Do Maternal Investments in Human Capital Affect Children's Academic Achievement?[⊗]

Quinn Moore
Department of Economics
University of Michigan

Lucie Schmidt
Department of Economics
Williams College

May 2004

[⊗] Katie Vitello provided excellent research assistance. We are grateful to Richard Arum, Paula Baker, Rebecca Blank, Katalin Bognar, Charles Brown, Andreas Pape, Viji Sathy, Purvi Sevak, and Heidi Shierholz for useful comments and suggestions. All errors and omissions are our own. Moore wishes to acknowledge financial support from the National Science Foundation. Corresponding Author: Lucie Schmidt, Department of Economics, Fernald House, Williams College, Williamstown, MA 01267; lschmidt@williams.edu.

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Abstract

Children of educated mothers fare better on a variety of educational outcomes. However, little research has been done on the effects of human capital investments undertaken by mothers with children at home. Such investments have a theoretically ambiguous effect on child outcomes, since human capital investment reduces time spent with children but may have positive spillover effects on child investment. Using child- and sibling-fixed effects models to deal with unobserved heterogeneity, we find that cumulative maternal schooling undertaken during a child's lifetime has significant positive effects on child outcomes, and that negative time allocation effects are minimal.

I. Introduction

Maternal education level is consistently found to be positively correlated with children's cognitive development and educational outcomes. In 1998, the National Center for Education Statistics (NCES) reported that of first-time kindergartners, 16% of children with high school graduate mothers scored in the highest quartile on reading. For college-educated mothers, this percentage was 46%.[1] These strong correlations seem to suggest that from a policy standpoint, encouraging mothers to acquire additional education may positively affect children's educational outcomes. However, once time inputs are considered, the theoretical predictions of the effect of a mother's return to schooling are ambiguous. In this paper, we seek to answer an important policy relevant-question: What is the relationship between the educational investments of mothers and their children's outcomes?

There are several mechanisms through which parental educational decisions might affect child outcomes. The human capital investment model (Becker, 1981; Becker & Tomes, 1986) focuses on the key insight that resources within the family are limited, and that parents make decisions regarding the level of resources to invest in their children versus the amount to spend on consumption. This approach suggests that highly educated parents, with greater levels of income, may invest more in their children's education. In addition, highly skilled parents may be more productive in parenting,

[1] One possible mechanism for this effect is genetics, but differences in inputs to the parenting process may also be important. For example, NCES also reported that 39% of kindergartners with high school graduate mothers were read to every day, as compared with 59% of kindergartners whose mothers had a Bachelor's degree or higher.

generating larger increases in child human capital for a given cost. Alternative theories suggest possible role model effects, where the transmission of parental behaviors to children is through socialization (Woelfel and Haller, 1971).

As would be predicted from these theories, the existing empirical evidence consistently finds that higher levels of completed parental education are strongly and positively associated with child outcomes. For young children, higher levels of completed parental education are significantly positively correlated with higher standardized test scores (Liebowitz, 1977, Blau and Grossberg, 1992). For older children, high school graduation and years of schooling completed are positively and significantly affected by the level of completed parental education.[2] Furthermore, maternal education is generally found to have a larger effect than father's education on children's educational outcomes (Haveman and Wolfe, 1995).

A conclusion frequently drawn from these and related findings on the relationship between maternal education level and child academic achievement is that children would be well served if mothers were encouraged to obtain additional education. In a recent chapter of an edited volume on investments in children, Lisa Lynch argues:

> [O]ne of the most important determinants of education is parental education. If we want to raise education levels in the United States, we need to consider investments in both youths and their parents, recognizing that parents are teachers too. Raising the skills and education of incumbent workers not only makes them more productive in the workplace but also contributes to the education of their children (Lynch (2000), 43-44).

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[2] See Haveman and Wolfe (1995) for a survey of this literature.

Implicit in this policy prescription is the assumption that human capital investments undertaken by women while they are mothering children will have positive effects on family outcomes. It is not clear that this assumption is justified by theory. A simple model of household time allocation would suggest that time spent on human capital investment would reduce time spent with children, and thus negatively impact child outcomes. Alternatively, maternal time in education and training activities may have positive spillover effects on investment in children, including role model effects, improved ability to help with homework, and improved ability to navigate the educational system. In addition, increased family income associated with the attainment of higher levels of maternal education may also have a positive effect on children's outcomes. It is worth noting that the negative time allocation effects associated with maternal human capital investment are likely to be strongest in the contemporaneous period, while the positive spillover effects are likely to be less transient.

These competing theoretical effects provide ambiguous predictions for the relationship between maternal human capital investments and child outcomes. Similar ambiguous predictions exist regarding the effects of maternal labor force activity. Children may suffer as a result of increased time spent away from their mothers. However, increases in income, as well as positive role model effects associated with maternal labor force involvement, may be beneficial for children. While a large and growing literature has focused on the effects of maternal employment on child outcomes, there has been little attention paid to any similar effects of maternal schooling.

In this paper, we use data from the Child Supplement of the National Longitudinal Survey of Youth 1979 (NLSY79) to examine the effect of a mother undertaking schooling on her children's academic outcomes. In addition, we compare the effects of maternal schooling to effects of maternal labor force participation. Using both child-fixed effects and sibling-fixed effects models to deal with unobserved heterogeneity, we find evidence that negative effects due to decreased time allocated to children appear to be minimal. We also find that cumulative maternal schooling has significant positive effects on child outcomes. The remainder of the paper proceeds as follows: Section II discusses the theoretical and observed empirical relationships between maternal education, maternal employment, and children's outcomes. Section III explains our methodology, and Section IV describes our data. Section V presents results, and Section VI concludes.

II. Children's Outcomes and Maternal Education and Employment

Despite the strong positive relationship between child academic achievement and maternal educational *level*, the relationship between academic achievement and maternal educational *investment* is ambiguous. We develop a theoretical model that shows that under certain conditions, mothers who value their own consumption and the final level of their children's development will choose to go to school during their child's lifetime. We then discuss the theoretical implications of the maternal schooling decision for the child's development level.

A. Theoretical Model

Our theoretical framework is an adaptation of the framework developed by Stafford (1987) in modeling the tradeoff between women's market career and home career when they value the development of their children. In particular, we focus on maternal skill correlated with education and add this "maternal knowledge level" to the child's development function.

Children's development, $\dot{K}$, follows

(1)
$$\begin{aligned} \dot{K} &= Q(c_t, M_t, t), \\ &Q_c > 0,\ Q_{cc} < 0, \\ &Q_M > 0,\ Q_{MM} < 0, \\ &Q_{cM} > 0, \\ &Q_t < 0, \end{aligned}$$

where $Q(\cdot)$ is the function relating child development to maternal time spent on child, c_t, and child's age (time since birth), t. The portion of skill that is correlated with educational attainment, M_t, enters positively into the child development function both directly ($Q_M > 0$) and through an increase in the efficiency of time spent with children ($Q_{cM} > 0$). Maternal skill from education, or maternal knowledge level, changes according to

(2)
$$\begin{aligned} \dot{M}_t &= f(s_t) - \delta M_t, \\ &f_s > 0,\ f_{ss} < 0, \end{aligned}$$

where s_t represents maternal time invested in education, $f(\cdot)$ is a function relating this investment to knowledge levels, and δ is a depreciation rate. Total time is divided among market work, school, and childcare:

(3) $$1 \geq l_t + s_t + c_t.$$

Parents' welfare is a function of earnings and the child's development state at the end of the planning period;

(4) $$V = \int_0^T e^{-pt}\alpha l_t M_t^{\beta} dt + K_T,$$

where T is the end of the planning period, p is the discount rate, and α is the per unit wage rate. Thus $\alpha l_t M_t^{\beta}$ represents the income earned through labor market participation.[3] Child's development level at the end of the planning period, K_T, is the result of the accumulation of development given by equation (1),

(5) $$K_T = \int_0^T Q(c_t, M_t, t)dt.$$

Substituting (5) into (4), parents are solving the problem

(6) $$\begin{aligned} &\max_{l_t, s_t, c_t} \int_0^T e^{-pt}\alpha l_t M_t^{\beta} dt + \int_0^T Q(c_t, M_t, t)dt \\ &s.t. \quad 1 \geq l_t + s_t + c_t \\ &\qquad \dot{M}_t = f(s_t) - \delta M. \end{aligned}$$

This maximization leads to first order conditions

(7) $$\lambda_M f_s = Q_c = e^{-pt}\alpha M^{\beta}$$

where λ_M is the shadow value of knowledge at time t, which follows

(8) $$\dot{\lambda}_M = -e^{-pt}\beta\alpha l_t M_t^{\beta-1} - Q_M + \delta\lambda_M.$$

We explore the implications of this solution by restricting the functional form of $Q(\cdot)$ and $f(\cdot)$. In particular, we let child development evolve according to

[3] Here we make the simplification that production only depends on skill related to education. A more complicated skill set adds unnecessary complexity to the model.

(9) $$Q(c_t, M_t, t) = \gamma \ln(c_t) + \sigma \ln(M_t), \quad 0 < \gamma < 1, \; 0 < \sigma < 1.$$

This equation gives us decreasing returns to both maternal time spent with children and maternal knowledge level. This is a simplification in that the returns to the inputs are not dependent on the child's age, nor do the returns to maternal time spent with children increase with maternal knowledge level (i.e. the cross derivative is not positive).

We let maternal time spent on schooling increase maternal knowledge level according to

(10) $$f(s_t) = \varphi \ln(s_t), \; 0 < \varphi < 1.$$

This equation has the desired property that knowledge level increases at a decreasing rate with maternal time spent on education at time *t*.

Using the first order conditions, these functional restrictions give us the following time paths for maternal time spent on child care and education:

(11) $$c_t = \frac{\gamma}{\alpha} e^{pt} M_t^{-\beta},$$

(12) $$s_t = \frac{\varphi}{\alpha} e^{pt} M_t^{-\beta} \lambda_M .$$

The state and costate variables then follow

(13) $$\dot{M}_t = \varphi \ln(e^{pt} \frac{\varphi}{\alpha}) - \varphi\beta \ln(M_t) + \varphi \ln(\lambda_M) - \delta M_t, \text{ and}$$

(14) $$\dot{\lambda}_M = -M^{-1}(e^{-pt} \beta\alpha M_t^{\beta} - \beta\varphi\lambda_M - \beta\gamma + \sigma) + \delta\lambda_M .$$

Which leads to isoclines of

(15) $$\lambda_M = e^{-pt} \frac{\alpha}{\varphi} M_t^{\beta} e^{\frac{\delta}{\varphi} M_t}, \text{ and}$$

(16) $$\lambda_M = \frac{e^{-pt}\beta\alpha M^{\beta} + \sigma - \beta\gamma}{\delta M_t + \beta\varphi}.$$

We derive the intercepts and the derivatives of these isoclines in the appendix. Figure 1 presents the phase diagram in the case where $\frac{\sigma}{\beta} > \gamma$.[4] An individual with initial knowledge level M_0, which is lower than the level of knowledge where the isoclines intersect, will invest in additional education for a period before allowing her knowledge to depreciate. An individual with initial knowledge greater than the level of knowledge where the isoclines intersect will allow her knowledge to depreciate for the entire planning period.

This theoretical model shows that under certain circumstances mothers who value both consumption and the development of their children will take time away from labor market and child care time in order to pursue further education. We are interested in the

[4]This assumption is related to the relative productivity of maternal knowledge (scaled up by the knowledge parameter in the labor market) and maternal childcare time in the child development function. It is not necessary for the implications of the model to be reasonable. If $\sigma - \beta\gamma < 0$, the X-intercept of the costate variable isocline is negative and there are two possible cases. If the state and costate isoclines do not cross, all individuals, regardless of M_0, will allow their knowledge levels to depreciate. If the isoclines do cross, there will be a region of M_0 for which individuals will invest in education; all individuals with M_0 outside of this range will simply allow their knowledge to depreciate. The region of M_0 where individuals invest in education will be that between the two values of M where the isoclines intersect.

implications of this decision for the development of children. The direction of this relationship is ambiguous. Within the framework of our theoretical model, children's development level at time *t* is represented by

$$(17) \qquad K_t = \int_0^{t_1} Q(c_t, M_t, t)dt + \int_{t_1}^{t_2} Q(c_t, M_t, t)dt + \int_{t_2}^{t} Q(c_t, M_t, t)dt,$$

$$s_t > 0 \text{ if } t \in (t_1, t_2),$$

where time t_1 through t_2 is a period during which the child's mother was in school.[5]

Although it is not possible to find a closed form solution even with the simple functional forms used above, we can characterize the changes in K_t that would result from a period of maternal schooling. In particular, the direction of the change in K_t will depend on the length of time that the mother is in school, the size of the benefit from additional maternal knowledge, and the amount of time after leaving school that the child is able to enjoy the benefits of the higher maternal knowledge level.

During the period that the mother is in school, time spent with children, c_t, will be reduced.[6] Since $Q_c > 0$, the lower value of c_t during the period of maternal schooling

[5] If $Q(c_t, M_t, t)$ has a form such that Q_c is very large for small values of *t* (i.e. the benefits of time spent with children are high during early childhood), then it is likely that $t_1 > 0$. However if *t* does not enter into $Q(c_t, M_t, t)$ independently, as is the case in the functional forms we selected above, then $t_1 = 0$.

[6] If there is no crowding out of c_t then there will be no negative effect of schooling on children's development. Most reasonable functional forms would result in some decline

will have the effect of reducing K_t. However, the increased maternal knowledge that results from schooling leads to greater levels of child development both directly ($Q_M > 0$) through role model effects and other direct benefits of increased knowledge, and by making time spent with children more efficient ($Q_{cM} > 0$) through improved ability to help with homework and other education-related improvements in parenting efficiency. The size of these positive effects will depend upon the magnitude of Q_M and Q_{cM}, and upon the length of time that children are able to enjoy these benefits. The earlier the schooling takes place, the longer children will enjoy these benefits. The competing negative time allocation effect and positive spillover effect lead to an ambiguous theoretical prediction for the effect on child cognitive development of maternal educational investments made during the child's lifetime.

B. Previous Research

There is evidence that supports the notion that maternal educational investments might have positive spillover effects on children's outcomes. This could be due to the existence of role model effects. In qualitative research on mothers who return to school, Kelly (1982) reports that children of these mothers showed increased interest in and commitment to their own schoolwork. In addition, positive spillovers might exist if education increased a mother's ability to help with homework, or made her more likely to read to her children. Higher levels of parental education have been found to be correlated with more studying, less television watching, and more reading on the part of children

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in both c_t and l_t during the period where $s_t > 0$.

(Timmer et al, 1985). Tracey and Young (2002) find that types of maternal interaction with children depend upon educational level. Mothers with high school education were more likely to correct their children's errors during oral reading, while college-educated mothers tended to ask more high-level critical thinking questions. This was the case even though there were equal numbers of above- and below-average readers in each group. Furthermore, it has been suggested that the process of educational attainment in the United States involves coordination of multiple decisions (choice of classes, participation in extra-curricular activities), and that parental assistance is necessary for successful navigation of this system (Baker and Stevenson, 1986). Mothers who invest in their own education might learn about the educational system and be better able to help their children succeed within that system.[7] As shown in the theoretical model above, these positive spillover effects compete with negative time allocation effects to provide ambiguous predictions for the direction of the relationship between maternal schooling and child outcomes.

The related literature on the effects of maternal employment on child outcomes deals with the same theoretical ambiguities, and finds somewhat mixed results.[8] Most of

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[7] It is important to note that with the exception of the Kelly (1982) article, the papers discussed in this paragraph look at the relationship between educational level and inputs to the child development process. They do not look specifically at how changes in maternal education level affect parenting practices. In addition, these papers cannot answer the question of whether maternal education *causes* better parenting practices.

[8] An additional effect in the maternal employment case is that working mothers have higher incomes from labor force work. This income may be used to purchase resources

this literature has focused on maternal employment during early childhood. Stafford (1987) analyzes time use data collected in 1975-76, and finds that mother's market time during the two years before children started school had a negative significant effect on subsequent teacher ratings of children's cognitive skills. Blau and Grossberg (1992) find a negative effect on standardized test scores of maternal employment in a child's first year, but a positive effect of almost the same magnitude of maternal employment in the child's second and third years. Baum (2003) looks at maternal work during the early months of an infant's life and finds that switching from no work to fulltime work in the first year reduces test scores by 2.5 percentile points, and that maternal labor supply partially affects child development through increased family income. Ruhm (2004) finds a significant negative impact of early maternal employment on test scores for 5 and 6 year olds. Waldfogel et al (2002) find a negative effect of early employment on white children as old as 7 or 8.

The literature on the effects of maternal employment on school-aged children is more limited. Hanushek (1992) uses a sample of low-income black families from the Gary Income Maintenance Experiment and finds no effect of maternal labor force participation in grades 2-6 on test scores. Haveman, Wolfe, and Spaulding (1991) use the

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that compensate for reduced time at home. For mothers in school, this compensating source of income is not available. However, if education increases lifetime earnings and capital markets are perfect, a mother could borrow against her future income to purchase additional resources to invest in her children. We believe that for the segment of the population we study, liquidity constraints play a large role, and therefore ignore this possibility.

Panel Study of Income Dynamics, and find that the number of years the mother worked during the child's life has a positive and significant effect on the child's educational attainment. Aughinbaugh and Gittleman (2002) use the NLSY and find little evidence that maternal employment during adolescence increases a teenager's involvement in risky activities. Baum (2004) also uses the NLSY, and finds that maternal employment in early childhood and preadolescent years does not have a significant effect on high school grades, but that employment in adolescent years does have a negative significant effect.

While there is a large literature examining the effects of maternal employment on child outcomes, little has been done on the effects of maternal schooling. One exception is a study by Rosenzweig and Wolpin (1994) that uses data from the NLSY Child Supplement for 1986 and 1988. They find that mothers who remain in school after having a child do not hurt the cognitive scores of that child, and that they increase the cognitive scores of future children.

While we attempt to answer the same question, this paper differs from that of Rosenzweig and Wolpin in several ways. First, we use many more waves of data, including data through 2000 in our analysis. This is important for two reasons. First, it makes the sample more representative. In the Rosenzweig and Wolpin analysis, to be included in the sample mothers must have had two children by the age of 25. These children are therefore born to very young mothers, and these families may not be representative of families in general. In addition, it increases our sample size and allows us to estimate effects of maternal schooling with greater precision. Finally, we use both child- and sibling-fixed effects specifications rather than a sibling fixed effect specification alone, as in Rosenzweig and Wolpin (1994). We discuss this methodological choice in greater detail in the next section.

III. Methodology

We are interested in estimating the causal relationship between maternal schooling and child outcomes, and in comparing this relationship to the relationship between maternal employment and child outcomes. As a baseline, we first estimate the following equation by Ordinary Least Squares (OLS):

$$(18)\qquad Outcome_{it} = \alpha + MominSch_{it}\beta_1 + MominLF_{it}\beta_2 + X_{it}\gamma + \varepsilon_{it}$$

where $Outcome_{it}$ is a measure of a child's cognitive abilities in year t, $YrsMominSch_{it}$ is the number of years of the child's life that the mother spent in school as of year t, and $YrsMominLF_{it}$ is the number of years of the child's life that the mother spent in the labor force as of year t. X_{it} is a vector of child characteristics in year t.

The OLS approach does not account for the presence of unobservable characteristics that may be correlated with both maternal education and child outcomes (μ_i). If these are a factor, then the OLS estimate of the effect of maternal education on child outcomes will be biased. The existing literature on the effects of maternal employment addresses this unobserved heterogeneity with three main methodological approaches. First, researchers add a wide variety of background variables to try to control for most of the heterogeneity across mothers (e.g. Baum (2003) and (2004), Ruhm (2004), Waldfogel et al (2002), and Aughinbaugh and Gittleman (2002). Second, some papers use an instrumental variables (IV) approach, where they instrument for maternal labor force participation through local labor market conditions, or through welfare reform or child care availability variables (e.g. Aughinbaugh and Gittleman (2002), Blau and Grossberg (1992), and Baum (2003). Finally, some papers use a fixed effects approach, where they try to difference out fixed characteristics associated with the mother (sibling-fixed effects) or the individual child (child-fixed effects). Most of the papers that use this approach use the sibling-fixed effects approach (e.g. Aughinbaugh and Gittleman (2002), Rosenzweig and Wolpin (1994).[9]

There are problems with each of these approaches. Controlling for a wide variety of background characteristics can reduce the bias associated with unobserved heterogeneity, but cannot completely eliminate it. The IV approach can be an attractive way to analyze the effects of maternal labor force participation, since local labor market conditions clearly affect employment decisions. However, it is unclear that there are adequate instruments for maternal schooling decisions.

The use of sibling-fixed effects controls for family characteristics, but does not account for differences between siblings in unobservable characteristics that may be correlated with both maternal schooling decisions and child outcomes. For instance, if one sibling was struggling academically and therefore did not perform well on a cognitive test, the mother might be less likely to leave that child to enroll in school herself. If there are child-specific fixed effects, it is not necessarily true that within-family estimates will be less biased than OLS (Griliches, 1979).

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[9] Other independent variables examined with the sibling-fixed effects approach include child care variables (Blau (1999)) and maternal welfare participation (Levine and Zimmerman (2000)).

The child-fixed effects model will difference out both child- and family-fixed effects. However, this approach also differences out anything that occurred before the child's first observation. Thus this specification cannot be used to study the effects of early childhood maternal human capital investment or employment if the academic achievement measures are only collected on school-age children, as is the case in our data.

Since we are interested in the contemporaneous effect of maternal human capital investment and maternal employment, we rely on a child-fixed effects model as our primary specification. In addition to identifying contemporaneous effects more cleanly than a sibling model, this approach also allows for more full use of the data since we can use single children in addition to those from multiple child families.

However, we are also interested in comparing the effects of maternal schooling to the results from the existing literature on maternal employment. Since much of this literature has focused on early childhood, we also implement a sibling-fixed effects model. This model allows us to identify early childhood effects where the child-fixed effects specification would not.

For the child-fixed effects framework, we exploit the fact that the same assessments were taken multiple times for each child. Reestimating equation (17) in a CFE framework is equivalent to estimating the following model:

$$(19)\quad \begin{aligned}(Outcome_{it} - \overline{Outcome}_i) &= (YrsMominSch_{it} - \overline{YrsMominSch}_i)\beta_1 \\ &+ (YrsMominLF_{it} - \overline{YrsMominLF}_i)\beta_2 + (X_{it} - \overline{X}_i)\beta_3 + \varepsilon_{it},\end{aligned}$$

where $\overline{Outcome_i}$ represents the average outcome for child *i* across all observations of that individual, $\overline{YrsMominSch_i}$ represents the average number of years the mother of child *I* was in school during that child's lifetime, and so forth. This approach regresses *changes* in child assessments on *changes* in maternal schooling and *changes* in maternal labor force participation. Both family-specific and child-specific characteristics that are constant over time will be differenced out.

In addition to removing the time constant unobserved heterogeneity associated with each child, some important observed characteristics, are differenced out. This includes things like race and gender. Most importantly for our analysis, any information on early childhood, such as whether or not the mother was employed or in school during the child's first five years of life, is lost. Since child academic achievement measures are not available for very young children and the CFE specification differences out early child-specific characteristics, this specification does not allow us to compare these results directly to the large and increasing literature which looks at the effects of early maternal employment on child cognitive outcomes.

In order to examine the effects of early childhood maternal human capital investment and employment we exploit the fact that the same assessments were taken multiple children within from the same family, and reestimate equation (17) in a sibling-fixed effects (SFE) framework. The sibling model we use differs slightly from that typically used in the literature (e.g. Blau (1999), Levine and Zimmerman (2000) in that we compare siblings at the same age rather than in the same year. Thus we are taking observations of children from the same family in different survey years. We use this methodology for two reasons. First, this methodology allows us to identify contemporaneous effects of interest, whereas a sibling model with observations from the same calendar year would difference out all contemporaneous information. Second, the effect of early childhood maternal human capital investment and maternal employment is likely to vary as a child ages. For instance, we would not expect that maternal employment during the first year of a child's life would have the same marginal effect on academic achievement scores at age 6 as it would at age 12, particularly if early employment affects cognitive development in a way that alters a child's academic achievement growth path. Comparing children at the same age is likely to identify early childhood effects more accurately.

Our sibling model is equivalent to estimating the following model:

$$(20) \quad (Outcome_{if}^{a} - \overline{Outcome}_{f}^{a}) = (YrsMominSch_{if}^{a} - \overline{YrsMominSch}_{f}^{a})\beta_1 + (YrsMominLF_{if}^{a} - \overline{YrsMominLF}_{f}^{a})\beta_2 + (X_{if}^{a} - \overline{X}_{f}^{a})\beta_3 + \varepsilon_{if}^{a},$$

where $Outcome_{if}^{a}$ is the outcome for child *i* in family *f* at age *a*, $\overline{Outcome}_{f}^{a}$ represents the average outcome for family *f* across all children in that family at age *a*, and so forth. This approach regresses *differences* in sibling assessments on *differences* in siblings' maternal schooling exposure and *differences* in siblings' maternal labor force participation exposure. As in the child-fixed effects specification and in the sibling-fixed effects model typically used in the literature, this model differences out any time-constant characteristics associated with the family, including any time-constant unobserved heterogeneity. However, this approach does *not* deal with any child-specific unobserved heterogeneity.

Since the focus of the sibling approach is on early childhood effects, we conduct these analyses on children at the earliest point our data allows. However, these achievement scores were administered every other year, as will be discussed in Section IV below. In order to prevent dropping siblings that are spaced an odd number of years apart, we include all children in families with more than one child for whom we have a valid achievement score during the earliest *two* ages in which the test was administered. Thus, if the test is first administered after a child reaches age 6, our sample will be comprised of 6 and 7 year old children. We include an age dummy to control for age differences in academic achievement.

Finally, one potential problem with fixed-effects approaches more generally is the presence of measurement error. In forming differences across either children or siblings, the bias associated with measurement error becomes larger, since the signal-to-noise ratio decreases with the differencing process (Griliches, 1979). However, Blackburn and Neumark (1995) find little evidence that schooling in the NLSY is measured with error.

IV. Data

Our data come from the National Longitudinal Survey of Youth 1979 (NLSY79). The NLSY79 began as nationally representative sample of 12,686 young men and women who were 14-22 years old when they were first surveyed in 1979. These individuals were interviewed annually through 1994, and are currently being interviewed every other year. The survey contains detailed questions on educational attainment and training investments, as well as full marriage, fertility, and employment histories for all female respondents.

Beginning in 1986, all children born to the 6,283 female respondents of the original NLSY79 were surveyed. The child survey administers psychological and cognitive assessments of each child every other year. Other questions collect information on child-parent interactions and maternal involvement in children's schoolwork.[10] These data provide a rich source with which to answer the questions posed in the earlier sections of this paper.

Our sample includes the 8175 children born to the 4219 women originally surveyed by the NLSY in 1979 who had children over the age of 6 in 2000 (i.e. had given birth to children by 1994). We restrict our sample to children between the ages of 6 and 14. Since the child-fixed effects (CFE) specification requires at least two assessments, and assessments were administered every other year, children in this sample must then be at least age 8 by 2000. Summary statistics are presented in Table 1.

Educational attainment of the mother at her initial survey in 1979 was collected, as were any changes in her educational status throughout the survey period. As such, we have a complete history of the educational investments of the women in our sample. We can compare these to children's birth dates to identify which mothers were investing in their own education while they had children at home, and therefore would be subject to the competing demands on resources outlined in Section II. We classify a mother as in school if she reports being enrolled in the past year. Of the children in our sample, 1128, or 14 percent, had a mother who attended school at some point between the ages of 6 and

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[10] An additional Young Adult supplement is administered to children 15 and older. The YA supplement is modeled on the original NLSY79 survey administered to the parents, and collects information on variables including schooling, training, work experiences and expectations. We do not use the YA supplement in this paper, but plan to expand this line of research to look at completed educational attainment.

14. Of these children, 949 (84 percent) had a mother who attended school beyond the high school level. Most of these mothers did not complete a degree, however, as 289 children, or 26 percent of the children who experienced maternal schooling saw their mothers complete a degree.

We use four categories of maternal educational attainment: mother has a high school degree or equivalent, mother has an associate's degree, and mother has a four-year college degree or higher (mother did not complete high school is the omitted category). The categories are coded such that regression coefficients for each variable represents the marginal benefit of acquiring a given degree. For example, the estimated coefficient on the college degree variable represents the additional benefit in a given child outcome from having the mother acquire a college degree, rather than the cumulative benefit of all of the mother's education through college. In order to compare the effects of maternal education to the effects of maternal labor force participation, we also define variables that measure whether the mother reported being in the labor force in a given year.

The *X* vector of child characteristics includes birth order, whether the child was first born, the mother's age at the birth of the child, race, a set of age dummies, mother's current marital status, and years the child spent in a two parent home. Again, it is important to note that any child characteristics that do not change over time will be differenced out in the child-fixed effects specification, while any time constant characteristics associated with the family will be differenced out in the sibling-fixed effects specification. This will include some observable characteristics originally included in the X_i vector (i.e. sex, race, birth order, and mother's age at birth for CFE;

race, and mother's age at birth for SFE), and will also include the unobserved characteristics found in μ_i .[11]

We examine three child outcome measures in this paper: the Peabody Individual Achievement Test in reading recognition (PIAT-R), the Peabody Individual Achievement Test in math (PIAT-M), and a Behavioral Problems Index (BPI). The PIAT-R measures word recognition and pronunciation ability, with 84 items increasing in difficulty from preschool to high school levels. The PIAT-M measures a child's attainment in mathematics as taught in mainstream education, with 84 items beginning with early skills

[11] Even though child care arrangements may affect the relationship between maternal schooling and child cognitive outcomes, we do not control for any child care information, for three reasons. First, since we are looking at maternal schooling for children who are in school, child care may play less of a role. Second, the literature that looks at the child care measures in the NLSY finds no significant direct effect of these measures on child cognitive outcomes (Blau, 1999), as well as no moderating effect on the relationship between maternal employment and child cognitive measures (Baum (2003); Ruhm (2004); Waldfogel et al (2002)). Work using the National Institute of Child Health and Development Study of Early Child Care (NICHD-SECC) does find an effect of child care type and quality on children's cognitive outcomes, suggesting that these factors do matter (Brooks-Gunn et al, 2002). It is possible that the measures in the NLSY do not adequately capture significant differences in quality across various child care arrangements. Third, our primary specification, the child-fixed effects model, would not be able to take advantage of the NLSY childcare data, which only relates to the first three years of life.

and progressively increasing in difficulty to concepts in geometry and trigonometry. The BPI measures the frequency, range, and type of childhood behavior problems. These assessments have been used widely in the literature on the effects of maternal employment and maternal schooling described in Section II. For all three assessments, the NLSY provides raw scores, age-specific percentile scores, and "standard" scores that transform the age-specific percentile score to have a mean of 100 and a standard deviation of 15. We choose to use raw scores since the differencing involved in the child fixed-effects specification is more sensible with raw scores than with age-specific percentiles. Moreover, the original PIAT manual notes that, "a further limitation of percentile ranks, since they are *only* ranks, or ordinal data, is that they are not appropriately utilized in a number of mathematical operations that are important tools of analysis, such as addition and subtraction. This greatly limits their research potential" (Dunn and Markwardt, 1970: 42).[12] Additional detailed information on these assessments can be found in Center for Human Resource Research (2002).

V. Results

Results from estimation of the OLS and CFE models can be found in Table 2. For each of the three outcome measures, the OLS results are presented first, and the CFE results can be found in the next column. The OLS results are as would be expected. Children who are firstborn have higher scores on both reading and math assessments, consistent with previous literature (e.g. Lindert, 1977). The number of years in a single-

[12] We also implemented our analyses using percentile and standard scores. These results are qualitatively similar to those presented here.

parent home reduces math and reading test scores and increases behavioral problems.[13],[14] Mothers who are older when they give birth have children with higher test scores, and fewer behavioral problems. The OLS effects of maternal schooling are positive and strongly significant. Each year that the mother spends in school raises reading scores by 0.54 points (on a mean PIAT-R score of 40) and math scores by 0.42 points (on a mean PIAT-M score of 37). It also reduces behavioral problems by 0.14 points, on a mean BPI score of 10.

The results from the CFE models show positive, significant effects of both maternal schooling and maternal labor force participation on cognitive outcomes.[15, 16]

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[13] However, it is important to note that we have not controlled for family income. Since income is systematically lower in single-parent families versus two-parent families, if income is correlated with test scores and behavioral problems these coefficients are an over-estimate of the actual effect.

[14] Although the OLS results for years in a single parent household are as expected, we find a positive significant effect for years in a single parent household using CFE analysis. This result is puzzling and it is unclear what bias is generating this result. However our results are the same qualitatively when this variable is excluded from the analysis.

[15] Note that while the cumulative years in school variable is the number of years the mother was in school during the child's life up to the time of the observation, in the CFE specification the variable differences out the number of years the mother was in school before the first assessment.

[16] We have also run specifications where we break labor force participation into full and

The effect of an additional year of maternal schooling is to increase the PIAT-R by 0.50 points and the PIAT-M by 0.23 points. The effects of cumulative labor force participation are similar in magnitude at 0.53 and 0.26; these effects are not statistically different from the effects of maternal schooling. We do find some evidence for negative time allocation effects, in that an additional year in the labor force significantly increases the behavioral problems index by 0.08 points. The effect of maternal time in school on the BPI is also positive, although it is not significant. These results suggest that while maternal labor force participation provides a benefit for cognitive outcomes, it is associated with a cost in a greater incidence of behavioral problems.

In Table 3, we control for maternal education level. Because the coefficients are defined from within-child variation across time, results from the maternal education level variables in this regression can be interpreted as the change in child outcome measures that result from the mother attaining the extra level of education during the child's school age years. The addition of education level causes the estimated effect of maternal years of schooling on the math and reading assessment scores to fall, suggesting that some of this effect might be due to degree acquisition. There is some suggestive evidence of positive effects of acquisition of two- and four-year degrees on math and reading scores, although these effects are less precisely estimated. Even after controlling for degree acquisition, there is still a positive significant effect of years of maternal education on reading scores.

Although Tables 2 and 3 show little evidence of a dominant negative time allocation effect, that type of effect might be most important if the mother is currently in

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part time participation. This does not qualitatively change the results.

school. In particular, the negative component effects of maternal schooling and labor force participation may be more important in the present due to reduced time allocated to children, while the positive effects due to different parenting practices, role model effects, or possible labor force effects may last into the future.[17] In addition, we would like to compare the effects of contemporaneous maternal schooling on child outcomes to the effects of contemporaneous maternal employment. Table 4 presents results from CFE models that control for whether the mother was in school at the time of the assessment, and for whether the mother was in the labor force at the time of the assessment.

The results for the PIAT-R are largely consistent with the story told in the previous paragraph. Contemporaneous schooling and labor force involvement both have a negative effect on reading scores, with the effect of maternal labor force participation being statistically significant. However, cumulative schooling and labor force involvement are both positive and significant, increasing reading scores by .51 points and .54 points per year, respectively. Although both maternal schooling and labor force participation seem to provide similar long-term benefits, there seems to be evidence that contemporaneous schooling has less of a negative effect (-0.12) than contemporaneous labor force participation (-0.30), However, we fail to reject that these two coefficients are equal.

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[17] We have also estimated models where we allow for an interaction between contemporaneous schooling and contemporaneous employment. The interaction variables are never statistically different from zero, and their inclusion does not qualitatively change the results presented in Table 4.

For math scores, we find no statistically significant effect of contemporaneous schooling or labor force participation, but we do find positive effects of cumulative schooling and labor force participation that are similar in magnitude to those presented in the earlier tables.

While the cognitive test scores show evidence of short-term costs but longer-term benefits to maternal schooling and employment, we find evidence of a negative time allocation effect on behavioral problems due to maternal labor force participation. Although there is no significant effect of cumulative labor force participation on behavioral problems once we control for current labor force participation, the contemporaneous effects of maternal employment are quite large. Contemporaneous maternal labor force participation increases behavioral problems by 0.37 points, and this effect is statistically significant at the one-percent level.

We next estimate the CFE models for two subgroups of women – those who did not have a high school degree at the time of their child's sixth birthday, and those who had only a high school degree at the time of their child's sixth birthday.[18] We do this for two reasons. First, the previous results we presented combine effects from women who were obtaining different levels of education (i.e. women working towards a GED were combined with women working towards a BA). By breaking the sample into these subgroups, we can be more certain that years of maternal schooling mean similar things

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[18] We have also estimated the CFE models separately for women who did not have a high school degree at the time of the child's birth, and for women who had only a high school degree at the time of the child's birth. The results from this alternate specification are not qualitatively different from the results presented here.

across women. In addition, there may be unobserved characteristics that are related to both the timing of schooling and the childbearing decision. If this is the case, results from a full sample of children may not accurately estimate the relevant policy parameters. Results from these regressions can be found in Tables 5 and 6.

Panel A of Table 5 provides results for children whose mothers had no high school degree. We find some evidence of both a negative contemporaneous effect and a positive cumulative effect of maternal education, although these coefficients are not precisely estimated.   We do find negative significant effects of cumulative maternal schooling on behavioral problems. For maternal employment, the patterns are similar to those found earlier in the paper, as contemporaneous labor force employment has a negative effect on test scores, but cumulative employment has a positive and strongly significant effect on both reading and math scores. These effects of cumulative labor force participation are larger in magnitude than are the effects for the entire sample.

However, for this group of women, there are positive effects of *completion* of the high school degree. Results in Panel B of Table 5 show that completion of a high school degree leads to an increase in reading scores of 2.64 points that is statistically significant at the five-percent level. There is also an increase in math scores of 1.81 points, but this effect is less precisely estimated.   The literature on the return to schooling in terms of higher wages shows evidence of "sheepskin effects" (e.g. Hungerford and Solon (1987); Jaeger and Page (1996)), but it is unclear why acquisition of a degree should lead to a significant increase in children's test scores.

For mothers with only a high school degree at the time of the child's birth, the results in Panel A of Table 6 show no negative significant effects of current labor force involvement or schooling on test scores. There remain significant positive effects of both cumulative schooling and cumulative labor force participation on math and reading test scores. Panel B of Table 6 also shows evidence of sheepskin effects. However, these effects are less precisely estimated. For this group of children, the process of maternal schooling seems to be more important than degree acquisition.

It is also possible that the effects of maternal education vary depending upon the marital status of the mother. If the child is part of a two-parent family, decreases in maternal time devoted to the family may be offset by increases in paternal time. The positive spillover effects may also differ by family type. Previous evidence on the effects of early maternal employment finds a greater cost in cognitive development to those children in two-parent families than in one-parent families (e.g. Ruhm, 2004). In Table 7 we re-estimate our CFE models separately for children by the marital status of their mother at the time of the assessment.[19,20] These results provide evidence that maternal schooling and labor force participation have a larger positive effect on the cognitive development of children in single-parent families. There is some evidence, suggested by a significant negative effect on math scores, that children of single mothers are more

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[19] This classification has some problems; most notably both groups may include children who spent different amounts of time in two-parent versus one-parent homes. The regressions do include controls for the number of years spent in a single parent home.

[20] We have also estimated models for two-parent families where we control for father's labor force involvement, which has no significant effect on children's test scores (and a negative effect on behavioral problems). The addition of this variable does not change our estimated effects of maternal education.

subject to a time allocation effect. However, the cumulative effects of both maternal schooling and labor force participation are positive and strongly significant for children in single parent families. For married mothers, the effects are insubstantial for schooling, and negative and significant for labor force participation.

We next break results out separately for children by gender. These results are found in Table 8. The cumulative effects of maternal labor force participation are similar between boys and girls, although boys are hurt more by current labor force participation than are girls. This is consistent with results found in Hill and Duncan (1987) and Brooks-Gunn et al (2002). The cumulative positive effects of maternal education are large and strongly significant for boys, while they are not statistically different from zero for girls. However, they are not statistically different from each other.[21]

While the time allocation effects of maternal schooling and maternal labor force participation might be expected to be similar, one major difference is that maternal labor force participation increases family income, which can be used to purchase additional inputs into the production of child quality, such as private schools, tutors, or other development-stimulating activities. This suggests that if family income were controlled for, that the positive cumulative effects of maternal labor force participation would fall. To test this, we ran regressions that included family income. Family income is clearly

[21] The coefficients on cumulative schooling are close to being statistically different for girls and boys for math scores (p-value of 0.1028). One possible explanation for differential effects by gender is that since boys tend to struggle more in school than girls, with lower test scores and higher incidence of behavioral problems, that perhaps maternal schooling can help to counteract this disadvantage.

endogenously determined with schooling and labor force participation decisions. However, the inclusion of this variable allows us to determine whether family income plays a large role in the maternal labor force participation results presented in the earlier tables. The results from this regression are presented in Table 9. Family income has no significant effect on children's outcomes.[22] However, its inclusion into the regression reduces the positive significant effects of cumulative labor force participation. The original estimated coefficient of 0.54 falls to 0.39, while the effect of maternal labor force participation on math scores is no longer statistically significant from zero.

Sibling-fixed effects Model

Since there may be reason to believe that time allocation effects could have more serious cognitive development consequences for very young children, we implement the SFE model described in Section II in order to determine the effect of maternal schooling undertaken during a child's early childhood. SFE results are presented in Table 10.[23] While the results show no significant effects of maternal employment in either the first

[22] The lack of a family income effect could be due to the fact that our variation comes from changes in income over very short periods of time.

[23] In addition to the variables used in the CFE analyses, all SFE models also control for whether the child was first born, the sex of the child, and the number of years separating the child from the firstborn child. Each of these variables is differenced out in the CFE specification. All of the control variables not related to maternal schooling or employment are of the expected sign, including number of years the child lived in a single parent home.

year or subsequent years, there are significant effects related to maternal schooling. There is evidence of a large negative effect on math and reading scores of maternal schooling undertaken during the child's first year. These results suggest that during the child's first year of life, the negative time allocation effects associated with maternal schooling dominate any positive spillover effects. However, there are significant positive effects on both math and reading scores for maternal schooling undertaken after the child's first year and before ages 6 or 7. For reading scores, the estimated coefficient is 0.48, which is similar in magnitude to the coefficient estimated with the CFE approach, while for math scores the estimated coefficient of 0.79. Both of these effects are statistically significant at the five-percent level or less.

In Table 11, we add degree acquisition to the SFE specification. While the effects of years of maternal schooling are largely unchanged, we find evidence of sheepskin effects for both an associates degree (with a 3.07 point increase in math scores), and a college degree (with a 5.52 point increase in reading scores). There is some evidence of a negative effect of acquisition of a high school degree, with an increase in the Behavioral Problems Index of 2.06 points. In general, the results from the SFE models tell the same story as the CFE results presented earlier. Cumulative years of maternal schooling undertaken after the child's first year of life have a positive significant effect on children's test scores, suggesting that the positive spillovers associated with maternal schooling dominate any negative impacts associated from reduced time at home.

VI. Conclusion

Strong associations between maternal level of education and children's academic outcomes are often pointed to as a justification for encouraging mothers to invest in higher education. However, there are theoretical reasons, similar to those relevant to maternal employment, to believe that the negative time allocation effects could have a negative effect on child outcomes.

In this paper, we examine the effect of maternal human capital investments on children's academic outcomes. Using a CFE specification, we find little evidence of negative time allocation effects associated with mothers' return to school. We also find positive effects of cumulative maternal schooling on child assessments. These results, which are robust to a variety of specification tests, suggest that maternal investments in education, even if undertaken while the children are at home, may have positive spillovers on children's academic outcomes.

The finding that maternal human capital investment has lasting positive spillovers is supported by our SFE analysis. We find that maternal schooling undertaken during early childhood, after the child's first year, has a positive significant effect on academic achievement at ages 6 or 7. These spillovers increase further the expected rate of return on continued schooling for these women.

Our results have implications for the ongoing debate regarding the classification of education as a work-related activity for purposes of welfare eligibility. The JOBS program established by the Family Support Act of 1988 placed a large emphasis on education and training, but this emphasis was reduced as part of major welfare reform in 1996.[24] However, current proposals attempt to reinstate educational activities as

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[24] An important exception affects teenagers. Under PRWORA, federal funds cannot be

qualified work activities by the definition of the Personal Responsibility Work Opportunity Reconciliation Act (PRWORA). Our results suggest that these proposals could have positive effects on the academic achievement of children in welfare-dependent families.

spent on an unmarried, custodial minor parent unless the parent has completed high school or its equivalent, or participated in appropriate educational activities.

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Figure 1: Phase Diagram , $\frac{\sigma}{\beta} > \gamma$

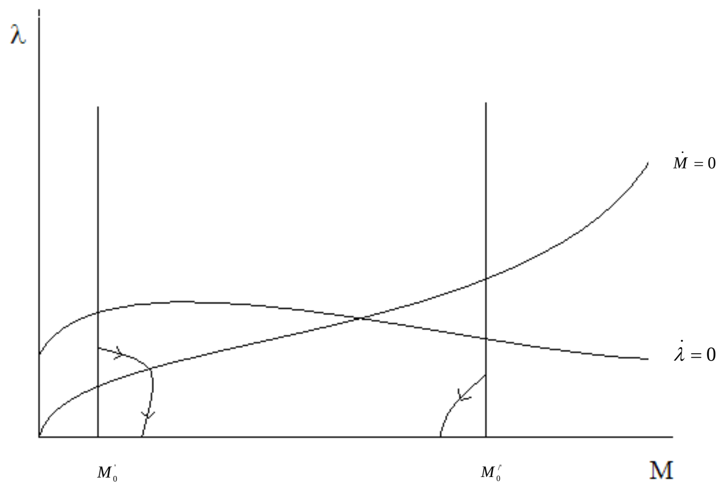

Table 1: Summary Statistics

Variable Name	Mean	Standard Deviation
PIAT_R	40.17	17.93
PIAT_M	37.03	16.07
BPI	10.20	6.16
Maternal Education		
High School Degree	0.81	0.39
Associate's Degree	0.13	0.34
College Degree	0.08	0.27
Years in single parent home before age 3	0.76	1.22
Years in single parent home age 3+	1.87	2.94
Age	9.67	2.50
Mom's age at child's birth	23.35	3.77
Mother in school this year	0.04	0.20
Mother in school total	0.46	1.08
Mother in labor force this year	0.51	0.50
Mother in labor force total	4.57	4.00
Mother married	0.40	0.49
Family income	40255	65921
Sample size	33108	

Notes: There are 19683 observations with a valid PIAT-R score, 19798 observations with a valid PIAT-M score, and 20225 observations with a valid BPI score.

Table 2: Effects of Maternal Years of Schooling and Employment on Child Outcomes Ordinary Least Squares and Child-fixed effects Specifications

	PIAT-R		PIAT-M		BPI	
Variable Name	OLS	CFE	OLS	CFE	OLS	CFE
Mom in school total	0.54***	0.50***	0.42***	0.23*	-0.14***	0.17
	(0.10)	(0.15)	(0.08	(0.14)	(0.05)	(0.11)
Mom in labor force	0.29***	0.53***	0.24***	0.26***	-0.08***	0.08*
total	(0.04)	(0.06)	(0.03)	(0.06)	(0.02)	(0.04)
Years single mother home before age 6	-0.48***	--	-0.38***	--	0.19***	--
	(0.07)		(0.05)		(0.03)	
Years single mother	-0.05	0.73***	-0.10*	0.39***	0.18***	-0.01
home age 6+	(0.06)	(0.06)	(0.05)	(0.05)	(0.04)	(0.04)
First born	3.55***	--	1.95***	--	-0.40***	--
	(0.28)		(0.22)		(0.13)	
Female	1.94***	--	-0.12	--	-0.93***	--
	(0.26)		(0.20)		(0.12)	
Nonwhite	-2.95***	--	-3.90***	--	-0.10	--
	(0.29)		(0.22)		(0.14)	
		--		--		--
Mother's age at child's	0.37***	--	0.33***	--	-0.07***	--
birth	(0.04)		(0.03)		(0.02)	
n observations	19683	18881	19798	19350	20225	19627
n children		5470		5488		5651

Notes: Outcome measures are the raw score on the PIAT Reading Recognition Test (PIAT-R), the raw score on the PIAT Math Test (PIAT-M), and the raw score on the Behavioral Problems Index (BPI). Regressions also include age dummies. OLS regressions calculate robust standard errors that account for multiple observations per child. Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level.

Table 3: Effects of Maternal Years of Schooling, Maternal Employment, and Completed Education Level, Child-fixed effects Models

	PIAT-R	PIAT-M	BPI
Mom in school total	0.36**	0.14	0.08
	(0.17)	(0.16)	(0.12)
Mom in labor force total	0.53***	0.26***	0.08*
	(0.06)	(0.06)	(0.04)
Maternal education			
High School	-0.51	0.84	1.35*
	(1.08)	(0.98)	(0.76)
Associate's Degree	1.03	0.37	0.52
	(0.75)	(0.69)	(0.54)
College Degree	1.34	0.85	0.47
	(1.14)	(1.04)	(0.80)
n observations	18881	19350	19627
n children	5470	5488	5651

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 4: Contemporaneous and Cumulative Effects of Maternal Schooling and Maternal Employment, Child-fixed effects Models

	PIAT-R	PIAT-M	BPI
Mom in school this year	-0.12	0.09	0.14
	(0.27)	(0.25)	(0.19)
Mom in school total	0.51***	0.22	0.16
	(0.25)	(0.14)	(0.11)
Mom in labor force this year	-0.30*	0.06	0.37***
	(0.17)	(0.16)	(0.12)
Mom in labor force total	0.54***	0.26***	0.07
	(0.06)	(0.06)	(0.04)
n observations	18881	19350	19627
n children	5470	5488	5651

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 5: Effects of Maternal Years of Schooling and Maternal Employment, Where Mother Did Not Have High School Degree by Child's 6th Birthday, Child-fixed effects Models

	PIAT-R	PIAT-M	BPI
A. Contemporaneous and Cumulative Schooling Only			
Mom in school this year	-0.31	-0.74	0.83
	(0.78)	(0.74)	(0.58)
Mom in school total	0.06	0.74	1.01***
	(0.51)	(0.48)	(0.37)
Mom in labor force this	-0.64*	-0.48	0.74***
year	(0.36)	(0.34)	(0.27)
Mom in labor force total	0.76***	0.51***	-0.02
	(0.12)	(0.14)	(0.11)
B. Include Degree Acquisition			
Mom in school this year	-0.50	-0.84	0.83
	(0.78)	(0.74)	(0.58)
Mom in school total	-0.49	0.36	1.00**
	(0.58)	(0.54)	(0.42)
Mom in labor force this	-0.62*	-0.47	0.74***
year	(0.36)	(0.34)	(0.27)
Mom in labor force total	0.75***	0.49***	-0.02
	(0.14)	(0.14)	(0.11)
Maternal Education			
High School	2.64**	1.81	0.06
	(1.28)	(1.19)	(0.95)
N	3112	3196	3297
	889	895	936

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 6: Effects of Maternal Years of Schooling and Maternal Employment, Where Mother Had Only a High School Degree by Child's 6th Birthday, Child-fixed effects Models

	PIAT-R	PIAT-M	BPI
A. Contemporaneous and Cumulative Schooling Only			
Mom in school this year	0.00	0.25	0.00
	(0.33)	(0.31)	(0.23)
Mom in school total	0.44**	0.10	-0.01
	(0.18)	(0.16)	(0.12)
Mom in labor force this year	-0.12	0.16	0.33**
	(0.21)	(0.20)	(0.15)
Mom in labor force total	0.41***	0.15**	0.08
	(0.07)	(0.07)	(0.05)
B. Include Degree Acquisition			
Mom in school this year	0.13	0.34	0.11
	(0.34)	(0.31)	(0.24)
Mom in school total	0.27	-0.03	-0.16
	(0.21)	(0.19)	(0.15)
Mom in labor force this year	-0.13	0.15	0.32**
	(0.21)	(0.20)	(0.15)
Mom in labor force total	0.41***	0.15**	0.08
	(0.07)	(0.07)	0.05
Maternal Education			
Associate's degree	1.16	0.48	0.72
	(0.81)	(0.75)	(0.58)
College degree	0.29	1.26	1.15
	(1.42)	(1.28)	(0.97)
N	11869	12212	12360
	3261	3274	3378

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 7: Effects of Maternal Schooling and Maternal Employment, by Marital Status, Child-fixed effects Models

	PIAT-R	PIAT-M	BPI
A. Mom married in current year			
Mom in school this year	-0.34	0.36	0.13
	(0.40)	(0.38)	(0.29)
Mom in school total	0.29	0.13	0.44***
	(0.23)	(0.21)	(0.16)
Mom in labor force this	-0.34	0.09	0.59***
year	(0.23)	(0.33)	(0.16)
Mom in labor force total	-0.26**	-0.20**	0.12*
	(0.11)	(0.31)	(0.07)
n observations	9613	9861	10187
n children	2957	2974	3103
B. Mom not married this year			
Mom in school this year	-0.24	-0.40	0.21
	(0.37)	(0.35)	(0.27)
Mom in school total	0.79***	0.43**	-0.18
	(0.23)	(0.22)	(0.17)
Mom in labor force this	0.00	0.08	0.17
year	(0.26)	(0.25)	(0.20)
Mom in labor force total	0.95***	0.31***	0.07
	(0.11)	(0.11)	(0.09)
n observations	8672	8836	9771
n children	2683	2696	2719

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 8: Contemporaneous Effects of Maternal Schooling and Maternal Employment, By Gender, Child-fixed effects Models

	PIAT-R	PIAT-M	BPI
Mom in school this year X Boy	-0.06	0.12	0.35
	(0.37)	(0.34)	(0.26)
Mom in school this year X Girl	-0.22	0.13	-0.12
	(0.38)	(0.35)	(0.27)
Mom in school total X Boy	0.66***	0.45**	0.07
	(0.22)	(0.20)	(0.15)
Mom in school total X Girl	0.35	-0.01	0.26*
	(0.21)	(0.20)	(0.15)
Mom in labor force this year X Boy	-0.49**	0.16	0.26
	(0.24	(0.22)	(0.17)
Mom in labor force this year X Girl	-0.11	-0.04	0.49***
	(0.24)	(0.22)	(0.17)
Mom in labor force total X Boy	0.38***	0.38***	0.05
	(0.07)	(0.06)	(0.05)
Mom in labor force total year X Girl	0.70***	0.14**	0.08*
	(0.07)	(0.07)	(0.05)
n observations	18881	19350	19627
n children	5470	5488	5651

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 9: Effects of Maternal Schooling, Maternal Employment, and Family Income, Child-fixed effects Models

	PIAT-R	PIAT-M	BPI
Mom in school this year	-0.22	0.13	0.12
	(0.32)	(0.30)	(0.23)
Mom in school total	0.40**	0.13	0.12
	(0.18)	(0.17)	(0.13)
Mom in labor force this year	-0.35*	0.09	0.49***
	(0.20)	(0.19)	(0.14)
Mom in labor force total	0.39***	0.12	0.17***
	(0.09)	(0.08)	(0.06)
Family income	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
n observations	12783	13076	13282
n children	3996	4015	4162

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 10: Contemporaneous Effects of Maternal Schooling and Maternal Employment, Sibling-fixed effects Models

	PIAT-R	PIAT-M	BPI
Mom in school during	-1.06**	-1.26***	0.23
child's first year	(0.46)	(0.48)	(0.41)
Years mom in school	0.48**	0.79***	0.26
since child's first year	(0.21)	(0.22)	(0.19)
Mom employed during	-0.30	0.26	0.04
child's first year	(0.31)	(0.32)	(0.27)
Years mom employed	-0.09	0.09	0.01
since child's first year	(0.11)	(0.11)	(0.09)
N	4719	4809	4863
	1920	1950	1986

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Table 11: Effects of Maternal Schooling and Maternal Employment, Sibling-fixed effects Models

	PIAT-R	PIAT-M	BPI
Mom in school during	-1.03**	-1.28***	0.26
child's first year	(0.46)	(0.48)	(0.41)
Years mom in school	0.37*	0.72***	0.28
since child's first year	(0.22)	(0.23)	(0.19)
Mom employed during	-0.30	0.26	0.04
child's first year	(0.31)	(0.32)	(0.27)
Years mom employed	0.08	0.10	0.00
since child's first year	(0.11)	(0.11)	(0.09)
Maternal education			
High School	1.09	-0.07	2.06*
	(1.30)	(1.33)	(1.13)
Associate's Degree	0.55	3.07**	-1.29
	(1.48)	(1.57)	(1.24)
College Degree	5.52*	-2.11	-0.21
	(2.90)	(3.04)	(2.59)
N	4719	4809	4863
	1920	1950	1986

Notes: Standard errors in parentheses. Levels of statistical significance: *** denotes significance at the one-percent level; ** at the five-percent level; and * at the ten-percent level. Outcome measures are described in Section IV.

Appendix: Derivation of the Phase Diagram

In order to draw the phase diagram, we must find the intercepts of each isocline, as well as the first and second derivatives. In the text, we derived isoclines of

(A1) $$\lambda_M = e^{-pt} \frac{\alpha}{\varphi} M_t^{\beta} e^{\frac{\delta}{\varphi}M_t}, \text{ and}$$

(A2) $$\lambda_M = \frac{e^{-pt}\beta\alpha M^{\beta} + \sigma - \beta\gamma}{\delta M_t + \beta\varphi}$$
$$= e^{-pt}\beta\alpha(\delta M_t^{1-\beta} + \beta\varphi M^{-\beta})^{-1} + (\sigma - \beta\gamma)(\beta\varphi + \delta M)^{-1}.$$

If the costate variable is placed on the Y-axis and the state variable on the X-axis, as is standard, both the Y-intercept and the X-intercept of (A1) occur at 0. The Y-intercept of (A2) is $\frac{\sigma - \beta\gamma}{\beta\varphi}$, while the X-intercept is $\left(\frac{\beta\gamma - \sigma}{e^{-pt}\beta\alpha}\right)^{1/\beta}$. Note that the sign of these intercepts depends on the sign of $\sigma - \beta\gamma$ which is related to the weight of log maternal knowledge level in the child development function compared to the weight of log maternal time spent on child care (multiplied by the exponent on maternal knowledge in the production function). In particular, if $\sigma > \beta\gamma$, the Y-intercept is positive while the X-intercept is negative. If $\sigma < \beta\gamma$ then the Y-intercept is negative while the X-intercept is positive. Note also that (16) crosses the X-intercept only once.

The state variable isocline, (A1), has a positive first derivative while the second derivative is negative for a region before becoming positive. In particular, the first derivative is

(A3) $$\left.\frac{\partial\lambda}{\partial M}\right|_{\dot{M}=0} = e^{-pt}\frac{\beta\alpha}{\varphi} M_t^{\beta-1} e^{\frac{\delta}{\varphi}M_t} + e^{-pt}\frac{\alpha\delta}{\varphi^2} M_t^{\beta} e^{\frac{\delta}{\varphi}M_t},$$

which is positive for all positive values of *M*. The limit of the first derivative as *M* goes to either 0 or infinity is infinity. The second derivative of the state variable isocline is

$$\text{(A4)} \qquad \left.\frac{\partial^2 \lambda}{\partial M^2}\right|_{\dot{M}=0} = e^{-pt}\,\frac{\alpha}{\varphi} M_t^{\beta} e^{\frac{\delta}{\varphi}M_t} \left(\frac{2\beta\delta}{\varphi} M_t^{-1} + \left(\frac{\delta}{\varphi}\right)^2 - (1-\beta)\beta M_t^{-2}\right),$$

which is negative if $M_t < \frac{\varphi}{\delta}\left(\sqrt{\beta} - \beta\right)$ and positive if $M_t > \frac{\varphi}{\delta}\left(\sqrt{\beta} - \beta\right)$. This isocline is drawn in Figure 1.

The shape of the isocline associated with the costate variable, (A2), depends on the relationship between $\frac{\sigma}{\beta}$ and γ. The first derivative of the costate variable isocline is

$$\text{(A5)} \qquad \left.\frac{\partial \lambda}{\partial M}\right|_{\dot{\lambda}=0} = \frac{-e^{-pt}\beta\alpha((1-\beta)\delta - \beta^2\varphi M^{-1})}{M^{\beta}(\delta M^{1-\beta} + \beta\varphi M^{-\beta})^2} + \frac{\delta(\beta\gamma - \sigma)}{(\delta M + \beta\varphi)^2}.$$

For positive values of *M*, the first term is positive when $M < \frac{\beta^2\varphi}{(1-\beta)\delta}$, negative when $M > \frac{\beta^2\varphi}{(1-\beta)\delta}$, and has a limit of infinity as M goes to 0. The sign of the second term depends on the relationship between $\frac{\sigma}{\beta}$ and γ. The second term is negative if $\frac{\sigma}{\beta} > \gamma$. If this is so then $\left.\frac{\partial \lambda}{\partial M}\right|_{\dot{\lambda}=0} > 0$ when $M < A$, where A<$\frac{\beta^2\varphi}{(1-\beta)\delta}$, and $\left.\frac{\partial \lambda}{\partial M}\right|_{\dot{\lambda}=0} < 0$ when $M > A.$ Thus, if $\frac{\sigma}{\beta} > \gamma$, the costate isocline will be an "inverted U" turning at point A with a positive Y-intercept and a negative X-intercept, as shown in Figure 1.