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

(Job Market Paper)

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Abstract

This paper investigates the sequential college attendance decision of high school females and quantifies the impact of marriage on women's college choice. A dynamic choice model of school attendance, labor supply, and marriage is formulated and structurally estimated using panel data from the National Longitudinal Survey of Youth 1979 (NLSY79). Results show that when I zero out the benefits from marriage in the estimated model, the predicted college graduation rate drops by 6 percentage points, from 38% to 32%. Based on the estimated model, changes in family income, parental education, and cognitive ability predict an increase in enrollment of about 8 percentage points between the early 1980's to the early 2000's. Improvements in potential husbands' schooling predict an additional 4 percentage points increase. The dramatic increase in female's college premium accounts for only a 3 percentage points increase in enrollment, yet it accounts for a 10 percentage points increase in college graduation.

JEL classification: J12, J22, I21

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1 Introduction

The primary motivation for going to college considered in the existing empirical literature is the increase in earnings power that college education provides (Willis and Rosen 1979, Keane and Wolpin 2001). The literature has ignored another potentially important benefit of college: college improves marriage opportunities by providing a social venue to meet potential spouses. Furthermore, a college-educated individual is substantially more likely to have a college-educated spouse. Thus, the individual enjoys educational balance in the household and benefits from the earnings power of the spouse. 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 married women.[1]

This paper examines the choice of women on whether to attend and complete college, taking into account not only the labor market effects but also the marriage market effects. In addition, the effects of direct and opportunity costs of college as well as the effects of individual ability and family background are jointly considered.[2] To empirically disentangle all these effects, a dynamic choice model is formulated and estimated in which women decide whether to enroll and how long to stay in college, whether and when to work, when and to whom to marry. The novelty of this paper is in providing a quantitative assessment as to what extent women's college decision is determined by expectations of future marriage.

In the model, the college decision and marriage is linked in the following way. First, it is assumed that meeting technology is such that women who go to college get more marriage offers. For a college woman, any given offer is not necessarily more likely to be from a college man. But since she gets more offers, over any time interval she is more likely to have more offers of college educated men. Second, it is assumed that there exists a disutility from the educational imbalance in the household. When one spouse has a college degree and the other does not, it detracts from

[1] The "Marriage effect" on schooling choice, in general, seems to be larger for young women. When a sample of NLSY79 youths were asked the reason why they left school without a degree, approximately 25% of women chose the response categories "getting married, pregnancy, or home responsibilities" as the main reason as compared to only 5% of their male counterparts who chose the same categories.

[2] Cameron and Heckman (1998, 2001) emphasize effects of family background on college attendance; Cameron and Taber (2004) test for the importance of the credit market based on different impacts of direct schooling costs and opportunity costs if borrowing constraints were operative; Keane and Wolpin (2001) and Eckstein and Wolpin (1999) allow for joint decisions on schooling and labor supply.

marital bliss. Thus, highly educated women marry highly educated men. This phenomenon is known as educational assortative mating (Becker 1973) and is well documented.[3]

There are a number of difficulties with assessing the impact of marriage on college choice. The first difficulty is due to the dynamic simultaneity of college attendance, labor force participation, and marriage decisions. The dynamics of the decision process are due to the dependence of current choices on previous choices. For instance, whether or not one will complete the senior year of college depends crucially on if the individual finishes junior year. An example of simultaneous decisions is when a good job offer or marriage proposal comes along, it is likely to induce a woman to drop out of college. Without understanding the dynamic process by which individuals determine college enrollment and graduation, it is impossible to quantify the effects of alternative determinants, including expectations on future earnings and marriage.

The second difficulty is due to the endogenous self-selection of college, employment, and marriage decisions. The earnings gain from attending and completing college, known as the college premium, increases in individual skills or abilities, and those who have highest skills are the most likely to attend college. A statistical analysis could then attribute the effect of skills on college attendance to college premium. Individual skills are also likely to be correlated with preference for marriage. If it is the case that women who value marriage more have low skills systematically and are therefore less likely to attend college, then the estimated effect of marriage on college attendance would be downwardly biased. Self-selection is controlled by allowing for unobserved types in skills and in marriage,[4] and letting skills be correlated with background characteristics such as family income, parental education, and individual cognitive ability. Hence, the structural model implements a correction for selection biases which is based on an explicit dynamic decision process.

[3] For married women with college degrees, 60 percent of their husbands are also college graduates. On the other hand only 6 percent of married women with high school degrees marry to college men, according to a sample of high school young women from NLSY79. Similar pattern holds for different samples from census data. See Mare (1991) for trends in educational assortative mating from the 1930s to the 1980s. Pencavel (1998) studies the interaction between educational assortative mating and married couple's labor supply.

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

The model is estimated by using a sample of high school white females from the National Longitudinal Survey of Youth 1979 (NLSY79). NLSY79 is a panel which provides dates for the beginning and ending of college, employment, and marriage. It also provides detailed information on an individual's background, wages if employed, and spouse's years of schooling and income if married. To empirically implement the model, it is first solved numerically. Then choice proportions, transitions, and wages over 10 years as well as the joint schooling distribution of married spouses are simulated and the method of moments is used to estimate the parameters. Empirical identification is secured from the conditional transitions from all of the chosen states to new states for 10 years.[5] For example, a college graduate woman's transition from employment to nonemployment following marriage would rationalize the marriage incentive for college attendance besides the earning incentive. Simulations using the estimated parameters show that the structural model fits the dynamics of college enrollment, dropout, and graduation, the transition from school to work, and the transition from school to marriage, etc.

To assess the importance of marriage on college attendance, a counterfactual economy is considered in which benefits from marriage are ruled out. Therefore, homogeneity in educational background between husband and wife does not increase the utility from marriage and college attendance does not increase the marriage offer rate. The equilibrium choices are numerically simulated in such a hypothetical world and a comparison is made of predicted college enrollment and graduation with the actual economy. In the real economy, the college enrollment rate is 61% for high school females and graduation rate is 38%. With no benefits from marriage, the college enrollment rate would drop to 58% and the graduation rate would drop to 32%.

The estimation of the model is based on a NLSY79 sample who were graduating from high school in the early 1980's. Between the early 1980's and the early 2000's, college enrollment rates increased from 61% to 80%.[6] I use the model which is estimated from the NLSY79 sample to account for this increase and have the following findings. Improved background on family income, parental education, and individual cognitive ability of a sample from the National Longitudinal

[5] Each year individuals choose from eight alternatives, so 64 transitions are observed from one year to another over a period of ten years.

[6] These are enrollment rates of white females with 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 complete a GED (General Equivalency Diploma). It is well known that GED is not equivalent to high school diploma (Cameron and Heckman 1993).

Survey of Youth 1997 (NLSY97) would predict enrollment to increase by 8 percentage points. Changes in potential husbands' schooling imply an additional 4 percentage points increase in enrollment rate. The dramatic increase in female's college premium would increase college enrollment by 3 percentage points, yet it can account for a 10 percentage points increase in college graduation. On the other hand, the increase in college tuition would predict only 1 percentage point drop in enrollment. Overall the estimated model does well in predicting college enrollment behavior in the early 2000's, which is consistent with the stability of the structural model.[7]

This paper is organized as follows. In Section II, a dynamic discrete choice model is constructed which is designed to capture the interaction among women's schooling, labor supply, and marital choices. Section III describes the NLSY data from which the model is estimated and presents descriptive statistics. Section IV discusses the estimation method and identification issues. Estimation results are given in Section V. Section VI provides counterfactual simulations. Section VII presents the conclusion.

2 The Model

2.1 The Basic Structure

Choices about college attendance, employment, and marriage are made within social institutions. I first specify these social environment including the college, the labor market, and the marriage market, and describe how each choice is made.

The College and the Attendance Choice Consider a young woman who finishes high school and decides whether to enroll in college. She may attend college right after graduation or she may go later. If she enrolls, she must pay an annual cost of tuition and room and board $c_S = cs$ to accumulate one year of college. In the next year, she makes a decision on whether to continue studying. This decision is conditional on her previous schooling choices. When the woman is in college, she has the option to work, and/or get married at the same time. But employment and marriage in college may affect negatively the value of schooling due to time constraint. She may

[7] 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 of the current policy regime. The out of sample prediction indicates that the structural model is likely stable across cohorts.

drop out of college altogether when she takes a job and/or marries a man. I assume that college degree is completed in four years from grade 13 to grade 16. Consider graduate school is going to grade 17, when the woman attends grade 17 or beyond, she pays an extra cost cg. Thus the cost of graduate school is c_S = cs + cg for S > 16.

The Labor Market and the Employment Choice The woman can work independent of her attendance and marital status. She receives job offers at rate $p_{E_t}^{h_{t-1}}$, which depends on her schooling level $E_t \in \{hg, sc, cg\}$ and previous labor market attachment $h_{t-1} \in \{0, 1\}$. Wage offer varies if she works in college or she works during post-college time. Hourly wage offer w_t for employment in college is assumed to be log normal such that $\ln w_t = \beta_{0c} + \epsilon_{wct}$, where $\epsilon_{wct} \sim N(0, \sigma_{wc}^2)$ is an idiosyncratic shock. Hourly wage offer for post-college employment is assumed to depend on prior education and work experience as measured by cumulative years of schooling S_t, whether a college degree is received and cumulative years of experience H_t and on an idiosyncratic shock. The wage function thus follows Mincer's (1974) formulation:

$$\ln w_t = \beta_0 + \beta_1 S_t + \beta_2 H_t + \beta_3 H_t^2 + \beta_4 I(S_t \geq 16) + \epsilon_{wt},$$

where $I(\cdot)$ is an indicator function which equals one if the individual has a college degree and $\epsilon_{wt} \sim N(0, \sigma_w^2)$. The constant term β_0 can be interpreted as a composite of skill rental price and the level of individual (nonschool) premarket skill. β_1 and β_2 measure the effect of school attainment and work experience on the wage. β_4 is the wage premium due to college graduation. I allow for measurement error in observed wages, 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: $u \sim N\left(0, \sigma_u^2\right)$.

The Marriage Market and the Marriage Choice Every year the woman receives a marriage proposal with some probability depending on her age, schooling level, and previous marital status. The marriage offer arrival rate when she is single has the following logistic form:

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

A woman with college education should fare better on the marriage market. I model this in a simple way. A college educated woman gets a higher rate of offers so we expect b_3 to be positive. Marriage offers are not homogenous. They are made by men with different years of schooling S_t^H. The schooling distribution of potential husbands is assumed to be exogenous and discrete. This distribution remains the same independent of woman's characteristics. But my specification implies that over any given time interval, a college woman will get more offers of any kind, including offers from college men. Let the proportion of type g potential husband be μ_g, and the number of husband's types be G, so $\sum_{g=1}^{G} \mu_g = 1$. Then the probability of receiving a marriage proposal from a type g man is $\mu_g \Pr_t$. With probability $1 - \Pr_t$, no offer is received. If the woman is married, she always has the option to stay married. If she chooses to have a divorce, she will receive a random offer as a single woman next period.

Marriage decision is based on the woman's evaluation of marriage.[8] I use a function M to specify all emotional, biological and economic values for her related to marriage. This marriage value M at time t is assumed to depend on her own (S_t) and her husband's schooling $\left(S_t^H\right)$, on her age (age_t), on whether they have children (f_t), and on marriage duration ($mdur_t$).

$$M_t = a_0 + a_1 \Delta S_t^2 + a_2 age_t + a_3 f_t + a_4 mdur_t,$$

where $\Delta S_t = S_t - S_t^H$ is the difference between spouses' years of schooling, f_t equals one if at least one child is in the household and zero otherwise. a_0 can be interpreted as permanent preference for marriage. A negative a_1 is consistent with positive assortative mating in education.[9] That is, educational imbalance in the household causes disutility, which could be due to disagreement on the consumption of public goods, etc. a_2 reflects the woman's varying preference for a stable relationship over time. a_3 and a_4 measure the impact of children and previous marriage choices. Children are likely to increase marriage utility. The dependence of marriage value on the duration of marriage reflects a possible increase in the bond between spouses. Value of marriage varies as

[8] For simplicity, I do not model marriage as a match outcome. Strategic behavior within the household is also not considered explicitly.

[9] I use a simple way to model educational assortative mating. In Becker (1973), mating is positive assortative if schooling levels are complements in production. Shimer and Smith (2000) derives 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.

the marriage evolves. a new valuation of marriage could lead to a divorce.[10]

If the woman accepts a marriage offer from a man, part of the man's income is available for her consumption. The net transfer of income by the man to the woman depends on her work decision. We would expect the transfer to be smaller when the woman works. The model focuses primarily on female's decision process and assumes that married men always work full time in the labor market.[11] The earnings of (potential) husband is specified as

$$\ln y_t^H = \rho_0 + \rho_1 S_t^H + \rho_2 EX_t^H + \rho_3 EX_t^{H2} + \epsilon_{y^H t},$$

where S_t^H is his years of schooling, EX_t^H is potential experience,[12] and ϵ_{y^H} is the productivity shock. I also allow for measurement error in observed husband's income. When the woman is single and receives an offer from a man, she observes only his schooling thus mean incomes, and she knows the distribution of ϵ_{y^H} and uses it to predict his future income. While if she is married, she observes the husband's true income, that is, she knows both S_t^H and $\epsilon_{y^H t}$.

Choice Set At the beginning of each school year if the woman has a job offer and a marriage proposal, she chooses whether to attend school, whether to work in the labor market and whether to get or stay married. The choice set for her thus consists of eight mutually exclusive and exhaustive alternatives. Let s_t, h_t, m_t be indicators for school attendance, employment, and marital status respectively, each alternative will be a triple $(s_t, h_t, m_t) \in J = \{(s_t, h_t, m_t) : s_t \in \{0,1\}, h_t \in \{0,1\}, m_t \in \{0,1\}\}$, i.e., not attend school, not work, and single $(0,0,0)$, or attend school, not work, and single $(1,0,0)$, or not attend school, work, and single $(0,1,0)$, or attend school, work, and single $(1,1,0)$, not attend school, not work, and married $(0,0,1)$, or attend school, not work, and married $(1,0,1)$, or not attend school, work, and married $(0,1,1)$, or attend school, work, and married $(1,1,1)$. If she receives no job offer then she chooses among only four alternatives: $\{(s_t, 0, m_t) : s_t \in \{0,1\}, m_t \in \{0,1\}\}$ and if she has no marriage offer, she also

[10] There are two general causes for divorce. First, search is costly and meeting occurs randomly. Second, match quality is uncertain. Dissolving a marriage may be costly. (Weiss 1997, Weiss and Willis 1997). This issue deserves separate study and I leave it for future research. Here I assume the direct divorce cost is zero, what a woman gives up is the value of marriage when she has a divorce.

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

[12] In the computation, I use married women's age as a proxy for husbands' age and potential experience. This reduces one dimension in the state space and it does not change the main results.

chooses only among four options: $\{(s_t, h_t, 0) : s_t \in \{0,1\}, h_t \in \{0,1\}\}$. If neither job or marriage offers are received, her choice set is reduced to two alternatives: $\{(s_t, 0, 0) : s_t \in \{0,1\}\}$.

The Arrival of Children In general, both the number and ages of children may be important in determining female's choices. However, I assume that the fertility effect can be adequately captured by a single indicator of the presence of any children f_t. The stochastic process that governs f_t over time is characterized by the specification of the exogenous probability of a first birth at t.[13] I specify this process as following logit form:

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

The annual rate for the first birth depends on the female's education, her marital status in the previous period, her age and the marriage duration. Note that the fertility rate is not necessarily zero for single women. A single mother is observed if this woman gives birth to a child before marriage or she is the custody parent after a divorce.

Preferences and Constraints The woman has preferences over choice variables, i.e. consumption c_t, school attendance s_t, labor force participation h_t, and marital status m_t, conditional on the state space Ω_t, which is specified later. The utility per period at time t is given by $U_t(c_t, s_t, h_t, m_t|\Omega_t)$.

Let U_t^{shm} be the utility associated with choice (s, h, m) at period t, which is known to the individual at time t but is random from the perspective of periods prior to t. U_t^{shm} is given by:

$$\begin{aligned} U_t^{shm} = \; & (\alpha_1 + \alpha_2 s_t + \alpha_3 h_t + \alpha_4 m_t) c_t \\ & + v_1 s_t (1 - h_t)(1 - m_t) + v_2 s_t h_t (1 - m_t) + v_3 s_t (1 - h_t) m_t + v_4 s_t h_t m_t \\ & + v_5 (1 - h_t) f_t + v_6 (1 - h_t)(1 - f_t) + M_t m_t + \varepsilon_t^{shm}. \end{aligned}$$

[13] In this model fertility is exogenous. It is clear that a more complete model should explicitly incorporate fertility decision as 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.

The utility function is assumed to be linear in consumption. The marginal utility of consumption depends on current school, work and marital status of the individual. v_1 to v_4 evaluates the net utility of attending school given employment status h_t and marital status m_t. The utility of school interacts with labor supply since more involvement in the market work may prevent individuals from engaging in school activities, representing the time constraint. It also depends on marital status if marriage requires leaving school or simply school utility is lower if married. The value of nonemployment is assumed to depend on children as represented by v_5 and v_6. M_t is the utility value of marriage as previously specified. Finally, ϵ_t^{shm}'s are alternative-specific random components representing random variations in the individual's preference for school and work, as well as changes in the utility derived from getting married or being married.

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

$$c_t + c_S \cdot s_t + cc \cdot f_t = y_t h_t + \psi(h_t) y_t^H m_t.$$

c_S is the direct cost of schooling, $c_S = cs$ for $12 < S \leq 16$ and $c_S = cs + cg$ for $S > 16$. cc is the total cost related to having children in the household. y_t denotes the annual earnings of the female. y_t^H is the husband's income and $\psi(h_t)$ represents the fraction of his income that is available for the woman's consumption, which depends on her employment status. This transfer may be interpreted as the woman's share of the accumulated common property. In this specification, there is no borrowing and saving decisions. The budget constraint is assumed to be satisfied period by period.[14]

Optimization Problem The objective of the female is to maximize the expected present discounted value of utility over a finite horizon from the first year after high school graduation to a known terminal time T, i.e.,

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

[14] The introduction of savings and borrowing decisions in a model like this is not straightforward, and will generally lead to a considerable expansion of the choice set and the state space. Keane and Wolpin (2001) used a model with borrowing and lending to study the effect of parental transfers on educational attainment.

where β > 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 female, that affect current utilities or the probability distribution of any of the future utilities. As the model is specified, the state variables include years of schooling, years of working experience, marriage duration, all previous choices, age, fertility, and the contemporaneous shocks, the $/_t$'s. The random shocks $/_t = \{/_t^1, \cdots, /_t^8, /_{wt}, /_{wct}, /_{y^H t}\}$ are jointly serially independent, noncorrelated and have a joint normal distribution $F(/_t)$. They are known to the female in period t, but unknown before t. 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 given current realization of the state space.

2.2 Heterogeneity

Initial Conditions and Heterogeneity The basic model I consider above corresponds to the decision problem of a representative female. However young women differ in many aspects at high school graduation. They may differ in family background as measured by parental schooling, number of siblings, family income etc. They may differ in cognitive background as measured by AFQT test scores. They may also have different high school grades and SAT scores. The abilities and preferences of individuals are likely to vary, too, in unobserved ways (like motivation, perseverance or ambition) that are both persistent and correlated with observed traits (like test scores). All these characteristics, both observed and unobserved, may affect youth's college decisions. For example, those with greater endowments of unobserved skills may be more likely to attend college and postpone marriage and workforce entry. They may also have better family background and higher test scores. To consistently estimate the parameters, the model takes into account both the unobserved heterogeneity and its correlation with observed background.[15]

Assume that there exist $k = 1, 2, \cdots, K$ different skill types (Heckman and Singer 1984).[16] The *ex ante* probability that a female i is of type k is denoted by P_i^k. To capture the correlation between a woman's unobservable type and her background, I allow P_i^k to depend on her observed

[15] There are different ways to introduce observed and unobserved heterogeneity into a schooling model. Cameron and Heckman (2001) uses background variables as explanatory variables in their econometric model. Eckstein and Wolpin (1999) treats heterogeneity as unobservable and finds that unobserved types are correlated with observed background variables. Keane and Wolpin (2001) includes the joint distribution of unobserved type and some observables in the likelihood function. Cameron and Taber (2004) adopts all of them in different model specifications.

[16] I choose $K = 3$ after sensitivity analysis.

initial traits at high school graduation, namely, mother's schooling S_i^m, father's schooling S_i^f, number of siblings N_i^{sib}, household structure at 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. For $k = 2, \cdots, K$,

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

and normalize P_i^1 as

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

Achievement scores like high school grades and SAT scores may affect college entrance indirectly by the correlation with ability types like other background variables. They may also affect college choice directly if college acceptance depends on the grades or SAT scores. Due to data limitation as explained in the next section, I leave the introduction of grades to a schooling model like this to future research.

Further Parameterization with Heterogeneity I allow women of different skill types to have distinct taste for school and for nonemployment, different skill rental price and returns to schooling. In my estimation, these parameters will be type specific. The type specific utility function for individual i of type k when choosing alternative (s, h, m) at time t becomes

$$\begin{aligned} U_{it}^{shm} &= (\alpha_1 + \alpha_2 s_{it} + \alpha_3 h_{it} + \alpha_4 m_{it})c_{it} \\ &\quad + v_1^k s_{it}(1-h_{it})(1-m_{it}) + v_2^k s_{it}h_{it}(1-m_{it}) + v_3^k s_{it}(1-h_{it})m_{it} + v_4^k s_{it}h_{it}m_{it} \\ &\quad + v_5^k(1-h_{it})f_{it} + v_6^k(1-h_{it})(1-f_{it}) + M_{it}m_{it} + \epsilon_{it}^{shm}. \end{aligned}$$

Women with different skills also have different wage offer distributions. For skill type k, the wage offer when working in college is given by $\ln w_{it} = \beta_{0c}^k + l_{iwct}$, and the wage offer when working after college is determined by

$$\ln w_{it} = \beta_0^k + \beta_1^k S_{it} + \beta_2 H_{it} + \beta_3 H_{it}^2 + \beta_4 I\,(S_{it} \geq 16) + l_{iwt}.$$

We expect high skill women have both higher skill rental price and higher returns to schooling.

Furthermore women may also differ in taste for marriage and marriageability in the marriage market. I assume that there exist $m = 1, 2, \cdots, M$ different marriage types. A woman of skill type k has probability π_k^m of being marriage type m, so $\sum_{m=1}^{M} \pi_k^m = 1$ for all k. The value of marriage is then type specific:

$$M_{it} = a_0^m + a_1^m \Delta S_{it}^2 + a_2 age_{it} + a_3 f_{it} + a_4 mdur_{it}.$$

Women with high a_0 are more family oriented. If a_1 is negative and large in absolute value, it indicates that this type of women care much about schooling balance with their husbands. Moreover the marriage offer probability is also type specific such that:

$$\Pr_{it} = \frac{\exp(b_0^m + b_1 age_{it} + b_2 age_{it}^2 + b_3 I\,(S_{it} > 12))}{1 + \exp(b_0^m + b_1 age_{it} + b_2 age_{it}^2 + b_3 I\,(S_{it} > 12))}.$$

2.3 Solution to the Decision Problem

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

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

The current utility at time t is defined as before, and the female maximizes the expected present value of her life time utility by the choice of $\{c_{it}, s_{it}, h_{it}, m_{it}\}$ for all $t = 1, 2, \cdots T_i$. Ω_{it} is the state space at t.

The value function can be written as the maximum over alternative-specific value functions

$V_{it}(\Omega_{it}) = \max_{(s_t,h_t,m_t)\in J}\{V_{it}^{shm}(\Omega_{it})\}$, which obeys the Bellman equation:

$$V_{it}^{shm}(\Omega_{it}) = U_{it}^{shm} + \beta E[V_{it+1}(\Omega_{it+1})|\Omega_{it},\ (s_t, h_t, m_t) \text{ is chosen at t}].$$

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. We can separate the state space into a nonstochastic part and a stochastic part. Let $\overline{\Omega_{it}}$ be the nonstochastic part of the state space, which includes types, years of schooling, years of experience, marriage duration, age, choices, fertility and husband's schooling in the previous period, that is, $\overline{\Omega_{it}} = [\text{type}_i, S_{it}, H_{it}, \text{mdur}_{it}, \text{age}_{it}, s_{it-1}, h_{it-1}, m_{it-1}, f_{it-1}, S_{it-1}^{H}]$. Some of these state variables evolve endogenously: $S_{it} = S_{it-1} + s_{it}$, $H_{it} = H_{it-1} + h_{it}$, $\text{mdur}_{it} = m_{it}[\text{mdur}_{it-1} + m_{it}]$. Some of them are assumed to evolve exogenously: individual type, age, fertility status. The stochastic part of the state space includes the vector of the random shocks $/_{it} = [/_{i1t}, \cdots, /_{i8t}, /_{iwct}, /_{iwt}, /_{iy_Ht}]$, as well as job offer, marriage offer, and fertility realizations.

The model does not have an analytical solution, but it can be solved backwards numerically. To simplify the model, I assume that the optimization problem is divided into two sub-periods, as in Eckstein and Wolpin (1999). During the first $T_i - 1$, for each individual i, the model is solved explicitly. At the terminal period T_i, the current utility is given by $U_{iT_i}^{shm}$, and the expected future utility is assumed to be a given linear function of Ω_{iT_i}.

$$V_{iT_i}^{shm}(\Omega_{iT_i}) = U_{iT_i}^{shm} + \beta\{V_{iT_i+1}(\Omega_{iT_i+1})|\Omega_{iT_i},\ (s_{T_i}, h_{T_i}, m_{T_i}) \text{ is chosen at } T_i\}.$$

The present value of individual i's utility at $T_i + 1$ has following linear functional form in the state variables, $V_{iT_i+1}(\Omega_{iT_i+1}) = \delta_1 S_{iT_i+1} + \delta_2 H_{iT_i+1} + \delta_3 H_{iT_i+1}^2 + \delta_4 I(m_{iT_i} = 1)$.

Using the end condition, and assuming a known distribution of $/_{it}$, the individual's optimization problem is solved recursively from the final period T_i. The numerical complexity arises because the value function requires high dimensional integrations for the computation of the "E max function" at each point of the state space. Following the procedure proposed in Keane and Wolpin (1994), I use Monte Carlo integrations to evaluate the integrals.

2.4 A Simple Example

I use a simple two-period model to illustrate how the marriage market, through the marriage offer rate, assortative mating and husband's income, affects women's college choice. In the model, high school women decide whether to attend college in the first period and whether to marry in the second period. The model does not distinguish between college attendance and graduation. It sheds some light on the importance of unobserved heterogeneity and the interplay between the marriage market and the college choice.

There is a continuum of individuals in the model. I normalize the size to one. Each individual i is a woman with a high school degree. Her ability is δ_i which is randomly drawn from some known, fixed distribution $\Phi(\cdot)$. Individuals in the model live for two periods. In the first period, all of them are single and they simply decide whether to attend and graduate from college. To acquire college education, they need to pay a fixed cost cs. In the second period, everyone has finished formal schooling and the only remaining choice is marital status. Schooling and labor supply are mutually exclusive. Individuals either attend school or work in each period. Labor earnings depend on both individual schooling S_i and ability δ_i and take the form of $\ln y(S_i, \delta_i) = \beta_0(\delta_i) + \beta_1 S_i$. Skill rental price β_0 depends on ability, $\beta_0'(\delta) > 0$, and β_1 measures the effect of education on earnings.

Let p be the marriage offer arrival rate in the second period. There exist measure one potential husbands in the economy with proportion μ being college graduates and proportion $1 - \mu$ being high school graduates. Each woman then has probability μp to receive an offer from a college man, $(1 - \mu)p$ to receive an offer from a high school man and $1 - p$ probability with no offer. College is assumed to be an active matching place such that marriage offer rate of college women p^1 is greater than that of high school women p^0. A marriage is formulated only if a woman receives and accepts an offer. A married woman benefits from her marriage in two ways: first, marriage provides utility denoted by M; second, a fraction ψ of her husband's income y^H is available for her consumption. Husband's income increases in his schooling S^H.

The preference of individual i is linear and of the form $U_{it} = c_{it} + M_{it} m_{it}$, where c_{it} is the consumption at t, m_{it} denotes marital status ($m_{i1} = 0$) and M_{it} is the net utility value of marriage. Let s_{it} denote the schooling choice for individual i. s_{it} equals one if she attends school and zero otherwise. Each individual i solves the following problem:

$$\begin{aligned} & \mathrm{Max}_{\{s_{i1},m_{i2}\}} E\{c_{i1} + \beta[c_{i2} + M_{i2} m_{i2}]\} \\ \text{s.t. } c_{i1} + cs \cdot s_{i1} & \leq (1 - s_{i1}) y(1, \delta_i) \\ c_{i2} & \leq y(1 + s_{i1}, \delta_i) + \psi y^H \left(S_{i2}^H\right) m_{i2}, \end{aligned}$$

where the expectation is taken over the marriage offer probabilities.

The value of marriage is specified as $M_{i2} = a_0 - \gamma(S_{i2} - S_{i2}^H)^2$, where S_{i2} and S_{i2}^H are individual i and her husband's schooling. There are only two schooling levels in the model and I use $S = 1$ to denote high school and $S = 2$ to denote college. The value of marriage first depends on some permanent utility value a_0 through affection, children etc. The value of marriage also depends on the couple's homogeneity in education background. If they are different in schooling level, disutility γ occurs.

The model can be solved analytically. In the second period, the marital choice depends on total marriage value $\psi y^H \left(S^H\right) + a_0 - \gamma(S - S^H)^2$. A marriage is formulated if this value is positive. College choice at $t = 1$ depends on individual ability. Since earnings increase with ability, all individuals with ability above some threshold attend college.

The benefits of marrying a high school man and a college man are $\psi y^H(1) + a_0$ and $\psi y^H(2) + a_0$ respectively. If a woman marries a man with different schooling level, then cost γ occurs. When $\gamma < \psi y^H(1) + a_0$, no matter which type the man is, the net value of marriage is always positive. Therefore all women accept offers from both types of men and match is random.[17] When $\psi y^H(1) + a_0 < \gamma < \psi y^H(2) + a_0$, a high school woman accepts all offers since even if she marries a college man and γ occurs, college husband's higher income compensates for the cost. However college women are more selective in this case, they choose college men only. Positive assortative matching thus appears. When $\gamma > \psi y^H(2) + a_0$, the cost of marrying someone with different schooling level is so high that a woman will only choose a man with the same educational attainment. Then the assortative mating is perfect. Therefore we have the next proposition providing sufficient

[17] This result holds for the two-period model or a multiple-period model with on the marriage search. For a finite horizon model with more than two periods and married women receive no outside offers, it may be optimal for women to wait until a good match comes to marry.

conditions under which positive assortative mating appears.

Proposition 1 *(Assortative mating) Degree of assortative mating in education depends positively on* γ*. When* $\gamma < \psi y^H(1) + a_0$*, the match is random; when* $\psi y^H(1) + a_0 < \gamma < \psi y^H(2) + a_0$*, positive assortative mating exists; when* $\gamma > \psi y^H(2) + a_0$*, the match is perfectly assortative.*

The next proposition shows how future marriage affects college choice.

Proposition 2 *(Marriage ⇒ College) Given* $\alpha_1 > \ln(\frac{1+\beta}{\beta})$*, the more college men available, the more women attend college; the more college increases marriage offer rate, the more women attend college. College enrollment also increases in* γ *when* $\psi y^H(1) + a_0 < \gamma < \psi y^H(2) + a_0$*.*

Proof. *See Appendix A.* ■

3 Data

3.1 The Sample

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. These individuals were interviewed annually through 1994 and are now interviewed on a biennial basis. The sample contains a core random sample and oversamples blacks, Hispanics, "disadvantaged" whites, and members of the military. A key feature of this survey is that it gathers information in an event history format, in which dates are collected for the beginning and ending of important life events such as employment, education and marriage. I follow each individual in my sample for up to ten years since they received their high school diploma.

The sample used in the present analysis consists of white females from the core random sample of 2,279 individuals. I keep those who have received a high school diploma and reported graduation date. All women in the sample graduated from high school during May to August between 1980-1983. I further restrict my sample such that every woman graduated from high school between age 17 and 19, single and with no children.[18] I dropped 89 individuals from the sample because of

[18]Complete schooling history is not available before 1980, therefore the sample is restricted to high school grad-

inconsistent or incomplete observations on schooling, employment or marital choices. This leaves me with a sample of 582 women born between 1961-1964. Another 95 women are excluded from this study since their family background information is not complete. Selected individuals stay in the sample up to ten 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. Data based on answers to retrospective questions are aggregated as described in Appendix B. Some descriptive statistics are shown in Table 1. On average, this sample of high school graduate women completed more than 14 years of schooling.

3.2 Women's Choices and Transitions

Figure 1 presents the proportions of women who are in college, who are employed, who are married, and who have children for the first ten years since graduating from high school. Conditional on high school graduation, 61 percent of my sample acquired at least some post secondary education and 38 percent had at least four years of post secondary schooling. 49 percent of the sample attend college in the first year after high school. Attendance falls by 4 to 5 percent annually throughout the next three years. Then we observe a more than 15 percent discrete drop in attendance after the fourth year, corresponding to typical college graduation. The attendance rate continues to fall but stays around 9 percent after seven years. This reflects the fact that some women return to school. About one third of women in the sample have the experience of leaving and subsequently returning to school.[19] This may due to female's low returns to experience. The labor force participation rate increases from 43 percent to about 80 percent in the first six years after high school. Then it becomes flat and declines slightly, reflecting the well-known hump-shaped female labor supply profile. This is consistent with women getting married and withdrawing from the labor market. By the tenth year the percentage of women who are married has increased to about 66 percent and the percentage of women who have children has increased to 45 percent.

Table 2 shows the disaggregate choice proportions. Each entry of the table is the proportion

uates after 1980. 7 individuals graduated after 1983. 9 individuals graduated before 17 or after 19. More than 96% of the sample receive high school diploma during May to August. 24 women were married or had children at graduation.

[19] This is very different from men. In Cameron and Heckman (2001), it is documented that only 2-6 percent of high school graduates and 6-12 percent of dropouts report at least one episode of leaving and then returning to school.

of women who chose one of the eight alternatives in each year after high school. Conditional proportions can be easily calculated from this table. The 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 school. It indicates low complementarity between marriage and school. The attendance rate for married women is always below 10 percent as compared to single women whose attendance rate is as high as 51 percent in the first year after high school.

Even though the sample women are in their twenties, many of them have already undergone one or more changes in marital status. 142 women (29%) remained single throughout the sample period, 25 (5%) married twice, 54 (11%) experience at least one divorce. Most (about 60 percent) of divorced women never went to college. Marriage seems to be more stable for well educated women.[20] Table 3 shows mean transitions between attendance and non-attendance; between employment and non-employment; and between being single and being married. Each row presents the probability of moving to one state at t + 1 given the choice at t. Persistence in choices is indicated by the high probability on the diagonal.

As a parsimonious way of describing the joint patterns of school attendance, marriage, and employment, Table 4 and 5 present probit results. Women, who are younger, who are single, who have no children, and who do not work, are more likely to attend college. Women, who have children, who are older, who do not work, and who are not at school, are more likely to be married. Women who have more experience, who are younger and not in school, who are single with no children, and more schooling are more likely to work. Furthermore column (2) and column (3) of Table 5 display employment probits for married women with two different specifications. Comparing these results, we observe the following: first, women with low income husbands are more likely to work;[21] second, without controlling for husband's income, schooling has less effect on employment. This is probably due to the fact that a highly educated woman marries more

[20] From life cycle perspective, this number is probably biased since college graduates get married much later. Therefore it is less likely for us to observe their divorce over the same period of time. However some aggregate data show the same pattern. Based on data from the National Survey of Family Growth (NSFG), "Cohabitation, Marriage, Divorce, and Remarriage in the United States" Table 25 reports that among non-Hispanic 20 to 44 years 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 high school education.

[21] For example, in the 10th year of the sample, 86 percent of women with husband's earnings less than 20 thousand worked and only 55 percent of those with husband's earnings over 80 thousand worked.

often to a man with higher education and income, which induces her to work less. Therefore without controlling for husband's income, the effect of schooling on employment probability is under estimated.

3.3 Women's Wages

Real hourly wages are obtained as explained in Appendix B. Table 6 reports both the mean and deciles of hourly wages. The mean wage more than doubles over ten years. Except for the first year mean wage is always greater than the median wage showing the wage distribution is skewed. The observed wage distribution shifts to the right and becomes more dispersed as women accumulate more schooling and experience.

In solving the dynamic programme, actual hours worked are ignored. Potential annual earnings, obtained by multiplying hourly wage by 2000 hours, is used. Each woman is essentially assumed to be deciding about full-time work and the wage rate is assumed to be independent of hours worked. Among all the wage observations, wages of women who work when at school are much lower and less dispersed. Following the convention, I use wage observations after formal schooling to run an OLS log wage regression on years of 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.

3.4 Marriages

Mean age at the first marriage is approximately 22, 23, and 25 for high school women, some college, and college women respectively. At the time of first marriage, men are on average three years older than women, nevertheless women have slightly higher schooling. Mean annual income of husbands is around 35 thousand. It increases from 21 thousand to 38 thousand during the sample period.

Married couples tend to share a common schooling background. The correlation between women's highest grades completed (HGC) and their husbands' HGC at the first marriage is as much as 0.55. At time of the first marriage, 42 percent of the couples have the same educational attainment. About 80 percent of the couples have at most two years schooling difference. Table 7 shows schooling homogamy by husband's schooling distribution conditional on married women's education. High school women are very likely to marry high school men. As a matter of fact, 78 percent of them marry men with a high school education or less. As women accumulate more schooling, they tend to marry men with more education. For college women, 60 percent of their husbands are college graduates as compared to for high school women, less than 7 percent of their spouses are college graduates. Women with some college education, but who never finish 4 years of college, seem to be more similar to high school graduates. If schooling homogamy provides positive value to marriage, we expect marriages in which partners share similar education background be more stable. Due to lack of observations, however, distributions of schooling difference are not statistically different for marriages survived and divorced during the sample periods.

3.5 Background at High School Graduation

I use both family and cognitive background variables as initial conditions in the schooling model. 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 NLSY as a person living at home or not at home but living in a dorm or military barrack. Thus family income is generally not known for older NLSY respondents. A two year average was constructed for family income at ages 15 and 16 if available. Family income at age 14 and age 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 type of information gathered for each of up to 64 courses included grade level at which the course was taken, a code for the high school course, the final or computed grade for that course, the source of the final grade, and the credits received.[22] The ASVAB consists of a battery of 10 tests that measure knowledge and skill in 10 different areas. Armed Forces Qualifications Test score (AFQT) is a composite score derived from 4 sections of the battery (namely arithmetic reasoning, word knowledge, paragraph comprehension and math knowledge) and widely used as cognitive ability indicator. AFQT89 percentile scores are used in this study.

College entrance examination scores may be important for college application. They are not included in the analysis since the number of respondents for whom these scores are available is low. 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. This study assumes that an SAT score is of second order importance conditional on ability.

Table 8 illustrates the potential importance of family and cognitive background in determining school, employment and marriage outcomes. As the first panel of the table shows, the difference in completed schooling between high school women whose mother did not complete high school and women whose mother completed college is over 3 years. Of the former group, 64 percent of them never attend college while about 82 percent of the latter completed college. Similar patterns hold for women's schooling conditional on father's education. Given women's schooling differences, labor market and marriage outcomes are also significantly related to parents' schooling. The real hourly wage rate over the ages of 25 and 28 for those who are employed increases more than half over the range of parents' schooling. Much fewer women whose mother or father completed college marry at the age of 25. The third and fourth panels of the table show outcomes in school, employment and marriage conditional on number of siblings and household structure. Number of sibling has small effect on schooling outcome if it is less than four. Having more than four siblings reduces years of schooling and real hourly wage. 24 percent of women with no sibling are

[22] High school grades may be important for college decision, which I leave for future research due to the complications in collecting data (see Eckstein and Wolpin 1999).

married at age 25 while 59 percent of women with more than four sibling are married at the same age. Women who live with both parents obtain half year more schooling, marry slightly less at age 25 and their hourly wage is lower. The fifth and sixth panels show the well known correlation between family income, cognitive ability and youths' outcomes. Women whose family income is greater than twice the median obtain almost two years more schooling than women whose family income is less than half of the median. Women from rich family also perform significantly better in the labor market and fewer of them are married at age 25. AFQT scores are strongly correlated with schooling outcome. 79 percent of women with top 20 percentile of AFQT scores complete college while 77 percent of women with bottom 20 percentile AFQT scores never attend college. The former group's hourly wage almost doubles as compared to the latter. The last panel of the table shows that on average women finish high school at 18. Those who graduate at age 17 obtain 1.8 more years of schooling and do significantly better in the labor market than those who graduate at age 19.

4 Estimation

After solving the optimization problem, I generate data from the behavior model and use simulated method of moments (McFadden 1989, Pakes and Pollard 1989) to estimate parameters in the economy.[23]

4.1 Simulated Method of Moments Estimator

Specification I restrict the model to have exogenous processes on fertility and exogenous schooling distribution of potential husbands. The discount factor β is set to be 0.96, i.e. an annual rate of time preference of 4 percent. Parameters to be estimated consist of parameters that correlate observed background with unobserved types, utility parameters, parameters in the budget constraint, parameters in the marriage offer function and the value of marriage, women's wage equations, men's earning equation, end condition and the variance covariance matrix of idiosyncratic shocks.

[23] Simulated maximum likelihood estimator is efficient but it requires the number of simulation be large. SMM estimator, however, is asymptotically normal as long as the number of observations is large.

Data I have a sample of white female high school graduates indexed by $i = 1, \cdots, 487$. I observe their family and cognitive background (mother's schooling, father's schooling, number of siblings, household structure at 14, net family income, AFQT score and age at high school graduation), their schooling, employment and marital status every year $(s_{it}^D, h_{it}^D, m_{it}^D)$, their observed wages if employed (w_{it}^{oD}) and characteristics of the first marriage (woman i's own schooling S_i^D, her husband's years of schooling S_i^{HD}, and annual income y_i^{HD}) if married, for $i = 1, \cdots, 487$ and $t = 1, \cdots, T_i$, where the superscript D denotes the data.

Simulations I simulate individual choices, wages, husbands' schooling and income from the model in a consistent way as in the data. All women start with 12 years of schooling, no labor market experience, and having never married or had children. For each individual i, I first simulate her type conditional on her background. At the beginning of the first year, $t_i = 1$, all other uncertainty in the economy is also realized. Preference and productivity shocks are known to woman i, as well as whether job offer, marriage offer or child arrives and the type of offers received. Using the distribution of the shocks, she also forms expectations on future utility and earnings given her current decision. She makes joint decision on schooling, employment and marriage $(s_{i1}^S, h_{i1}^S, m_{i1}^S)$. Her wage w_{i1}^S is recorded if employed and her husband's schooling S_i^{HS} and income y_i^{HS} are recorded if married. The states are then updated. Now at $t_i = 2$, conditional on the current states and all the idiosyncratic shocks, $(s_{i2}^S, h_{i2}^S, m_{i2}^S)$, w_{i2}^S, S_i^{HS}, y_i^{HS} are simulated. If a woman is working and her wage is observed, I simulate the measurement error to obtain the "observed" wage according to $w_{it_i}^{oS} = w_{it_i}^S \exp(u)$. Observed husband's income is simulated in a similar way. Given the value of parameters, I simulate data from the model for $N^S = 25$ times for each individual.

Moments The moments used include the proportions of women who choose each of the eight alternatives in each year as in Table 2 and the aggregated proportion attending college, working and married as shown in Figure 1; the proportions of high school graduate, some college and college graduate women; transitions moments as in Table 3; husband's schooling distribution conditional on married women's education as in Table 7; mean and standard deviation of husband's annual income; as well as observed mean wage and wage decile moments as in Table 6. In total, there are 254 data moments. For each simulation, the same moments are computed and the simulated moments are averaged over all simulations.

Implementation Simulated method of moments is implemented by using these moments. Let m_j^D be moment j in the data and $m_j^S(\theta)$ be moment j from the model simulation given the parameter vector θ. The moment vector is

$$g'(\theta) = [m_1^D - m_1^S(\theta), \cdots, m_j^D - m_j^S(\theta), \cdots, m_J^D - m_J^S(\theta)],$$

where J is the total number of moments and J = 254. I minimize the objective function $J(\theta) = g(\theta)'Wg(\theta)$ with respect to θ, where the weighting matrix W is set to be the identity matrix. I bootstrap the standard errors.

4.2 Identification Issues

In general the non-linearity makes it difficult to establish theoretical and practical identification. Although the model is complex it is nevertheless possible to provide intuition concerning the identification of the importance of the three sources, namely, the background, the earnings, and the marriage.

Background variables enter the model as covariates of discrete types. First, given the assumption that types are discrete and uniformly distributed, we can identify the joint distribution of types, i.e. the proportions, from a cross section as in Roy model (Heckman and Honore, 1990). Second, type specific parameters are like persistent individual effect, which are identified by repeated observations on individuals. Third, in the data, girls whose mother went to college go to college and girls with high test score go to college. Mother's schooling, test scores, etc. are exogenous, so it is easy to identify the correlation between these background variables and unobserved types, given the type distribution.

In order to identify the earnings effect on college decision, we need to estimate a nonlinear simultaneous equation system. We need to first identify the causal effect of college on earnings, then we need to identify the causal effect of expected earnings on college decision. The college wage premium is identified from the wage data on those who enrolled college, those who graduated from college, and those who didn't attend college, like in a Heckman selection model. Given that the wage is log normal, the treatment effect of college is identified. The dynamic programming model provides the decision rule for college attendance and graduation conditional on wage premium. The decision rule is essentially a structural probit equation. i.i.d. wage shocks provide exogenous variation in wage premium.

Similarly we need to estimate another nonlinear simultaneous equation system to identify the marriage effect on college decision. We do not observe marriage utility but we observe marriage outcome. Like in McFadden's random utility model, parameters in the marriage utility function can be identified. The observations that high educated women marry highly educated men provide the variation to identify the disutility of school difference. The transition from singlehood to marriage conditional on schooling identifies effect of college on marriage offer rate. Women's own wage can be used as an exclusion restriction as it affects schooling but not the marriage utility. Given the dynamic programming model, the structural probit equation of college decision thus also includes the expected value of marriage. Then the idiosyncratic shocks on the value of marriage play exactly the same role as the wage residuals.

We can write down the wage equation, the marriage utility function, and structural probit equations for each of the joint choices (8 choices) for every year (10 years). These are approximations of the dynamic joint decision process without coherent cross equation restrictions. With the exclusion restrictions from the model, coefficients from reduced form estimates are functions of the structural parameters.

As another way to think about identification, a necessary condition is that each parameter should affect some moments in the distribution. Consider first the parameters in the labor earning processes. The identification apparently rests on the wage data. We observe only accepted wages and high skill women obtain more schooling than low skill women. Conventional OLS regression thus suffers sample selection and endogeneity biases. The solution to the optimization problem provides the sample selection rules, which serves the same purpose as would a sample selection correction in a two-step procedure. Unobserved heterogeneity is explicitly specified so that the endogeneity bias is also corrected. Similarly, men's earning process is identified by observed husband's earning data.

Consider next the identification of the utility function parameters. If the model were static, the proportion of the choices identify the constants in the utility function. The value of schooling v_1 to v_4 are identified by the attendance conditional on labor supply and marital status. Similarly the value of nonemployment v_5 to v_6 are identified by the participation rate conditional on fertility. As an example, write alternative specific utility function incorporating the budget constraint as following (given $f_t = 0$ and $S_t < 16$):

$$
\begin{aligned}
U_t^1 &= v_{6t} + \epsilon_t^1, \\
U_t^2 &= -(\alpha_1 + \alpha_2)cs + v_{1t} + v_{6t} + \epsilon_t^2, \\
U_t^3 &= (\alpha_1 + \alpha_3)y_t + \epsilon_t^3, \\
U_t^4 &= (\alpha_1 + \alpha_2 + \alpha_3)(y_t - cs) + v_{2t} + \epsilon_t^4, \\
U_t^5 &= (\alpha_1 + \alpha_4)\psi(0)y_t^H + v_{6t} + M_t + \epsilon_t^5, \\
U_t^6 &= (\alpha_1 + \alpha_2 + \alpha_4)(\psi(0)\, y_t^H - cs) + v_{3t} + v_{6t} + M_t + \epsilon_t^6, \\
U_t^7 &= (\alpha_1 + \alpha_3 + \alpha_4)(y_t + \psi(1)\, y_t^H) + M_t + \epsilon_t^7, \\
U_t^8 &= (\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4)(y_t + \psi(1)\, y_t^H - cs) + v_{4t} + M_t + \epsilon_t^8.
\end{aligned}
$$

The maximization problem written in this "reduced form" representation is similar to a static multinomial choice model. The coefficients are functions of the utility and budget constraint parameters. All parameters in these equation are identified by the proportions of choices and the variation in women's earnings and husbands' earnings except for the cost of college cs. cs enters the model linearly with the value of schooling v_1 to v_4. In the estimation, I set $cs = 7,515$ in 2000 dollars[24]. The cost of graduate school, however, can be identified by the discrete drop in attendance after four years. With regard to parameters in the value of marriage, the effects of age, fertility, and marriage duration on the value of marriage can be identified by conditional marriage proportions and marriage transitions. The disutility from the difference in schooling is identified by husband's schooling distribution conditional on married women's schooling.

The panel data provides conditional transitions from eight states to eight new states from

[24] According to National Center for Education Statistics (NCES, Digest of Education Statistics, 1990, pp285, Table 281), the average total tuition room and board cost was $7,515 (dollars of 2000) during 1980-1988.

one year to another for 10 years. These transitions would allow us to identify parameters in our structural model which characterize the dynamics: the job offer probabilities, the marriage offer function, etc. The terminal value parameters are identified by their joint restrictions on the transitions between states over time and the cross section choice.

5 Estimation Results

The model is estimated by minimizing the squared difference between data and simulated moments as previously defined. In this section I discuss the estimation results and their economic interpretation, as well as the fit of the model to observed moments, followed by an out of sample prediction.

The probability of the first birth is estimated separately and used as inputs to the estimation algorithm.[25] I estimate a logit using individual's characteristics to determine the probability of having first child for each period. The results are presented in Appendix C. Schooling has a negative effect on the probability of having children, which is consistent with the observation that highly educated women tend to have fewer children and have the first birth at older age. The estimates also show that married women are more likely than single women to have children and as they become older, their probability of having at least one child increases but at a diminishing rate. Potential husbands' schooling distribution is treated as exogenous in the model. I calculate the schooling distribution of 22 to 35 years old white males between 1980 to 1983 from CPS and use it as non-parametric estimates of potential husbands' schooling distribution. These estimates are also presented in Appendix C.

5.1 Parameter Estimates

The model's estimated parameters are reported in Appendix D with standard errors in parentheses. In total, there are 102 parameters. The first panel reports the estimates of the parameters in the utility function. Marginal utility from consumption is estimated to be 1.158 for single,

[25] 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. With unobserved heterogeneity, the two step procedure is in general not consistent. I assume the potential bias is small and adopt two step procedure as in Van Der Klaauw (1996).

non-employed women, who are not in college. The negativity of α_2, α_3 and α_4 implies that the utility gains from consumption decrease when women attend school, work or stay married. Estimated utility values of school and nonemployment indicate significant heterogeneity between women's skill types. With respect to tastes for school, type one likes school the least, type two the next and type three is the type who likes school the most independent of working and marital status, as can be observed from the rank order of values of v_1, v_2, v_3 and v_4's. Attending school when married brings disutility for all types, which is consistent with women leaving school after marriage. The value of nonemployment is higher when children are not present. Type two's have the highest value for nonemployment.

Average annual expenses for graduate school are around $35,552. The estimated cost of children is $42,370. Although this amount may seem large, it is important to remember that in the model, child care does not take time but it should be included in the estimated cost. This estimate also sums over the total number of children women may have which is around three. Without specifying the strategic behavior within the household, the model predicts that nonemployed married women receive 48.4 percent of their husbands' income, while employed married women get 32.4 percent. This is consistent with the case when married couples share their income. If the man specializes in the marketplace and the woman at home, the stay home married woman is compensated by the husband. Higher income the husband earns, *ceteris paribus*, less likely the married woman works at the marketplace.

According to the estimated correlation between background and type, λ's, higher parental education, fewer siblings, living with both parents at 14, higher family income, good AFQT score and graduate high school at an early age increase the probability of being skill type two. Similarly parental schooling, family income and AFQT score also have positive (but less) impact on the probability of being skill type three. We expect these two types have higher skills relative to the first type. As seen from the estimates of conditional marriage type proportions, π's, each skill type has different distribution of marriage types. For example, all skill type 2's are marriage type 1 but only 66% of skill type 3's belong to marriage type 1.

Job offer rates depend positively on labor market attachment in the previous year. Offer rate for employed women is higher than for non-employed women independent of schooling. Women with some college or college degree always receive more job offers than high school women. According to the estimates of the wage equation parameters, both skill rental price and return to schooling are the lowest for the first type. Type two have the highest skill rental price while type three have the highest return to schooling. Each additional year of schooling increases wages by 4.2%, 5.5%, 6.2% respectively for each type. Note that the estimated return to schooling are much lower than the OLS estimates, providing evidence that without controlling for self selection, the returns to schooling is upward biased.[26] Wages increase by 10.1% with each additional year of after school experience and the depreciation is 0.08%. The return to experience seems high since my sample is at the beginning of their labor market experience, when they accumulate skills fast and shop for jobs frequently. College graduation increases wage by 29.6% conditional on years of schooling and experience. Even though skill type 1's have much lower skill rental price and returns to schooling for the formal labor market, they seem to have comparative advantage for jobs available at school as indicated by the highest β_{0c}. Wages offers received in school are much less dispersed than those received out of school.

Based on the estimates from the marriage evaluation rule, the negative a_1 shows that education attainment of both spouses are complements within the family. Women value marriage more when they grow older, which is captured by positive a_2. The value of marriage also depends positively on the presence of child and marriage duration. Children provide large utility for women, which is consistent with the argument that the main reason why people marry is to have their own children. Positive dependence on marriage duration reflects the likely accumulation of physical and emotional bond between the spouses associated with marriage. The estimates of the marriage offer probability function show that age and college attendance have significant effect on the arrival probability of marriage offers. We also observe considerable heterogeneity between marriage types. Women from various marriage types differ in their permanent value for marriage a_0, marriage offer arrival rate b_0, and their preference for husbands' schooling a_1. Marriage type 1's fixed value for marriage is the lowest and the difference in schooling with the husbands gives them the largest disutility. Interestingly, they receive marriage offers most often among all types. Potential husband's earning function is increasing in schooling and concave in experience.

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

5.2 Within-Sample Fit

Choice Proportions and Transitions Given the estimated parameters of the model, I calculate the predicted proportions of women who choose each alternative in each year after high school. Figure 2 (a) and (b) depict 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 9 presents the within-sample χ^2 goodness of fit statistics for the model with respect to choice proportions, by years after high school graduation. The model prediction is statistically the same as the data moments at the five percent level. As for the overall schooling distribution, the model predicts 61.0% of the sample attend college and 38.0% finish four-year college as compared in the data 61.4% attend at least one year college and 37.8% complete four years.

Table 10 presents the predicted mean transitions based on the same simulations that generated 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 nonemployment. Individual heterogeneity and state dependency generate persistence in the model.

Wage Moments The estimated model fits well the trend and the level of the mean and deciles of accepted wages. Figure 3 (a) compares the model's mean wage and median wage profiles, with the parallel moments in the data. With the accumulation of both schooling and experience, mean wage doubles from \$6.2 to \$12.7. Mean hourly wage jumps by \$2 in the 5th year, reflecting college women joining the labor force with one year lag. The model does not capture this feature but it well captures the trend in both mean wage and median wage. The model predicts median wage lower than mean wage, indicating a skewed wage distribution as we observed in the data. Moreover, the growing distance between median and mean reveals wages to be more dispersed. Figure 3 (b) compares the mean and standard deviation for husband's annual income. Again the model is able to fit the level and the trend of both.

Assortative Matching in Education As Table 11 presents, the predicted husband's schooling distribution conditional on married women's schooling level matches data closely. In the model, high school graduate women like to marry college men for their high income, but they suffer from the difference in education background and they receive fewer marriage proposals. The model underpredicts their probability of marrying college men. Women who attend college but never finish four years behave more like high school graduates. Overall the model can fit the conditional schooling distribution of husbands.

Comparison with Reduced Form Model A comparison of within sample prediction from the structural model and a multinomial probit model is another method of assessing the fit of the model. The reduced form parameters of the probit are unspecified functions of the structural parameters of the optimization model. Likelihood ratio chi-square tests yield values of 1485, 1684 and 1771 for attendance, marriage and employment probit models in Table 4 and 5. If we use reduced form model to fit the observed distribution of data with all the rich transitions, we potentially need to specify eight nested multinomial simultaneous equations for every year, and all of them should include individual fix effect. This system of equations would probably have more parameters than the structural model I consider here.

5.3 Observed and Unobserved Heterogeneity

As can be seen in Appendix D, there is considerable variation in type-specific skill endowments and preferences. Table 12 presents selected characteristics at the end of the sample period on the basis of simulations using the estimated model. I first consider unobserved types in skills. Skill types differ substantially in their highest grades completed, work experience, marriage duration and choices in the 10th year after high school graduation. Among type 1's, 74% never attend college and none of them finish four years college for those 26% who attend. Only 5% of type 2's are high school graduates only and 72% graduate from college. An overwhelmingly 98% of type 3's graduate from college. Basically Type 1 is the high school type, type 2 is the college type and type 3 is the graduate school type. High skill type also tend to work more after leaving school. The hourly wage for the second type is 48% higher than the hourly wage for the first type. The hourly wage for the third type is low because many of them are working when in graduate school.

Not only are these unobserved skill traits related to school performance and work experience, they are also related to marriage experiences. Each skill type consists different composition of marriage types. Skill type 1's consist of mostly marriage type 1 and 2. In particular, 73.2% of skill type 1's belong to marriage type 1 and 26.0% of them are marriage type 2. Almost all skill type 2's belong to marriage type 1. For skill type 3's, 64.0% are marriage type 1, 14.9% are marriage type 2 and the rest 21.1% are marriage type 3. The estimates of type specific b_0's show that marriage type 1 receive much more offers than type 3, even more than type 2. Figure 4 shows how the value of marriage depends on school differences of the couple for each type and for different age groups. The top panel plots the value of marriage M by the difference in years of schooling with potential husband for single 25-year old women with no children. Type 1's are the most choosy type. When husband's income is not taken into consideration, type 1's accept marriage proposals only from men with the same schooling whereas type 2's also accept offers from men with one year schooling difference and type 3's marry men with up to 4 years difference in schooling. The dotted line illustrates potential husband's incomes, which are increasing in their schooling. Under the assumption that married women can consume part of their husbands income, marriage opportunity would be more attractive when husband's income is taken into account. The bottom panel in figure 4 shows the age effect on marital choice. As women grow older, they become less selective but the effect is relatively small.

Given the importance of unobserved types in determining women's schooling, employment and marriage choices, and observed correlation between family and cognitive background with outcomes, the model predicts strong correlation between observed background variables and unobserved types. Although I cannot determine each individual's actual type, I can assign a set of type probabilities conditional on her family and cognitive background. Table 13 shows the correlation between observed background with unobserved skill types. Since background variables are likely correlated with each other, for example, if both parents are college graduates, family income is probably in top quantile, table 8 cannot separate the influence from each background variable. I consider the marginal contribution of each variable on the skill type distribution. For example, to study the correlation between mother's schooling and young women's skill type, I fix other background variables at the sample means and then compute the type probabilities conditional on mothers being high school incomplete, high school graduates, some college or college graduates. As Table 13 shows, family and cognitive background variables have strong predictive power on the probabilities of being skill type 1 and type 2. Higher completed schooling of parents, family income and AFQT score, and lower number of siblings imply higher proportion of skill type 2 and lower proportion of skill type 1. Mother's schooling has stronger correlation with the skill types than father's schooling. Conditional on everything else, family income is not a strong predictor for skill types at least if the income is below twice of the median income.[27] Furthermore living with both parents at age 14 and graduating high school at younger age increase the probability of being type 2. The probability of being type 3, however, is not strongly correlated with background variables.

5.4 Out of Sample Predictions for NLSY97 Sample

The National Longitudinal Survey of Youth 1997 (NLSY97) is designed to be representative of the U.S. population in 1997 born during the period 1980 to 1984. NLSY97 sample consists of 8,984 youths age 12-16 as of December 31, 1996. Two subsamples comprise the NLSY97 sample: a cross section random sample and supplemental oversamples of Hispanics and blacks. NLSY97 gathers information in an event history format like NLSY79. Since these two surveys ask the same questions to respondents I can use them to compare college enrollment behavior in the early 1980s and in the early 2000s.

NLSY97 rounds 1-6 with event history released in October 2004 is used in this study. I construct comparable data from the NLSY97 using the same restrictions as for the NLSY79 sample. First I restrict my sample to white females in the cross section sample with 2,317 individuals. I keep those who have received a high school diploma between 1997-2000. All women in the sample graduated from high school between 17 to 19, were never in the military, and were single with no children at graduation. Individuals with incomplete observations on schooling, employment, or marital choices are dropped from the sample. Finally I keep women with complete background information. Selected 537 individuals born between 1980-1983 are observed up to five years.

Figure 5 compares college attendance profiles between NLSY97 and NLSY79. Note that only four-year data are available for NLSY97 sample conditional on having enough number of observations. College enrollment increased by 19 percentage points, from 61% to 80% between

[27] This is consistent with Cameron and Taber (2004)'s finding that liquidity constraints have little impact on schooling attainment.

these two cohorts.[28] Is the estimated schooling model able to predict this change in college enrollment? To answer this question, I simulate the estimated model for the NLSY97 sample.

The observed changes over this period are (1) changes in background such as family income, parental education and cognitive ability; (2) changes in the schooling distribution of potential husbands; (3) changes in college premium for both males and females; (4) changes in direct cost of college. Table 14 compares the background of the NLSY79 sample and the NLSY97 sample[29]. Even though the NLSY97 sample have more siblings and are more likely from broken families, they have better background in terms of family income, parental education and cognitive ability. On average their parents obtain more than one year of schooling, family income is 13 thousand dollars higher, percentile cognitive score is 10 percentage points higher and they also graduate high school 0.1 years younger. I assume that the NLSY97 sample use the schooling distribution of 22-to-35-year old white males between 1997 and 2000 to predict their future husbands' schooling distribution. As shown in Table 15, college enrollment of white males increased by 5 percentage points.[30] Between 1980s to 2000s, skill premium for both males and females increased dramatically.[31] To estimate the changes in the college premium is complex. The returns to schooling for both males and females are estimated in the structural model to control for selection. Without a similar structural model estimated for the new cohort, we can not obtain a consistent estimate of the returns to schooling. I adopt a much more parsimonious method. As Figure 6 shows, the relative wage between some college and high school graduate females increased by 50%, while the relative wage between college graduate and high school graduate females doubled between the early 1980s and the early 2000s.[32] These premiums can be attributed to the returns to ability

[28] At the same time, labor force participation pattern stays the same. The young cohort tends to marry less or later. But if we take the cohabitation into account, the proportion of having a partner/spouse converge to the marriage profile of the old cohort. To consider cohabitation as a separate choice variable is left for future research.

[29] I use the same variable definitions except for cognitive ability percentile scores. For NLSY79, AFQT percentile score generated by the department of defense is presented. For NLSY97, however, ASVAB math and verbal percentile score generated by NLS is used. It 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 similar to AFQT score and is the most comparable variable.

[30] CPS changed schooling classification in 1992. Prior to 1991, we have information on the number of grades attended and completed upto 18 years. After 1992, however, we only have information on an individual's highest degree received. I classify those who have some college but no degree as completed 13 years, those who have bachelors degree as completed 16 years, those who have masters degree as completed 17 years and those who have professional or doctorate degrees as completed 18 years.

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

[32] Similar pattern holds for men's college premium. Here, I only consider the effects of changes in female's college

or the returns to college (Taber 2001). I simply treat them as college premium to have an upper bound for the changes in college premium for the new cohort. I assume in the model, for the new cohort, the returns to each additional year of schooling (β_1's) increases by 50% and the returns to college graduation (β_4) doubles for all types. Figure 7 shows the time trend of changes in direct cost of college inclusive of tuition, room and board according to National Center for Education Statistics. The average total cost between 1980-1988 is used as the cost for NLSY79 sample and I use the average total cost between 1997-2003 to approximate the cost for NLSY97 sample.

Given these changes, I predict enrollment behavior of the NLSY97 sample using the estimated model based on the NLSY79 sample. In the first simulation, potential husbands' schooling distribution, the earning processes, and the cost of college are fixed at the levels for NLSY79 sample, and the NLSY97 sample's background variables are used. College enrollment would increase by 8 percentage points, from 61% to 69%. This increase is simply because women who have better background have a higher probability of being high skilled. In the second simulation, the females face potential husbands with better education, the model predicts female's college enrollment would increase by an additional 4 percentage points due to educational assortative mating. In the third simulation, females expect the dramatic increase in their own college premium. The college enrollment increases by 3 percentage points more. In the last simulation, the NLSY97 sample have to pay the new average cost of college (around $11,030 in 2000 dollars). College enrollment would drop by 1 percentage point. The model, which is estimated based on a sample attending college in the early 1980s, can predict the enrollment behavior in the early 2000s. Since most school premium is conditional on college graduation, the effect of increasing college premium on college enrollment is relatively small but it has a large effect on college graduation. In fact, it can account for a 10 percentage points increase in the college graduation rate. Figure 8 depicts college attendance profiles conditional on each exogenous change. It will be very interesting to see if the model can predict the college graduation behavior well for the new cohort when data is available.

premium. Since available earnings data for husbands is not as good as the wage data for females, the specification of husband's earnings does not take graduation premium into account. When I use OLS estimates of men's earnings equation for both samples using CPS data, changes in men's earning process have negligible effects on women's college enrollment rate.

6 Simulations

6.1 How Much Does Marriage Matter to College Decision?

I run counterfactual simulations to study the effects of marriage on women's college decision. I compare women's schooling distribution from each simulation with the baseline given estimated parameters. Table 16 presents the simulation results.

The first simulation analyzes the case when women do not care about the relative schooling background of husbands. Setting $a_1 = a_2 = 0$, the model predicts no correlation between couples' education because matching is random. The only gain through the marriage market in this case is that college attendance increases marriage offer rate. Therefore we observe that women cluster at the level of some college. College enrollment would increase by 14.7 percentage points and graduation would drop by 6.9 percentage points. Type 1's have more incentive to attend college and type 2's have less tendency to graduate.

In the second simulation, I assume that college does not increase the marriage offer rate, i.e. $b_3 = 0$. College graduation rate increases slightly by 1.4 percentage points but college enrollment drops by 6.6 percentage points. Based on the type specific simulation, 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 rate drops by half. The marriage offer rate has almost no effect on type 2's enrollment. In fact, setting b_3 to zero increases their college graduation rate simply because they are less likely to get married and drop out of college when the marriage offer rate is lower.

Women benefit from expected marriage from educational assortative mating and the marriage offer rate. When I zero out both benefits in the third simulation, college enrollment drops by around 3 percentage points, from 61% to 58% and the college graduation rate drops by 6 percentage points, from 38% to 32%. The drop in enrollment is mainly due to type 1's stopping going to college to meet more potential spouses. On the other hand, the fact that type 2's have less incentive to graduate to match their schooling with college graduate men attributes to the drop in graduation.

If the marriage option is not available altogether, the only incentive to attend college is to increase future earnings. Then the benefits of higher wages become more important in the college decision. Furthermore the estimated utility of schooling is negative and large when women are married. Even if women do not attend college to gain from a higher marriage offer rate and assortative matching, they tend to drop out college following marriage. Therefore when women are always single, they will invest more and stay longer in college. In the simulation where marriage offers are never received, enrollment would increase by 1.7 percentage points and graduation would increase by 11 percentage points. The effects are the strongest for type 2's, 99.8% of whom would graduate from college.

6.2 The Impact of the Return to Schooling

Table 17 shows the impact of the return to schooling.[33] With 10% increase in the return of each additional year of schooling (β_1's), the enrollment rate would increase by 0.2 percentage points and the graduation rate would increase by 0.3 percentage points. If the return of each additional year of schooling increases by 50%, college enrollment and graduation rates would increase by 1.5 percentage points and 1.8 percentage points, respectively. Enrollment increases are mainly from type 1's and graduation increases are mainly 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 increase graduation by 0.4 percentage points. Even with 50% increase β_4, college enrollment would increase only by 0.2 percentage points and graduation would increase by 2 percentage points. These effects are due to the response of type 2's.

6.3 Education Policy Experiments

In Table 18, I present evidence on the impact of two policy interventions to increase educational attainment: college tuition subsidies and college graduation bonus. These education policy experiments assume the impact of policy-induced skill supply responses on equilibrium skill rental prices are negligible.[34]

[33] 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 and 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.

[34] Two recent papers, Donghoon Lee (2005) and Heckman et al (1998), have made a start at developing solution and estimation methods that can account for the general equilibrium feedbacks. However, their results are very divergent.

College Tuition Subsidies I first simulate the effect of an experiment that provides a 50% tuition subsidy (a reduction in cs by 50%) for each year of college attendance. Average completed schooling level increases by 0.1 years, from 14.3 to 14.4 years. College attendance rate increases from 61% to 63% and graduation rate increases from 38% to 39%. Because college graduation is so prevalent among type 3's regardless of the subsidy, the increases in college graduation rates are mostly from type 2's. At the same time more type 1's attend college with the tuition subsidy.

Graduation Bonuses In contrast to tuition subsidies, which are based only on attendance, graduation bonuses rewards individuals for years of schooling that are completed. Graduation bonus schemes provide monetary payment for college graduation. In the second policy experiment, reported in panel (2) of Table 18, the effect of $5000 graduation bonus is presented. College attendance rate increases slightly by 0.2 percentage points and graduation rate increases from 38% to 40.3%. The low skill type 1's are not affected by the policy variation.

7 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 on longitudinal data that includes 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, and in particular, the estimates of the model are used to assess the effect of the expectations of marriage on college choice due to educational assortative mating and potential husband's income and due to the marriage offer rate.

The main results can be summarized as follows: First, marriage plays a significant role in a female's college choice. When the benefits from marriage are ruled out in the estimated model and everything else is kept the same, the predicted college enrollment drops by 3 percentage points, from 61 percent to 58 percent, and college graduation drops by 6 percentage points, from 38 percent to 32 percent. This prediction is for women graduating from high school in the early 1980s, as is the sample used to estimate the model. Second, the estimated model from the early

1980s does well in predicting college enrollment behavior in the early 2000s. College enrollment rates increased from 61 to 80 percent over this period. The model predicts the following: given (1) changes in family income, parental education and individual cognitive ability, (2) changes in potential husbands' schooling, (3) changes in female's college premium, (4) changes in the direct cost of college, college enrollment would increase by 8 percentage points, 4 percentage points, and 3 percentage points and decrease by 1 percentage point, respectively. The prediction for the new cohort is not only a validation of the model, it also provides evidence of the stability of the structural model for policy analysis.

The U.S. labor market has experienced some dramatic changes over the past few decades. First of all, female's college enrollment and graduation rates have been expanding constantly. At the same time, labor force participation rate of married females increased from 40 percent to 71 percent between 1964 and 2003. 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, the women's college enrollment rate and graduation rate exceed those of men but their labor force participation is much lower than men's labor force participation, especially for married women. If the increase in earnings power were the only gain from investing in education and there were no discrimination towards females, we would not expect female's labor force participation rate to be much lower than male's. This paper provides a mechanism which is consistent with this puzzling fact. Suppose some women attend to college only to improve their future marriage, they would withdraw from the workplace following marriage. Therefore married women's labor force participation is low. An open question would be what is the socially optimal level of schooling when some people invest in education, but do not work.

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AppendixA: Proofs

Proof of Proposition 2:

The model can be solved backwards. At t = 2, alternative specific value functions conditional on female's schooling $S_i = k$ and male's schooling $S_i^H = j$ can be written as following:

$$\begin{aligned} V_{i2}(1;k,j) &= y(k,\delta_i) + \psi y^H(j) + a_0 - \gamma(k-j)^2, \\ V_{i2}(0;k) &= y(k,\delta_i), \quad k = 1,2, j = 1,2. \end{aligned}$$

$V_2(1)$ and $V_2(0)$ are values of being married and being single respectively. The problem is solved separately in three cases.

Case 1: If $\gamma < \psi y^H(1) + a_0$, every woman marries when an offer arrives so match is random.

At t = 1, value of not attending college is

$$\begin{aligned} V_{i1}(0) &= y(1,\delta_i) + \beta E \max[V_{i2}(0), V_{i2}(1)] \\ &= y(1,\delta_i) + \beta \left[\mu p^0 V_{i2}(1;1,2) + (1-\mu)p^0 V_{i2}(1;1,1) + \left(1-p^0\right) V_{i2}(0;1)\right]. \end{aligned}$$

Similarly value of attending college is

$$\begin{aligned} V_{i1}(1) &= -cs + \beta E \max[V_{i2}(0), V_{i2}(1)] \\ &= -cs + \beta \left[\mu p^1 V_{i2}(1;2,2) + (1-\mu) p^1 V_{i2}(1;2,1) + \left(1-p^1\right) V_{i2}(0;2)\right]. \end{aligned}$$

Individual i attends college if and only if $V_{i1}(1) \geq V_{i1}(0)$. Assume $\beta_1 > \ln(\frac{1+\beta}{\beta})$, then attending college is the dominant strategy if and only if $\delta_i \geq \delta_1^* = \beta_0^{-1}\left(\ln \frac{A_1}{e^{\beta_1}[\beta e^{\beta_1} - (1+\beta)]}\right)$, where

$$A_1 = cs + \beta\left(p^0 - p^1\right)[\mu\psi y^H(2) + (1-\mu)\psi y^H(1) + a_0] + \beta[(1-\mu)p^1 - \mu p^0]\gamma.$$

All individuals with ability above threshold δ_1^* choose to attend college. Therefore a fraction $\Phi_1 = \Phi(\delta_1^*)$ of women are high school graduates and the rest are college graduates.

It is straightforward to show that $\partial A_1/\partial(cs) > 0$, $\partial A_1/\partial\mu < 0$, that is, college enrollment decreases in the cost of college and increases in the number of college men available. Furthermore

$$\frac{\partial A_1}{\partial p^1} = -\beta\{\mu\psi y^H(2) + \mu a_0 + (1-\mu)[\psi y^H(1) + a_0 - \gamma]\} < 0,$$

so college enrollment also increases in p^1. But the sign of $\partial A_1/\partial\gamma = \beta[(1-\mu)p^1 - \mu p^0]$ is ambiguous.

Case 2: If $\psi y^H(1) + a_0 < \gamma < \psi y^H(2) + a_0$, high school graduate women accept all marriage offers but college graduate women marry only if offers are from college men. We can derive similar threshold condition in ability δ_2^*, such that individuals attend college if $\delta_i \geq \delta_2^*$. $\delta_2^* = \beta_0^{-1}\left(\ln\frac{A_2}{e^{\beta_1}[\beta e^{\beta_1} - (1+\beta)]}\right)$, where

$$A_2 = cs + \beta\left(p^0 - p^1\right)\mu[\psi y^H(2) + a_0] + \beta(1-\mu)p^0[\psi y^H(1) + a_0] - \beta\mu p^0\gamma.$$

Therefore $\partial A_2/\partial\mu < 0$, $\partial A_2/\partial p^1 < 0$ and $\partial A_2/\partial\gamma < 0$. That is, college enrollment increases if there are more college men available, if college enhances access to marriage offers more, and if women care more about the homogeneity in schooling.

Case 3: If $\gamma > \psi y^H(2) + a_0$, whenever there is a miss match in education, the disutility is overwhelming. High school women only marry high school men and college women only marry college men so the sorting is perfect. The threshold ability for college is $\delta_3^* = \beta_0^{-1}\left(\ln\frac{A_3}{e^{\beta_1}[\beta e^{\beta_1} - (1+\beta)]}\right)$, where

$$A_3 = cs + \beta\{(1-\mu)p^0[\psi y^H(1) + a_0] - \mu p^1[\psi y^H(2) + a_0]\}.$$

And again $\partial A_3/\partial\mu < 0$, $\partial A_3/\partial p^1 < 0$.

Appendix B: Data Construction

Recall that 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. The 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 received 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 youth enrolled in regular school in each month of the previous year. This question started in 1981. I thus have individual's monthly schooling status from January 1980. I treat a woman as an attendee if she reported having attended school for at least 6 months in the school year[35]. Questions on month and year respondents receive high school diploma are used to determine the graduation date. Combined this date with respondent's date of birth, her age at graduation is computed.

Employment and wage: NLSY79 workhistory 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 at least in 26 weeks of the year, and annual hours worked 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 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: an individual is

[35] For simplicity, I do not consider measurement error on choices.

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 NLSY79 until the 1990 survey and the decision 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 respondent's spouse received 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 and they 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's characteristics such as age and highest grades completed.

Appendix C: Inputs of the Model

Tabel C1: Logit Estimates of the Arrival Probability of theFirst 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)

Table C2: Potential Husbands' Schooling Distribution

Years of schooling	11 or less	12	13	14	15	16	17	18 or more
Percentage	6.88	41.69	8.65	11.03	5.30	16.16	3.53	6.77

Appendix D: Parameter Estimates

Parameters	
Utility function	
α_1	1.158 (1.96e-3)
α_2	-0.025 (4.14e-5)
α_3	-0.016 (2.38e-5)
α_4	-0.004 (5.94e-6)
v_1^1	-6.154e+4 (2.16e+2)
v_1^2	3.952e+4 (6.11e+1)
v_1^3	6.255e+4 (8.84e+1)
v_2^1	-1.125e+5 (2.72e+2)
v_2^2	2.537e+4 (4.05e+1)
v_2^3	1.095e+5 (2.34e+2)
v_3^1	-5.154e+5 (1.02e+3)
v_3^2	-2.778e+5 (3.63e+2)
v_3^3	-2.060e+4 (5.99e+1)
v_4^1	-6.041e+5 (1.83e+3)
v_4^2	-6.268e+5 (1.90e+3)
v_4^3	-2.290e+4 (3.58e+1)
v_5^1	3.490e+3 (5.12)
v_5^2	9.956e+3 (1.99e+1)
v_5^3	8.116e+3 (1.35e+1)
v_6^1	1.432e+4 (4.72e+1)
v_6^2	2.481e+4 (3.59e+1)
v_6^3	9.622e+3 (2.91e+1)
Budget constraint	
cg	3.555e+4 (9.71e+1)
cc	4.237e+4 (1.31e+2)
$\psi(0)$	0.324 (1.04e-3)
$\psi(1)$	0.484 (1.51e-3)
Job offers	
p_{hg}^0	0.772 (2.38e-3)
p_{sc}^0	0.760 (1.34e-3)
p_{cg}^0	0.707 (2.20e-3)
p_{hg}^1	0.957 (6.56e-6)
p_{sc}^1	0.999 (1.88e-6)
p_{cg}^1	1.000 (2.63e-7)

Parameters	
Type proportions	
λ_0^2	-6.729 (1.00e-2)
λ_1^2	0.410 (1.90e-3)
λ_2^2	0.120 (1.99e-4)
λ_3^2	-0.565 (8.20e-5)
λ_4^2	1.077 (2.17e-3)
λ_5^2	0.063 (7.70e-5)
λ_6^2	0.066 (2.14e-4)
λ_7^2	-0.188 (5.09e-4)
λ_0^3	-7.150 (9.47e-3)
λ_1^3	0.240 (6.20e-4)
λ_2^3	0.108 (1.94e-4)
λ_3^3	-0.115 (1.76e-4)
λ_4^3	-0.318 (6.05e-4)
λ_5^3	0.026 (3.60e-5)
λ_6^3	0.033 (4.55e-5)
λ_7^3	0.017 (2.86e-5)
π_1^1	0.732 (2.43e-3)
π_1^2	0.260 (2.41e-3)
π_2^1	1.000 (2.97e-6)
π_2^2	0.000 (2.11e-6)
π_3^1	0.659 (5.72e-4)
π_3^2	0.137 (2.82e-4)
Earnings	
β_0^1	1.132 (1.80e-3)
β_0^2	1.217 (2.42e-3)
β_0^3	1.193 (2.23e-3)
β_1^1	0.042 (5.97e-5)
β_1^2	0.055 (6.90e-5)
β_1^3	0.062 (8.60e-5)
β_2	0.101 (2.05e-4)
β_3	-0.751e-3 (1.17e-6)
β_4	0.296 (8.63e-4)
β_{0c}^1	2.362 (6.67e-3)
β_{0c}^2	1.929 (2.27e-3)
β_{0c}^3	2.214 (6.85e-3)
σ_w	0.366 (7.05e-4)
σ_{wc}	0.113 (2.09e-4)
σ_u	0.165 (4.53e-4)

Parameters	
Marriage value	
a_0^1	-7.878e+3 (1.32e+1)
a_0^2	-1.111e+3 (1.90)
a_0^3	5.953e+4 (2.35e+2)
a_1^1	-6.060e+3 (2.94e+1)
a_1^2	-4.908e+3 (1.43e+1)
a_1^3	-3.305e+3 (5.89)
a_2	0.841e+3 (1.96)
a_3	1.396e+4 (4.58e+1)
a_4	5.154e+3 (7.27)
Marriage offer	
b_0^1	-6.185 (1.16e-2)
b_0^2	-12.53 (1.76e-2)
b_0^3	-7.870 (2.48e-2)
b_1	0.219 (3.31e-4)
b_2	-0.368e-3 (1.20e-6)
b_3	0.640 (1.02e-3)
Husband's earning	
ρ_0	9.379 (1.23e-2)
ρ_1	0.043 (1.10e-4)
ρ_2	0.058 (8.50e-5)
ρ_3	-0.144e-2 (2.70e-6)
σ_{y^H}	0.550 (9.32e-4)
σ_{μ_y}	0.158 (3.24e-4)
Shocks	
σ_1	2.879e+4 (6.10e+1)
σ_2	1.302e+4 (3.80e+1)
σ_3	1.122e+4 (1.86e+1)
σ_4	1.298e+4 (2.07e+1)
σ_5	4.129e+4 (1.21e+2)
σ_6	1.684e+5 (3.22e+2)
σ_7	7.642e+4 (1.17e+2)
σ_8	2.159e+5 (7.73e+2)
End condition	
δ_1	2.484e+4 (9.33e+1)
δ_2	2.715e+4 (6.55e+1)
δ_3	-0.265e+2 (3.99e-2)
δ_4	2.662e+4 (9.20e+1)

Table 1: Descriptive Statistics

Variable	Mean	Standard deviation	Number of observations
	Sample of 487 individuals		
Years in sample	9.79	1.09	487
Age at high school graduation	17.89	0.44	487
Highest grade completed (HGC)	14.31	2.39	487
Years of total experience	6.73	2.66	487
Marriage duration in years	3.84	3.25	487
	Sample of 345 at the first marriages		
Women's age	23.06	2.64	345
Men's age	26.08	4.23	345
Women's HGC	13.56	1.87	345
Men's HGC	13.28	2.27	345
	Sample of 4,770 person-year observations		
Age	23.34	2.90	4770
Attend school (percent)	24	42	4770
Work (percent)	69	46	4770
Married (percent)	38	49	4770
Child (percent)	22	41	4770
Hourly wage*	9.88	8.27	3126
Husband's annual earnings*	34,896	41,124	1858

* In 2000 dollars.

Table 2: 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.

Table 3: Mean Transitions

From\To	Attend	Not-Attend
Attend	66.45	33.55
Not-Attend	5.31	94.69
From\To	Work	Non-employed
Work	88.76	11.24
Non-employed	34.77	65.23
From\To	Single	Married
Single	87.71	12.29
Married	3.63	96.37

Table 4: Attendance and Marriage Probits

	Attendance probit	Marriage probit
Constant	1.949 (0.198)	-3.480 (0.191)
Age	-0.069 (0.009)	0.132 (0.008)
Participation	-1.242 (0.052)	-0.090 (0.055)
Presence of children	-1.044 (0.089)	1.236 (0.056)
Marital status	-0.629 (0.062)	
Attendance		-0.749 (0.064)
Log likelihood (No. of obs.)	-1863.0 (4770)	-2334.4 (4770)
Likelihood Ratio χ^2	1485.2	1684.1

Table 5: Employment Probits

	All women (1)	Married women (2)	Married women (3)
Constant	1.396 (0.265)	2.440 (0.439)	2.235 (0.464)
Experience	0.616 (0.034)	0.499 (0.052)	0.457 (0.056)
Experience squared	-0.041 (0.004)	-0.025 (0.006)	-0.021 (0.006)
Age	-0.125 (0.016)	-0.170 (0.022)	-0.161 (0.024)
Schooling	0.128 (0.017)	0.114 (0.023)	0.128 (0.025)
Attendance	-1.275 (0.057)	-0.834 (0.136)	-0.820 (0.144)
Presence of children	-0.967 (0.065)	-0.961 (0.075)	-0.980 (0.078)
Marital status	-0.322 (0.059)		
Husband's earnings (thousands)			-0.003 (0.0008)
Log likelihood (No. of obs.)	-2079.8 (4,770)	-870.9 (1,831)	-805.1 (1,711)
Likelihood Ratio χ^2	1771.0	489.6	433.7

Table 6: Mean and Deciles of Women's Hourly Wage

Year	Mean (no. of obs.)	Wage Deciles 10%	20%	30%	40%	50%	60%	70%	80%	90%
1	6.17 (175)	4.64	5.33	5.87	5.98	6.24	6.39	6.51	6.90	7.54
2	6.81 (248)	5.02	5.76	5.96	6.15	6.38	6.76	7.22	7.73	8.83
3	6.93(262)	5.12	5.79	5.98	6.36	6.69	7.14	7.50	8.27	9.53
4	7.59(295)	4.97	5.61	6.07	6.62	7.13	7.60	8.44	9.47	10.72
5	8.01(359)	5.26	5.73	6.38	6.96	7.46	8.16	9.05	10.26	11.89
6	10.01(367)	5.84	6.56	7.31	8.03	8.80	9.47	10.52	12.30	14.62
7	11.38(358)	6.28	7.46	8.39	9.17	10.19	11.20	12.57	14.40	17.28
8	12.66(367)	6.06	7.38	8.33	9.30	10.61	11.83	13.68	15.59	18.90
9	12.65(350)	6.23	7.66	8.47	9.46	11.04	12.37	14.30	15.96	19.36
10	12.70(345)	6.25	7.75	8.85	9.88	11.49	12.91	14.80	17.11	19.58

Table 7: Assortative Mating in Education at the First Marriage

Married Women's Schooling	Husband's Schooling: HS or less	Some College	College Graduates
HS Graduates	77.7	15.7	6.6
Some College	42.9	38.5	18.7
College Graduates	19.5	20.7	59.8
Correlation in Years of Schooling: 0.55			

Table 8: Background and Outcomes

	No. of Obs.	HGC	% HS graduate	% some college	% college graduate	Mean hourly wage (std. err.) at 25-28	% married at 25
All	487	14.3	38.6	23.6	37.8	12.7 (0.7)	52.0
Mother's Schooling:							
Non-high school graduate	100	12.9	64.0	24.0	12.0	11.3 (1.0)	58.0
High school graduate	267	14.2	39.7	25.5	34.8	12.1 (0.7)	53.9
Some college	60	15.2	21.7	28.3	50.0	12.4 (0.7)	53.3
Collge graduate	60	16.3	8.3	10.0	81.7	17.9 (3.7)	31.7
Father's Schooling:							
Non-high school graduate	114	13.2	59.7	21.0	19.3	10.3 (0.8)	64.9
High school graduate	205	13.9	44.4	26.8	28.8	12.0 (0.7)	53.2
Some college	64	14.8	23.4	31.3	45.3	11.3 (0.6)	56.3
College graduate	104	16.1	13.5	15.4	71.1	17.4 (2.5)	32.7
Number of Siblings:							
0	17	14.7	35.3	17.7	47.0	17.3 (4.9)	23.5
1	94	14.6	33.0	25.5	41.5	12.4 (0.8)	48.9
2	144	14.5	36.1	24.3	39.6	12.7 (0.8)	49.3
3	104	14.5	35.6	21.1	43.3	13.7 (2.2)	54.8
4+	128	13.7	48.4	24.2	27.4	11.5 (1.3)	58.6
Household Structure at 14:							
Live with both parents	68	13.9	41.2	33.8	25.0	15.8 (3.3)	48.5
Not live with both parents	419	14.4	38.2	22.0	39.8	12.2 (0.5)	52.5
Net Family Income:							
$Y <= 1/2$median	40	13.8	47.5	25.0	27.5	12.0 (2.4)	60.0
$1/2$median$< Y <=$median	204	13.9	44.1	29.4	26.5	12.8 (1.3)	56.4
median$< Y <= 2$median	210	14.6	33.8	19.5	46.7	12.6 (0.8)	46.7
$Y > 2$median	33	15.6	24.2	12.1	63.6	13.6 (1.3)	48.5
AFQT Percentile Score							
AFQT<=20	48	12.5	77.1	18.7	4.2	9.8 (1.1)	58.3
20<AFQT<=50	173	13.3	57.2	26.0	16.8	11.5 (1.1)	57.8
50<AFQT<=80	191	14.9	25.1	25.7	49.2	12.2 (0.5)	52.9
AFQT>80	75	16.3	5.3	16.0	78.7	18.5 (3.1)	32.0
Age at High School Graduation							
17	76	15.0	28.9	21.1	50.0	14.3 (1.5)	57.9
18	389	14.2	39.6	23.6	36.8	12.6 (0.8)	51.2
19	22	13.2	54.6	31.8	13.6	9.1 (0.8)	45.5

Table 9: Chi-Square Goodness-of-Fit Tests of the Within-Sample Choice Distribution

Year	Choices								χ^2 Row
	NNS	ANS	NWS	AWS	NNM	ANM	NWM	AWM	
1	0.71	0.73	0.13	0.00	1.09	0.01	0.10	0.01	2.77
2	0.01	0.06	0.21	0.02	0.00	0.04	0.18	0.01	0.52
3	0.02	0.04	0.15	0.01	0.03	1.27	0.01	0.46	1.99
4	0.00	0.10	0.04	0.04	0.19	0.25	0.02	0.24	0.87
5	0.69	0.86	0.55	0.01	0.60	0.12	0.12	0.18	3.13
6	0.24	0.01	0.07	0.02	0.01	0.07	0.02	0.01	0.44
7	0.01	0.06	0.01	0.45	0.05	0.26	0.02	0.92	1.78
8	0.17	0.19	0.11	0.22	0.04	0.04	0.01	0.44	1.21
9	0.27	0.79	0.00	0.41	0.06	0.02	0.09	0.78	2.42
10	0.01	0.39	0.07	0.61	0.06	0.01	0.02	0.97	2.13

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, $\chi^2_7(0.05) = 14.07$.

Table 10: Fit of the Mean Transitions

From\To	Attend	Not-Attend
Attend	63.23 (66.45)	36.77 (33.55)
Not-Attend	5.97 (5.31)	94.03 (94.69)

From\To	Work	Not Work
Work	83.47 (88.76)	16.53 (11.24)
Not Work	46.60 (34.77)	53.40 (65.23)

From\To	Single	Married
Single	87.31 (87.71)	12.69 (12.29)
Married	4.75 (3.63)	95.25 (96.37)

Note: Data moments are in parentheses.

Table 11: Predicted Matching in Education at The First Marriage

Married Women's	Husbands' Schooling		
Schooling	HS Graduates	Some College	College Graduates
HS Graduates	69.6 (77.7)	27.2 (15.7)	3.2 (6.6)
Some College	44.7 (42.9)	36.4 (38.5)	18.9 (18.7)
College Graduates	11.9 (19.5)	32.5 (20.7)	55.6 (59.8)

Note: Data moments are in parentheses.

Table 12: Selected Characteristics in the 10th Year After Graduation by Skill Type

	Skill Type One	Skill Type Two	Skill Type Three
Sample proportions	49.6	40.6	9.8
Proportions of			
High school graduates	73.8	4.7	0.0
Some college	26.2	23.5	2.2
College graduates	0.0	71.8	97.8
Years of			
Schooling	12.3	15.6	19.9
Experience (after school)	7.8	5.1	1.7
Marriage duration	3.7	4.0	3.3
Proportion who			
Attend school	0.3	6.8	78.8
Work	75.6	74.4	86.0
Marry	62.6	70.8	43.0
Mean hourly wage			
($2000)	11.7	17.3	12.0

Note: Sample proportions are based on 5,000 simulations and other characteristics are based on simulations for 5,000 individuals of each type.

Table 13: Relationship of Selected Family Background Characteristics to Skill Types

	% Skill Type 1	% Skill Type 2	% Skill Type 3
All	49.6	40.6	9.8
Mother's Schooling:			
Non-high school graduate	69.4	20.3	10.3
High school graduate	51.9	35.1	13.0
Some college	37.1	49.2	13.7
Collge graduate	19.3	68.2	12.5
Father's Schooling:			
Non-high school graduate	59.7	29.5	10.8
High school graduate	51.0	36.1	12.9
Some college	45.8	40.2	14.0
College graduate	37.1	47.1	15.8
Number of Siblings:			
0	20.1	72.4	7.5
1	29.3	61.1	9.6
2	40.2	47.9	11.9
3	51.6	35.0	13.4
4+	61.6	24.0	14.4
Household Structure at 14:			
Live with both parents	48.6	38.5	12.9
Not live with both parents	61.2	16.6	22.2
Net Family Income:			
$Y <= 1/2$median	55.0	31.9	13.1
$1/2$median$< Y <=$median	52.0	34.8	13.2
median$< Y <= 2$median	47.5	39.3	13.2
$Y > 2$median	38.0	49.3	12.7
AFQT Percentile Score			
AFQT<=20	88.6	5.1	6.3
20<AFQT<=50	70.9	18.5	10.6
50<AFQT<=80	33.5	53.9	12.6
AFQT>80	10.8	80.2	9.0
Age at High School Graduation			
17	46.3	41.5	12.2
18	49.6	37.0	13.3
19	53.0	32.6	14.4

Note: Results are based on 5,000 simulations.

Table 14: Background Differencs: NLSY79 v.s. 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

Table 15: 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	6.40	37.34	21.75	4.79	3.89	20.48	3.46	1.89

Note: statistics are based on 22 to 35 years old white males whose years of schooling are at least 10 years from CPS 1980-1983 and 1997-2000.

Table 16: The Impact of Marriage Expectations on Education Outcome by Skill Types

	All	Type 1	Type 2	Type 3
Baseline Model				
Mean HGC	14.3	12.3	15.6	19.9
% HS Graduate	39.0	73.8	4.7	0.0
% Some College	23.0	26.2	23.5	2.2
% College Graduate	38.0	0	71.8	97.8
(1) No Educational Assortative Mating ($a_1 = a_2 = 0$)				
Mean HGC	14.3	12.6	15.2	19.4
% HS Graduate	24.3	45.4	3.7	0
% Some College	44.6	54.6	43.5	1.8
% College Graduate	31.1	0	52.8	98.2
(2) College Does Not Increase Marriage Offers ($b_3 = 0$)				
Mean HGC	14.3	12.1	15.7	20.3
% HS Graduate	45.6	86.9	5.3	0.0
% Some College	15.0	13.1	19.2	2.4
% College Graduate	39.4	0	75.5	97.6
(3) Both (2) and (3) Hold ($a_1 = a_2 = 0,\ b_3 = 0$)				
Mean HGC	14.2	12.2	15.3	19.7
% HS Graduate	42.5	80.8	5.6	0
% Some College	25.3	19.2	38.1	1.6
% College Graduate	32.2	0	56.3	98.4
(4) No Marriage Offers ($Pr_t = 0$)				
Mean HGC	15.0	12.3	16.9	21.8
% HS Graduate	37.3	74.5	0	0
% Some College	13.7	25.5	0.2	0
% College Graduate	49.0	0	99.8	100