The Causal Effect of Fertility Timing on Educational Attainment: An Identification Test Using the Longitudinal Structure of Schooling

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Abstract

The strong correlation between educational attainment and fertility timing is well documented. For instance, young mothers seldom go on to earn a college degree. Researchers often use controls for observable characteristics or sibling fixed effects to determine whether this correlation reflects causation or simply unobserved factors. Using the cumulative nature of educational investment, this paper demonstrates that the key identifying assumption behind these approaches does not hold. Mothers and observably similar non-mothers begin college on the same footing but their paths diverge well before the former enters pregnancy. No such divergence should exist if the causal effect of childbirth is the only reason educational attainment is lower for mothers than similar non-mothers. This finding suggests that time-varying factors that cause women to leave school and then enter parenthood are also behind the correlation. Controls for pre-determined characteristics and fixed effects do not address this temporal source of omitted variable bias.

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1 Introduction

Educational attainment and timing of entry into parenthood are intimately related. At the individual level, adolescent childbearing is thought to be a major social and economic problem in the United States, largely through its perceived adverse effect on schooling. This view is supported by numerous studies that document a strong correlation between educational attainment and fertility timing. Individuals who have children early are less likely to graduate from high school, attend college, or receive a college degree. Consequently, teenage parents have lower incomes, are more likely to be in poverty, and more likely to be receiving welfare assistance as adults than their peers who delayed parenthood. At the aggregate level, the long-run trend in educational attainment moves in the opposite direction of that for age at first childbirth. Over the past century, the fraction of American women earning a college degree has risen tremendously, while women have increasingly delayed entry into parenthood.

Though the earliest research interpreted the relationship between fertility timing and educational attainment as causal[2], establishing such a causal link is confounded by at least two identification issues. First, the observed correlation may be due to factors that influence some individuals to have children while young and also to receive less formal education, independent of their fertility decisions. Women who give birth at young ages are observably very different than those who give birth later. Teenage mothers are more likely to come from low-income and single-parent families, have parents with low education levels, and become sexually active at younger ages.[3] Even if these observed differences could be perfectly accounted for, unobserved differences between teenage mothers and their peers may still remain. If unobserved differences are also correlated with educational aspirations, then even comparisons that condition on observable characteristics will overstate the causal effect of teenage childbirth on educational attainment. Simultaneity is a second identification issue. Women who face poor schooling prospects due to bad grades or other barriers to post-secondary education may begin childbearing earlier because they face a lower opportunity cost of doing so. In this case, diminished educational opportunities influence fertility decisions, rather than the reverse.

Previous researchers have mostly been concerned with omitted variable bias and sometimes with simultaneity. They have employed four main strategies for addressing this: controlling for observable characteristics, sibling fixed effects, quasi-randomization, and instrumental variables. Geronimus and Korenman (1992) compare sisters whose first births were at different ages to account for unobserved differences in family background. Large cross-sectional differences in socioeconomic outcomes between teenage mothers and other women are greatly diminished when sister fixed effects are included. They conclude that the oft-cited negative correlation between education and teenage fertility is largely due to unobserved family factors which influence both fertility and education. Family fixed effects models do not satisfactorily solve the omitted variable problem

[2] See Hofferth (1987) for a review of the early literature.

[3] See Abrahamse (1988) for a review of this evidence.

and do not address the issue of simultaneity. Any within-family heterogeneity that causes one sister to become pregnant in her teens and the other to not, is left unexplained. The identifying assumption in family fixed effects models is that any within-family unobserved heterogeneity in determinants of education is uncorrelated with fertility decisions. Furthermore, if within-family heterogeneity is greater than that across families, any bias will be amplified.

Estimates from natural experiments address both omitted variables bias and reverse causality. Hotz et al (1997) used quasi-randomization attributed to miscarriages as a source of variation in fertility timing. Outcome differences between mothers whose teenage pregnancy resulted in miscarriage and those who gave birth are negligible. The authors thus conclude that selection bias vastly overstates the negative consequences of teenage childbearing. Bronars and Grogger (1994) compare teenage mothers whose first birth were to twins to those with single child first births and conclude that unexpected twins have no effect on years of schooling or high school graduation rates of white mothers, but have significant negative effects for black mothers. External validity is a drawback of both of these studies: fertility outcomes resulting from miscarriages and twin births may have different effects than fertility outcomes generally.

Instrumental variables estimates using the availability of family planning services potentially address both identification problems and have a clear causal interpretation, but results have been mixed. Women whose fertility decisions are changed by the availability of abortion services have presumably not chosen to become pregnant. An unwanted pregnancy (when abortion is not an option) may have a causal effect on outcomes. Ribar (1994) uses age at menarche, the availability of Ob/Gyn physicians, and the state abortion rate to instrument for teen childbearing and finds no effect of teenage fertility on high school graduation once endogeneity is eliminated using two-stage least squares. Olsen and Farkas (1989) have similar findings about high school dropouts. Recent authors using similar approaches have come to different conclusions, however. Angrist and Evans (1996) use variation in the availability of abortion services over time and across states induced by state abortion reforms in the 1970s as an instrument. They find that abortion liberalization reduced teen fertility, teen marriage, and out-of-wedlock births and increased schooling and employment rates considerably among African American. Klepinger et al (1999) use extensive state and county-level indicators of the cost of fertility and fertility control and also find strong detrimental effects of teenage childbearing on educational attainment, accumulated work experience, and wages.

Despite extensive empirical examination, there is no current consensus about the existence or magnitude of a causal effect of fertility timing on educational attainment. This paper contributes to this previous body of work in at least three areas. First, I examine the fertility decisions and educational behavior beyond high school. Previous work has focused almost exclusively on the relation between teenage childbearing and high school graduation, with relatively little attention paid to postsecondary educational outcomes. The longitudinal approach taken also illuminates the proximate mechanism through which early childbirth and ultimate educational attainment are related. As noted by Moffitt (2005), most studies of teenage childbirth "that have attempted to address the endogeneity problem have not been able to determine the mechanism by which postponement affects outcomes, which makes it difficult to interpret the results." Previous research has not demonstrated whether young mothers leave school earlier, attend college less intensively, or begin on a completely different educational trajectory than non-mothers. This study attempts to answer this question. Methodologically, I test the validity of the key identification assumption underlying much previous cross-sectional work. It is often assumed that observably similar individuals constitute an appropriate control group for women who enter parenthood early. The longitudinal nature of educational investment permits the testing of this assumption using pre-birth course-taking behavior. This identification test has a long history in labor economics, particularly in the study of job training and welfare programs, but has yet to be applied to the study of fertility and education.[4] Lastly, I also demonstrate the use of the estimated birth hazard rate as a parsimonious way of matching mothers with a control group. This approach may be useful in other applications where "treatment" has a temporal component.

Using cross-sectional analysis as a baseline, I find that women who give birth shortly after high school accumulate significantly fewer college credits and are much less likely to obtain a college degree than those who give birth later or not at all. This difference diminishes, though does not disappear, when a rich set of demographic, family background, fertility and educational expectations, and sexual behavior controls are included. Turning to the longitudinal analysis, there is clear evidence of time-varying heterogeneity among women with similar predetermined characteristics. The participation rates and credits taken by mothers and non-mothers diverge well before the actual childbirth event, even though observably-similar women do begin college on the same footing. The strong relationship between timing of childbirth and educational attainment appears to be driven by time-varying factors that cause women to reduce educational investment and eventually enter parenthood, not by a sharp break in educational investment at the time of childbirth.

This paper is organized as follows. The next section briefly discusses several theoretical considerations. Section Three introduces my data and empirical approach. The main cross-sectional and longitudinal results are reported in Section Four. This section also introduces a method for identifying a proper control group of non-mothers using the estimated birth hazard. Section Five concludes.

2 Theoretical Considerations

Household production and human capital theory (Becker 1965 and 1993) provides a theoretical framework for understanding the relationship between fertility timing and educational investment. According to the theory, young children

[4]For an application of this identification test to the analysis of job training programs, see Ashenfelter and Card (1985).

place significant time demands on their parents, increasing the opportunity costs of non-household activities such as school and work. Mothers may reduce educational investment and work hours at all points in the lifecycle in response to these increased opportunity costs. Diminished labor supply in the future also reduces the returns to a given educational investment, reducing the optimal amount of schooling still further. While informative, these static models do not attempt to explain the temporal pattern of educational investment over the lifecycle. If the time cost of children is greatest in the years immediately following childbirth, then childbirth also changes the relative opportunity costs of schooling and work between time periods. The opportunity cost of school is low in the years proceeding childbirth and after children grow up, and highest in between. If childbirth is anticipated, then mothers should inter-temporally shift their educational investments to the periods before childbirth and after children age. A final consideration is that the time demands of young children can be unpredictable; parenthood requires schedule flexibility. The relative flexibility of school and work schedules will influence mothers' decision to devote non-household time to school or work. With the widespread availability of abortion services, fertility can also be more easily timed to accommodate desired educational investment. Mothers may simply postpone childbirth until after college. Overall, standard household production and human capital theory predicts that childbirth should be associated with lower levels of both educational investment and labor supply over the lifecycle. These effects should be most pronounced in the years immediately following childbirth if mothers substitute investment inter-temporally.

3 Data and Empirical Approach

3.1 The Data

The data for this analysis is the National Education Longitudinal Study of 1988 (NELS), fourth follow-up, which was collected and published by the National Center for Educational Statistics (NCES). NELS is a nationally representative sample of U.S. 8th graders in 1988. Respondents were interviewed five times (1988, 1990, 1992, 1994, and 2000) and the sample was refreshed in 1992 to provide a nationally representative sample of the high school class of 1992. Following the 2000 interview, postsecondary transcripts were collected for all respondents who reported ever attending any type of postsecondary schooling (including 4-year, 2-year, and vocational schools), or for whom evidence of their attendance was found in Federal financial aid records. All of my data comes from the restricted use (confidential) version of the 1992 and 2000 surveys and the corresponding postsecondary transcripts. There are 12,244 individuals in the complete dataset.

I have restricted my sample in several ways. I include only women who have attended post-secondary schooling at some time prior to the 2000 survey. All men and any women who have never attended postsecondary schooling are excluded. I am primarily concerned with the educational consequences of post-high school fertility. Therefore, I exclude all women whose first childbirth came before August 1992 or an individual's high school graduation date, whichever is later. I conduct longitudinal analysis using calendar time in relation to the typical high school graduation time, so I also exclude women who graduate before January of 1992 or for whom graduation date is missing in order to minimize timing measurement error. Lastly, I restrict analysis to women that participated in both the 1992 and 2000 surveys and for who complete transcript data was obtained. The restricted sample consists of 4,385 women, including 1,059 mothers. Missing values for some of the control variables used in estimation of the birth hazard model reduced my sample further to 2,107 women for all longitudinal analysis contained in Section Four.

3.2 Summary Statistics

The first two columns of Table 1 contain basic summary statistics for all women in my sample. On average, women have accumulated 112 units of college credits within eight years of high school graduation and half have earned a Bachelors degree. Approximately one quarter give birth to their first child during this period. Births are relatively rare in the first two years after high school, but are spread fairly evenly in the six years that follow. The racial and ethnic composition is similar to that for the unrestricted (12,144 observations) dataset, with whites comprising 81% of the sample, and the balance being mostly black (9%) and Asian (7%). Individuals of Hispanic ethnicity are 12% of the sample. Slightly more than one-third have a parent who has earned a college degree, and most come from a two-earner household.

The next six columns break out these statistics by the timing of first childbirth. Women who had children within four years of high school earned fewer college credits and were much less likely to earn a college degree than those who had children later or not at all. However, young mothers are also more likely to come from disadvantaged backgrounds – parental education and household income, for instance, are both lower for mothers who give birth early. Young mothers also tend to come from larger families and are more likely to have a sister that experienced a pregnancy during high school.

Table 2 demonstrates that education and fertility expectations also vary considerably with timing of first birth. Though 82% of all students expected to achieve a Bachelor's degree, only 66% of mothers who gave birth early expect to. Young mothers were also less likely to plan to go to college immediately after high school. It is also apparent that the actual timing of fertility only roughly conforms to expectations. Few high school seniors expect to have their first child before the age of twenty-two (which roughly corresponds to what I categorized as early births), even among those who eventually do. Early mothers do begin the process towards parenthood earlier: seventy-nine percent of early mothers were sexually active by the end of 1992, compared to only sixty-five and fifty-eight percent for later and non-mothers, respectively.

Much previous work on the effects of early fertility has been concerned with the likely presence of unobserved factors that would compel some women to begin parenthood young and also obtain less education. Figure 1 documents the presence of these factors. There is a strong relationship between women's educational aspirations and expected fertility timing. Women that plan to have children when young are also less likely to aspire to a Bachelor's degree. Almost all women that plan to delay parenthood until their late twenties or later expect to obtain a college degree and many more aspire to a graduate or professional degree. Failing to account for this correlation will overstate the adverse consequences of early childbirth on educational attainment.

3.3 Empirical Approach

I examine the relationship between fertility timing and educational investment in several ways. I first document the cross-sectional differences in educational outcomes (degree attainment and credit accumulation) by timing of first birth, both with and without adjustments for a rich set of background characteristics and expectations using ordinary least squares. The assumptions needed to interpret these differences as the causal effect of fertility timing on educational attainment are strong and almost surely not met in my data. However, the proximate sources of these unexplained differences are what I intend to shed light on using longitudinal data. The longitudinal approach recognizes that educational outcomes are the result of an accumulation of educational investments made over time. I conjecture that if differences in outcomes are due to differences in the timing of childbirth, then childbirth should disrupt this pattern of investment around the time childbirth actually occurs. If the temporal pattern of educational investment is unrelated to the timing of childbirth, then I will conclude that early fertility alone is not the causal explanation for reduced educational attainment among early mothers. To implement this, I search for a drop in educational investment intensity precisely at the time of childbirth and immediately following. I also account for the differences in likely educational investments in absence of childbirth, based on characteristics that are observable at the end of high school.

4 Results

This section presents the empirical results of the paper. As a basis for comparison with previous work, I first present cross-sectional estimates of the effect of fertility timing on educational outcomes such as credit accumulation and degree attainment. This is followed by a descriptive analysis of the longitudinal nature of educational investment and its relationship to fertility timing, in order to document several new stylized facts. The third part develops and implements a method for matching mothers to similar non-mothers using predicted birth hazards. The resulting matched control groups are used in the final part to generate longitudinal estimates and to test the main identification assumption of this and previous work.

4.1 Cross-sectional Estimates

Table 3 reports cross section estimates of the effect of birth timing on post-secondary credit accumulation. Linear models were estimated using least squares. Each model includes eight birth-year indicator variables (one for each academic year of first childbirth) and the indicated control variables. Coefficients in column (1) are unadjusted for covariates; they calculate the unadjusted mean difference in accumulated college credits between mothers and non-mothers, by the year of first childbirth. Women who gave birth within the first year of graduating from high school accumulated 76 fewer college credits than women who had not yet had children seven years later. The accumulated credit difference between mothers and non-mothers is monotonically increasing with time from high school. Women who gave birth in the eighth year after high school accumulate 53 more college credits than the first cohort of mothers, yet still accumulate 23 fewer than non-mothers.

Columns (2) through (5) include an increasingly rich set of control variables observed in respondent's senior year of high school (1992), including family background, educational expectations, expected timing of childbirth, and sexual behavior. Accumulated credit differentials are reduced considerably – by 30 to 40% – when controls are included, but the differentials are not eliminated entirely. Even after controlling for background, expectations, and sexual behavior, the earliest mothers accumulate 44 fewer college credits than non-mothers. All differences are significant at conventional levels. Table 4 repeats this analysis using degree attainment as the dependent variable. The same linear models were fit using Probit regression. Early mothers are 40 to 50% less likely to obtain an Associates or Bachelor's degree within eight years of high school graduation than non-mothers, even after accounting for observable differences in background, expectations, and sexual behavior. Degree attainment differentials are hardly diminished when these observable characteristics are accounted for.

While not directly comparable to previous work, these cross-sectional estimates are similar to those found in recent studies using abortion laws and the availability of family planning services as instrumental variables. Klepinger, Lundberg, and Plotnick (1999) find that teenage childbearing reduces years of schooling by about two and one half years. Forty-four college credits are roughly equivalent to about two years of full-time college attendance.

The identifying assumption in this and previous cross-sectional analyses is that individuals' timing of first childbirth is uncorrelated with unobservable determinants of educational attainment. This assumption is inherently not testable with cross-sectional data, though evidence from siblings models suggests it is likely violated (Gernonimus and Korenman 1992). Longitudinal data can be used to partially address this shortcoming. The educational outcomes analyzed in Tables 3 and 4, and most of the previous literature, are the cumulative result of educational investments made incrementally over many time periods. Receiving a Bachelor's degree is not a decision made at one point in time. Rather, it is the end result of a sequence of decisions to enroll in and complete college courses over a span of four to eight or more years. The remainder of this paper exploits this cumulative nature of educational attainment to partially test the above identification assumption. Intuitively, the pre-birth course-taking behavior between women who enter childbirth early and women in an appropriate control group should be similar. Cross-sectional approaches do not permit a such a test. I also document the temporal relationship between childbirth and educational investment during the eight years following high school, differentiating between several possible mechanisms through which early childbirth is negatively related to educational attainment. Young mothers may leave school earlier, attend college less intensively, or begin on a completely different educational trajectory than non-mothers, but cross-sectional analyses cannot distinguish between these mechanisms.

4.2 The Longitudinal Nature of Educational Attainment

Figure 2 plots the average postsecondary credits taken by women in the first sixteen semesters (eight years) following high school, separately by semester of first childbirth.[5] Women in the final panel had not yet had a child by the Spring of 2000. Their course-taking behavior is as expected from "traditional" college students: on average, they take 12 to 14 credits per semester (approximately full-time) for four years, then reduce investment levels significantly thereafter. The drop-off in credit accumulation precisely after eight semesters is much smaller for women who have children, though smaller sample sizes make these series much noisier than for non-mothers.

The vertical line in each graph indicates the semester of first childbirth. In most cases, educational investment declines steadily in the semesters leading up to childbirth and flattens out afterwards. There is no evidence of a precipitous drop in educational investment precisely at the time of childbirth; the investment decline is much more gradual. Investment falls approximately linearly until childbirth then stabilizes afterwards.

Figures 3 and 4 decompose average credits taken into postsecondary participation and credits taken conditional on participation in each semester, respectively. The time profile of participation (Figure 3) and total average credits taken (Figure 2) are remarkably similar, save for the Spring-Fall seasonality in credits. This suggests that nearly all adjustment in post-secondary educational investment occurs on the participation margin, rather than in investment intensity. Figure 4 plots the average credits taken conditional on taking at least one college credit. There is very little discernible adjustment in the number of credits individuals take, either over time or with childbirth. On average, those participating in post-secondary education take 10 to 15 units of college credit both before and after childbirth and regardless of how much time has passed since high school.

[5] Courses beginning in the months January through July are classified as in the Spring semester, while the Fall includes all courses beginning in August through December. Semester of first childbirth was classified similarly. Since more of the summer months were included in the Spring, the number of credits taken in the Spring tends to be greater than the number of credits taken in the Fall

Figures 2 through 4 also demonstrate the extent of heterogeneity present in the sample. Women who give birth in 1994 or earlier begin college with much lower participation rates and as a result accumulate far fewer credits than those who begin parenthood later, even before the onset of parenthood. There is much more pre-birth similarity among women who begin parenthood in 1995 or later, though women who delay parenthood until at least 1997 appear to start off even stronger. The next section addresses this initial condition heterogeneity by matching mothers with non-mothers with similar estimated birth hazard rates. This approach is similar in spirit to propensity score methods used to deal with non-random treatment assignment, when assignment is assumed to be random conditional on observable covariates.[6] The primary limitation of this approach is that differences attributable to unobserved factors cannot be accounted for.

4.3 Counterfactual Educational Investment

To formalize the temporal relationship between childbirth and educational investment displayed in Figures 2 through 4, I will estimate a model of the form

$$y_{i,t} = f_i(t) + \delta_{-1} D_{i,t}^{-1} + \delta_0 D_{i,t}^{0} + \delta_1 D_{i,t}^{1} + \varepsilon_{i,t} \qquad (1)$$

where $y_{i,t}$ is the number of credits taken or an indicator for post-secondary participation by individual i in period t. $D_{i,t}^{k}$ is an indicator for time relative to childbirth. $D_{i,t}^{k}$ equals one if individual i had a child k periods earlier (where k can be positive), and zero otherwise. For notational simplicity, in Equation (1) I have only included birth time indicators for one period before and one period after childbirth. However, I include 15 period (semester) lags and leads in the specifications I actually estimate. $f_i(t)$ is the number of credits individual i would have taken in period t had they not had a childbirth (discussed further below) and $\varepsilon_{i,t}$ is an individual-time error component. Coefficients on the birth time indicators, $\{\delta_k\}$, measure the credit or participation differences between actual and predicted behavior in the current period, having had a child k periods earlier. These are the parameters of interest. For instance, δ_0 is the credit or participation drop in the period of childbirth, relative to not having had a child. I initially assume these differences to be constant across individuals and over calendar time, though I relax this assumption later.[7]

The primary identification problem in implementing Equation (1) is the estimation of $f_i(t)$. $f_i(t)$ is the counterfactual educational investment profile for individual i. This counterfactual is never observed so it must be estimated using women who have not yet given birth in my sample period (the "untreated") as a control group and by restricting the functional form of $f_i(t)$, for which there

[6] See Rosenbaum and Rubin (1984) for a discussion of the propensity score method.

[7] This formulation is an application of the "event-study" approach utilized by Jacobson, LaLonde, and Sullivan (1993) to estimate the earnings loss experienced by displaced workers. This method can be thought of as a generalized difference-in-difference, where a treatment-control difference is calculated at all points before and after treatment.

are numerous plausible choices.[8] $f_i(t) = \gamma_t$ assumes that all individuals would have the same post-secondary investment pattern absent childbirth. Figures 2 through 4 refute the validity of this assumption. Mothers who give birth early begin post-secondary schooling on a different trajectory from mothers who delay parenthood. $f_i(t) = \gamma_t + X_i\beta$, where X_i is a vector of individual and family characteristics, assumes that the heterogeneity in $f_i(t)$ shifts the intercept of the time profile by a fixed amount that is proportional to individual and background characteristics. This specification has the undesirable property that predicted credits or participation may be negative. $f_i(t) = \gamma_t \cdot (X_i\beta)$ allows individual characteristics to scale the average profile by a fixed amount. This specification restricts all individuals to have the identical profile shape, other than a proportional scale factor. To permit individual characteristics to affect the counterfactual profile in a more general way, I specify $f_i(t) = \gamma_{t,g(i)}$, where $\gamma_{t,g(i)}$ is the average credits or participation rate of non-mothers in group $g(i)$ in period t. Group $g(i)$ is the group of women with comparable birth hazard rates as individual i, based on characteristics observable at the end of high school.

To match mothers and non-mothers into groups with similar predicted timing of first birth, I estimate a Cox proportional hazard model using maximum likelihood, as in Equation (2).

$$h_i = h_0 \cdot e^{X_i\beta + \varepsilon_i} \tag{2}$$

h_i is the probability that individual i has a child during any particular month after high school, having not had a child by the end of the previous month.[9] This probability is assumed to be constant over time, but varies across individuals. I include a rich set of covariates observed at the end of high school in the estimation, including: race, Hispanic ethnicity, parent's highest education level, mother and father labor force participation, log of family income, sister high school pregnancy, own educational expectations and plans to attend college immediately, expected age of first childbirth, year of first sexual intercourse, and use of birth control during first sexual intercourse.[10] The predicted hazard rate from the estimation of Equation (2) parsimoniously summarizes the likelihood that an individual will have a child early based on characteristics observable at the end of high school.

Figure 5 suggests that the estimated hazard rate at the end of high school does a decent job predicting timing of first birth. Figure 5 plots the median and spread of predicted hazard rate by actual year of first childbirth. Women who gave birth earliest had the highest risk of childbirth based on factors observable at the end of high school. The median hazard rate generally decreases, though

[8] Throughout this paper I will refer to women who have not yet given birth during my sample period as "non-mothers" though many of them will eventually give birth sometime after my sample period.

[9] In estimating the hazard rate, I specify months since July 1992 as the time an individual is at risk before the event (childbirth) occurs. Non-mothers were included in the hazard rate estimation, but their time at risk is censored at 96 months.

[10] Results from estimation of the proportional hazard model are contained in Appendix Table A1.

not monotonically, as childbirth is delayed. Fortunately for the matching strategy described above, there is considerable overlap across childbirth years. For instance, most mothers that gave birth within a year out of high school have a comparable non-mother who was at a similar risk for early childbirth at the end of high school. I use these similarly-risked non-mothers as a control group in estimation of the counterfactual educational investment profile of mothers. This approach is a specific form of matching where the weight each control variable receives in the matching algorithm is related to its importance to predicting birth timing.

Individuals were sorted by estimated hazard rate and divided into ten ordered groups based on this ranking. Table 5 displays the mean difference for several important characteristics between mothers and non-mothers within each hazard group.[11] By construction, mothers and non-mothers with similar estimated hazard rates are observably very similar. In only one of the hazard groups (group 8) is there a significant difference between mothers and non-mothers in more than two of the characteristics examined. Based on this quality of balance across observable characteristics and the predictive power of the predicted hazard rate, I use similarly-risked non-mothers to estimate $f_i(t)$ for each mother in my sample.

4.4 Longitudinal Estimates

To construct a counterfactual educational investment profile for mothers, I estimate Equation (3) using probit regression for the sample of non-mothers.

$$y_{i,t} = \sum_{j=1}^{j=10} \left[G_{i,j} \cdot \sum_{s=1}^{s=16} \left(\gamma_{j,s} \cdot T_{s,t} \right) \right] + \varepsilon_{i,t} \tag{3}$$

$G_{i,j}$ is a hazard group indicator equal to 1 if individual i is in hazard group j, and zero otherwise. $T_{s,t}$ is a time indicator equal to 1 if $s = t$ and zero otherwise. The double summation in Equation (3) is shorthand for a set of 160 group x time indicator variables (10 groups x 16 time periods). The estimated parameters of interest $\{\gamma_{j,s}\}$ are the average number of credits taken (or average participation rate) by non-mothers in hazard group j at time s. The coefficients obtained from estimating Equation (3) are used to predict participation for the entire sample, including mothers.

Figure 6 plots the actual and predicted postsecondary participation rate separately by semester of first childbirth.[12] Participation rate is predicted for mothers in each birth cohort using non-mothers with comparable birth hazard rates, as estimated by characteristics observable at the end of high school. As before, the vertical line indicates the semester of first childbirth. Several features of Figure 6 are striking. Most important, the actual participation rate

[11] Appendix Table A2 contains the group means in addition to their difference.

[12] Analogous analysis on average postsecondary credits taken, which was conducted but not reported here, produces nearly identical qualitative and quantitative results.

deviates from its prediction well before the event of pregnancy for most groups. For example, women who gave birth in Fall 1995 had similar participation rates as non-mothers with similar birth hazards immediately following high school. By Fall 1994, however, the participation rate of eventual mothers is twenty percentage points lower, even though their future pregnancy is still unknown. Participation rates fall even further immediately preceding and during the semester of childbirth. This general pattern of significant pre-birth decline in relative participation rate holds for most birth cohorts prior to 1998.[13] Women whose first childbirth occurs in the Fall of 1998 or later have similar postsecondary participation rates as non-mothers with comparable birth hazards, presumably because Bachelor's degrees have been mostly earned by this time and participation in graduate education is less deterred by parenthood.

For expositional ease, Figure 7 plots the actual minus predicted postsecondary participation rate following high school, separately by semester of first childbirth. If mothers' educational investments followed the same time path as non-mothers with comparable fertility risk at the end of high school, then each plot would lie precisely on the zero line. Alternatively, if mothers took a fixed number of fewer courses than observably similar non-mothers, each plot would be a horizontal line below zero. Both of these cases are clearly rejected by the data. Mothers' temporal pattern of educational investment deviates significantly from that of observably similar non-mothers over the eight years following high school. The deviation is most significant for the earliest mothers and appears to be approximately centered and symmetric around the time of first birth. Mothers reduce postsecondary participation in the years leading up to their first childbirth then gradually catch up to their non-mother peers (albeit to a lower absolute level of participation) in the years following. Contrary to the prediction of theory, the reduction in educational investment associated with childbirth is gradual and begins several years before the actual birth occurs, not sharply at the time of birth.

One advantage of the longitudinal approach is that the comparability of mothers and similar-risk non-mothers can be directly tested in the periods before childbirth. Intuitively, the pre-birth course-taking and participation pattern of mothers and comparable-risk non-mothers should be similar. If this condition holds, the plots in Figure 7 should lie on the zero horizontal axis in the years preceding childbirth. From the Spring of 1994 onwards, mothers do have similar participation rates as non-mothers immediately after high school. The deviations are all negligible in the first semester after high school, but increase dramatically shortly thereafter. This indicates that characteristics observable at the end of high school such as family background, educational aspirations, and fertility expectations are useful predictors of immediate postsecondary education behavior, but this predictive power erodes quickly.

To quantify the average magnitude and timing of this dip across all mothers, I estimate a model which combines Equations (1) and (3). I estimate Equation

[13] This does not apply to mothers in the first two birth cohorts for which pre-pregnancy educational experience does not exist.

(4) using Probit regression for participation rate.

$$\begin{aligned} y_{i,t} &= \sum_{j=1}^{j=10} \left[G_{i,j} \cdot \sum_{s=1}^{s=16} \left(\gamma_{j,s} \cdot T_{s,t} \right) \right] \\ &\quad + (early)_i \cdot \sum_{k=-15}^{k=15} \left(\delta_k^{early} \cdot D_{i,t}^k \right) \\ &\quad + (late)_i \cdot \sum_{k=-15}^{k=15} \left(\delta_k^{late} \cdot D_{i,t}^k \right) + \varepsilon_{i,t} \end{aligned} \tag{4}$$

The first component of the right hand side of Equation (4) estimates the counterfactual educational investment pattern for mothers using non-mothers with a similar fertility risk at the end of high school. This is an estimate of $f_i(t)$ in Equation (1). The last two terms calculate the average deviation from this estimated counterfactual for the fifteen periods before and after childbirth, separately for births that occur early or late. Conceptually, this procedure realigns the graphs in Figure 7 around a common vertical line at the time of childbirth to create a common "event time" relative to childbirth. The coefficients $\{\delta_k\}$ are the average deviation of each plot from the zero horizontal axis for each "event time" period. Since the deviation from predicted behavior around the time of childbirth is much smaller for later births than for earlier ones, I permit $\{\delta_k\}$ to vary with birth timing as well. The indicator variables $(early)_i$ and $(late)_i$ denote a childbirth occurring before or after August 1, 1996, by which time a large number of students have obtained Bachelor's degrees.

Panel A in Figure 8 plots the estimated coefficients $\{\delta_k\}$ from Equation (4). Childbirth is predicated by a sustained decline in participation for at least three years, and is followed by a gradual recovery, albeit to a lower absolute level. By the time of childbirth, early mothers have a participation rate that is 40 percentage points lower (approximately half of the base) than comparable non-mothers. The participation deviation at childbirth is approximately twice as large for early mothers compared to mothers who delay parenthood until four years after high school. Panel B restricts $\delta_k^{early} = \delta_k^{late}$, but includes individual fixed effects. In addition to the counterfactual attendance pattern predicted from non-mothers, this specification permits each mother to have a different average participation rate. The basic results are robust to this alternative specification. Though mothers begin postsecondary education at a rate and intensity comparable to non-mothers, investment begins to fall immediately thereafter for early mothers and after only a few years for late mothers.

5 Conclusion

Like previous studies, I have found that women who enter parenthood earlier have much lower levels of postsecondary educational investment over the eight years following high school. This sustained lower level of investment results in much lower rates of degree attainment by the end of the eight years studied. Less than half of this discrepancy is explained by factors such as background, educational aspirations, fertility expectations, and sexual activity that is observed or stated at the end of high school. Though these factors predict postsecondary behavior immediately after high school reasonably well, eventual mothers deviate sharply from this prediction shortly thereafter, even before the event of childhood. The implication is that studies that control only for fixed individual effects or differences in pre-determined observable characteristics do not address a major time-varying source of omitted variable bias.

Eventual mothers reduce educational investment, primarily through non-participation rather than lower intensity, well before the actual occurrence of parenthood. This suggests that parenthood, per se, is not the causal explanation for the strong link between fertility timing and educational outcomes, at least for women who give birth after high school. The presence of time-varying factors that compel women to halt education then eventually enter parenthood provides a better fit of the data. Deliberate postponement of childbirth until after completion of postsecondary education is one such explanation. This finding is consistent with Upchurch, Lillard, and Panis (2002), who find strong evidence that women purposely sequence childbirth and school attendance. A dynamic model of the simultaneous childbirth-education sequencing decision seems to be a necessary framework for exploring this topic.

This paper has left several areas for future research. Most importantly, it would be fruitful to examine the temporal relationship between women's labor supply, educational investment, and timing of first birth. Childbirth-induced adjustments in work hours could not be accounted for in the proceeding analysis. There also appears to be differences in the pre-birth rate of decline in education investment by fertility timing. Understanding the sources of these differences may further illuminate why women choose to discontinue postsecondary education and how this choice is related to fertility decisions. Other life events – notably marriage – are also absent from this analysis. These events likely change the risk of pregnancy over an individual's lifetime. A time-dependent hazard model that relaxes the constant proportional hazard assumption by incorporating these life events would probably do a better job of predicting pre-birth behavior than the static one I have employed. I leave these task for future work.

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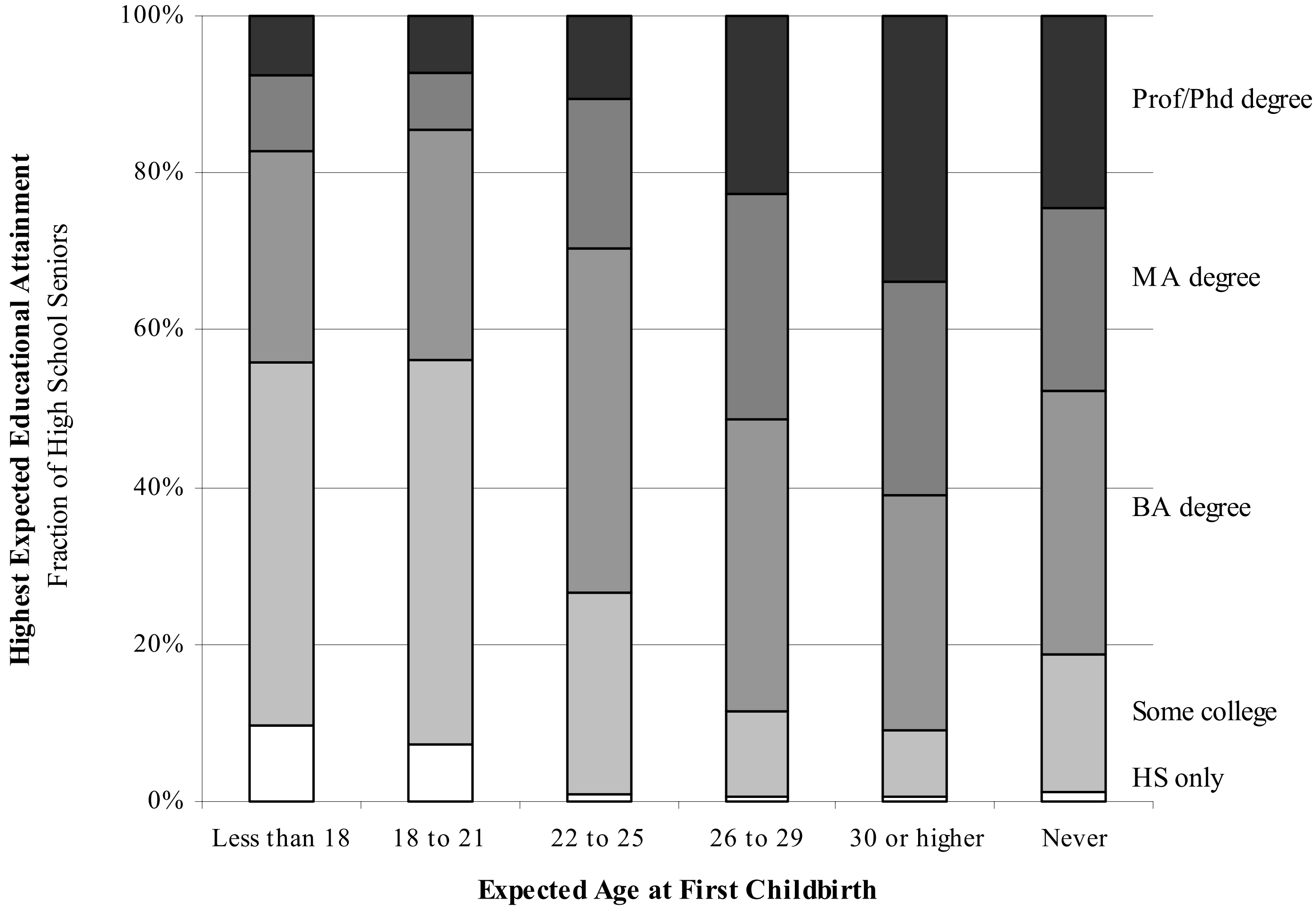
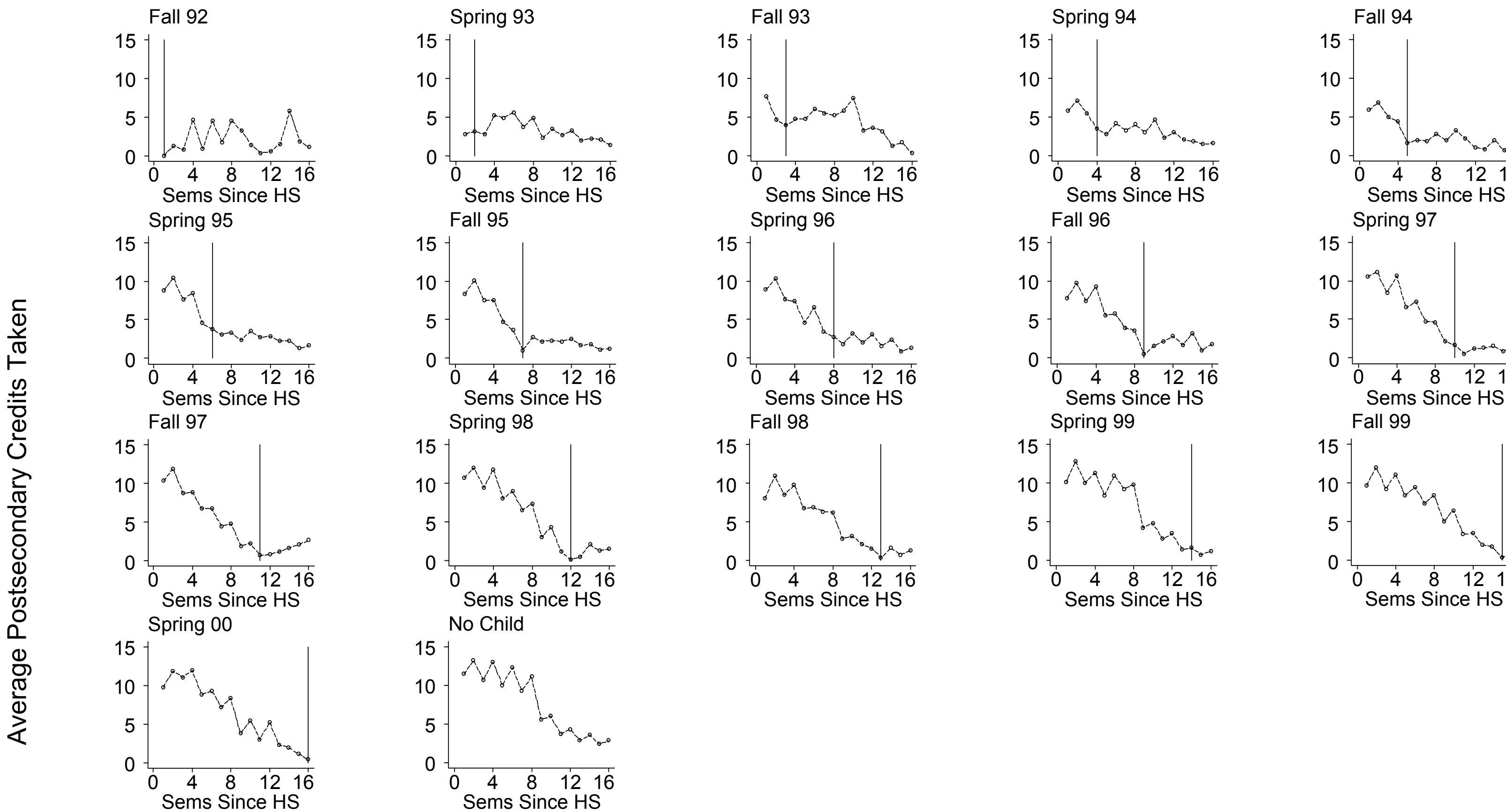
Figure 1 – Education and Childbirth Expectations



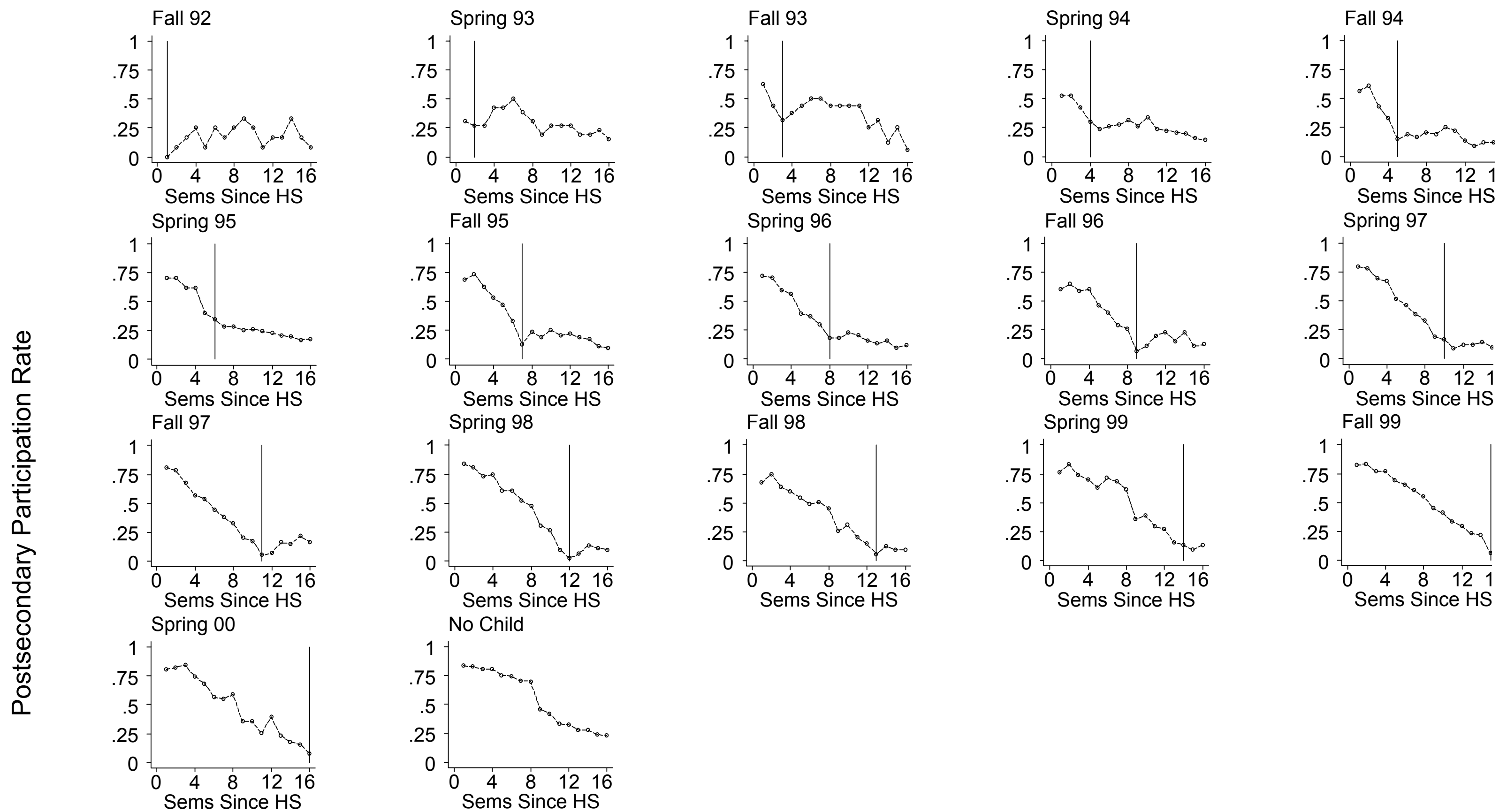
Notes: Expectations are as of 1992, when most respondents were in their senior year of high school

Figure 2 – Average Postsecondary Credits Taken, By Semester of First Childbirth



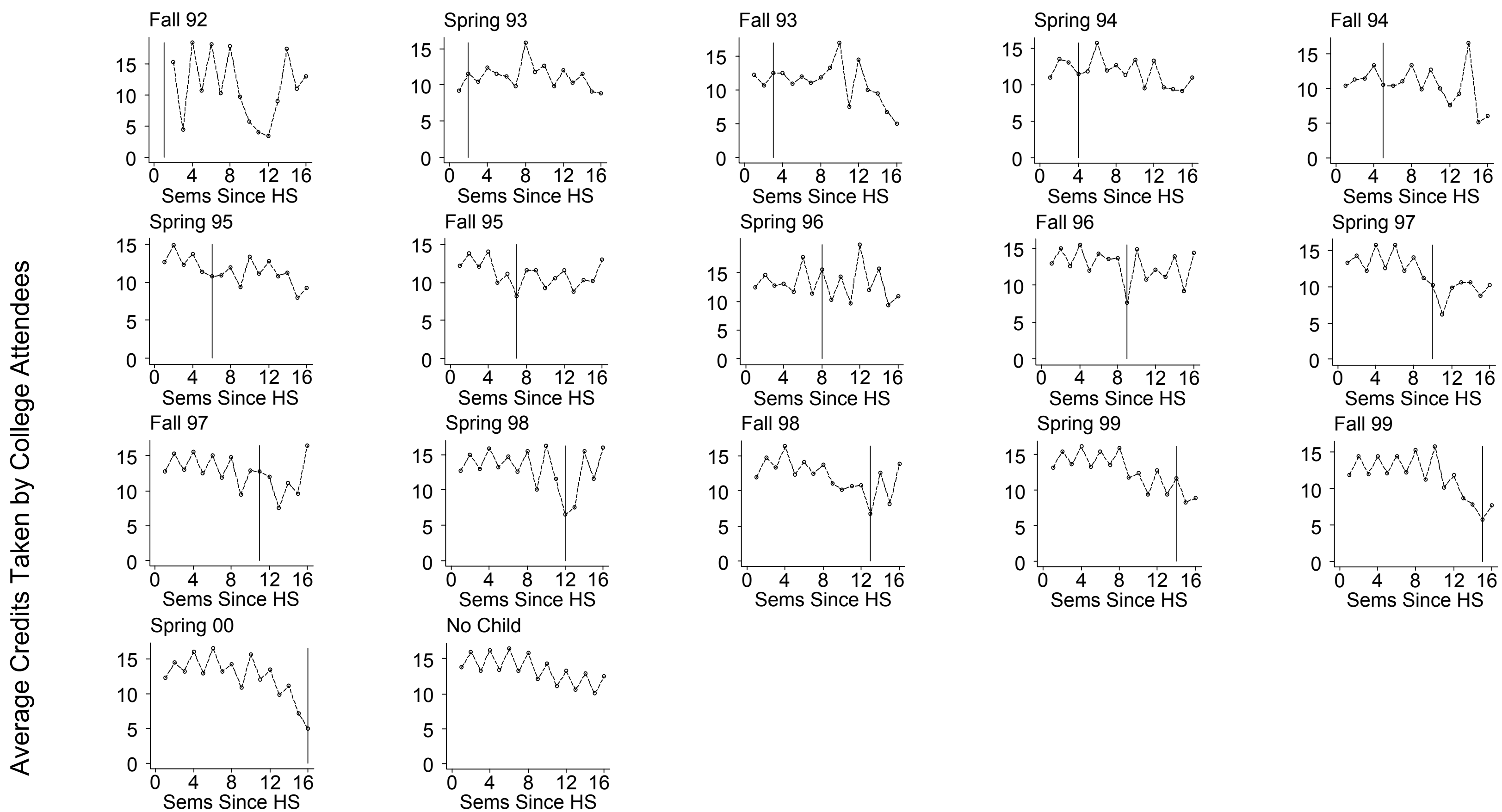
Notes: Vertical lines indicate the semester of first childbirth. Spring includes the months January to July while Fall includes August through December.

Figure 3 – Average Postsecondary Participation Rate, By Semester of First Childbirth



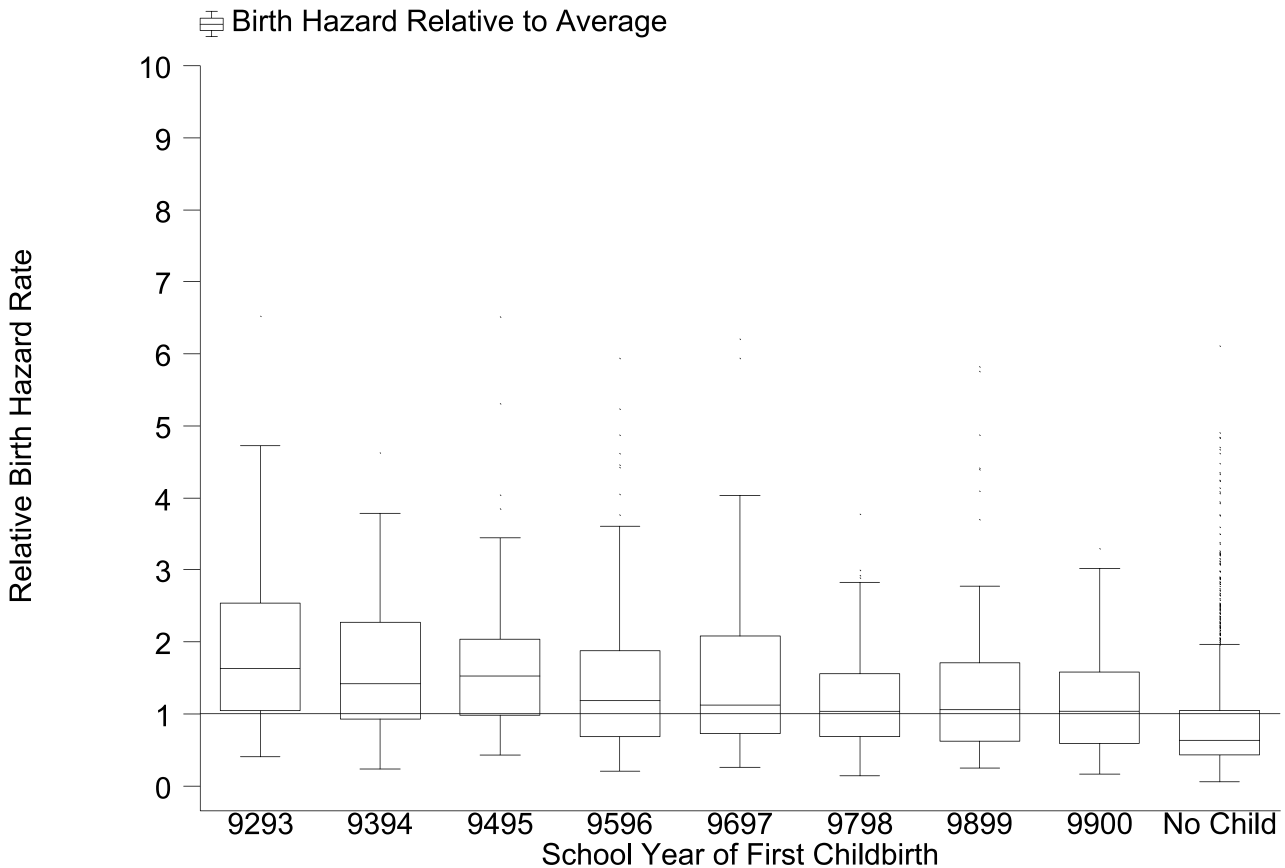
Notes: Vertical line indicates the semester of first childbirth. Postsecondary participation is indicated by taking at least one unit of credit in the semester. Spring includes the months January to July while Fall includes August through December.

Figure 4 – Average Postsecondary Credits Taken Among Participants, By Semester of First Childbirth



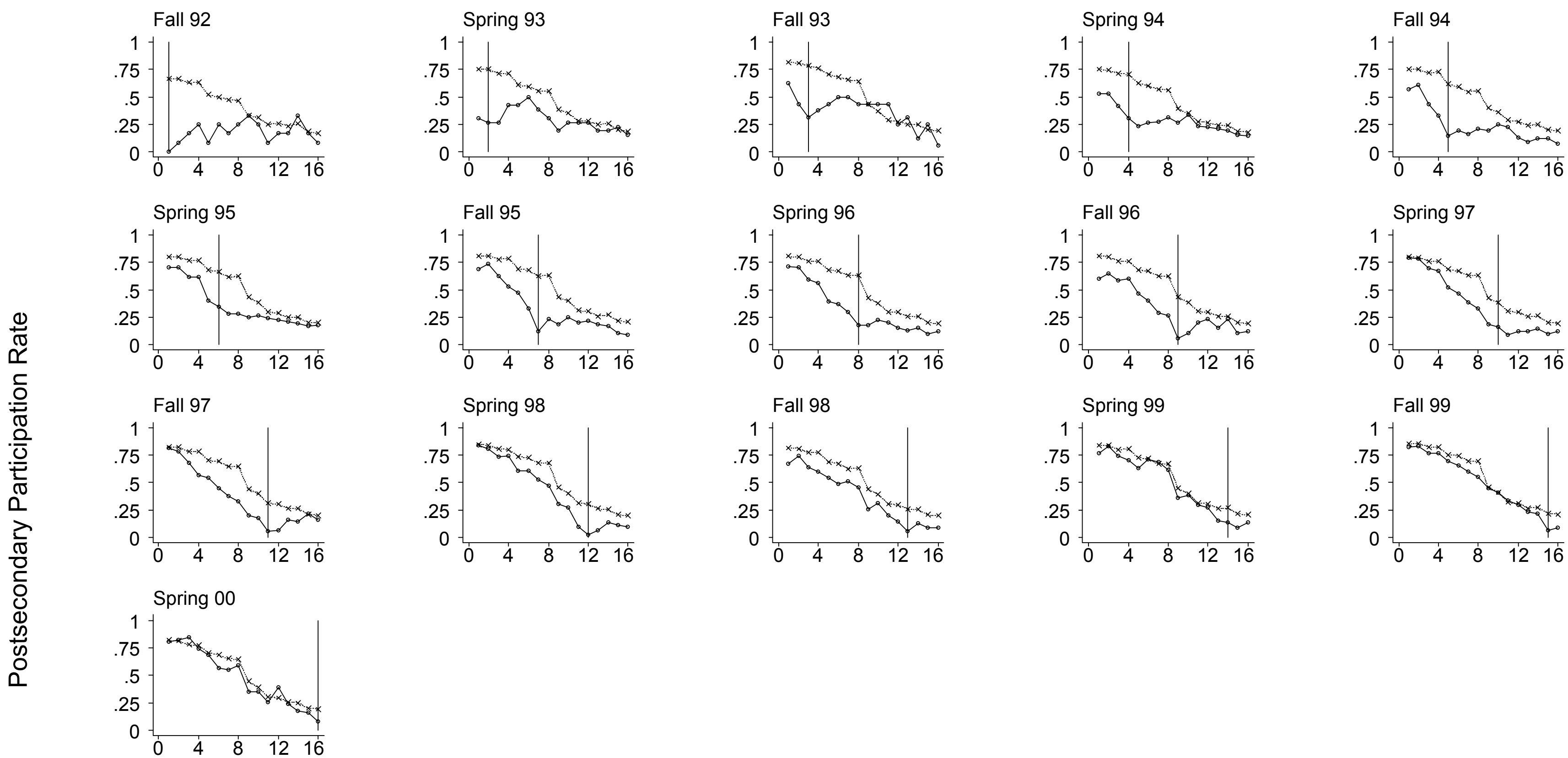
Notes: Vertical line indicates the semester of first childbirth. Spring includes the months January to July while Fall includes August through December.

Figure 5 – Box Plot of Childbirth Hazard Rate, by Actual Year of First Childbirth



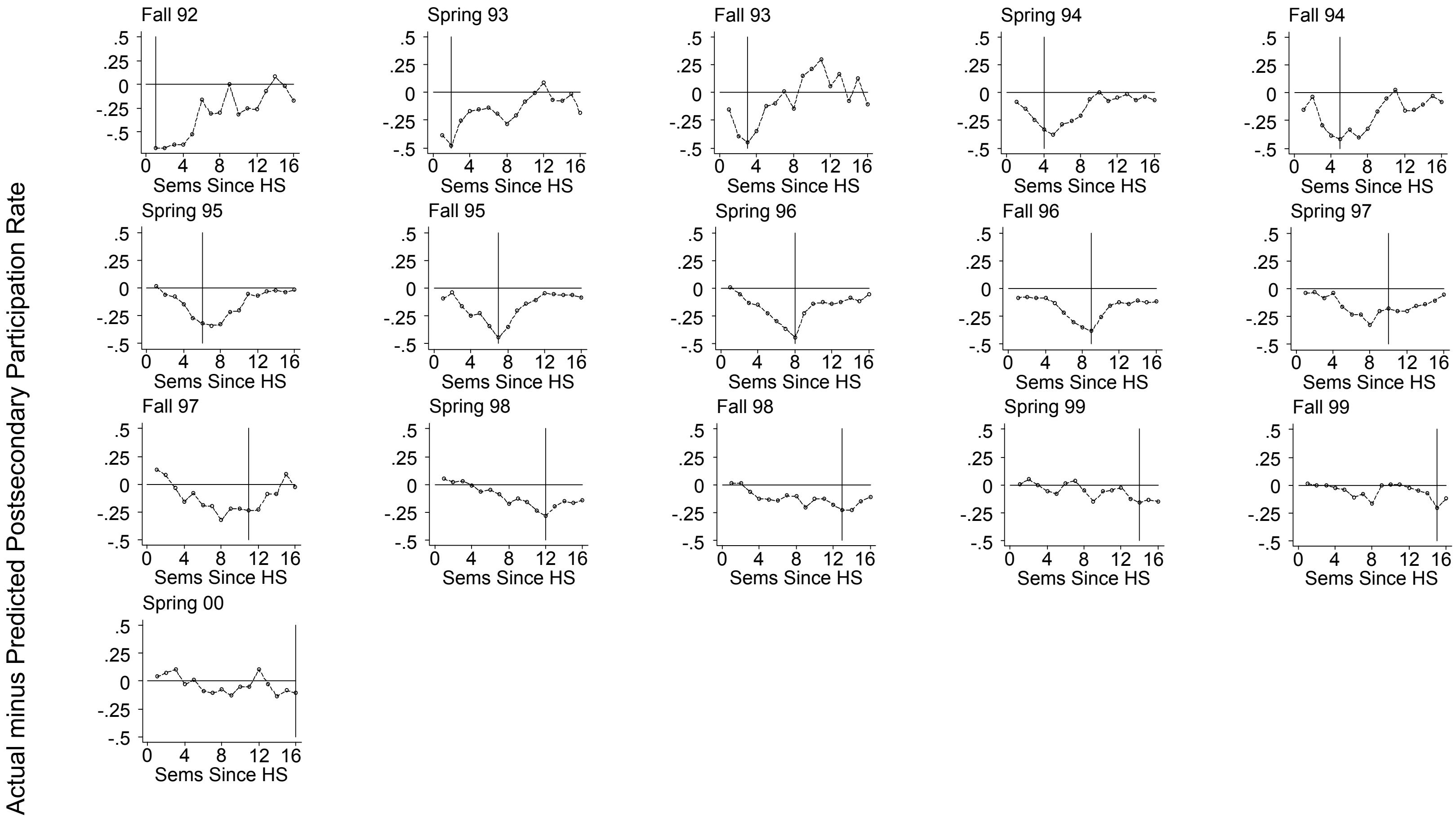
Notes: Predicted relative hazard rates were normalized by the average for the entire sample. The middle line of each box is the median for each group, while the top and bottom of the box give the 75th and 25th percentile, respectively. Vertical lines extend 1.5 times the inter-quartile range.

Figure 6 –Predicted and Actual Postsecondary Participation Rate, by Semester of First Childbirth



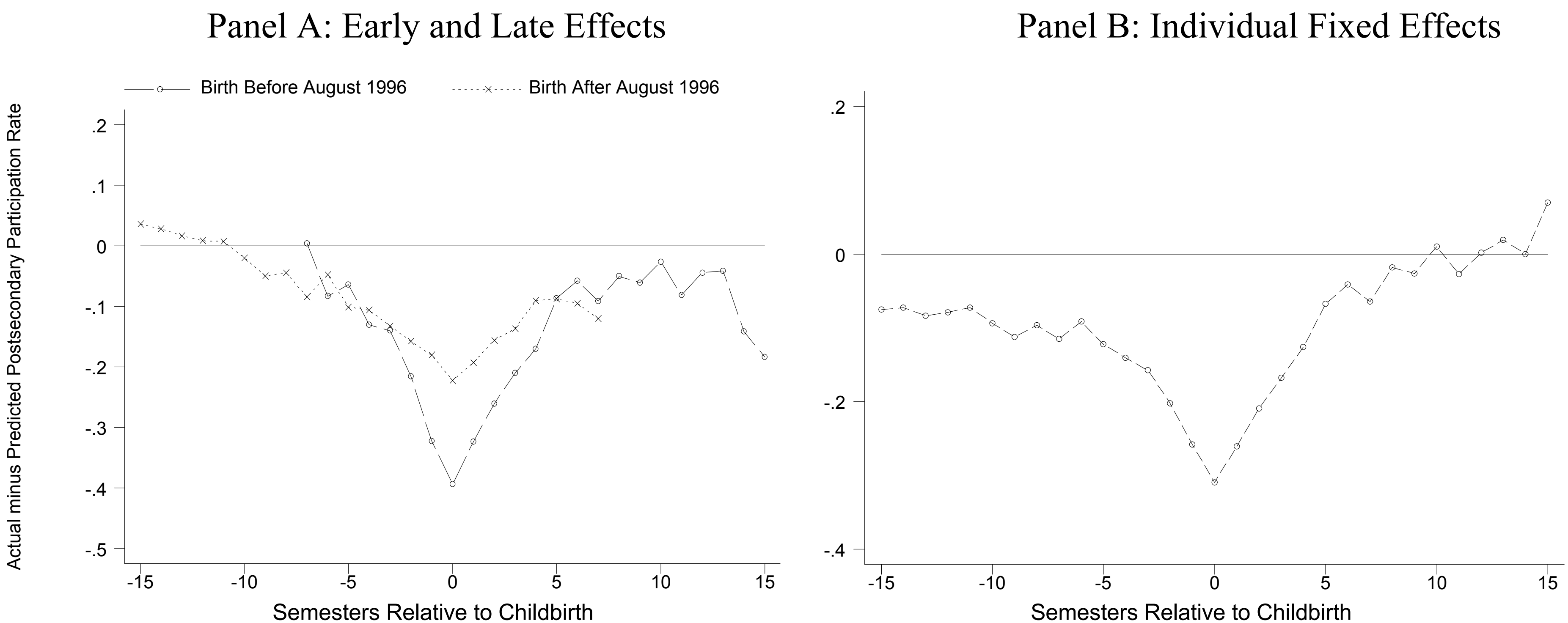
Notes: Solid lines indicate actual participation rate of mothers with the indicated birth year. Dashed lines are participation rates predicted using non-mothers with similar pre-determined characteristics. Vertical line indicates the semester of first childbirth. Spring includes the months January to July while Fall includes August through December.

Figure 7 – Deviation from Predicted Average Postsecondary Participation Rate, By Semester of First Childbirth



Notes: Vertical line indicates the semester of first childbirth. Postsecondary participation is indicated by taking at least one unit of credit in the semester.

Figure 8 - Average Deviation from Predicted Postsecondary Participation Rate



Notes: Because the educational data is restricted to August 1992 through July 2000, coefficients cannot be estimated more than seven semesters before childbirth for early mothers or more than seven semesters after childbirth for late mothers. The plots in Panel A are therefore truncated at these points.

TABLE 1 – SUMMARY STATISTICS
FERTILITY TIMING, EDUCATIONAL OUTCOMES, AND BACKGROUND

	Overall		Early Birth[1]		Late Birth[2]		No Childbirth	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Educational outcomes[3]								
Cumulative college credits	112.40	65.32	60.25	51.19	88.24	58.37	123.90	63.57
Associates degree or higher	0.59	0.49	0.24	0.43	0.44	0.50	0.67	0.47
Bachelors degree or higher	0.50	0.50	0.12	0.32	0.33	0.47	0.58	0.49
Academic year of first childbirth[4]								
1992-3	0.01	0.09	0.08	0.28	0.00	0.00	0.00	0.00
1993-4	0.02	0.14	0.20	0.40	0.00	0.00	0.00	0.00
1994-5	0.04	0.20	0.38	0.49	0.00	0.00	0.00	0.00
1995-6	0.03	0.18	0.33	0.47	0.00	0.00	0.00	0.00
1996-7	0.04	0.19	0.00	0.00	0.26	0.44	0.00	0.00
1997-8	0.04	0.19	0.00	0.00	0.26	0.44	0.00	0.00
1998-9	0.04	0.19	0.00	0.00	0.27	0.45	0.00	0.00
1999-2000	0.03	0.17	0.00	0.00	0.21	0.41	0.00	0.00
No childbirth	0.76	0.43	0.00	0.00	0.00	0.00	1.00	0.00
Demographic characteristics and family background								
White	0.81	0.39	0.79	0.41	0.84	0.37	0.81	0.39
Black	0.09	0.29	0.14	0.35	0.10	0.30	0.08	0.28
Amer. Indian/AK Native	0.01	0.11	0.02	0.13	0.01	0.11	0.01	0.11
Asian	0.07	0.26	0.02	0.14	0.03	0.18	0.08	0.28
Hawaiian/Pacific Islander	0.01	0.12	0.03	0.17	0.01	0.12	0.01	0.11
Hispanic	0.12	0.33	0.19	0.39	0.12	0.33	0.11	0.31
Highest parent's education								
less than high school	0.07	0.25	0.11	0.31	0.08	0.27	0.06	0.23
High school	0.17	0.37	0.23	0.42	0.20	0.40	0.15	0.36
Some college	0.40	0.49	0.47	0.50	0.46	0.50	0.39	0.49
Bachelors	0.18	0.39	0.13	0.33	0.16	0.37	0.20	0.40
Masters	0.11	0.31	0.04	0.20	0.07	0.26	0.12	0.33
Professional/Ph.D	0.07	0.25	0.02	0.14	0.03	0.16	0.08	0.28
Father worked	0.92	0.28	0.88	0.33	0.92	0.28	0.92	0.27
Mother worked	0.91	0.29	0.88	0.32	0.91	0.29	0.91	0.28
One wage earner	0.35	0.48	0.40	0.49	0.34	0.47	0.35	0.48
Two wage earners	0.61	0.49	0.58	0.49	0.62	0.49	0.61	0.49
Three or more wage earners	0.04	0.19	0.02	0.15	0.04	0.19	0.04	0.19
Family income, 1991	55,597	54,252	40,280	39,574	45,886	40,972	59,425	57,416
Number of siblings	2.43	2.03	3.05	2.62	2.71	2.10	2.30	1.90
Sister was pregnant in HS	0.05	0.21	0.08	0.27	0.07	0.26	0.04	0.19
Observations[5]	4385		452		607		3326	

Notes:
1. Childbirth before August 1996.
2. Childbirth during or after August 1996.
3. Educational outcomes are as of July 2000.
4. Academic year is August through July.
5. Due to missing values, some summary statistics were calculated over fewer observations

TABLE 2 – SUMMARY STATISTICS
EDUCATION AND FERTILITY EXPECTATIONS AND SEXUAL BEHAVIORS

	Overall		Early Birth[1]		Late Birth[2]		No Birth	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Highest education expected[3]								
High school only	0.01	0.10	0.02	0.15	0.02	0.13	0.01	0.09
Some college	0.17	0.38	0.32	0.47	0.25	0.44	0.14	0.34
Bachelor's degree	0.38	0.49	0.38	0.49	0.40	0.49	0.38	0.48
Master's degree	0.24	0.43	0.16	0.37	0.19	0.39	0.26	0.44
Professional/Ph.D	0.19	0.40	0.12	0.32	0.14	0.35	0.21	0.41
Plan to go directly to college[3]	0.92	0.28	0.83	0.38	0.90	0.31	0.93	0.25
Highest education expected by father[3]								
High school only	0.08	0.28	0.15	0.35	0.10	0.30	0.07	0.26
Some college	0.11	0.31	0.18	0.39	0.17	0.37	0.09	0.29
Bachelor's degree	0.42	0.49	0.40	0.49	0.41	0.49	0.42	0.49
Master's degree	0.19	0.39	0.14	0.35	0.16	0.36	0.21	0.41
Professional/Ph.D	0.19	0.39	0.13	0.34	0.16	0.37	0.20	0.40
Expected age of first childbirth[3]								
Before 18	0.02	0.12	0.01	0.09	0.00	0.06	0.02	0.14
18 to 21	0.04	0.18	0.09	0.29	0.06	0.24	0.02	0.15
22 to 25	0.30	0.46	0.48	0.50	0.43	0.49	0.25	0.44
26 to 29	0.48	0.50	0.33	0.47	0.40	0.49	0.52	0.50
30 or later	0.10	0.30	0.06	0.23	0.07	0.26	0.11	0.32
never	0.06	0.24	0.04	0.19	0.04	0.19	0.07	0.26
Year of first sexual intercourse								
Before 1988	0.01	0.11	0.04	0.18	0.02	0.13	0.01	0.10
1988	0.04	0.19	0.04	0.21	0.04	0.20	0.04	0.18
1989	0.09	0.28	0.15	0.36	0.09	0.29	0.08	0.27
1990	0.14	0.35	0.19	0.39	0.15	0.36	0.14	0.34
1991	0.15	0.36	0.21	0.40	0.16	0.36	0.15	0.35
1992	0.17	0.38	0.17	0.37	0.19	0.39	0.17	0.38
Later than 1992	0.39	0.49	0.21	0.41	0.35	0.48	0.42	0.49
Observations[5]	4385		452		607		3326	

Notes:
1. Childbirth before August 1996.
2. Childbirth during or after August 1996.
3. Expectations at the time of the survey in 1992, when respondents were in their senior year of high school. Parental expectations were derived from interviews with the students' parents.
4. Due to missing values, some summary statistics were calculated over fewer observations.

TABLE 3 – CROSS-SECTION ESTIMATES OF FERTILITY TIMING AND CREDIT ACCUMULATION
(ORDINARY LEAST SQUARES REGRESSION)

	Dependent variable: cumulative post-secondary credits[1]				
Academic year of first childbirth[2]	(1)	(2)	(3)	(4)	(5)
1992-3	-76.24	-56.48	-48.66	-46.51	-44.24
	(7.08)	(8.35)	(13.18)	(14.36)	(15.85)
1993-4	-65.43	-55.17	-47.56	-44.07	-37.46
	(5.11)	(5.64)	(7.02)	(7.24)	(7.49)
1994-5	-64.72	-52.15	-40.49	-41.41	-37.38
	(4.02)	(4.54)	(5.32)	(5.65)	(5.84)
1995-6	-58.04	-45.64	-40.27	-42.10	-41.30
	(4.61)	(4.90)	(5.40)	(5.35)	(5.44)
1996-7	-50.40	-44.60	-36.76	-37.79	-36.78
	(4.78)	(5.16)	(5.19)	(5.46)	(5.84)
1997-8	-39.74	-30.29	-23.57	-24.33	-23.65
	(4.80)	(5.13)	(5.36)	(5.24)	(5.36)
1998-9	-27.97	-18.93	-14.40	-16.64	-15.65
	(4.57)	(5.01)	(4.90)	(5.14)	(5.16)
1999-2000	-22.77	-18.90	-12.94	-13.79	-13.03
	(5.03)	(5.13)	(4.74)	(4.93)	(5.13)
Control Variables					
Background[3]	No	Yes	Yes	Yes	Yes
Educational Expectations[4]	No	No	Yes	Yes	Yes
Expected age at first childbirth	No	No	No	Yes	Yes
Age became sexually active	No	No	No	No	Yes
Observations	4385	3326	2812	2644	2467
R-squared	0.11	0.25	0.36	0.37	0.37

Notes: Robust standard errors are in parenthesis. All coefficients are significant at the 1% confidence level except that for 1999-2000 in specification (5), which is significant at the 5% level.

1. As of July 2000.
2. Academic year is August through July. The omitted category is women who have not yet had children as of July 2000.
3. Background variables includes race, parent's education, mother and father employment status, family income, and having a sister with a high school pregnancy
4. Educational expectations include own and father's educational expectations and indicator for planning to go directly to college after high school.

TABLE 4 – CROSS-SECTION ESTIMATES OF FERTILITY TIMING AND DEGREE ATTAINMENT
(PROBIT REGRESSION)

Panel A:	Dependent variable: received Associates degree or higher[1]				
Academic year of first childbirth[2]	(1)	(2)	(3)	(4)	(5)
1992-3	-0.416	-0.451	-0.514	-0.504	-0.465
	(0.060)**	(0.081)**	(0.102)**	(0.111)**	(0.134)**
1993-4	-0.425	-0.403	-0.364	-0.344	-0.312
	(0.039)**	(0.056)**	(0.082)**	(0.086)**	(0.090)**
1994-5	-0.405	-0.418	-0.414	-0.421	-0.399
	(0.030)**	(0.040)**	(0.051)**	(0.053)**	(0.057)**
1995-6	-0.413	-0.372	-0.362	-0.369	-0.364
	(0.032)**	(0.046)**	(0.055)**	(0.056)**	(0.058)**
1996-7	-0.308	-0.289	-0.255	-0.262	-0.267
	(0.037)**	(0.046)**	(0.055)**	(0.057)**	(0.061)**
1997-8	-0.290	-0.263	-0.247	-0.243	-0.217
	(0.037)**	(0.048)**	(0.056)**	(0.058)**	(0.062)**
1998-9	-0.197	-0.166	-0.103	-0.115	-0.086
	(0.039)**	(0.048)**	(0.055)	(0.058)*	(0.059)
1999-2000	-0.115	-0.076	-0.031	-0.052	-0.047
	(0.045)*	(0.050)	(0.054)	(0.056)	(0.059)
Panel B:	Dependent variable: received Bachelor's degree or higher[1]				
1992-3	-0.478	-0.484	-0.490	-0.490	-0.482
	(0.018)**	(0.055)**	(0.080)**	(0.084)**	(0.105)**
1993-4	-0.414	-0.423	-0.458	-0.444	-0.408
	(0.027)**	(0.043)**	(0.050)**	(0.057)**	(0.071)**
1994-5	-0.400	-0.397	-0.385	-0.383	-0.352
	(0.023)**	(0.035)**	(0.047)**	(0.048)**	(0.054)**
1995-6	-0.422	-0.436	-0.463	-0.460	-0.469
	(0.022)**	(0.032)**	(0.036)**	(0.039)**	(0.041)**
1996-7	-0.336	-0.331	-0.333	-0.352	-0.362
	(0.029)**	(0.040)**	(0.050)**	(0.052)**	(0.053)**
1997-8	-0.298	-0.293	-0.292	-0.281	-0.277
	(0.031)**	(0.042)**	(0.052)**	(0.054)**	(0.058)**
1998-9	-0.154	-0.103	-0.061	-0.081	-0.062
	(0.037)**	(0.048)*	(0.060)	(0.061)	(0.063)
1999-2000	-0.157	-0.123	-0.093	-0.100	-0.115
	(0.041)**	(0.051)*	(0.057)	(0.058)	(0.063)
Control Variables					
Background[3]	No	Yes	Yes	Yes	Yes
Educational Expectations[4]	No	No	Yes	Yes	Yes
Expected age at first childbirth	No	No	No	Yes	Yes
Age became sexually active	No	No	No	No	Yes
Observations	4385	3326	2812	2644	2467
Log Likelihood (Panel A)	-2770	-1870	-1435	-1336	-1219
Log Likelihood (Panel B)	-2798	-1860	-1378	-1286	-1164

Notes: Robust standard errors are in parenthesis. * and ** denote significance at the 5% and 1% level of confidence, respectively.

1. As of July 2000.
2. Academic year is August through July. The omitted category is women who have not yet had children as of July 2000.
3. Background variables includes race, parent's education, mother and father employment status, family income, and having a sister with a high school pregnancy
4. Educational expectations include own and father's educational expectations and indicator for planning to go directly to college after high school.

TABLE 5 – BALANCE OF OBSERVABLE CHARACTERISTICS WITHIN HAZARD GROUPS

	Mean difference between mothers and non-mothers within each hazard rate group									
	Hazard Rate Group (1 = lowest hazard rate, 10 = highest hazard rate)									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
White	0.087	0.052	0.000	-0.042	-0.039	-0.040	0.021	-0.092**	0.052	0.021
	(0.168)	(0.085)	(0.052)	(0.043)	(0.050)	(0.046)	(0.050)	(0.045)	(0.046)	(0.054)
Black	-0.004	0.019	-0.010	0.013	0.067	0.030	-0.037	0.080**	-0.066	-0.021
	(0.021)	(0.051)	(0.031)	(0.034)	(0.036)	(0.044)	(0.042)	(0.040)	(0.042)	(0.049)
Asian	-0.064	-0.055	0.018	0.008	-0.004	0.014	0.007	0.013	0.008	0.000
	(0.166)	(0.071)	(0.041)	(0.023)	(0.031)	(0.013)	(0.011)	(0.008)	(0.007)	(0.000)
Hispanic	0.199**	-0.009	0.039	0.004	-0.018	-0.023	0.025	-0.003	-0.006	-0.005
	(0.056)	(0.045)	(0.043)	(0.045)	(0.039)	(0.029)	(0.034)	(0.041)	(0.036)	(0.039)
Expect BA or higher	-0.092	-0.024	0.010	-0.008	0.023	0.029	-0.027	0.009	0.000	-0.111
	(0.050)	(0.028)	(0.031)	(0.023)	(0.029)	(0.058)	(0.050)	(0.054)	(0.058)	(0.058)
Parent has BA or higher	-0.008	0.008	0.084	-0.091	-0.052	0.025	-0.061	-0.047	0.033	0.052
	(0.104)	(0.085)	(0.084)	(0.084)	(0.070)	(0.068)	(0.061)	(0.053)	(0.043)	(0.030)
Log family income,	-0.090	0.096	-0.077	0.013	0.098	-0.073	-0.041	-0.174**	0.059	0.009
1991	(0.277)	(0.157)	(0.114)	(0.097)	(0.101)	(0.102)	(0.091)	(0.090)	(0.087)	(0.106)
Direct to college	0.015	0.024	0.022	-0.034	-0.010	-0.015	0.045	-0.042	0.003	-0.073
	(0.041)	(0.031)	(0.023)	(0.025)	(0.026)	(0.032)	(0.034)	(0.032)	(0.038)	(0.056)
Expect children	0.069	-0.179**	0.021	0.013	0.055	-0.098	-0.064	0.146**	-0.066	0.014
age 26 or later	(0.085)	(0.055)	(0.050)	(0.042)	(0.046)	(0.057)	(0.065)	(0.065)	(0.046)	(0.033)
Expect marriage	-0.056	-0.211**	-0.030	-0.070	-0.041	-0.091	-0.047	-0.041	0.006	0.060
age 26 or later	(0.170)	(0.105)	(0.085)	(0.086)	(0.076)	(0.072)	(0.057)	(0.049)	(0.031)	(0.031)
First sex before 1991	0.020	-0.046	0.025	0.047	0.036	-0.016	-0.042	0.079	-0.015	0.012
	(0.098)	(0.058)	(0.052)	(0.049)	(0.061)	(0.072)	(0.063)	(0.062)	(0.059)	(0.058)
First sex 1991-1992	-0.133	0.087	-0.059	-0.091	-0.013	-0.029	-0.055	0.042	0.025	0.003
	(0.145)	(0.095)	(0.079)	(0.084)	(0.076)	(0.074)	(0.064)	(0.066)	(0.061)	(0.054)
First sex after 1992	0.114	-0.041	0.034	0.045	-0.023	0.045	0.097	-0.121**	-0.010	-0.015
	(0.160)	(0.101)	(0.084)	(0.087)	(0.075)	(0.071)	(0.062)	(0.062)	(0.048)	(0.031)
obs (no child)	262	245	230	233	215	217	193	189	147	128
obs (child)	9	25	40	39	53	53	80	78	123	142

Notes: Standard errors of mean difference are in parenthesis. ** denotes significant difference at 1% level.

TABLE A1 – ESTIMATES OF PROPORTIONAL HAZARD MODEL

Dependent Variable (event): Have first child in month t after high school		
	Hazard Ratio	z-statistic
Black	0.19744	(1.48)
Asian	-0.66353	(2.49)*
Amer. Indian/AK Native	-0.09070	(0.25)
Hawaiian/Pacific Islander	0.49444	(1.67)
Hispanic	0.01573	(0.10)
Highest parent's education		
less than high school	-0.17320	(0.93)
High school	-0.22718	(1.25)
Some college	-0.31131	(1.50)
Bachelors	-0.60740	(2.48)*
Masters	-1.15527	(3.35)**
Father worked	0.08516	(0.59)
Mother worked	-0.12799	(0.92)
Family income, 1991	-0.17743	(2.98)**
Sister was pregnant in HS	0.35151	(2.25)*
Highest education expected		
Some college	-0.28277	(0.90)
Bachelor's degree	-0.58524	(1.83)
Master's degree	-0.76313	(2.32)*
Professional/Ph.D	-0.74906	(2.23)*
Plan to go directly to college[3]	-0.22077	(1.57)
Expected age of first childbirth		
Before 18	-1.27394	(2.05)*
18 to 21	0.96336	(3.52)**
22 to 25	0.97248	(4.45)**
26 to 29	0.31461	(1.43)
30 or later	0.26732	(1.03)
Year of first sexual intercourse		
Before 1988	1.00998	(2.84)**
1988	0.66941	(2.08)*
1989	0.43987	(1.49)
1990	0.58964	(2.48)*
1991	0.43940	(1.62)
1992	0.41724	(1.43)
Before 1988 x birth control	-0.29990	(0.52)
1988 x birth control	-0.12372	(0.33)
1989 x birth control	0.20881	(0.67)
1990 x birth control	-0.18544	(0.75)
1991 x birth control	-0.15050	(0.54)
1992 x birth control	-0.32499	(1.08)
Number of observations	2701	
Number of events (childbirths)	642	

Notes: * significant at 5%; ** significant at 1%

TABLE A2 – BALANCE OF HAZARD RATE QUANTILES

Dependent Variable (event): Have first child in month t after high school

	Quantile1 out of 10			Quantile2 out of 10			Quantile3 out of 10			Quantile4 out of 10			Quantile5 out of 10		
	No Child	Child	Diff.	No Child	Child	Diff.	No Child	Child	Diff.	No Child	Child	Diff.	No Child	Child	Diff.
hazard	0.024	0.026	0.002	0.043	0.045	0.001	0.057	0.056	-0.000	0.067	0.068	0.000	0.080	0.081	0.001
	(0.007)	(0.006)	(0.002)	(0.005)	(0.005)	(0.001)	(0.003)	(0.003)	(0.001)	(0.003)	(0.003)	(0.001)	(0.004)	(0.004)	(0.001)
white	0.580	0.667	0.087	0.788	0.840	0.052	0.900	0.900	0.000	0.940	0.897	-0.042	0.888	0.849	-0.039
	(0.494)	(0.500)	(0.168)	(0.410)	(0.374)	(0.085)	(0.301)	(0.304)	(0.052)	(0.238)	(0.307)	(0.043)	(0.316)	(0.361)	(0.050)
black	0.004	0.000	-0.004	0.061	0.080	0.019	0.035	0.025	-0.010	0.039	0.051	0.013	0.047	0.113	0.067
	(0.062)	(0.000)	(0.021)	(0.240)	(0.277)	(0.051)	(0.184)	(0.158)	(0.031)	(0.193)	(0.223)	(0.034)	(0.211)	(0.320)	(0.036)
asian	0.397	0.333	-0.064	0.135	0.080	-0.055	0.057	0.075	0.018	0.017	0.026	0.008	0.042	0.038	-0.004
	(0.490)	(0.500)	(0.166)	(0.342)	(0.277)	(0.071)	(0.231)	(0.267)	(0.041)	(0.130)	(0.160)	(0.023)	(0.201)	(0.192)	(0.031)
hispanic	0.023	0.222	0.199*	0.049	0.040	-0.009	0.061	0.100	0.039	0.073	0.077	0.004	0.074	0.057	-0.018
	(0.150)	(0.441)	(0.056)	(0.216)	(0.200)	(0.045)	(0.240)	(0.304)	(0.043)	(0.261)	(0.270)	(0.045)	(0.263)	(0.233)	(0.039)
expect BA+	0.981	0.889	-0.092	0.984	0.960	-0.024	0.965	0.975	0.010	0.983	0.974	-0.008	0.958	0.981	0.023
	(0.137)	(0.333)	(0.050)	(0.127)	(0.200)	(0.028)	(0.184)	(0.158)	(0.031)	(0.130)	(0.160)	(0.023)	(0.201)	(0.137)	(0.029)
parents expect BA+	0.897	0.889	-0.008	0.792	0.800	0.008	0.591	0.675	0.084	0.399	0.308	-0.091	0.298	0.245	-0.052
	(0.305)	(0.333)	(0.104)	(0.407)	(0.408)	(0.085)	(0.493)	(0.474)	(0.084)	(0.491)	(0.468)	(0.084)	(0.458)	(0.434)	(0.070)
log family income '91	11.476	11.387	-0.090	11.082	11.178	0.096	10.956	10.879	-0.077	10.731	10.745	0.013	10.509	10.607	0.098
	(0.814)	(0.917)	(0.277)	(0.752)	(0.736)	(0.157)	(0.668)	(0.661)	(0.114)	(0.559)	(0.572)	(0.097)	(0.656)	(0.674)	(0.101)
direct to college	0.985	1.000	0.015	0.976	1.000	0.024	0.978	1.000	0.022	0.983	0.949	-0.034	0.972	0.962	-0.010
	(0.123)	(0.000)	(0.041)	(0.155)	(0.000)	(0.031)	(0.146)	(0.000)	(0.023)	(0.130)	(0.223)	(0.025)	(0.165)	(0.192)	(0.026)
exp first child 26+	0.931	1.000	0.069	0.939	0.760	-0.179*	0.904	0.925	0.021	0.936	0.949	0.013	0.888	0.943	0.055
	(0.253)	(0.000)	(0.085)	(0.240)	(0.436)	(0.055)	(0.295)	(0.267)	(0.050)	(0.246)	(0.223)	(0.042)	(0.316)	(0.233)	(0.046)
exp marr. 26+	0.500	0.444	-0.056	0.531	0.320	-0.211*	0.430	0.400	-0.030	0.455	0.385	-0.070	0.419	0.377	-0.041
	(0.501)	(0.527)	(0.170)	(0.500)	(0.476)	(0.105)	(0.496)	(0.496)	(0.085)	(0.499)	(0.493)	(0.086)	(0.494)	(0.489)	(0.076)
first sex before 1991	0.092	0.111	0.020	0.086	0.040	-0.046	0.100	0.125	0.025	0.082	0.128	0.047	0.191	0.226	0.036
	(0.289)	(0.333)	(0.098)	(0.281)	(0.200)	(0.058)	(0.301)	(0.335)	(0.052)	(0.274)	(0.339)	(0.049)	(0.394)	(0.423)	(0.061)
first sex 1991-92	0.244	0.111	-0.133	0.273	0.360	0.087	0.309	0.250	-0.059	0.399	0.308	-0.091	0.428	0.415	-0.013
	(0.430)	(0.333)	(0.145)	(0.447)	(0.490)	(0.095)	(0.463)	(0.439)	(0.079)	(0.491)	(0.468)	(0.084)	(0.496)	(0.497)	(0.076)
first sex after 1992	0.664	0.778	0.114	0.641	0.600	-0.041	0.591	0.625	0.034	0.519	0.564	0.045	0.381	0.358	-0.023
	(0.473)	(0.441)	(0.160)	(0.481)	(0.500)	(0.101)	(0.493)	(0.490)	(0.084)	(0.501)	(0.502)	(0.087)	(0.487)	(0.484)	(0.075)
obs	262	9		245	25		230	40		233	39		215	53	

TABLE A2 – BALANCE OF HAZARD RATE QUANTILES (CONT.)
Dependent Variable (event): Have first child in month t after high school

	Quantile6 out of 10			Quantile7 out of 10			Quantile8 out of 10			Quantile9 out of 10			Quantile10 out of 10		
	No Child	Child	Diff.	No Child	Child	Diff.	No Child	Child	Diff.	No Child	Child	Diff.	No Child	Child	Diff.
hazard	0.097	0.100	0.003*	0.120	0.120	-0.000	0.153	0.154	0.001	0.205	0.209	0.003	0.348	0.393	0.045
	(0.005)	(0.006)	(0.001)	(0.008)	(0.008)	(0.001)	(0.013)	(0.012)	(0.002)	(0.019)	(0.021)	(0.002)	(0.096)	(0.203)	(0.020)
white	0.908	0.868	-0.040	0.829	0.850	0.021	0.899	0.808	-0.092*	0.810	0.862	0.052	0.719	0.739	0.021
	(0.290)	(0.342)	(0.046)	(0.377)	(0.359)	(0.050)	(0.302)	(0.397)	(0.045)	(0.394)	(0.347)	(0.046)	(0.451)	(0.440)	(0.054)
black	0.083	0.113	0.030	0.124	0.087	-0.037	0.074	0.154	0.080*	0.163	0.098	-0.066	0.211	0.190	-0.021
	(0.276)	(0.320)	(0.044)	(0.331)	(0.284)	(0.042)	(0.263)	(0.363)	(0.040)	(0.371)	(0.298)	(0.042)	(0.410)	(0.394)	(0.049)
asian	0.005	0.019	0.014	0.005	0.013	0.007	0.000	0.013	0.013	0.000	0.008	0.008	0.000	0.000	0.000
	(0.068)	(0.137)	(0.013)	(0.072)	(0.112)	(0.011)	(0.000)	(0.113)	(0.008)	(0.000)	(0.090)	(0.007)	(0.000)	(0.000)	(0.000)
hispanic	0.041	0.019	-0.023	0.062	0.087	0.025	0.106	0.103	-0.003	0.095	0.089	-0.006	0.117	0.113	-0.005
	(0.200)	(0.137)	(0.029)	(0.242)	(0.284)	(0.034)	(0.308)	(0.305)	(0.041)	(0.295)	(0.287)	(0.036)	(0.323)	(0.317)	(0.039)
expect BA+	0.820	0.849	0.029	0.839	0.813	-0.027	0.799	0.808	0.009	0.667	0.667	0.000	0.414	0.303	-0.111
	(0.385)	(0.361)	(0.058)	(0.368)	(0.393)	(0.050)	(0.402)	(0.397)	(0.054)	(0.473)	(0.473)	(0.058)	(0.494)	(0.461)	(0.058)
parents	0.258	0.283	0.025	0.311	0.250	-0.061	0.201	0.154	-0.047	0.129	0.163	0.033	0.039	0.092	0.052
expect BA+	(0.439)	(0.455)	(0.068)	(0.464)	(0.436)	(0.061)	(0.402)	(0.363)	(0.053)	(0.337)	(0.371)	(0.043)	(0.195)	(0.289)	(0.030)
log family	10.621	10.547	-0.073	10.499	10.458	-0.041	10.481	10.307	-0.174*	10.305	10.364	0.059	9.978	9.987	0.009
income '91	(0.636)	(0.773)	(0.102)	(0.689)	(0.686)	(0.091)	(0.683)	(0.627)	(0.090)	(0.712)	(0.709)	(0.087)	(0.900)	(0.842)	(0.106)
direct to	0.959	0.943	-0.015	0.917	0.963	0.045	0.952	0.910	-0.042	0.891	0.894	0.003	0.742	0.669	-0.073
college	(0.200)	(0.233)	(0.032)	(0.276)	(0.191)	(0.034)	(0.214)	(0.288)	(0.032)	(0.313)	(0.309)	(0.038)	(0.439)	(0.472)	(0.056)
exp first	0.853	0.755	-0.098	0.627	0.563	-0.064	0.328	0.474	0.146*	0.204	0.138	-0.066	0.070	0.085	0.014
child 26+	(0.355)	(0.434)	(0.057)	(0.485)	(0.499)	(0.065)	(0.471)	(0.503)	(0.065)	(0.404)	(0.347)	(0.046)	(0.257)	(0.279)	(0.033)
exp marr.	0.355	0.264	-0.091	0.259	0.212	-0.047	0.169	0.128	-0.041	0.068	0.074	0.006	0.039	0.099	0.060
26+	(0.480)	(0.445)	(0.072)	(0.439)	(0.412)	(0.057)	(0.376)	(0.336)	(0.049)	(0.253)	(0.262)	(0.031)	(0.195)	(0.299)	(0.031)
first sex	0.336	0.321	-0.016	0.342	0.300	-0.042	0.280	0.359	0.079	0.381	0.366	-0.015	0.664	0.676	0.012
before 1991	(0.474)	(0.471)	(0.072)	(0.476)	(0.461)	(0.063)	(0.450)	(0.483)	(0.062)	(0.487)	(0.484)	(0.059)	(0.474)	(0.470)	(0.058)
first sex	0.369	0.340	-0.029	0.368	0.313	-0.055	0.381	0.423	0.042	0.422	0.447	0.025	0.258	0.261	0.003
1991-92	(0.484)	(0.478)	(0.074)	(0.483)	(0.466)	(0.064)	(0.487)	(0.497)	(0.066)	(0.496)	(0.499)	(0.061)	(0.439)	(0.440)	(0.054)
first sex	0.295	0.340	0.045	0.290	0.388	0.097	0.339	0.218	-0.121*	0.197	0.187	-0.010	0.078	0.063	-0.015
after 1992	(0.457)	(0.478)	(0.071)	(0.455)	(0.490)	(0.062)	(0.474)	(0.416)	(0.062)	(0.399)	(0.391)	(0.048)	(0.269)	(0.245)	(0.031)
obs	217	53		193	80		189	78		147	123		128	142	