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

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This article investigates the sequential college attendance decision of young women and quantifies the effect of marriage expectations on their decision to attend and graduate from college. A dynamic choice model of college attendance, labor supply, and marriage is formulated and structurally estimated using panel data from the NLSY79. The model is used to simulate the effects of no marriage benefits and finds that the predicted college enrollment rate will drop from 58.0% to 50.5%. Using the estimated model, the college attendance behavior for a younger cohort from the NLSY97 is predicted and used to validate the behavioral model.

I. Introduction

According to the existing empirical literature (Willis and Rosen 1979), an increase in earnings power is the primary motivation for going to college. However, this literature has ignored a potentially important benefit of college: that college improves marriage opportunities by providing a social venue to meet potential spouses. A college-educated individual is substantially more likely to have a college-educated spouse and thus to enjoy

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educational balance in the household and benefits from the spouse's earnings power. Although this "marriage benefit" of college surely applies to both sexes, it is likely to be particularly more important for women because married men on average have higher labor force participation rates and higher incomes than do married women. If the marriage benefit is a major component of returns to college, its omission will bias downward the estimated returns to college. Without knowing the relevant returns to college, we can neither understand gender differentials in educational attainment nor draw proper education policy inferences.

The first goal of this article is to quantify how much gains in the marriage market might account for women's college attendance and graduation decisions. To this end, I construct and estimate a dynamic model of the joint schooling, marriage, and employment decisions made by young women. In the model, women who attend and graduate from college enjoy three types of gains in the marriage market. First, attending college can increase the arrival rate of marriage proposals. Second, women prefer having spouses with education levels similar to their own,¹ which provides them with an incentive to go to college if the majority of potential spouses have college degrees. Third, there may exist a monetary transfer from the husband to the wife within the marriage: women in college have more chances to meet and marry men with higher education and therefore higher earning potential, providing another incentive to attend college. Other determinants of the college decision, including the cost of college, individual ability, family background, and gains in the labor market, are also considered.

The second goal of this article is to assess the validity of the dynamic behavior model by exploiting data from two comparable panel surveys. Todd and Wolpin (2006) discuss different model validation tests and provide an excellent example using a social experiment. In this article, I use out-of-sample predictions, which compare two cohorts, to assess the validity of a structurally estimated model. I first estimate how exogenous sources determine individual behavior (e.g., college attendance) based on data from a baseline cohort. The validity of the model is then assessed according to how well the variations over time in the exogenous sources predict the change in individual behavior observed for a younger cohort.

A central empirical challenge in assessing the effect of marriage on college decisions is the dynamic simultaneity of the decisions. The dynamics of the decision process is due to the dependence of current choices

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

on previous choices. Whether a woman will complete her senior year of college is largely determined by whether she finishes her junior year; her labor force participation depends on her labor market experience; her marital experience (marriage duration and children) is of crucial importance to her marriage decisions. The simultaneity of the decision process is the nature of human behavior. Women normally make schooling decisions jointly with work and marriage decisions simply because a job offer or a marriage proposal is the opportunity cost of attending college. For example, 3 years after high school graduation, almost half of all single women (47.6%) are still in college, whereas only 9.7% of married women remain in college. Without understanding the dynamic process of the joint decisions made by women, quantifying which factors determine each choice, including the sequential college attendance decision, is impossible.

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

The model is estimated using a sample of high school white females from the National Longitudinal Survey of Youth 1979 (NLSY79). To assess the importance of marriage on college attendance, a counterfactual economy is considered where all benefits from marriage are ruled out. The optimal choices are numerically simulated in such a hypothetical world, and a comparison is made of the predicted college enrollment with the actual economy. In the benchmark economy, the college enrollment rate is 58% and the graduation rate is 37.0% for female high school

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

graduates.³ With no benefits from marriage, the college enrollment rate drops to 50.5%, whereas the graduation rate increases slightly to 39.0%. In an alternative counterfactual economy where marriage is not a feasible option for women, the college enrollment rate drops to 51.8% and the graduation rate increases to 48.8%. When women always stay single, attending college generates no benefits through the marriage market; thus, the enrollment rate declines. In contrast, once a woman has attended college, she is less likely to drop out of school if she stays single. Therefore the graduation rate increases when the option to marry is not available.

The estimation of the model is based on an NLSY79 sample of young women who were graduating from high school in the early 1980s. About 20 years later, the college enrollment rate of an NLSY97 sample increases to 80%. These two NLSY samples provide a unique source for model validation because almost identical survey instruments have been used by the Bureau of Labor Statistics. The estimated model based on the NLSY79 sample can predict well the college attendance behavior of the NLSY97 sample. The result is consistent with the stability of the structural model; that is, “fundamental” parameters of the individual are invariant to changes in the environment.⁴

This article builds on existing literature on dynamic schooling choice models. Willis and Rosen (1979) find that individuals self-select themselves into the schooling level for which they have comparative advantage and that expected lifetime earnings gains affect the decision to attend college. Eckstein and Wolpin (1999) and Cameron and Heckman (2001) find that family background and unobserved ability are the most important determinants of the schooling decision. These studies focus almost exclusively on how individual characteristics and gains in the labor market influence a male’s decision to attend school, but they are silent regarding the effect of gains in the marriage market and how women’s education decisions are made in general. This article also builds on recent work that estimates the dynamic models of employment and marriage. In particular, Gould (2008) estimates a dynamic model of marriage and employment on a sample of men. Van Der Klaauw (1996) constructs and estimates a structural dynamic model that explicitly addresses the joint decision on marital status and labor force participation for females. Seitz (2007) ex-

³ Throughout this article, the college enrollment rate refers to the proportion of individuals among female high school graduates who have attended any college within 10 years since high school graduation. The college graduation rate corresponds to the proportion of individuals among female high school graduates who have graduated from college with a bachelor’s degree within 10 years since high school graduation.

⁴ As discussed in Wolpin (1996), a major advantage of structural estimation is that it is capable of performing counterfactual policy experiments that entail extrapolations outside the current policy regime.

tends Van Der Klaauw's model to an equilibrium setting. However, the schooling decision is taken as given in both models. Keane and Wolpin (2010) extend the choice set to include schooling, fertility, and welfare participation, but their focus is on racial differences in behavior and the effect of the welfare program.

This article also contributes to the literature considering the interactions between marital status and the schooling decision. Following the seminal work of Becker (1973), the economics literature on marriage highlights that one's own schooling can improve the spousal schooling one acquires in the marriage market (Boulier and Rosenzweig 1984; Behrman, Rosenzweig, and Taubman 1994; Weiss 1997). Interactions between education investment, assortative mating, and marriage outcome have been studied in recent theoretic models of individual behavior (Iyigun and Walsh 2007; Chiappori, Iyigun, and Weiss 2009). This article explicitly models the interdependence of these decisions and quantifies how much gains in the marriage market affect the education decision.

The remainder of this article proceeds as follows. Section II specifies an empirical model of joint school, work, and marriage decisions. Section III describes the NLSY79 data from which the model is estimated. Section IV discusses the estimation method and identification issues. Section V gives the estimation results. Section VI discusses the validation of the model. Section VII provides counterfactual simulations, and Section VIII concludes the article.

II. The Model

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

A. The Basic Structure

Consider a woman who has graduated from high school. Initially she has 12 years of school, no work experience, and has never been married or had children. Each year she chooses whether to attend college, work full-time, or get or stay married. In total, there are eight mutually exclusive and exhaustive choices. Let s_t , h_t , and m_t be the indicators for school attendance, full-time employment, and marital status, respectively. Each alternative will be a triple (s_t, h_t, m_t) .⁵ Her choice set is $\Psi = \{(s_t, h_t, m_t) : s_t \in \{0, 1\}, h_t \in \{0, 1\}, m_t \in \{0, 1\}\}$.

⁵ For example, $(s_t, h_t, m_t) = (0, 0, 0)$ corresponds to not attending school, not working, and being single.

1. Preferences and Constraints

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

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

The subscript for individuals is suppressed because a representative woman is considered. The marginal utility of consumption depends on college attendance, employment, and marital status, as captured by the parameters α_1 – α_4 . Parameters v_1 – v_4 evaluate the net utility of attending school given employment and marital status. Fertility $f_t \in \{0, 1\}$ is an indicator of the presence of any children. The effects of having children on working are represented by v_5 and v_6 .⁶ Variable M_t is the value of marriage, as specified below. Finally, $\varepsilon_t^{(s,h,m)}$ 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 marriage. They are jointly serially independent, noncorrelated, and have a joint normal distribution $F(\varepsilon_t)$. They are known to the individual in period t but are unknown before t .

The choice decision is subject to the budget constraint given by

$$c_t + (c_s \times s_t) + (cc \times f_t) = y_t h_t + g(y_t^H), \quad (2)$$

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

⁶ Eckstein and Wolpin (1999) find that the utility of attending school is important in the education decision and depends on the employment status. Based on the observation that married women are much less likely to attend school, I allow the utility of attending school to depend on both employment and marital status. Previous studies have also found that the presence of children has a significant effect on the disutility of working (e.g., Van Der Klaauw 1996). Therefore, the value of leisure is assumed to depend on fertility.

to be satisfied period by period.⁷ Although all choices are made jointly, to clarify the model, I will discuss college attendance, labor supply, and marriage choices separately.

2. *The College Attendance Choice*

A young woman makes a sequential college attendance decision every year after high school graduation. If she attends any postsecondary school, she has to pay for tuition and room and board. The direct cost of 1 year in college equals c_s . A college degree is assumed to be completed in 4 years. When a woman attends graduate school, she pays an extra tuition cost c_g , that is, $c_s = c_s + c_g$.

In a static world, the total cost of 1 year of school is c_s plus the forgone earnings. The benefit to the young woman of attending college is the consumption value of school, v_1 , v_2 , v_3 , or v_4 , depending on her employment and marital status. The utility of school interacts with the labor supply because more involvement in market work may prevent individuals from engaging in college activities; this interaction represents the time constraint. The utility of school also depends on marital status if marriage requires leaving school or if school utility is different when married.

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

3. *The Employment Choice*

A woman receives job offers with probability $p_{E_j}^{b_{t-1}}$ every year. The job offer rate depends on her schooling level $E_j \in \{E_{hg}, E_{sc}, E_{cg}\}$, where

⁷ For a nonemployed single woman, consumption can be negative if she attends school or has children. However, utility is well defined because utility is assumed to be linear in consumption. In addition, the relative ranking, instead of the level, of the utility associated with each alternative determines individual choice. A more complete model should incorporate parental transfers and saving decisions, similar to what is done in Keane and Wolpin (2001). The saving decision is simplified from the model because Cameron and Heckman (1998, 2001) find that the short-run liquidity constraints proxied by current family income play no significant role in college attendance decisions. Cameron and Taber (2004) also find no evidence that borrowing constraints play an important role in educational attainment. Keane (2002) reviews recent work on the importance of borrowing constraints and the effect of financial aid programs.

E_{hg} , E_{sc} , and E_{cg} correspond to high school graduates, those with some college, and college graduates, respectively. The job offer rate also depends on previous labor market attachment $h_{t-1} \in \{0, 1\}$, where h_{t-1} equals one if the woman worked in the previous year and zero otherwise. As in Eckstein and Wolpin (1989), potential annual earnings are obtained by multiplying hourly wage by 2,000 hours: $y_t = \omega_t \times 2,000$. Essentially, each woman is assumed to be deciding about full-time work, and the wage rate is assumed to be independent of hours worked.

The hourly wage follows:

$$\ln \omega_t = \beta_0 + \beta_1 S_t + \beta_2 H_t + \beta_3 H_t^2 + \beta_4 I(S_t \geq 16) + \beta_5 I(1 - h_{t-1}) + \varepsilon_{\omega t}, \quad (3)$$

where S_t and H_t are years of schooling and work experience, and they evolve according to $S_t = S_{t-1} + s_t$ and $H_t = H_{t-1} + h_t$, respectively. The schooling coefficient β_1 measures the earnings return of each additional year of school. The quadratic term in work experience is meant to capture the depreciation of human capital so that wage is hump-shaped over the life cycle. Indicator function $I(S_t \geq 16)$ equals one if the individual has a college degree, and therefore its coefficient β_4 captures the sheepskin effect of a college degree. To account for the effect of the previous period's employment choice on current wage, a dummy variable $I(1 - h_{t-1})$ for moving from nonemployment to work is included in the wage equation. If there is a reentry cost associated with depreciation of human capital, we expect β_5 to be negative. The productivity shock $\varepsilon_{\omega t}$ is normally distributed with a mean zero and standard deviation σ_{ω} . The wage offer distribution varies if the woman works while in college. The hourly wage in college is assumed to be log normal, such that $\ln \omega_t = \beta_{0c} + \varepsilon_{\omega c t}$, where $\varepsilon_{\omega c t} \sim N(0, \sigma_{\omega c}^2)$. A measurement error in observed wages is allowed, such that $\ln \omega^o = \ln \omega + u$, where ω^o is the observed wage, ω is the true wage, and the error term is normally distributed: $u \sim N(0, \sigma_u^2)$.⁸ At time t , the woman observes the wage rate (hereby earnings) and decides whether to work. Before time t , she does not observe $\varepsilon_{\omega t}$, but she knows how wage and earnings evolve and the distribution of $\varepsilon_{\omega t}$. That is, she knows the expected earnings gains from the labor market as denoted by β_1 and β_4 .

4. The Marriage Choice

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

$$P_t = \frac{\exp [b_0 + b_1 \text{age}_t + b_2 \text{age}_t^2 + b_3 I(S_t > 12)]}{1 + \exp [b_0 + b_1 \text{age}_t + b_2 \text{age}_t^2 + b_3 I(S_t > 12)]}. \quad (4)$$

⁸ Measurement error is introduced to account for wage observations below the minimum wage.

The meeting technology is such that high school and college women may receive different numbers of offers. The parameter b_3 determines the difference and is to be estimated. If a college provides a social venue for young people to meet, b_3 may be positive. The distribution of potential husbands is assumed to be exogenous and remains the same for all women.⁹ Let μ_{S^H} be the fraction of men with S^H years of schooling; then, the probability of receiving a proposal from a man with S^H is $\mu_{S^H}P_t$. With probability $1 - P_t$, no offer is received. A married woman faces an exogenous separation shock η initiated by her husband. If no divorce shock is received, she has the option to either stay married or divorce her husband.

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

$$M_t = a_0 + a_1\Delta S_t^2 + a_2\text{age}_t + a_3f_t + a_4\text{mdur}_t + a_5b_t f_t. \quad (5)$$

The constant a_0 can be interpreted as the permanent preference for marriage. Educational imbalance in the household may reduce marriage utility, for example, because a disagreement occurs on the consumption of public goods. The couple's difference in schooling is denoted by $\Delta S_t = S_t - S_t^H$. The coefficient a_1 measures the effect of educational imbalance on marriage utility, and its negative value will lead to positive assortative matching in education.¹⁰ Variable a_2 reflects a woman's varying preference for marriage over time, while variables a_3 , a_4 , and a_5 measure the effect of children and previous marriage choices. Children are likely to increase marriage utility by a_3 , but this effect depends on whether the mother works, as captured by a_5 . Marriage duration in the current marriage, mdur_t , evolves according to $\text{mdur}_t = m_t[\text{mdur}_{t-1} + m_t]$. The dependence of M on marriage duration reflects a possible increase in the bond between spouses. The value of marriage varies as the marriage evolves. The random components of marriage value are included in the utility shocks ε 's.

At least two competing hypotheses can generate a positive correlation between spousal education attainment. The first hypothesis is education

⁹ The distribution of men is expected to vary by their own schooling decisions and by women's educational status. However, to address these issues empirically, I need to observe both spouses' sequential choices and also need information on dating (as discussed below), which is not available from NLSY. Incorporating the general equilibrium aspect of the marriage market into a dynamic decision model like this is left for future research. See Fernández, Guner, and Knowles (2005) for a symmetric general equilibrium model.

¹⁰ Mating is positive assortative if schooling levels are complements in production (Becker 1973). The difference in education squared with a negative coefficient is a simple way to model complementarity. Shimer and Smith (2000) derive more complex sufficient conditions for assortative mating under search costs. Wong (2003) specifies the production function as the product of the types (e.g., education) in her empirical study of marriage matching.

complementarity: similar schooling backgrounds generate higher utility for marriage. The second hypothesis is geographic proximity: highly educated women meet highly educated men more often in college. Following Becker (1973), this study adopts the first hypothesis. Although who marries whom is observed, whom individuals meet and where these meetings take place are not observed. Therefore, it is difficult to separate the two hypotheses empirically without imposing some ad hoc assumptions.¹¹ Based on first-contact e-mails within an online dating service, Hitsch, Hortaçsu, and Ariely (2010) provide evidence that women, in particular, prefer men with similar education levels.¹² Their study shows that even without geographic proximity, preferences for similar educational backgrounds play an important role in the matching process.

The direct cost of marriage is not explicitly specified in the model, but one can interpret the permanent value of marriage a_0 as net of marriage cost. In addition, the opportunity cost of marriage is implicitly built into the model. Suppose a woman meets a man whose education is much lower than hers, and she accepts his marriage proposal because the current shock to marriage utility is positive and large. Suppose in the next period she receives an average shock to marriage utility. When she was single, she should have rejected the marriage offer because the match was bad. However, because she did marry and marriage value increases with children (if she has any) and marriage duration,¹³ it might not be optimal for her to terminate the marriage.¹⁴ Therefore, the opportunity cost of marriage is the possibility that one would be trapped in a bad match and lose the option value for a better match.

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

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

where Z_t are the variables affecting the woman's bargaining power and intramarriage distribution of household income. Similarly, a divorced woman

¹¹ If the sex ratio in college and the rate of marriage are observed, the effect of geographic proximity can be potentially separated. Unfortunately, the NLSY79 data contain no information on which college each woman attended.

¹² Compared with high school-educated men, men with a master's degree receive 48% fewer first-contact e-mails from high school-educated women, 22% more e-mails from college-educated women, and 82% more e-mails from women with (or working toward) a graduate degree (Hitsch et al. 2010).

¹³ Weiss and Willis (1997) show that the presence of children stabilizes the marriage.

¹⁴ The model assumes that a married woman cannot get an outside marriage proposal. She can either stay married with her current spouse or get a divorce. Once she is divorced, she will stay divorced for at least 1 year.

with children also receives a monetary transfer from her ex-husband, such that $g(y_i^H) = \psi_d(b_i, Z_i)y_i^H$.

The model focuses primarily on the female's decision process and assumes that married men always work full-time in the labor market.¹⁵ The earnings of a (potential) husband depend on his schooling and experience. They are specified as

$$\ln y_i^H = \rho_0 + \rho_1 S_i^H + \rho_2 EX_i^H + \rho_3 EX_i^{H2} + \varepsilon_{Hi}. \quad (6)$$

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

When a marriage offer is received, a single woman makes a "take it or leave it" decision based on the utility value of marriage M , (potential) husband's income y^H , and the realization of shocks attached to marriage. If she rejects the proposal, she will get a new draw from the distribution of potential husbands the next year. A divorce is observed if a separation is initiated by the husband or if a married woman chooses to quit the marriage when a negative shock on marriage utility or the husband's earnings arrives. When a woman makes a decision to go to college (most likely before she makes the marriage decision), she knows (in expectation) how she will fare in the marriage market depending on her schooling decision. She has expectations about how often she will receive marriage proposals, the direct value of marrying each type of man, and the amount of transfer from a future husband.

5. *The Arrival of Children*

In general, both the number and ages of children may be important in determining women's choices. However, I assume that the fertility effect can be adequately captured by a single indicator of the presence of any children. The stochastic process that governs fertility over time is specified as the following logit form:¹⁶

¹⁵ As argued by Van Der Klaauw (1996), given that 95% of the male population works in a representative sample, this is not a very restrictive assumption.

¹⁶ In this model, fertility is exogenous. Clearly, a more complete model should explicitly incorporate fertility decisions as a choice variable. However, to avoid the modeling and estimation complications resulting from an increase in the choice set and the dimension of the state space, the focus here will be on the interaction among schooling, employment, and marriage decisions conditional on the fertility in each period.

$$\Pr(f_t = 1|f_{t-1} = 0) = \frac{\exp\{c_0 + c_1S_t + c_2m_{t-1} + c_3age_t + c_4age_t^2 + c_5mdur_t\}}{1 + \exp\{c_0 + c_1S_t + c_2m_{t-1} + c_3age_t + c_4age_t^2 + c_5mdur_t\}}, \tag{7}$$

whereas $\Pr(f_t = 1|f_{t-1} = 1) = 1$. The cost of children is cc . Note that the fertility rate is not necessarily zero for a single woman. A single mother is observed if this woman gives birth to a child before marriage.¹⁷

6. The Optimization Problem

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

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

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

B. Heterogeneity

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

Assume that there exist $k = 1, 2, \dots, K$ different skill types. Denote the ex ante probability that a woman i is of type k by π_i^k . Let π_i^k depend on her observed initial traits, including mother’s schooling, S_i^m ; father’s schooling, S_i^f ; number of siblings, N_i^{sib} ; household structure (whether she lives with both parents) at age 14, HH_i ; net family income, Y_i^0 ; AFQT

¹⁷ In the sample, 19% of the mothers are single. These observations are important to identify separately the cost of children, cc , and the marriage value attributable to children, a_3 . All mothers pay cc for their children, but only married mothers enjoy a_3 through their marriage.

score, AFQT_{*i*}; and age at high school graduation, AGE_{*i*}^o, in the form of a multinomial logit.¹⁸ For $k = 2, \dots, K$,

$$\pi_i^k = \frac{\exp[\lambda_0^k + \lambda_1^k S_i^m + \lambda_2^k S_i^f + \lambda_3^k N_i^{sib} + \lambda_4^k HH_i + \lambda_5^k Y_i^o + \lambda_6^k AFQT_i + \lambda_7^k AGE_i^o]}{1 + \sum_{i=2}^K \exp[\lambda_0^i + \lambda_1^i S_i^m + \lambda_2^i S_i^f + \lambda_3^i N_i^{sib} + \lambda_4^i HH_i + \lambda_5^i Y_i^o + \lambda_6^i AFQT_i + \lambda_7^i AGE_i^o]} \tag{9}$$

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

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

Furthermore, women may also differ in preference for marriage and marriageability in the marriage market. Assume that there exist $m = 1, 2, \dots, M$ different marriage types.¹⁹ Marriage type probabilities are conditional on skill types. A woman of skill type k has the probability ω_k^m of being marriage type m , so that $\sum_{m=1}^M \omega_k^m = 1$ for all k . These conditional probability parameters ω_k^m are estimated within the structural model. They depend on background variables only through skill-type probabilities. Each marriage type has a distinct preference for marriage (a_0 and a_1) and marriage offer rate (b_0).

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

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

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

Divorce legislation governs the right to divorce and influences the as-

¹⁸ Achievement scores such as high school grades and SAT scores may affect college choice indirectly by the correlation with ability types like other background variables. They may also affect college entrance directly if college acceptance depends on grades or SAT scores. Due to data limitations, I leave the introduction of grades to a schooling model such as this one to future research.

¹⁹ $K = M = 3$ were chosen after sensitivity analysis.

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

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

That is, a married woman receives half of her husband's income if she does not work.²⁰ Otherwise, if she is employed, the transfer depends on the divorce law indicator Z_{it} , with one corresponding to a mutual agreement to divorce and zero if a unilateral divorce is allowed.²¹ Transfers from an ex-husband to a divorced woman with children also depend on divorce legislation and her employment status. They are specified in a similar way:

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

Previous studies (e.g., Chiappori, Fortin, and Lacroix 2002) indicate that the mutual-consent-divorce law is favorable to women and increases their bargaining power.²² Therefore, the coefficients on divorce law dummy Z_{it} are expected to be positive.

C. Solution to the Decision Problem

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

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

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

²⁰ This assumption is made because a_0 and ψ are not separately identified.

²¹ The existence of a local college and the state divorce legislation are assumed to be exogenous in eqq. (10) and (11). Although migration is potentially endogenous and related to schooling cost or state divorce law, the local college variable Col_{it} and the divorce law variable Z_{it} can be interpreted as indicators of local demand conditions that affect education and marriage decisions. This is similar to the fact that local labor demand conditions, such as unemployment rate and wages, are commonly used as instruments for employment choice.

²² Chiappori et al. (2002) find that a one-point increase in the divorce laws index, which is favorable to women, induces husbands to transfer an additional \$4,310 to their wives.

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

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

The solution to the model can be characterized by sequential cut-off rules. In this multiple-period model with multiple choices, the cut-off values do not have analytical forms, but the model can be solved backward and the cut-off values can be simulated numerically. The numerical complexity arises because the value function has to be computed at each point of the state space. The state space for this model is large because the choice set contains eight elements ($s \times b \times m$), and the state space increases exponentially with respect to the decision periods within the lifetime horizon, which is known as the "curse of dimensionality." The terminal date T_i should correspond to the last period where the value function is determined by the state variables. One can solve the model over an arbitrarily long horizon, for example, until age 65. However, in a model like this, a huge computational burden is involved. Instead, similar to the method used in Keane and Wolpin (2001) and Eckstein and Wolpin (1999), the backward recursion starts at a computationally convenient terminal period, $T_i = T^*$.²³ During the first $T^* - 1$ periods, for each individual i , the model is solved explicitly. At the terminal period T^* ,

$$\begin{aligned}
 &V_{iT^*}^{(s,b,m)}(\Omega_{iT^*}) = U_{iT^*}(c_{T^*}, s_{T^*}, h_{T^*}, m_{T^*}) \\
 &+ \beta E[V_{iT^*+1}(\Omega_{iT^*+1})|\Omega_{iT^*}, (s_{T^*}, h_{T^*}, m_{T^*}) \text{ is chosen at } T^*].
 \end{aligned}
 \tag{15}$$

As with the rest of the model, prior random shocks to wages or preferences only affect decisions through state variables, including years of schooling, experience, and marriage duration. Therefore, a polynomial form of the

²³ In the empirical estimation, the terminal period is set to 10 so that $T^* = 10$. The model was solved explicitly for 10 years for all individuals.

state variables at the terminal period was used to estimate the terminal value function,²⁴ namely,

$$V_{iT^*+1}(\Omega_{iT^*+1}) = \delta_1 S_{iT^*+1} + \delta_2 H_{iT^*+1} + \delta_3 H_{iT^*+1}^2 + \delta_4 \text{mdur}_{iT^*+1}. \quad (16)$$

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

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

III. Data

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

The analysis was focused on a fairly homogenous population, which consists of white females from the NLSY79 core random sample who received a high school diploma and reported a graduation date. All women in the sample graduated from high school during May to August between 1980 and 1983. The sample is restricted to women who graduated from high school between the ages of 17 and 19. At the time of the graduation, the women were single and had no children.²⁵ Eighty-nine individuals were dropped from the sample because of inconsistent or incomplete observations on schooling, employment, or marital choices. This left a sample of 582 women born between 1961 and 1964. Another 95 women were excluded from this study because their family background information was not complete. Selected individuals remained in the sample up to 10 years as long as consecutive annual schooling, employment, and marriage profiles were observed. The empirical analysis was based on this sample of 487 females, with a total of 4,770 person-year observations.

²⁴ In an early specification search, a skill-type specific constant was included in the terminal condition. However, the estimated values were not significantly different from zero; therefore, the constant was dropped from eq. (16).

²⁵ Complete schooling history is not available before 1980; therefore, the sample is restricted to high school graduates after 1980. Seven individuals graduated after 1983. Nine individuals graduated before 17 or after 19. More than 96% of the sample received a high school diploma during May to August. Twenty-four women were married or had children at the time of graduation.

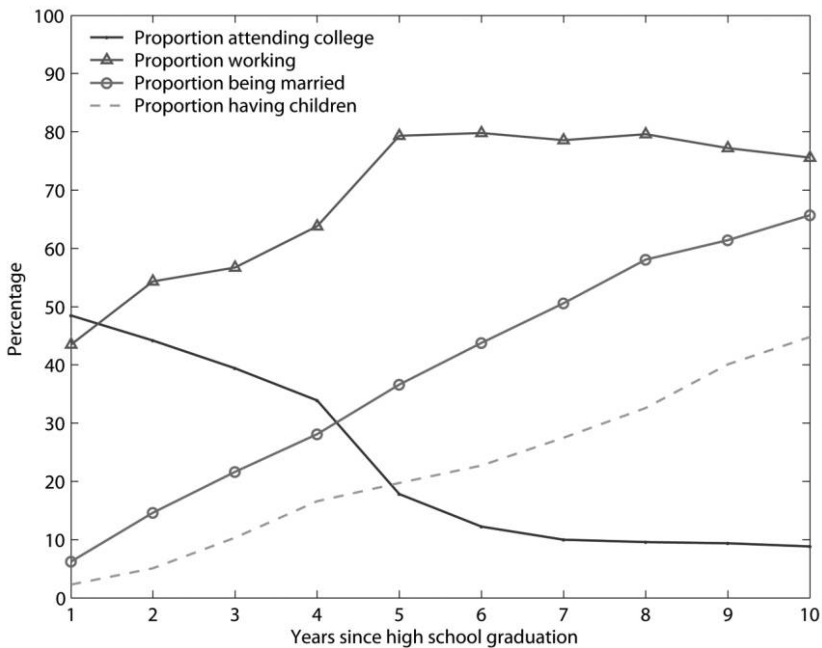


FIG. 1.—Proportions attending college, working, married, and having children. Color version of this figure is available as an online enhancement.

The details of data construction and variable definitions are described in appendix A in the online version of this article.

Figure 1 presents the college attendance, employment, marriage rates, and the fraction of women having children within the first 10 years after high school graduation. Among all women in the sample, 48% attended college in the first year after high school graduation. Some women entered college for the first time several years later: about 61% of the sample attended college for at least 1 year. College attendance falls by 4%–5% annually throughout the first 3 years. After the fourth year, a discrete drop of more than 15% is observed, corresponding to typical college graduation. The attendance rate continues to fall but remains around 9% after 7 years. This pattern reflects the fact that some women return to school.²⁶ The labor force participation rate exhibits the well-known hump

²⁶ About one-third of the women in the sample had the experience of leaving and subsequently returning to school. This is very different from the experience of men. Cameron and Heckman (2001) document that only 2%–6% of high school graduates and 6%–12% of dropouts report at least one episode of leaving and then returning to school.

Table 1
Choice Proportions by Years after High School

Year	No. Observations	NNS	ANS	NWS	AWS	NNM	ANM	NWM	AWM
1	487	15.2	37.6	30.6	10.5	3.5	.2	2.3	.2
2	486	9.5	31.7	32.7	11.5	4.1	.4	9.5	.6
3	485	8.0	26.8	33.0	10.5	6.6	1.9	13.0	.2
4	481	6.2	21.0	33.9	10.8	7.5	1.5	18.5	.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	.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	.9	27.0	3.4	18.6	1.9	42.6	2.6

NOTE.—NNS = not-attend, not-work, single; ANS = attend, not-work, single; NWS = not-attend, work, single; AWS = attend, work, single; NNM = not-attend, not-work, married; ANM = attend, not-work, married; NWM = not-attend, work, married; AWM = attend, work, married.

shape. It increases from 43% to about 80% in the first 6 years and then becomes flat and declines slightly. The percentages of women who are married and women who have children increase over time. At a more disaggregate level, table 1 shows the proportion of women who choose each of the eight alternatives. The labor force participation rate of married women is significantly lower than that of single women except for the first few years when few women are married. Another interesting observation is that very few married women stay in college, which indicates low complementarity between marriage and college.

Real hourly wages are obtained as explained in appendix A in the online version of this article. In solving the dynamic programming problem, actual hours worked are ignored. Annual earnings are obtained by multiplying the hourly wage by 2,000 hours. Among all the wage observations, wages of women who work while in school are much lower and less dispersed. When wage observations for women who are not in school are used to run an ordinary least squares (OLS) log wage regression on years of schooling and experience, the regression yields the following coefficients with the 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), and β_3 (experience²) = -0.005 (0.001). The concavity of the experience profile and the positive schooling effect are consistent with those in many other studies.

Seventy-one percent of the sample married at least once. Married couples tend to share a common schooling background. At the time of the first marriage, 42% of the couples had the same educational attainment, and the correlation between spousal years of schooling was 0.55. Sixty percent of college women's husbands were college graduates, whereas less

Table 2
Background and Schooling Outcomes

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

than 7% of high school women's husbands were college graduates.²⁷ Although the sample women were in their twenties, many of them had already undergone one or more changes in marital status. Throughout the sample period, 142 women (29%) remained single, 25 (5%) married twice, and 54 (11%) experienced at least one divorce. Most of the divorced women did not go to college.²⁸

Detailed family and cognitive background variables are constructed for the selected sample. Table 2 illustrates the potential importance of background in determining school outcomes. Both parents' education levels have a strong positive correlation with women's schooling outcomes. Women whose family income is greater than twice the median obtain almost 2 years more schooling than women whose family income is less than half of the

²⁷ If schooling homogamy provides positive value to marriage, marriages in which partners share similar educational backgrounds are expected to be more stable. However, due to the small number of observations, the joint schooling distributions are not statistically different in marriages that survived and ended in divorce during the sample periods.

²⁸ From a life-cycle perspective, this number is probably biased because college graduates get married later. Therefore, observing their divorce over the same time span is less likely. However, some aggregate data show the same pattern. According to the data from the National Survey of Family Growth, among non-Hispanic 20-44-year-old white women in 1995, the probability of first marriage disruption after 15 years is 55% for high school dropouts, 45% for high school graduates, and 36% for women with more than a high school education.

median. AFQT scores are strongly correlated with schooling outcome. Seventy-nine percent of women in the top 20 percentile of AFQT scores completed college, whereas 77% of the women in the bottom 20 percentile AFQT scores did not attend college. Furthermore, the number of siblings has little effect on schooling outcome if less than four and reduces the number of years in college otherwise (not shown in table 2). Women who live with both parents at age 14 obtain a half year more schooling than those from broken families. Those who graduate from high school earlier subsequently do significantly better in school than those who graduate later.

The NLSY geocode was used to identify each individual's county and state of residence and match that individual with the local school information and state divorce law index. Annual data on location, type of institution, and other variables associated with all colleges in the United States are available from the Department of Education's annual Integrated Postsecondary Education Data System (IPEDS) Institutional Characteristics surveys.²⁹ "Local college" is a dummy variable for the presence of any 2-year or 4-year college in the county of residence at age 18. Among all women in the sample, 88.3% of them lived in a county with a local college. State-level features of divorce legislation are from the data appendix of Wolfers (2006). A binary indicator for mutual-consent-divorce law is constructed for each individual based on her state of residence. In the sample, 46.8% of women lived in a state with mutual-consent-divorce law in 1985.

IV. Estimation Method

A. Simulated Maximum Likelihood Estimation

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

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

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

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

The solution to the individual's optimization problem provides the within-period choice probabilities. To illustrate the computation of the likelihood, let us consider a specific outcome at some period. Suppose a woman who chooses not to attend school but to work full-time instead reports receiving a wage ω_t^o and marries a man who has S_t^H years of

²⁹ Data can be downloaded from <http://www.nces.ed.gov/ipeds/datacenter/DataFiles.aspx>.

schooling and earns an annual income y_t^{oH} in period t . Further, assume that the individual enters the period being single and having state space Ω_t . The probability of this outcome is

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

This probability has three components: the first term on the right-hand side is the probability of receiving a job offer and a marriage proposal from a man with S_t^H years of school $P_{E_j}^{b_{t-1}} P_t \mu_{S_t^H}$, the second term is the choice probability of not attending school and accepting both the job offer and the marriage proposal, and the last term is the probability of observing the woman's wage w_t^o and her husband's income y_t^{oH} . The choice probability involves the calculation of multivariate integrals as in general multinomial choice problems. I calculate the joint probability of choosing $(s_t = 0, b_t = 1, m_t = 1)$ conditional on the true wage and income by a smoothed simulator, following Eckstein and Wolpin (1999). For each of $k = 1, 2, \dots, K$ draws of the error vector, the ε 's, a smoothed simulator of the probability that $(0, 1, 1)$ is chosen, is given by the kernel

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

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

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

The model is restricted to have an exogenous process on fertility and an exogenous schooling distribution of potential husbands. I estimate the probability of a first birth separately and use it as input to the estimation algorithm.³⁰ Results from the logit estimation are presented in appendix

³⁰ The probability of the first birth depends on schooling and marital status, which are correlated with unobservables (i.e., ability, taste for marriage, etc.). Therefore, the logit estimates may be biased and inconsistent. I assume that the potential bias is small and adopt a two-step procedure as in Van Der Klaauw (1996).

B in the online version of this article. Schooling has a negative effect on the probability of having children. Married women are more likely to have children than single women. As women become older, their probability of having at least one child increases but at a diminishing rate. I calculate the schooling distribution of 22–35-year-old white males between 1980 and 1983 from the CPS and use it as the nonparametric estimates of potential husbands’ schooling distribution (table 7). Furthermore, the discount factor β is set to 0.96, that is, an annual rate of time preference of 4%.

For the selected sample indexed by $i = 1, \dots, N$, I observe each individual’s family and cognitive background, the presence of any college at her county of residence Col_i , and the state divorce law Z_i ; schooling, employment, marital status, and fertility every year $(s_{it}, b_{it}, m_{it}, f_{it})$; wages if employed (w_{it}^o) ; and characteristics of the first marriage: husband’s schooling S_{it}^H and annual income y_{it}^H , if married, for $t = 1, \dots, T^*$. I assume that the parameters describing the initial preferences, ability, and market skills are related to measured family and cognitive background. As discussed in Section II.B, there are $K \times M$ discrete types in total, and each type is described by a vector of parameters. Note that local college and state divorce law affect the school cost and marriage benefit, and therefore both of them are in the state space. The likelihood function for individual i in this case is a finite mixture of the type-specific likelihoods, namely,

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

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

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

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

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

where $s_i(\theta_0) = \partial L_i(\theta_0) / \partial \theta'$ and θ_0 is the true value of θ .

B. Identification Issues

Although the model is complex, discussing the intuition on parameter identification is nevertheless possible.³¹ Starting with the two earnings equations, (3) and (6), the coefficients are identified by the data on wages

³¹ Discussion of a simple two-period example is available on my Web page. It illustrates analytically how various sources determine college decisions, discusses the related empirical issues, and examines the identification of the model.

and husbands' earnings. I only observe wages for those who work, but the solution to the optimization problem provides the sample selection rules. The identification of the utility function parameters follows closely that of Keane and Wolpin (1997) and Eckstein and Wolpin (1999). In particular, because the cost of college (cs) enters the model linearly with the value of schooling v_1-v_4 , γ_0 was set to be 7,515 in the estimation based on the estimates from the National Center for Education Statistics from 1980–1988 (NCES 1990, 285, table 291). The cost of graduate school (cg) is identified because it only occurs during post-college attendance.

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

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

The question is, of course, whether all these gains in the marriage market can be attributed to schooling. The observed differences of husbands'

education and earnings between college women and high school women reflect not only the returns to college but also the returns to differences in some unobserved characteristics of women (e.g., attractiveness) between the two groups. To correct this type of self-selection bias, the presence of any college in one's county of residence is used as an exclusion restriction.³² As shown by Card (1993) and others, the existence of a local college reduces the cost of college but does not influence the decision as to whom and when to marry.

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

There are two concerns about using husband's earnings as an exclusion restriction. First, although a rich husband (conditional on his education) increases the probabilities of getting and staying married for a woman, its effect on the "expected" gains to marriage might be small because idiosyncratic shocks could cancel them out. To address this concern, I introduce into the model "distributional factors" (Chiappori et al. 2002), which exogenously shift women's perspective in the marriage market. Specifically, a dummy for mutual-consent-divorce law was used as a distributional factor,³³ and the transfer parameter ψ was specified as a function of regional variations in the features of the divorce law as in equations

³² In the Willis-Rosen model (1979), family background is used as an exclusion restriction for school decision, which shifts marginal cost of education but does not influence earnings directly. In this model, family background is correlated with unobserved ability, which affects schooling decision directly. However, ability is allowed to be correlated with unobserved characteristics in the marriage market, which affect both marriage preferences and marriage offer rates. Thus, family background also affects the value of marriage and therefore cannot be used as an exclusion restriction for schooling decision.

³³ Chiappori et al. (2002) also suggest other distributional factors. For example, sex ratio may affect the relative spousal bargaining power. However, for each ex-ante different type of individual, the dynamic programming problem needs to be solved separately. I restricted my attention to a single dummy for unilateral-divorce law, so that the model is solved for 36 types: nine unobserved skill and marriage types \times two types for the existence of local college \times two types for unilateral-divorce law.

(11) and (12). The divorce law index shifts the (expected) value of marriage by affecting transfers from the husband but has no direct effect on college attendance. Thus, the effect of expected gains in the marriage market on school decision is identified.

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

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

V. Estimation Results

A. Parameter Estimates

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

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

According to the estimates of the wage equation parameters, both skill rental price and return to schooling are the lowest for skill type 1. Type 2 women have the highest skill rental price, whereas skill type 3 women have the highest return to schooling. Each additional year of schooling increases wages by 5.0%, 6.0%, 6.2%, respectively, for each type. Note that the estimated returns to schooling are much lower than the OLS

estimates, providing evidence that without controlling for self-selection, the earnings return to education is upward biased.³⁴ College graduation increases wages by 29.6% conditional on years of schooling and experience. Although skill type 1 women have a much lower skill rental price and much lower returns to schooling for the formal labor market, they seem to have a comparative advantage for jobs available at school as indicated by the highest β_{0c} .

In the estimated marriage evaluation rule, the negative a_1 confirms that the education attainment of both spouses are complements within the family. The value of marriage increases with age, children, and marriage duration. The estimated b_3 in the marriage offer probability function shows that college attendance increases the marriage offer rate significantly.³⁵ Considerable heterogeneity is also observed among marriage types. Marriage type 1's fixed value for marriage (a_0) is the lowest, and the difference in schooling of the husbands gives them the largest disutility (a_1). Thus, they seem to be the most choosy. At the same time, they seem to be the most attractive type because they receive marriage offers most often (highest b_0). Interestingly, almost all skill type 2 women belong to this marriage type.

B. Within-Sample Fit

This section presents evidence on the within-sample fit of the model. Given the estimated parameters, I calculate the predicted proportions of women who choose each alternative in every year after high school. Figure 2 shows 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 closely. Formally, table 3 presents the within-sample χ^2 goodness of fit statistics for the model with respect to choice proportions. The model prediction is statistically the same as the data moments at the 5% level. As for the overall schooling distribution, the model predicts that 58.0% of the sample high school graduates will attend college and that 37.0% will finish a 4-year degree compared with what is observed in the data: 61.4% attended at least 1 year of college and 37.8% completed 4 years. Table 4 presents the predicted mean transitions based on the same simulations that generate the choice distributions in

³⁴ See Card (2001) for a recent survey on the complexity in estimating the earnings return to schooling.

³⁵ Interestingly, Van Der Klaauw claims that "the yearly probability of meeting a potential spouse is lower for women with more years of education" (refer to ω_2 in table 4 of Van Der Klaauw 1996). In Van Der Klaauw's model, schooling is treated as an exogenous characteristic. If the type of individuals who are more likely to attend school are less likely to marry or if they are more likely to marry later, his estimated effect of schooling on marriage offer rate would be downward biased.

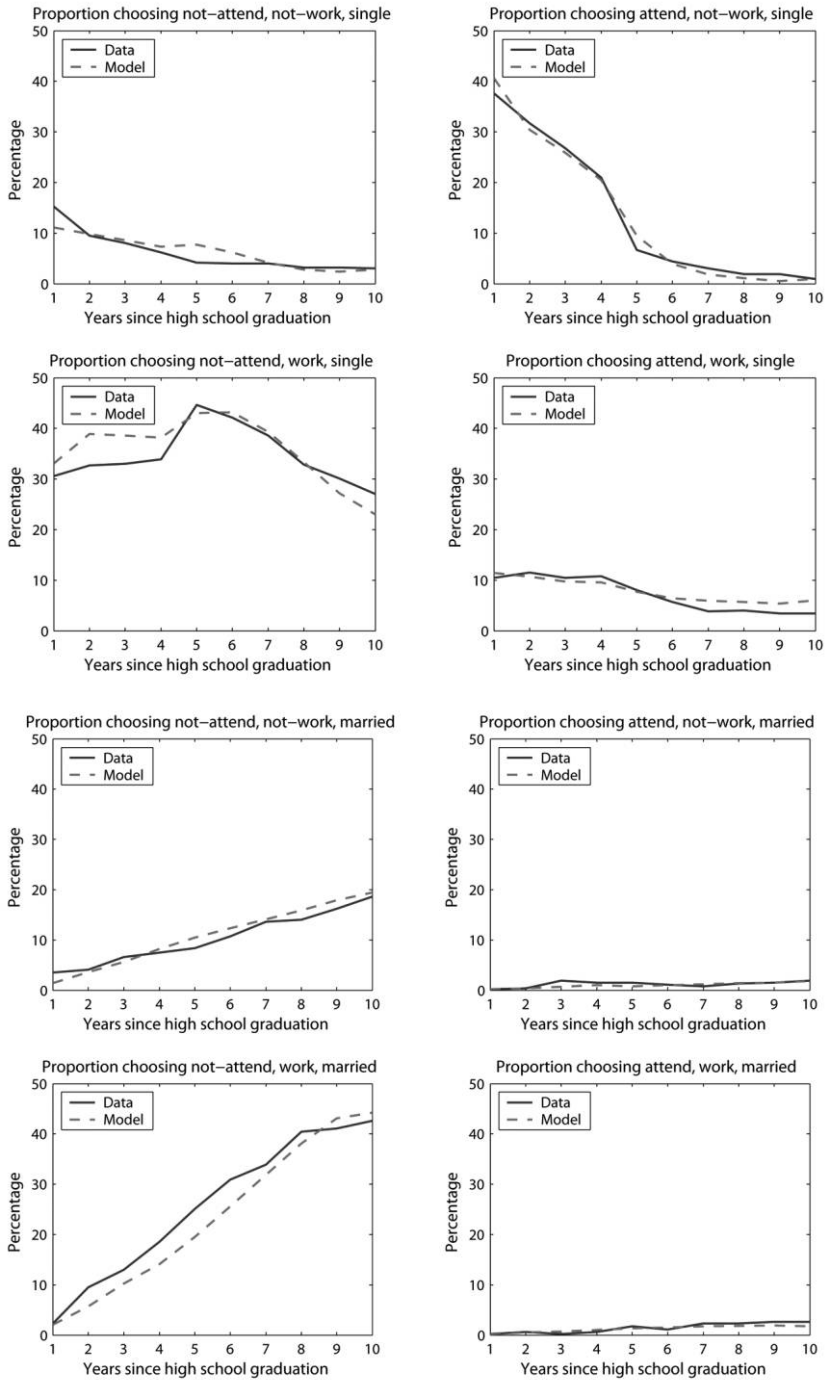


FIG. 2.—Fit of choice proportions. Color version of this figure is available as an online enhancement.

Table 3
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	1.55	.22	.19	.08	2.89	.01	.01	.08	5.04
2	.01	.06	.97	.06	.07	.01	2.44	.03	3.65
3	.03	.03	.82	.07	.16	2.02	.76	.35	4.25
4	.17	.01	.49	.14	.06	.24	1.38	.17	2.67
5	1.61	.85	.06	.01	.43	.62	1.63	.10	5.30
6	.76	.06	.03	.08	.20	.01	1.13	.13	2.41
7	.00	.70	.01	.72	.02	.08	.12	.28	1.94
8	.05	.69	.01	.47	.21	.01	.14	.16	1.74
9	.24	3.99	.30	.76	.16	.00	.09	.21	5.75
10	.01	.01	.68	1.13	.03	.00	.06	.42	2.34

NOTE.—NNS = not-attend, not-work, single; ANS = attend, not-work, single; NWS = not-attend, work, single; AWS = attend, work, single; NNM = not-attend, not-work, married; ANM = attend, not-work, married; NWM = not-attend, work, married; AWM = attend, work, married. $\chi^2 = \sum_{i=1}^k (O_i - E_i)^2 / E_i$, where O_i is the observed frequency for bin i and E_i is the expected frequency for bin i ; $\chi^2(0.05) = 14.07$.

Table 4
Fit of the Mean Transitions

From/To:	Attend	Not Attend
Attend	65.83 (66.45)	34.17 (33.55)
Not Attend	5.26 (5.31)	94.74 (94.69)
From/To:	Work	Not Work
Work	82.83 (88.76)	17.17 (11.24)
Not Work	45.30 (34.77)	54.70 (65.23)
From/To:	Single	Married
Single	87.36 (87.71)	12.64 (12.29)
Married	4.34 (3.63)	95.66 (96.37)

NOTE.—Data moments are in parentheses.

figure 2. The model can match transitions reasonably well. The data demonstrate much persistence in each state; the model recovers persistence in attendance status and marital status but somewhat underpredicts the persistence in nonemployment. Figure 3 demonstrates further the fitting of divorce transitions. Let divorce rate at time t be p_t^d ; the cumulative marriage survival rate at T_0 is defined as $\prod_{t=1}^{T_0} (1 - p_t^d)$. Year-to-year divorce rates are quite volatile in the data because the number of observations is small. Therefore, I present the cumulative marriage survival rates instead in figure 3. The model prediction follows the data very closely. The trends

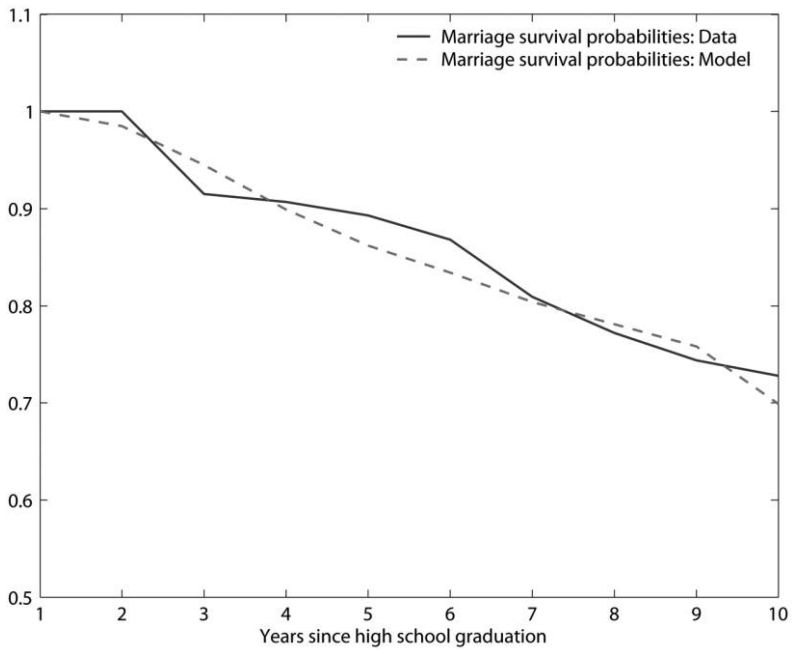


FIG. 3.—Fit of marriage survival rates. Color version of this figure is available as an online enhancement.

Table 5
Predicted Matching in Education at First Marriage

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

NOTE.—Data moments are in parentheses.

and the levels of women's wages and married men's annual incomes are also well fitted by the estimated model.

As presented in table 5, the predicted husbands' schooling distribution, conditional on married women's schooling level, matches the data closely. In the model, although high school graduate women would like to marry college men for their high incomes, they suffer from the difference in

educational background and receive fewer marriage proposals. The model underpredicts their probability of marrying college men. Women who attend college but never finish their 4-year degree (some college) behave more like high school graduates. Overall, the model can fit the conditional schooling distribution of husbands.

VI. Model Validation

A. The NLSY97 Sample

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

A dramatic increase in college enrollment from 61% to 80% is observed when I compare the NLSY79 and the NLSY97 samples.³⁶ Figure 4 compares the two college attendance profiles. Note that only 4-year data are available for the NLSY97 sample conditional on having a large enough number of observations. The two attendance profiles are almost parallel with each other for the first 4 years.³⁷

The two samples differ in many respects, which may lead to different schooling outcomes. First, as shown in table 6, the NLSY97 women's parental education, family income, and AFQT scores are significantly higher than those of the NLSY79 women. Second, the schooling distribution of potential husbands has changed from 1980 to 2000 (table 7). Third, between 1980 and 2000, the relative wage between some college and high school females increases by 50%, whereas the relative wage between college and high school females doubles (fig. 5).³⁸ Fourth, the

³⁶ These are enrollment rates of white females with a high school diploma based on the NLSY79 and the NLSY97 samples. The enrollment rates from the NCES and CPS are lower because their high school graduates include individuals who completed the General Equivalency Diploma (GED). A GED is not equivalent to a high school diploma (Cameron and Heckman 1993).

³⁷ At the same time, the labor force participation pattern for the young cohort stays the same. The young cohort tends to marry less or later. However, if I take cohabitation into account, the proportion of having a partner/spouse converges to the marriage profile of the old cohort.

³⁸ The increase in college premium is well documented in the literature; see Katz and Murphy (1992), Card and DiNardo (2002), and Eckstein and Nagypál (2004).

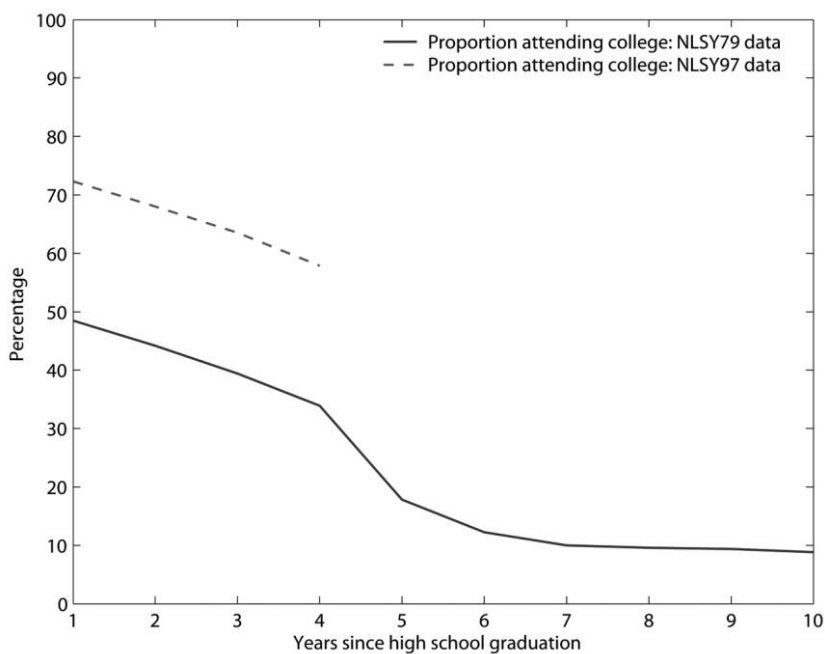


FIG. 4.—College enrollment: NLSY79 and NLSY97 samples. Color version of this figure is available as an online enhancement.

Table 6
Background Differences: NLSY79 versus NLSY97

Variable Name	NLSY79	NLSY97
Highest grade completed of mother at 14	12.3 (.09)	13.6 (.10)
Highest grade completed of father at 14	12.6 (.13)	13.8 (.12)
Number of siblings at 14	2.8 (.08)	3.4 (.10)
Broken home at 14	.14 (.01)	.16 (.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 (.02)	17.8 (.02)

NOTE.—Standard errors of the means are in parentheses.

* See appendix A in the online version of this article for changes in definition.

Table 7
Schooling Distribution of the Potential Husbands of the NLSY79 and NLSY97 Samples

Cohort	Years of School							
	11 or Less	12	13	14	15	16	17	18 or More
NLSY79	6.88	41.69	8.65	11.03	5.30	16.16	3.53	6.77
NLSY97	8.03	40.41	8.53	11.97	4.40	18.24	2.60	5.83

NOTE.—Statistics are based on 22–35-year-old white males whose years of schooling are at least 10 years from Current Population Survey, 1980–83 and 1997–2000. The Current Population Survey changed its schooling classification in 1992. Prior to 1992, information on the number of grades attended and completed was collected up to 18 years. However, after 1992, education attainment is categorized to the highest degree received. I used the test from the February 1990 CPS (for details, see Kominski and Siegel [1993]), where both questions were asked to the same individuals to reclassify the degrees as the highest grades completed.

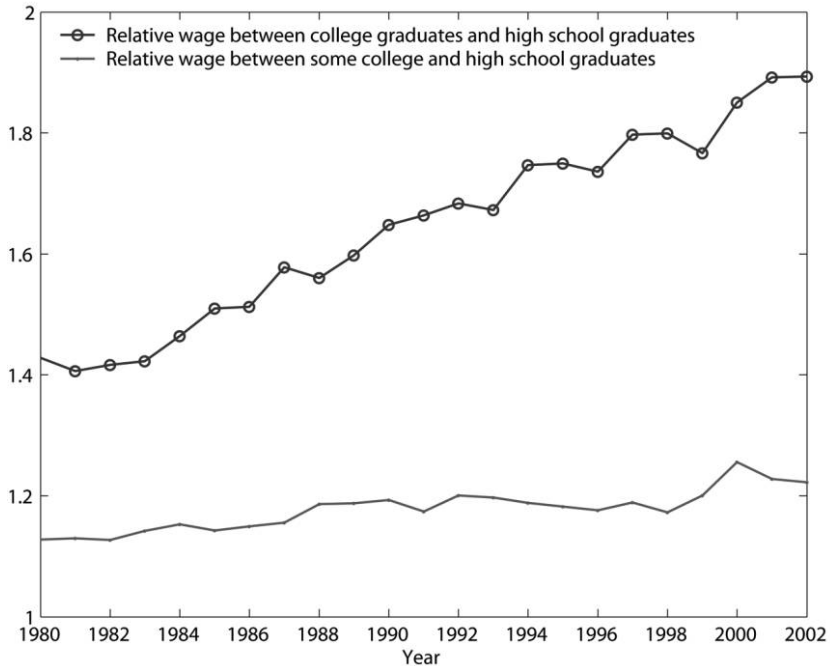


FIG. 5.—Relative wages of white females from CPS 1980–2002. Color version of this figure is available as an online enhancement.

cost of college has increased dramatically in the past 2 decades according to the NCES (fig. 6).

B. Out-of-Sample Predictions

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

In the first simulation, all parameters are fixed at the estimated values based on the NLSY79 sample, but I use the background variables of the

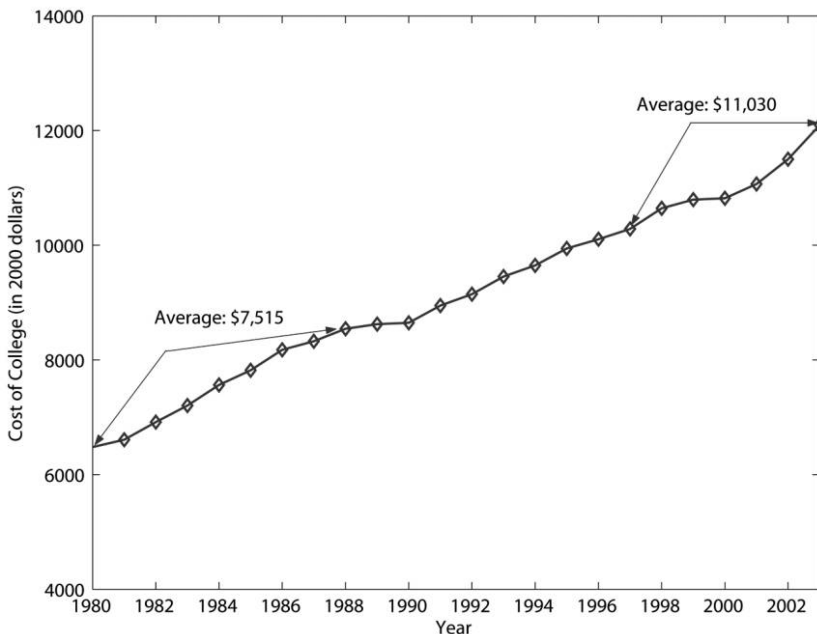


FIG. 6.—Changes in direct cost of college. Color version of this figure is available as an online enhancement.

NLSY97 sample and integrate them into equation (9) to predict each individual's skill type. Individuals in the NLSY97 sample have higher parental education and test scores on average; thus, they are more likely to be a high skill type. The simulation result is indicated by the dotted line. In the first year after high school graduation, the attendance rate increases from 48.5% to 62.9%. Overall, college enrollment increases by more than 10 percentage points, from 58.0% to 68.4%. Heterogeneity in background has a lasting effect: as seen in the graph, it improves both attendance and graduation. The background effect is due to the increased number of highly skilled women.

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

In the third simulation, in addition to the changes in the background

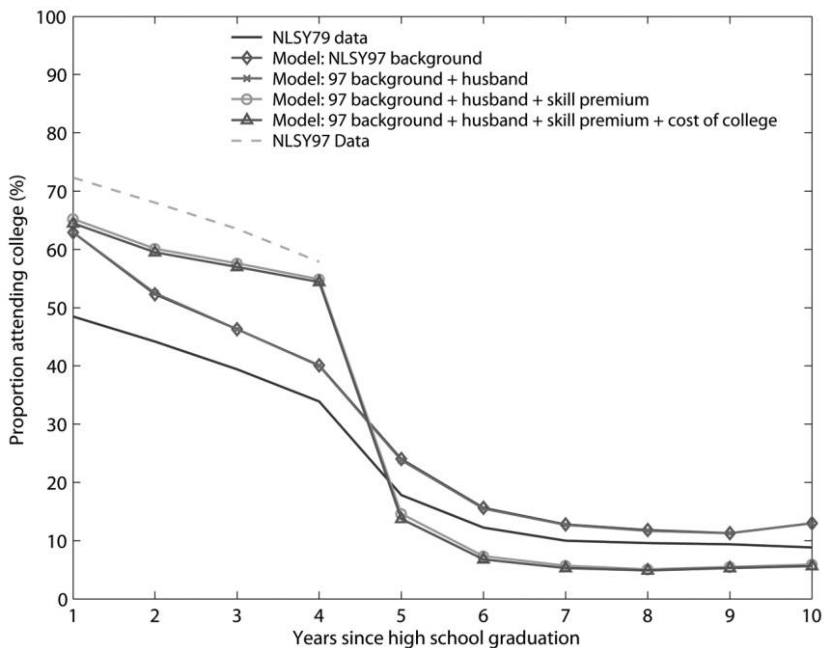


FIG. 7.—Out-of-sample prediction: College attendance profile for NLSY97 sample. Color version of this figure is available as an online enhancement.

and husbands, I allow women to have expectations on the dramatic increase in earning returns to schooling. The earning returns to schooling for the NLSY79 sample are estimated in the structural model to control for selection. Without a similar structural model estimated for the new cohort, we cannot obtain a consistent estimate for the new returns. I adopt a much more parsimonious method. As shown in figure 5, the relative wage between females with a high school diploma and some college education increased by 50%, whereas the relative wage between females who graduated from high school and those who graduated from college doubled between the early 1980s and the early 2000s.³⁹ For the new cohort, I assume that the returns to each additional year of schooling (β_1 's) increase by 50% and that the returns to college graduation (β_4) double. In this simulation, when women solve the dynamic programming problem, they use the new β_1 and β_4 to formulate expectations on their future earnings. The line with circles shows the simulation results: the effect of increasing the college premium on college enrollment is small, but it has a large effect on college graduation.⁴⁰ The reason is that the premium of a college degree increases most dramatically.

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

Given all the changes in the background, potential husbands' schooling distribution, college premium, and tuition cost, the predicted college attendance profile (the line with triangles) is very close to the actual attendance profile of the NLSY97 sample (the dashed line on top) as shown in figure 7. The model, which is estimated based on a sample of women attending college in the early 1980s, predicts well the enrollment behavior in the early 2000s. Overall, the prediction for the NLSY97 sample indicates that the individual preference parameters are invariant to the environment. Furthermore, to account for the dramatic increase in educational attainment, the shift in the skill distribution (through the background) plays an essential role. The rising skill premium has small effects on college enrollment but large effects on graduation, and the rising tuition plays an insignificant role. Although the marriage market can play an important role in college enrollment through the improvement of matching efficiency via marriage offer probabilities (b_3), there is no direct measure available. The education distribution of po-

³⁹ These premiums may be attributed to the returns to ability or the returns to college (Taber 2001). I simply treat the premiums as the returns to college to have an upper bound for the changes in college premium for the new cohort.

⁴⁰ Changes in men's college premium have insignificant effects.

tential husbands barely changes; thus, the effect of educational assortative mating is negligible.

VII. Simulations

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

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

The top panel of the table shows the schooling outcomes from the baseline model. The mean highest grade completed is 14.3 years for the whole sample, 12.2 years for type 1, 15.5 years for type 2, and 19.6 years for type 3. The next two rows show the college enrollment and graduation rates, that is, the proportion of women who attend any college, and the proportion of those who graduate from a 4-year college or university. In

Table 8
Effect of Marriage on Education Outcome by Skill Types

	All	Type 1	Type 2	Type 3
(0) Baseline model:				
Mean highest grade completed	14.3	12.2	15.5	19.6
College enrollment rate	58.0	18.4	97.2	99.7
College graduation rate	37.0	.0	67.7	95.5
(1) College does not increase marriage offers ($b_3 = 0$):				
Mean highest grade completed	14.4	12.0	15.7	20.2
College enrollment rate	50.8	4.3	97.0	99.7
College graduation rate	40.4	.0	76.0	96.1
(2) No educational assortative mating ($a_1 = 0$):				
Mean highest grade completed	14.3	12.4	15.4	19.4
College enrollment rate	66.6	36.3	96.5	99.8
College graduation rate	33.8	.0	58.9	96.7
(3) No transfers from husbands:				
Mean highest grade completed	14.3	12.1	15.6	19.7
College enrollment rate	54.8	11.7	97.5	99.7
College graduation rate	38.8	.0	72.2	95.8
(4) (1)–(3) hold ($b_3 = 0$, $a_1 = 0$, and no transfers):				
Mean highest grade completed	14.4	12.0	15.7	19.9
College enrollment rate	50.5	4.3	96.5	99.8
College graduation rate	39.0	.0	71.7	97.2
(5) No marriage offers:				
Mean highest grade completed	14.8	12.0	16.5	21.6
College enrollment rate	51.8	3.9	99.8	99.8
College graduation rate	48.8	.0	97.4	98.1
(6) All husbands are college graduates:				
Mean highest grade completed	14.8	13.0	16.0	19.1
College enrollment rate	74.2	49.3	99.8	99.8
College graduation rate	44.6	.5	85.9	97.5

the baseline model, the college enrollment rate is 58.0%, and the graduation rate is 37.0% for the whole sample.

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

In the first simulation, I assume that college does not increase the marriage offer rate, that is, $b_3 = 0$. The college graduation rate increases by 3.4 percentage points, but college enrollment drops by 7.2 percentage points. Based on the type-specific simulations, type 1 women are those who attend college for more marriage opportunities. If college has no effect on the marriage offer rate, their enrollment drops by more than 70%. The marriage offer rate has little effect on type 2 women's enrollment, but setting b_3 to zero increases their college graduation rate. When college does not increase the marriage offer rate, fewer marriage offers are available for college attendees, and they are less likely to get married while in college. Based on the estimated parameters (v_3 and v_4), being married significantly reduces the consumption value of school and increases the tendency to drop out. If women are less likely to get married in school, they are less likely to drop out of college; therefore, the graduation rate goes up.

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

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

points. For types 2 and 3, the second effect drives the graduation rates up.

These three simulations indicate that each of the marriage gains has a different effect on college enrollment and graduation. Marriage gains from college attendance mostly come from the fact that the marriage offer rate is higher if a woman attends college and from the husband's transfer of earnings within the marriage. Almost all type 2 and type 3 women attend college even without any marriage gains; therefore, changes in college attendance responding to the decrease in marriage gains come almost entirely from type 1. In contrast, marriage gains from college graduation mostly come from educational assortative mating. Type 1 women never graduate from college, and type 3 women almost always graduate; thus, only type 2 are less likely to graduate without the marriage gains through assortative mating.

When I zero out all marriage benefits in the fourth simulation, college enrollment rate drops by 7.5 percentage points (from 58.0% to 50.5%), and the college graduation rate increases slightly by 2 percentage points. The drop in enrollment occurs mainly because fewer type 1 women attend college to meet more potential spouses. In contrast, the fact that types 2 and 3 are less likely to get married in college because of the lower marriage offer probability contributes to the increase in graduation rates.

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

To investigate further the effects of assortative mating in education, I run an experiment where all potential husbands are college graduates. The model predicts that college enrollment for women will increase by 16.2 percentage points and that graduation will increase by 7.6 percentage points. Under this scenario, type 1 women attend college more often. Almost all type 2 women attend college, and 86% of them will graduate. When there is a dramatic change in men's schooling distribution, as shown in this experiment, it can have a large effect on women's schooling decisions through educational assortative matching.⁴¹

⁴¹ I would like to thank an anonymous referee for pointing out that this result

Table 9
Effect of Earnings on Education Outcome by Skill Types

	All	Type 1	Type 2	Type 3
Baseline model:				
Mean highest grade completed	14.3	12.2	15.5	19.6
College enrollment rate	58.0	18.4	97.2	99.7
College graduation rate	37.0	.0	67.7	95.5
(1) 10% increase in return to 1 year of schooling (β_1 's):				
Mean highest grade completed	14.3	12.2	15.5	19.4
College enrollment rate	57.6	17.6	97.3	99.7
College graduation rate	37.3	.0	68.5	95.4
(2) 50% increase in return to 1 year of schooling (β_1 's):				
Mean highest grade completed	14.2	12.2	15.6	18.5
College enrollment rate	56.4	15.0	97.4	99.8
College graduation rate	39.4	.0	73.8	95.2
(3) 10% increase in return to college graduation (β_1):				
Mean highest grade completed	14.3	12.2	15.5	19.6
College enrollment rate	58.0	18.4	97.3	99.7
College graduation rate	37.4	.0	68.7	95.5
(4) 50% increase in return to college graduation (β_1):				
Mean highest grade completed	14.3	12.2	15.6	19.4
College enrollment rate	58.0	18.4	97.3	99.7
College graduation rate	39.3	.0	73.0	95.6
(5) No earnings return to college:				
Mean highest grade completed	14.3	12.1	15.4	19.6
College enrollment rate	55.8	14.1	97.0	99.7
College graduation rate	32.5	.0	56.2	95.4

B. How Much Do Earnings Matter to College Decisions?

Table 9 shows the effect of the earnings return to schooling by skill types.⁴² As the schooling coefficient β_1 increases, college enrollment may increase because expected earnings returns increase. However, college enrollment may also decrease because the high school wage, which is the opportunity cost of college attendance, also increases in β_1 . With a 10% increase in the return for each additional year of schooling (β_1 's), the enrollment rate drops slightly by 0.4 percentage points, and the graduation rate increases by 0.3 percentage points. When β_1 goes up, the opportunity cost of college goes up, and type 1 women are less likely to attend college. For type 2 women, the benefits outweigh the cost, and they increase their

could account for some of the black-white education gap due to different pools of potential husbands faced by black and white females.

⁴² 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 macroeconomics; 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.

schooling investment. If the return of each additional year of schooling increases by 50%, college enrollment drops by 1.6 percentage points, and graduation rate increases by 2.4 percentage points. Enrollment decline is caused by type 1, whereas graduation increase is caused by type 2. On the other hand, a 10% increase in returns to college graduation (β_4) has almost no effect on enrollment and increases graduation rate by 0.4 percentage points. Even with a 50% increase in β_4 , college enrollment has almost no change, and graduation increases by 2.3 percentage points. These effects are due to the response of type 2 women.

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

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

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

C. How Much Does Heterogeneity Matter to College Decisions?

As shown in the estimated parameters, there is considerable variation in type-specific skill endowments and preferences. Based on simulations using the estimated model, skill types differ substantially in their education attainment. College attendance rates are 18.4%, 97.2%, and 99.7% for skill types 1, 2, and 3, respectively. None of the skill type 1 women earn a 4-year college degree. For skill type 2 women, 67.7% of them graduate from college, whereas for skill type 3 women, an overwhelming 95.5% graduate. Type 1 is the high school type, type 2 is the college type, and type 3 is the graduate school type.⁴³ In the sample, around 50% of women belong to skill type 1, 38% belong to skill type 2, and the rest (12%) belong to skill type 3.

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

⁴³ Each skill type also consists of a different composition of marriage types. Different marriage types exhibit little behavioral differences; therefore, the discussions are focused on skill types.

Table 10
Effect of Background and Heterogeneity on Education Outcome

	Baseline Model	Increase S^m by 1 Year	Increase S^f by 1 Year	Increase Y° by \$5,000	Increase AFQT by 10 Percentile
% skill type 1	49.9	45.1	48.2	49.6	42.3
% skill type 2	38.3	42.4	39.4	38.6	45.7
% skill type 3	11.8	12.5	12.4	11.8	12.0
Mean highest grade completed	14.3	14.5	14.4	14.3	14.6
Enrollment rate	58.0	61.8	59.4	58.3	64.1
Graduation rate	37.0	40.7	38.5	37.2	42.7

NOTE.— S^m = mother's schooling; S^f = father's schooling; Y° = family income.

college attainment will increase. Table 10 presents the effect of changing background variables on the skill distribution and education outcome. Increasing mother's schooling by 1 year implies a 3.8 percentage points increase in college enrollment on average. Increasing father's schooling by 1 year has a similar effect, but the size is smaller. The elasticity of increasing family income on school outcome is very small. The effect of a \$5,000 increase in family income is almost negligible. The AFQT score is a strong predictor of education outcome. A 10 percentile upward shift of AFQT score implies a 6.1 percentage points increase in enrollment and a 5.7 percentage points increase in graduation. Although different modeling strategies and different samples are used, I reach a conclusion similar to that reached by Cameron and Heckman (2001): the short-run liquidity constraint as indicated by family income at college-going age is not as important as the long-run family background, including parental education and test score.

D. Counterfactual Experiments

In table 11, I present evidence on the effect of two counterfactual experiments in the marriage market on educational attainment. These experiments assume that the effect of induced skill supply responses on equilibrium skill rental prices is negligible.⁴⁴

1. Increase in b_3

With the widespread use of the internet, online dating is now a popular service. The education profile of online dating service users shows that they are on average more educated than the general population (Hitsch et al. 2010). If one supposes that college women have more access to an

⁴⁴ In two recent papers, Heckman, Lochner, and Taber (1998) and Donghoon Lee (2005) start developing solution and estimation methods that can account for the general equilibrium feedbacks. However, their results are very different.

Table 11
Counterfactual Experiments

	College Enrollment Rate	College Graduation Rate
Baseline model	58.0	37.0
(1) Increase b_3 by 20%	65.8	36.2
(2) \$5,000 marriage bonus	61.2	36.2

online dating service, then b_3 is increased after the introduction of the Internet and online dating sites. I simulate the effect of an experiment that provides a 20% increase in b_3 , from 0.677 to 0.812. The college attendance rate increases from 58.0% to 65.8%, but the graduation rate decreases slightly from 37.0% to 36.2%. The increase in b_3 raises the return to college attendance, and thus more women attend college. At the same time, more marriage proposals imply earlier marriage; therefore, more women may drop out of college.

2. Marriage Bonuses

Pro-marriage policy is advocated because of the potential positive association between (healthy) marriage and a variety of child outcomes. Here, I analyze the effect of a pro-marriage policy on women's own education outcomes. Suppose the government provides a \$5,000 subsidy once a woman is married. In row 2 of table 11, the effect of this \$5,000 marriage bonus is presented. College enrollment increases by 3.2 percentage points, and the graduation rate drops from 37% to 36.2%. Overall, the effect of a pro-marriage policy on women's college attainment is mixed: although the rising return in the marriage market may encourage people to attend college, the rising value of marriage may also induce them to marry earlier and more likely drop out of school.

VIII. Concluding Remarks

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

The main results are summarized as follows. First, marriage plays a significant role in a woman's decision to attend college. When the benefits from marriage are ruled out in the estimated model and everything else

is kept the same, the predicted college enrollment drops by 7.5 percentage points, from 58.0% to 50.5%. The effect on college graduation is smaller: the predicted graduation rate increases from 37% to 39%. In contrast, earnings return has relatively small effects on college attendance but has significant effects on college graduation. Overall, the observed and unobserved heterogeneity is the most important determinant of women's college decisions. Second, the estimated model from the early 1980s does well in predicting college enrollment behavior in the early 2000s. The prediction for the new sample is not only a validation of the model but also provides evidence of the stability of the structural model for policy analysis.

An important caveat to the measured effect of marriage on college decision is that the current study is based on a partial equilibrium analysis. As women make their college decisions based on the schooling distribution of men, men also make the same decisions. Therefore, both genders' schooling distributions are an equilibrium outcome. A complete analysis requires a general equilibrium model of the marriage market, which is left for future work.⁴⁵

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

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⁴⁵ To implement such a model empirically, we need to observe both spouses' sequential choices. In addition, in a general equilibrium model of the marriage market, we may extend our discussion on heterogeneity to both women and men.

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