Women's College Decisions: How Much Does Marriage Matter?

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Abstract

This paper investigates the sequential college attendance decisions of young women and quantifies the impact of marriage expectations on their decisions to attend and graduate from college. A dynamic choice model of college attendance, labor supply, and marriage is formulated and structurally estimated using panel data from the National Longitudinal Survey of Youth 1979 (NLSY79). The model is used to simulate the effects of no marriage benefits and finds that the predicted college enrollment rate would drop from 58.0% to 50.5%. Using the estimated model, the college attendance behavior for a younger cohort (data taken from the NLSY97) is predicted and used to validate the behavioral model.

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1 Introduction

According to the existing empirical literature (Willis and Rosen 1979), the increase in earnings power is the primary motivation for going to college. However, this literature has ignored a potentially important benefit of college: that college improves marriage opportunities by providing a social venue in which to meet potential spouses. A college-educated individual is substantially more likely to have a college-educated spouse and thus enjoys educational balance in the household and benefits from the spouse's earnings power. While this "marriage benefit" of college surely applies to both sexes, it is likely to be particularly important for women since married men on average have higher labor force participation rates and higher incomes than do married women. If the marriage benefit is a major component of returns to college, its omission will bias downward the estimated returns to college. Without knowing the relevant returns to college, we can neither understand gender differentials in educational attainment nor can we draw proper education policy inferences.

The first goal of this paper is to quantify how much gains in the marriage market might account for women's college attendance and graduation decisions. To this end, I constructed and estimated a dynamic model of the joint schooling, marriage, and employment decisions made by young women. In the model, women who attend and graduate from college enjoy three types of gains in the marriage market. First, attending college can increase the arrival rate of marriage proposals. Second, women prefer having spouses with education levels similar to their own,[1] which provides incentives to go to college if a majority of potential spouses have college degrees. The last benefit is the transfer from their husbands within the marriage: women in college have more chances to meet and marry men with higher educations and therefore higher earning potential, which provides another incentive to attend college. In addition, other determinants of college decision, including the cost of college, individual ability, family background, and gains in the labor market, are considered.

The second goal of this paper is to assess the validity of the dynamic behavior model by exploiting data from two comparable panel surveys. Todd and Wolpin (2003) discussed different model validation tests and provided an excellent example using a social experiment. In this paper, I use out-of-sample predictions, which compare two cohorts, to assess the validity of a structurally estimated model. I first estimate how exogenous sources determine individual behavior (for example, college attendance) based on data from a baseline cohort.

[1] This is consistent with positive assortative mating in education (Becker 1973). The fact that highly educated women marry highly educated men is well documented (Mare 1991; Pencavel 1998). Benham (1974) points out that women's education can improve a husband's productivity and earnings, but it is difficult to conclude whether this effect is due to human capital accumulation within the household or assortative mating. This paper will focus on the assortative mating aspect.

Then, the validity of the model is assessed according to how well the variations over time in the exogenous sources predict the change in individual behavior observed for a younger cohort.

A central empirical challenge in assessing the impact of marriage on college decisions is the dynamic simultaneity of the decisions. The dynamics of the decision process are due to the dependence of current choices on previous choices. Whether or not a woman will complete her senior year of college is largely determined by whether she finishes her junior year; her labor force participation depends on her labor market experience; her marital experience (marriage duration and children) is of crucial importance to her marriage decisions. The simultaneity of the decision process is the nature of human behavior. Women normally make schooling decisions jointly with work and marriage decisions simply because a job offer or marriage proposal is the opportunity cost of attending college. For example, 3 years after high school graduation almost half of all single women (47.6%) are still in college while only 9.7% of married women remain in college. Without understanding the *dynamic* process of the *joint* decisions made by women, it is impossible to quantify what factors determine each choice, including the sequential college attendance decision.

A further challenge is due to the endogenous self-selection of the decision process. College premium, which is the relative wage between college and high school graduates, increases in individual skills or abilities, and those with the highest skills are the most likely to attend college. A statistical analysis could then attribute the effect of skills on college attendance to earnings gains. Similarly, self-selection exists in the marriage market. If exogenously less attractive women receive more schooling, *ceteris paribus*, than do more attractive women (Boulier and Rosenzweig 1984), the estimated effect of marriage on college attendance would be biased in a simple regression analysis. Self-selection is controlled in the behavior model by allowing for unobserved types in skills and in marriage[2], and the dynamic decision process is solved for each type. Hence, the model implements a correction for the selection biases.

The model is estimated by using a sample of high school white females from the National Longitudinal Survey of Youth 1979 (NLSY79). To assess the importance of marriage on college attendance, a counterfactual economy is considered in which all benefits from marriage are ruled out. The optimal choices are numerically simulated in such a hypothetical world, and a comparison is made of predicted college enrollment with the actual economy. In the

[2] Modeling skill as multidimensional is pioneered by Willis and Rosen (1979) and Heckman and Sedlacek (1985), formally incorporating Roy's (1951) self-selection model. More recently, Keane and Wolpin (1997, 2001) and Eckstein and Wolpin (1999) integrate ability selection in a dynamic setting of employment and schooling choices. In this paper, both unobserved skill and marriage types are used in a broad sense. For example, skill types may differ in motivation, perseverance, and tastes for school, and marriage types may vary in attractiveness and preference for marriage.

benchmark economy, the college enrollment rate is 58% and the graduation rate is 37.0% for female high school graduates. With no benefits from marriage, the college enrollment rate would drop to 50.5%, while the graduation rate would increase slightly to 39.0%. In an alternative counterfactual economy where marriage is not a feasible option for women, the college enrollment rate would drop to 51.8% and the graduation rate would increase to 48.8%. When women always stay single, attending college generates no benefits through the marriage market so the enrollment rate would decline. In the meantime, once a woman has attended college, she is less likely to drop out of school if she stays single. Therefore the graduate rate would increase when the option to marry is not available.

The estimation of the model is based on a NLSY79 sample of young women who were graduating from high school in the early 1980's. About 20 years later, the college enrollment rate of a NLSY97 sample increases to 80%. These two NLSY samples provide a unique source for model validation since almost identical survey instruments have been used by the Bureau of Labor Statistics. The estimated model based on the NLSY79 sample is able to predict well the college attendance behavior of the NLSY97 sample. The result is consistent with the stability of the structural model; that is, "fundamental" parameters of the individual are invariant to changes in the environment.[3]

This paper builds on existing literature on dynamic schooling choice models. Willis and Rosen (1979) find that individuals self-select themselves into the schooling level for which they have comparative advantage and that expected lifetime earnings gains affect the decision to attend college. Cameron and Heckman (2001) and Eckstein and Wolpin (1999) find that family background and unobserved ability are the most important determinants of schooling decision. These studies focus almost exclusively on how individual characteristics and gains in the labor market influence a male's decision to attend school but are silent regarding the impact of gains in the marriage market and how women's education decisions are made in general. This paper also builds on recent work that estimates dynamic models of employment and marriage. In particular, Gould (2003) estimates a dynamic model of marriage and employment on a sample of men. Van Der Klaauw (1996) constructs and estimates a structural dynamic model that explicitly addresses the joint decision on marital status and labor force participation for females. Seitz (2007) extends Van Der Klaauw's model to an equilibrium setting. However, schooling decision is taken as given in both models. Keane and Wolpin (2006) extend the choice set to include schooling, fertility, and welfare participation, but their focus is on racial differences in behavior and the impact of the welfare program.

[3] As discussed in Wolpin (1996), a major advantage of structural estimation is that it is capable of performing counterfactual policy experiments that entail extrapolations outside the current policy regime.

This paper also contributes to a literature considering interactions between marital status and schooling decision. Following the seminal work of Becker (1973), the economics literature on marriage has highlighted that one's own schooling can improve the spousal schooling one acquires in the marriage market (Boulier and Rosenzweig 1984; Behrman, Rosenzweig and Taubman 1994; and Weiss 1997). Interactions between education investment, assortative mating, and marriage outcome have been studied in recent theoretic models of individual behavior (Iyigun and Walsh 2005; Weiss 2006). This paper explicitly models the interdependence of these decisions and quantifies how much gains in the marriage market affect the education decision.

The remainder of the paper proceeds as follows. Section 2 specifies an empirical model of joint school, work, and marriage decisions. Section 3 describes the NLSY79 data from which the model is estimated. Section 4 discusses the estimation method and identification issues. Section 5 gives the estimation results. Section 6 discusses the validation of the model. Section 7 provides counterfactual simulations, and Section 8 concludes the paper.

2 The Model

In this section, I specify an empirical model in which young women make college attendance, labor supply, and marriage decisions simultaneously during each year after they graduate from high school.

2.1 The Basic Structure

Consider a woman who has graduated from high school. Initially she has 12 years of school, no work experience, has never been married or had children. Each year she chooses whether to attend college, whether to work full time, and whether to get or stay married. In total, there are eight mutually exclusive and exhaustive choices. Let s_t, h_t, m_t be the indicators for school attendance, full-time employment, and marital status, respectively; then, each alternative will be a triple (s_t, h_t, m_t).[4] Her choice set is $\Psi = \{(s_t, h_t, m_t) : s_t \in \{0,1\}, h_t \in \{0,1\}, m_t \in \{0,1\}\}$.

[4] For example, $(s_t, h_t, m_t) = (0,0,0)$ corresponds to not attending school, not working, and being single.

2.1.1 Preferences and Constraints

The contemporaneous utility $U_t(c_t, s_t, h_t, m_t)$ is assumed to be linear in consumption (c_t) and has the following form:

$$\begin{aligned} U_t(c_t, s_t, h_t, m_t) &= (\alpha_1 + \alpha_2 s_t + \alpha_3 h_t + \alpha_4 m_t)c_t \\ &\quad + v_1 s_t(1-h_t)(1-m_t) + v_2 s_t h_t(1-m_t) + v_3 s_t(1-h_t)m_t + v_4 s_t h_t m_t \\ &\quad + v_5(1-h_t)f_t + v_6(1-h_t)(1-f_t) + M_t m_t + \epsilon_t^{(s,h,m)}. \end{aligned} \tag{1}$$

The subscript for individuals is suppressed since a representative woman is considered. The marginal utility of consumption depends on college attendance, employment, and marital status as captured by the parameters α_1 to α_4. Parameters v_1 to v_4 evaluate the net utility of attending school given employment and marital status. Fertility $f_t \in \{0, 1\}$ is an indicator of the presence of any children. The effects of having children on working are represented by v_5 and v_6. M_t is the value of marriage as specified below. Finally, $\epsilon_t^{(s,h,m)}$s are alternative-specific random components representing random variations in the individual's preference for school and for work, as well as changes in the utility derived from marriage. They are jointly serially independent, noncorrelated, and have a joint normal distribution $F(\epsilon_t)$. They are known to the individual in period t, but unknown before t.

The choice decision is subject to the budget constraint given by:

$$c_t + c_S \cdot s_t + cc \cdot f_t = y_t h_t + g(y_t^H). \tag{2}$$

c_S is the direct annual cost of school. cc is the cost of children. y_t denotes the annual earnings of the woman. If a woman is married or divorced with a child, she can receive a transfer $g(y_t^H)$ from her husband or ex-husband, where y_t^H is her husband's earnings. This transfer may be interpreted as the woman's share of accumulated common property. There are no borrowing and saving decisions. The budget constraint is assumed to be satisfied period by period.[5]

Even though all choices are made jointly, it helps understanding to discuss college attendance, labor supply, and marriage choices separately.

[5] Cameron and Heckman (1998, 2001) find that the short-run liquidity constraints proxied by current family income play no significant role in college attendance decisions. Cameron and Taber (2004) also find no evidence that borrowing constraints play an important role in educational attainment. Keane (2002) reviews recent work on the importance of borrowing constraints and the impact of financial aid programs.

2.1.2 The College Attendance Choice

A young woman makes a sequential college attendance decision every year after high school graduation. If she attends any post-secondary school, she has to pay for tuition and room and board. The direct cost of one year in college equals cs. A college degree is assumed to be completed in 4 years. When a woman attends graduate school, she pays an extra tuition cost cg, that is, $c_S = cs + cg$.

In a static world, the total cost of one year of school is c_S plus the foregone earnings. The benefit to the young woman of attending college is the consumption value of school, v_1, v_2, v_3, or v_4, depending on her employment and marital status. The utility of school interacts with labor supply since more involvement in market work may prevent individuals from engaging in college activities; this interaction represents the time constraint. The utility of school also depends on marital status if marriage requires leaving school or if school utility is different when married.

In a dynamic world, however, the college attendance decision also involves expectations of future costs and benefits. In particular, a woman has expectations for her labor market and marriage market outcomes that are conditional on her college decisions. Even though she does not observe the realizations of future earnings or future marriage value, she knows the distribution and thus is able to formulate expectations. When she makes a college decision early in her life, she takes these expectations into account. In the meantime, the sequential and stochastic nature of the schooling decision process accounts for the fact that some women may obtain more education after they get married.

2.1.3 The Employment Choice

A woman receives job offers with probability $p_{E_j}^{h_{t-1}}$ every year. The job offer rate depends on her schooling level $E_j \in \{E_{hg}, E_{sc}, E_{cg}\}$, where E_{hg}, E_{sc}, E_{cg} correspond to high school graduates, some college, and college graduates, respectively. The job offer rate also depends on previous labor market attachment $h_{t-1} \in \{0, 1\}$, where h_{t-1} equals 1 if she worked in the previous year and 0 otherwise. As in Eckstein and Wolpin (1989), potential annual earnings are obtained by multiplying hourly wage by 2000 hours: $y_t = w_t \cdot 2000$. Essentially, each woman is assumed to be deciding about full-time work, and the wage rate is assumed to be independent of hours worked.

The hourly wage follows:

$$\ln w_t = \beta_0 + \beta_1 S_t + \beta_2 H_t + \beta_3 H_t^2 + \beta_4 I(S_t \geq 16) + \beta_5 I(1 - h_{t-1}) + \epsilon_{wt}, \tag{3}$$

where S_t and H_t are years of schooling and work experience, and they evolve according to

$S_t = S_{t-1} + s_t$ and $H_t = H_{t-1} + h_t$. The schooling coefficient β_1 measures the earnings return of each additional year of school. The quadratic term in work experience is meant to capture the depreciation of human capital so that wage is hump-shaped over the lifecycle. $I(S_t \geq 16)$ is an indicator function which equals one if the individual has a college degree, and therefore, its coefficient β_4 captures the sheepskin effect of a college degree. In order to account for the impact of previous period's employment choice on current wage, a dummy variable $I(1 - h_{t-1})$ for moving from nonemployment to work is included in the wage equation. If there is a re-entry cost associated with depreciation of human capital, we expect β_5 to be negative. The productivity shock ϵ_{wt} is normally distributed with mean zero and standard deviation σ_w. The wage offer distribution varies if she works while in college. The hourly wage in college is assumed to be log normal, such that $\ln w_t = \beta_{0c} + \epsilon_{wct}$, where $\epsilon_{wct} \sim N(0, \sigma_{wc}^2)$. A measurement error in observed wages was allowed, such that $\ln w^o = \ln w + u$, where w^o is the observed wage, w is the true wage, and the error term is normally distributed: $u \sim N(0, \sigma_u^2)$.[6] At time t, the woman observes the wage rate (hereby earnings) and decides whether to work. Before time t, she does not observe ϵ_{wt}, but she knows how wage and earnings evolve and the distribution of ϵ_{wt}. That is, she knows the expected earnings gains from the labor market as denoted by β_1 and β_4.

2.1.4 The Marriage Choice

A single woman receives marriage proposals with probability P, which depends on her age and her schooling level. In particular,

$$P_t = \frac{\exp(b_0 + b_1 age_t + b_2 age_t^2 + b_3 I(S_t > 12))}{1 + \exp(b_0 + b_1 age_t + b_2 age_t^2 + b_3 I(S_t > 12))}. \tag{4}$$

The meeting technology is such that high school and college women may receive different numbers of offers. The parameter b_3 determines the difference and is to be estimated. If a college provides a social venue for young people to meet, b_3 may be positive. The distribution of potential husbands is assumed to be exogenous and remains the same for all women.[7] Let μ_{S^H} be the fraction of men with S^H years of schooling; then, the probability of receiving a proposal from a man with S^H is $\mu_{S^H} P_t$. With probability $1 - P_t$, no offer is received. A married woman faces an exogenous separation shock η initiated by her husband. If no

[6] Measurement error is introduced to account for wage observations below the minimum wage.

[7] The distribution of men is expected to vary by their own schooling decisions and by women's educational status. However, to address these issues empirically, I need to observe *both* spouses' sequential choices and also need information on dating (as discussed below), which is not available from NLSY. Incorporating the general equilibrium aspect of the marriage market into a dynamic decision model like this is left for future research. See Fernández, Guner and Knowles (2005) for a symmetric general equilibrium model.

divorce shock is received, she has the options to either stay married or divorce her husband.

The nonstochastic component of all emotional and biological values related to marriage is denoted by M and is specified as follows,

$$M_t = a_0 + a_1 \Delta S_t^2 + a_2 age_t + a_3 f_t + a_4 mdur_t + a_5 h_t f_t. \tag{5}$$

The constant a_0 can be interpreted as the permanent preference for marriage. Educational imbalance in the household might reduce marriage utility, for example, because a disagreement occurs on the consumption of public goods. The couple's difference in schooling is denoted by $\Delta S_t = S_t - S_t^H$. The coefficient a_1 measures the impact of educational imbalance on marriage utility, and its negative value will lead to positive assortative matching in education.[8] a_2 reflects a woman's varying preference for marriage over time. a_3, a_4, and a_5 measure the impact of children and previous marriage choices. Children are likely to increase marriage utility by a_3, but this effect depends on whether the mother works, as captured by a_5. Marriage duration in the current marriage, $mdur_t$, evolves according to $mdur_t = m_t[mdur_{t-1} + m_t]$. The dependence of M on marriage duration reflects a possible increase in the bond between spouses. The value of marriage varies as the marriage evolves. The random components of marriage value are included in the utility shocks ϵ's.

At least two competing hypotheses can generate a positive correlation between spousal education attainment. The first hypothesis is education complementarity; similar schooling backgrounds generate higher utility for marriage. The second hypothesis is geographic proximity; highly educated women meet highly educated men more often in college. Following Becker (1973), this study adopts the first hypothesis. Even though who marries whom is observed, whom individuals meet and where these meetings take place are not observed. Therefore, it is difficult to empirically separate the two hypotheses without imposing some ad hoc assumptions.[9] Based on first-contact e-mails within an online dating service, Hitsch, Hortaçsu and Ariely (2006) provide evidence that women, in particular, prefer men with similar education levels.[10] Their study shows that even without geographic proximity, pref-

[8]Mating is positive assortative if schooling levels are complements in production (Becker 1973). The difference in education squared with a negative coefficient is a simple way to model complementarity. Shimer and Smith (2000) derive more complex sufficient conditions for assortative mating under search costs. Wong (2003) specifies the production function as the product of the types (e.g., education) in her empirical study of marriage matching.

[9]If the sex ratio in college and the rate of marriage are observed, the effect of geographic proximity can be potentially separated. Unfortunately, the NLSY79 data contains no information on which college each woman attends.

[10]Compared to high-school-educated men, men with a master's degree receive 48% fewer first-contact e-mails from high-school-educated women, 22% more e-mails from college-educated women, and 82% more e-mails from women with (or working towards) a graduate degree (Hitsch, Hortaçsu and Ariely 2006).

erences for similar educational backgrounds play an important role in the matching process.

The direct cost of marriage is not explicitly specified in the model, but one can interpret the permanent value of marriage a_0 as net of marriage cost. In addition, the opportunity cost of marriage is implicitly built in the model. Suppose a woman meets a man whose education is much lower than hers, and she accepts his marriage proposal because the current shock to marriage utility is positive and large. Suppose in the next period she receives an average shock to marriage utility. When she was single, she should have rejected the marriage offer because the match is bad. However, since she did marry and marriage value increases with children (if she has one) and marriage duration,[11] it might not be optimal for her to terminate the marriage.[12] The opportunity cost of marriage is therefore the possibility that one would be trapped in a bad match and lose the option value for a better match.

A married woman receives a monetary transfer $g\left(y_t^H\right)$ from her husband. The net transfer is a fraction of her husband's income, and the fraction depends on her employment status and her relative bargaining position in the marriage.

$$g(y_t^H) = \psi_m(h_t, Z_t)y_t^H,$$

where Z_t are variables which affect the woman's bargaining power and intramarriage distribution of household income. Similarly a divorced woman with children also receives a monetary transfer from her ex-husband, such that $g(y_t^H) = \psi_d(h_t, Z_t)y_t^H$.

The model focuses primarily on the female's decision process and assumes that married men always work full time in the labor market.[13] The earnings of a (potential) husband depend on his schooling and experience and are specified as

$$\ln y_t^H = \rho_0 + \rho_1 S_t^H + \rho_2 EX_t^H + \rho_3 EX_t^{H2} + \epsilon_{Ht}. \tag{6}$$

A measurement error is allowed for in the observed husband's income. When a single woman receives a marriage proposal, she knows his schooling and the distribution of ϵ_H. A married woman always observes the husband's true income; therefore, she knows both S_t^H and ϵ_{Ht}.

When a marriage offer is received, a single woman makes a "take it or leave it" decision based on the utility value of marriage M, (potential) husband's income y^H, and the realization of shocks attached to marriage. If she rejects the proposal, she will get a new

[11] Weiss and Willis (1997) show that the presence of children stabilizes the marriage.

[12] The model assumes that a married woman cannot get an outside marriage proposal. She can either stay married with her current spouse or get a divorce. Once she is divorced, she will stay divorced for at least one year.

[13] As argued by Van Der Klaauw (1996), given that 95% of the male population works in a representative sample, this is not a very restrictive assumption.

draw from the distribution of potential husbands the next year. A divorce is observed if a separation is initiated by the husband or if a married woman chooses to quit marriage when a negative shock on marriage utility or husband's earnings arrives. When a woman makes a decision to go to college (most likely before she makes the marriage decision), she knows (in expectation) how she will fare in the marriage market depending on her schooling decision. She has expectations about how often she will receive marriage proposals, the direct value of marrying each type of man, and the amount of transfer from a future husband.

2.1.5 The Arrival of Children

In general, both the number and ages of children may be important in determining women's choices. However, I assume that the fertility effect can be adequately captured by a single indicator of the presence of any children. The stochastic process that governs fertility over time is specified as the following logit form:[14]

$$\Pr(f_t = 1 | f_{t-1} = 0) = \frac{\exp\{c_0 + c_1 S_t + c_2 m_{t-1} + c_3 age_t + c_4 age_t^2 + c_5 mdur_t\}}{1 + \exp\{c_0 + c_1 S_t + c_2 m_{t-1} + c_3 age_t + c_4 age_t^2 + c_5 mdur_t\}}, \tag{7}$$

while $\Pr(f_t = 1 | f_{t-1} = 1) = 1$. The cost of children is cc. Note that the fertility rate is not necessarily zero for a single woman. A single mother is observed if this woman gives birth to a child before marriage.[15]

2.1.6 The Optimization Problem

The objective of a woman is to maximize the expected present discounted value of utility over a finite horizon; i.e.,

$$\max_{\{c_t, s_t, h_t, m_t\}} E\left[\sum_{t=1}^{T} \beta^{t-1} U_t(c_t, s_t, h_t, m_t | \Omega_t)\right], \tag{8}$$

where $\beta > 0$ is the woman's subjective discount factor and Ω_t is the state space at time t. The state space consists of all factors known to the woman that affect current utilities or the probability distribution of the future utilities. Choice of the optimal sequence of control variables $\{c_t, s_t, h_t, m_t\}$ for $t = 1, \cdots, T$ maximizes the expected present value.

[14] In this model, fertility is exogenous. It is clear that a more complete model should explicitly incorporate fertility decisions as a choice variable. However, to avoid the modeling and estimation complications resulting from an increase in the choice set and the dimension of the state space, the focus here will be on the interaction of schooling, employment, and marriage decisions conditional on fertility in each period.

[15] In the sample, 19% of the mothers are single. These observations are important to separately identify the cost of children, cc, and the marriage value attributable to children, a_3. All mothers pay cc for their children, but only married mothers enjoy a_3 through their marriage.

2.2 Heterogeneity

The model considered above corresponds to the decision problem of a representative woman. At high school graduation, however, young women differ in many aspects: their family backgrounds as measured by parental education levels, number of siblings, and family income; their cognitive backgrounds as measured by $AFQT$ test scores; and their high school grades and SAT scores. The abilities and preferences of individual women are likely to vary, too, in unobserved ways (e.g., motivation, perseverance, or ambition) that are both persistent and correlated with observed traits. These characteristics may affect a young woman's college decisions. For example, those whose parents are highly educated may more likely be endowed with high unobserved skills. They may be more likely to attend college and to postpone marriage and workforce entry.

Assume that there exist $k = 1, 2, \cdots, K$ different skill types. Denote the *ex ante* probability that a woman i is of type k by π_i^k. Let π_i^k depend on her observed initial traits, including mother's schooling S_i^m, father's schooling S_i^f, number of siblings N_i^{sib}, household structure (whether she lives with both parents) at age 14 HH_i, net family income Y_i^0, AFQT score $AFQT_i$, and age at high school graduation AGE_i^0, in the form of a multinomial logit.[16] For $k = 2, \cdots, K$,

$$\pi_i^k = \frac{\exp\left[\begin{array}{c}\lambda_0^k + \lambda_1^k S_i^m + \lambda_2^k S_i^f + \lambda_3^k N_i^{sib} + \lambda_4^k HH_i \\ +\lambda_5^k Y_i^0 + \lambda_6^k AFQT_i + \lambda_7^k AGE_i^0\end{array}\right]}{1 + \sum_{l=2}^K \exp\left[\begin{array}{c}\lambda_0^l + \lambda_1^l S_i^m + \lambda_2^l S_i^f + \lambda_3^l N_i^{sib} + \lambda_4^l HH_i \\ +\lambda_5^l Y_i^0 + \lambda_6^l AFQT_i + \lambda_7^l AGE_i^0\end{array}\right]}, \tag{9}$$

and normalize π_i^1 as $1 - \sum_{k=2}^K \pi_i^k$.

Women of different skill types have distinct tastes for school and for nonemployment (the v's in the utility function), different skill rental prices (β_0 and β_{0c}), and different earning returns to schooling (β_1). Therefore, these parameters will be type-specific and potentially correlated with observed characteristics.

Furthermore, women may also differ in taste for marriage and marriageability in the marriage market. Assume that there exist $m = 1, 2, \cdots, M$ different marriage types.[17] Marriage type probabilities are conditional on skill types. A woman of skill type k has the probability ω_k^m of being marriage type m, so that $\sum_{m=1}^M \omega_k^m = 1$ for all k. These conditional

[16] Achievement scores such as high school grades and SAT scores may affect college choice indirectly by the correlation with ability types like other background variables. They may also affect college entrance directly if college acceptance depends on grades or SAT scores. Because of data limitations, I leave the introduction of grades to a schooling model such as this one to future research.

[17] $K = M = 3$ were chosen after sensitivity analysis.

probability parameters ω_k^m are estimated within the structural model. They depend on background variables only through skill-type probabilities. Each marriage type has distinct preferences for marriage (a_0 and a_1), and marriage offer rates (b_0).

The costs and benefits of choices on school, employment, and marriage are also affected by many individual-specific exogenous factors. This discussion will focus on two of them: one related to the cost of education and the other related to the benefit of marriage. The direct cost of college for individual i at date t is specified as

$$cs_{it} = \gamma_0 + \gamma_1 Col_{it} + u_{it}. \tag{10}$$

The variable Col_{it} is a dummy for the presence of any college in individual i's county of residence. Card (1993) and many following papers show that the existence of a local college would reduce the cost of college. Therefore the coefficient γ_1 is expected to be negative. The constant γ_0 represents the cost of college in a county without a local college. The error term u_{it} is *i.i.d.* idiosyncratic shocks, which can be absorbed into the utility shocks associated with school attendance.

Divorce legislation governs the right to divorce and influences the assignment of property rights between spouses when a marriage ends. They will affect the relative bargaining power of each spouse and the allocation of common property within marriage because at least divorce matters as an outside option. The adoption of unilateral-divorce law in a woman's resident state was allowed to affect intrahousehold distribution of income. In particular, the fraction of a husband's income transferred to a married woman i at time t is specified as

$$\begin{aligned} \psi_m(h_{it}, Z_{it}) &= 0.5 && \text{if } h_{it} = 0, \\ \psi_m(h_{it}, Z_{it}) &= \theta_0 + \theta_1 Z_{it} && \text{if } h_{it} = 1. \end{aligned} \tag{11}$$

That is, a married woman receives half of her husband's income if she does not work.[18] Otherwise if she is employed, the transfer depends on the divorce law indicator Z_{it}, with one corresponding to a mutual agreement to divorce and zero if a unilateral divorce is allowed. Transfers from an ex-husband to a divorced woman with children also depend on divorce legislation and her employment status and are specified in a similar way:

$$\psi_d(h_{it}, Z_{it}) = \tau_0 + \tau_1 Z_{it} + \tau_2 h_{it}. \tag{12}$$

Previous studies (Chiappori et al 2002) indicate that mutual-content-divorce law is favorable

[18]This assumption was made because a_0 and ψ are not separately identified.

to women and increases their bargaining power.[19] Therefore the coefficients on divorce law dummy Z_{it} are expected to be positive.

2.3 Solution to the Decision Problem

To solve the optimization problem, the value function $V_{it}(\Omega_{it})$ is defined as the maximal value of the individual i's optimization problem at t:

$$V_{it}(\Omega_{it}) = \max_{\{c_{it}, s_{it}, h_{it}, m_{it}\}} E\left[\sum_{\tau=t}^{T_i} \beta^{\tau-t} U(c_{i\tau}, s_{i\tau}, h_{i\tau}, m_{i\tau}|\Omega_{it})\right]. \tag{13}$$

The value function can be written as the maximum over alternative-specific value functions $V_{it}(\Omega_{it}) = \max_{(s_t,h_t,m_t)\in J}\{V_{it}^{(s,h,m)}(\Omega_{it})\}$, which obeys the Bellman equation:

$$V_{it}^{(s,h,m)}(\Omega_{it}) = U_{it}\left(c_t, s_t, h_t, m_t\right) + \beta E[V_{it+1}(\Omega_{it+1})|\Omega_{it},\ (s_t, h_t, m_t) \text{ is chosen at } t]. \tag{14}$$

The alternative-specific value function assumes that future choices are optimally made for any given current decision. The randomness in utility arises from the fact that Ω_{it+1} is observable to the individual at time $t+1$ but unobservable at time t or before. The state space can be separated into a nonstochastic part and a stochastic part. Let $\overline{\Omega_{it}}$ be the nonstochastic part of the state space, which includes skill and marriage types, local college index, state divorce law index, years of schooling, years of experience, marriage duration, age, choices, fertility, and husband's schooling in the previous period. Some of these state variables evolve endogenously: $S_{it} = S_{it-1} + s_{it}$, $H_{it} = H_{it-1} + h_{it}$, $mdur_{it} = m_{it}[mdur_{it-1} + m_{it}]$. The stochastic part of the state space includes the vector of the random shocks $[\epsilon_{it}^{(0,0,0)}, \cdots, \epsilon_{it}^{(1,1,1)}, \epsilon_{iwct}, \epsilon_{iwt}, \epsilon_{iHt}]$, as well as job offer, marriage offer, and fertility realizations.

The solution to the model can be characterized by sequential cut-off rules. In this multiple-period model with multiple choices, the cut-off values do not have analytical forms, but the model can be solved backwards and the cut-off values can be simulated numerically. The numerical complexity arises because the value function has to be computed at each point of the state space. The state space for this model is large because the choice set contains eight elements ($s \times h \times m$) and the state space increases exponentially with respect to the decision periods within the lifetime horizon, which is known as "curse of dimensionality." The terminal date T_i should correspond to the last period in which the value function is determined by state variables. One can solve the model over an arbitrarily long horizon, for example, until age 65. But in a model like this, a huge computational burden is involved.

[19]Chiappori, Fortin and Lacroix (2002) find that a one-point increase in the divorce laws index that is favorable to women induces husbands to transfer an additional $4,310 to their wives.

Instead, similar to Keane and Wolpin (2001) and Eckstein and Wolpin (1999), the backward recursion starts at a computationally convenient terminal period, $T_i = T^*$.[20] During the first $T^* - 1$ periods, for each individual i, the model is solved explicitly. At the terminal period T^*,

$$V_{iT^*}^{(s,h,m)}(\Omega_{iT^*}) = U_{iT^*}\left(c_{T^*}, s_{T^*}, h_{T^*}, m_{T^*}\right) + \beta\{V_{iT^*+1}(\Omega_{iT^*+1})|\Omega_{iT^*}, (s_{T^*}, h_{T^*}, m_{T^*}) \text{ is chosen at } T^*\}. \tag{15}$$

As with the rest of the model, prior random shocks to wages or preferences only affect decisions through state variables including years of schooling, experience, and marriage duration. Therefore a polynomial form of the state variables at the terminal period was used to estimate the terminal value function[21], namely:

$$V_{iT^*+1}(\Omega_{iT^*+1}) = \delta_1 S_{iT^*+1} + \delta_2 H_{iT^*+1} + \delta_3 H_{iT^*+1}^2 + \delta_4 mdur_{iT^*+1}. \tag{16}$$

The parameters of this terminal condition are estimated along with the structural parameters of the model.

By using the end condition, and assuming a known distribution of ϵ_{it}, each individual's optimization problem was solved recursively from the final period T^*. Solving the dynamic programming problem requires high-dimensional integrations for computing the "$E\max$ function" at each point of the state space. As discussed in Keane and Wolpin (1994), Monte Carlo integrations were used to evaluate the integrals.

3 Data

The micro data are taken from the 1979-98 waves of the National Longitudinal Survey of Youth 1979 (NLSY79). The NLSY79 is a nationally representative sample of 12,686 young men and women who were 14-22 years old when they were first surveyed in 1979. A key feature of these surveys is that they gather information in an event history format in which dates are collected for the beginning and ending of important life events such as education, employment, and marriage.

The analysis was focused on a fairly homogenous population, which consists of white females from the NLSY79 core random sample, who have received a high school diploma and have a reported graduation date. All women in the sample graduated from high school

[20] In the empirical estimation, the terminal period is set to be 10 so that $T^* = 10$. The model was solved explicitly for 10 years for all individuals.

[21] In an early specification search, a skill-type specific constant was included in the terminal condition. But the estimated values were not significant from zero, and, therefore, the constant has been dropped from equation (16).

during May to August between 1980-1983. The sample is restricted to women who graduated from high school between the ages 17 and 19. At the time of graduation, they were single and had no children.[22] Eighty-nine individuals are dropped from the sample because of inconsistent or incomplete observations on schooling, employment, or marital choices. This left a sample of 582 women born between 1961-1964. Another 95 women were excluded from this study since their family background information is not complete. Selected individuals stayed in the sample up to 10 years as long as consecutive annual schooling, employment, and marriage profiles are observed. The empirical analysis is based on this sample of 487 females with a total of 4,770 person-year observations. The details of data construction and variable definitions are described in Appendix A.

Figure 1 presents college attendance, employment, marriage rates, and the fraction of women having children within the first 10 years after high school graduation. Among all women in the sample, 48% of them attended college in the first year after high school graduation. Some women entered college for the first time several years later, and, therefore, about 61% of the sample had attended college for at least one year. College attendance falls by 4% to 5% annually throughout the first 3 years. After the fourth year, a more than 15% discrete drop is observed, corresponding to typical college graduation. The attendance rate continues to fall but stays around 9% after 7 years. This pattern reflects the fact that some women return to school.[23] The labor force participation rate exhibits the well-known hump-shape. It increases from 43% to about 80% in the first 6 years, then becomes flat and declines slightly. The percentages of women who are married and women who have children have increased over time. At a more disaggregate level, Table 1 shows the proportion of women who choose each of the eight alternatives. The labor force participation rate of married women is significantly lower than that of single women except for the first few years when few women are married. Another interesting observation is that very few married women stay in college, which indicates low complementarity between marriage and college.

Real hourly wages are obtained as explained in Appendix A. In solving the dynamic programming problem, actual hours worked are ignored. Annual earnings are obtained by multiplying hourly wage by 2000 hours. Among all the wage observations, wages of women who work while in school are much lower and less dispersed. When wage observations for women who are not in school are used to run an OLS log wage regression on years of

[22] Complete schooling history is not available before 1980; therefore, the sample is restricted to high school graduates after 1980. 7 individuals graduated after 1983. 9 individuals graduated before 17 or after 19. More than 96% of the sample received a high school diploma during May to August. 24 women were married or had children at graduation.

[23] About one third of women in the sample had the experience of leaving and subsequently returning to school. This is very different from men. Cameron and Heckman (2001) document that only 2-6% of high school graduates and 6-12% of dropouts report at least one episode of leaving and then returning to school.

Table 1: Choice Proportions by Years After High School

Year	No. Obs	NNS	ANS	NWS	AWS	NNM	ANM	NWM	AWM
1	(487)	15.2	37.6	30.6	10.5	3.5	0.2	2.3	0.2
2	(486)	9.5	31.7	32.7	11.5	4.1	0.4	9.5	0.6
3	(485)	8.0	26.8	33.0	10.5	6.6	1.9	13.0	0.2
4	(481)	6.2	21.0	33.9	10.8	7.5	1.5	18.5	0.6
5	(478)	4.2	6.7	44.6	7.9	8.4	1.5	25.1	1.7
6	(475)	4.0	4.4	42.1	5.7	10.7	1.1	30.9	1.1
7	(472)	4.0	3.0	38.6	3.8	13.6	0.8	33.9	2.3
8	(470)	3.2	1.9	32.8	4.0	14.0	1.3	40.4	2.3
9	(469)	3.2	1.9	30.1	3.4	16.2	1.5	41.2	2.6
10	(467)	3.0	0.9	27.0	3.4	18.6	1.9	42.6	2.6

Note:
NNS denotes not-attend, not-work, single; ANS denotes attend, not-work, single;
NWS denotes not-attend, work, single; AWS denotes attend, work, single;
NNM denotes not-attend, not-work, married; ANM denotes attend, not-work, married;
NWM denotes not-attend, work, married; AWM denotes attend, work, married.

schooling and experience, the regression yields the following coefficients with standard errors in parentheses: β_0(constant) = 0.712 (0.051), β_1(schooling) = 0.081 (0.004) , β_2(experience) = 0.122 (0.009) , β_3(experience^2) = -0.005 (0.001) . The concavity of the experience profile and the positive schooling effect are consistent with many other studies.

Seventy-one percent of the sample had married at least once. Married couples tend to share a common schooling background. At the time of the first marriage, 42% of the couples had the same educational attainment and the correlation between spousal years of schooling was 0.55. Sixty percent of college women's husbands were college graduates, while less than 7% of high school women's husbands were college graduates.[24] Even though the sample women were in their twenties, many of them had already undergone one or more changes in marital status. Throughout the sample period, 142 women (29%) had remained single, 25 (5%) had married twice, and 54 (11%) had experienced at least one divorce. Most of the divorced women had not gone to college.[25]

Detailed family and cognitive background variables are constructed for the selected sam-

[24] If schooling homogamy provides positive value to marriage, marriages in which partners share similar educational backgrounds are expected to be more stable. Because of the small number of observations, however, the joint schooling distributions are not statistically different for marriages survived and divorced during the sample periods.

[25] From a life-cycle perspective, this number is probably biased since college graduates get married later. Therefore, it is less likely for us to observe their divorce over the same time span. However, some aggregate data show the same pattern. According to data from the National Survey of Family Growth (NSFG), among nonHispanic 20 to 44-year-old white women in 1995, the probability of first marriage disruption after 15 years is 55% for high school dropouts, 45% for high school graduates, and 36% for women with more than a high school education.

Table 2: Background and Schooling Outcomes

	No. of Obs.	HGC	Enrollment Rate	Graduation Rate
All	487	14.3	61.4	37.8
Mother's Schooling:				
Non-high school graduate	100	12.9	36.0	12.0
High school graduate	267	14.2	60.3	34.8
Some college	60	15.2	78.3	50.0
College graduate	60	16.3	91.7	81.7
Father's Schooling:				
Non-high school graduate	114	13.2	40.3	19.3
High school graduate	205	13.9	55.6	28.8
Some college	64	14.8	76.6	45.3
College graduate	104	16.1	86.5	71.1
Net Family Income:				
$Y <= 1/2$median	40	13.8	52.5	27.5
1/2median$< Y <=$median	204	13.9	55.9	26.5
median$< Y <= 2$median	210	14.6	66.2	46.7
$Y > 2$median	33	15.6	75.8	63.6
AFQT Percentile Score				
AFQT<=20	48	12.5	22.9	4.2
20<AFQT<=50	173	13.3	42.8	16.8
50<AFQT<=80	191	14.9	74.9	49.2
AFQT>80	75	16.3	94.7	78.7

HGC: Highest Grade Completed.

ple. Table 2 illustrates the potential importance of background in determining school outcomes. Both parents' education levels have strong positive correlation with women's schooling outcomes. Women whose family income is greater than twice the median obtain almost 2 years more schooling than women whose family income is less than half of the median. $AFQT$ scores are strongly correlated with schooling outcome. Seventy-nine percent of women in the top 20 percentile of $AFQT$ scores complete college, while 77% of women in the bottom 20 percentile $AFQT$ scores never attend college. Furthermore (not shown in Table 2), the number of siblings has little effect on schooling outcome if less than four and reduces number of years in college otherwise. Women who live with both parents at age 14 obtain a half year more schooling than those from broken families. Those who graduate from high school earlier subsequently do significantly better in school than those who graduate later.

NLSY geocode was used to identify each individual's county and state of residence and match them with local school information and state divorce law index. Annual data on location, type of institution, and other variables associated with all colleges in the U.S. are available from the Department of Education's annual IPEDS "Institutional Characteristics" surveys.[26] "Local college" is a dummy variable for the presence of any 2-year or 4-year college in the county of residence at age 18. Among all women in the sample, 88.3% of them live in a county with a local college. State-level features of divorce legislation are from the data appendix of Wolfers (2006). A binary indicator for mutual-content-divorce law is constructed for each individual based on her state of residence. In the sample, 46.8% of women lived in a state with mutual-content-divorce law in 1985.

4 Estimation Method

4.1 Simulated Maximum Likelihood Estimation

The solution of the model serves as an input to the estimation procedure. The model is estimated by simulated maximum likelihood.

At any time t, denote the vector of outcomes as $O_t = \{(s_t, h_t, m_t), w_t^o, S_t^H, y_t^{oH}\}$. The likelihood function for a sample of I individuals from period $t = 1, 2, ..., T^*$ is given by

$$\Pi_{i=1}^{I} \Pr(O_{i1}, O_{i2}, ..., O_{iT^*}|\Omega_{i0}).$$

The joint serial independence among the shocks implies that the likelihood function can be written as the product of within-period outcome probabilities.

The solution to the individual's optimization problem provides the within-period choice probabilities. To illustrate the computation of the likelihood, let us consider a specific outcome at some period. Suppose a woman who chooses not to attend school but to work full-time reports receiving a wage w_t^o, and marries a man who has S_t^H years of schooling and earns annual income y_t^{oH} in period t. Further, assume that the individual enters the period being single and having state space Ω_t. The probability of this outcome is

$$\begin{aligned} & \Pr[(0,1,1), w_t^o, S_t^H, y_t^{oH}|\Omega_t] \\ = \; & P_{E_j}^{h_{t-1}} P_t \mu_{S_t^H} \Pr[V_t^{(0,1,1)} = \max_{j \in J} V_t^j | w_t, S_t^H, y_t^H, \Omega_t] \Pr(w_t, w_t^o|\Omega_t) \Pr(y_t^H, y_t^{oH}|\Omega_t). \quad (17) \end{aligned}$$

This probability has three components: the first term on the right-hand side is the probability of receiving a job offer and a marriage proposal from a man with S_t^H years of school $P_{E_j}^{h_{t-1}} P_t \mu_{S_t^H}$; the second term is the choice probability of not attending school and accepting both the job offer and the marriage proposal; and the last term on the right-hand side of

[26] Data can be downloaded from http://nces.ed.gov/ipeds/datacenter/DataFiles.aspx.

(17) is the probability of observing the woman's wage w_t^o and her husband income y_t^{oH}. The choice probability involves the calculation of multivariate integrals as in general multinomial choice problems. I calculate the joint probability of choosing $(s_t = 0, h_t = 1, m_t = 1)$ conditional on the true wage and income by a smoothed simulator following Eckstein and Wolpin (1999). For each of $k = 1, 2, ..., K$ draws of the error vector, the $\epsilon' s$, a smoothed simulator of the probability that $(0, 1, 1)$ is chosen is given by the kernel

$$\exp[\frac{V_{tk}^{(0,1,1)} - \max_{j \in J}(V_{tk}^j)}{\tau}] / \sum_i \exp[\frac{V_{tk}^i - \max_{j \in J}(V_{tk}^j)}{\tau}],$$

with τ the smoothing parameter and was set at 500. The integral is then the average of the kernel over the K draws. The probabilities of observing a reported wage w_t^o for the woman and a reported annual income y_t^{oH} for her husband are the joint density of the observed and true wage and the joint density of the observed and true husband's income, respectively. Probabilities of other outcomes are calculated similarly.

For the purpose of estimation, the choice probabilities are a function of the parameters of the model conditional on the data of outcomes. Given parameter values, the dynamic programming problem is solved numerically and the likelihood function is computed. The process is iterated over the parameter vector until the likelihood is maximized.

The model is restricted to have an exogenous process on fertility and exogenous schooling distribution of potential husbands. I estimate the probability of a first birth separately and use it as an input to the estimation algorithm.[27] Results from the logit estimation are presented in Appendix B. Schooling has a negative impact on the probability of having children. Married women are more likely to have children than are single women. As women become older, their probability of having at least one child increases but at a diminishing rate. I calculate the schooling distribution of 22 to 35-year-old white males between 1980 and 1983 from CPS and use it as nonparametric estimates of potential husbands' schooling distribution (Table 7). Furthermore, the discount factor β is set to be 0.96, i.e., an annual rate of time preference of 4%.

For the selected sample indexed by $i = 1, \cdots, N$, I observe each individual's family and cognitive background, the presence of any college at her county of residence Col_i, and the state divorce law Z_i; schooling, employment, marital status, and fertility every year $(s_{it}, h_{it}, m_{it}, f_{it})$; wages if employed (w_{it}^o); and characteristics of the first marriage: husband's schooling S_{it}^H and annual income y_{it}^H, if married, for $t = 1, \cdots, T^*$. I have assumed that the

[27] The probability of the first birth depends on schooling and marital status, which are correlated with unobservables (ability, taste for marriage, etc.). Therefore, the logit estimates may be biased and inconsistent. I assume that the potential bias is small and adopt a two-step procedure as in Van Der Klaauw (1996).

parameters describing initial preferences, ability, and market skills are related to measured family and cognitive background. As discussed in Section 2.2, there are $K \times M$ discrete types in total and each type would be described by a vector of parameters. Note that local college and state divorce law would affect the school cost and marriage benefit, and, therefore, both of them are in the state space. The likelihood function for individual i in this case would be a finite mixture of the type-specific likelihoods, namely

$$L_i(\theta) = \prod_{t=1}^{T^*} \sum_{k=1}^{K} \sum_{m=1}^{M} \pi_i^k \omega_k^m \Pr[(s_{it}, h_{it}, m_{it}), w_{it}^o, S_{it}^H, y_{it}^{oH} | \Omega_{it}] \Pr(f_{it} | \Omega_{it}),$$

where the skill-type probability π_i^k is determined by equation (9). The sample log likelihood function is

$$\log L(\theta) = \sum_{i=1}^{N} \log L_i(\theta).$$

The resulting estimate of θ, $\widehat{\theta}$ satisfies

$$\sqrt{N}(\widehat{\theta} - \theta_0) \rightarrow N(0, E[s_i(\theta_0) s_i(\theta_0)']^{-1}),$$

where $s_i(\theta_0) = \partial L_i(\theta_0)/\partial \theta'$ and θ_0 is the true value of θ. BHHH procedure was used to calculate the standard errors.

4.2 Identification Issues

Although the model is complex, it is nevertheless possible to discuss intuition regarding parameter identification.[28] Starting with the two earnings equations (3) and (6), the coefficients are identified by the data on wages and husbands' earnings. We only observe wages for those who work, but the solution to the optimization problem provides the sample selection rules. The identification of the utility function parameters follows closely to Keane and Wolpin (1997) and Eckstein and Wolpin (1999). In particular, since the cost of college cs enters the model linearly with the value of schooling v_1 to v_4, γ_0 was set to be $7,515$ in the estimation based on the estimates from the National Center for Education Statistics[29] during 1980-1988. The cost of graduate school, cg, is identified since it only occurs during post-college attendance.

The main hypothesis tested in the paper is that women attend college to improve their

[28] Discussion on a simple two-period example is available on the author's web page to illustrate analytically how various sources determine college decisions, discuss the related empirical issues, and examine the identification of the model.

[29] NCES, Digest of Education Statistics, 1990, pp 285, Table 281.

future marriage. There are three types of gains in the marriage market enjoyed by women with college education. Firstly, attending college can increase marriage offer probabilities. Even though a college woman and a high school woman draw their potential spouses from the same distribution, the college woman is more likely to marry a better husband since she has a larger pool to choose from. This is captured by the parameter b_3 in the empirical model. Secondly, women prefer having a spouse with similar education level (a_1), which provides incentives to attend college if a majority of potential spouses have college education. The last benefit is the transfer from their husband within the marriage: women with college education have higher chance to meet and marry men with higher education thereby higher earnings, which provides another incentive to attend college. Parameters related to this effect are the share of the husband's earnings that a wife can get (ψ) and the male's college premium (ρ_1).

First, assume that the relationship between college attendance and gains in the marriage market is causal. The available data to identify these gains include: transition probabilities from singlehood to being married; transition probabilities from being married to being divorced; women's age, education, and earnings; and husbands' age, education, and earnings. As in a standard search model, either the marriage offer rate or the reservation value of marriage can be identified, but not both, given marriage transition probabilities or duration of being single. However, in this model, I can take advantage of transition rates conditional on women's own and spousal education levels. Since the reservation value of marriage varies with the women's own and spousal characteristics following the parametric specification, I can identify not only the marriage offer probabilities but also the parameters which determine the value of marriage, including the preference parameter for assortative mating (a_1). Furthermore, male's earnings parameters are estimated from husbands' wages.

The question is, of course, whether all these gains in the marriage market can be attributed to schooling. The observed differences of husbands' education and earnings between college women and high school women reflect not only the returns to college, but also the returns to differences in some unobserved characteristics of women (for example, attractiveness) between the two groups. To correct for this type of self-selection bias, the presence of any college in one's county of residence was used as an exclusive restriction.[30] As shown by Card (1993) and others, the existence of a local college would reduce the cost of college, but it does not influence the decision as to whom and when to marry.

[30] In the Willis-Rosen model (1979), familiy background is used as an exclusive restriction for school decision, which shifts marginal cost of education but does not influence earnings directly. In this model, family background is correlated with unobserved ability, which affects schooling decision directly. But ability is allowed to be correlated with unobserved characteristics in the marriage market which affect both marriage preferences and marriage offer rates. So family background also affects the value of marriage and therefore cannot be used as an exclusive restriction for schooling decision.

Once the causal impact of schooling on marriage outcome is identified, the next step is to quantify how much the gains in the marriage market affect schooling decisions. In the model, husbands' earnings enter the marriage decision but not the decision to attend college. A woman, with or without college education, randomly meets a potential spouse from an exogenously given distribution. Conditional on her own and the husband's educational attainment, the woman is more likely to accept a marriage proposal or stay in her current marriage if the (potential) husband's income is high, either because of his age/experience or because of large productivity realization. Husbands' earnings directly affect the value of marriage and thus the marriage decision, but affect schooling decision only through its impact on marriage.

Two concerns are in place regarding using husbands' earnings as an exclusive restriction. Firstly, even though a rich husband (conditional on his education) increases probabilities of getting and staying married for a woman, its impact on the "expected" gains to marriage might be small because idiosyncratic shocks could cancel out. To address this concern, I introduce into the model "distributional factors" (Chiappori, Fortin and Lacroix, 2002) which exogenously shift women's perspective in the marriage market. Specifically a dummy for mutual-content-divorce law was used as a distributional factor,[31] and the transfer parameter ψ was specified as a function of regional variations in features of divorce law as in equations (11) and (12). The divorce law index shifts the (expected) value of marriage by affecting transfers from husband, but it has no direct impact on college attendance. Thus the impact of expected gains in the marriage market on school decision is identified.

Observed husbands' earnings apparently come from a selected sample–incomes of those potential husbands who are single or divorced are not observed. Since marriage is an endogenous decision and husbands' earnings parameters are estimated within the structural model, this type of self-selection is explicitly modeled. However, taking into account the unobservable ability for males and the matching on unobservables in the marriage market is left for future research, given the very limited data available for husbands in the sample.

Overall, the functional form, distributional assumptions, and exclusive restrictions embedded in the model provide a sample selection correction similar to the one in either a two-step or full-information procedure. Without such selection rules incorporated into the structural model, a simple reduced form analysis would generate biased estimates.

[31] Chiappori, Fortin and Lacroix (2002) have also suggested other distributional factors. For example, sex ratio may affect the relative spousal bargaining power. However, for each ex-ante different type of individual, the dynamic programming problem needs to be solved separately. I restricted my attention to a single dummy for unilateral-divorce law, so that the model is solved for 36 types: 9 unobserved skill and marriage types $\times$ 2 types for the existence of local college $\times$ 2 types for unilateral-divorce law.

5 Estimation Results

5.1 Parameter Estimates

Parameter estimates, and their standard errors, are reported in Appendix C. Some of the parameters are not of direct interest, although parameters on background, earnings, and marriage are worth highlighting.

The model is fit with three skill types. According to the estimated correlation between background and skill types, the λ's, higher parental education, fewer siblings, living with both parents at 14, higher family income, good $AFQT$ score, and graduation from high school at an early age imply higher probability of being skill Type 2. Similarly, parental schooling, family income, and $AFQT$ score also have a positive (but lesser) impact on the probability of being skill Type 3. The estimated utility values of school indicate significant preference heterogeneity among skill types. According to the rank order of the values of v_1, v_2, v_3, and v_4's, skill Type 3 has the highest value of school, skill Type 2 the next, and skill Type 1 the lowest, independent of working and marital status.

According to the estimates of the wage equation parameters, both skill rental price and return to schooling are the lowest for skill Type 1. Type 2's have the highest skill rental price while skill Type 3's have the highest return to schooling. Each additional year of schooling increases wages by 5.0%, 6.0%, 6.2%, respectively, for each type. Note that the estimated returns to schooling are much lower than the OLS estimates, providing evidence that without controlling for self-selection, the earnings return to education are upward biased.[32] College graduation increases wages by 29.6% conditional on years of schooling and experience. Even though skill Type 1's have a much lower skill rental price and much lower returns to schooling for the formal labor market, they seem to have a comparative advantage for jobs available at school as indicated by the highest β_{0c}.

In the estimated marriage evaluation rule, the negative a_1 confirms that education attainment of both spouses are complements within the family. The value of marriage increases with age, children, and marriage duration. The estimated b_3 in the marriage offer probability function shows that college attendance increases the marriage offer rate significantly.[33] Considerable heterogeneity is also observed among marriage types. Marriage Type 1's fixed value for marriage (a_0) is the lowest, and the difference in schooling with the husband's

[32] See Card (2001) for a recent survey on the complexity in estimating the earnings return to schooling.

[33] Interestingly, Van Der Klaauw claims that "the yearly probability of meeting a potential spouse is lower for women with more years of education" (refer to ω_2 in Table 4 of Van Der Klaauw 1996). In Van Der Klaauw's model, schooling is treated as an exogenous characteristic. If the type of individuals who are more likely to attend school are less likely to marry or if they are more likely to marry later, his estimated impact of schooling on marriage offer rate would be downward-biased.

Table 3: Chi-Square Goodness-of-Fit Tests of the Within-Sample Choice Distribution

	Choices								
Year	NNS	ANS	NWS	AWS	NNM	ANM	NWM	AWM	χ^2 Row
1	1.55	0.22	0.19	0.08	2.89	0.01	0.01	0.08	5.04
2	0.01	0.06	0.97	0.06	0.07	0.01	2.44	0.03	3.65
3	0.03	0.03	0.82	0.07	0.16	2.02	0.76	0.35	4.25
4	0.17	0.01	0.49	0.14	0.06	0.24	1.38	0.17	2.67
5	1.61	0.85	0.06	0.01	0.43	0.62	1.63	0.10	5.30
6	0.76	0.06	0.03	0.08	0.20	0.01	1.13	0.13	2.41
7	0.00	0.70	0.01	0.72	0.02	0.08	0.12	0.28	1.94
8	0.05	0.69	0.01	0.47	0.21	0.01	0.14	0.16	1.74
9	0.24	3.99	0.30	0.76	0.16	0.00	0.09	0.21	5.75
10	0.01	0.01	0.68	1.13	0.03	0.00	0.06	0.42	2.34

Note: $\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$, where O_i is the observed frequency for bin i and E_i is the expected frequency for bin i, $\chi^2_7(0.05) = 14.07$.

gives them the largest disutility (a_1). Thus, they seem to be the most choosy. At the same time, they seem to be the most attractive type since they receive marriage offers most often (highest b_0). Interestingly, almost all skill Type 2's belong to this marriage type.

5.2 Within-Sample Fit

This section presents evidence on the within-sample fit of the model. Given the estimated parameters, I calculate the predicted proportions of women who choose each alternative in every year after high school. Figure 2 depicts the fit of the model to the choice proportions. Each of the profiles implied by the estimated model has approximately the right shape and matches the levels of the data quite closely. More formally, Table 3 presents the within-sample χ^2 goodness of fit statistics for the model with respect to choice proportions. The model prediction is statistically the same as the data moments at the 5% level. As for the overall schooling distribution, the model predicts that 58.0% of the sample high school graduates will attend college and that 37.0% of them will finish a 4-year degree as compared with what is in the data: 61.4% attended at least one year of college and 37.8% completed 4 years. Table 4 presents the predicted mean transitions based on the same simulations that generate the choice distributions in Figure 2. The model can match transitions reasonably well. The data demonstrates much persistence in each state; the model recovers persistence in attendance status and marital status but somewhat underpredicts the persistence in non-employment. Figure 3 further demonstrates the fitting of divorce transitions. Let divorce rate at time t be p_t^d, the cumulative marriage survival rate at T_0 is defined as $\Pi_{t=1}^{T_0}(1 - p_t^d)$. Year-to-year divorce rates are quite volatile in the data because the number of observations

Table 4: Fit of the Mean Transitions

From\To	Attend	Not Attend
Attend	65.83 (66.45)	34.17 (33.55)
Not-Attend	5.26 (5.31)	94.74 (94.69)

From\To	Work	Not Work
Work	82.83 (88.76)	17.17 (11.24)
Not Work	45.30 (34.77)	54.70 (65.23)

From\To	Single	Married
Single	87.36 (87.71)	12.64 (12.29)
Married	4.34 (3.63)	95.66 (96.37)

Note: Data moments are in parentheses.

Table 5: Predicted Matching in Education at the First Marriage

Married Women's	Husbands' Schooling		
Schooling	HS Graduates	Some College	College Graduates
HS Graduates	70.3 (77.7)	28.0 (15.7)	1.7 (6.6)
Some College	46.0 (42.9)	37.0 (38.5)	17.0 (18.7)
College Graduates	9.2 (19.5)	31.3 (20.7)	59.5 (59.8)

Note: Data moments are in parentheses.

is small. Therefore I present the cumulative marriage survival rates instead in Figure 3. The model prediction follows the data very closely. The trends and the levels of women's wages and married men's annual incomes are also well fitted by the estimated model.

As Table 5 presents, the predicted husband's schooling distribution, conditional on married women's schooling level, matches the data closely. In the model, even though high school graduate women like to marry college men for their high incomes, they suffer from the difference in educational background and receive fewer marriage proposals. The model underpredicts their probability of marrying college men. Women who attend college but never finish their 4-year degree (some college) behave more like high school graduates. Overall, the model can fit the conditional schooling distribution of husbands.

Table 6: Background Differencs: NLSY79 vs NLSY97

Variable Name	NLSY79	NLSY97
Highest grade completed of mother at 14	12.3 (0.09)	13.6 (0.10)
Highest grade completed of father at 14	12.6 (0.13)	13.8 (0.12)
Number of siblings at 14	2.8 (0.08)	3.4 (0.10)
Broken home at 14	0.14 (0.01)	0.16 (0.02)
Family income (in thousands 2000 dollars)	65.3 (1.50)	78.5 (2.68)
AFQT score*	53.9 (1.08)	63.5 (1.00)
Age at high school graduation	17.9 (0.02)	17.8 (0.02)

Note: Standard errors of the means are in parentheses
* See Appendix A for changes in definition.

6 Model Validation

6.1 The NLSY97 Sample

For the purpose of model validation, a comparable sample is constructed from the National Longitudinal Survey of Youth 1997 (NLSY97) rounds 1-6. The NLSY97 sample consists of 8,984 youths who were 12-16 years old as of December 31, 1996. Since both NLSY79 and NLSY97 use the same instruments, they provide a unique source for comparing lifetime behavior between a cohort born in the early 1960s and a cohort born in the early 1980s. In constructing the NLSY97 sample, all restrictions are the same or kept as close as possible to those on the NLSY79 sample. A selected 537 women, who graduated from high school between 1997-2000, are observed for up to 5 years.

A dramatic increase in college enrollment from 61% to 80% is observed when I compare the NLSY79 and the NLSY97 samples.[34] Figure 4 compares the two college attendance profiles. Note that only 4-year data are available for the NLSY97 sample conditional on having a large enough number of observations. The two attendance profiles are almost parallel with each other for the first 4 years.[35]

The two samples differ in many respects, which may lead to the different schooling outcomes. First, as shown in Table 6, the NLSY97 women's parental education, family income, and $AFQT$ scores are significantly higher than those of the NLSY79 women. Second,

[34] These are enrollment rates of white females with a high school diploma based on the NLSY79 and the NLSY97 samples. The enrollment rates from the National Center for Education Statistics (NCES) and CPS are lower since their high school graduates include individuals who completed GED (General Equivalency Diploma). It is well known that a GED is not equivalent to a high school diploma (Cameron and Heckman 1993).

[35] At the same time, the labor force participation pattern for the young cohort stays the same. The young cohort tends to marry less or later. But if I take cohabitation into account, the proportion of having a partner/spouse converges to the marriage profile of the old cohort.

Table 7: Schooling Distribution of NLSY79 and NLSY97 Sample's Potential Husbands

Cohort\Yrs of school	11 or less	12	13	14	15	16	17	18 or more
NLSY79	6.88	41.69	8.65	11.03	5.30	16.16	3.53	6.77
NLSY97	8.03	40.41	8.53	11.97	4.40	18.24	2.60	5.83

Note: statistics are based on 22 to 35-year-old white males whose years of schooling are at least 10 years from CPS 1980-1983 and 1997-2000. CPS changed schooling classification in 1992. Prior to 1991, information on the number of grades attended and completed was collected up to 18 years. After 1992, however, education attainment is categorized to highest degree received. I used the test from the February 1990 CPS (details see Kominski and Siegel 1993), in which both questions were asked of the same individuals, to reclassify the degrees as highest grades completed.

the schooling distribution of potential husbands has changed from 1980 to 2000 (Table 7). Third, between 1980 and 2000, the relative wage between some college and high school females increases by 50%, while the relative wage between college and high school females doubles (Figure 5).[36] Fourth, the cost of college has increased dramatically in the last two decades according to the National Center for Education Statistics (Figure 6).

6.2 Out of Sample Predictions

The underlying structure of economic relations is estimated based on data from the NLSY79 sample. The validity of the model is assessed according to how well estimates of the model predict the change in individual lifetime choices, especially college enrollment. The basic idea is that if the structural model is a good approximation of how individuals make college decisions, it should be able to predict the new sample's behavior while keeping individual preferences constant. The differences in behavioral outcomes should be accounted for by changes in the forces driving the decision to attend college: background variables, potential husbands, expected earnings, and schooling cost, which are determined outside the model. Figure 7 presents the prediction of college attendance profile for the NLSY97 sample.

In the first simulation, all parameters are fixed at the estimated values based on the NLSY79 sample, but I use the NLSY97 sample's background variables and plug them into equation (9) to predict each individual's skill type. Since individuals in the NLSY97 sample have higher parental education and test scores on average, they are more likely to be a high skill type. The simulation result is shown by the line with dots. In the first year after high school graduation, the attendance rate would increase from 48.5% to 62.9%. Overall

[36] The increase in college premium is well documented in the literature; see Katz and Murphy (1992), Card and DiNardo (2002), and Eckstein and Nagypál (2004).

college enrollment would increase by more than 10 percentage points, from 58.0% to 68.4%. Heterogeneity in background has a lasting effect: as seen in the graph, it improves both attendance and graduation. The background effect is due to the increased number of high-skilled women.

In the second simulation, in addition to the improved background, I also allow young women to face a new pool of potential husbands. The schooling distributions for potential husbands of both NLSY79 and NLSY97 samples are given in Table 7. Overall, these two distributions are very similar. As shown by the dashed line, the model predicts that the college attendance of women would almost stay identical because the change in husbands' educational attainment is very small.

In the third simulation, in addition to changes in background and husbands, I allow women to have expectations on the dramatic increase in earning returns to schooling. The earning returns to schooling for the NLSY79 sample are estimated in the structural model to control for selection. Without a similar structural model estimated for the new cohort, we cannot obtain a consistent estimate for the new returns. I adopt a much more parsimonious method. As Figure 5 shows, the relative wage between females with a high school diploma and some college education increased by 50%, while the relative wage between females who have graduated from high school and who have graduated from college doubled between the early 1980s and the early 2000s.[37] For the new cohort, I assume that the returns to each additional year of schooling (β_1's) would increase by 50%, and that the returns to college graduation (β_4) would double. In this simulation, when women solve the dynamic programing problem, they use the new β_1 and β_4 to formulate expectations on their future earnings. The line with circles shows the simulation results: the effect of increasing the college premium on college enrollment is small, but it has a large effect on college graduation.[38] The reason is that the premium of a college degree has increased most dramatically.

In addition to all the above changes, in the last simulation, I also allow women in the new sample to pay a higher cost for college (around \$11,030 in 2000 dollars), that is, γ_0 is increased from 7,515 to 11,030. As shown by the line with triangles, the tuition effect is small as the college enrollment drops by only 1 percentage point.

Given all the changes in background, potential husbands' schooling distribution, college premium, and tuition cost, the predicted college attendance profile (the line with the triangle) is very close to the actual attendance profile of the NLSY97 sample (the dashed line on the top) as shown in Figure 7. The model, which is estimated based on a sample of women

[37] These premiums may be attributed to the returns to ability or the returns to college (Taber 2001). I simply treat the premiums as the returns to college to have an upper bound for the changes in college premium for the new cohort.

[38] Changes in men's college premium have insignificant effects.

attending college in the early 1980s, predicts well the enrollment behavior in the early 2000s. Overall, the prediction for the NLSY97 sample indicates that the individual preference parameters are invariant to the environment. Furthermore, to account for the dramatic increase in educational attainment, the shift in the skill distribution (through background) plays an essential role. The rising skill premium has small effects on college enrollment but large effects on graduation, and the rising tuition plays an insignificant role. Even though the marriage market could play an important role in college enrollment through the improvement of matching efficiency via marriage offer probabilities (b_3), there is no direct measure available. Since the education distribution of potential husbands barely changes, the effect of educational assortative mating is negligible.

7 Simulations

7.1 How Much Does Marriage Matter to Women's College Decisions?

I run counterfactual simulations to study the effects of marriage on women's college decision. I compare women's education outcome from each simulation with the baseline outcome predicted by the model given the estimated parameters. Table 8 presents the simulation results by skill types.

The top panel of the table shows the schooling outcomes from the baseline model. Mean highest grade completed is 14.3 years for the whole sample, 12.2 years for Type 1's, 15.5 years for Type 2's, and 19.6 years for Type 3's. The next two rows show the college enrollment and graduation rates, that is, the proportion of women who have attended any college, and the proportion of those who have graduated from a 4-year college or university. In the baseline model, the college enrollment rate is 58.0%, and the graduation rate is 37.0% for the whole sample.

As discussed earlier, there are three types of gains in the marriage market enjoyed by women with a college education. Firstly, attending college can increase marriage offer probabilities ($b_3 > 0$). Secondly, women prefer having a spouse with similar education level ($a_1 < 0$), which provides incentives to attend college if a majority of potential spouses have a college education. Thirdly, women with a college education have a higher chance to meet and marry men with a higher education and thereby higher earnings, and therefore benefit from transfer from their husbands.

In the first simulation, I assume that college does not increase the marriage offer rate, i.e., $b_3 = 0$. The college graduation rate would increase by 3.4 percentage points, but college

Table 8: Impact of Marriage on Education Outcome by Skill Types

	All	Type 1	Type 2	Type 3
Baseline Model				
Mean HGC	14.3	12.2	15.5	19.6
College Enrollment Rate	58.0	18.4	97.2	99.7
College Graduation Rate	37.0	0	67.7	95.5
(1) College Does Not Increase Marriage Offers ($b_3 = 0$)				
Mean HGC	14.4	12.0	15.7	20.2
College Enrollment Rate	50.8	4.3	97.0	99.7
College Graduation Rate	40.4	0	76.0	96.1
(2) No Educational Assortative Mating ($a_1 = 0$)				
Mean HGC	14.3	12.4	15.4	19.4
College Enrollment Rate	66.6	36.3	96.5	99.8
College Graduation Rate	33.8	0.0	58.9	96.7
(3) No Transfers From Husbands				
Mean HGC	14.3	12.1	15.6	19.7
College Enrollment Rate	54.8	11.7	97.5	99.7
College Graduation Rate	38.8	0	72.2	95.8
(4) Both (1)-(3) Hold ($b_3 = 0, a_1 = 0,$ and no transfers)				
Mean HGC	14.4	12.0	15.7	19.9
College Enrollment Rate	50.5	4.3	96.5	99.8
College Graduation Rate	39.0	0	71.7	97.2
(5) No Marriage Offers				
Mean HGC	14.8	12.0	16.5	21.6
College Enrollment Rate	51.8	3.9	99.8	99.8
College Graduation Rate	48.8	0	97.4	98.1
(6) All Husbands Are College Graduates				
Mean HGC	14.8	13.0	16.0	19.1
College Enrollment Rate	74.2	49.3	99.8	99.8
College Graduation Rate	44.6	0.5	85.9	97.5

enrollment would drop by 7.2 percentage points. Based on the type-specific simulations, Type 1's are the type who attend college for more marriage opportunities. If college has no effect on the marriage offer rate, their enrollment would drop by more than 70 percent. The marriage offer rate has little effect on Type 2's enrollment. In fact, setting b_3 to zero would increase their college graduation rate because they are less likely to get married and drop out of college when the marriage offer rate is lower.

The second simulation analyzes cases in which women do not care about the relative schooling background of husbands. Setting $a_1 = 0$, the model predicts no correlation between couples' educations because matching is random. College enrollment would increase by 8.6 percentage points, and graduation would drop by 3.2 percentage points. Type 1's have more incentive to attend college because they would not care about matching with high school men but would want to take advantage of the higher marriage offer rate. Type 2's have less tendency to graduate to match with men with a college degree.

If women receive no transfers from their husbands or ex-husbands, as in the third experiment, two opposing effects are expected on the schooling outcome. First, marriage return to college may go down because otherwise college women benefit from their husband's higher education and subsequent higher earnings. Second, since the value of marriage goes down when transfers become zero, women are less likely to marry while in school and, hence, less likely to drop out. For Type 1's, the first effect dominates, and their enrollment would drop by 6.7 percentage points. For Type 2's and Type 3's, the second effect drives the graduation rates up.

These three simulations indicate that each one of the marriage gains have differing impact on college enrollment and graduation. Marriage gains from college attendance mostly come from the fact that marriage offer rate is higher if a woman attends college and come from husband's transfers within marriage. Almost all Type 2 and Type 3 women would attend college even without any marriage gains; therefore, changes in college attendance responding to decrease in marriage gains come almost entirely from Type 1. On the other hand, marriage gains from college graduation mostly come from educational assortative mating. Since Type 1's never graduate from college and Type 3's almost always graduate, only Type 2's would be less likely to graduate without the marriage gains through assortative mating.

When I zero out all marriage benefits in the fourth simulation, college enrollment rate would drop by 7.5 percentage points (from 58.0% to 50.5%), and the college graduation rate would increase slightly by 2 percentage points. The drop in enrollment occurs mainly because fewer Type 1's would attend college to meet more potential spouses. On the other hand, the fact that Type 2's and Type 3's are less likely to get married in college because of the lower marriage offer probability would contribute to the increase in graduation rates.

If the marriage option is not available, the only incentive to attend college is to increase future earnings. For skill Type 1's, since a large part of the gains of attending college is the increase in marriage opportunity, the college attendance rate would drop when earnings become the only gain. When marriage offers are never received, the enrollment of skill Type 1's would drop by 14.5 percentage points. The estimated utility of schooling is negative and large when women are married; therefore, marriage is destructive for school continuation. For Type 2's and Type 3's, if they never receive marriage offers, they would be less likely to drop out and more likely to graduate from college. Therefore, overall the college enrollment would decrease by 6.2 percentage points, but the graduation rate would increase by 11.8 percentage points.

To further investigate the effects of assortative mating in education, I ran an experiment in which all potential husbands were college graduates. The model predicts that college enrollment for women would increase by 16.2 percentage points and that graduation would increase by 7.6 percentage points. Under this scenario, Type 1's attend college much more often. Almost all Type 2's would attend college, and 86% of them would graduate. When there is a dramatic change in men's schooling distribution, as shown in this experiment, it can have a large impact on women's schooling decisions through educational assortative matching.[39]

7.2 How Much Does Earning Matter to College Decisions?

Table 9 shows the impact of the earnings return to schooling by skill types.[40] As the schooling coefficient β_1 increases, college enrollment might increase because expected earnings returns increase. But college enrollment might also decrease because high school wage, which is the opportunity cost of college attendance, also increases in β_1. With a 10% increase in the return for each additional year of schooling (β_1's), the enrollment rate would drop slightly by 0.4 percentage points, and the graduation rate would increase by 0.3 percentage points. When β_1 goes up, the opportunity cost of college goes up, and Type 1's are less likely to attend college. For Type 2's, the benefits outweigh the cost, and they increase their schooling investment. If the return of each additional year of schooling increases by 50%, college enrollment would drop by 1.6 percentage points, and graduation rates would increase

[39] I thank an anonymous referee for pointing out that this result may be able to account for some of the black-white education gap due to different pools of potential husbands faced by black and white females.

[40] This exercise considers the wage elasticity of college enrollment. The wage elasticity of labor supply has been a topic of considerable interest in both labor and macro economics; it correlates with both marriage and schooling choices. In Van Der Klaauw (1996), marital status is a choice variable. Eckstein and Wolpin (1989) and Imai and Keane (2004) include post-school human capital accumulation in a life-cycle labor supply model.

by 2.4 percentage points. Enrollment decline is from Type 1's, and graduation increase is from Type 2's. On the other hand, a 10% increase in returns to college graduation (β_4) would have almost no effect on enrollment and would increase graduation rate by 0.4 percentage points. Even with a 50% increase β_4, college enrollment would have almost no change, and graduation would increase by 2.3 percentage points. These effects are due to the response of Type 2's.

In the last experiment, it is assumed that college provides no additional returns to earnings. The wage equation (3) becomes

$$\ln w_t = \beta_0 + \beta_1 \times 12 + \beta_2 H_t + \beta_3 H_t^2 + \beta_5 I(1 - h_{t-1}) + \epsilon_{wt}.$$

For all types, the opportunity cost of college enrollment stays the same, but the return for additional education goes to zero. Therefore both enrollment and graduation rates would go down for all types. For Type 1's, enrollment would drop by 4.3 percentage points. For Type 2's, enrollment would drop slightly by 0.2 percentage points, but many of them lose the incentive to graduate; therefore, their graduation rate would drop by 11.5 percentage points. For Type 3's, graduation rate would drop slightly by 0.1 percentage points. Overall earnings return seems to have a larger effect on graduation rate.

7.3 How Much Does Heterogeneity Matter to College Decisions?

As shown in the estimated parameters, there is considerable variation in type-specific skill endowments and preferences. Based on simulations using the estimated model, skill types differ substantially in their education attainment. College attendance rates are 18.4%, 97.2%, and 99.7% for skill Type 1's, Type 2's, and Type 3's, respectively. None of skill Type 1's earn a 4-year college degree. For skill Type 2's, 67.7% of them graduate from college, while for skill Type 3's, an overwhelming 95.5% graduate. Type 1 is the high school type, Type 2 is the college type, and Type 3 is the graduate school type.[41] In the sample, around 50% of women belong to skill Type 1, 38% belong to skill Type 2, and the rest–12% belong to skill Type 3.

The model predicts a strong correlation between observed background variables and unobserved types. Changes in background variables will shift the distribution of unobserved skill types. For example, if a mother's schooling level is increased, her daughter is more likely to be a skill Type 2, which values school more and has higher earning return from college compared with a woman who is a skill Type 1. Therefore, the average college attainment

[41] Each skill type also consists of a different composition of marriage types. Different marriage types exhibit little behavioral differences, and, therefore, the discussions are focused on skill types.

Table 9: Impact of Earnings on Education Outcome by Skill Types

	All	Type 1	Type 2	Type 3
Baseline Model				
Mean HGC	14.3	12.2	15.5	19.6
College Enrollment Rate	58.0	18.4	97.2	99.7
College Graduation Rate	37.0	0	67.7	95.5
(1) 10% Increase in Return to One Year of Schooling (β_1's)				
Mean HGC	14.3	12.2	15.5	19.4
College Enrollment Rate	57.6	17.6	97.3	99.7
College Graduation Rate	37.3	0	68.5	95.4
(2) 50% Increase in Return to One Year of Schooling (β_1's)				
Mean HGC	14.2	12.2	15.6	18.5
College Enrollment Rate	56.4	15.0	97.4	99.8
College Graduation Rate	39.4	0	73.8	95.2
(3) 10% Increase in Return to College Graduation (β_4)				
Mean HGC	14.3	12.2	15.5	19.6
College Enrollment Rate	58.0	18.4	97.3	99.7
College Graduation Rate	37.4	0	68.7	95.5
(4) 50% Increase in Return to College Graduation (β_4)				
Mean HGC	14.3	12.2	15.6	19.4
College Enrollment Rate	58.0	18.4	97.3	99.7
College Graduation Rate	39.3	0	73.0	95.6
(5) No Earnings Return to College				
Mean HGC	14.3	12.1	15.4	19.6
College Enrollment Rate	55.8	14.1	97.0	99.7
College Graduation Rate	32.5	0	56.2	95.4

Table 10: Impact of Background and Heterogeneity on Education Outcome

	Baseline Model	Increase S^m by 1 Year	Increase S^f by 1 Year	Increase Y^0 by \$5000	Increase $AFQT$ by 10 percentile
% Skill Type 1	49.9	45.1	48.2	49.6	42.3
% Skill Type 2	38.3	42.4	39.4	38.6	45.7
% Skill Type 3	11.8	12.5	12.4	11.8	12.0
Mean HGC	14.3	14.5	14.4	14.3	14.6
Enrollment Rate	58.0	61.8	59.4	58.3	64.1
Graduation Rate	37.0	40.7	38.5	37.2	42.7

S^m: mother's schooling; S^f: father's schooling; Y^0: family income.

will increase. Table 10 presents the impact of changing background variables on the skill distribution and education outcome. Increasing mother's schooling by one year implies a 3.8 percentage points increase in college enrollment on average. Increasing father's schooling by one year has a similar effect, but the size is smaller. The elasticity of increasing family income on school outcome is very small. The effect of a $5000 increase in family income is almost negligible. $AFQT$ score is a strong predictor of education outcome. A 10 percentile upward shift of $AFQT$ score implies a 6.1 percentage points increase in enrollment and a 5.7 percentage points increase in graduation. Even though different modeling strategies and different samples are used, I reached a conclusion similar to that reached by Cameron and Heckman (2001): the short-run liquidity constraint as indicated by family income at college-going age is not as important as the long-run family background, including parental education and test score.

7.4 Counterfactual Experiments

In Table 11, I present evidence on the impact of two counterfactual experiments in the marriage market on educational attainment. These experiments assume that the impact of induced skill supply responses on equilibrium skill rental prices are negligible.[42]

Increase in b_3 With the widespread use of the Internet, online dating is now a popular service. The education profile of online dating service users shows that they are on average more educated than the general population (Hitsch, Hortaçsu and Ariely 2006). If one supposes that college women have more access to an online dating service, then b_3 is increased after the introduction of the Internet and online dating sites. I simulate the effect of an

[42] Two recent papers by Donghoon Lee (2005) and Heckman et al (1998) start developing solution and estimation methods that can account for the general equilibrium feedbacks. However, their results are very different.

Table 11: Counterfactual Experiments

	College Enrollment Rate	College Graduation Rate
Baseline Model	58.0	37.0
(1) Increase b_3 by 20%	65.8	36.2
(2) \$5000 marriage bonus	61.2	36.2

experiment that provides a 20% increase in b_3, from 0.677 to 0.812. College attendance rate would increase from 58.0% to 65.8%, but graduation rate would decrease slightly from 37.0% to 36.2%. The increase in b_3 would raise the return to college attendance so more women would attend college. At the same time, more marriage proposals would imply earlier marriage; therefore, more women might drop out of college.

Marriage Bonuses Promarriage policy is advocated because of the potential positive association between (healthy) marriage and a variety of child outcomes. Here, I analyze the impact of a promarriage policy on women's own education outcomes. Suppose the government provides a $5000 subsidy once a woman is married. In panel (2) of Table 11, the effect of this $5000 marriage bonus is presented. College enrollment would increase by 3.2 percentage points, and the graduation rate would drop from 37% to 36.2%. Overall, the effect of a promarriage policy on women's college attainment is mixed: even though the rising return in the marriage market would encourage people to attend college, the rising value of marriage would also induce them to marry earlier and become more likely to drop out of school.

8 Concluding Remarks

In this paper, I have formulated and empirically implemented a structural dynamic model of high school graduate women's sequential decisions on college attendance, work, and marriage. The model is estimated using longitudinal data that include information about school attendance, labor force participation, marital status, wages, and spousal characteristics. The estimates of the model are used to quantify the importance of alternative reasons for college attendance and graduation. In particular, the estimates of the model are used to assess the effect of the expectations of marriage on college choice because of the marriage offer rate, educational assortative mating, and potential husband's income.

The main results can be summarized as follows. First, marriage plays a significant role in a female's decision to attend college. When the benefits from marriage are ruled out in the estimated model and everything else is kept the same, the predicted college enrollment would drop by 7.5 percentage points, from 58.0% to 50.5%. The impact on college graduation is smaller: the predicted graduation rate would increase from 37% to 39%. In contrast, earning return has relatively small effects on college attendance but significant effects on college graduation. Overall, the observed and unobserved heterogeneity is the most important determinant of women's college decisions. Second, the estimated model from the early 1980s does well in predicting college enrollment behavior in the early 2000s. The prediction for the new sample is not only a validation of the model, but it also provides evidence of the stability of the structural model for policy analysis.

An important caveat to the measured impact of marriage on college decision is that the current study is based on a partial equilibrium analysis. As women make their college decisions based on the schooling distribution of men, men are making the same decisions. Therefore, both genders' schooling distributions are an equilibrium outcome. A complete analysis would require a general equilibrium model of the marriage market, which is left for future work.[43]

The U.S. labor market has experienced some striking changes over the past few decades. First of all, female college enrollment and graduation rates have been expanding constantly. At the same time, the labor force participation rate of married females has increased dramatically. These two trends are consistent with each other because as women become more educated, the returns from working are higher. However, for cohorts born since the mid 1950s and the early 1960s, women's college enrollment and graduation rates exceed those of men, but women's labor force participation rates are much lower than are men's, especially for married women. If the increase in earnings power were the only gain from investing in education and if there were no discrimination towards females, we would not expect the labor force participation rate of females to be much lower than that of males. The marriage market may be a promising direction to explore based on the results of this paper.

[43] To empirically implement such a model, we need to observe *both* spouses' sequential choices. In addition, in a general equilibrium model of the marriage market, we may extend our discussion on heterogeneity to both women and men.

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Appendix A: Data Construction

In the model, each period is a year. This characterization of the decision process implies that some of the data must be aggregated to match the model. Details of the data construction follow.

Timing: I follow each woman in the model after she graduates from high school. A year in the model is defined as a school year from September to August. Suppose a woman receives her high school diploma in June 1985; the first year corresponds to calendar month September 1985 to August 1986.

Schooling: In order to construct the annual school attendance, I first derive monthly attendance on the basis of a question concerning whether the women are enrolled in regular school in each month of the previous year. This question starts in 1981. I thus have the women's monthly schooling status from January 1980. I treat a woman as an attendee if she reports having attended school for at least 6 months during the school year[44]. Questions about the month and year in which respondents receive a high school diploma are used to determine the graduation date. This date is combined with the respondent's date of birth to compute her age at graduation.

Employment and wage: NLSY79 work history records weekly hours worked for each week since the beginning of 1978. Annual hours worked is based on accumulating weekly hours worked over the school year. A woman in the model is defined as employed if her working hours are reported during at least 26 weeks of the year, and annual hours worked are at least 1000 hours.

The employment history information is employer-based. All references to a "job" should be understood as references to an employer. The variable "hourly rate of pay job #1-5" in the work history file provides the hourly wage rate for each job. The associated wage on multiple jobs held is the average, and data are constructed such that maximum number of jobs held in a year is five. I use coded real hourly wage in 2000 dollars. Nominal wage data are deflated by CPI from BLS CPI-U. The hourly wages are top-coded at $300 and bottom-coded at $1.

Marital status and fertility: Month/year in which the first, the second, and the third marriage began and month/year in which the first and the second marriage ended are recorded in NLSY79. I aggregate monthly marital status into annual status according to the following criteria: an individual is defined as married in a year if she is married for at least 6 months in the year. This definition of marriage does not include those who cohabit. Detailed cohabitation information is not available in the NLSY79 until the 1990 survey, and the decision

[44] Measurement error on choices is not considered.

to cohabit is quite different from the decision to marry (see Brien et al 1999). Cohabitation is not treated as a separate choice to limit the state space. Based on a question about the birth date of the first child born to NLSY79 respondents, the fertility history on the first child can be constructed. For simplicity, I follow the birth of the first child only and ignore child mortality.

Spouses' characteristics: NLSY ask every year how much a respondent's spouse receives from "wages, salary, commissions or tips from all jobs before deductions for taxes or anything else." I use this question to construct husbands' annual earnings, which are converted to real income in 2000 dollars. NLSY household roster provides each family member's highest grade completed and their relationship to the youth respondent. I first obtain the spouse's household number, then link it to corresponding family member characteristics such as age and highest grade completed.

Background: Highest grade completed of a woman's mother and father, number of siblings, and whether the woman came from a broken family (i.e., one or both biological parents were absent) are measured at age 14. Family income measures parental income for dependent respondents. A dependent is defined by the NLSY as a person living at home or not at home but living in a dorm or military barrack. A 2-year average is constructed for family income at ages 15 and 16, if available. Family income at ages 14 and 17 is used if the data are missing at age 15 or 16. Family income is measured in 2000 dollars.

Three surveys, conducted independently of the regular NLSY79 interviews, collected aptitude and intelligence score information: (1) The Armed Services Vocational Aptitude Battery ($ASVAB$), a special survey administered in 1980 to NLSY79 respondents (94% of the 1979 sample participated); (2) the 1980 survey of high schools, which collected scores from various aptitude/intelligence tests and a variety of college entrance exams such as the Preliminary Scholastic Aptitude Test ($PSAT$), the Scholastic Aptitude Test (SAT), and the American College Test (ACT); and (3) the 1980-83 collection of high school transcript information. The $ASVAB$ consists of a battery of 10 tests that measure knowledge and skill in 10 different areas. The Armed Forces Qualifications Test score ($AFQT$) is a composite score derived from four sections of the battery (namely, arithmetic reasoning, word knowledge, paragraph comprehension, and math knowledge) and is widely used as a cognitive ability indicator. $AFQT89$ percentile scores are used in the estimation.

For NLSY97, the $AFQT$ score is not available. However, the $ASVAB$ math and verbal percentile score generated by NLS is an age-adjusted, weighted average percentile score of four batteries from $ASVAB$: Mathematical Knowledge (MK), Arithmetic Reasoning (AR), Word Knowledge (WK), and Paragraph Comprehension (PC). The formula is essentially the same as for AFQT scores, and I treat them as comparable variables.

College entrance examination scores may be important for college applications. They are not included in the analysis since the number of respondents for whom these scores are available is low. I consider three major college entrance exams, namely $PSAT$, SAT, and ACT, within my sample: 93 individuals report SAT scores, 109 report $PSAT$ scores, and 102 report ACT scores. Overall, only 40% of the sample has at least one usable test score. When evaluating applications, schools use an SAT type of achievement score as a signal for individual ability. I assume that SAT scores or high school grades are of second order importance conditional on ability.

Appendix B: Inputs of the Model

Table C: Logit Estimates of the Arrival Probability of the First Child

Coefficient	Estimates (Std. Err.)
c_0 : Constant	-12.385 (3.460)
c_1 : Education	-0.343 (0.026)
c_2 : Last period's marital status	1.461 (0.126)
c_3 : Age	1.041 (0.291)
c_4 : Age^2	-0.018 (0.006)
c_5 : Marriage duration	0.310 (0.031)

Appendix C: Parameter Estimates

	Parameter	Estimate	Standard Error
Women's Post-School Wage Function			
Years of schooling skill Type 1	β_1^1	0.050	(0.008)
Years of schooling skill Type 2	β_1^2	0.060	(0.005)
Years of schooling skill Type 3	β_1^3	0.062	(0.003)
Years of experience	β_2	0.101	(0.006)
Experience squared	β_3	-0.001	(0.0007)
College graduation dummy	β_4	0.296	(0.011)
Re-entry into labor market	β_5	-0.088	(0.008)
Constant skill Type 1	β_0^1	1.132	(0.102)
Constant skill Type 2	β_0^2	1.278	(0.077)
Constant skill Type 3	β_0^3	1.193	(0.048)
True error standard deviation	σ_w	0.366	(0.002)
Women's Wage Function in College			
Constant skill Type 1	β_{0c}^1	2.656	(0.007)
Constant skill Type 2	β_{0c}^2	1.929	(0.004)
Constant skill Type 3	β_{0c}^3	2.214	(0.002)
True error standard deviation	σ_{wc}	0.114	(0.0002)
Measurement error standard deviation	σ_u	0.165	(0.001)
Husband's Earnings Function			
Years of schooling	ρ_1	0.043	(0.004)
Years of experience	ρ_2	0.058	(0.022)
Experience squared	ρ_3	-0.001	(0.002)
Constant	ρ_0	9.378	(0.072)
True error standard deviation	σ_H	0.550	(0.002)
Measurement error standard deviation	σ_{u_y}	0.158	(0.003)
Job Offer Rates			
High school, not working last year	$p_{E_{hg}}^0$	0.892	(0.010)
Some college, not working last year	$p_{E_{sc}}^0$	0.878	(0.012)
College graduate, not working last year	$p_{E_{cg}}^0$	0.707	(0.011)
High school, working last year	$p_{E_{hg}}^1$	9.996e-1	(0.275)
Some college, working last year	$p_{E_{sc}}^1$	9.999e-1	(0.270)
College graduate, working last year	$p_{E_{cg}}^1$	1.000	(0.253)

Appendix C: Parameter Estimates (continued)

	Parameter	Estimate	Standard Error
Value of Marriage			
Constant marriage Type 1	a_0^1	-8272	(2.368e+4)
Constant marriage Type 2	a_0^2	-1111	(2.718e+4)
Constant marriage Type 3	a_0^3	8.065e+4	(2.492e+4)
Education difference marriage Type 1	a_1^1	-8084	(318.7)
Education difference marriage Type 2	a_1^2	-4908	(767.7)
Education difference marriage Type 3	a_1^3	-3305	(127.0)
Age	a_2	1867	(929.2)
Children	a_3	1.466e+4	(5622)
Marriage duration	a_4	7949	(1224)
Interaction between work and children	a_5	-765.4	(3220)
Marriage Offer Rates			
Constant marriage Type 1	b_0^1	-8.103	(0.700)
Constant marriage Type 2	b_0^2	-13.65	(1.009)
Constant marriage Type 3	b_0^3	-9.000	(0.670)
Age	b_1	0.286	(0.058)
Age squared	b_2	-0.308e-3	(0.001)
College attendance dummy	b_3	0.677	(0.028)
Exogenous divorce shock	η	0.013	(0.002)
Shocks on Choices			
Not-attend, not-work, single	σ_1	3.805e+4	(576.8)
Attend, not-work, single	σ_2	1.302e+4	(161.4)
Not-attend, work, single	σ_3	1.122e+4	(140.2)
Attend, work, single	σ_4	1.298e+4	(136.7)
Not-attend, not-work, married	σ_5	4.129e+4	(2614)
Attend, not-work, married	σ_6	1.768e+5	(7445)
Not-attend, work, married	σ_7	7.642e+4	(4251)
Attend, work, married	σ_8	2.749e+5	(1.063e+4)
End Condition			
Years of schooling	δ_1	2.609e+4	(7125)
Years of experience	δ_2	3.932e+4	(3270)
Experience squared	δ_3	-26.46	(78.57)
Marriage duration	δ_4	5641	(4452)

Appendix C: Parameter Estimates (continued)

	Parameter	Estimate	Standard Error
Marginal Utility of Consumption			
Not-attend, not-work, single	α_1	1.216	(0.027)
Deviation if attend college	α_2	-0.029	(0.015)
Deviation if work	α_3	-0.016	(0.014)
Deviation if married	α_4	-0.004	(0.046)
Consumption Value of College			
Not-work, single, skill Type 1	v_1^1	-8.952e+4	(6918)
Not-work, single, skill Type 2	v_1^2	4.150e+4	(6781)
Not-work, single, skill Type 3	v_1^3	6.255e+4	(7328)
Work, single, skill Type 1	v_2^1	-1.229e+5	(6217)
Work, single, skill Type 2	v_2^2	2.562e+4	(5830)
Work, single, skill Type 3	v_2^3	1.290e+5	(5969)
Not-work, married, skill Type 1	v_3^1	-5.466e+5	(8.949e+4)
Not-work, married, skill Type 2	v_3^2	-3.055e+5	(1.480e+4)
Not-work, married, skill Type 3	v_3^3	-2.537e+4	(8950)
Work, married, skill Type 1	v_4^1	-7.047e+5	(2.795e+4)
Work, married, skill Type 2	v_4^2	-7.049e+5	(1.686e+5)
Work, married, skill Type 3	v_4^3	-2.383e+4	(1.087e+4)
Value of Non-employment			
With children, skill Type 1	v_5^1	3490	(2875)
With children, skill Type 2	v_5^2	9956	(3269)
With children, skill Type 3	v_5^3	8116	(6876)
Without children, skill Type 1	v_6^1	1.533e+4	(2467)
Without children, skill Type 2	v_6^2	3.757e+4	(2559)
Without children, skill Type 3	v_6^3	9718	(6285)
Budget Constraint Parameters			
Cost of children	cc	6.589e+4	(4026)
Cost of graduate school (additional)	cg	4.200e+4	(878.8)
Local college effect	γ_1	-2123	(820.7)
Fraction of husband's income available when working	θ_0	0.145	(0.371)
Additional marriage transfer if mutual-content divorce	θ_1	0.020	(0.070)
Divorce transfer when not working	τ_0	0.184	(0.265)
Additional divorce transfer if mutual-content divorce	τ_1	0.027	(0.400)
Additional divorce transfer when working	τ_2	-0.110	(0.184)

Appendix C: Parameter Estimates (continued)

	Parameter	Estimate	Standard Error
Probability of Being Skill Type 2			
Constant	λ_0^2	-6.729	(6.913)
Mother's schooling	λ_1^2	0.411	(0.094)
Father's schooling	λ_2^2	0.127	(0.063)
Number of siblings	λ_3^2	-0.829	(0.096)
Live with both parents at age 14	λ_4^2	1.185	(0.468)
Net family income	λ_5^2	0.067	(0.055)
AFQT score	λ_6^2	0.071	(0.007)
Age at high school graduation	λ_7^2	-0.197	(0.368)
Probability of Being Skill Type 3			
Constant	λ_0^3	-7.150	(6.223)
Mother's schooling	λ_1^3	0.241	(0.099)
Father's schooling	λ_2^3	0.113	(0.061)
Number of siblings	λ_3^3	-0.138	(0.091)
Live with both parents at age 14	λ_4^3	-0.334	(0.471)
Net family income	λ_5^3	0.029	(0.057)
AFQT score	λ_6^3	0.032	(0.008)
Age at high school graduation	λ_7^3	0.022	(0.338)
Joint Distribution of Skill and Marriage Types			
Probability of skill Type 1 to be marriage Type 1	ω_1^1	0.924	(0.326)
Probability of skill Type 1 to be marriage Type 2	ω_1^2	0.074	(0.625)
Probability of skill Type 2 to be marriage Type 1	ω_2^1	9.997e-1	(0.446)
Probability of skill Type 2 to be marriage Type 2	ω_2^2	1.75e-4	(1.163)
Probability of skill Type 3 to be marriage Type 1	ω_3^1	0.672	(0.381)
Probability of skill Type 3 to be marriage Type 2	ω_3^2	0.129	(0.828)

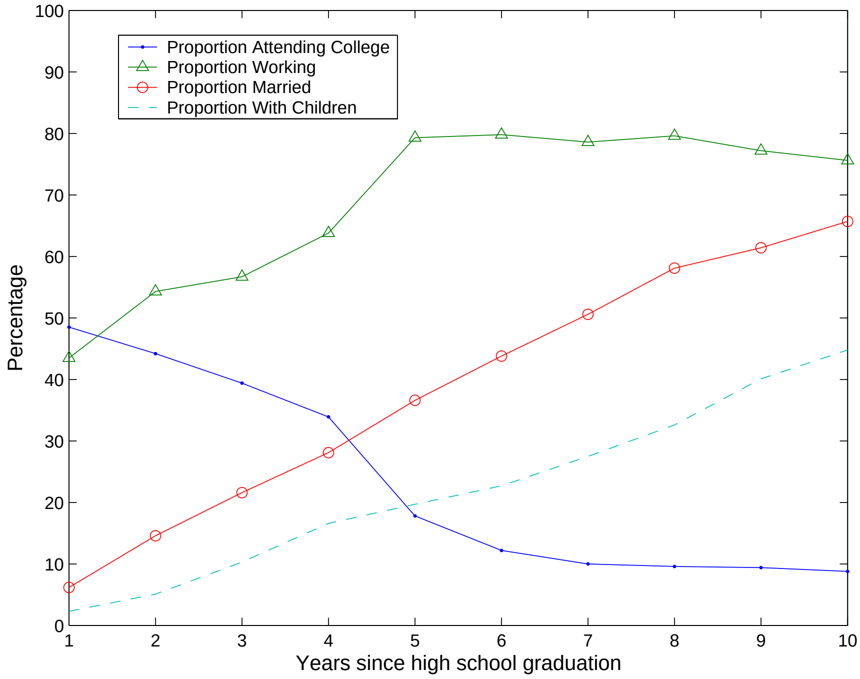

Figure 1: Proportions Attending College, Working, Married, and Having Children

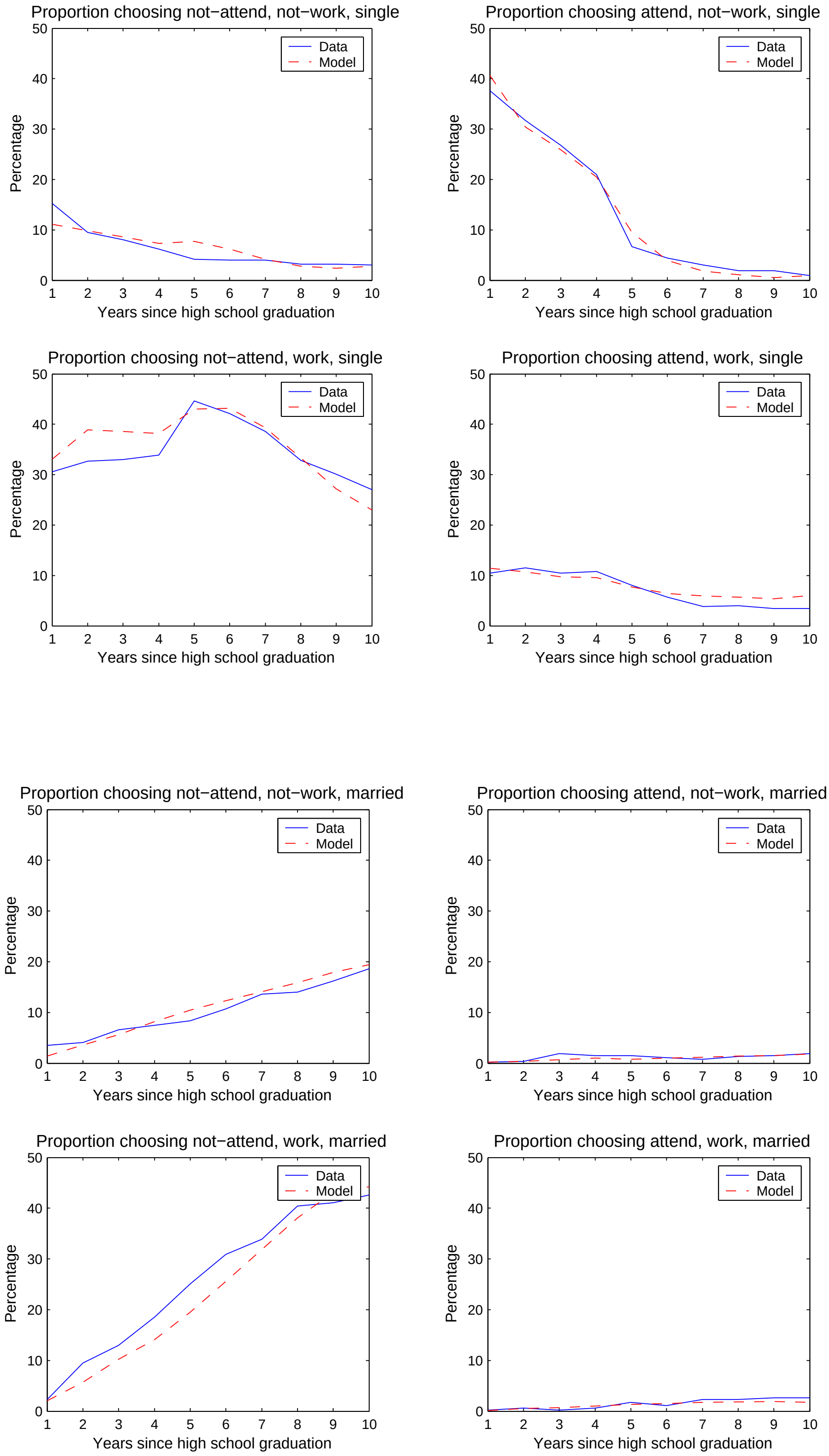

Figure 2: Fit of Choice Proportions

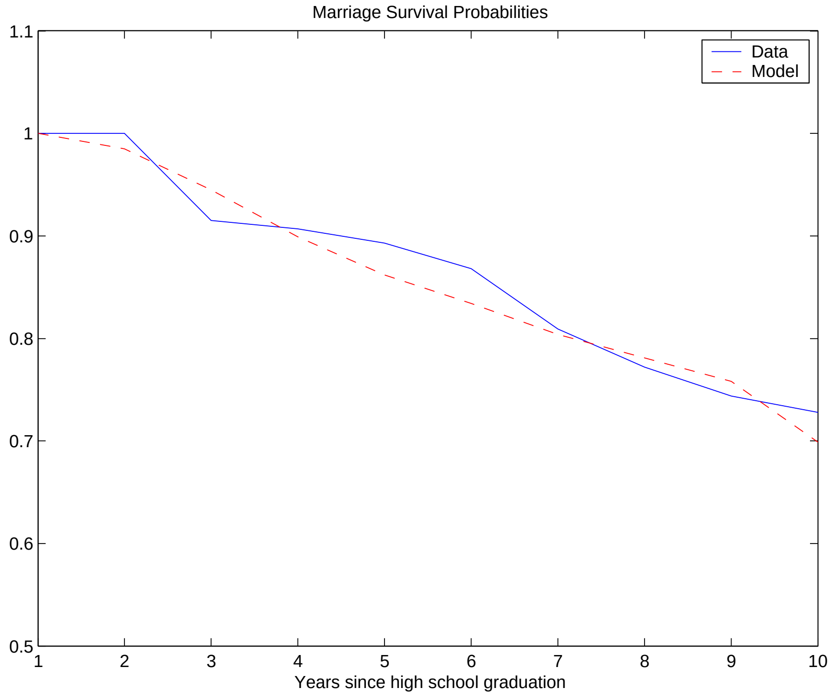

Figure 3: Fit of Marriage Survival Rates

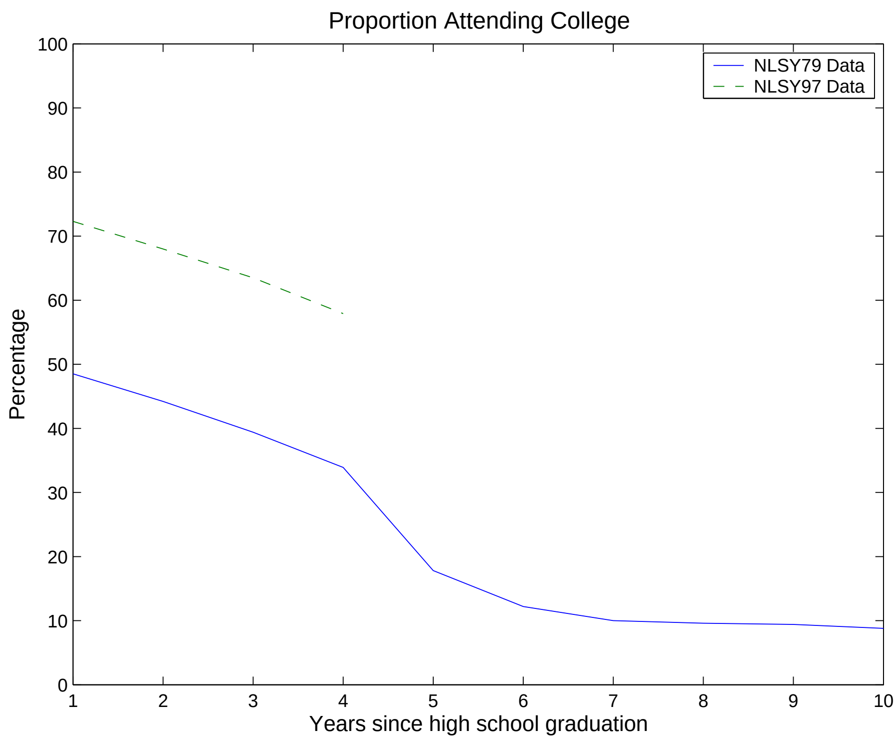

Figure 4: College Enrollment: NLSY79 and NLSY97 Samples

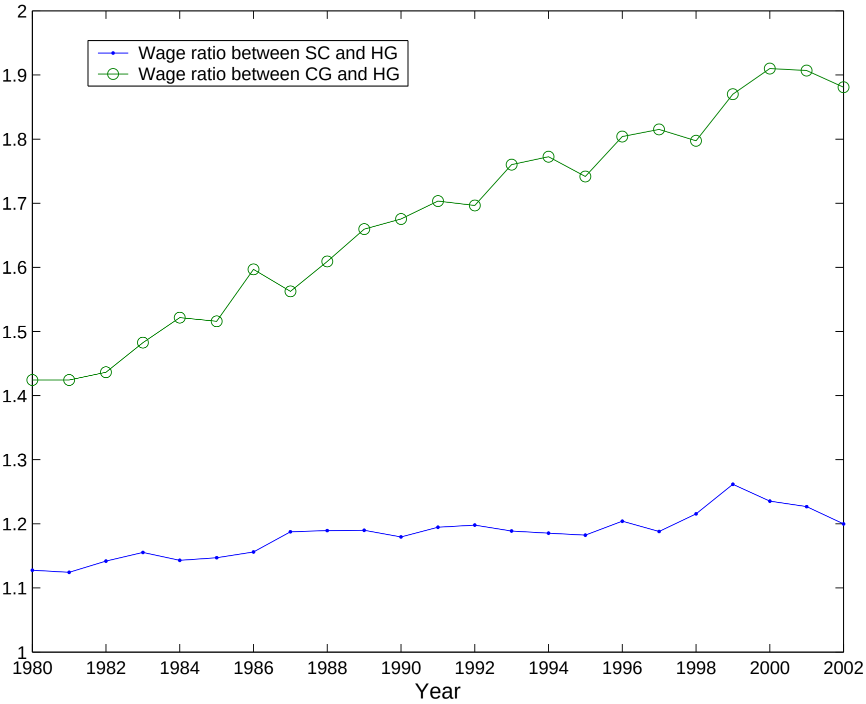

Figure 5: Relative Wages of White Females from CPS 1980-2002

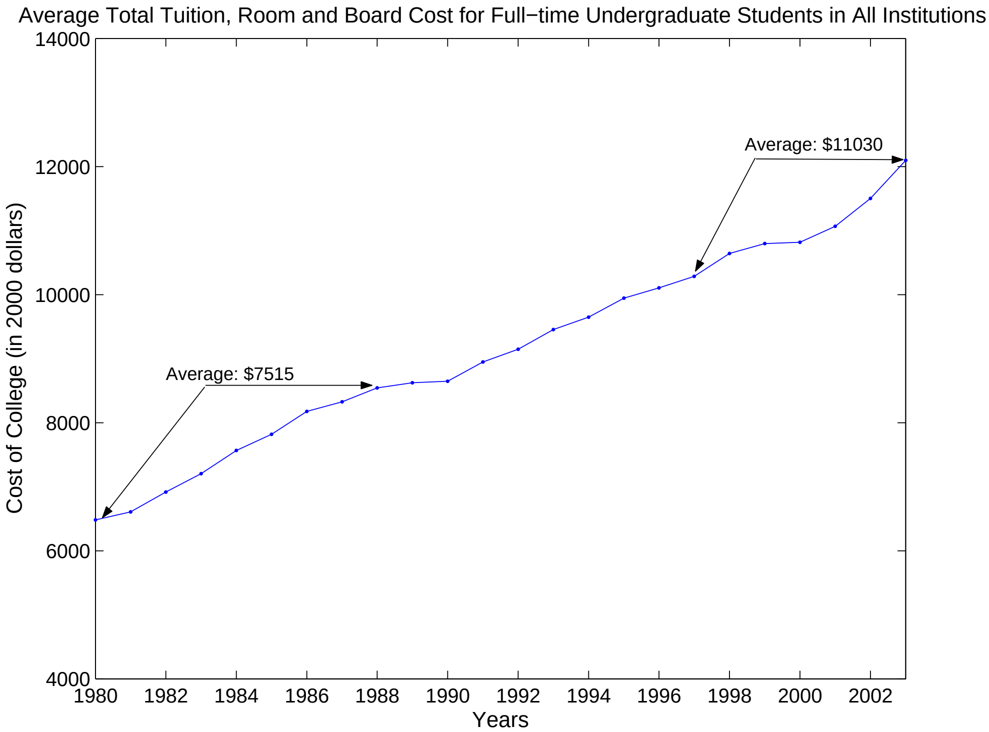

Figure 6: Changes in Direct Cost of College

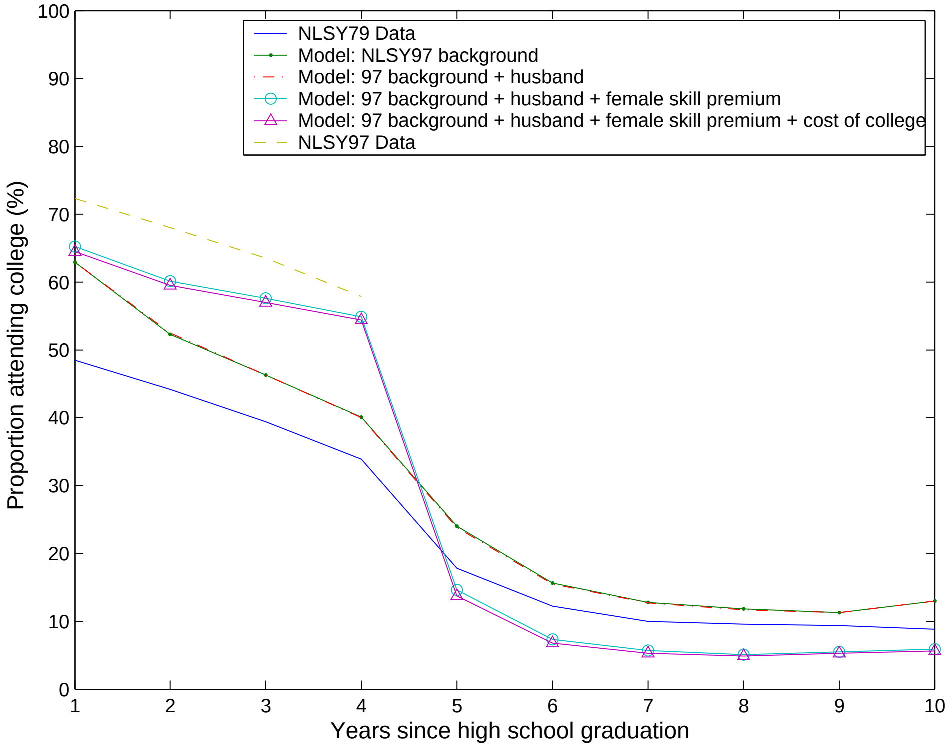

Figure 7: Out-of-Sample Prediction: College Attendance Profile for NLSY97 Sample