primarily in the Developmental Psychology literature. Recent reviews of this literature can be found in Love, Schochet and Meckstroth (1996), Blau (1999), Lamb (1996), Haveman and Wolf (1994) and Ruhm (2000). Less than half of these studies provide results that are interpretable in terms of effects of specific inputs.[5] Most of these studies present simple correlations between inputs and child outcomes and do not include additional controls for family characteristics and/or child characteristics. Furthermore, some of these studies use small samples, often nonrandomly selected. In most cases, no control for self-selection of children into child care arrangements (and/or the group of working mothers) was implemented.[6]

Sample-selection issues are likely to be important in this context. First, high ability women will be more likely to have higher wages and hence more likely to use higher quality daycare. In this case, a statistical analysis would attribute the effect of the woman's higher skills to child care quality, and the estimated effects of daycare quality on child's cognitive outcomes would be upwardly biased. Similarly, it might be the case that parents tend to place a certain type of children, say the ones who develop more slowly, in higher quality daycare in order to compensate. In this case, the direction of the bias would go in the opposite direction, i.e., the effect of daycare quality on children's development would be underestimated.

In Table 1 we summarize recent published papers that use data from the NLSY to assess the

[5] Some studies show associations between clusters of child care arrangements and children's development instead of assessing the impact of each input (Howes and Rubenstein (1985), Peterson and Peterson (1986), Studer (1992)). In some other cases, coefficient estimates or signs of the estimated effects are not provided by authors (e.g., Howes and Rubenstein (1981)).

[6] See for example, Burchinal et al. (1996) and Parcel and Menaghan (1990).

effect of maternal employment on children's cognitive outcomes. [7] It is clear from looking at this table that the evidence is quite inconclusive. Approximately a third of the studies report positive effects of maternal employment, a third report negative effects and the remaining report either insignificant effects or effects that vary depending on the group studied or the timing of inputs.

A similar picture can be observed in Table 2 where we report a summary of recent papers that evaluate the effects of daycare use (and/or daycare quality) on chidren's outcomes.[8] In this case again, effects range from positive to negative and are in most cases either insignificant or vary with the specific sample used or the quality of daycare.

The main reason for the diversity of these results may well be the common limitation of failing to control for potential biases that may arise due to the endogeneity of employment and child care choices. A few recent studies have tried to overcome this problem by either using a more extensive set of explanatory variables, using instrumental variables or running fixed effects models. To make the exposition more clear it would be useful to have a specific framework in mind. The following is a typical equation estimated in these papers:

$$\ln S_{ijt} = \mu_j + \delta_{ij} + \alpha_1 T_{ijt} + \alpha_2 C_{ijt} + \alpha_3 G_{ijt} + \alpha_4 X_{ijt} + \varepsilon_{ijt} \quad (1)$$

where S_{ijt} is the child's cognitive outcome, μ_j is a family effect, δ_{ij} is a child effect, T_{ijt} is a measure of maternal time with the child, C_{ijt} is a measure of nonmaternal care (child care), G_{ijt} represents goods and services used in the production of child's ability, X_{ijt} is a vector of child and family characteristics such as gender, race, birthweight, mother's age, education, etc., and ε_{ijt} is a transitory (serially uncorrelated) effect.

Several issues associated with the estimation of equation (1) given the available data arise. First, while this is a general setup that underlies most of these papers, very few actually estimate this equation. Most of them focus on either maternal time or child care use only. This means that they are estimating a misspecified version of the child's cognitive ability production function in which relevant inputs are being omitted. Second, there is no particular reason why only current inputs (i.e., maternal time, child care and goods used at the time of the outcome) should be relevant. For example, one could think of the effect of inputs cumulating over time or having a more general

[7] There are several papers, such as Todd and Wolpin (2001), Rosenzweig and Wolpin (1994), Rosenzweig and Schultz (1983), on the general topic of the specification/estimation of cognitive ability production functions. We summarize here only studies related in particular to the parental time and child care inputs.
[8] In this case we do not restrict ourselves to studies that use NLSY data only.

specification according to which the whole history of inputs since childbirth matters for the child's outcome at time *t*. Most of these papers do not discuss the implications of such a specification or the assumptions required for equation (1) to be consistent with a more general ability production function.[9]

Third, in most of these studies maternal time (H_{ijt}) is measured by maternal employment; child care use is measured in a variety of ways by using (1) total child care used since childbirth, (2) total child care used by type/quality, (3) the year of initiation of daycare participation, and/or (4) characteristics of child care used such as infant-adult ratio, infant class size and teacher training; and G_{ijt} is generally measured by either household income or the HOME environment index which measures not only physical characteristics of the household but also features of the parent-child relationship. In order for equation (1) estimated by using these measures to be consistent with a child human capital production function we require several assumptions. In addition, the interpretation of the coefficients is not straightforward and often does not coincide with the effect of the right hand side variable on the child's outcome given that the explanatory variables are not exactly inputs that go into the production function but rather proxies for those. Neither of these issues is discussed in this literature.[10] Both will be made clear and discussed in detail in Section 4.

Finally, most of the papers estimate equation (1) by OLS which means that they ignore the potential endogeneity of inputs (H_{ijt}, C_{ijt} and G_{ijt}) to μ_j and δ_{ij}. A few recent studies have tried to overcome this problem by either using a more extensive set of explanatory variables or using instrumental variables. Blau and Grossberg (1992) used 874 3-4 year olds in 1986. To correct for potential heterogeneity bias, they estimated their basic equation (similar to (1)) using instrumental variables for maternal labor supply. However, the instruments, such as region of residence and maternal and child health, may be debatable since they may affect child outcomes directly. They concluded that maternal employment in the first year after birth is associated with lower PPVT scores, while the contrary is true for the second and third years of employment.

James-Burdumy (2005) estimated IV FE models using a sample of 498 children in the NLSY. However, her instruments (local market conditions) turn out to be weak and thus the IV FE

[9] Notable exceptions are Blau (1999) and Duncan (2003). Some of the papers use maternal employment (and/or child care use) at different years after childbirth but do not discuss the implications of their choice in terms of the assumptions underlying the specification of the production function (e.g., Waldfogel et al. (2002), Vandell and Ramanan (1992), and Baydar and Brooks-Gunn (1991)).

[10] A notable exception is James-Burdumy (2005). She discusses in detail the relationship between a child's production function and her estimating equation by pointing out the difficulty in interpreting the coefficients in the latter.

model is rejected in favor of the FE model. According to her results, the effect of maternal employment varies depending on the particular cognitive ability assessment used and the timing of employment. It is plausible that mothers make time compensations for children depending on their ability type. In this case, using a household fixed effect model would not be appropriate, since maternal employment is correlated with the sibling specific part of the cognitive ability endowment. In other words, while the household FE gets rid of μ_j it does not take care of δ_{ijt}, and to the extent that the child-specific effect is correlated with input choices then the estimated coefficients will still be biased. In addition, the FE estimator would require that input choices are unresponsive to prior sibling outcomes (otherwise ε_{ijt} might be correlated with inputs to sibling i').

Blau (1999), Duncan (2003) and Chase-Lansdale et al. (2003) estimate child fixed effects to assess the effect of day care (in the case of Blau and Duncan) and maternal employment (in the case of Chase-Lansdale et al.) on children's outcomes. Chase-Lansdale et al. (2003) analyzed 2402 low-income families during the recent era of welfare reform. Their results from child fixed effects models suggest that mothers' transitions off welfare and into employment are not associated with negative outcomes for preschoolers.[11] In the case of a child fixed effects estimator, identification of the production function parameters would require that the effect of each input is independent of the age at which it was applied and the effect of the ability endowment is independent of the achievement age. Both seem like implausible assumptions. In addition, because any prior achievement outcome is known when later input decisions are made, consistent estimation of the parameters would require the assumption that later input choices are uncorrelated with prior own achievement outcomes.[12]

Finally, Bernal (2003) develops a model of work and child care choices of women after birth. Estimation of the child's cognitive ability production function, which includes mother's time and child care use as inputs, jointly with the mother's work and child care decision rules enables her to implement a selection correction, in the sense that she can adjust for the fact that certain types of children are more likely to be put in child care and/or to have working mothers. Her results suggest that the effects of maternal employment and child care use on children's cognitive ability are rather sizeable. In particular, an additional year of working experience and child care use is associated with

[11] These authors do not attempt to use the changes in welfare rules as instruments for maternal employment as we do.
[12] Todd and Wolpin (2005) estimate a child fixed effects model by using IV (in order to relax this assumption) to evaluate the effect of home and schooling inputs on children's cognitive outcomes. In particular, they use input levels prior to the earlier achievement observation as instruments.

a reduction of approximately 2% in cognitive ability test scores of children ages 3 through 7.

Bernal restricted the sample to women that did not have an additional child for at least five years after birth. This enabled her to avoid modeling fertility decisions and mothers' time allocation among multiple preschool aged children. However, her results may not generalize to larger familiar. In our reduced form framework we let the effects of maternal work and day care depend on the number of children. Additionally, she relies on a set of exclusion restrictions to identify the structural parameters of the child ability production function, and these may be debatable. Her basic identification assumption is that short run movements in mothers' and husbands' wage rates enter the mother's working and child care decision rules, but do not directly affect child's ability (for example, movement along the mother's and father's age-wage profile generates exogenous variation in their wage rates, which in turn affects the mother's work and child care decisions but does not directly affect child outcomes). We believe that additional (and stronger) instruments are available for single mothers. In this paper, we propose to use the variation in welfare rules to achieve a stronger basis for identification.

2.2 Relationship between early test scores and subsequent outcomes (wages, education, etc.)

Several studies have examined the relationship between early test scores and subsequent outcomes like educational attainment and wages. We briefly summarize some of these studies in this section. Neal and Johnson (1996) use NLSY data to show that the Armed Qualification Test score (AFQT), which is widely used as a measure of cognitive ability, at ages 14 to 21 was a highly significant predictor of wages at ages 26 to 29. Murnane, Willett and Levy (1995) use data from two longitudinal surveys of American high school seniors to show that there is a relationship between the mathematics test scores of students measured in the senior year of high school, and the wages of 24 year old men and women. Zax and Rees (1998) use the Wisconsin Longitudinal Study of Social and Psychological Factors in Aspiration and Attainment (WLS) to assess the relationship between IQ scores at age 17 and wages at ages 35 and 53. They find that indeed measures of IQ at age 17 are strong predictors of wages at both, 35 and 53.

Hutchison, Prosser and Wedge (1979) examine the British National Child Development Study (NCDS) to link test scores at age 7 and test scores at age 16. Similarly, Connolly, Micklewright and Nickell (1992) examine the relationship between test scores at age 7 and earnings at age 23 in a sample of young men who left school at age 16 using the NCDS. More recently, Robertson and Symons (1996) and Harmon and Walker (1998) examined the effects of age 7 test scores on earnings at age 33. All of these studies find significant positive effects of cognitive

outcomes at age 7 on subsequent earnings. Currie and Thomas (2001) use the NCDS to show that a one standard deviation increase in age 16 math scores is associated with a 14% higher wage rate at age 33 (for low or medium-SES individuals), and would increase employment probabilities by 7% at age 33. In addition, they provide evidence that age 7 (math) test scores are strong predictors of age 16 math test scores.

In Appendix 1 we present some evidence using data from the NLSY that math and reading test scores measured as early as age 4 are significantly correlated with educational attainment of young adults ages 18 and older. For example, a one-point increase in math test scores at age 6 (which is approximately equivalent to a 1% increase given that the mean is 99.7) is significantly associated with an increase in educational attainment at age 18 or later of approximately a quarter of a month. Similarly in the case of math test scores measured at ages 7 and 8. In addition, a one-point increase in reading test scores at age 7 (approximately equivalent to a 1% increase) is significantly associated with an increase in education attainment at age 18 of approximately a third of a month. Similar results are obtained in the case of reading test scores measured at 5, 6 and 8.

3. Welfare Rules and their Effects on Work and Child Care Decisions of Mothers

In order to construct our instruments, we collected detailed information about State welfare policies from many sources, including the State Policy Documentation Project (SPDP), GAO (1997), the Administration for Children & Families (DHHS) TANF Annual Reports to Congress (1997 to 2001), Center for Law and Social Policy (1995), Gallagher et al (1998), Hotz and Scholz (2002), Office of Family Assistance (1999), Department of Agriculture (USDA), Urban Institute, Center on Budget and Policy Priorities (CBPP), Green Book (various years), Internal Revenue Services (IRS) and various State TANF policy handbooks.

Using the collected welfare policy variables, together with detailed individual demographic variables, we constructed two types of variables. The first group contains individual level policy variables. These are constructed from the individual's demographic variables in conjunction with relevant policy variables. Since we have individual level data, we exploited every opportunity to tailor policy variables to the individuals based on their demographics (e.g., calculating the appropriate AFDC/TANF benefit level for a woman based on her number of children, determining whether or not a woman could be subject to time limits given the age of youngest child, etc). The second group of variables corresponds to State level policy variables. It includes all variables that vary across States and time, but do not vary across individuals in the same State and year.

In the following sections we outline the main aspects of the 1996 Welfare Reform and Section 1115 Welfare Waivers which are relevant to this work, in the sense that they generated plausible exogenous variation in work incentives, child care prices and availability. We discuss both the way in which we expect these rules to effect on work and child care decisions of single mothers, and how the policy variables were constructed and coded.

3.1. Time Limits

Under AFDC, single mothers with children under 18 were *entitled* to receive benefits, as long as they met the income and asset eligibility requirements. But under the Section 1115 Waivers, and under TANF, the states could set time limits on benefit receipt. Indeed, PWRORA forbids States from using federal funds to provide benefits to adults beyond a 60-month lifetime time limit (except that 20 percent of a State's caseload can be exempted), and it allows states to set shorter time limits. However, States may use their own funds to aid families that have reached the federal time limit. Thus, for instance, New York and Michigan do not impose termination time limits,[13] California imposes a 5-year time limit but at that point only the adult share of benefits is cut, and Texas and Florida impose termination time limits in the 2-3 year range.

We can think of the potential impact of time limits as falling in one of two types: anticipatory and direct effects. The latter are simply related to the fact that a welfare recipient who reaches the time limit becomes immediately ineligible for benefits (so long as the limit is being enforced). The former is associated with the more subtle idea that if an individual is forward-looking and is faced with a welfare time limit then she will try to "save" or "bank" months of eligibility, in order to use them when it is truly necessary.[14]

In this paper, we use several variables to capture the impact of time limits. These incorporate both time limits created under TANF and earlier under AFDC waivers. One set of variables will capture variations at the state level, while others are individual-specific in the sense that they capture whether a specific woman in the sample could potentially be subject to a given rule. These variables are summarized in Table 3. Each variable has up to three subscripts: i for individual, s for State and t for period (quarter in our case).

[13] That is, these States have chosen to use State funds to provide benefits to families beyond the 60-month Federal limit.
[14] In a dynamic setting, a single mother should make welfare participation decisions by comparing the value of current period welfare benefits to the value of current period potential earnings plus the "option value" of conserving a month of benefit eligibility. Grogger and Michalopoulos (1999) point out that this option value is, *ceteris paribus*, an increasing function of the time horizon over which benefits may be used (the number of months/years until the woman's youngest child reaches 18) and a decreasing function of the stock of remaining months of eligibility. For instance, the option value of preserving a month of eligibility is greater when the woman has only one month left than when she has 60.

First, we include a dummy for whether the State of residence of a single mother had imposed a time limit (TLI_{st}) in time t and a variable that indicates the length of the time limit in state s at time t (TL_LENGTH_{st}). In addition, we include a dummy for whether the time limit could be binding for that particular woman (TL_HIT_{ist}). The latter is individual specific since it accounts for the age of this woman's children. In other words, a single mother whose oldest child is A^o years old cannot have received welfare for more than A^o years. This means that the time limit cannot bind for this woman unless A^o exceeds the limit, regardless of how many years ago her State implemented time limits.

Note that TLI_{st} captures an anticipatory effect of time limits, while TL_HIT_{ist} captures a direct effect. Some additional variables that capture anticipatory and direct effects of time limits on work decisions were constructed: First, a variable that we call "months elapsed since the implementation of time limits" ($ELAPSED\_TL_{st}$). Second, a variable called "months elapsed since the time limits could first potentially bind" for a given woman ($ELAPSED\_TL\_HIT_{ist}$). Third, we constructed a variable that measures the length of the time horizon over which a woman will be categorically eligible for benefits, which can be thought of as increasing the option value of "banking" welfare eligibility. This is equal to the remaining time until her youngest child reaches age 18 ($REMAIN\_ELIG_{ist}$). Finally, as we mentioned before, the option value of "banking" welfare eligibility is decreasing in the stock of eligible months that a woman currently possesses. This measure is constructed by calculating the maximum number of months that a woman could have received welfare since her State started her clock and subtracting this from the State time limit. We call this variable $REMAIN\_TL\_ELIG_{ist}$. Finally, many States mitigate the impact of hitting a time limit by only deleting the adult portion of benefits (i.e., continuing the child portion). We indicate this feature by $DCHILDBEN_{st}$.

It is worth emphasizing that we assume the woman's demographics and the welfare policy rules she faces are exogenous. In order for our policy variables to be valid instruments we require that they be only functions of the demographic and policy variables. For example, we do not want to use a woman's actual welfare participation history to construct the remaining months on her time limit clock, because actual participation decisions are endogenous. Similarly, in constructing $REMAIN\_ELIG_{ist}$, we ignore the fact that a woman can always extend her months of categorical eligibility by having another child.

3.2. Work Requirements and Exemptions

Under PRWORA, with a few exceptions, recipients must participate in "work activities" as soon as job ready, or no later than two years after coming on assistance.[15] In FY 1997, each State had to ensure that 25 percent of all families in the state were engaged in work activities. This percentage increased to 50 percent in fiscal year 2002. Many States have chosen to adopt shorter work requirement time limit clocks. Under the first wave of TANF plans (adopted approximately from October 1996 to January 1998), 20 States required welfare recipients to start participating in work activities immediately. Under the second wave of revised TANF plans (roughly two years after the first wave), 25 States required immediate work participation. Of the remaining States, most adopted the 24-month maximum allowed under the federal law.

Thus, due to variation in when States implemented their TANF plans, and in the length of their work requirement time clocks, there is substantial variation across States in how early single mothers could have been subject to binding work requirements. For example, work requirements adopted under AFDC waivers could have hit as early as mid-1994 in Iowa, October 1995 in Michigan, and mid-1996 in Wisconsin. Later TANF work requirements could have bind as early as the Fall of 1996 in Alabama, Connecticut, Florida, Oregon and Utah among a few other States. However, work requirements were not binding until December 1998 in New York or February 1999 in New Jersey.

Also, States have the option to exempt single parents with children up to 1 year of age from work requirements and have the flexibility to provide exemptions to other families. A few states only exempt single mothers with children under 3 or 6 months (e.g., California), while others chose to grant longer exemptions. Thus, within a State, there is variation across women in whether work requirements can be binding, based on age of the youngest child.

In order to capture these effects, we constructed the following variables. The first, $CHILD\_EXEM_{st}$ is a dummy variable that indicates whether state s has an age of youngest child exemption in place at t and AGE$_CHILD_EXEM_{st}$ is the age of youngest child below which a woman is exempt from work requirements. In addition, WR_HIT_{ist}, is an indicator for whether the woman could have been subject to work requirements. It is constructed based on when a work requirement could have first hit in State s, in conjunction with the age of the woman's youngest child and the State's age exemption.

[15] "Work activities" include: 1) unsubsidized employment, 2) subsidized private sector employment, 3) subsidized public sector employment, 4) work experience, 5) on-the-job training, 6) job search and job readiness assistance, 7) community service programs, 8) vocational educational training, and 9) the provision of child care services to an individual who is participating in a community service program.

Besides the age of youngest child exemption, many States allow a few other exemptions from work requirements under TANF. These include exemptions for single parents with children under age 6 who are unable to obtain child care, and for recipients who are disabled or have a disabled household member. Thus, we constructed an additional variable, $EXEMP_{st}$, for the total number of work requirement exemptions. Also, States also differ in the type of sanction imposed in case the recipient does not satisfy the work requirement. A "partial" sanction generally means that only the adult portion of benefits is taken away while the children's portion is not. In 1996, 9 States had imposed a full sanction. By 1997, the number of States with a full sanction increased to 23 and to 30 by 1998. The measure $WR\_ULT\_SANC_{st}$ is a dummy for whether State s imposes a full sanction. Both these variables can be thought of as measures of strictness with which States enforced work requirement time limits.

Finally, we include a dummy DWR_{st} for whether a State has a work requirement time limit in effect. This indicator captures the fact that, in principle, work requirements can also have anticipatory effects. If a State adopts a work requirement with a 24-month work time limit clock, this can create an incentive to avoid welfare participation even before the 24 months are used up. This could be done to preserve time on the clock, or just because the value of human capital investment today is increased given that expected future welfare participation is reduced. Two additional measures we include are WR_LENGTH_{st}, which is the length of the work requirement in months, and $ELAPSED\_WR_{st}$, which is the time elapsed since the work requirement was implemented. Lastly, we also constructed a variable called $ELAPSED\_WR\_HIT_{ist}$, which is the time elapsed since woman I may be potentially subject to work requirements.

3.3. AFDC/TANF Benefit Levels, Earnings Disregards and Benefit Reduction Rates

AFDC/TANF benefits for eligible participants are, roughly speaking, determined by a formula in which a State specific grant level (or payment standard), which is an increasing function of number of children under 18, is reduced by some percentage of the recipient's income (net of work expense deductions). One variable we use to characterize the system is the maximum *potential* real monthly AFDC/TANF benefit amount, assuming zero earnings, constructed using the State payment standard for the corresponding family size of the single mother. We call this variable

BEN_{ist}. We put this variable in real terms using a region-specific CPI.[16]

Under AFDC, benefits were reduced as income increased according to a "benefit reduction rate" that we denote BRR. This tax was applied after allowance for deductions for work and child care expenses. The deduction amounts and the BRR changed several times over the history of the program. In 1967, the BRR was decreased from 100% (i.e., a dollar-for-dollar reduction of benefits for each dollar of earnings net of deductions) to 67%. In 1982, it was increased back up to 100%. Since 1982, the work expense deduction was set at $90 per month, and there was an additional child care expense deduction. Under waivers and the TANF program, the BRR was made State specific, and it now varies considerably across States.

In addition, the AFDC program incorporated "earnings disregards" in an effort to encourage work among participants. That is, if an AFDC recipient started working, then for a period of time, a fraction of her earnings (on top of the amounts set aside for work and child care expenses) would not be subject to the BRR. Generally, this disregard would consist of a "flat" component (e.g., the first $30 of monthly earnings) and a "percentage" part (e.g., one-third of earnings beyond the flat part). Both would be eliminated after a certain number of months of work.

Starting in late 1992, many states obtained waivers to increase the income disregard and hence, encourage work. Under PRWORA, States are not required to adopt any particular earned income disregards, so a great deal of State heterogeneity has emerged. A few States expanded disregards and allowed them to apply indefinitely. For example, starting in 1998, California set a "flat" disregard of $225 of month earnings and a "percentage" disregard of 50% of additional monthly earnings, with no phase-out of either over time. Flat disregards varied from $0 to $252 across states, while percentage disregards varied from 0% to 100%.

Clearly, earnings disregards and the BRR affect a woman's incentive to work and use child care directly, by shifting her budget constraint, in particular, her after-tax wage rate. Note that changes in an indefinite percentage disregard are equivalent to changes in the BRR, so we code both together in the variable $PERC\_DISREGARD_{st}$. Flat disregards are coded in $FLAT\_DISREGARD_{st}$.

3.4. Child Support Enforcement and Child Support Income

Child support is an important source of income for single women with dependent children, despite the widespread non-payment by non-custodial fathers.[17] Under AFDC, recipients were

[16] BLS has computed the CPI from (or before) 1980 for 24 metropolitan areas. For individuals residing in one of these 24 metropolitan areas we deflated potential benefits by the corresponding CPI. The potential benefits of individuals in other areas were deflated using a region-specific (western, south, midwest and northeast) CPI.

required to assign all child support collections, up to the amount of benefits they receive, to the welfare agency. States were required to pass-through the first $50 of current month child support payments to the family for which they were collected. The amount of this pass-through was disregarded, so families received this amount as additional income. It did not count against the recipients' income in determining their family's AFDC eligibility or the assistance grant amount. The remainder of the child support collected was shared between the state and the federal government to reimburse the cost of providing AFDC assistance. Between January 1993 and August 1996 states requested and received waivers of a number of provisions related to child support enforcement. The most common types of waivers included changes in the pass-through amount, or allowing single mothers to keep child support payments. In case of the latter, they would be subject to certain disregards just like earned income.

Under TANF, recipients are still required to assign child support collections to the welfare agency. However, the $50 pass-through has been eliminated. States may still opt to pass-through some of the funds collected to the custodial family. States establish their own policy in terms of whether or not to disregard the pass-through. Clearly, by shifting a single mother's budget constraint, the way in which child support income is treated has an effect on the woman's incentives to work and/or use child care. At the same time, enhance pass-throughs or disregards may also increase the incentive to participate in welfare. To account for these effects we include measures of the flat and percentage disregards in the state of residence of a woman ($FLAT_DISREGARD_{st}$ and $PERC\_DISREGARD_{st}$) under both AFDC waivers and TANF.

Aside from these AFDC or TANF rules, child support income collection has also been affected by the Child Support Enforcement (CSE) program. This program was enacted in 1975 to address the problem of non-payment of child support by non-custodial parents. For instance, CSE has implemented programs to locate absent parents and establish paternity. CSE expenditures have significantly increased from $2.9 billion in 1996 to $5.1 billion in 2002 (76% increase). These expenditures are an important indication of how likely is a single women of collecting child support. We include a measure of State level CSE activity by taking the State CSE expenditure and dividing it by the State population of single mothers ($ENFORCE_{st}$). Variation across States and over time in CSE spending, provides two key sources of variation that identify the effects of child support enforcement expenditures on welfare participation and work.

[17] In 2002, child support accounted for approximately 6.5% of single mother's real incomes (March CPS).

3.5. Child Care Subsidies and the Child Care and Development Fund (CCDF)

In the late 1980s, several programs were created that expanded Federal support for child care. The Family Support Act (FSA) of 1988 created two programs, AFDC Child Care and Transitional Child Care (TCC). The first program funds child care services of AFDC families who are working or participating in an approved work, education, or training program. The second program funds care for families for up to 1 year after they leave AFDC to start working. In both cases, AFDC participation determined eligibility. The Omnibus Budget Reconciliation Act (OBRA) of 1990 created the At-Risk Child Care Program and the Child Care and Development Grant (CCDBG). The former funds care for working families who are "at risk" of becoming eligible for AFDC if they are not given child care assistance. The latter program provides subsidies to low-income working families generally. Unlike AFDC Child Care and TCC, these benefits were not an entitlement. Under PRWORA these four pre-existing programs were consolidated into the Child Care and Development Fund (CCDF). The CCDF is a block grant to states to provide subsidized child care programs for low-income families, including those who are not current or former cash assistance recipients. Under the CCDF, states have autonomy to design child care assistance programs for low-income families and a great deal of heterogeneity has emerged across States in the design of their child care subsidy programs. In particular, income eligibility criteria, reimbursement rate ceilings and parent co-payments (States may require a contribution from the family to the cost of child care) vary significantly across states. Additionally states differ in terms of whether they give priority to low-income families who are on TANF or just transitioning off TANF.

As an additional policy instrument, we use the State CCDF expenditure per single mother ($CHILDCARE_{st}$). This variable measures the availability and generosity of child care subsidies in a State. An alternative to measure the generosity of a State's child care program would be to use detailed program parameters, such as, monthly income eligibility criteria, reimbursement rate ceilings or the co-payment rates, which are State specific and have also varied over time. We opt not to use these measures due to problems associated with rationing. For example, a State with a seemingly generous program (e.g., high income eligibility threshold and low co-payment) will tend to have a longer waiting list. Hence, program generosity can be more accurately measured by the States' actual per-case expenditure.

3.6. Other Contemporaneous Policy Changes: The Earned Income Tax Credit

The Earned Income Tax Credit (EITC), enacted in 1975, is a refundable Federal income tax credit that supplements wages for low-income working families. Major expansions of the federal EITC occurred in 1986, 1991, 1994 and 1996. Because of these expansions, the number of families receiving EITC increased from 6.2 million in 1975 to 19.5 million in 2000 (U.S. House of Representatives Green Book 2000, pg 813).

The EITC rules specify four parameters, a "phase-in" and "phase-out" rate, and a "phase-in" and "phase-out" income range. These parameters depend on family size. After the expansions in the mid-1990s, the EITC became a sizable wage subsidy to low and moderate-income families. Thus, it may provide an important work incentive. For example, in 2003, the phase-in and phase-out rates for a family with one child are 34% and 15.98%, respectively. As of 2003, 17 States have enacted State earned income tax credits that supplement the federal credit.[18] To account for this effect we construct the EITC phase-in rate ($EITC_{ist}$) using Federal and State level EITC rules together with the mother's family composition.

4. The Child's Cognitive Ability Production Function

The child's cognitive ability production function that we present in this section is consistent with theoretical notions that child development is a cumulative process that depends upon the interaction between the history of family and child care/school inputs and the genetic endowments. The human capital production function framework (see Ben Porath (1967)), conceives the process of knowledge acquisition as a production process in which current and past inputs interact with an individual's genetic ability endowment to produce a cognitive outcome. Leibowitz (1974) adapted the original human capital production framework to assess whether home investments in children add to preschool stocks of human capital. In this context, the process of acquiring preschool human capital is analogous to the acquisition of human capital through schooling or on-the-job training, except that, at preschool ages, the inputs are generated by parental decisions rather than the child's own decisions.

Let A_{it} be child i's cognitive ability t periods after birth. We write a production function:

$$ln\, A_{it} = A(\tilde{T}_{it}, \tilde{G}_{it}, \tilde{C}_{it}, \omega_i) \tag{2}$$

where $\tilde{T}_{it}$ is a vector of period-by-period maternal time inputs up through period t, $\tilde{G}_{it}$ is a vector

[18] We collect this information from Fang and Keane (2004).

of goods inputs, $\tilde{C}_{it}$ is a vector of day-care/pre-school time inputs, and ω_i is the child's ability endowment. The goods inputs would include things like books and toys that enhance cognitive development. The school inputs would include the contribution of alternative care providers' time to the child's cognitive development, which may be more or less effective than mother's own time. In addition, care in a group setting may contribute to the child's development by stimulating interaction with other children, learning activities at pre-school, etc..

Several difficult issues arise in the estimation of (2). The first is that estimation of a completely general form of the function, in which inputs at age *t* have a potentially different effect on ability at each age t', and in which the ability endowment ω_i has a potentially different effect on ability at each age, is not feasible due to proliferation of parameters. For instance, if the effect of just one input (say, maternal time) is allowed to differ between every pair of input and output periods *t* and t', and we examine outcomes for 20 quarters (5 years) after birth, we obtain 20*21/2=210 parameters describing effects of that input alone on ability. Thus, to avoid exhausting the degrees of freedom in the data, we will obviously need to restrict how the inputs enter (2).

One possible simplification, familiar from the human capital literature, is to assume that: (i) only cumulative inputs matter, rather than their timing, and (ii) that the effect of the permanent unobservable is constant over time (e.g., in the standard Mincer earnings function, only cumulative education and experience are assumed to affect human capital, and the unobserved skill endowment is typically assumed to have a constant effect on log earnings). We will first consider a specialization of (2) that adopts these assumptions, and consider some feasible relaxations later. Letting $\hat{X}_{it} = \sum_{\tau=1,t} X_{it}$ be the cumulative amount of input *X* up through time *t*, and assuming that cumulative inputs affect $ln\, A_{it}$ linearly, we would obtain a special case of (2) that takes the form:

$$ln\, A_{it} = \alpha_0 + \alpha_1 \hat{T}_{it} + \alpha_2 \hat{C}_{it} + \alpha_3\, ln\, \hat{G}_{it} + \omega_i \tag{3}$$

We will now consider the other problems that arise in estimating the production function in the context of the special case in (3).[19]

The second difficult issue is the selection (or endogeneity) problem that arises because the inputs may be correlated with the child's ability endowment ω_i. To clarify this problem, we start by assuming the ability endowment is given by the equation:

[19] Letting cumulative goods enter in log form is analytically convenient, for reasons that will become apparent later.

(4) $$\omega_i = \beta_0 + \beta_1 E_i + \hat{\omega}_i,$$

where E_i is a vector of characteristics of the mother, such as her education, which are correlated with child ability, and $\hat{\omega}_i$ is the part of the child's ability endowment that is mean independent of the mother's characteristics.

Next, assume that the mother's reduced-form decision rule for choosing the day-care/pre-school time input can be written as:

(5) $$C_{it} = \pi_0 + \pi_1 E_i + \pi_2 \hat{\omega}_i + \pi_3 cc_{it} + \pi_4 R_{it} + \varepsilon_{it}^c,$$

where cc_{it} is the price per unit of day care time that the mother faces at time t, R_{it} is a set of welfare program rules facing the mother at time t, and ε_{it}^c is a stochastic term that subsumes several factors, including tastes for child care use (including both permanent and transitory taste shocks), shocks to child care availability, and shocks to the mother's offered wage rate.

Of course, decisions about child care time use are made jointly with decisions about labor supply, so the mother's characteristics E_i enter (5) because they affect the mother's offer wage. The welfare rules R_{it} matter because they affect how income varies with earnings, and because they may involve work requirements. The mother's decisions about work and child care utilization may also be affected by child ability (e.g., if mothers want to compensate for learning difficulties by spending more time with a child).[20] Thus, E_i and $\hat{\omega}_i$ both enter (5) because of their correlation with the child's ability (as determined by (4)). Thus, (5) clarifies the endogeneity of $\widehat{C}_{it}$ in (3), since the $C_{i\tau}$ for τ=1,t are determined in part by E_i and $\hat{\omega}_i$, which, in turn, are correlated with ω_i in (3), as shown by (4). Equation (5) also clarifies why the welfare rules R_{it} may serve as instruments for $\widehat{C}_{it}$ in estimating (3).

The third issue that arises in estimating (3) is the measurement of maternal time inputs. One could imagine a model where mothers decide how much "quality" time to devote to the child while at home (e.g., children's time is divided between day-care, "quality" time with the mother, and time spent sitting in front of the TV while at home with the mother). Given that we don't observe actual contact time between mothers and children (let alone the subset of this that is "quality" time), we

[20] Suppose mothers engage in compensating behavior by spending more time with low ability children. If this is the case then mothers are more likely to work (use child care) if they have high ability children. In this case, the estimated effect of maternal employment (child care) on child's cognitive ability would be upwardly biased.

simply side-step the issue by assuming that $T_{it} = T\text{-}C_{it}$, where T is total time in a period. Thus, we distinguish between only two types of time (i.e., time with the mother and time in child-care). This means we can rewrite (3) as:

$$(6) \qquad ln\, A_{it} = \alpha_0 + (\alpha_1 T)\cdot t + (\alpha_2 - \alpha_1)\widehat{C}_{it} + \alpha_3\, ln\, \widehat{G}_{it} + \omega_i$$

which clarifies that we can only really estimate $\alpha_2 - \alpha_1$, the effect of time in child-care relative to the effect of mother's time.

The fourth difficult issue that arises in estimation of (3) is that the goods inputs G_{it} are, to a great extent, unobserved. For example, the NLSY contains information on number of books in the home, but lacks other potentially important goods inputs like ****. To deal with this, consider a specification where the decision rule for cumulative monetary investment (in the form of goods) in the child's ability (conditional on work, income and child-care usage decisions) is given by:

$$(7) \qquad ln\, \widehat{G}_{it} = \gamma_0 + \gamma_1 E_i + \gamma_2 \hat{\omega}_i + \gamma_3 \widehat{C}_{it} + \gamma_4\, ln\, \widehat{I}_{it} + \gamma_5 t + \varepsilon^g_{it}.$$

In (7) cumulative investment may depend on E_i for three distinct reasons: (i) E_i affects permanent income, (ii) E_i affects tastes for child cognitive ability, and (iii) E_i is correlated with the child's cognitive ability endowment, which may affect the mother's returns to investment in child ability. The $\hat{\omega}_i$ component of the child's ability endowment enters for reason (iii). Cumulative child care time $\widehat{C}_{it}$ enters (7) because, if child-care time does affect child ability, then mothers may attempt to compensate for these effects by altering goods inputs.

Cumulative income since birth of the child, $\hat{I}_{it}$, enters (7) to the extent that short run fluctuations in income affect investment in children. This occurs both because (i) short run fluctuations in income do affect permanent income – although this effect should be small, and (ii), there may be liquidity constraints. Finally, equation (7) also contains a time effect (i.e., cumulative goods investment grows with age) and a stochastic term ε^g_{it}. This stochastic term captures the mother's idiosyncratic tastes for investment in the form of goods. This would arise due to heterogeneous preferences for child quality.

Now, substituting (7) into (6) we obtain:

$$
\begin{aligned}
ln\, A_{it} &= \alpha_0 + (\alpha_1 T)\cdot t + (\alpha_2 - \alpha_1)\widehat{C}_{it} \\
&\quad + \alpha_3[\gamma_0 + \gamma_1 E_i + \gamma_2 \hat{\omega}_i + \gamma_3 \widehat{C}_{it} + \gamma_4\, ln\, \widehat{I}_{it} + \gamma_5 t + \varepsilon^g_{it}] + \omega_i \\
&= (\alpha_0 + \alpha_3\gamma_0) + (\alpha_1 T + \alpha_3\gamma_5)\cdot t + (\alpha_2 - \alpha_1 + \alpha_3\gamma_3)\widehat{C}_{it} \\
&\quad + \alpha_3\gamma_4\, ln\, \widehat{I}_{it} + \alpha_3\gamma_1 E_i + (1 + \alpha_3\gamma_2)\hat{\omega}_i + \alpha_3\varepsilon^g_{it} \qquad (8) \\
&= \beta_0 + \beta_1\cdot t + \beta_2\widehat{C}_{it} + \beta_3\, ln\, \widehat{I}_{it} + \beta_4 E_i + \hat{\hat{\omega}}_i + \hat{\varepsilon}^g_{it}
\end{aligned}
$$

Equation (8) is estimable, because all the independent variables are observable. However, we must be careful about the appropriate estimation method and the interpretation of the estimates. As we have already noted, child care utilization may be correlated with the unobserved part of the child's ability endowment $\hat{\omega}_i$. Furthermore, child care use may also be correlated with $\hat{\varepsilon}^g_{utt}$, the unobserved taste shifter in equation (7), if tastes for child care usage ε^c_{it} in (5) are correlated with tastes for goods investment in children, as seems plausible.[21] Thus, estimation of (8) using OLS is not appropriate. To our knowledge, it has not been previously noted that consistent estimation of an equation like (8) requires instruments that are not only uncorrelated with the unobserved part of the child's skill endowment, $\hat{\omega}_i$, but also with the mother's tastes for goods investment in the child, ε^c_{it}. We argue that the welfare rule parameters R_{it} that enter the child care usage decision rule (5) provide plausibly exogenous instruments that, as we will see, have good predictive power for child care usage.

The cumulative income variable in (8) is also potentially endogenous, for multiple reasons. First, income depends on the jointly made child care use and work decisions. Hence it is potentially correlated with child ability for the same reasons as were operative for child care usage. Second, income depends on the mother's wage rate, which depends on her ability endowment. To the extent that this ability endowment is not perfectly captured by mother's education, and the residual part is correlated with the child ability endowment, this will also generate correlation between the mother's income and $\hat{\omega}_i$. Thus, we need to instrument for mother's income as well. Again, we will argue that

[21] For instance, a mother with a high taste for child quality may both spend more time with the child (i.e., use less day care) and invest more in the child in the form of goods. This would tend to bias estimated effects of day care usage in a negative direction, since not only the maternal time input but also the goods input is lower for children in day care.

the welfare rules R_{it} provide a plausibly valid instrument, since they should have important effects on work decisions, yet it is plausible that they are uncorrelated with child ability endowments.

Assuming that instrumental variables provides consistent estimates of (8), it is important to recognize that the child care "effect" that is estimated is $\beta_2 = \alpha_2 - \alpha_1 + \alpha_3 \cdot \gamma_3$. This is the effect of child care time (α_2) relative to the effect of mother's time (α_1) plus the effect of any change in goods inputs that the mother may choose as a result of using day care ($\alpha_3 \cdot \gamma_3$). In light of this, it is important to understand the limitations of IV estimates of (8). For instance, such estimates cannot tell us how a policy like child care subsidies would affect child cognitive ability outcomes. Such subsidies would not only alter day care use, but also goods inputs, and in a way not captured by $\alpha_3 \cdot \gamma_3$. The problem arises because, while α_1, α_2, and α_3 are structural parameters of the production technology (3), the parameter γ_3 comes from the decision rule for goods inputs (7), which is not policy invariant.

Thus, when interpreting our estimated effects of child care usage on child cognitive outcomes, one must be careful to only view them as applying to policy experiments that do not alter the decision rule for goods in investment in children (7). As this decision rule is conditional on work, income and child-care usage decisions, it will be invariant to policies that leave the budget constraint conditional on those decisions unchanged. A work requirement that induces a woman to work and use child care, but that leaves her wage rate and the cost of care unaffected, would fall into this category.

While we have considered particular functional forms in order to clarify the estimation issues, we will consider several variants of these in our empirical work. For instance, our specification of the production function allows for interactions between child care use and observed characteristics of the mother (such as education) in order to capture the notion that the effect of home inputs on child's cognitive ability might vary depending on the type of mother. We also test for differences in the effect of separation from the mother depending on the characteristics/type of the alternative provider of child care.

Besides mother's education, we allow for a number of other characteristics of the mother and child to be correlated with the child's cognitive ability endowment as in (5). Thus, the production function that we estimate is:

$$(9) \qquad ln\, A_{it} = \beta_o + \beta_1 \cdot t + \beta_2 \widehat{C}_{it} + \beta_3\, ln\, \widehat{I}_{it} + \underline{\beta}_4 Z_i + \hat{\hat{\omega}}_i + \hat{\varepsilon}^g_{it},$$

where $\underline{\beta}_4$ is a vector of parameters associated with characteristics Z_i of the mother and the child. A

detailed description of the variables included in vector Z_i can be found in Table 4.

Now we will discuss various generalizations or alternative formulations of (9) that we will also consider.

Note that, in general, the effect of income differences could cumulate over time, but we do not know exactly at what rate. We can in principle introduce both cumulative income and current income in the same regression, and let the data reveal which matters more. Similarly, we do not know *a priori* whether it is the cumulative number of periods a child spends in day care, or whether the child is in day care in the current period that matters for current test scores. For this reason, we estimate different specifications and let the data tell which matters most for children's development.

Finally, note that the econometrician does not observe actual cognitive ability of children, but instead has available a set of (age adjusted) cognitive ability test scores from which it is possible to infer the child's cognitive ability. Let S_t be the (age adjusted) test scores observed in period t and let measurement error be specified as:

$$(10) \qquad ln\, S_{it} = ln\, A_{it} + \eta_1 d_{i1t} + \eta_2 d_{i2t} + \varepsilon_{it}$$

where d_{1t} and d_{2t} are cognitive ability test dummies[22] which capture the fact that the means on the different cognitive ability tests differ, and ε_{it} is measurement error.

By replacing (10) into (9) we obtain the equation that is finally estimated:

$$(11) \qquad ln\, S_{it} = \beta_o + \beta_1 \cdot t + \beta_2 \widehat{C}_{it} + \beta_3\, ln\, \widehat{I}_{it} + \underline{\beta}_4 Z_i + \eta_1 d_{i1t} + \eta_2 d_{i2t} + \upsilon_{it}$$

where $\upsilon_{it} = \hat{\hat{\omega}}_i + \hat{\varepsilon}^g_{it} + \varepsilon_{it}$. Note that since $\hat{\hat{\omega}}_i$, the child's ability endowment, and $\hat{\varepsilon}^g_{it}$, the unobserved taste shifter for goods investment in children, are moved into the error term, estimation of equation (11) by OLS would yield biased estimates of the relevant effects (β_2 and β_3) for reasons we have discussed in detail.

For this reason, in this paper we estimate equation (11) by using a set of State and time specific welfare and child care subsidies rules as instrumental variables for home inputs. These variables were described in detail in Section 3. The basic intuition is that these rules capture changes in incentives to work and/or use child care because they change child care prices and child care availability, the mother's budget constraint, the choice set available to the mother at a given period

[22] In particular, d_{1t}=1 if S_t corresponds to the Peabody Picture Vocabulary Test, 0 otherwise and d_{2t}=1 if S_t corresponds to the Peabody Individual Achievement Test- Math Section.

of time and/or incentives associated with mothers' forward-looking behavior. In particular, we estimate equation (11) using children's test scores at ages 3, 4, 5 and 6 and cumulative (or current) inputs up to the date of the test.

5. Data

We use data from the National Longitudinal Survey of Youth. The NLSY (1979 youth cohort) consists of 12,686 individuals, approximately half of them women, who were 14-21 years of age as of January 1, 1979. The sample consists of a core random sample and an oversample of blacks, Hispanics, poor whites and the military. Interviews were first conducted in 1979 and have been conducted annually to the present. On a regular basis, the NLSY79 has collected pre- and postnatal care information from the sample of women as they became mothers. During 1986, 1988, 1992, and 1994-2000 retrospective data were gathered that allows us to construct complete child care histories during each of the first three years of the child's life. In particular, if the mother reported having used at least 10 hours per week of some kind of child care during the quarter, she is assumed to have used child care during the corresponding period. In addition, data on whether the mother used child care or not during the 4 weeks prior to the interview date are available for the 1982-86, 1988, 1992 and 1994-2000 survey years. This information allows us to construct at least partial histories of child care for the fourth and fifth years after birth.

In 1986 a separate survey of all children born to NLSY79 female respondents began. The child survey includes assessments of each child as well as additional demographic and development information collected from either the mother or the child. A battery of child cognitive, socio-emotional, and psychological well-being questions have been administered biennially for children of appropriate age.

Finally we use the geocode data that allows us to identify the residence state of each individual in order to be able to model the effect of state-specific welfare benefits and rules. Different rules imply different budget constraints and choice sets which the individual will face when deciding on work and child care.

5.1. Maternal Time Inputs and Child Assessments

If a woman reported having used at least 10 hours per week of some kind of child care[23] then she is assumed to have used child care during the corresponding period. We define the following

[23] Types of child care include care by a relative or non-relative, day care center, nursery/preschool or regular school.

indicator function:

$$I_t^c = \begin{cases} 1 & \text{if mother works full – time and used child care} \\ 0.5 & \text{if mother works part – time and used child care} \\ 0.5 & \text{if mother did not work and used child care} \\ 0 & \text{otherwise} \end{cases}$$

This definition is adopted in order to capture better the idea that child care use is a measure of the amount of time that the child is separated from the mother. Child care is then defined as cumulative child care ($\widehat{C}_t$), average child care ($\overline{C}_t$) or current child care (C_t) depending on the specification in the following way:

$$\widehat{C}_t = \sum_{\tau=1}^{t} I_\tau^c, \quad \overline{C}_t = \frac{\sum_{\tau=1}^{t} I_\tau^c}{t} \quad \text{and} \quad C_t = I_t^c$$

where *t* is the age of the child.

It is important to mention that complete child care histories are only available for the first three years after childbirth. Hence we construct child care choices for years 4 and 5 (after childbirth) based on the observed child care history. First, we let I_t^c=1 for mothers who report to have been working in a given period *t* after the third year. If the mother is working she has to have used child care that period. Second, for mothers who do not work in a given period *t* we impute the child care choice based on the predicted probability of using child care from a probit model that we estimate using observed child care histories.[24]

Finally, total real household income refers to reported income from all sources including wages, public assistance, unemployment benefits, interest or dividends, pension, rentals, alimony, child support and/or transfers from family or relatives. Household income is deflated using a region-specific CPI just as we did in the case of maximum real potential welfare benefits to account for differences in costs of living across metropolitan areas. As in the case of child care use, we estimate different specifications using cumulative annual real household income (since childbirth), average annual real household income and current real household income.

We use as measures of the child's cognitive ability the scores on the Peabody Picture Vocabulary Test (PPVT) at age 3, 4 and 5, and the Peabody Individual Achievement Test Reading Recognition subtest (PIAT-R) and Mathematics subtest (PIAT-M) at age 5 and 6. Both assessments

[24] The results of this probit are presented in Appendix 2.

are among the most widely used for preschool and early school-aged children. The PPVT is a vocabulary test for standard American English and provides a quick estimate of verbal ability and scholastic aptitude. The PIAT-M measures attainment in mathematics. It consists of eighty-four multiple-choice items of increasing difficulty. It begins with such early skills as numeral recognition and progresses to measuring advanced concepts in geometry and trigonometry. Finally the PIAT-R measures word recognition and pronunciation ability.[25]

5.2. The Sample

We use the sample of single mothers in the NLSY to estimate the child's ability production function. In particular, we require that women in our sample are single (or do not cohabitate with a male co-resident) during five years following the birth of the child and that we observe at least one test score for the child. We allow for women with multiple children. Furthermore, we interact inputs (C_t and I_t) with the number of children to account for the issue that day care use (maternal employment) and income would be expected to affect child outcomes differently depending on the number of children. Also, note that number of children may itself be endogenous in such an equation (e.g., there is a quality/quantity tradeoff). Welfare rule parameters are again used as instruments here.

There are 1,519 mothers in the NLSY who were single (with no co-resident male) during the first five years after the birth of the child and at least one test score observation was available for the child. Of these women, 251 had children between 1990 and 2000, so they are impacted by welfare waivers and TANF. Much of our leverage for identification will come from comparing behavior and outcomes of these 251 women with those for the 1,268 women whose children were born earlier, since these two groups are subject to very different welfare rules.

In Table 5 we show mean characteristics of the women in this sample compared with characteristics of all women in the NLSY. Mothers in the sample are younger than the average mother in the NLSY by more than a year and are also less educated but only by approximately 9.6 months. A considerable percentage of mothers in the sample (83%) is Hispanic or black while this proportion is 47% in the NLSY. Approximately 39% of women in the sample worked at some point during the first year after giving birth compared to 47% in the NLSY sample. The hourly wage before childbirth (for women who worked before childbirth) was lower for women in the sample and equal to $4.39 (constant dollars of 1983). Finally, women in the sample had significantly more

[25] In Appendix 3 we present a brief description of these three cognitive ability tests.

children on average than the average woman in the NLSY (3.12 vs. 2.83).

Figure 1 displays employment and child care choices after birth of women in our sample. During the first quarter after birth, about 73% of single mothers stayed at home and did not use child care, 10% returned to work full time and 4.7% part-time while using child care. Around 11.5% stayed at home and used child care. By the end of the period (5^{th} year after childbirth), 29% of women were working full-time (and used child care) and 38% continued to stay at home and did not use child care and 17% stayed at home while using child care.

6. Estimation Results

In Table 6 we present means and standard errors of the variables used in the estimation of equation (4). For example, the average log (test score) in the sample is 4.50 with a standard deviation of 0.22. 64% of women in the sample worked prior to giving birth at an average hourly rate of $4.39 (1983 dollars). On average, women in the sample had worked 4.7 years prior to childbirth and 72% of women had never been married. Average annual real household income is $10.9 thousand (1983) dollars. Finally, the total number of quarters that mothers used child care in this sample is 7.1 on average and child care was used 37% of the time (up to the date of the test) on average.

Table 7 examines the correlation of the instruments with the endogenous regressors (home inputs, C_t and I_t, and the number of children). The first column shows the R^2 of the first stage regression that includes as regressors all the exogenous variables (Z_i) in equation (10). The second column shows the R^2 of the first stage regression that includes both the exogenous variables in the main equation and all the policy variables described in Table 3. In most cases, the R^2 significantly increases from column 1 to column 2 which suggests that the welfare policy variables are quite powerful instruments. In addition, for each regressor, the instruments are jointly significant (p-value<0.001).

6.1. Estimation of the Standard Child's Ability Production Function

The first thing we want to assess is whether the effect of child care (and income) cumulates over time or is child care (and income) used in the current period what matters the most for determining children's achievement. Table 8a presents OLS and IV estimates of various specifications of equation (10). In particular, we include various combinations of cumulative and current *income* together with cumulative child care. Similarly, Table 8b presents various

specifications of (10) that include combinations of cumulative and current *child care* estimated both by OLS and IV. First, note by looking at both, Table 8a and Table 8b, that OLS estimates of the effect of child care on children's achievement are indeed upwardly biased as we expected (regardless of the measure of child care that we use). Once we use instrumental variables, the effect of child care declines with respect to the OLS estimates. Something similar happens with the estimates of the effect of household income on children's achievement, although this is not true in all cases. Second, the estimated effect of household income since the birth of the child is quantitatively small, and statistically insignificant (see columns 1 through 3 in Table 8a), given controls for mother's education. This is consistent with a view that permanent income is significant in determining parental investment in children, and hence the children's achievement, while transitory income is not.[26] Mother's education is highly significant in the child's cognitive ability production function and the magnitude of the effect is rather sizeable, but we make no attempt to disentangle the extent to which this reflects genetic transmission of maternal ability to the child vs. the impact of maternal permanent income on investment in children.

Third, both cumulative and current child care turn out to be significant (see columns 2 and 3 in Table 8b) in determining children's achievement. This result implies that recent separation from the mother matters and the effect of maternal time cumulates over time. In particular, an additional quarter of cumulative child care is associated with a reduction of approximately 0.71% in test scores[27]. That implies that using child care for one additional year, which reduces maternal contact time with the child, is associated with a reduction of about 2.62% in child's test scores, approximately 0.14 standard deviations. It is worth reminding the reader that this effect should be interpreted as effect of child care time (α_2) relative to the effect of mother's time (α_1) plus the effect of any change in goods inputs that the mother may choose as a result of using day care ($\alpha_3 \cdot \gamma_3$).

In order to assess the extent to which the effect of maternal time inputs on children's ability varies with the type of mother, we estimated equation (10) by including interactions between child care use and mother's education. In addition, we included interactions between child care and the number of children to allow for the possibility that the effect of home inputs varies depending on the

[26] This finding is reminiscent of the findings by Keane and Wolpin (2001) and Cameron and Heckman (1998) to the effect that transitory fluctuations in parental income have little effect on college attendance decisions by youth. In addition, it is consistent with findings by Blau (1999) and Carneiro and Heckman (2002) according to which permanent household income is significant in determining investments in children while transitory income is not.

[27] Bernal (2004) reports that the total effect of separation from the mother, which includes cumulative maternal employment and cumulative child care, is about 0.51% per year. She estimates the child's cognitive ability production function using the sample of married mothers in the NLSY.

number of siblings. The results are presented in Table 9. Column (1) and (2) include cumulative child care and are estimated by OLS and IV respectively while columns (3) and (4) include current child care.[28] These results indicate that the interaction between education and child care use is negative which is what we expected (child care would have a stronger negative effect the higher the education of the mother). However, this effect is not statistically significant which implies that the effect of child care use (which tends to reduce maternal contact time with the child in our framework) does not really vary with the education of the mother.

Finally, the interaction between child care and the number of children is negative but does not turn out to be significant, which means that the effect of maternal time on child's ability does not significantly vary with the number of siblings.

6.2. Age-specific Effects

The developmental psychology literature has long argued that the effect of home inputs on children's achievement crucially depends upon the time at which inputs are applied. For this reason, we estimated different specifications of equation (10) in which the effect of home inputs are allowed to vary with the age of the child. In Table 10 we present results of the first stage regressions for inputs at different ages (as well as different types of child care which we will discuss in the next section). One can see that welfare policy variables are quite powerful instruments in this case as well given the increase in the R^2 from the first column (only exogenous variables in the main equation included) to the second column (including the exogenous variables together will all the policy variables as instruments).

In Table 11 we present OLS and IV results of this estimation. Results from the IV estimation indicate that child used during the first year after childbirth does not have any detrimental effect on children's cognitive outcomes. On the other hand, cumulative child care used from the second year on has a significant and negative effect on children's achievement. This result is in agreement with the idea that child-mother interactions are more valuable when the child is ready to engage in more challenging tasks like learning a language and less so during initial stages when the child requires just feeding and very basic care. In particular, our results suggest that every additional quarter of child care after the end of the second year after childbirth is associated with a reduction of 1.4% in test scores which is a rather sizeable effect.

[28] Both, education and the number of children, are de-meaned before interacting them with inputs. Hence, the coefficient on the input can be interpreted as the effect for the average woman in the sample.

6.3. Different types of child care

In principle, one would expect the effect of separation time from the mother to differ depending on the type of child care available. In the optimal scenario we would like to evaluate the effect of child care on achievement depending on its quality. However, measuring quality with the data available in the NLSY is not an easy task. As a first approximation to this question we use instead different types of child care. In particular, we first differentiate between formal and non-formal child care. On one hand, non-formal child care refers to care provided by a relative (other parent of the child, siblings, grandparents or other relatives) or an individual who is not a relative of the child. On the other hand, formal child care is defined as any child care which is center-based, e.g., day care, nursery, pre-K or any other formal arrangement. We then turn to splitting up child care into finer type categories.[29]

The results presented in Table 12, indicate that formal child care (i.e., pre-school, formal center based care) does not have any adverse effect on cognitive outcomes. Only non-formal types of child care lead to significant reductions in child's achievement. In particular, an additional year of informal child care use is associated with a reduction of 3.5% in test scores. The estimated effect for formal care is actually positive, but insignificant. This result is consistent with the notion that a critical feature of child care is that the child could in principle benefit significantly from interactions with his/her peers regardless of the type of interactions he/she engages in with the adult in charge of the group. For example, if interactions with other children are effective in building up features such as communication skills, discipline, persistence, etc. then cognitive ability might be easier to produce. We do not, however, provide evidence that this is the mechanism in place.

In Table 13 we explore the possibility that the effect of different types of child care might vary depending on the characteristics of the mother. We do this by including interactions of both, formal and informal child care use, with mother's education. The results indicate that non-formal child care use has a significant negative effect on child's achievement regardless of the education of the mother while formal employment does not have a significant effect on the child's cognitive ability.

While it is hard to verify whether formal child care refers to child care that is of better quality than non-formal child care, we argue that this might be the case given that formal child care is more likely to be used by more educated women (which in turn determines permanent income). This

[29] In Table 10 we present first stage regressions to assess how good the instruments for predicting child care by type are. The results indicate that these are in fact powerful instruments.

would imply that formal child care is typically used by women who would be able to afford more expensive types of child care. In Table 14 we present an OLS regression of total formal child care use (in number of quarters) on several observed characteristics of the mother. The results indicate that in fact, women with higher education, fewer number of children and living in urban areas are in fact associated with more formal child care use.

Finally, in order to further explore these results we estimated equation (10) using a finer classification of child care types. In particular, we define the following three types of child care:

Child Care Types

Type	Description
1	Provided by a relative
2	Provided by a non-relative
3	All center-based

In Table 15 we present the percentage of children in a given childcare arrangement by the mother's employment status each of the three years after childbirth. Care provided by relatives is the most used childcare arrangement accounting for over 50% during the third year after the birth of the child. Center-based arrangements account for about 30% of childcare used in the third year and the reminder is accounted for by care provided by nonrelatives.

In Table 16 we present the results of this estimation. The first column shows OLS estimates while the second presents the IV estimates. Interestingly, the effect of child care provided by relatives is negative and statistically significant while care provided by nonrelatives and formal care do not have any significant effect on children's achievement. Very often a relative of the child lives in the mother's household. This individual provides child care while the mother is out working but is in general not paid. Hence the incentives to provide a good quality care are very low. In principle, one can think of this person as just being around in the household without providing a stimulating environment for the child. On the other hand, nonrelatives (e.g. nanny) and more formal types of child care tend to be more effective in providing a stimulating environment for the child or at the very least, be characterized by an individual (generally an adult) who is specifically paid to care for the child. In particular, we find that an additional year of child care provided by nonrelatives is associated with a reduction of 3.4% in test scores.

Lastly, we present a summary of our results in Table 17. These results make evident that there are important differences across types of child care and across child age ranges. Formal child care (i.e., pre-school, formal center based care) does not have any adverse effect on cognitive outcomes, nor does formal or informal care in the first two years after the birth of the child. Only non-formal types of child care lead to significant reductions in child's achievement, in particular, if used after the first year after childbirth. In particular, an additional quarter of informal child care used after the 1st year after childbirth is associated with a reduction of 1.5% in test scores. The estimated effect for formal care is actually positive, but insignificant. Maternal education is highly significant in the child's cognitive ability production function and the magnitude of this effect is rather sizeable.

7. Conclusions

This paper evaluates the effects of home inputs on children's cognitive development using the sample of single mothers in the National Longitudinal Survey of Youth (NLSY). In particular, we assess the effects of child care use (which in our framework tends to reduce maternal contact time with the child) and household income on children's test scores at 3, 4, 5 and 6 years old. Of course, an important selection problem arises when trying to assess the impact of maternal time and income on children's development. To deal with this, we take advantage of (plausibly) exogenous variation in employment and child care choices of single mothers generated by the differences in welfare regulations across states and over time. This approach is motivated by the fact that the Welfare Reform of 1996, as well as earlier State level changes adopted under Section 1115 Welfare Waivers, generated substantial increases in work and child care use. Thus, we construct a comprehensive set of welfare policy variables at the individual and State level, and use them as instrumental variables in order to estimate child cognitive ability production functions.

The main changes in the welfare system under both Section 1115 Waivers and TANF that are relevant for our exercise could be grouped into the following categories: termination and work requirement time limits, earnings disregard, child care assistance and child support enforcement. States differ greatly in terms of the rules they have adopted in each of these dimensions. Thus, we construct an extensive set of State and individual-specific welfare rules variables, and use these as instrumental variables in the estimation of the cognitive ability production function. Most of the leverage for identification comes from comparing behavior and child outcomes of women who had children between 1990 and 2000, so they were impacted by welfare waivers and TANF, with women

whose children were born earlier, since these two groups are subject to very different welfare rules.

The study of the case of single mothers extends earlier work by Bernal (2003), who estimated the effects of parental time inputs on children of married women in the NLSY. A key motivation of this work is to see whether her results on the importance of maternal time inputs generalize from married to single mothers. Second, the study of single mothers is of special interest, given the huge welfare policy changes that have substantially altered their work decisions in recent years.

The main results indicate that the effect of child care use on children's achievement is negative, significant and rather sizeable. In particular, one additional year of child use is associated with a reduction of approximately 2.8% in test scores (depending slightly on the particular specification of the cognitive ability production function). This corresponds to 0.14 standard deviations, so it is a substantial effect.

However, this general finding masks important differences across types of child care and across child age ranges. Formal child care (i.e., pre-school, formal center based care) does not have any adverse effect on cognitive outcomes, nor does formal or informal care in the first year after the birth of the child. Only non-formal types of child care lead to significant reductions in child's achievement, in particular, if used after the first year after childbirth. In particular, an additional year of informal child care use is associated with a reduction of 3.5% in test scores. The estimated effect for formal care is actually positive, but insignificant.

In addition, the estimated effect of household income since the birth of the child is quantitatively small, and statistically insignificant, given controls for mother's education. This is consistent with a view that permanent income is significant in determining parental investment in children, and hence the children's achievement, while transitory income is not.[30] Mother's education is highly significant in the child's cognitive ability production function, but we make no attempt to disentangle the extent to which this reflects genetic transmission of maternal ability to the child vs. the impact of maternal permanent income on investment in children.

The results presented are quite interesting in the sense that they suggest that while separation from the mother has a negative effect on child's ability this can be partially offset by the appropriate choice of day care.

[30] This finding is reminiscent of the findings by Keane and Wolpin (2001) and Cameron and Heckman (1998) to the effect that transitory fluctuations in parental income have little effect on college attendance decisions by youth.

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Table 1

Literature Review: The effect of maternal employment on children's cognitive ability

(Studies that use NLSY data)

Author, year	Sample	Method	Effect of mother's employment
Mott, 1991	2387 1-4 yr olds	OLS	Negative effects
Harvey, 1999	3-12 yr olds	OLS	Negative effects
Ruhm, 2000	3-6 yr olds	OLS	Negative effects
Han et al., 2001	462 birth-8 yrs	OLS	Negative effects
Vandel & Ramanan, 1992	1889 2nd graders	OLS	Positive effects
Parcel & Menaghan, 1994	768 3-6 yr olds	OLS	Positive effects
Greenstein, 1995	2040 4-6 yr olds	OLS	Insignificant effects
Moore & Driscoll, 1997	1154 5-14 yr olds	OLS	Insignificant effects
James-Burdumy, 2005	498 3-4 yr olds	FE and IV FE[1]	Differing depending on test used
Waldfogel, et al., 2000	1872 birth-8 yrs	OLS and FE	Differing depending on group
Desai, et al., 1989	503 4 yr olds	OLS	Differing depending on group
Baydar & Brooks-Gunn, 1991	572 4 yr olds	OLS	Differing depending on timing
Blau & Grossberg, 1992	8784 3-4 yr olds	OLS and IV[2]	Differing depending on timing

[1] Household FE, and instruments are local market conditions, e.g., county unemployment rate and percentage of the labor force in the services sector.

[2] Instruments are fitted values of tobit regressions for maternal labor supply on race, region or residence, maternal and child health, marital status, nonmaternal family income, and the predicted wage.

Table 2

Literature Review: The effect of child care on children's cognitive ability

Author, year	Sample	Method	Effect of child care use
Blau, 1999	2000+ 3-5 yr olds	OLS and FE[1]	Negative effects
Baydar and Brooks-Gunn, 1991	572 4 yr olds	OLS	Negative effects (vary with timing)
Desai, et al., 1989	503 4 yr olds	OLS	Negative effects (only for boys)
Vandell & Corasaniti, 1990	236 8-year olds	OLS	Negative effects
Thornburg et al., 1990	835 kindergarten children	OLS	Insignificant effects
Ackerman-Ross and Khanna, 1989	3-yr olds, whites	OLS	Insignificant effects
Parcel and Menaghan, 1990	697 3-6 yr olds	OLS	Insignificant effects
Studer, 1992	95 children	OLS	Insignificant effects
Burchinal et al., 1995	6-12 yr olds	OLS	Insignificant effects
Caughy, et al., 1994	867 5-6 year olds	OLS	Differing depending on background
Dunn, 1993	4-yr olds, middle-class	OLS	Differing depending on quality of daycare
Clarke-Stewart et al., 1994	2-4 yr olds, middle class	OLS	Differing depending on quality of daycare
NDCS, Ruopp, et al., 1979	1600 preschool children	Experiment[2]	Differing depending on measure of quality
NICHD, Duncan, 2003	1162 24-54 months old	OLS and FE[3]	Positive effects (of high quality daycare)

[1] Household fixed effects.

[2] National Day Care Study randomly assigned to classrooms with different staff-child ratios and teachers with different levels of training. However, the 64 day care centers were not randomly selected.

[3] Child fixed effects.

Table 3

List of Instruments

Variable	Description
	Individual Level Welfare Policy Variables
BEN_{ist}	Real AFDC/TANF maximum benefits, calculated using the state level benefit rule and the mother's family composition.
$EITC_{ist}$	EITC phase in rate constructed fromboth the federal and state level EITC rules, together with mother's family composition.
TL_HIT_{ist}	Dummy variable indicating whether a woman would have hit time limit
$ELAPSED\_TL\_HIT_{ist}$	Time elapsed since woman i may potentially be subject to time limit
$REMAIN\_TL\_ELIG_{ist}$	Maximum potential remaining length of a woman's time limit, constructed: TL_LENGTH_{st}-min{$AGE\_OLDEST\_CHILD_{ist}$, $ELAPSED\_TL_{st}$}
$REMAIN\_ELIG_{ist}$	Remaining length of time to be categorically eligible for welfare benefits: 18-$AGE\_YOUNGEST\_CHILD_{ist}$
WR_HIT_{ist}	Indicator for whether a woman could be subject to a work requirement: =1 if[$WR\_LENGTH_{st} \leq \min\{AGE\_OLDEST\_CHILD_{ist}, ELAPSED\_WR_{st}\}$ & $AGE\_YOUNGEST\_CHILD_{ist} \geq AGE\_CHILD\_EXEM_{st}$]
$ELAPSED\_WR\_HIT_{ist}$	Time elapsed since woman i may be potentially subject to work requirement
	State Level Policy Variables
TLI_{st}	Dummy for whether state s has time limit in place in period t.
TL_LENGTH_{st}	Length of time limit in state s in period t.
$ELAPSED\_TL_{st}$	Time (in months) elapsed since the implementation of time limit in state s.
$DCHILDBEN_{st}$	Dummy variable indicating whether the child portion of the welfare benefit continues after time limit exhaustion
DWR_{st}	Dummy for whether state s has work requirement in place in period t.
WR_LENGTH_{st}	Length (in months) of work requirement limit in state s in period t.
$ELAPSED\_WR_{st}$	Time (in months) elapsed since the implementation of work requirement in state s.
$CHILD\_EXEM_{st}$	Dummy for whether state s has age of youngest child exemption in place at t
$AGE\_CHILD\_EXEM_{st}$	Age of youngest child below which the mother will be exempted from work requirement in state s at time t.
$WR\_ULT\_SANC_{st}$	Dummy for whether state s has a full sanction for non-compliance of work requirement in state s at time t.
$EXEMP_{st}$	Number of work requirement exemptions in state s
$FLAT\_DISREGARD_{st}$	Flat amount of earnings disregarded in calculating the benefit amount.
$PERC\_DISREGARD_{st}$	Benefit reduction rate (Does not include phase-out)
$CHILDCARE_{st}$	CCDF expenditure per single mother in state s at time t.
$ENFORCE_{st}$	Child support enforcement expenditure in state s at year t per single mother.
	Other Local Market Variables
UE_{st}	Unemployment rate in State s in period t
$SWAGE_{st}$	Hourly wage rate at the 20th percentile of the wage distribution in State s in period t.

Table 4

Control Variables in the Cognitive Ability Production Function

Variable	Description
AGE_i	Mother's age at childbirth
$EDUC_i$	Mother's educational attainment at childbirth
$I[WORK\_BEF]_i$	Dummy for whether mother worked prior to childbirth
$I[WORK\_BEF]_i$ x $HWAGE_{oi}$	Work dummy interacted with the average hourly wage* of the mother prior to childbirth
$EXPBEF_i$	Mother's total work experience (in number of years) prior to childbirth
$MARAFT_i$	Mother's marital status at time of child's test
$URBAN_i$	Urban/Rural residence at time of child's test
$NUMCHILD_i$	Number of children
$RACE_i$	Child's race (1 if black/hispanic, 0 otherwise)
$GENDER_i$	Child's gender (1 if male, 0 if female)
BW_i	Child's birthweight
$AGECHILD_i$	Child's age at assessment date
$dPPVT_i$	Dummy for whether the corresponding test is PPVT
$dMATH_i$	Dummy for whether the corresponding test is PIAT-MATH

*Average hourly wage for the 18-month period prior to childbirth

Table 5

Mean Characteristics of Mothers in the Sample

Description		NLSY	Our Sample	ttest
Worked within 4 quarters after birth		0.47	0.39	**
		(0.004)	(0.015)	
Mother's age in years at birth		24.8	23.13	**
		(0.053)	(0.054)	
Mother's education in years at birth year		12.0	11.2	**
		(0.024)	(0.054)	
Hispanic or Black		0.47	0.83	**
		(0.004)	(0.013)	
Hourly wage before birth		6.71	4.39	**
		(0.22)	(0.06)	
	Obs	5728	977	
Total number of children of mother		2.83	3.12	**
		(0.012)	(0.043)	
Father present at birth		0.55	-	
		(0.004)		
Observations		4814	1519	

Table 6

Summary of Variables used in the Empirical Analysis

Variable	Mean (standard error)
log(Test Score)	4.49855 (0.2204)
Mother's education	11.208 (1.8972)
Mother's age	23.136 (4.5820)
Boys (Children of single mothers)	0.4976 (0.5001)
Hispanic or Black	0.8262 (0.3790)
Birthweight	111.97 (21.9760)
Mother worked before giving birth	0.6431 (0.4792)
Wage rate prior to giving birth	4.3938 (2.0075)
Accumulated work experience prior to giving birth (number of years)	4.7202 (6.0088)
Never married after childbirth	0.7215 (0.4483)
Separated after childbirth	0.1540 (0.3611)
Divorced after childbirth	0.1158 (0.3201)
Urban	0.8189 (0.3851)
Average Yearly Income (Thousands)	10.92743 (13.5677)
Cumulative Income (Thousands)	51.1787 (67.4148)
Average Child Care Use (% of periods)	0.3777 (0.3203)
Cumulative Child Care Use (Quarters)	7.0923 (6.1273)

Table 7

R-squared Values for First Stage Regressions of Inputs on Instruments Set

Input	R-squared with variables in main eqtn as instruments	R-squared adding policy variables to instrument lis
Cumulative Child Care Use	0.4529	0.5136
Average Child Care Use	0.4442	0.5056
Current Child Care Use	0.3171	0.3620
Cumulative Non-formal Child Care	0.3249	0.3847
Average Non-formal Child Care	0.3141	0.3739
Cumulative Formal Child Care	0.0806	0.1191
Average Formal Child Care	0.0826	0.1172
Cumulative Income	0.2002	0.2462
Current Income	0.1008	0.1166
Average Income	0.1435	0.1929
Number of Children	0.2286	0.4420

Instrument list in first column: mother's education and age, child's race, gender, birthweight, indicator for whether mother worked prior to giving birth or not, work indicator interacted with wage rate prior to giving birth, accumulated work experience prior to giving birth, marital status, urban/rural, test dummies.
Instrument list in second column: Same as in first column plus all policy variables in Table 1.

Table 8a

Does Income Matter for Children's Achievement?

Independent Variable -> Log(Test Score)

	(1)	(2)	(3)	(4)	(5)	(6)
Log(Cumulative Income)	0.05368	0.02860		-0.00480	0.00186	
	(0.0297)	(0.0215)		(0.0058)	(0.0046)	
Log(Current Income)	-0.04991		-0.00185	0.00795		0.00575
	(0.0397)		(0.0286)	(0.0043)		(0.0034)
Cumulative Child Care	-0.00749	-0.00714	-0.00592	0.00095	0.00101	0.00085
	(0.0029) **	(0.0029) *	(0.0027) *	(0.0007)	(0.0007)	(0.0007)
Mother's education	0.01771	0.01544	0.01708	0.01344	0.01356	0.01338
	(0.0033) **	(0.0027) **	(0.0032) **	(0.0020) **	(0.0020) **	(0.0020) **
Child's age	0.03149	0.03660	0.04351	0.03017	0.02824	0.02889
	(0.0111) **	(0.0101) **	(0.0086) **	(0.0067) **	(0.0066) **	(0.0065) **
Method of Estimation	IV	IV	IV	OLS	OLS	OLS
Number of Observations	3,787	3,787	3,787	3,787	3,787	3,787
R-squared	0.3083	0.3416	0.3482	0.3710	0.3704	0.3708

Instruments are: all policy variables, educ, workbef, workbef*wage, expbef, race, gender, BW, mom's age, marital status, urban/rural, test dummies, unemployment rate in State and avg hrly wage at 20 percentile of wage distribution in State.

Table 8b

Do maternal time inputs matter for children's achievement?

Independent Variable -> Log(Test Score)

	(1)	(2)	(3)	(4)	(5)	(6)
Cumulative Child Care	-0.00487	-0.00714		-0.00102	0.00101	
	(0.0067)	(0.0029) *		(0.0010)	(0.0007)	
Current Child Care	-0.01128		-0.03109	0.00955		0.00708
	(0.0303)		(0.0131) *	(0.0032) **		(0.0022) **
Log(Cumulative Income)	0.03125	0.02860	0.03381	0.00141	0.00186	0.00055
	(0.0228)	(0.0215)	(0.0227)	(0.0046)	(0.0046)	(0.0045)
Mother's education	0.01572	0.01544	0.01597	0.02764	0.01356	0.01309
	(0.0028) **	(0.0027) **	(0.0028) **	(0.0081) **	(0.0020) **	(0.0019) **
Child's age	0.03328	0.03660	0.02627	0.03067	0.02824	0.02938
	(0.0135)	(0.0101) **	(0.0095)	(0.0066) **	(0.0066) **	(0.0065)
Estimation Method	IV	IV	IV	OLS	OLS	OLS
Number of Observations	3,787	3,787	3,787	3,787	3,787	3,787
R-squared	0.3349	0.3416	0.3192	0.3718	0.3704	0.3717

Instruments are: all policy variables, educ, workbef, workbef*wage, expbef, race, gender, BW, mom's age, marital status, urban/rural, test dummies, unemployment rate in State and avg hrly wage at 20 percentile of wage distribution in State.

Table 9

Estimation of the Cognitive Ability Production Function including Interaction Terms

Independent Variable -> Log(Score)

	Mean (sd error)	(1)		(2)	(3)		(4)	
Log(Cumulative Income)	3.6332	0.00162		0.03146	0.00037		0.02382	
	(0.7304)	(0.0046)		(0.0245)	(0.0045)		(0.0249)	
Cumulative Child Care	7.0927	0.00088		-0.00604				
	(6.1273)	(0.0007)		(0.0034)				
Current Child Care	1.7437				0.00665		-0.02194	
	(1.5957)				(0.0023)	**	(0.0141)	
$\tilde{}$								
Education*(Cum./ Current Child Care)	85.2842	-0.00071		-0.00239	-0.00128		-0.01246	
	(78.7920)	(0.0003)	**	(0.0028)	(0.0011)		(0.0082)	
Number of Children*(Cum./Current Child Care)	7.7095	-0.00112		-0.00423	-0.00219		-0.01017	
	(10.8655)	(0.0004)		(0.0023)	(0.0016)		(0.0091)	
Mother's Education	11.210	0.01828		0.03002	0.01526		0.03670	
	(1.8567)	(0.0027)	**	(0.0196)	(0.0027)	**	(0.0149)	*
No. of observations		3,787		3,787	3,787		3,787	
Estimation Method		OLS		IV	OLS		IV	
R-squared		0.3723		0.3388	0.3721		0.3246	

$\tilde{}$

Education=Education-$\overline{\text{Education}}$ (same for Number of Children)

Instrument list includes: all policy variables, educ, workbef, workbef*wage, expbef, race, urban/rural, test dummies, gender, BW, mom's age, marital status and unemployment rate in State and avg hrly wage at 20 percentile of wage distribution in State.

Table 10

R-squared Values for First Stage Regressions of Inputs on Instruments Set

Input	R-squared with variables in main eqtn as instruments	R-squared adding policy variables to instrument lis
Cumulative Formal Child Care	0.0806	0.1191
Cumulative Non-Formal Child Care	0.3249	0.3847
Cumulative Child Care by Nonrelatives	0.0925	0.1252
Cumulative Child Care by Relatives	0.2094	0.2775
Cumulative Child Care in 1st year	0.3442	0.3893
Cumulative Child Care after 1st Year	0.4352	0.4951
Cumulative Formal Child Care in 1st Year	0.0418	0.0799
Cumulative Formal Child Care after 1st Year	0.0805	0.1153
Cumulative Non-Formal Child Care in 1st Year	0.2785	0.3225
Cumulative Non-Formal Child Care after 1st Year	0.3026	0.3614

Instrument list in first column: mother's education and age, child's race, gender, birthweight, indicator for whether mother worked prior to giving birth or not, work indicator interacted with wage rate prior to giving birth, accumulated work experience prior to giving birth, marital status, urban/rural, test dummies.
Instrument list in second column: Same as in first column plus all policy variables in Table 1.

Table 11

Age-Specific Effects of Home Inputs on Children's Achievement

Independent Variable -> Log(Score)

	Mean (sd error)	(1)	(2)	
Log(Cumulative Income)	3.6332	0.00170	0.03405	
	(0.7304)	(0.0046)	(0.0221)	
Cumulative Child Care 1st year	1.0817	0.00483	0.02786	
	(1.3332)	(0.0031)	(0.0201)	
Cumulative Child Care after 1st year	6.0110	0.00027	-0.01418	
	(5.1614)	(0.0009)	(0.0049)	**
No. of observations		3,787	3,787	
Method of Estimation		OLS	IV	
R-squared		0.3707	0.3220	

Instruments are: all policy variables, educ, workbef, expbef, workbef*wage, race,urban/rural test dummies, gender, BW, mom's age, marital status, and unemployment rate in State and avg hrly wage at 20 percentile of wage distribution in State.

Table 12

Effect of Different Types of Child Care on Children's Achievement

Independent Variable -> Log(Score)

	Mean (s.d.)	(1)	(2)
Log(Cumulative Income)	3.6332	0.00166	0.03492
	(0.7304)	(0.0046)	(0.0220)
Cumulative Non-formal child care	5.85331	0.00065	-0.00876
	(5.8728)	(0.0007)	(0.0030) **
Cumulative Formal child care	1.2229	0.00324	0.00379
	(3.0551)	(0.0011) **	(0.0054)
No. of observations		3,787	3,787
Method of Estimation		OLS	IV
R-squared		0.3715	0.3241

Non-formal child care: other parent, sibling, grandparent, other relative, nonrelative of child.
Formal child care: day care, nursery, pre-K, mother at work, other formal arrangement.
Instruments are: all policy variables, educ, workbef, workbef*wage, expbef, race, urban/rural, test dummies, gender, BW, mom's age, marital status, unemployment rate in State and avg hrly wage at 20 percentile of wage distribution in State.

Table 13

Child Care Types and Interactions with Maternal Education

Independent Variable -> Log(Score)

	(1)	(2)
Log(Cumulative Income)	0.00261	0.02930
	(0.0046)	(0.0248)
Cumulative Non-formal child care	0.00068	-0.00863
	(0.0007)	(0.0040) *
Cumulative Formal child care	0.00412	0.01046
	(0.0012) **	(0.0067)
$\tilde{}$		
Mother's education * Non-formal	-0.00050	-0.00118
	(0.0003)	(0.0038)
$\tilde{}$		
Mother's education * Formal	-0.00120	-0.00655
	(0.0006) *	(0.0039)
No. of observations	3,787	3,787
Method of Estimation	OLS	IV
R-squared	0.3726	0.3145

$\tilde{}$ $\overline{}$

Education=Education - Education

Table 14

Who is using formal child care?

Independent Variable -> Formal Child care (0 if non-formal)	(1)
Mother's education	0.12126
	(0.0149) **
Mother's age at birth	-0.01140
	(0.0056) *
Number of children	-0.08925
	(0.0191) **
Urban/rural	0.17590
	(0.0637) **
No. of observations	12,167
Method of Estimation	Logit
R-squared	0.0116

Table 15

Percentage of Children in a Given Child Care Arrangement

Child Care arrangement	Relative			Nonrelative			Center-based		
Mother's working status	No work	Part-time	Full-time	No work	Part-time	Full-time	No work	Part-time	Full-time
Year 1	19.40	19.17	30.07	7.12	3.83	7.96	5.60	2.14	4.72
Year 2	16.05	18.77	26.39	5.71	4.30	8.83	6.45	4.30	9.20
Year 3	12.68	16.25	25.15	5.85	3.42	6.18	11.51	6.26	12.71

Source: Mothers in the subsample we use from the National Longitudinal Survey of Youth.

Table 16

Effect of Different Types of Child Care on Child's Achievement

Independent Variable -> Log(Score)	Mean (sd error)	(1)	(2)
Log(Cumulative Income)	3.6332	0.00178	0.04303
	(0.7304)	(0.0046)	(0.0225)
Cumulative Child Care by Relatives	5.00766	0.00033	-0.00858
	(5.7360)	(0.0007)	(0.0029) **
Cumulative Child Care by Nonrelatives	1.14537	0.00168	0.00254
	(3.3549)	(0.0010)	(0.0061)
Cumulative Formal Child Care	1.2229	0.00327	0.00584
(Daycare, Nursery, Pre-K, Other)	(3.0551)	(0.0011) **	(0.0056)
No. of observations		3787	3787
Method of Estimation		OLS	IV
R-squared		0.3718	0.3131

Instruments are: all policy variables, educ, workbef, workbef*wage, expbef, race, urban/rural, test dummies,gender,BW, mom's age, marital status, unemployment rate in State and avg hrly wage at 20 percentile of wage distribution in State.

Table 17

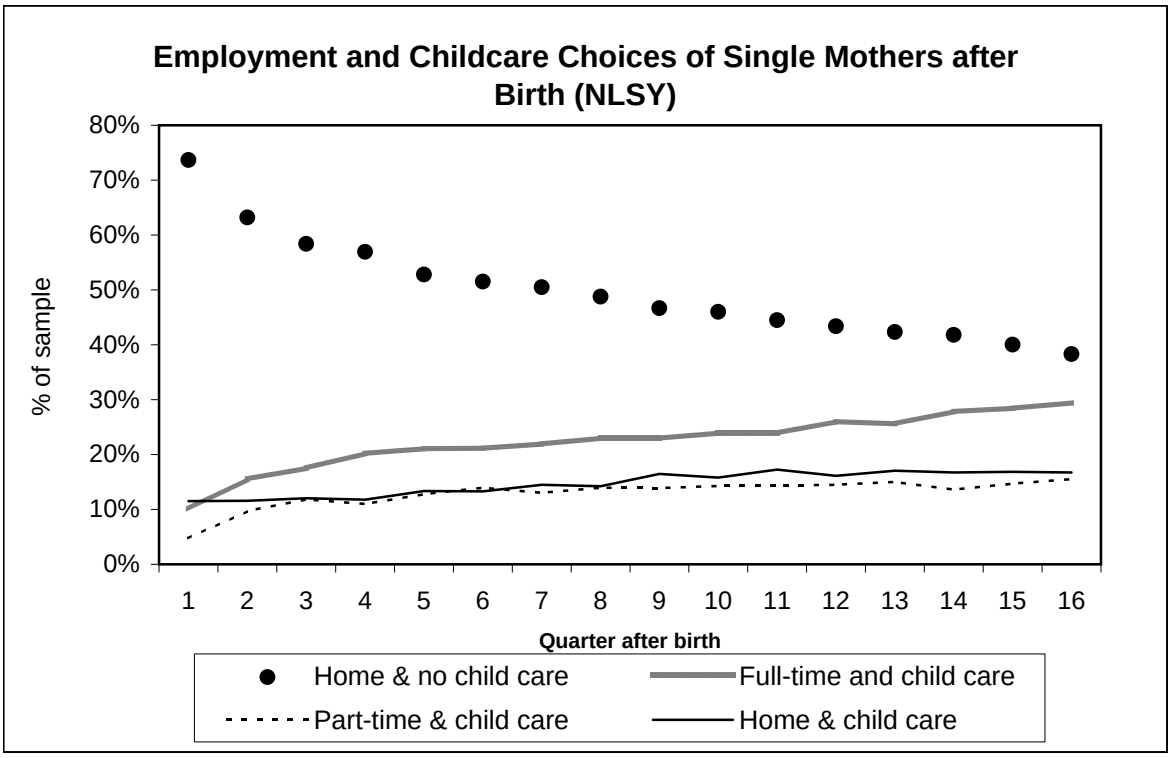
Child Care Type and Age-Specific Effects

Independent Variable -> Log(Score)

	(1)	(2)
Log(Cumulative Income)	0.00162	0.03187
	(0.0046)	(0.0235)
Cumulative Non-formal child care in 1st year	0.00569	0.03184
	(0.0032)	(0.0217)
Cumulative Formal child care in 1st year	0.00002	-0.06270
	(0.0065)	(0.0605)
Cumulative Non-Formal after 1st year	-0.00037	-0.01573
	(0.0009)	(0.0053) **
Cumulative Formal after 1st year	0.00350	0.01755
	(0.0015) *	(0.0140)
Mother's Education	0.01341	0.01338
	(0.0020) **	(0.0031) **
No. of observations	3,787	3,787
Method of Estimation	OLS	IV
R-squared	0.3721	0.2695

Instruments are: all policy variables, educ, workbef, workbef*wage, expbef, race, urban/rural, test dummies,gender,BW, mom's age, marital status, unemployment rate in State and avg hrly wage at 20 percentile of wage distribution in State.

Figure 1


Employment and Childcare Choices of Single Mothers after Birth (NLSY)
% of sample
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Quarter after birth
Home & no child care
Full-time and child care
Part-time & child care
Home & child care

Appendix 1, Table 1

Effect of PIAT math score on highest grade completed by 2000 (sample=young adults 18 years or older)

Independent Variable -> Highest grade completed by 2000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Child's age	0.71401	0.69766	0.47309	0.45409	0.45553	0.43364	0.37124	0.37089
	(0.0746) **	(0.0753) **	(0.0739) **	(0.0437) **	(0.0442) **	(0.0437) **	(0.0302) **	(0.0298) **
Highest grade completed by mother	0.07918	0.07037	0.11736	0.10131	0.09371	0.07064	0.10381	0.0907
	(0.0305) **	(0.0310) *	(0.0246) **	(0.0247) **	(0.0257) **	(0.0257) **	(0.0209) **	(0.0208) **
Highest grade completed by father	0.02249	0.02196	0.01055	0.00872	0.02134	0.02084	0.02006	0.01862
	(0.0075) **	(0.0075) **	(0.0063)	(0.0063)	(0.0069) **	(0.0068) **	(0.0055) **	(0.0054) **
Number of siblings	-0.14261	-0.13519	-0.10860	-0.08797	-0.12012	-0.10681	-0.11070	-0.09881
	(0.0540) **	(0.0541) *	(0.0429) **	(0.0428) *	(0.0448) **	(0.0441) *	(0.0371) **	(0.0367) **
Birthorder	-0.15080	-0.13690	-0.11102	-0.11429	-0.29831	-0.27837	-0.14830	-0.12800
	(0.0952)	(0.0955)	(0.0760)	(0.0753)	(0.0826) **	(0.0813) **	(0.0680) *	(0.0674)
Race (1=Non-white)	-0.02519	0.01885	-0.18257	-0.08331	-0.08243	0.04393	-0.12843	-0.02866
	(0.1375)	(0.1403)	(0.1147)	(0.1162)	(0.1298)	(0.1299)	(0.1021)	(0.1030)
Gender (1=Male)	-0.42276	-0.41110	-0.44052	-0.39409	-0.39885	-0.38089	-0.37596	-0.36932
	(0.1233) **	(0.1233) **	(0.1013) **	(0.1010) **	(0.1115) **	(0.1097) **	(0.0895) **	(0.0885) **
Mother's age at child's birth	-0.00402	-0.00718	0.03689	0.02752	0.02122	0.01163	0.02408	0.02141
	(0.0333)	(0.0333)	(0.0281)	(0.0279)	(0.0303)	(0.0299)	(0.0253)	(0.0250)
Math test score at 5,6, 7 and 8 respectively		0.00695		0.01942		0.02636		0.01873
		(0.0046)		(0.0048) **		(0.0052) **		(0.0039) **
Constant	-2.89019	-3.15490	0.50874	-0.79186	1.57898	-0.28850	2.86558	1.13114
	(1.8040)	(1.8096)	(1.1989)	(1.2295)	(1.2647)	(1.2959)	(0.9632) **	(1.0185)
No. of observations	451	451	747	747	725	725	953	953
R-squared	0.2731	0.2770	0.2193	0.2363	0.2376	0.2644	0.2342	0.2524

All estimated by OLS.

Appendix 1, Table 2

Effect of PIAT reading score on highest grade completed by 2000 (sample=young adults 18 years or older)

Independent Variable -> Highest grade completed by 2000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Child's age	0.72641	0.68911	0.48339	0.45601	0.44787	0.41965	0.37423	0.36614
	(0.0744) **	(0.0759) **	(0.0439) **	(0.0438) **	(0.0444) **	(0.0435) **	(0.0303) **	(0.0298) **
Highest grade completed by mother	0.08719	0.06956	0.11852	0.10068	0.09516	0.06815	0.10881	0.09303
	(0.0299) **	(0.0308) *	(0.0246) **	(0.0246) **	(0.0261) **	(0.0257) **	(0.0212) **	(0.0211) **
Highest grade completed by father	0.02140	0.02103	0.01145	0.01055	0.02059	0.01905	0.01836	0.01708
	(0.0075) **	(0.0074) **	(0.0064)	(0.0063)	(0.0069) **	(0.0068) **	(0.0055) **	(0.0054) **
Number of siblings	-0.13678	-0.12196	-0.10301	-0.08956	-0.11714	-0.09503	-0.11297	-0.08873
	(0.0532) **	(0.0533) *	(0.0428) *	(0.0424) *	(0.0438) **	(0.0428) *	(0.0374) **	(0.0370) *
Birthorder	-0.12581	0.09980	0.10297	-0.07822	-0.29154	-0.22705	-0.14569	-0.10268
	(0.0943)	(0.0946)	(0.0758)	(0.0750)	(0.0825) **	(0.0809) **	(0.0683) *	(0.0675)
Race (1=Non-white)	-0.05501	-0.01070	-0.21423	-0.21101	-0.10961	-0.03640	-0.12561	-0.02483
	(0.1368)	(0.1376)	(0.1148)	(0.1133)	(0.1303)	(0.1275)	(0.1024)	(0.1020)
Gender (1=Male)	-0.43075	-0.41201	-0.42985	-0.37530	-0.38355	-0.31066	-0.37185	-0.32158
	(0.1227) **	(0.1224) **	(0.1013) **	(0.1007) **	(0.1115) **	(0.1095) **	(0.0902) **	(0.0892) **
Mother's age at child's birth	-0.01734	-0.01962	0.04418	0.03350	0.01723	0.00605	0.02654	0.01373
	(0.0330)	(0.0328)	(0.0280)	(0.0278)	(0.0303)	(0.0296)	(0.0255)	(0.0252)
Math test score at 5,6, 7 and 8 respectively		0.01072		0.02483		0.02843		0.02079
		(0.0047) *		(0.0055) **		(0.0045) **		(0.0034) **
Constant	-2.98847	-3.27195	0.12992	-1.56154	1.77338	-0.27716	2.71491	0.95156
	(1.7899)	(1.7862)	(1.1978)	(1.2405)	(1.2676)	(1.2772)	(0.9669) **	(0.9946)
No. of observations	446	446	739	739	724	724	947	947
R-squared	0.2800	0.2882	0.2247	0.2457	0.2301	0.2705	0.2308	0.2589

All estimated by OLS.

Appendix 2

Probit we use to predicted child care choices of non-working women in years 4 and 5 after childbirth

Dependent Variable-> Pr(using child care in *t*)	
Whether worked before giving birth	0.59202 (0.2078) **
(Whether worked before) x (Avg. wage before)	-0.06419 (0.0398) *
Total work experience (prior to giving birth)	-0.00599 (0.0194)
Child's race	-0.08744 (0.1702)
Child's gender	0.04967 (0.1196)
Mother's education	0.08213 (0.0384) **
Total work experience since child birth	-0.39835 (0.0698) **
Total child care use since child birth	0.22263 (0.0527) **
Whether used child care or not in *t-1*	1.78009 (0.1639) **
Estimation	Probit
Number of observations	867
Pseudo-R^2	0.4585

Additional controls: Marital status at child birth (never married, separated, divorced, widowed), urban/rural residence and mother's age at birth.

Appendix 3

Cognitive Ability Tests in our NLSY sample

Descriptive Statistics

	PPVT			PIAT - Math		PIAT-Reading	
Child's Age	3	4	5	5	6	5	6
Sample (N=1,519)	80.263	74.334	83.767	94.719	94.802	104.089	100.585
	(14.952)	(19.512)	(17.504)	(14.329)	(11.727)	(15.319)	(9.462)
Non-whites	78.007	70.836	82.135	93.836	94.247	103.358	100.482
	(14.169)	(17.958)	(16.889)	(14.289)	(11.685)	(15.454)	(9.269)
Whites	92.167	89.299	93.852	99.576	97.657	108.100	101.112
	(13.348)	(18.885)	(18.001)	(13.634)	(11.578)	(13.970)	(10.422)
Maternal education (12 yrs+)	82.820	78.748	88.743	97.084	96.823	106.755	102.265
	(14.369)	(18.917)	(17.648)	(14.178)	(11.663)	(15.131)	(9.425)
Maternal education (<12 yrs)	76.301	68.748	79.508	91.767	92.751	100.697	98.847
	(15.025)	(18.847)	(16.245)	(13.991)	(11.449)	(14.909)	(9.197)
Male	79.753	72.242	83.035	93.726	93.710	102.557	99.232
	(14.664)	(20.048)	(18.143)	(14.307)	(12.292)	(15.563)	(9.404)
Female	80.707	76.299	84.569	95.739	95.827	105.685	101.838
	(15.225)	(18.820)	(16.783)	(14.305)	(11.091)	(14.922)	(9.357)

PPVT: Peabody Picture Vocabulary Test

PIAT: Peabody Individual Achievement Test