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THE IMPACT OF COLLEGE EDUCATION ON FERTILITY: EVIDENCE FOR HETEROGENEOUS EFFECTS*

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THE IMPACT OF COLLEGE EDUCATION ON FERTILITY:
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ABSTRACT

Despite a substantial literature on the effects of education on women's fertility, little is known about possible variation in effects by selection into college. Women's increasing educational attainment motivates further attention to the impact of education on fertility patterns, particularly among college-educated women who have a low likelihood of attending and completing college. With data on U.S. women from the National Longitudinal Survey of Youth 1979, we examine effects of timely college attendance and completion by propensity score strata using a hierarchical linear model and stratum-specific discrete-time event-history models. We find evidence for significant, systematic variation in effects. The fertility-decreasing college effect is concentrated among disadvantaged women with a low propensity for college attendance and completion, approaches zero as the propensity for college increases, and then reverses to a fertility-increasing effect among the most advantaged women.

Keywords: college education; fertility; causality; heterogeneity; NLSY;

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Higher education influences women's career aspirations, labor market involvement and experiences, familial roles, and fertility (Becker 1991; Rindfuss, Bumpass, and St. John 1980). Research has indicated wide and widening differences in family patterns by educational attainment in the United States, characterized as a demographic divide between the more and less educated (McLanahan 2004). Women's significantly increasing educational attainment (Buchman and DiPrete 2006) motivates further attention to the impact of higher education, particularly among women who have a low likelihood of college education. Women at the margin of college attendance are those for whom the expansion of higher education exerts its greatest impact. Despite a substantial literature on the effects of college on women's fertility, scholars have not considered variation in effects by selection into college. This study fills this gap, examining effects of college on women's fertility by the probability a woman attends and completes college.

EDUCATION AND FERTILITY

Average Effects of Education on Fertility

Research has shown that on average educated women who desire occupational advancement delay the onset of childbearing and have fewer children, whereas less-educated women have children at relatively young ages (Blossfeld and Huinink 1991; Brewster and Rindfuss 2000; Caucutt, Guner, and Knowles 2002; Martín-García and Baizán 2006; McCall 2000; Rindfuss, Bumpass, and St. John 1980; Rindfuss, Morgan, and Offut

1996; Spain and Bianchi 1996). At least one study indicates college attendance is more consequential than completion in decreasing fertility (Blossfeld and Huinink 1991).[1]

Several explanations have been advanced to explain educational differentials in fertility. Among them, "opportunity costs" is perhaps the most prominent (Becker 1981; Blossfeld and Huinink 1991). When making family and career decisions, women weigh competing demands on their time, energy, and commitment. Demands compete because of role incompatibility between childrearing and participating in economically productive work in modern industrial society (Brewster and Rindfuss 2000; Goldin and Katz 2000). Because women with higher educational attainment and higher potential wages confront higher opportunity costs to childbearing (Ellwood and Jencks 2004), researchers have presumed economic incentives explain a portion of fertility differentials among different educational groups.[2] Conversely, as childcare has become more available and acceptable (Rindfuss and Brewster and 1996), the most advantaged women who are more likely to be married and have firmly established careers use higher income to buffer some of the time and energy costs of raising children (Martin 2000; Spain and Bianchi 1996). Moreover, insofar as employers strive to keep their most valuable employees, high-ability educated women may effectively negotiate one or more maternity leaves without deflecting their career trajectories.

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[1] Studies on marriage find negative average effects of college attendance and positive average effects of completion (Cherlin 2009; Thornton, Axinn, and Xie 2007; Thornton, Axinn, and Teachman 1995; Xie et al. 2003).

[2] In addition to the lower likelihood of labor force participation, Budig and England (2001) find that employed mothers suffer an average per-child wage penalty of approximately 5%, possibly resulting from employer discrimination against mothers (Correll, Benard, and Paik 2007). Amuedo-Dorantes and Kimmel (2005) contend, however, that educated women who delay fertility do not experience a motherhood wage penalty.

Another explanation for educational differentials in fertility involves cultural norms. Women from unequal socioeconomic backgrounds and differential access to college assemble disparate notions of personal success. Educational and career attainment mark advantaged young women's early goals, whereas childbearing, whether or not within the bounds of marriage, marks young disadvantaged women's social identity and achievement (Edin and Kefalas 2005; Furstenberg 1976; Wilson 1987). The difference between advantaged and disadvantaged young women's goals relates to opportunity costs, as motherhood offers a valid social role for women who perceive "little access to the academic degrees, high status marriages, and rewarding professions that provide many middle- and upper-class women with gratifying social identities" (Edin and Kefalas 2005, p. 171).

A third explanation involves the disassociation between marriage and fertility among less-educated women relative to the strong association among educated women. In recent decades, family patterns of women at the top of the socioeconomic order have diverged from women at the bottom (Lundberg and Pollack 2007). Highly educated women postpone parenthood as well as marriage while less-educated women postpone only marriage. Given patterns of educational homogamy (Schwartz and Mare 2005), less-educated women are appreciably affected by the deterioration of less-educated men's employment stability and economic prospects (Autor, Katz, and Kearney 2006; Cherlin 2009; Wilson 1987). When "marriageable" men are relatively scarce, (non-marital) childbearing is a potential family-formation strategy among economically disadvantaged women (Edin and Kafalas 2005; Furstenberg 2001, 2003; Oppenheimer 1988, 1994; South and Lloyd 1992; Upchurch, Lillard, and Panis 2002; Willis 1999). Consequently, non-marital births have increased dramatically among disadvantaged less-educated women

(Ellwood and Jencks 2004). Furstenberg (2003) contends "marriage has become something of a luxury good" reserved for advantaged women (p. 36). And as advantaged women are reluctant to engage in non-marital childbearing, marital delay is associated with fertility delay (Caucutt, Guner, and Knowles 2002).

The discussion above does not differentiate between intended and unintended births. Musick et al. [forthcoming] argue that the college attendance effect on fertility is largely the result of unintended births. They are skeptical that opportunity costs explain unintended childbearing. Still, all three explanations posed above help to clarify unintended fertility differentials if less-educated women who have fewer economic and traditional family prospects are less likely to take precautions to avoid pregnancy. Mirowsky and Ross (2007) argue that disadvantaged women lack a strong sense of efficacy and positive future outlook, and thus engage in more risky behavior. By contrast, women with high occupational aspirations less willingly engage in intercourse or unprotected intercourse because of the threat of possible pregnancy.

Pre-Treatment Heterogeneity and College Effects on Fertility

Scholars recognize evaluating the impact of college on fertility requires accounting for the nonrandom selection of women who go to college and those who do not (Upchurch, Lillard, and Panis 2002). If observed and unobserved factors are correlated both with selection into higher education and fertility patterns, estimates of college effects based on fertility comparisons between women with and without higher education will be biased. This bias is conventionally labeled “pre-treatment heterogeneity bias” or “selection bias.” In addition to the concern over factors such as unobserved ability and motivation influencing educational attainment, the relationship between education and fertility is the outcome of a particularly complex, potentially reciprocal process (Ahituv and Tienda 2004; Rindfuss, Bumpass, and St. John 1980). A woman who intends to go to college may lower her fertility preference and take precautions to avoid pregnancy (Marini 1984), whereas a woman who has low aspirations and expectations regarding her educational prospects may begin a family early in her life course (Upchurch, Lillard, and Panis 2002).

Treatment Effect Heterogeneity and College Effects on Fertility

Social scientists increasingly recognize two kinds of selection bias, an issue overlooked in the literature on education and fertility discussed above. The first kind is due to heterogeneity in preexisting conditions or attributes associated with both educational attainment and fertility, i.e., pre-treatment heterogeneity bias we discuss above. The second kind is *treatment effect heterogeneity*, i.e., systematic variation in the effect of education on women's fertility. Although homogeneous college are generally assumed in the prior literature on education and fertility, women's response to college may differ. Both pre-treatment and treatment effect heterogeneity bias threaten the validity of causal inference with observational data (Angrist and Krueger 1999). An estimate of the effect of education on fertility is essentially a weighted average of heterogeneous effects, a quantity that depends upon population composition (Angrist and Kruger 1999; Brand and Xie [forthcoming]; Card 1999; Heckman, Urzua, and Vytlacil 2006; Morgan and Winship 2007).

A straightforward approach to studying effect heterogeneity is locating empirical patterns of treatment effects as a function of observed covariates. A few studies that have modeled variation in college effects on fertility examined the interaction between college and specific covariates influencing college attainment, such as race. For example, Musick et al. [forthcoming] and Yang and Morgan (2003) found a greater effect of college on fertility for black than for white women. Although such studies offer some evidence as to variation in college effects on women's fertility, examining interactions with individual covariates quickly exhausts degrees of freedom as more covariates are considered and more importantly, misses their implications for selection bias. For the question of comparing college effects between those who go to college and those who do not, the most consequential interaction is between college attainment and the propensity for college attainment. Indeed, Heckman, Urzua, and Vytlacil (2006), summarizing the econometric and statistical literature on causal effects, remarked that the propensity score plays the *central role* in selection models. We thus focus on variation in effects of college on fertility by the probability a woman obtains a college education.

Theories on Heterogeneous College Effects

If we allow for variation in college effects on fertility by the propensity for college, what theoretical predictions can we make as to the pattern in effect? Given the consequential role of education in contemporary societies, questions about access to and the impact of education have long occupied the attention of scholars. Prior studies addressing college effect heterogeneity have focused on the economic impact, formulating theoretical postulations accordingly. Premised on principles of self-selection and comparative advantage, one theory is that individuals who have the highest economic returns to college are rationally the most likely to select into college (Becker 1964;

Carneiro, Heckman, and Vytlacil 2007; Mincer 1974; Willis and Rosen 1979). What the theory predicts as to heterogeneity in effects of college on fertility is less clear. The premise presumably implies that women with a high propensity for college secure high economic returns via low rates of intermittent labor force participation and low rates of fertility.

The comparative advantage perspective is not the only theory guiding research on heterogeneous college effects. A prominent tradition in sociological research on the determinants of higher education is that many non-economic factors predict college attendance because college-going behavior is governed not only by rational cost-benefit analyses, but by cultural and social norms and circumstances (Beattie 2002; Boudon 1974; Brand and Xie [forthcoming]; Coleman 1988; Smith and Powell 1990). For persons in socially advantaged positions, college is a culturally expected outcome and thus less exclusively and intentionally linked to economic gain than it is for persons in less advantaged groups, for whom college is a novelty that may well demand economic justification. Moreover, earnings prospects are particularly bleak for disadvantaged low-skilled workers who increasingly face limited labor market opportunities, yielding such individuals an acutely significant benefit to college. Individuals with more advantaged social backgrounds, in the absence of college, can still rely on their advantaged social and cultural capital and ability. Brand and Xie [forthcoming] find empirical support for heterogeneity in the economic returns to college indicating individuals with the lowest probability of completing college benefit the *most* rather than the least from college. They label this a pattern of negative selection. Other studies also find evidence suggesting negative selection in heterogeneous effects of schooling (Brand and Halaby 2006; Bryk, Lee, and Holland 1993; Card 1995, 2001; Hoffer, Greeley, and Coleman 1985; Morgan 2001).

Considering the literature on negative selection in heterogeneous returns to schooling, we hypothesize women with lower propensities for college attendance and completion have larger fertility-decreasing effects of college compared with women with higher propensities for college. We expect the fertility-decreasing effect of college will be concentrated among low propensity, disadvantaged women for two reasons: (1) low propensity college-educated women's high economic incentive motivates relatively low fertility; and (2) low propensity less-educated women's particularly poor labor market prospects and attendant low economic opportunity costs coupled with cultural norms of success via (even non-marital) motherhood motivates relatively high fertility. The resultant high fertility differential between more and less educated women from disadvantaged social backgrounds generates a large fertility decreasing college effect. We expect this differential to decline as the propensity for college increases.

ANALYTIC STRATEGY

Our analysis proceeds in five steps. First, we estimate the probability for two distinct treatment conditions based upon a set of observed covariates: (i) hte probability a woman attends college by age 19; and (ii) the probability a woman completes college by age 23. The control groups consist of women who completed at least high school by age 19 but did not attend college by age 19 for the college attendance analysis and did not complete college by age 23 for the college completion analysis. We restrict the sample to high school completers as women without a high school degree are not "at risk" of a college education (Brand and Xie 2007). The most disadvantaged women, who are among those with the highest fertility rates (Astone and Upchurch 1994), are thus excluded. Because of the complex potentially reciprocal process of education and fertility, we examine *timely* college attendance and completion. The more time we allow for women to attend and to complete college, the more likely a woman's fertility affects her educational attainment. To obtain probabilities of college attendance and completion given a set of observed covariates, we generate estimated propensity scores for each woman in the sample using probit regression models of the following form:

$$P = p(d_i = 1 \mid \boldsymbol{X}) = \Phi\left(\sum_{k=0}^{K} (\beta_k \boldsymbol{X}_{ik}) \right), \qquad (1)$$

where P is the propensity score; d_i indicates whether or not individual i ($i = 1, \ldots, n$) attends college for our first treatment condition and completes college for our second treatment condition; and $\boldsymbol{X}$ represents a vector of observed pre-college covariates. We invoke an "ignorability" or "selection on observables" assumption that conditional on a rich set of pre-treatment covariates, there are no additional confounders between college and non-college goers. The economics and sociology literatures inform us of a variety of family and personal attributes which we use to predict college attainment and include in $\boldsymbol{X}$. We also include fertility prior to college attendance and completion.

Second, we estimate effects of education on women's fertility under an assumption of college effect homogeneity. We evaluate average effects of college attendance by age 19 and college completion by age 23 on number of children by age 41 (the oldest observed age of all members in our sample) using poisson regression models controlling for estimated propensity scores. A poisson model fits the number of occurrences of the event, in this case childbearing.[3] Our estimator takes the following form:

$$ln(r_i) = \alpha + \delta d_i + \beta P_i, \qquad (2)$$

where r_i is the number of children for the i^{th} observation; d_i indicates whether or not a woman attends college or not for the first model and completes college or not for the second model; and P_i represents the propensity for college attendance for the first model and completion for the second model as estimated by equation (1). The parameter δ is the average effect of college attendance for the first model and completion for the second model on the number of children born by age 41. The seminal work of Rosenbaum and Rubin (1983, 1984) demonstrates it is sufficient to condition on the propensity score as a function of $\boldsymbol{X}$ rather than $\boldsymbol{X}$ itself, which we do here for simplicity.

Third, we evaluate systematic variation in the effects of college attendance and completion on fertility (i.e., we allow δ in equation (2) to be heterogeneous). We assess whether or not population heterogeneity in the propensity for college is associated with heterogeneity in effects of college on fertility using the following hierarchical linear model: (i) we group respondents into balanced propensity score strata, in which average values of the propensity score and values of each covariate between college and non-college women do not significantly differ (p<.001); (ii) in level-1, we estimate stratum-specific treatment effects using a poisson regression model; and (iii) in level-2, we examine effects by propensity score strata, and summarize the trend in the variation of effects using a

[3] We did not find evidence of overdispersion, i.e., the variance of r is not greater than the mean of r, and thus we use a poisson rather than a negative binomial regression model.

hierarchical linear model (Brand and Xie [forthcoming]; Xie and Wu 2005).[4] We estimate our level-1 model by:

$$ln(r_i) = \alpha_s + \delta_s d_i, \quad (3)$$

where the s subscript represents the propensity score stratum. We estimate our level-2 model by:

$$\delta_s = \gamma + \zeta S + \varepsilon, \quad (4)$$

where level-1 slopes (δ's) are regressed on propensity score rank indicated by S, and ζ represents the level-2 slope. We use variance-weighted least squares to estimate (4), and thus do not assume homogeneity of variances across the δ's.

Fourth, we estimate propensity stratum-specific discrete-time event-history models of the effects of college attendance and completion on probability of first birth. Event-history models allow for the possibility some censoring occurs at age 41, as a (small) proportion of women have not begun or completed their childbearing. More importantly, it enables assessment of the age pattern in the heterogeneous effects of college on fertility. We let T denote a discrete-time variable taking the values $t = 1, \dots, q$, and f_{it} denote a binary variable equal to 1 if a first birth occurs to the i^{th} observation at time t and 0 otherwise. The stratum-specific conditional probability a first birth occurs at time t is the discrete-time hazard rate (Powers and Xie 2008):

$$ln \frac{fit}{1-fit} = \alpha_{ts} + \delta_s d_i + \lambda_{1s} A_{it} + \lambda_{2s} A_{it}^2, \quad (5)$$

[4] Our approach is similar to propensity score matching as women's observed differences are characterized by propensity scores. The two methods differ in how comparisons are constructed. Using propensity score matching, comparison by treatment status is first made on an individual basis and then averaged over a population using propensity score matching. Using our approach, comparison by treatment status is first constructed for a relatively homogeneous group based on propensity scores and then examined across different groups of similar propensity scores through a hierarchical linear model.

where A indicates age and all other terms are defined above.[5] We only examine age patterns for first birth; we have too few cases to estimate heterogeneous effects of college for second and third births conditional upon having a first or second birth. We thus examine the age pattern of the onset of women's fertility with these models, while our hierarchical linear models discussed above account for total fertility. Timing of a first birth is particularly consequential; it involves major changes in a woman's lifestyle and her economic opportunities, and affects total number of children born (Spain and Bianchi 1996). Finally, we conduct auxiliary analyses, i.e., stratum-specific descriptive statistics of potential mechanisms, to help interpret our main results.

A focus on variation in treatment effects by observed covariates is limited, as we overlook heterogeneity in effects due to unobserved variables. Without the ignorability assumption, however, alternative models for heterogeneous treatment effects, e.g. switching regression or marginal treatment effects, depend upon strong parametric or exclusion assumptions about unobservable variables (see Brand and Xie [forthcoming] for a discussion of these alternative approaches). We thus appreciate analyses under the ignorability assumption are the most data can tell us without additional unverifiable assumptions.

DATA, MEASURES, AND DESCRIPTIVE STATISTICS

We use panel data from the National Longitudinal Survey of Youth 1979 (NLSY), a nationally representative sample of 12,686 respondents who were 14-22 years old when they were first interviewed in 1979. These individuals were interviewed annually through

[5] We explored several representations of age and decided a squared term adequately represented the observed curvature.

1994 and are currently interviewed on a biennial basis. We use information gathered from 1979 though 2006. NLSY women represent the late baby boom cohort, women largely carrying the brunt of housework and child care while increasingly simultaneously working in the paid labor force (Spain and Bianchi 1996). The data have been used extensively for studying access to and the impact of education and the relationship between education and fertility (e.g., Musick et al. [forthcoming]; Upchurch, Lilliard, and Panis 2002).

We restricted our sample to women (n = 6,283) who were 14-17 years old at the baseline survey in 1979 (n = 2,736), who had completed at least the 12th grade when they were 19 years old (n = 2,090), and who did not have any missing data on college attainment and the set of pre-treatment covariates used in our analysis (n = 1,818).[6] We set these sample restrictions to ensure all measures we use are pre-college, particularly ability, and to compare college goers with women who completed at least a high school education. We lose additional cases of slightly less advantaged women in models with fertility by age 41 as the outcome (i.e., in our poisson but not our event-history models, n=1,388), mainly the result of attrition in our final (2006) survey wave.

Our treated group of college attendees consists of women who completed at least the first year of college by age 19, and our treated group of college completers consists of women who completed college by age 23. Our control group of non-college attendees consists of women who completed high school by age 19 but did not attend college by age 19, and our control group of non-college completers consists of women who completed high school by age 19 but did not complete college by age 23. Of those women with some

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[6] We impute missing values for parents' income (355 values), high school college-preparatory program (135 values), and parents' encouragement (90 values) based on all available background covariates.

college by age 19, roughly half complete college by age 23 and two thirds complete by their early 40s. About two fifths of non-college attendees attend college later, although less than 14% completes college, and less than 12% of non-college completers complete college later. Non-college attendees who attend college at some future point represent a distinct treatment group who are on average more disadvantaged than timely college attendees.[7] We do not restrict the control group to women who never attend college; we follow Brand and Xie (2007) in this regard, and adopt a "forward looking approach," collapsing all future paths when assessing the treatment at a particular time. That is, we focus on whether or not a college education occurs at a particular time and remain agnostic about future educational acquisition, allowing the reference to be a composite of future counterfactual paths.

Table 1 list measures of our observed pre-college covariates. These measures have figured prominently in sociological studies of educational and occupational attainment and their measurement is mostly straightforward. Parents' income is measured as total family income in 1979 dollars. College-track indicates whether or not the student enrolled in a college-preparatory curriculum in high school. 'Friends' plans' indicates the highest level of schooling a respondent reported his or her friends planned to obtain in 1979. In 1980, 94% of the NLSY respondents were administered the ASVAB, a battery of ten intelligence tests measuring knowledge and skill in areas such as mathematics and language. We follow the practice of Cawley et al. (1997) and first residualize each of the ASVAB tests on age at the time of the test separately by race and ethnicity. Residuals were standardized to mean

[7] Roughly two fifths of timely college attendees begin college at a community college and two thirds of those who attend college after age 19 begin at a community college. Less than one fifth of timely college completers begin college at a community college. These statistics are in line with research on inequality in college pathways (Rosenbaum, Deli-Amen, and Person 2006).

zero and variance one. We then construct a scale of the standardized residuals (α = .92) which has a mean of zero, standard deviation of 0.75, and a range of -3 to 2.5. We evaluate women with comparable fertility histories prior to treatment status: we include an indicator for whether a woman had a child by age 18 for the college attendance models, and we include indicators for whether a woman had a child by age 18 and had a child by age 22 (i.e., before and during college) for the college completion models.

We report descriptive statistics of all pre-college variables and fertility in Table 1. The likelihood of college varies by race and ethnicity with non-Hispanic whites more likely to attend and complete than blacks and Hispanics. Timely college goers are more likely to have families with high incomes, highly educated parents, intact families, and few siblings than non-timely college goers. Additionally, women with higher levels of secondary school academic success and higher levels of cognitive ability are more likely to attend and complete college. Students who received higher levels of encouragement from parents to attend college and had friends who planned to attend college are more likely to attend and complete college. Those who had children at early ages are less likely to attend and complete college. These descriptive statistics suggest that many non-economic factors figure in the educational attainment of youth.

RESULTS

Propensity Score Models

We first derive estimated propensity scores for each woman in the sample using probit regressions predicting the odds of attending relative to not attending college and the odds of completing relative to not completing college using the set of pre-college covariates described in Table 1.[8] As Φ is the cumulative normal distribution, the β's are z-scores that indicate the expected change in standard deviation units in the latent dependent variable. The results support the literature on the determinants of college attainment. Black and Hispanic students are significantly less likely to complete college, although not less likely to attend college, net of socioeconomic background. Ability and achievement in high school significantly predict timely college attendance and completion, as do parents' encouragement and friends' plans. For instance, the predicted probability of attending college is about .30 for college-preparatory women and .20 for women who were not in a college-preparatory track, with other independent variables held at their mean (Long and Freese, Stata module --spost, prtab--). Ability, academic achievement, and parents' encouragement are notably strong predictors of college attainment. Pre-college fertility is among the strongest predictors of women's college attainment, demonstrating the reciprocal relationship between women's schooling and childbearing. The predicted probability of attending college is .25 for women who did not have a child by age 18 and .06 for women who had a child by age 18; similarly, the predicted probability of completing college is .10 for women who did not have a child by age 18 and .01 otherwise.

Homogenous College Effects on Fertility

Table 3 provides the estimated effects of timely college attendance and completion on number of children using poisson regression analyses controlling for the propensity score estimated above under an assumption of treatment effect homogeneity. The results suggest a significant 10% decrease in the number of children born by age 41 associated

[8] In order to achieve balanced propensity score strata, the covariate sets are slightly different in our two model specifications.

with college attendance and a non-significant 8% increase associated with timely college completion -- a noteworthy difference. Propensity for college has a highly significant negative effect on fertility in both models.

Heterogeneous College Effects on Fertility

Average effects of college on fertility reported in Table 3 conceal underlying systematic college effect heterogeneity shaped by the population composition of college goers. To assess college effect heterogeneity, we first generate balanced propensity score strata. We estimate propensity scores from the probit regressions described above; then we use the Stata module --pscore-- (Becker and Ichino 2002) to obtain balanced propensity score strata. Balance is satisfied when within each interval of the propensity score the average propensity score and the means of each covariate do not significantly differ between treated (college) and control (non-college) units. The frequency distributions for the treatment and control groups run in opposite directions: for college-educated women the frequency count increases with the propensity score whereas for non-college-educated women the count decreases. There is, however, overlap within each stratum: for each propensity score stratum there are both college and non-college educated women.[9]

Table 4 provides covariate means by propensity score strata and college attendance. These statistics demonstrate the balance achieved and the characteristics of a typical

[9] We did not initially, however, have a sufficient number (roughly at least 20 cases) of non-college goers in the final stratum for the hierarchical linear model and therefore collapse the final two strata and adjust for the estimated propensity score in level-1 analyses for both college attendance and completion models. We also did not initially have a sufficient number of college completers in the first strata, and we therefore also collapse the first two strata and adjust for the estimated propensity score for the college completion model.

woman within each stratum.[10] In general, stratum 1 is characteristic of a woman with a disadvantaged socioeconomic background and low academic achievement and stratum 5 is characteristic of a woman with an advantaged socioeconomic background and high academic achievement. Women with parents who are high school drop-outs, four siblings, low ability, enrolled in a non-academic track, and friends who do not plan to go to college are characteristic of stratum 1. By contrast, women with parents who have some college, one sibling, high ability, enrolled in an academic track, and friends who plan to go to college are characteristic of stratum 5. Roughly one-quarter of low propensity women who attend college have had a child by age 18, while virtually no women in the higher propensities have children in their teens. Statistics are comparable for college completion (not shown, available upon request).[11]

Table 5 and Figures 1 and 2 report our main results, our hierarchical linear model of heterogeneous effects of college on fertility (Jann, Brand, and Xie 2008, Stata module --hte--). The level-2 slope for the college attendance model indicates a significant decline in the fertility-decreasing effect of college, a difference of 0.12 for each unit change in propensity score rank. That is, level-1 estimates range from a significant 40% decrease in the number of children for women with a low propensity to attend college (stratum 1), to a marginally

[10] Hispanic was not balanced in stratum 1 for the college attendance model, as evidenced from Table 4, and was thus added as a covariate in our level-1 models.

[11] Comparing Table 4 to the analogous table for college completion, however, we observe that women with a college degree and their matched controls are more advantaged than women with some college and their matched controls. This disparity is most noticeable comparing college attendees to completers in the lowest stratum.

significant 20% decrease in stratum 2, to a non-significant 6% increase in the number of children for women with a high propensity to attend college (stratum 5).[12]

Similarly for college completion, the level-2 slope indicates a significant 0.14 reduction in the number of children for each unit change in propensity score rank. Level-1 estimates range from a marginally significant 30% decrease in the rate of childbearing for women with a low propensity to complete college (stratum 1) to a marginally significant 38% increase in the childbearing rate for women with a high propensity to complete college (stratum 5). We thus observe a stronger fertility-decreasing impact for more disadvantaged low propensity college attendees relative to low propensity completers. Substantiating the literature suggesting the most advantaged woman are likely to have social and economic support for childbearing, we observe a fertility-increasing effect of college completion among high propensity women (stratum 5).

Figure 1 for college attendance and Figure 2 for completion summarize the results in Table 5. "Dots" in Figures 1 and 2 represent point estimates of level-1 slopes, stratum-specific poisson regression effects of college on number of children by age 41. The linear plots in the figures are the level-2 variance-weighted least squares slopes. We reverse the *y*-axis scale to emphasize the fertility-decreasing impact of college. The results for college attendance and completion are similar in that the level-2 slopes indicate a comparable significant decline in the fertility-decreasing effect of college as the propensity for college

[12] In results not shown, we also explore heterogeneous effects of college attendance by age 20, age 21, and age 22 on number of children by age 41. Level-1 slopes indicate slightly smaller effects of college on fertility and level-2 slopes indicate a slightly more nuanced trend in effects. Still, substantive conclusions are comparable to analyses based on college attendance by age 19 for each of these analyses.

increases. The figures depict the notably systematic linear trend in college effects across propensity score strata; indeed, the level-1 slopes fall remarkably close to the level-2 lines.

Stratum-Specific Event-History Analyses

Figures 3 for college attendance and Figure 4 for completion illustrate college effects on the probability of first birth by propensity score strata using discrete-time event-history models.[13] Event-history models provide a sensitivity test for possible (differential) misspecification of our models due to censoring of fertility by age, and provide a depiction of heterogeneous age patterns in the onset of childbearing. The risk set is age 19 through 41 for the college attendance model, and age 23 through 41 for the completion model. Women who had a first birth prior to age 19 for the attendance model and prior to age 23 for the completion model are no longer at risk of a first birth and are thus excluded from the respective analyses. Once again, the restriction limits the sample to more advantaged women. Figures 3 and 4 confirm Figures 1 and 2 in suggesting systematic variation in the college effect on the probability of first birth, attesting to the robustness of our aforementioned results. We find the large fertility-decreasing impact of college attendance for the most disadvantaged women concentrates in their early to mid-20s and flattens in their early to mid-30s, as fewer women remain at risk of a first birth. Women with a mid-propensity to attend college have a mid-range fertility-decreasing impact of college which flattens in women's early to mid-30s. And women with the highest propensity to attend college show no effect of college attendance on fertility -- a flat nil effect from age 19

[13] In analyses available upon request, we examine discrete-time probability of first birth by age under the assumption of homogeneity. We observe a fertility-decreasing average college attendance effect in the mid- to late-20s that approaches zero in the late 30s. The average college completion effect is slightly positive and remains constant over time from age 23 to 41.

through 41. Examining separate curves for college and non-college goers rather than the difference between educational groups (results available upon request), we observe an increase in the fertility peak with college propensity and socioeconomic advantage: from the early 20s for disadvantaged women to the early 30s for advantaged women.

Figure 4 for college completion is like Figure 3 in that there is evidence for systematic variation in college effects on the probability of first birth, with the fertility-decreasing college effect concentrated among low-propensity, disadvantaged women. It differs in that the fertility-decreasing effect for low propensity women is smaller; of course, as we note above, a critical portion of the fertility-decreasing effect of college attendance occurs prior to age 23. Women with a mid-propensity to complete college have no effect of college on first birth age 23 through 41. The most noticeable difference between the college attendance and completion models is college completion increases the probability of first birth for high propensity women, particularly in their mid-30s.

Auxiliary Analyses

In an effort to understand the mechanisms underlying the heterogeneous effects we observe, Table 6 offers additional descriptive statistics by propensity score strata. We first report differences between college and non-college attendees and completers mean number of children at age 41. The mean number of children decreases with the propensity score for non-college educated women (from 2.3 to 1.6 for non-college attendees and from 2.2 to 1.3 for non-college completers), but the mean number of children increases with the propensity score for college-educated women (from 1.5 to 1.6 for college attendees and from 1.3 to 1.8 for college completers). Thus, the empirical mechanics of the large fertility-decreasing effect of college for low propensity women support our supposition: marked high fertility among disadvantaged non-college educated women stands in contrast to low fertility among disadvantaged college-educated women. Low fertility undifferentiated by college status among more advantaged women generates smaller effects of college as propensity increases.

We also hypothesize above that low propensity college-educated women are especially economically motivated, and this may help explain lower overall fertility. We might expect then such women spend more time employed. Table 6 reports proportion of years women reported they were employed from age 25 through 41. Results lend modest support: low propensity educated women have the highest levels of employment, although there is only a 4-7% difference in the proportion of time employed compared with high propensity educated women. More striking is the discrepancy between low propensity women with and without college education; college appears to appreciably alter the level of employment trajectory for disadvantaged women. Although we do not observe a substantial difference in employment between low and high propensity women, there nevertheless could still be a difference in work commitment, perceived importance of labor market activity, and attitudes regarding work-family compatibility (McLanahan and Adams 1987). Egalitarian gender-role attitudes and equal division of domestic responsibilities are more likely among women and men from advantaged social backgrounds with educated parents (Waite and Goldsheider 1992).

Marriage patterns offer another possible mechanism for differential fertility. College goers have on average lower non-marital childbearing (Mincieli et al. 2007). Disadvantaged educated women with poorer marriage prospects than advantaged educated women yet a similar reluctance to bear children outside of marriage may suppress fertility. In Table 6, we report proportion of time women were married with a spouse present from age 25 through 41. Indeed, years spent married increases with social advantage. We shall continue to explore heterogeneous college effects on marriage trajectories in future research.

SUMMARY AND DISCUSSION

Extant literature on education and fertility suggests college postpones a woman's first birth and decreases number of children born, and college attendance may be more consequential than completion. Our findings support prior studies under an assumption of treatment effect homogeneity: we observe a significant fertility-decreasing average effect of timely college attendance and an insignificant average effect of timely college completion. We reveal, however, how average effects conceal substantial, systematic effect heterogeneity resulting from the selective composition of the college-going population. Our hierarchical linear models indicate a strikingly monotonic decline in the fertility-decreasing impact of college attendance and completion as women's socioeconomic advantage and propensity for college increases. That the fertility-decreasing effect of college concentrates among lowest propensity women is an especially noteworthy finding. Also notable, as propensity for college increases, the effect reverses: we find a fertility-increasing impact of college completion among the most advantaged, highest ability women. Using stratum-specific event-history models, we account for censoring by age and further validate the systematic pattern of college effect heterogeneity. Event-history analyses also reveal that the college effect on first birth among low propensity women occurs largely in women's early 20s.

Sociological research offers a theoretical foundation for our empirical result: educated women from disadvantaged socioeconomic backgrounds wittingly utilize college for economic gain and consequently limit fertility, while less-educated women from disadvantaged backgrounds have particularly poor labor market prospects and deem motherhood their means to personal fulfillment. Moreover, disadvantaged women may perceive and encounter greater role incompatibility between market work and fertility than advantaged women. Educated, advantaged women grow up in families in which they develop a strong sense of efficacy, and they are more likely to have amenable employers, economically-sufficient spouses, socioeconomic resources available for childcare, and other support mechanisms enabling childbearing with less financial and occupational apprehension.

Our findings yield a new result that is statistically powerful and theoretically coherent. Still, there are a few limitations to this study. First, the empirical patterns approach we use hinges on the ignorability assumption, i.e., that we have adequately accounted for all covariates influencing college attainment and fertility. Ignorability can never be verified for observational data; its plausibility depends upon the availability of observed covariates predicting treatment. Although we use a rich set of variables, including pre-college fertility, to predict college-going behavior, measurement of theoretically relevant confounders only renders ignorability more plausible. Indeed, one interpretation of our result is that the observed pattern of effects is attributable to differential selectivity, with low propensity more selective than high propensity women.

Second, we focus on the heterogeneous effects of *timely* college attendance and completion. We impose this age restriction because of the potentially reciprocal process between education and fertility and because our analytic strategy is sufficiently complex. Nevertheless, future research should develop a dynamic model of college effect heterogeneity on fertility with time-varying treatments and outcomes, simultaneously addressing potential reciprocity between education and childbearing. Finally, fertility is but one aspect of family life. As we note above, we plan to consider heterogeneous effects of college on marriage more fully in future research.

Recent sociological research suggests individuals who are least likely to obtain a college education benefit most from college in terms of earnings (Brand and Xie [forthcoming]). We offer evidence of a corresponding result for fertility: women who are least likely to obtain a college education experience the largest effect of college on fertility. Whether or not we describe this result as low propensity women *benefiting* the most from college however, is more dubious than in the case of earnings. On the one hand, college may alter the characteristic path these women would have journeyed, marked by single motherhood in young adulthood and correlated socioeconomic adversity. On the other hand, upward mobility for these women comes with its own opportunity cost: fewer or no children. Relative to high propensity educated women's life course, low propensity educated women remain disadvantaged with respect to family life. Thus, even equalizing educational attainment, polarization of family patterns by socioeconomic origins persists. The United States is the only industrialized nation without policies to support working mothers' conflicting responsibilities, most tellingly in the absence of subsidized childcare services and parental leave policies supportive of families. Women from disadvantaged family backgrounds who pursue higher education and careers and lack support for childbearing are acutely affected by social and institutional incompatibility between labor market participation and motherhood.

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Table 1. Descriptive Statistics of Pre-College Covariates and Fertility,NLSY Women (N=1,818)

	No College Attendance by Age 19		College Attendance by Age 19		No College Completion by Age 23		College Completion by Age 23	
Variables	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Race								
Black	0.139	(0.346)	0.101	(0.302)	0.145	(0.352)	0.067	(0.251)
Hispanic	0.056	(0.229)	0.035	(0.185)	0.057	(0.232)	0.023	(0.149)
Family background								
Mother's education	11.438	(2.310)	13.069	(2.456)	11.548	(2.334)	13.350	(2.441)
Father's education	11.493	(3.095)	13.773	(3.352)	11.632	(3.145)	14.218	(3.261)
Parents' income*	20690	(11662)	25424	(12951)	20347	(11048)	28540	(14079)
Intact family age 14 (0-1)	0.752	(0.432)	0.807	(0.395)	0.741	(0.438)	0.867	(0.340)
Number of siblings	3.281	(2.169)	2.669	(1.802)	3.265	(2.182)	2.477	(1.533)
U.S. born (0-1)	0.958	(0.201)	0.972	(0.166)	0.952	(0.213)	0.964	(0.189)
Rural residence age 14 (0-1)	0.235	(0.424)	0.202	(0.402)	0.236	(0.425)	0.183	(0.388)
Southern residence age 14 (0-1)	0.325	(0.469)	0.345	(0.476)	0.341	(0.474)	0.299	(0.458)
Catholic (0-1)	0.319	(0.466)	0.342	(0.475)	0.322	(0.467)	0.341	(0.475)
Jewish (0-1)	0.003	(0.056)	0.037	(0.190)	0.006	(0.074)	0.043	(0.203)
Ability and academics								
Mental ability*	0.092	(0.618)	0.646	(0.562)	0.113	(0.607)	0.798	(0.514)
College track (0-1)	0.257	(0.426)	0.565	(0.491)	0.277	(0.437)	0.622	(0.479)
Social-psychological								
Parents' encouragement (0-1)	0.687	(0.455)	0.866	(0.337)	0.701	(0.450)	0.893	(0.307)
Friends' plans	13.934	(2.055)	15.239	(1.845)	14.012	(2.057)	15.499	(1.721)
Fertility history								
Had a child by age 18	0.074	(0.262)	0.005	(0.069)	0.067	(0.250)	0.002	(0.046)
Had a child by age 22	0.336	(0.472)	0.077	(0.267)	0.318	(0.461)	0.026	(0.157)
Fertility*								
Number of children age 41	1.892	(1.300)	1.584	(1.234)	1.840	(1.314)	1.698	(1.172)
Sample Size	1308		510		1488		330	
Weighted Sample Prop.	0.68		0.32		0.77		0.23	

Notes: Parents' income is measured as total net family income in 1979 dollars. Ability is measured with a scale of standardized residuals of the ASVAB. Fertility by age 41 is based on a sample of 1,388. All statistics are weighted by a NLSY panel weight.

Table 2. Propensity Score Probit Regression Models Predicting College Attendance/Completion (N=1,818)

Variables	College Attendance	College Completion
Black	-0.021	-0.482 **
	(0.095)	(0.170)
Hispanic	-0.082	-0.454 **
	(0.121)	(0.153)
Mother's edu.	0.044 *	0.025
	(0.018)	(0.021)
Father's edu.	0.017	0.036 *
	(0.014)	(0.016)
Parents' inc. (1979 $1,000s)	-0.193	0.282
	(0.356)	(0.411)
Intact family	0.005	0.112
	(0.084)	(0.107)
Num. of siblings	-0.036 *	-0.029
	(0.017)	(0.022)
U.S. born	0.116	---
	(0.164)	
Rural res.	-0.072	-0.177
	(0.089)	(0.108)
Southern res.	0.171 *	-0.065
	(0.077)	(0.109)
Black * Southern	---	0.562 *
		(0.217)
Catholic	0.083	-0.154
	(0.086)	(0.103)
Jewish	0.909 *	0.314
	(0.376)	(0.354)
Mental ability	0.555 ***	0.883 ***
	(0.062)	(0.127)
Mental ability^2	---	-0.074
		(0.093)
College track	0.329 ***	0.271 **
	(0.077)	(0.090)
Parents' enc.	0.303 **	0.295 *
	(0.093)	(0.117)
Friends' plans	0.086 ***	0.083 ***
	(0.018)	(0.023)
Child by age 18	-0.892 ***	-0.183
	(0.213)	(0.405)
Child by age 22	---	-1.108 ***
		(0.165)
Constant	-3.080 ***	-3.206 ***
	(0.358)	(0.407)
LR χ^2	429.28	568.64
P > $\chi 2$	0.000	0.000

Notes: Numbers in parentheses are standard errors. Covariates for the college attendance versus completion models differ according to which varables were necessary to balanced propensity score strata.

* p <. 05 ** p < .01 *** p < .001 (two-tailed tests)

Table 3. Homogenous Effects of College Attendance and Completion on Fertility (N=1,388)

Poisson Regression Models	**College Attendance Model**		**College Completion Model**	
College Attendance	-0.108	*	---	
	(0.051)			
Incidence rate ratio	0.898			
College Completion	---		0.075	
			(0.065)	
Incidence rate ratio			1.078	
Propensity Score	-0.415	***	-0.716	***
	(0.110)		(0.122)	
Incidence rate ratio	0.660		0.489	
Constant	0.753	***	0.720	***
	(0.032)		(0.025)	
LR χ^2	34.30		45.45	
P > χ2	0.000		0.000	

Notes: Numbers in parentheses are standard errors.

Dependent variable is number of children by age 41. Propensity scores were generated by probit regression models of college attendance/completion on the set of pre-college exogenous covariates as summarized in Table 2.
* p <.05 ** p < .01 *** p < .001 (two-tailed tests)

Table 4. Mean Covariate Balance by Propensity Score Strata and Education for Models of College Attendance (N=1,818)

	Stratum 1 [0.0-0.1)		**Stratum 2** [0.1-0.2)		**Stratum 3** [0.2-0.4)		**Stratum 4** [0.4-0.6)		**Stratum 5** [0.6-1.0)	
Variables	**No Coll. Att.**	**Coll. Att.**	**No Coll. Att.**	**Coll. Att.**	**No Coll. Att.**	**Coll. Att.**	**No Coll. Att.**	**Coll. Att.**	**No Coll. Att.**	**Coll. Att.**
Black	0.30	0.16	0.24	0.36	0.29	0.28	0.18	0.25	0.29	0.16
Hispanic	0.18	0.63	0.15	0.16	0.15	0.15	0.19	0.09	0.20	0.07
Mother's edu.	9.34	7.16	10.60	10.96	11.56	11.65	12.39	12.77	13.52	14.11
Father's edu.	8.93	7.00	10.56	10.76	11.59	11.64	12.61	13.23	14.76	15.10
Parents' income	13785	12181	17656	16184	17649	18194	21855	22203	26856	29300
Intact family	0.65	0.58	0.67	0.64	0.67	0.67	0.78	0.78	0.73	0.82
Num. of siblings	4.75	5.21	3.48	3.84	3.31	3.04	2.95	2.75	2.37	2.19
U.S. born	0.94	0.84	0.97	0.96	0.95	0.97	0.80	0.96	0.95	0.95
Rural res.	0.22	0.10	0.24	0.28	0.21	0.18	0.20	0.22	0.19	0.17
Southern res.	0.40	0.21	0.37	0.48	0.37	0.40	0.40	0.41	0.42	0.30
Catholic	0.28	0.47	0.34	0.36	0.36	0.37	0.42	0.33	0.44	0.39
Jewish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.10
Mental ability	-0.41	-0.14	-0.03	-0.06	0.29	0.30	0.73	0.74	1.19	1.17
College track	0.08	0.16	0.12	0.11	0.35	0.37	0.64	0.66	0.90	0.88
Parents' enc.	0.52	0.47	0.70	0.66	0.81	0.86	0.94	0.91	0.96	0.95
Friends' plans	12.59	13.42	13.39	13.64	14.64	14.52	15.57	15.45	16.22	16.31
Child by age 18	0.27	0.21	0.04	0.00	0.01	0.01	0.00	0.00	0.00	0.01
Sample Size	431	19	294	50	376	151	148	165	59	125

Notes: "No Coll. Att." indicates women who did not attend college by age 19. "Coll Att." indicates women who attended college by age 19.

Table 5. Heterogeneous Effects of College Attendance and Completion on Fertility (N = 1,388)

	College Attendance Models	College Completion Models
Level-1 Slopes		
Poisson Regression		
P-Score Stratum 1: [0.0-0.1)	-0.500 *	-0.365 †
	(0.213)	(0.207)
Incidence rate ratio	0.606	0.694
P-Score Stratum 2: [0.1-0.2)	-0.228 †	-0.043
	(0.139)	(0.178)
Incidence rate ratio	0.796	0.958
P-Score Stratum 3: [0.2-0.4)	-0.134	0.131
	(0.085)	(0.118)
Incidence rate ratio	0.874	1.140
P-Score Stratum 4: [0.4-0.6)	0.004	0.11
	(0.101)	(0.141)
Incidence rate ratio	1.004	1.116
P-Score Stratum 5: [0.6-1.0)	0.054	0.324 †
	(0.142)	(0.191)
Incidence rate ratio	1.056	1.383
Level-2 Slopes	0.124 *	0.142 *
Variance Weighted Least Squares	(0.050)	(0.060)

Notes: Numbers in parentheses are standard errors.

Dependent variable is number of children by age 41. Propensity scores were generated by probit regression models of college attendance/completion on the set of pre-college exogenous covariates as summarized in Table 2. Propensity score strata were balanced such that mean values of covariates did not significantly differ between college and non-college goers.
† p < .10 * p <. 05 (two-tailed tests)

Table 6. Descriptive Statistics by Propensity Score Strata and Education (N=1,388)

Propensity Score Strata	Variables	No College Att. by Age 19	College Att. by Age 19	No College Comp. by Age 23	College Comp. by Age 23
Stratum 1:	*Number of children born*	2.314	1.500	2.169	1.333
[0.0-0.1)	*Proportion of years employed*	0.587	0.766	0.632	0.778
	Proportion of years married	0.497	0.477	0.509	0.556
Stratum 2:	*Number of children born*	1.853	1.475	1.445	1.385
[0.1-0.2)	*Proportion of years employed*	0.660	0.688	0.691	0.827
	Proportion of years married	0.533	0.566	0.551	0.703
Stratum 3:	*Number of children born*	1.797	1.571	1.512	1.724
[0.2-0.4)	*Proportion of years employed*	0.693	0.749	0.713	0.759
	Proportion of years married	0.581	0.627	0.614	0.726
Stratum 4:	*Number of children born*	1.619	1.626	1.349	1.506
[0.4-0.6)	*Proportion of years employed*	0.679	0.740	0.659	0.752
	Proportion of years married	0.582	0.641	0.582	0.700
Stratum 5:	*Number of children born*	1.556	1.637	1.308	1.776
[0.6-1.0)	*Proportion of years employed*	0.683	0.728	0.760	0.707
	Proportion of years married	0.630	0.648	0.535	0.705

Notes: Number of children born indicates mean number of children ever born by age 41. Proportion years married and employed indicates proportion years reported married (spouse present) and employed for women age 25-41.

Figure 1. HLM of College Effects on Fertility

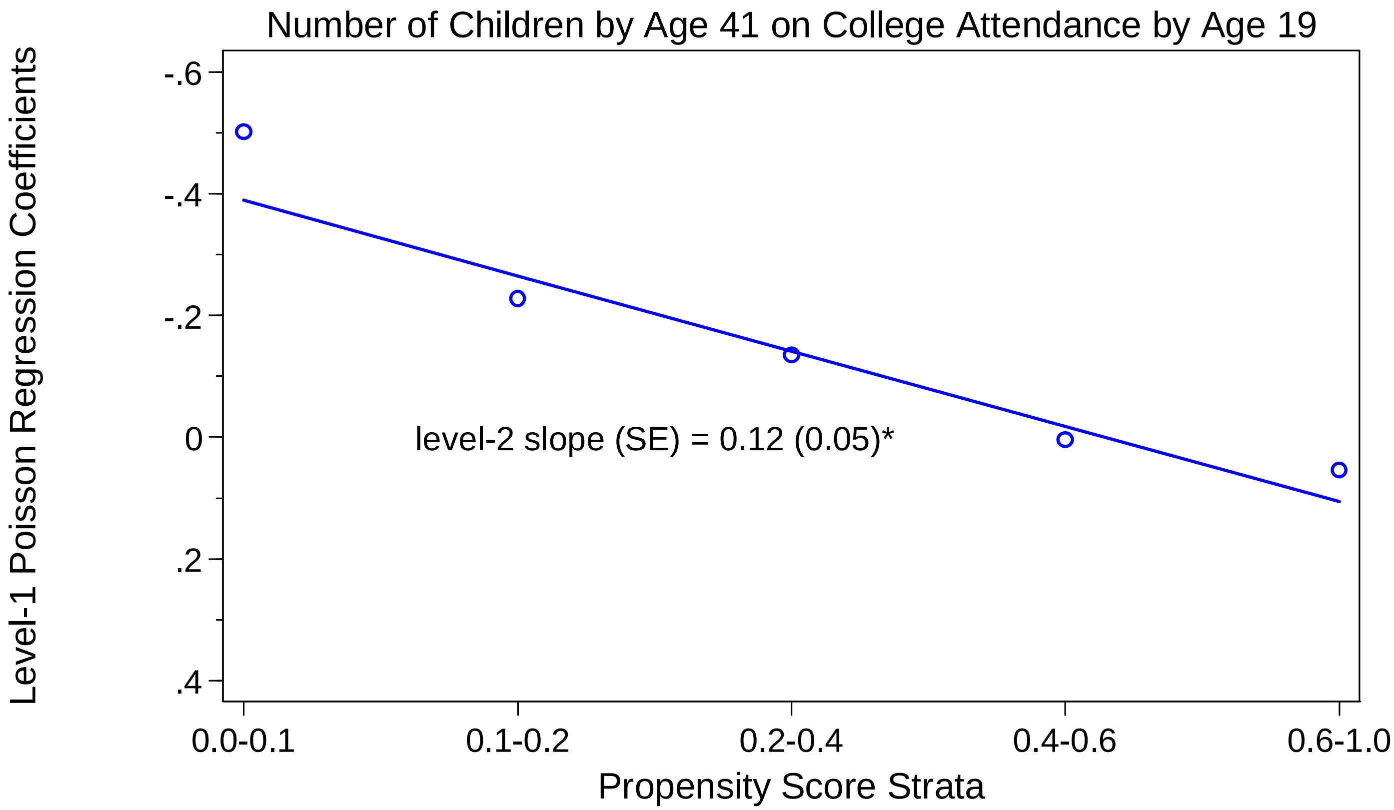

Figure 2. HLM of College Effects on Fertility

Number of Children by Age 41 on College Completion by Age 23

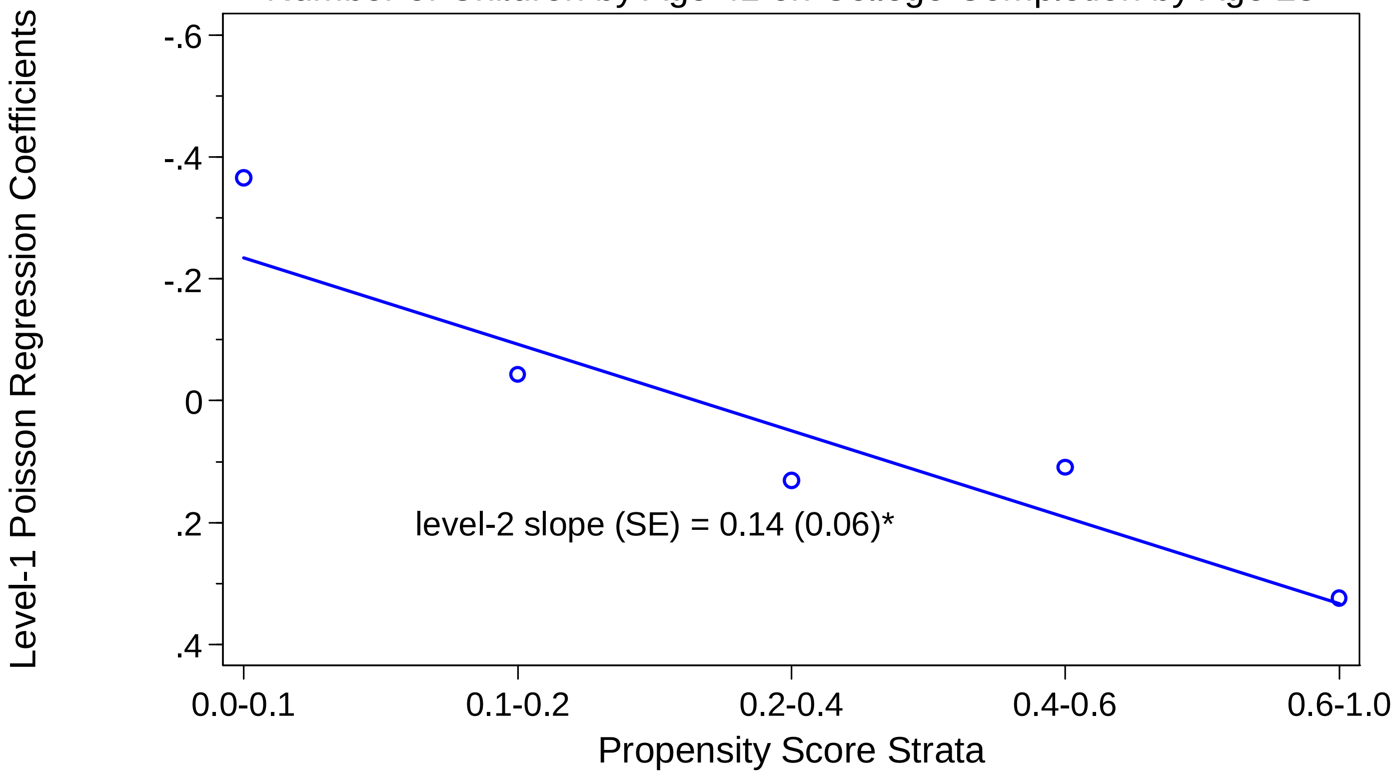

Figure 3.
College Attendance Effect on Discrete Time Probability of First Birth

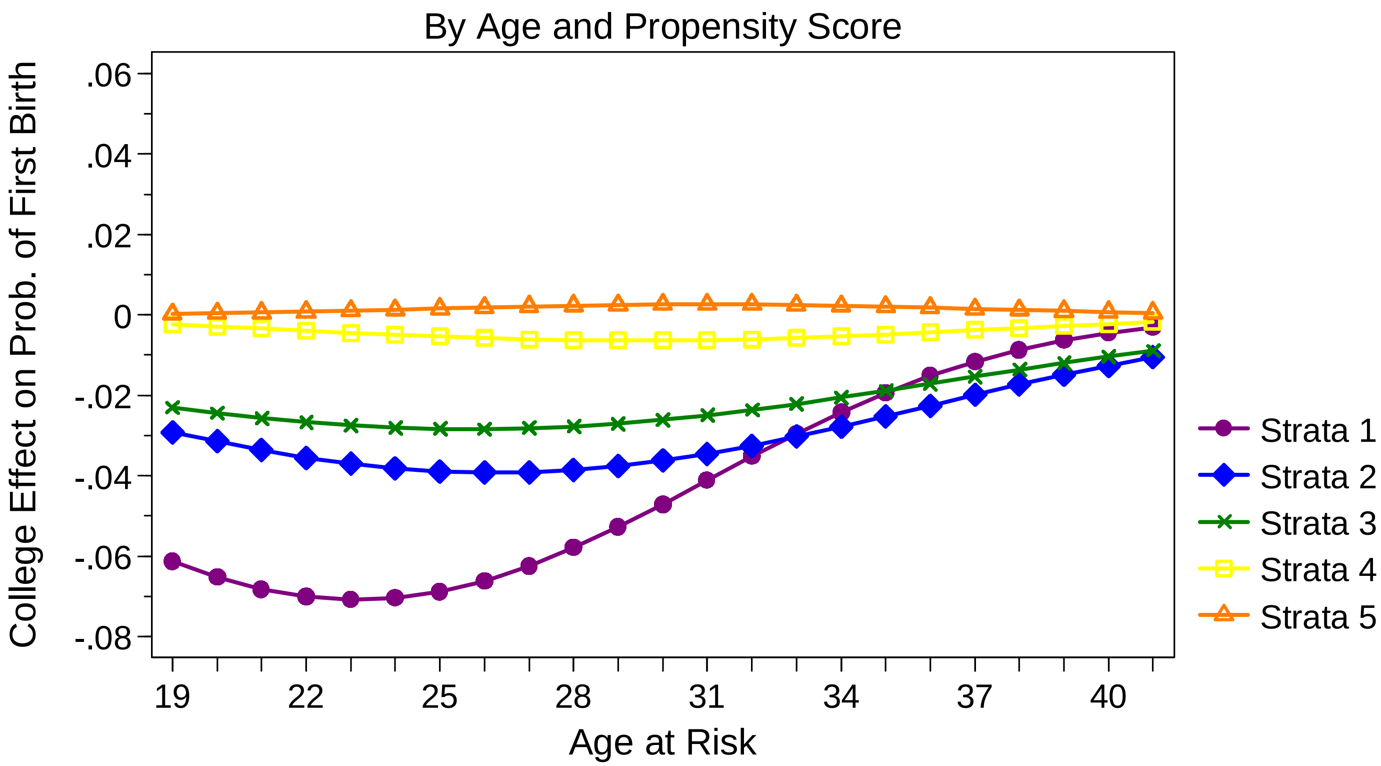

Figure 4.
College Completion Effect on Discrete Time Probability of First Birth