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Accounting for Racial Differences in Marriage and Employment

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Abstract

The extent to which marriage market conditions explain differences in marriage and employment decisions across blacks and whites and across men and women is considered in a dynamic, two-sided model of marriage. The quantity and quality of men and women in the marriage market evolve endogenously over time in the model, and in turn influence the allocation of income within married households and the ease with which single agents attract prospective mates. The parameters of the model are estimated using a panel of young men and women from the U.S. The results highlight the responsiveness of intra-household transfers to changes in marriage market opportunities and the importance of women's options outside marriage in determining the black-white gap in marriage rates. Policy experiments suggest that improving the socio-economic characteristics of blacks and reducing the black-white gap in earnings further decreases the black marriage rate, highlighting the importance of equilibrium effects.

Keywords: Sex Ratio, Equilibrium Search, Intra-Household Allocation
JEL Codes: J11, J12, J2, D83

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1 Introduction

Several well-documented empirical regularities illustrate the dramatic differences in family structure and employment behavior over time and across race and gender in the U.S. Blacks are less likely to marry than whites (Brien, 1997; Saluter, 1994). In addition, blacks who do form matches tend to delay marriage (DaVanzo and Rahman, 1993) and are more likely to divorce than whites (Martin and Bumpass, 1989). Several interesting trends regarding racial differences in employment also emerge from the data. Black males have lower employment rates than white males: data from the 1996 wave of the National Longitudinal Survey of Youth 1979 Cohort (NLSY79) indicate that the average employment rate for black men in their mid thirties is 80% as compared to 94% for white men. In contrast to men, the employment rate for black married women is relatively high, 77% as compared to 68% for white married women in the same sample.[1]

What forces underlie the racial differences in behavior? The most prominent explanations point to relatively poor marriage market conditions, on both quantity and quality dimensions, for black women as compared to white women. The quantity dimension of the marriage market is measured by the sex ratio, defined as the ratio of single men to single women, an indicator of the relative availability of men versus women in the marriage market (Becker, 1973). The sex ratio is consistently lower for blacks than for whites throughout recent history for many reasons, including racial differences in the sex ratio at birth and differences in homicide, accident and infant mortality rates (Guttentag and Secord, 1983; Espenshade, 1985).[2] As a result, the quantity of prospective spouses for black women is limited relative to white women, reducing the likelihood black women marry.

The quality of the marriage market can be measured by the distributions of socio-economic characteristics of men and women, including education and labor market

[1]Furthermore, married black women are also more likely to work than their single counterparts, while the converse holds for white women.

[2]In addition, a disproportionate number of black men enter the armed forces (Guttentag and Secord, 1983).

earnings. Wilson and Neckerman (1986) argue that differences in the quality of the pools of potential black and white husbands explain the relatively low marriage rates for black women: faced with poor prospects in the marriage market, black women are more inclined to remain single than to marry a spouse with poor socio-economic characteristics.[3]

This paper provides a unified framework within which to consider the links between aggregate conditions in the marriage market and individual employment, marriage and divorce decisions. The marriage market evolves endogenously over time within the model as individuals marry and divorce, driven in part by exogenous differences in the aggregate stocks of men and women and blacks and whites in the population. Differences in the aggregate stocks and in the spousal quality distributions across race and sex create imbalances in marriage market conditions. Such imbalances influence marriage and employment decisions through two channels.

First, in the spirit of Becker (1973) and Chiappori, Fortin and Lacroix (2002), supply and demand conditions play central roles in the intra-household allocation process: the sex ratio measures marital opportunities of both partners outside the current match and as such affects the share of marital income each agent can command within the current marriage. As a result, agents whose marital opportunities improve can attract higher quality spouses, receive larger income transfers within the household and are therefore less likely to work. This feature of the model is consistent with the high employment rates of white men as compared to black men and the opposing trend for women, for the stocks of black men observed in the data are lower than for black women while the converse holds for whites.[4]

Second, it is assumed marriage opportunities may not be available in every period and the sex ratio affects the amount of friction in the marriage market. In particular,

[3] This hypothesis has been tested extensively in the literature, for example Wood (1995) and Brien (1997). The smaller gender gap in earnings for blacks relative to whites and the availability of support programs for single women with children have also been cited as contributing factors to the differences in marriage rates across race (Espenshade, 1985).

[4] Grossbard-Schectman (1993) also constructs a model whereby favorable conditions in the marriage market improve the bargaining position of women and thus reduce female labor supply.

the rate at which women and men meet in the marriage market is a function of the relative size of the pools of single men and women as in Pissarides (1985). As a result, individuals who experience a decrease in their aggregate stock meet potential spouses with relative ease, for the number of potential competitors as compared to the number of prospective spouses declines. Individuals can therefore be more choosy regarding whether to marry and whether to divorce when faced with better prospects in marriage. Marriage market conditions therefore have two opposing effects on the decision to marry. On one hand, increases in intra-household transfers and higher contact rates increase the attractiveness of marriage and the opportunities to marry, respectively. On the other, individuals in limited supply face a better marriage market tomorrow and therefore have incentives to delay marriage or initiate divorce in the current period.

The structural parameters of the full dynamic model are estimated using a sample of men and women from the National Longitudinal Survey of Youth 1979 Cohort (NLSY79). The period of time covered in this paper (1979-1994) is characterized by substantial variation in the sex ratio, employment and marriage rates across race, region and time. Several results are worth highlighting. First, the sex ratio has the expected effect on intra-household transfers: more favorable opportunities in the marriage market translate into greater transfers within marriage. This finding confirms the important connection between the labor market and the marriage market, as increases in the sex ratio have important income effects on the employment decisions of married couples. In particular, those facing poor marriage market opportunities are allocated less resources within the household, a result consistent with the relatively high employment rates of black women relative to white women and the relatively low employment rates of black men relative to white men.

Second, the estimates indicate that the average married male pays a transfer to his wife that exceeds the non-labor income in the household. One implication of this finding is that marriage may be less desirable for those with low labor market earnings, as the transfer necessary to form a match is non-trivial. The options of black women outside marriage, combined with the poor labor market opportunities of black males, thus provide an explanation for the low marriage rates in the black population. Finally, the results indicate the presence of substantial search friction in the marriage market, where individuals with poor marriage market opportunities face relatively high search friction. Thus, as a result of the low sex ratio in the black marriage market, black women find it more difficult to contact a potential spouse than white women. Together, these results provide insight into the causes and consequences of differences in employment and marriage behavior across various groups in the population.

The use of a two-sided model of marriage and employment that treats the sex ratio as endogenous is particularly important if one is to consider the implications of policies that change the desirability of marriage.[5] Any policy change that alters marriage rates today will have implications for the composition of the marriage market and employment behavior in future periods. Treating the sex ratio as exogenous and ignoring the decisions made by both men and women in the marriage market prohibits the study of such effects. Furthermore, policies that target labor market outcomes may also have feedback effects on the marriage market that cannot be captured if marriage and employment decisions are not treated as joint decisions. The policy experiments conducted in this paper illustrate both points. For example, eliminating the black-white gap in earnings increases the earnings potential of black men and therefore the quality of the marital pool facing black women. However, eliminating the racial wage gap also improves labor market opportunities and quality of black women to such an extent that remaining single is now more attractive than it was before the policy change. As a result, improving the labor market outcomes for blacks serves to lower the black marriage rate in this instance.

The remainder of the paper proceeds as follows. Section 2 contains the theoretical model, constructed to account for the joint patterns of employment and marriage behavior across race and sex discussed above. In Section 3, the data used to construct

[5] Angrist (2002) uses changes in immigration policy in the US as a source of exogenous variation in his study of marriage rates and sex ratios but doesn't consider the equilibrium effects of an exogenous shock to the marriage market on future behavior.

the sex ratios and to estimate the model is described. The three stage estimation technique used to estimate the model is outlined in Section 4. In Section 5, the estimation results and model fit are presented. Section 6 contains several policy experiments that further illustrate the implications of the model and parameter estimates. Section 7 concludes.

2 The Model

The model builds on the work of Becker (1973), Chiappori et al. (2002) and van der Klaauw (1996), capturing relationships between employment, marital status and the marriage market. In every period, individuals of gender G, $G \in \{M, F\}$, maximize the present discounted value of expected utility over a finite horizon through the choice of marital and employment status. Employment opportunities are available in every period and individuals are assumed to either work full-time in the market or full-time at home. Marital status and employment status decisions are discrete in nature. The combination of marital and employment status decisions is equivalent to choosing one of four potential states: single and not working (sn), single and working (sh), married and not working (mn), married and working (mh). Denote the choice set for the single states $K_s = \{sn, sh\}$ and the choice set for the married states $K_m = \{mn, mh\}$.

It is assumed only single individuals are in the marriage market and that marriage opportunities may not be available in every period.[6] When marriage opportunities arrive, individuals decide to match or to remain single. Both partners must agree to marry for a match to form. If a match is made, individuals remain married for at least one period after which they may divorce. If agents decide to divorce, they must remain divorced for at least one period after which they re-enter the marriage market. The model abstracts from the process by which agents sort in the marriage market and assumes individuals randomly meet within marriage markets segmented by known,

[6] This assumption is consistent with other models of matching in marriage markets (Aiyagari, Greenwood and Güner, 2000; Brien, Lillard and Stern, 2001; Drewianka, 1998; and Wong, 1997).

exogenous characteristics. For ease of exposition, the model presented below considers the case of one marriage market. Under the assumption that individuals cannot choose their marriage market, the extension to several markets is straightforward and is considered in the empirical analysis.

Five factors determine the utility gains to marriage and employment. First, individuals receive utility directly from consumption (x_t) and each marital and employment state. Second, individuals receive utility from the presence of children in the household (c_t), where children are represented by an indicator equal to one if a first birth occurred and where the utility from children can vary depending on employment and marital status in the current period. Third, the utility from each state may also differ for individuals depending on their fixed exogenous individual characteristics, summarized by I possible types. Fourth, married individuals derive utility from match-specific marital capital L_t which accumulates according to:

$$L_{t+1} = (L_t + 1) \cdot 1(k_t \in K_m),$$

where $1(\cdot)$ is an indicator equal to one if the individual is in one of the married states. Finally, utility depends on an idiosyncratic component that differs depending on current employment and marriage decisions and is uncorrelated over states, time and individuals. The shock realized by an individual in state k and period t is denoted ϵ_{kt}. It is assumed that utility is linear in ϵ_{kt} and that shocks to current period utility are observed by agents before they make employment and marriage decisions in each period. The resulting utility function for an individual of type i and gender G in state k and period t can be expressed as

$$u_k^G(x_t, c_t, i, L_t) + \epsilon_{kt}^G, \tag{1}$$

$k \in \{K_s, K_m\}$, $i \in I$. The budget constraint is a function of two potential sources of income in the current period, labor market earnings (w_t) and non-labor income (y_t)

$$x_t = w_t + y_t. \tag{2}$$

Labor market earnings are assumed to depend on the individual's type and an *i.i.d.* idiosyncratic component (e_{wt}), where the shocks to current period earnings are observed by agents before they make their employment and marriage decisions in each period

$$w_t = \begin{cases} w^G(i) + e_{wt} & \text{if } k \in \{sh, mh\}, \\ 0 & \text{otherwise.} \end{cases} \quad (3)$$

Non-labor income differs depending on the current marital state to capture the notion that different sources of non-labor income may be available to individuals depending on their current marital status. If single, non-labor income may also differ depending on whether the individual is working or not working. If married, the couple receives total non-labor income y_{mt}, where y_{mt} is a function of exogenous characteristics of both partners in the marriage. In each instance, non-labor income is also a function of *i.i.d.* idiosyncratic components (e^G_{snt}, e^G_{sht}, e_{mt}) observed by agents before they make their employment and marriage decisions in each period.

Non-labor income for married couples is divided among the partners for personal consumption according to a rule determining intra-household transfers in the spirit of Chiappori's (1992) sharing rule.[7] As in Chiappori, Fortin and Lacroix (2002), the income transfer depends on the current sex ratio (R_t) in the marriage market. The transfer also depends on the potential earnings ($\overline{w}^G$) of both partners in the marriage. The inclusion of earnings potential captures the idea that the quality of both spouses also plays a role in determining how resources are allocated in the household. It is assumed for simplicity that potential earnings are known by all agents in every period and are determined by the same characteristics that determine realized earnings. All three arguments influence intra-household allocations through their effect on an individual's opportunities outside the current marriage. The transfer for a married couple with a type i wife and a type j husband in period t can therefore be expressed as

$$\phi(R_t, \overline{w}^F(i), \overline{w}^M(j)).$$

The hypothesis that men transfer more resources to women when women face better

[7]Within Chiappori's (1992) general framework, it is assumed married individuals retain separate utility functions after matching. The model abstracts from the details of the bargaining process and requires only the assumption that intra-household allocations are Pareto efficient.

opportunities outside the marriage is consistent with a rule that is increasing in R_t. There is no constraint on the magnitude of the intra-household transfer; therefore the transfer may be greater than y_{mt}. Non-labor income can therefore be defined as

$$y_t = \begin{cases} y_k^G(i) + e_{kt} & \text{if } k \in K_s, \\ \phi(R_t, \overline{w}^F(i), \overline{w}^M(j)) & \text{if } G = F \text{ and } k \in K_m, \\ y_m(i, j_t) + e_{mt} - \phi(R_t, \overline{w}^F(i), \overline{w}^M(j)) & \text{if } G = M \text{ and } k \in K_m. \end{cases} \tag{4}$$

In this framework, as in Chiappori, Fortin and Lacroix, (2002), the sex ratio affects current period employment decisions directly through its effect on the intra-household allocation of income for married couples. Through the intra-household allocation process, the sex ratio also influences the behavior of single agents. In particular, movements in the sex ratio alter the intra-household transfers single agents face should they decide to marry and therefore alter the desirability of marriage.

2.1 Fertility

Children are not treated as choice variables in the model due to the complexity inherent in modelling fertility decisions explicitly in this framework. However, children play important roles in employment and marital status decisions for men and women. Therefore, it is assumed first births arrive stochastically within the model, where the determinants of a first birth vary with the agent's state in the previous period. It is further assumed $c_t = 1$ is an absorbing state to abstract from child mortality and the loss of access to children through divorce. Denote $\Gamma_s^G(\cdot)$ the fertility transition function for singles. First births for individuals who were single in the previous period depend on their exogenous characteristics, where $B_s^G(i,t)$ denotes the probability a single person of gender G and type i experiences a first birth in period t

$$\begin{aligned} \Gamma_s^G(c_t = 1 | c_{t-1} = 0) &= B_s^G(i,t) \\ \Gamma_s^G(c_t = 1 | c_{t-1} = 1) &= 1 \\ \Gamma_s^G(c_t = 0 | c_{t-1} = 0) &= 1 - B_s^G(i,t) \\ \Gamma_s^G(c_t = 0 | c_{t-1} = 1) &= 0, \end{aligned}$$

In addition to the exogenous characteristics of both partners and the marital-specific capital accumulated in the match, the probability of a birth for a married couple depends on the past fertility status of both partners. Two childless single agents who marry both benefit from children borne in the current marriage. Further, it is assumed that individuals do not receive utility from step-children and that step-children do not prevent the arrival of children in the current marriage if one of the spouses does not have children of their own. Denote $\Gamma_m(\cdot)$ the fertility transition function for married couples and c'_t the fertility status of the spouse. Therefore, the first birth arrival process for married couples is

$$\begin{aligned}
\Gamma_m(c_t = 1, c'_t = 1 | c_{t-1} = 0, c'_{t-1} = 1) &= B_m(i, j, t, L_{t-1}) \\
\Gamma_m(c_t = 1, c'_t = 1 | c_{t-1} = 0, c'_{t-1} = 0) &= B_m(i, j, t, L_{t-1}) \\
\Gamma_m(c_t = 0, c'_t | c_{t-1} = 0, c'_{t-1}) &= 1 - B_m(i, j, t, L_{t-1}) \\
\Gamma_m(c_t = 1, c'_t = 1 | c_{t-1} = 1, c'_{t-1} = 1) &= 1 \\
\Gamma_m(c_t = 0, c'_t | c_{t-1} = 1, c'_{t-1}) &= 0.
\end{aligned}$$

2.2 Marriage Market Friction

Individuals determine the utility they expect to receive in each marital and employment state as outlined above. However, it may be the case that marriage opportunities are not available in every period. A natural way to capture this idea is to introduce search friction in the model. In this context, the sex ratio determines the degree of difficulty agents face in contacting potential partners in the marriage market. Friction in the marriage market is modeled in the spirit of Pissarides (1985), where the total number of contacts in the marriage market (C_t) is a function of the stocks of single men (S_t^M) and women (S_t^F) in the current period. It is assumed the contact technology takes the following form

$$C_t = \min\{S_t^F, S_t^M\}, \tag{5}$$

which implies that all individuals in excess demand in the marriage market make a contact in the period. The probability that an individual will be contacted in the marriage market is equal to the total number of contacts in the marriage market divided by the total stock of single individuals of the same gender

$$p_t^G = \frac{C_t}{S_t^G}. \tag{6}$$

The effect of the sex ratio on search friction is readily observed, as the probability women are contacted in the marriage market is proportional to the probability men are contacted, where the factor of proportionality is the sex ratio

$$p_t^F = R_t p_t^M.$$

In other words, the sex ratio measures the degree of search friction faced by women relative to men, where a higher sex ratio translates into relatively less search friction for women than for men.

When a contact is made in the marriage market, agents draw a spouse of type j, $j \in \{1, 2, .., I\}$ and fertility status c', $c' \in \{0, 1\}$. Let G' denote the gender of an agent's spouse or potential spouse. Conditional on making a contact, the probability of drawing a potential spouse of type j and fertility status c' in period t is denoted $q_s^{G'}(j, c_t')$ and is simply the fraction of potential spouses of type j and fertility status c' in the marriage market in period t. The probability of contacting a potential spouse of type j and fertility status c' can then be expressed as

$$p_t^G q_s^{G'}(j, c_t'),$$

where $\sum_j \sum_{c'} q_s^{G'}(j, c_t') = 1$.

2.3 Value Functions

For ease of exposition, preferences are expressed in terms of the reduced form utility corresponding to each state in the following sections.[8] The reduced form utility for

[8]Appendix A contains further details on the reduced form representation of the model.

each agent, denoted $U_k^G(\cdot)$, varies depending on whether the agent is currently married or single; in particular, the transfer received by a currently married individual depends on the sex ratio in the marriage market and their spouse's type. Substituting (2)-(4) into (1) yields

$$U_k^G(i,c_t) + \varepsilon_{kt}^G = \begin{cases} \widetilde{U}_k^G(i,c_t) + \varepsilon_{kt}^G & \text{if } k \in K_s \\ \widetilde{U}_k^G(i,j,c_t,R_t,L_t) + \varepsilon_{kt}^G & \text{if } k \in K_m, \end{cases}$$

where the stochastic component of utility in the reduced form for state k (ε_{kt}^G) is a function of the random components of utility, earnings and non-labor income.

Given the specification for current period utility and search friction in the marriage market, it is of interest to consider the discounted expected utility of each alternative available to individuals when they make their employment and marital status decisions in every period. Let Ω_t denote the information set for an individual in period t. The information set in period t contains information on exogenous characteristics of men and women in the marriage market, the stock of marital-specific capital, the spouse's fertility status if married, and the current sex ratio and the stochastic components of utility in reduced form. Note that the value function for the single states depends only on the individual's type; the value function for the married states depends on the individual's type as well as their spouse's type. The value function is denoted V_{kt}^G and is described by

$$V_{kt}^G(\Omega_t,i,c_t) = \begin{cases} \widetilde{V}_{kt}^G(\Omega_t,i,c_t) & \text{if } k \in K_s \\ \widetilde{V}_{kt}^G(\Omega_t,i,j,c_t) & \text{if } k \in K_m. \end{cases}$$

The present discounted value of utility in state k can be then expressed as the sum of current period utility, given the realized value of the shocks in t, and the expected discounted value of future utility. The value function for a single agent of type i and fertility status c is

$$\widetilde{V}_{kt}^G(\Omega_t,i,c_t) = \widetilde{U}_k^G(i,c_t) + \varepsilon_{kt}^G + \beta E[v_{t+1}^G(\Omega_{t+1},i,c_{t+1})|k_t \in K_s], \tag{7}$$

where discount factor is denoted β, and the value function for an agent of type i and fertility status c, married to a spouse of type j is

$$\widetilde{V}_{kt}^G(\Omega_t,i,j,c_t) = \widetilde{U}_k^G(i,j,c_t,R_t,L_t) + \varepsilon_{kt}^G + \beta E[v_{t+1}^G(\Omega_{t+1},i,c_{t+1})|k_t \in K_m]. \tag{8}$$

The expectations in (7) and (8) are taken with respect to the stochastic components of utility in $t+1$ and with respect to the realization of next period's choice set. The stochastic realization of a child in the next period is incorporated in $v_{t+1}^G(\Omega_{t+1}, i, c_{t+1})$, where

$$v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) = \begin{cases} V_{t+1}^G(\Omega_{t+1}, i, 1) & \text{if } c_t = 1, \\ B^G(i,t) V_{t+1}^G(\Omega_{t+1}, i, 1) & \\ +(1 - B^G(i,t)) V_{t+1}^G(\Omega_{t+1}, i, 0) & \text{if } c_t = 0, \end{cases} \tag{9}$$

and

$$B^G(i,t) = \begin{cases} B_s^G(i,t) & \text{if } k_{t-1} \in K_s \\ B_m(i,j,t,L_t) & \text{if } k_{t-1} \in K_m \end{cases}$$

The value of being single for an individual of type i is defined as

$$\widetilde{V}_{st}^G(\Omega_t, i, c_t) = \max_{k \in K_s} \left\{ \widetilde{V}_{kt}^G(\Omega_t, i, c_t) \right\},$$

and the value of being married to a spouse of type j for an agent of type i can be expressed as

$$\widetilde{V}_{mt}^G(\Omega_t, i, j, c_t) = \max_{k \in K_m} \left\{ \widetilde{V}_{kt}^G(\Omega_t, i, j, c_t) \right\}.$$

One important feature of the model is that individuals take into account the likelihood of being accepted as a mate while single should they meet someone in the marriage market or, if currently married, of continuing to be accepted by their current spouse. This feature of the model is captured as follows. Define an indicator function that is equal to 1 if an agent of type i wants to marry a spouse of type j in period t. In particular,

$$J_t^G(i,j,c_t) = \begin{cases} 1 & \text{if } \widetilde{V}_{mt}^G(\Omega_t, i, j, c_t) \geq \widetilde{V}_{st}^G(\Omega_t, i, c_t) \\ 0 & \text{otherwise,} \end{cases}$$

which yields a more explicit form for the value functions on the right hand side of (7) and (8) as follows. Consider first agents who are single in t. If an agent of type i makes a contact in the marriage market with a potential spouse that wants to marry, the agent can choose among all four possible states. If the potential spouse does not want to marry or if no contact was made in the marriage market, agents must remain single and can only choose their employment status

$$E\big[V^G_{t+1}(\Omega_{t+1},i,c_{t+1})|k_t\in K_s\big]=p^G_{t+1}\Big[\sum_j\sum_{c'}q^{G'}_s(j,c'_{t+1})J^{G'}_t(j,i,c'_{t+1})\Big)$$
$$E_{\varepsilon_{t+1}}\max\Big\{\widetilde{V}^G_{st+1}(\Omega_{t+1},i,c_{t+1}),\widetilde{V}^G_{mt+1}(\Omega_{t+1},i,j,c_{t+1})\Big\}\Big]$$
$$+\Big[1-p^G_{t+1}\Big(\sum_j\sum_{c'}q^{G'}_s(j,c'_{t+1})J^{G'}_t(j,i,c'_{t+1})\Big)E_{\varepsilon_{t+1}}\big[\widetilde{V}^G_{st+1}(\Omega_{t+1},i,c_{t+1})\big]\Big].$$

Agents of type i who chose to be married in t are not in the marriage market in $t+1$. If their type j spouse is still alive and wants to remain married, individuals must decide whether to work and whether to remain with their current spouse. Individuals remain single and can only choose their employment status if they are exogenously separated from their current spouses or if their spouses no longer want to remain married

$$E\big[V^G_{t+1}(\Omega_{t+1},i,c_{t+1})|k_t\in K_m\big]=J^{G'}_{t+1}(j,i,c'_{t+1})$$
$$E_{\varepsilon_{t+1}}\max\Big\{\widetilde{V}^G_{st+1}(\Omega_{t+1},i,c_{t+1}),\widetilde{V}^G_{mt+1}(\Omega_{t+1},i,j,c_{t+1})\Big\}$$
$$+\big(1-J^{G'}_{t+1}(j,i,c'_{t+1})\big)E_{\varepsilon_{t+1}}\big[\widetilde{V}^G_{st+1}(\Omega_{t+1},i,c_{t+1})\big].$$

2.4 Reservation Values

The solution to the model outlined above is based on a set of reservation values, determined by individuals as follows. At the beginning of every period, individuals realize their current choice sets and the shocks to utility, wages and non-labor income. Once realized, it is possible to compute the value of each employment and marital status combination in the period t choice set. Individuals then choose the state yielding the highest level of utility.

The sequence of reservation values that form the solution to the problem faced by individuals in every period can be expressed in terms of the stochastic component of utility. For every state k , $k\in\{sh,mn,mh\}$, define ε^{G*}_{kt} such that individuals would like to remain single and not working for values of $\varepsilon^G_{snt}-\varepsilon^G_{kt}$ above ε^{G*}_{kt} and would like to choose state k for values of $\varepsilon^G_{snt}-\varepsilon^G_{kt}$ below ε^{G*}_{kt}. Define an indicator (d^G_{kt}) that is equal to one if state k is chosen by an individual of gender G in period t and 0 otherwise; ε_{kt}^{G*} is the value such that

$$\begin{aligned} & U_k^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1})|d_{kt}^G = 1] \\ = & U_{sn}^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1})|d_{snt}^G = 1] + \varepsilon_{kt}^{G*}. \end{aligned} \tag{10}$$

Now consider two possible states, $k, l \in K_t$, where K_t is the choice set available to the agent in the current period. State k is preferred to l if the value of choosing state k exceeds the value of choosing state l

$$\begin{aligned} & V_{kt}^G(\Omega_t, i, c_t) \geq V_{lt}^G(\Omega_t, i, c_t) \iff \\ & U_k^G(i, c_t) + \varepsilon_{kt}^G + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1})|d_{kt} = 1] \\ \geq & U_l^G(i, c_t) + \varepsilon_{lt}^G + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1})|d_{lt} = 1], \end{aligned} \tag{11}$$

The latter can be rewritten in terms of the reservation and realized values for the composite errors, using (10) and (11). The state yielding the highest level of utility satisfies

$$\varepsilon_{kt}^G - \varepsilon_{lt}^G \geq \varepsilon_{lt}^{G*} - \varepsilon_{kt}^{G*}.$$

The optimal policy for any $k \in K_t$, is therefore:

$$d_{kt}^G = \begin{cases} 1 & \text{iff } \varepsilon_{kt}^G - \varepsilon_{lt}^G \geq \varepsilon_{lt}^{G*} - \varepsilon_{kt}^{G*}, \forall l \in K_t \\ 0 & \text{otherwise.} \end{cases} \tag{12}$$

2.5 Equilibrium

The sex ratio evolves endogenously in the model, as the current marital status decisions of all the agents determine the sex ratio in the next period. Current marital status decisions depend on future conditions in the marriage market. Therefore, individuals must determine the value of the sex ratio in the next period when choosing their employment and marital status in the current period. The stocks of single men and women in the marriage market in period $t+1$ are a function of the flows in and out of the marriage market in the current period and are composed of two groups: the number of single agents in t that did not make a match and the number of married agents who divorce. The stock of singles with fertility status c and of type i at the beginning of period $t+1$ is

$$\begin{aligned} S_{t+1}^{G}(i,c_{t+1}) = \sum_{c} \Big[1 - p_t^G\Big(\sum_{j}\sum_{c'} q_s^{G'}(j,c_t')J_t^G(i,j,c_t)J_t^{G'}(j,i,c_t')\Big)\Big] \\ \cdot S_t^G(i,c_t)\Gamma_s^G(c_{t+1}|c_t) \\ + \sum_{c}\sum_{c'}\Big[1 - \Big(\sum_{j} q_m^G(i,j,c_t,c_t')J_t^G(i,j,c_t)J_t^{G'}(j,i,c_t')\Big)\Big] \\ \cdot M_t^G(i,j,c_t,c_t')\Gamma_m(c_{t+1},c_{t+1}'|c_t,c_t') + \Delta_s^G(i,c_t), \end{aligned} \tag{13}$$

$i,j \in \{1,2,..,I\}$ and $c,c' \in \{0,1\}$. The stock of married couples with exogenous types i,j and fertility status c,c' in t is denoted $M_t(i,j,c_t,c_t')$ and $q_m(i,j,c_t,c_t')$ is the exogenous fraction of individuals of type i and fertility status c married to spouses of type j and fertility status c' in period t, $\sum_i\sum_j\sum_c\sum_{c'} q_m^G(i,j,c_t,c_t') = 1$. The stock of singles is allowed to vary by $\Delta_s^G(i,c_t)$, which is specific to gender, year, type and fertility status. This feature is introduced to allow for exogenous differences in mortality and incarceration rates across different groups in the population and to match the exogenous differences in the aggregate stocks observed in the data. For simplicity, it is assumed that only the stock of singles, not married couples, changes exogenously over time.

The stock of married individuals in period $t+1$ is the sum of the number of married agents in t who remain married and the number of single agents in t who formed a match

$$\begin{aligned} M_{t+1}(i,j,c_{t+1},c_{t+1}') = \sum_{c}\sum_{c'}\Big[J_t^G(i,j,c_t)J_t^{G'}(j,i,c_t') \\ \cdot M_t(i,j,c_t,c_t')\Gamma_m(c_{t+1},c_{t+1}'|c_t,c_t')\Big] + p_t^G\Big[\sum_{c}\sum_{c'} q_s^G(i,c_t)q_s^{G'}(j,c_t') \\ \cdot J_t^G(i,j,c_t)J_t^{G'}(j,i,c_t')\Gamma_s^G(c_{t+1}|c_t)\Gamma_s^{G'}(c_{t+1}'|c_t')C_t\Big]. \end{aligned} \tag{14}$$

The total stock of single agents in the marriage market is the sum of the stocks of single agents of each type

$$S^G_{t+1} = \sum_i \sum_c S^G_{t+1}(i, c_{t+1}) \tag{15}$$

and the proportions of singles and married couples of each type and fertility status are defined as

$$q^G_s(i, c_{t+1}) = \frac{S^G_{t+1}(i, c_{t+1})}{S^G_{t+1}} \tag{16}$$

and

$$q_m(i, j, c_{t+1}, c'_{t+1}) = \frac{M_{t+1}(i, j, c_{t+1}, c'_{t+1})}{\sum_{i'} \sum_{j'} \sum_l \sum_{l'} M_{t+1}(i', j', l_{t+1}, l'_{t+1})}, \tag{17}$$

respectively. Finally, the sex ratio in period $t+1$ is defined as the ratio of single men to single women in the marriage market

$$R_{t+1} = \frac{S^M_{t+1}}{S^F_{t+1}}. \tag{18}$$

The above relations describe the manner in which the marriage market evolves over time. Marital status decisions in the current period depend on the value of the sex ratio in the following period and the value of the sex ratio in $t+1$ is determined by the marital status decisions made by individuals in the current period. In equilibrium, it must be the case that the stocks and sex ratio described by (13), (15) and (18) along with the type probabilities (16) and (17) are used by agents in evaluating the individual's problem. In other words, equilibrium requires that the decisions of all the agents in t generate values of R_{t+1}, $q^G_s(i, c_{t+1})$ and $q_m(i, j, c_{t+1}, c'_{t+1})$ that are consistent with the marital status decisions made by all men and women today.

3 Data

In order to estimate the model outlined above, it is necessary to employ a data set where individuals can be followed over time from the point they enter the marriage market. The NLSY79, a sample of 12,686 men and women who are between the ages of 14 and 22 in 1979, is well suited for this purpose. The composition of the sample allows one to follow a large group of individuals for up to 18 years from ages at which they enter the marriage market. The following restrictions are placed on the sample. First, individuals in the military and Hispanics are removed. Second, to accurately capture marital status transitions, observations following a break in an individual's history, as well as observations with missing or inconsistent information, are removed.[9] After restricting the age range in the sample as outlined below, the resulting sample size is 5,295 in 1979.

The NLSY79 sample is used to construct marital and employment status, as well as measures of labor market earnings and non-labor incomes, for use in estimation. An individual is defined as married if they are currently married or cohabiting and the marital history is constructed using annual information on marital status at the interview date in every year. Starting and ending dates of relationships are not used to construct the marital histories because this information is not available in all years for cohabitors.[10] As a result, some spells may be missed and the length of some spells may be measured inaccurately.[11] In particular, individuals who report being married or common-law in two consecutive periods are treated as if they are in the same relationship in both periods; in some instances it may be the case that the individual reports two distinct relationships that are treated as one relationship. Despite its shortcomings, this approach is used so that the definitions of marital status and the measurement of transitions are consistent across the years and across cohabitations and marriages. This does not appear to be a serious cause for concern, as only 135 person-year observations reported more than one marriage from one interview date to the next over the 1979 to 1996 sample period.[12]

[9] Individuals with only one valid observation are also removed.

[10] Information on the starting date of cohabitations, on whether individuals lived with their spouses before marriage and whether the respondent lived with their spouse continuously before marriage is only available in 1990 and 1992-1996. In the remaining years, information on current cohabitation status, but not changes in status between interviews, is available in every year.

[11] It is assumed marital status in 1978 is single for all respondents, thus the durations for some marriages may be measured inaccurately for this reason as well. However, the low marriage rates in 1979 suggest this assumption only affects a small number of matches.

[12] It is important to emphasize that this figure includes cohabitations at, but not between, interview

Employment status is measured by an indicator equal to one if individuals worked at least 775 hours in the interview year and zero otherwise. This measure thus includes individuals working at least 15 hours per week or at least 20 full time weeks per year.[13] Earnings are measured as annual income from wages, salaries and tips.[14] Non-labor income in this instance covers a broad range of categories, including farm income, unemployment benefits, alimony and child support. Income from social programs such as AFDC, food stamps, other public assistance and Supplement Security Income (SSI) is also included in non-labor income. In addition, income from other persons, veterans pay, workers compensation and disability benefits is included in non-labor income. The aforementioned sources of income are all included in order to maintain consistency over the sample period, as non-labor income is grouped in wide categories in the early years of the sample.[15] Earnings and non-labor income are subsequently converted to real terms, where 1981 is the base year. Educational attainment is measured by an indicator equal to 1 if respondents have at least a high school education and 0 otherwise. Regional indicators for the northeast, south and western portions of the U.S. are defined. An indicator equal to 1 when children are present and 0 otherwise is also defined. In the empirical specification, time is measured in terms of the number of years the individual has been in the marriage market. Finally, a race indicator equal to 1 if the respondent is black and 0 if white is constructed.

Table 1 contains sample statistics by race and sex for selected years in the panel. The data illustrate several interesting patterns. Starting with the empirical evidence

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dates. It is likely the number of cohabitations between interview dates is greater than the number of marriages, given the relative ease with which cohabitations can be dissolved and the greater stability of marriages as compared to cohabitations. See Brien, Lillard and Stern (2001) for a more complete discussion of these issues. It is also possible that relationships are missed in the marital history if an individual was single at two consecutive interview dates but married or cohabited between interview dates.

[13] Employment status is not available for individuals under the age of 16 and for a small number of 17 year olds in the NLSY79. This should not pose a problem in estimation as the vast majority of such individuals are enrolled in school full-time and are unlikely to have annual hours in the labor market above 775.

[14] The bottom of the earnings distribution is trimmed at the 5% level.

[15] In particular, for individuals not meeting any of a set of criteria (18 years and older, has child, enrolled in college, married or living outside their parent's home), all income with the exception of earnings and unemployment compensation is grouped in one category.

regarding children, black women are more likely than whites and black men to have an early birth. The fact that the birth rates for black men tend to be quite low despite the high birth rates for black women suggests the presence of many black single mothers. There also exist large differences in earnings across race and sex. White women have higher labor market earnings than black women by 1996 despite the similarities in educational attainment and fertility. In contrast to the findings regarding earnings, black women tend to have the highest levels of non-labor income in the latter years in the sample, likely due to the high participation rates in social assistance programs of black women relative to white women.

Marriage rates also tend to differ widely across race: the fraction of married men and women in the sample is consistently higher for whites than for blacks across the sample period. Within race, black women are less likely to be married than black men, while the converse holds for whites. Turning to the trends in employment rates, men are more likely to work than women within each racial group as expected. In the initial sample period, it appears whites are more likely to work than blacks: by 1996, there remains a substantial gap in the employment rates of black and white men, although the employment rates for women across race are quite similar. Table 2 contains employment rates by race and marital status for men and women in the 1996 cross-section. Comparing employment rates across race and marital status for men and women illustrates several interesting trends. The data suggest married white females have lower employment rates than their single counterparts, while the opposite trend emerges for black women. For men, whites tend to work more than blacks and married men tend to work more than single men. The differences in employment rates for men across race stand in contrast to the pattern for women, where black married women have higher employment rates than white married women. It is next of interest to consider how the cross-sectional differences in employment and marriage rates across race and sex relate to the trends in the sex ratio. To answer this question, it is necessary to determine an appropriate measure of outside marriage market opportunities.

3.1 Measurement of the Marriage Markets

In constructing sex ratios for the empirical analysis, I attempt to measure the marriage market for this recent cohort in a way that is sufficiently narrow so that an accurate measure is captured, yet sufficiently wide so as to minimize the degree to which individuals may be matching outside their specified market in the data. For simplicity, the marriage market is segmented by age, region and race in the empirical analysis.[16,17] The sample is subsequently limited to women aged 15 to 19 in 1979 and men aged 17 to 21, an age range that is sufficiently wide to minimize the number of individuals who match outside the chosen age range but sufficiently narrow so that the age groupings included in the first year of the marriage market can be considered exogenous.[18] Measures of the marriage market are also limited to single agents, as consistent with the model outlined below.

Once the marriage market is segmented by age, region and race, I re-weight the NLSY79 sampling weights such that the stocks of single and married men and women in each marriage market and year match the corresponding stocks in the Current Population Survey (CPS), and I construct measures of the stocks of single men and women in each market using the revised weights.[19] The NLSY79 sampling weights are re-weighted using the CPS because the weighting scheme in the NLSY79 may not be representative of the population in terms of age, sex, race and marital status and

[16]With regard to age, data from the NLSY79 suggest men tend to be older than their spouses by 2 to 3 years on average, with 90% marrying women who are less than three years older and seven years younger. It should be noted that age differences across men and women narrowed slightly over the same period the sex ratio declined. The median age at marriage for men is 23 and for women is 20 in 1950; in 1990 the median ages at marriage are 26 and 24 for men and women, respectively.

[17]Data from the Census indicate the strong presence of sorting on race: in 1980, 0.2% of all marriages in the U.S. were between black men and white women and 0.1% are between white men and black women. U.S. Bureau of the Census, Current Population Report, Series P20-509, "Household Characteristics: March 1997," and earlier reports.

[18]The NLSY79 contains limited sample sizes for individuals aged 14 and 22 in the data, making the use of a wider age category unattractive.

[19]In an effort to match the CPS data to the NLSY79 data as closely as possible, individuals serving in the military are excluded from the CPS for the construction of the weights. Since data are not available on cohabitors for the majority of years in the CPS, individuals who are cohabiting in the NLSY79 are treated as single for the purposes of assigning CPS weights but are treated as married in the construction of the stocks once the NLSY79 has been reweighted.

because attrition in the NLSY79 may result in mismeasurement of the stocks of single men and women in the marriage markets over time. In contrast to previous studies, I do not segment the marriage market further because of sample size limitations. In particular, the individual transitions in the NLSY79 data are used to measure changes in the sex ratio over time. The limited size of the panel therefore limits the degree to which the market can be segmented.

Based on the above assumptions, sex ratios are constructed for each marriage market as illustrated in Figure 1. Substantial differences exist in the initial sex ratios in 1979, where the sex ratio is approximately equal to 1 for whites and equal to 0.8 for blacks. The exception is the southern US, where the sex ratios are substantially below 1 for both demographic groups. The differences continue to widen over time as individuals flow out of the marriage market into relationships. Interestingly, the sex ratio for blacks tends to decrease over time, while the opposite trend emerges for whites. For blacks, the decline in the sex ratio over time reflects differences in mortality and incarceration rates across black men and women. For whites, the increase in the sex ratio is due in part to the larger influx of male immigrants to the U.S. as compared to females within recent decades.[20]

The differences in the sex ratio across race tend to coincide with the differences in employment and marriage rates over the same period, as illustrated in Figures 2 and 3. In general, the data indicate that those groups facing low sex ratios tend to have lower marriage and higher employment rates. For example, the marriage rates for white females are highest in the northwest of the United States, the region where the white sex ratio is greatest. The marriage rates for white women are higher than for white men in all regions with a high white sex ratio: only in the northeast, with a sex ratio near 1, are the marriage rates the same. With the exception of the west, black males have higher marriage rates than black females, consistent with the low sex ratios in all the regional black marriage markets. In terms of employment, the gap in employment rates across white men and white women is smallest in the northeast, where the sex

[20] U.S. Bureau of the Census, Current Population Report, Series P20-486, "Foreign-Born Population: March 1994".

ratio is relatively low; in the south and northwest, the gap in employment rates for whites is as high as 40% in some instances. In general, black males have higher employment rates than black females, but the gap in employment rates between black males and females narrows considerably as the sex ratio deteriorates for black women. In the following section, a model of employment and marriage is presented that can account for the differences in behavior across different groups within this cohort.

4 Econometric Specification

I estimate the structural parameters of the model using the three-stage estimation procedure of van der Klaauw (1996). In the first stage of estimation, the reduced form choice probabilities are derived from the solution to the dynamic programming problem and are jointly estimated with fertility using maximum likelihood. In the second stage, seven earnings and non-labor income equations are estimated as specified by (3) and (4). In particular, an earnings equation for each gender, non-labor income equations in the single, not-working and single working states for each gender and a non-labor income equation for married couples are estimated. In the final stage of estimation, the structural parameters of the model are recovered from the fertility and reduced form choice probabilities in combination with the earnings and non-labor income equations using a minimum distance estimator.

The primary advantage of the three stage method is the computational ease with which earnings and non-labor income are incorporated in estimation. It is necessary to estimate earnings and non-labor income equations for men and women: under van der Klaauw's (1996) approach, all seven equations can be estimated independently of the dynamic model. To do so, I assume the idiosyncratic components of earnings (e_{wt}) and non-labor income (e_{kt}) are linear in the reduced form choice probability errors (ε_{kt}).[21] Alternatively, if the model is estimated using full-information maximum likelihood, it is necessary to specify the joint distribution of the seven non-labor income and earnings equations, the two fertility probabilities for individuals and the

[21]See Dubin and McFadden (1984) and van der Klaauw (1996) for further details.

choice probability errors. Therefore, while the three stage estimator does impose assumptions regarding the form of the underlying errors, it is likely they are no more restrictive than the more demanding approach where assumptions are imposed on the underlying errors directly.

Before proceeding with estimation, the following functional forms are assigned to preferences and the sharing rule. It is assumed the utility function is linear in all arguments

$$u_k^G(x_t, c_t, i, L_t) = \gamma_k^G + \gamma_{xk}^G x_t + \gamma_{ck}^G c_t + \gamma_{ik}^G i^G + \gamma_L^G L_t, \tag{19}$$

where the γ's are utility conversion factors.[22] The sharing rule is specified as a linear function of the ratio of single men to women in the marriage market and the potential earnings of the type-i agent and their type-j spouse

$$\phi(R_t, \overline{w}^F(i), \overline{w}^M(j)) = \phi^R R_t + \phi^F \overline{w}^F(i) + \phi^M \overline{w}^M(j).$$

The parameters in the sharing rule can be interpreted as the change in the dollar value of the transfer resulting from a unit change in the corresponding argument. Finally, earnings and non-labor incomes are specified as linear functions of exogenous individual characteristics and the random components of earnings and non-labor income in each state, respectively.

4.1 Estimation of the Choice Probabilities and Fertility

The reduced form choice probabilities are estimated according to the optimal policy described by (12). Assuming the composite errors in period t are distributed *i.i.d.* extreme value,[23] the probability of choosing state k, conditional on choice set K_t, for

[22]The utility from children, consumption, and exogenous characteristics while single and not working are normalized to zero for identification purposes. Therefore, γ_{csh}^G, γ_{cmn}^G and γ_{cmh}^G are interpreted as the utility from children when in states sh, mn and mh, respectively, relative to the utility from children while single and not working. The parameters γ_{ish}^G, γ_{imn}^G and γ_{imh}^G are interpreted in an analogous fashion. Furthermore, γ_{xsh}^F, γ_{xsh}^M, γ_{xmh}^M are normalized to one for identification purposes.

[23]This assumption is commonly imposed in the estimation of dynamic discrete choice models, as it implies a convenient closed form solution for the choice probabilities. See van der Klaauw (1996), Rust (1987), and Berkovec and Stern (1991) for examples. Appendix A describes the expressions relating the composite errors to the underlying shocks to utility, earnings and non-labor income.

an individual of type i can be expressed as

$$\begin{aligned}\Pr(d_{kt}^G = 1 | K_t, i, c_t) &= \Pr[\varepsilon_{kt}^G - \varepsilon_{lt}^G \geq \varepsilon_{lt}^{G*} - \varepsilon_{kt}^{G*}, \forall l \in K_t] \\ &= \frac{\exp\{U_k^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) | d_{kt}^G = 1]\}}{\sum_{l \in K_t} \exp\{U_l^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) | d_{lt}^G = 1]\}}.\end{aligned}$$

Information on the respondent's race, the presence of children, education, region of residence, year in the marriage market and spousal education if married is used to estimate the reduced form choice probabilities.

Individuals are married if they choose state mn or state mh. Therefore, the probability individuals want to marry or remain married is

$$\begin{aligned}&\Pr\left(J_t^G(i, j, c_t) = 1\right) \\ &\qquad = \frac{\sum_{k \in \{K_m\}} \exp\{U_k^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) | d_{kt}^G = 1]\}}{\sum_{l \in \{K_s \cup K_m\}} \{U_l^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) | d_{lt}^G = 1]\}},\end{aligned}$$

where from (9)

$$v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) = \begin{cases} V_{t+1}^G(\Omega_{t+1}, i, c_{t+1} = 1) & \text{if } c_t = 1 \\ B^G(i, t) V_{t+1}^G(\Omega_{t+1}, i, c_{t+1} = 1) & \\ +(1 - B^G(i, t)) V_{t+1}^G(\Omega_{t+1}, i, c_{t+1} = 0) & \text{if } c_t = 0. \end{cases}$$

The problem faced by potential spouses is identical to that faced by individuals of the same gender in the sample. Therefore, the same characteristics (region, children, education of the potential spouses, education of the individual) that determine the individual choice probabilities determine the acceptance probabilities of the potential spouse.[24]

The probability an agent of gender G experiences a first birth in period t is logistically distributed, where the set of variables assumed to determine fertility includes the number of years since the agent initially entered the marriage market, race, education, and marital-specific capital if married. The incorporation of state-specific

[24]The implicit assumption being made is that both spouses share the same household (in the same region) after marriage. It is also assumed that individuals and spouses do not receive utility from step-children.

utility from children and first birth arrivals captures, albeit in a limited way, the notion that fertility and marital status decisions are inter-related. Annual data on the presence of children is used to identify the parameters in the first birth probabilities for respondents and potential spouses. I therefore specify the probability of a first birth as

$$B_s^G(i,t) = \frac{\exp(\lambda_{0s}^G + \lambda_{is}^G i + \lambda_{ts}^G t)}{1 + \exp(\lambda_{0s}^G + \lambda_{is}^G i + \lambda_{ts}^G t)}$$

for single individuals and

$$B_m(i,j,t,L_{t-1}) = \frac{\exp(\lambda_{0m} + \lambda_{im} i + \lambda_{jm} j + \lambda_{tm} t + \lambda_L L_{t-1})}{1 + \exp(\lambda_{0m} + \lambda_{im} i + \lambda_{jm} j + \lambda_{tm} t + \lambda_L L_{t-1})}$$

for married couples.

The probability of choosing state k in period t for an individual of type i is thus a function of the probability of contacting a potential spouse in the marriage market, the probability that the current or potential spouse finds the individual acceptable as a mate and the probability of realizing a particular choice set

$$\begin{aligned}
&\Pr\left(d_{kt}^G = 1 | i, c_t\right) = \\
&\quad p_t^G\Big(\sum_j \sum_{c'} q_s^{G'}(j,c'_t) Pr\big(J_t^{G'}(j,i,c'_t)=1\big)\Big) \Pr(d_{kt}^G = 1 | k \in \{K_s \cup K_m\}, i, c_t) \\
&\qquad + \Big[1 - p_t^G\Big(\sum_j \sum_{c'} q_s^{G'}(j,c'_t) Pr\big(J_t^{G'}(j,i,c'_t)=1\big)\Big)\Big] \Pr(d_{kt}^G = 1 | k \in K_s, i, c_t)
\end{aligned}$$

if $k_{t-1} \in K_s$ and

$$\begin{aligned}
&\Pr\left(d_{kt}^G = 1 | i, c_t\right) = \\
&\qquad\qquad J_t^{G'}(j,i,c'_{t+1}) \Pr(d_{kt}^G = 1 | k \in \{K_s \cup K_m\}, i, c_t) \\
&\qquad\qquad\qquad + \Big[1 - J_t^{G'}(j,i,c'_{t+1})\Big] \Pr(d_{kt}^G = 1 | k \in K_s, i, c_t)
\end{aligned}$$

if $k_{t-1} \in K_m$.

The likelihood function for the N individuals in the sample is

$$\pounds = \prod_{i=1}^{N} \Pr[d_{kT}^i | d_{kT-1}^i, ...d_{k2}^i, d_{k1}^i, i, \Theta] \cdots \Pr[d_{k2}^i | d_{k1}^i, i, \Theta] \cdot \Pr[d_{k1}^i | i, \Theta],$$

where Θ is the vector of reduced form parameters from the model.

4.2 Estimation of Earnings and Non-Labor Income

The estimation of earnings and non-labor income for individuals, spouses and potential spouses constitutes the second stage of estimation. The samples used to estimate the earnings and non-labor income equations depend upon the employment and marital status decisions of each individual. Earnings are only observed for labor market participants and thus are estimated on samples of working individuals only. The samples used to estimate non-labor income are also state dependent, since non-labor incomes are only observed in the data for individuals occupying a particular state. To control for the bias that may result from the use of non-random samples, non-labor income and earnings equations are selection-corrected in estimation using the choice probabilities obtained in the first stage.[25]

Earnings and non-labor income equations are estimated for men and women as well as for their spouses if married or potential spouses if single. The vector of characteristics that determine earnings for individuals include region of residence indicators, race, education and the number of years since the individual first entered the marriage market.[26] The vector of characteristics determining non-labor income is the same as that determining earnings with the addition of children, included to capture differences in the availability of social programs that depend on the presence of children, and spousal education if married. The coefficients in the earnings and non-labor income equations are identified by the data on earnings and non-labor income, respectively. Note that the sex ratio and spousal education enter the choice probabilities, and therefore the selection correction terms, but do not directly enter the earnings and non-labor income equations.

[25] A similar approach is implemented in Dubin and McFadden (1984).

[26] For full details regarding the estimation of the earnings and non-labor income equations, see Appendix B.

4.3 Estimation of the Structural Parameters

In the final stage of estimation, parameter estimates from the first two stages are used to obtain consistent estimates of the structural parameters of the model (Ψ). The combined system of reduced form choice probabilities, earnings, non-labor income and fertility probabilities results in a set of moment conditions relating the reduced form parameters to the structural parameters. Generalized method of moments (GMM) estimation is used to recover the structural parameters from the just-identified system. In particular, the structural parameters are estimated as

$$\widehat{\Psi} = \arg\min_{\Psi} [\widehat{\Theta} - g(\Psi)] W^{-1} [\widehat{\Theta} - g(\Psi)],$$

where g is the set of moment conditions imposing the restrictions between the reduced form and structural parameters of the model and $\widehat{\Theta}$ is the vector of reduced form parameters. The weighting matrix W is estimated using estimates of the covariance matrices from the first two stages in estimation and the outer-products of the first order conditions.[27] The asymptotic covariance matrix of this estimator (Hansen, 1982) is

$$\Sigma = [G' W^{-1} G]^{-1},$$

where G is a matrix of derivatives of the moment conditions, $G = \partial g(\widehat{\Psi})/\partial \Psi'$, and

$$\sqrt{N}(\widehat{\Psi} - \Psi) \rightarrow^{D} n[0, \Sigma]. \tag{20}$$

The preference parameters are identified as follows. Comparing the utility from the single, non-working state to each of the remaining states identifies the parameters representing the utility from exogenous characteristics, children, marital-specific capital, marriage and employment ($\gamma^G_{ik}, \gamma^G_{ck}, \gamma^G_L, \gamma^G_k$, $k \in \{sh, mn, mh\}$). For identification purposes, the consumption parameters for the single working states (γ^G_{xsh}) and for one of the married states for one of the spouses (γ^M_{xmh}) are normalized to 1. The utility from the spouse's education in the married, not working state is also normalized to zero. Comparing the utility from the married, non-working state to the

[27] For full details, see the Appendix and van der Klaauw (1996).

single, non-working state identifies the parameters in the sharing rule (ϕ^R, ϕ^M, ϕ^F). The sharing rule parameters are identified by the assumption that the male earnings potential only enters the female's utility function through intra-household transfers and likewise for females. Similarly, the parameter ϕ^R is identified by assuming that the sex ratio only influences utility directly through the sharing rule. Data are not available on rejections and acceptances of offers by both potential spouses in a match; however, the symmetry inherent in the two-sided model implies the same parameters that determine the utility from each state also determine the probabilities potential spouses want to marry.

As a final note before preceding to estimation, it should be mentioned that the equilibrium conditions are not imposed during estimation due to the extra computational costs imposed by doing so. In particular, imposing the equilibrium conditions entails solving for the equilibrium values of the sex ratio and proportions of singles and married couples of each type in the model between every iteration over the parameter estimates. However, when policy experiments are conducted using the model, the equilibrium conditions are imposed. This issue is discussed in further detail in Section 6.

5 Results

5.1 Parameter Estimates

The model presented above is estimated for the time period covering 1979 to 1994,[28] under the assumption the discount factor is equal to 0.95 so as to capture the forward-looking behavior of agents.[29,30] The estimated parameters determining the size of the intra-household transfer are presented in Table 3. Regarding the effects of earnings potential on the intra-household allocation process, the findings are consistent with

[28]For the purposes of this paper, 1994 is treated as the terminal period. To extend the time horizon, it is necessary to construct stocks of single agents using the equilibrium flow conditions for the years beyond the end of the sampling period.

[29]The estimates did not converge when attempts were made to estimate the discount factor.

[30]Parameter estimates from the reduced form models are presented in Appendix C.

those of Chiappori, Fortin and Lacroix (2002). In particular, the results predict that an increase of \$1.00 in the potential earnings of the wife results in a decrease in transfers from her spouse by approximately \$0.34, while an equivalent increase in the potential earnings of her spouse induces an increase in transfers to the female of \$0.22. Considering the signs of the sharing rule parameters, Chiappori et al. (2002) interpret the results as evidence of altruism within married couples.

It is worth emphasizing the finding that increases in the earnings potential of husbands and wives have opposing effects on transfers within the household. One implication of this result is that the probability a match forms between any two agents is decreasing in the difference between their potential earnings, a result consistent with positive sorting on earnings potential. More specifically, the transfers paid by spouses with higher earnings potential increase as the gap in earnings potential across the husband and wife increases. If the transfer paid by the high income spouse becomes sufficiently large, the probability that the utility from being single exceeds that from being married increases. As a result, the estimation results predict matches between spouses with low potential earnings and high potential earnings are less likely to form, consistent with the notion that quality matters in the marital sorting process.

The parameter estimate for the sex ratio in the transfer rule indicates that a 10% increase in the sex ratio increases annual transfers to the female by \$230 or approximately 16% of average non-labor marital income. This result is consistent with the interpretation that more favorable opportunities in the marriage market translate into greater bargaining power within the marriage. The results are also indicative of the relationship between the labor market and the marriage market, as an increase in the sex ratio has the expected income effect on the employment decisions of both household members. Although it is difficult to make direct comparisons between the two frameworks, the effect of the sex ratio on the distribution of income within married households in this paper appears consistent qualitatively with the results of Chiappori et al. (2002).[31]

[31] The model of Chiappori et al. (2002) is estimated on a sample of married couples in which both partners worked from the 1988 wave of the PSID. The sex ratio in their analysis was measured at

Together, the parameter estimates translate into average annual transfers of \$1,945 and \$2,151 to black and white women, respectively. The transfer received by a woman in the average household is composed of non-labor income and spousal labor market earnings, as average transfers to married women exceed total non-labor income by \$1,299 and \$1,204 for black and white men, respectively. The differences across males and females in intra-household transfers reflect differences in earnings potential across sex and the higher level of non-labor income available to single women relative to single men through programs such as AFDC. The fact that the average married male is predicted to pay part of his labor earnings to his spouse provides one explanation for the lower marriage rates in the black population relative to the white population.[32] If labor market earnings are lower for black males, as observed from Table 1, then marriage may be less desirable for black males simply because the transfer necessary to form a match is quite costly. Black women, alternatively, may not be willing to accept a lower transfer because their outside option of remaining single may be more attractive if the marital transfer becomes sufficiently low. The latter is reflected in Table 4, as black women are predicted to reject 43% of contacts in the marriage market. Both channels help explain the joint pattern of marriage and employment differences across sex and race in the data.

The relationship between marriage market conditions and marital behavior across race is further exacerbated by the fact that black women find it more difficult to contact a spouse than white women. The average contact probabilities over the sample period, constructed from the stocks of single males and females in the CPS according to (5) and (6), indicate the presence of substantial search friction, with relatively higher friction faced by those with poor marriage market opportunities. In particular, Table 4 indicates there is a larger spread in contact rates across sex for blacks than for whites. This is a direct result of the greater imbalance in marriage market conditions for blacks: it is predicted that 20% of single black women are

the state level and other factors, including variation in divorce laws, were included in the sharing rule.

[32] In fact, approximately 10% of married men in the sample would be unable to pay the transfer predicted by the model.

unable to make a contact in the marriage market over the course of a year.

A further determinant of the relatively low marriage rates of blacks can be observed upon examination of the estimated preference parameters in Table 5.[33] In particular, black women receive significantly less utility from marriage than white women. This result is consistent with previous studies that consider racial differences in marital behavior (Brien, 1997; Brien, Lillard and Stern, 2001). In contrast, there are no significant differences in preferences over marriage for black and white men. The differences in marriage behavior of black men can therefore be attributed to the differences in socio-economic characteristics and differences in marriage and labor market opportunities.

Regarding the remaining preference parameters, women prefer marriage to remaining single, while men prefer not working to working. The latter is consistent with receiving disutility from leisure as expected. Interestingly, the utility from marital-specific capital is much higher for men than for women. A commonly cited benefit of marriage is specialization of labor within the household, where women tend to devote more time to home production than men. For this reason, an increase in marital-specific capital for women likely represents a penalty of investing in human capital for home versus market production, as the former may not provide as many benefits outside the marriage as the latter. This pattern in the data may be consistent with a more general model, where men and women can choose whether to specialize in home versus market production.

Turning to the preference parameters for children, single working men and women receive less utility from children relative to the single, non-working state, likely reflecting the time costs of child rearing. It is also of interest to consider the effect of marital status on the probability of a first birth for men and women. The parameter estimates for the first birth probabilities are presented in Table 6. In particular, the effect of many of the determinants of first births differ depending on an individual's marital status. Educated men and women are more likely to have children while

[33] The parameter estimates for region, year and education are presented in Appendix D.

married and less likely to have children while single. Black men and women are more likely to experience a first birth while single, relative to whites, and are less likely to experience a first birth while married. Both findings highlight an interesting avenue for extending the model in future work.

5.2 Model Fit

A comparison of the employment and marriage rates generated by the model to those observed in the data provides an assessment of the performance of the model. A simulated sample of 5,000 individuals is created and the simulated and actual employment and marriage rates by race and sex are compared in Figures 4 and 5. The simulated employment rates match the employment rates in the data quite closely, although the simulated employment rates are slightly higher than the actual employment rates during the first few years of the sample period for white men and during the last few years for white women. Where the model does not match the data as well, however, is the marriage rates. First, the model over-predicts the proportion of married men and women in the early years in the marriage market. The youngest women and men in the sample are 15 and 17 years of age in the first year of the marriage market, respectively, and as such are primarily enrolled in school and unlikely to form a match. Although the model has difficulty accounting for the relatively slow transition to marriage for males in the early years, it is able to match the marriage rates for whites quite well in the remaining years.

Second, the model tends to over-predict the marriage rates for blacks over the entire sample period, suggesting the model is not sufficiently flexible to closely capture marriage trends across time for both marriage markets. Two factors in particular may be important in explaining the fit of the model in this respect. First, education is measured as an indicator equal to 1 if individuals attained at least a high school education. As indicated in Table 1, the high school completion rates for blacks and whites are roughly equal by 1996. However, the proportion of individuals with some post-secondary education is substantially higher for whites than for blacks. In particular, the fraction of women (men) with some post-secondary schooling, conditional on high school graduation, is 62% (59%) for whites as compared to 56% (49%) for blacks. Educational attainment is an important component of quality in the marriage market. A richer specification for education that more accurately captures the educational differences across race may therefore improve the ability of the model to fit the black marriage rates. The second factor is the effect of out-of-wedlock childbearing on marriage rates. Evidence from the literature indicates the prevalence of single parenthood is greatest among black females relative to all other groups in the population (DaVanzo and Rahman, 1993) and that children from past relationships reduce the likelihood of future marriage (Bennett, Bloom and Miller, 1995). As such, blacks may have lower marriage rates due to the greater incidence of lone parents in the black population. Allowing preferences over marriage to depend on whether children are carried into new relationships may further improve the ability of the model to explain the black-white marriage differential.

As mentioned earlier, the equilibrium conditions are not imposed during estimation. Therefore, it is of interest to consider whether the simulated marriage market conditions match the aggregate sex ratios in the data. Figure 6 indicates that the model tends to underestimate the sex ratios for both the black and white marriage markets. For whites, this finding is due to the fact that the model over-predicts marriage rates at the beginning of the sample period when the aggregate sex ratio is relatively low. Alternatively for blacks, the gap between the simulated and actual sex ratio remains constant over the most of the sample period, as the model over-predicts marriage rates to roughly the same extent for black men and women over the entire sample period.

6 Policy Experiments

In this section, a number of simulations are performed to further explore the implications of the parameter estimates and to consider several policy experiments designed to influence employment and family structure. Each is conducted on a simulated sample of 5,000 men and women and compared to a baseline specification that has the same sample proportions by race, sex, education and region as in the data. It should be emphasized that the policy experiments are equilibrium policy experiments: in other words, the sex ratios and proportions of men and women of each type and fertility status in the marriage market, as described by (13) to (18), are endogenous in each of the simulations presented below.

6.1 The Wilson hypothesis revisited

As mentioned in the introduction, a hypothesis raised by Wilson and Neckerman (1986) and Wilson (1990) in the literature on racial differences in the U.S. marriage markets is that marriage rates are lower in the black marriage market because black women face a deficit of *marriageable* men. In particular, many black men have characteristics, such as lower levels of educational attainment, that limit their desirability as spouses. Combined with the higher mortality and incarceration rates for black males than for other groups in the population, black men are in excess demand in the marriage market. If blacks matched in a market that had the same characteristics as the white marriage market, would black marriage rates be similar to those of whites? To answer this question, the following model simulation is performed. The black population is given the same number of men and women as in the white population and the same distribution of characteristics. For example, the average educational attainment for black males and females are the same as for their white counterparts, while the preference parameters, transfer rule, and the earnings profiles are kept the same as in the baseline economy. The results of this exercise, presented in Figure 7, suggest that providing blacks with the same marriage market opportunities as whites serves only to lower the marriage rate and employment rates for the black population.

Two underlying forces are behind the decline in marriage rates within the estimated model. The first is that the higher sex ratio for blacks implies less search friction for black women who are searching in the marriage market. As search becomes easier, women meet potential spouses with a higher likelihood than before.

Black females are therefore more likely to delay marriage and to wait for a better opportunity in the future. Second, although the socio-economic characteristics of black males now match those of whites, it is still the case that the labor market opportunities of black males in terms of earnings potential are still less favorable than for white males. In particular, the parameter estimates of the earnings equations suggest, holding all other characteristics constant, black males earn $3,210 less per year than white males.[34] Black females earn less than white females, but the black-white earnings gap for women is much less than that for men. Combined with the fact that the characteristics and opportunities of black women have improved, it is more difficult than before for black males to make marriage an attractive alternative for black women.

It is also of interest to observe the trend in the sex ratio over time for blacks as compared to whites in the baseline specification at the bottom of Figure 7. Recall, whites and blacks face the same aggregate stocks and proportions of men and women of each type in the population in this exercise. However, the trends in the sex ratio are dramatically different across blacks and whites. The reason the sex ratio increases faster for whites is because the marriage rates for whites are higher. As a result, the slight imbalance in the aggregate sex ratio for whites translates into a very large imbalance in the ratio of single men to single women.

The above exercise has interesting implications for policy analysis. Programs aimed to increase the educational attainments of black youths, or to reduce black mortality and incarceration rates, might be proposed as policy prescriptions designed to address the Wilson hypothesis. However, it is unlikely that such policies would improve the situation for only one side of the marriage market: black men and women would both benefit from most policy measures. This simulation shows that such policies may have unintended consequences for the marriage market, highlighting the importance of equilibrium effects in this setting.

[34]See Appendix D.

6.2 Black-White differences in labor market earnings

The earnings equations suggest that black males and females earn $3,210 and $1,456, respectively, less than whites with the same characteristics. If blacks with the same observable characteristics as whites received the same earnings, what would happen to marriage and employment behavior? In this experiment, the composition of the black population remains the same as in the baseline specification, but the earnings profiles are constrained to look the same for blacks as for whites. This experiment is implemented by setting the black indicators in the earnings equations to zero for men and women.[35]

The elimination of the black-white wage gap also reduces marriage rates for blacks, as indicated in Figure 8, because of the manner in which intra-household transfers respond to the change in labor market outcomes. Married women lose $500.85 (i.e. $1,465 increase in earnings multiplied by a 0.344 reduction in the transfer) in transfers, because of an increase in earnings potential, but gain $693.14 because the earnings potential of their spouses increases as well for a net increase in transfers of $192. If black women remain single and decide to work, they do not receive a transfer but experience a relatively large increase in utility as the utility from consumption is higher for single women than married women. Similarly, black males keep all their earnings increase if they decide to be single and gain 3.209 utils if single and working (relative to single and not working). Therefore, remaining single is now a more attractive alternative to marriage for both black men and women.

It is also worth noting that a large rise in employment rates for black women and men results from the policy change. The employment rates for black males in particular rise to above those that we observe in the data for white males, as black males receive more utility from the single, working state in the model than white males do.

[35] The parameter estimates for the earnings equations are presented in Appendix D.

6.3 Marriage subsidies

A final policy experiment considered here is one that has been widely debated by policy makers and widely discussed in the literature: the role of marriage taxes and subsidies (Brien, Lillard and Stern, 2001; Chade and Ventura, 2001a; 2001b; Alm and Whittington, 1995; Sjoquist and Walker, 1995). What happens to marital behavior if married couples receive a subsidy in this framework? The experiment is conducted by increasing the intercept in the non-labor income equation for married couples by \$500.[36] For the particular sample in question, this subsidy represents a relatively small increase in the total income available to married couples in which at least one spouse works.

The results of the marriage subsidy policy experiment are illustrated in Figure 9. The introduction of a marriage subsidy results in an initial rise in marriage rates in both marriage markets, as marriage becomes more attractive and financially viable earlier. However, as the pool of remaining singles declines, black marriage rates fall as the sex ratio declines and as the opportunities of black women in the labor market increase relative to those for black males.[37] Since males directly benefit from the increase in non-labor income in this case, there is an income effect on the employment decisions of white married men. The employment effect of the marriage subsidy is substantial for white males, where employment rates fall up to 20 percentage points for men who have been in the marriage market 4 to 5 years. The employment rate for black married men does not fall to the same extent as for whites, as the marriage subsidy is sufficiently large to enable more men to pay the transfer but not large enough to allow married blacks to enjoy more leisure time.

[36]The parameter estimates for non-labor income are presented in Appendix D.

[37]Earnings increase with age at a faster rate for women than for men. See Appendix D for further details.

7 Conclusion

This paper provides new insight into the causes and consequences of the dramatic differences in family structure and employment across sex and race that characterize recent U.S. history. The model is consistent with many of the stylized facts on the joint patterns of marriage and employment across race and sex, including the low marriage rates of blacks relative to whites, the high employment rates for black married women relative to white married women and the corresponding low employment rates for black men as compared to white men. The estimation results suggest that quality and quantity in the marriage market both matter. In particular, the presence of search friction in the marriage market, the responsiveness of intra-household transfers to the sex ratio, the quality of the marital pool, and the options of agents outside of marriage all play important roles in explaining the observed differences in behavior across blacks and whites.

The policy experiments presented here make two important points. First, any policy that impacts household formation decisions in the current period directly influences future conditions in the marriage market by changing the size and quality of the remaining pool of singles available to match. Second, the fact that men and women both respond to policies that alter the attractiveness of marriage and employment may produce predictions contrary to those produced by one-sided models of marriage. The policy experiments conducted here highlight the fact that policies aimed to reduce racial differences in socio-economic outcomes do not necessarily imply better opportunities for black women, as the quality of spouses on both sides of the marriage market will change.

Table 1: Sample Statistics by Race and Sex (Selected Years)

Variable	Black Men	Black Women	White Men	White Women
		1979		
Children	0.0413	0.1479	0.0398	0.0531
High School Diploma	0.4247	0.2152	0.5856	0.2871
Married	0.0465	0.0372	0.0825	0.0902
Working	0.4210	0.1180	0.6251	0.2541
Non-Labor Income	252.37	221.93	325.48	135.40
Earnings	6,781.28	4,620.12	7,845.96	4,629.34
		1985		
Children	0.2696	0.6028	0.3140	0.3455
High School Diploma	0.8073	0.8132	0.8448	0.8610
Married	0.2773	0.2632	0.4815	0.5366
Working	0.7508	0.4896	0.8908	0.6990
Non-Labor Income	541.05	1,440.42	737.82	693.08
Earnings	10,916.63	7,679.74	14,491.13	8,867.56
		1996		
Children	0.6361	0.8050	0.7043	0.7529
High School Diploma	0.8652	0.8475	0.8636	0.8869
Married	0.4979	0.3981	0.7127	0.7630
Working	0.7980	0.7101	0.9372	0.7030
Non-Labor Income	795.85	1,716.66	1,201.23	1,470.07
Earnings	17,937.47	13,474.80	24,616.36	15,386.95

Note: earnings are calculated on the samples of working men and women only.

Table 2: Employment Rates by Race and Marital Status, 1996 Cross Section

		White	Black
Men			
	Single	0.9091	0.6917
	Married	0.9486	0.9052
Women			
	Single	0.7751	0.6696
	Married	0.6806	0.7713

Table 3: Sharing Rule Parameters and Intra-Household Transfers

ϕ^R	2.296
	(0.059)
ϕ^F	-0.344
	(0.048)
ϕ^M	0.216
	(0.094)
Average Intra-Household Transfers	
Black Women	1945.76
White Women	2150.93
Black Men	-1298.89
White Men	-1204.53

Note: standard errors in parentheses.

Table 4: Contact and Estimated Acceptance Rates

	Contact Rate	Acceptance Rate (Single)
Black Females	0.814	0.574
White Females	0.887	0.655
Black Males	0.999	0.749
White Males	0.858	0.873

Table 5: Preference Parameters

	State		
	sh	*mn*	*mh*
	Women		
Intercept	-5.777	2.533	2.689
	(0.484)	(0.175)	(0.342)
Black	0.561	-1.187	-2.630
	(0.135)	(0.056)	(0.183)
Children	-2.801	0.015	-1.215
	(0.104)	(0.042)	(0.037)
Consumption	0.001	-0.00017	-0.00061
		(0.00007)	(0.00008)
Marital-Specific Capital		0.135	0.135
		(0.008)	(0.008)
	Men		
Intercept	-6.744	8.669	-4.239
	(0.877)	(1.939)	(0.812)
Black	2.153	0.577	-0.162
	(0.235)	(1.037)	(0.389)
Children	-0.695	-3.982	-4.380
	(0.157)	(0.220)	(0.175)
Consumption	0.001	0.0032	0.001
		(0.00218)	
Marital-Specific Capital		2.266	2.266
		(0.088)	(0.088)

Note: standard errors in parentheses.

Table 6: First Birth Probability Estimates

	Single Females	Single Males	Married Couples
Years in marriage market	-0.313	-0.366	-2.463
	(0.065)	(0.010)	(0.056)
Education of Female	-0.730		0.961
	(0.083)		(0.051)
Education of Male		0.401	1.485
		(0.078)	(0.283)
Black	1.032	1.533	-0.787
	(0.114)	(0.341)	(0.073)
Northeast	-0.907	1.716	0.074
	(0.117)	(0.432)	(0.090)
South	-0.277	0.888	0.077
	(0.114)	(0.257)	(0.051)
West	-0.477	2.367	-1.430
	(0.074)	(0.323)	(0.040)
Marital Specific Capital			-0.0821
			(0.0558)
Intercept	-2.363	-7.454	-1.427
	(0.079)	(0.175)	(0.074)

Note: standard errors in parentheses.

Figure 1: Sex Ratios by Race and Region

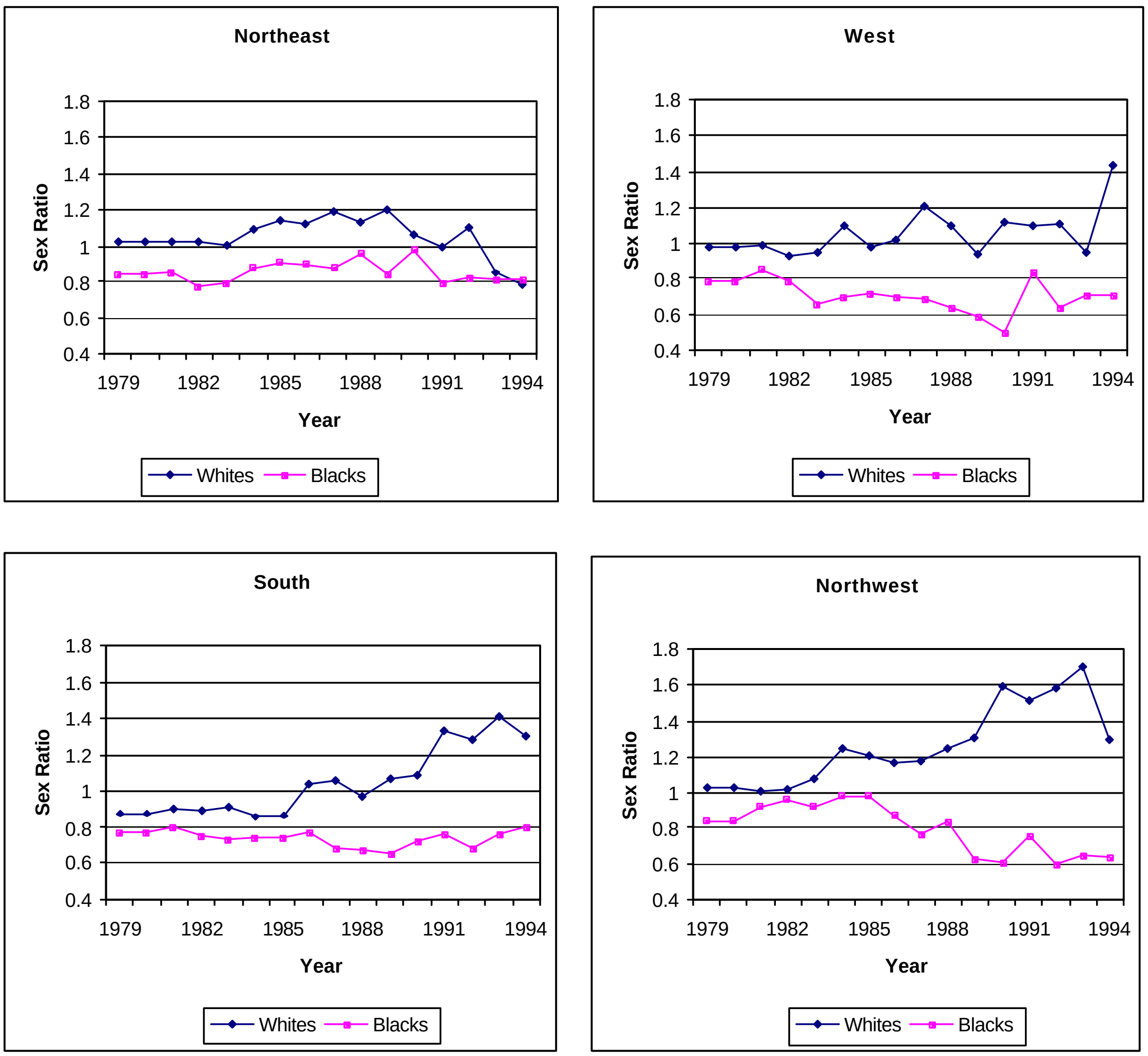


Figure 2: Marriage and Employment Rates by Region, Race and Sex

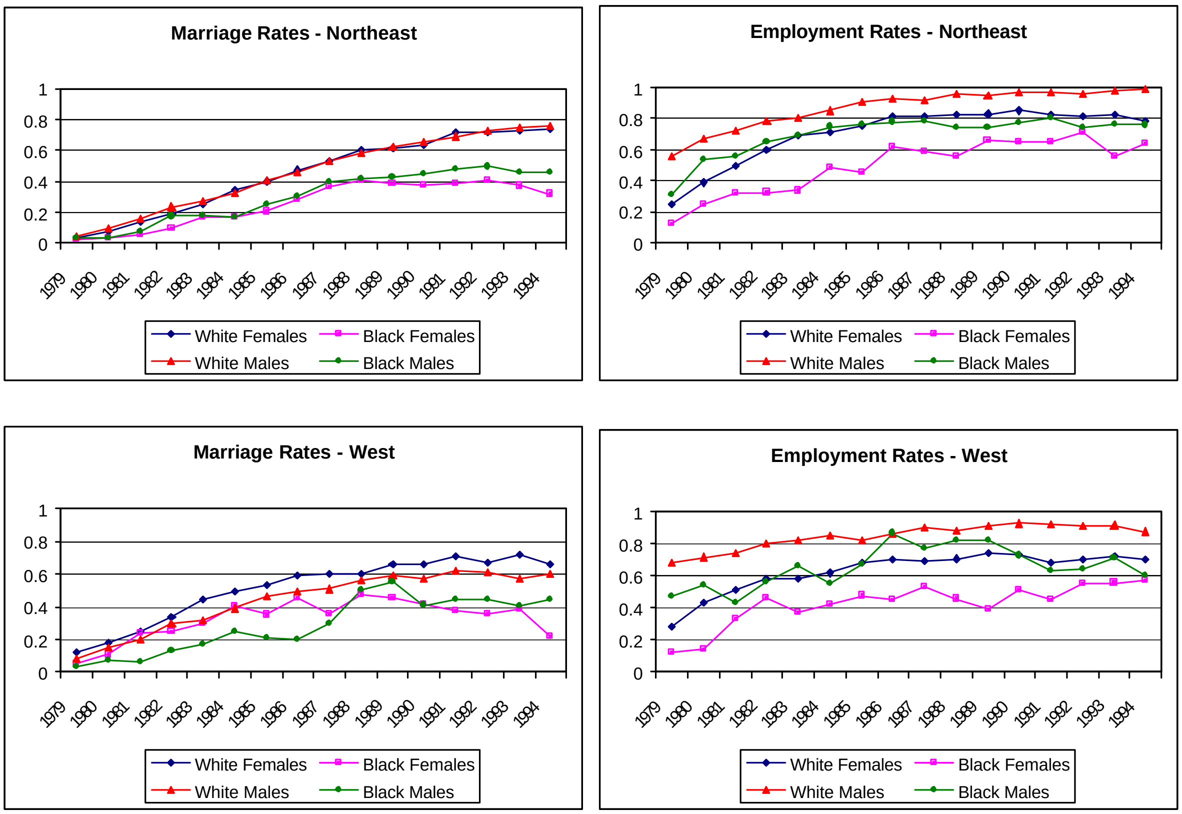


Figure 3: Marriage and Employment Rates by Region, Race and Sex

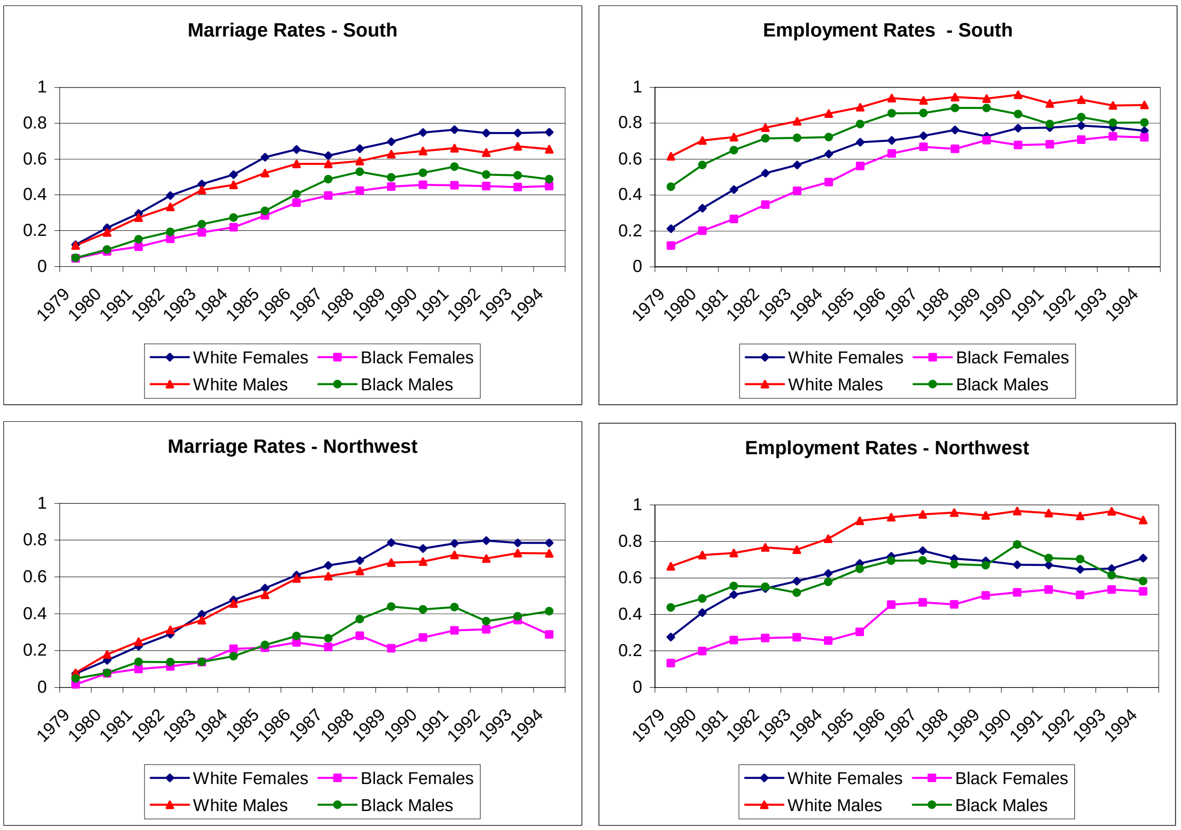


Figure 4: Comparison of Actual and Simulated Employment Rates

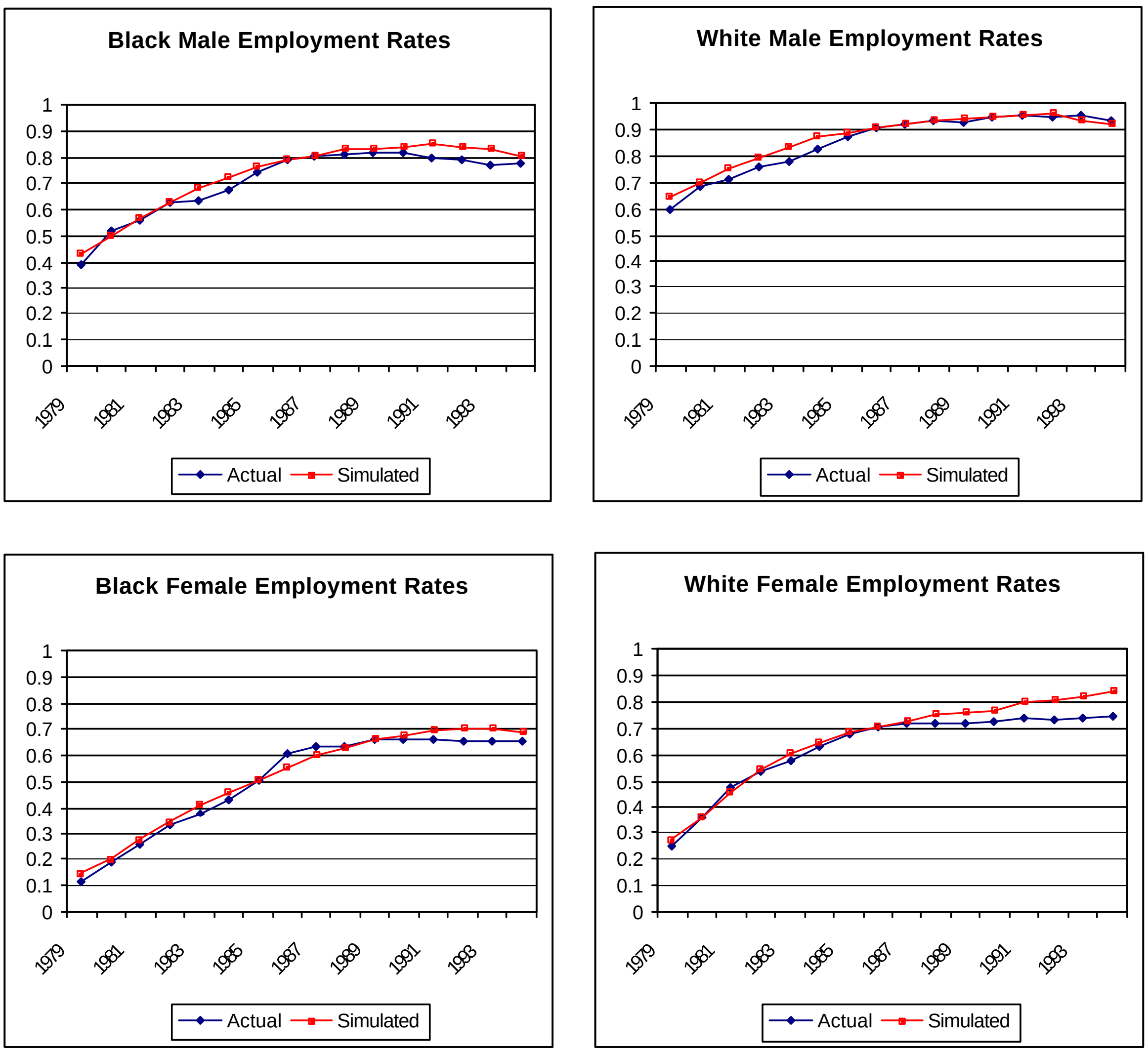
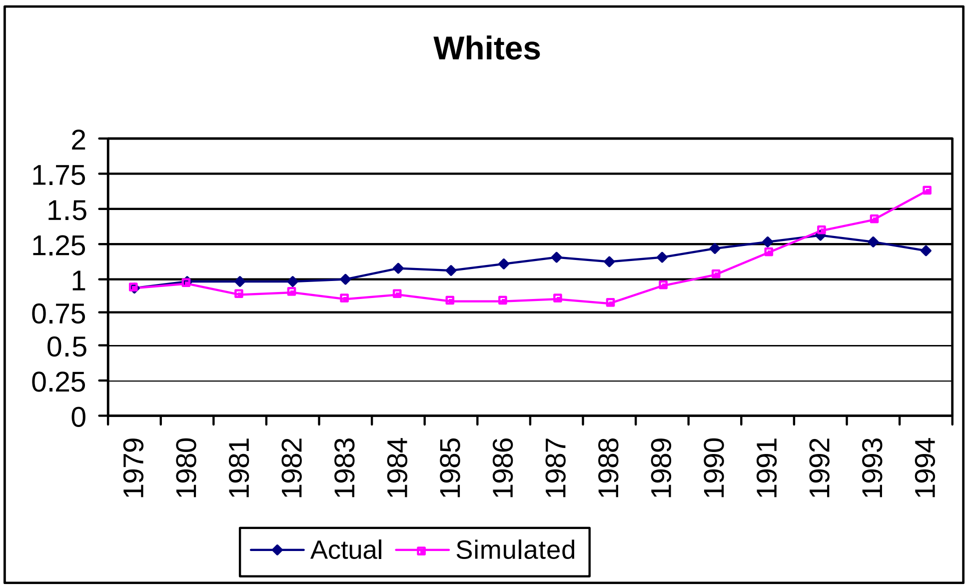


Figure 5: Comparison of Actual and Simulated Marriage Rates

Figure 6: Comparison of Actual and Simulated Sex Ratios, by Race



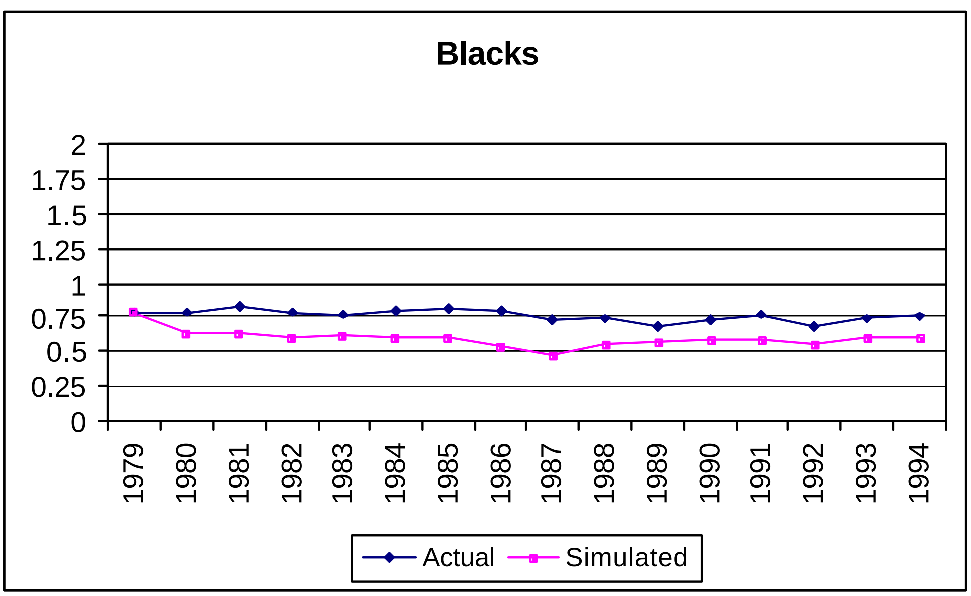


Figure 7: Black Marriage and Employment Behavior with Marriage Market Characteristics of Whites

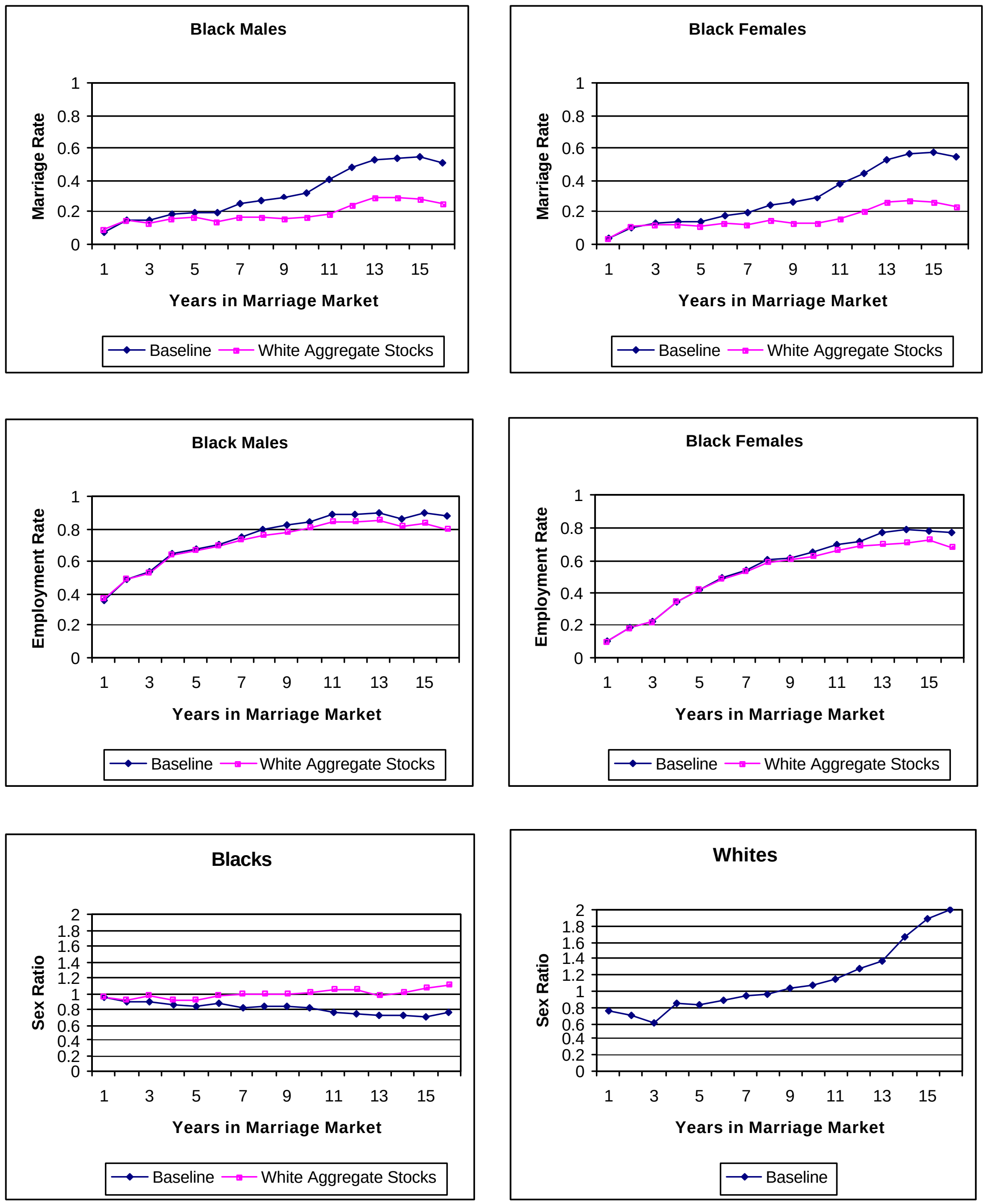


Figure 8: Black Marriage and Employment Behavior with Earnings Profiles of Whites

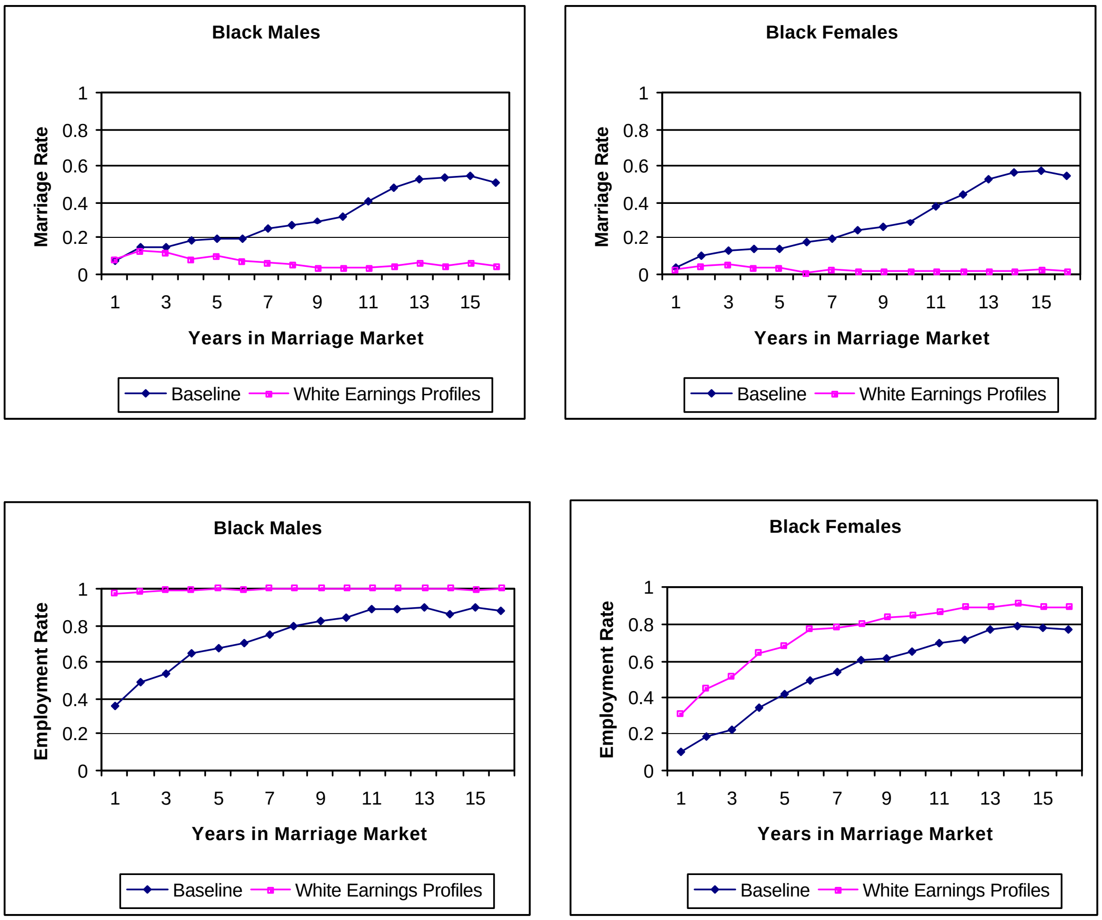
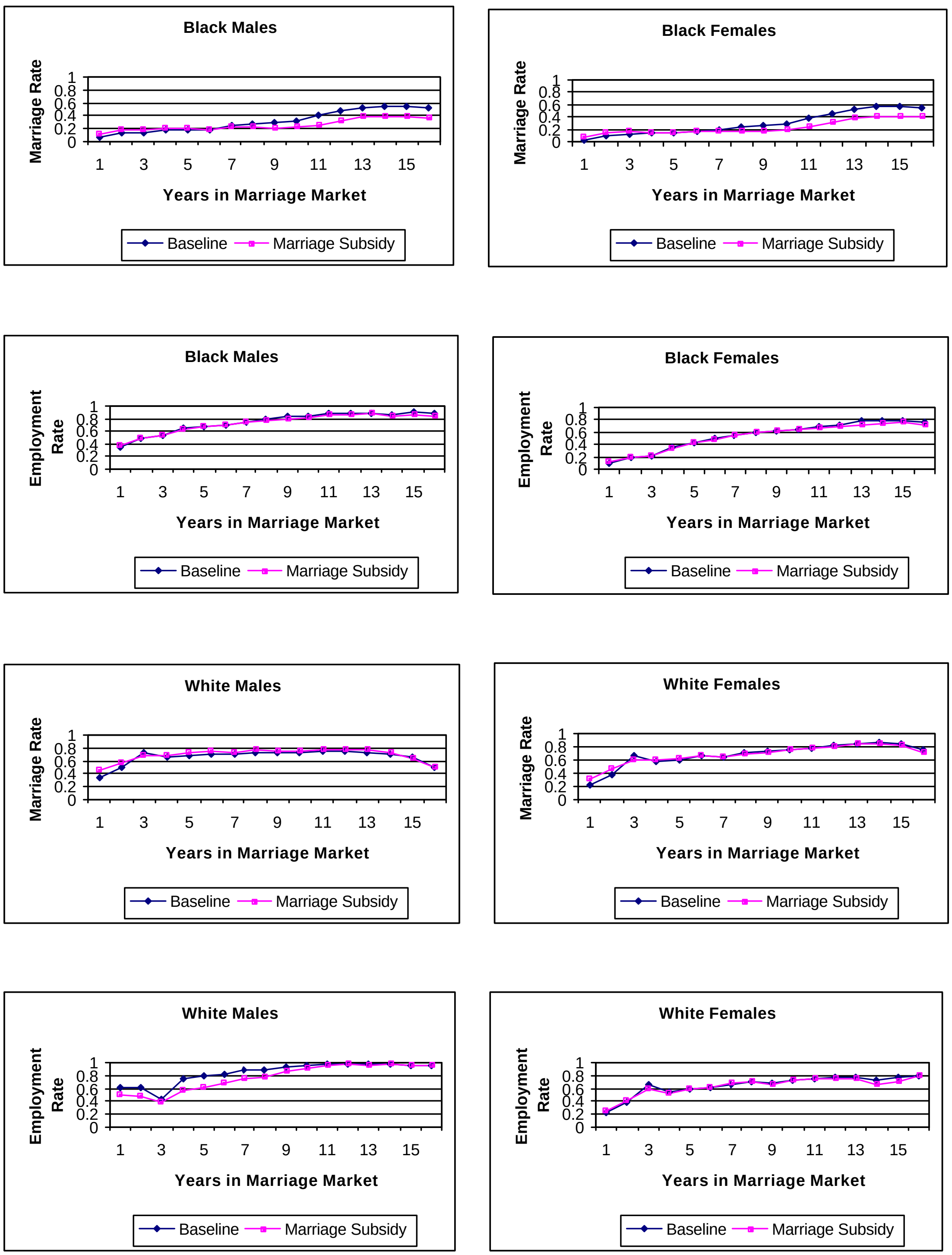


Figure 9: Marriage and Employment Behavior with Marriage Subsidy



A Reduced Form Representation of the Model

The reduced form representation of the model can be derived from the structural model by substituting (2)-(4) into (1). The discrete nature of the choice variables implies the value functions are only identified relative to a base. Therefore, the preference parameters for the single and not working state are normalized to zero and y^G_{snt} is subtracted from each state. The utility parameters in the remaining three states are thus to be interpreted as relative to the single, not-working state. The reduced form utility corresponding to each state is

Single, not working:

$$\epsilon^G_{snt}$$

Single, working:

$$\begin{aligned}\gamma^G_{sh} + \gamma^G_{csh} c^G_t + (\gamma^G_{ish} + \gamma^G_{xsh}(\alpha^G_i + \zeta^G_{ish}) - \gamma^G_{xsn}\zeta^G_{isn}) \cdot i \\ + \gamma^G_{xsh}(e^G_{wt} + e^G_{sht}) - \gamma^G_{xsn} e^G_{snt} + \epsilon^G_{sht}\end{aligned}$$

Married, not working:

Females

$$\begin{aligned}\gamma^F_{mn} + \gamma^F_{cmn} c^F_t + (\gamma^F_{imn} + \gamma^F_{xmn}\phi^F \alpha^F - \gamma^F_{xsn}\zeta^F_{sn}) \cdot i \\ + \gamma^F_{xmn}\phi^R R_t + \gamma^F_{xmn}\phi^M \alpha^M_j j + \gamma^F_L L_t - \gamma^F_{xsn} e^F_{snt} + \epsilon^F_{mnt}\end{aligned}$$

Males

$$\begin{aligned}\gamma^M_{mn} + \gamma^M_{cmn} c^M_t + (\gamma^M_{imn} + \gamma^M_{xmn}(\zeta^M_m - \phi^M \alpha^M) - \gamma^M_{xsn}\zeta^M_{sn}) \cdot i \\ + \gamma^M_{xmn}(\zeta^F_m - \phi^F \alpha^F_j) \cdot j - \gamma^M_{xmn}\phi^R R_t + \gamma^M_L L_t - \gamma^M_{xsn} e^M_{snt} + \gamma^M_{xmn} e_{mt} + \epsilon^M_{mnt}\end{aligned}$$

Married, working:

Females

$$\begin{aligned}\gamma^F_{mh} + \gamma^F_{cmh} c^F_t + (\gamma^F_{imh} + \gamma^F_{xmh}(1 + \phi^F)\alpha^F_i - \gamma^F_{xsn}\zeta^F_{sn}) \cdot i \\ + \gamma^F_{xmh}\phi^R R_t + \gamma^F_{xmh}\phi^M \alpha^M_j j + \gamma^F_L L_t - \gamma^F_{xsn} e^F_{snt} + \gamma^F_{xmh} e^F_{wt} + \epsilon^F_{mht}\end{aligned}$$

Males

$$\gamma_{mh}^M + \gamma_{cmh}^M c_t^M + (\gamma_{imh}^M + \gamma_{xmh}^M(\zeta_m^M + (1-\phi^M)\alpha_i^M) - \gamma_{xsn}^M \zeta_{sn}^M) \cdot i$$
$$+\gamma_{xmh}^M(\zeta_m^F - \phi^F \alpha_j^F) \cdot j - \gamma_{xmh}^M \phi^R R_t + \gamma_L^M L_t - \gamma_{xsn}^M e_{snt}^M + \gamma_{xmh}^M(e_{mt} + e_{wt}^M) + \epsilon_{mht}^M,$$

where the α's are parameters from the earnings equations and the ζ's are parameters from the non-labor income equations as defined in Appendix B.

Composite error terms $\varepsilon_{kt}^G,\ k \in \{sn, sh, mn, mh\}$ for the above reduced form representation can thus be defined as

$$\begin{aligned}
\varepsilon_{snt}^F &= \epsilon_{snt}^F \\
\varepsilon_{sht}^F &= \epsilon_{sht}^F + \gamma_{xsh}^F(e_{wt}^F + e_{sht}^F) - \gamma_{xsn}^F e_{snt}^F \\
\varepsilon_{mnt}^F &= \epsilon_{mnt}^F - \gamma_{xsn}^F e_{snt}^F \\
\varepsilon_{mht}^F &= \epsilon_{mht}^F - \gamma_{xsn}^F e_{snt}^F + \gamma_{xmh}^F e_{wt}^F
\end{aligned}$$

for women and

$$\begin{aligned}
\varepsilon_{snt}^M &= \epsilon_{snt}^M \\
\varepsilon_{sht}^M &= \gamma_{xsh}^M(e_{wt}^M + e_{sht}^M) - \gamma_{xsn}^M e_{snt}^M + \epsilon_{sht}^M \\
\varepsilon_{mnt}^M &= \epsilon_{mnt}^F - \gamma_{xsn}^F e_{snt}^F \\
\varepsilon_{mht}^M &= \epsilon_{mht}^M - \gamma_{xsn}^M e_{snt}^M + \gamma_{xmh}^M(e_{mt} + e_{wt}^M)
\end{aligned}$$

for men. Note that the problem faced by male and female agents within the model differs in two respects. First, preference parameters and the parameters in the earnings and non-labor income equations are allowed to vary across gender. Second, the budget constraints for married men and women differ due to the presence of intra-household transfers and the assumption that women receive transfers and men consume the couple's remaining marital non-labor income.

B Econometric Specification

B.1 Construction of the Likelihood Function

Following van der Klaauw (1996) and others, the extreme value assumption is shown to yield convenient analytical solutions to the expected value functions:

$$
\begin{aligned}
& E_{\varepsilon^G_{kt+1}}[V^G_{t+1}(\Omega_{t+1}, i, c_{t+1})|d^G_k = 1] \\
= {} & E_{\varepsilon^G_{kt+1}}\{\max_{k \in K} U^G(i, c_{t+1}) + \beta E[v^G_{t+2}(\Omega_{t+2}, i, c_{t+2}) \mid d^G_{kt+1} = 1] + \varepsilon^G_{kt+1}\} \\
= {} & \ln \sum_{k \in K} \exp[U^G(i, c_{t+2}) + \beta E[v^G_{t+2}(\Omega_{t+2}, i, c_{t+2}) \mid d^G_{kt+1} = 1].
\end{aligned}
$$

B.2 Estimation of Earnings and Non-Labor Income

Earnings and non-labor income are estimated on non-random samples, where the selection of the sample is determined by the employment and marital status decisions of the respondents. To control for sample selection bias selection correction terms are constructed as in van der Klaauw (1996) and Dubin and McFadden (1984) and included in estimation. Unbiased standard errors for the earnings and non-labor income equations can be calculated in the final stage of estimation as outlined in Section 4.3 of the text.

B.2.1 Earnings

As specified by the model and outlined above, earnings equations must be estimated for individuals and their spouses or potential spouses. Therefore, two sets of earnings equations are estimated. The first set utilizes individual characteristics for men and women. The earnings equation

$$w^G_t = \alpha^G_0 + \alpha^G_i i + \alpha^G_t t + e^G_{wt},$$

is estimated separately for men and for women, and is used by individuals in t when determining their personal earnings and by individuals married in $t-1$ when determining the earnings of their spouses in t. The earnings equation must be selection corrected for the fact that the sample used to estimate earnings is limited to labor market participants only. Using the result (Dubin and McFadden, 1984) that $E[e^G_{wt}|\varepsilon^G_{snt}, \varepsilon^G_{sht}, \varepsilon^G_{mnt}, \varepsilon^G_{mht}] = \sum_k r^G_k \varepsilon^G_{kt}$ with $\sum_k r^G_k = 0$ if the conditional expectation of e^G_{wt} is linear in the $\varepsilon^{G\prime}_{kt}s$, then

$$E[e^G_{wt}|d^G_{kt} = 1, K^G_t] = \sum_{j \in K^G_t, j \neq k} r^G_k [\frac{P^G_{jt} \ln P^G_{jt}}{1 - P^G_{jt}} + \ln P^G_{jt}]$$

where P^G_{jt} is the probability that alternative j is chosen by the individual of gender G in period t ($\Pr(d^G_{jt} = 1)$). Then, the conditional expectation of the error in the earnings equation for single, working individuals is:

$$\begin{aligned} E[e^G_{wt}|d^G_{sht} = 1] = \{&J^{G'}_{mt} E[e^G_{wt}|d^G_{sht} = 1, K^G_{mt}] \\ &+(1 - J^{G'}_{mt}) E[e^G_{wt}|d^G_{sht} = 1, K^G_{st}]\} 1(m^G_{t-1} = 1) \\ +\{p^G_t J^{G'}_{st} E[e^G_{wt}|d^G_{sht} = 1, K^G_{mt}] &+ (1 - p^G_t J^{G'}_{st}) E[e^G_{wt}|d^G_{sht} = 1, K^G_{st}]\} 1(m^G_{t-1} = 0) \end{aligned} \tag{21}$$

and the conditional expectation of the error in the earnings equation for married, working women and men is:

$$\begin{aligned} E[e^G_{wt}|d^G_{mht} = 1] &= J^{G'}_{mt} E[e^G_{wt}|d^G_{mht} = 1, K^G_{mt}] 1(m^G_{t-1} = 1) \\ &+ p^G_t J^{G'}_{st} E[e^G_{wt}|d^G_{mht} = 1, K^G_{mt}] 1(m^G_{t-1} = 0) \end{aligned} \tag{22}$$

Using (21) and (22) above, the conditional expectation of earnings can be expressed as

$$E[w^G_t|d^G_{sht} = 1 \text{ or } d^G_{mht} = 1] = \alpha^G_0 + \alpha^G_i i + \alpha^G_t t + r^G_{sh} R^G_{sht} + r^G_{mn} R^G_{mnt} + r^G_{mh} R^G_{mht}.$$

Define the terms A and B as

$$A = (1(m^G_{t-1} = 1) J^{G'}_{mt} + 1(m^G_{t-1} = 0) p^G_t J^{G'}_{st})$$

and

$$B = (1(m^G_{t-1} = 1)(1 - J^{G'}_{mt}) + 1(m^G_{t-1} = 0)(1 - p^G_t J^G_{st}))$$

respectively. Then, the selection correction terms can be defined as

$$\begin{aligned} R^G_{sht} = 1(d^G_{sht} = 1) &\left[A \left(-\frac{P^G_{snt} \ln P^G_{snt}}{1 - P^G_{snt}} - \ln P^G_{sht} \right) + B \left(-\frac{P^{*G}_{snt} \ln P^{*G}_{snt}}{1 - P^{*G}_{snt}} - \ln P^{*G}_{sht} \right) \right] \\ &+ 1(d^G_{mht} = 1) A \left(\frac{P^G_{sht} \ln P^G_{sht}}{1 - P^G_{sht}} - \frac{P^G_{snt} \ln P^G_{snt}}{1 - P^G_{snt}} \right) \end{aligned}$$

$$R^G_{mnt} = 1(d^G_{sht} = 1)\left[A\left(\frac{P^G_{mnt}\ln P^G_{mnt}}{1-P^G_{mnt}} - \frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right) + B\left(-\frac{P^{*F}_{snt}\ln P^{*F}_{snt}}{1-P^{*F}_{snt}} - \ln P^{*F}_{sht}\right)\right]$$
$$1(d^G_{mht} = 1)A\left(\frac{P^G_{mnt}\ln P^G_{mnt}}{1-P^G_{mnt}} - \frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right)$$

and

$$R^G_{mht} = 1(d^G_{sht} = 1)\left[A\left(\frac{P^G_{mht}\ln P^G_{mht}}{1-P^G_{mht}} - \frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right) + B\left(-\frac{P^{*G}_{snt}\ln P^{*G}_{snt}}{1-P^{*G}_{snt}} - \ln P^{*G}_{sht}\right)\right]$$
$$+1(d^G_{mht} = 1)A\left(-\frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}} - \ln P^G_{mht}\right),$$

where $1(\cdot)$ is an indicator function, $P^G_{kt} = \Pr(d^G_{kt} = 1|K^G_{mt})$ and $P^{*G}_{kt} = \Pr(d^G_{kt} = 1|K^G_{st})$. The resulting earnings equation to be estimated is

$$w^G_t = \alpha^G_0 + \alpha^G_i i + \alpha^G_t t + r^G_{sh}\widehat{R}^G_{sht} + r^G_{mn}\widehat{R}^G_{mnt} + r^G_{mh}\widehat{R}^G_{mht} + \epsilon^G_{wt}, \tag{23}$$

where $\widehat{R}^G_{sht}$, $\widehat{R}^G_{mnt}$, and $\widehat{R}^G_{mht}$ are estimated by replacing the $P^{G\prime}_{kt}s$ and $P^{*G\prime}_{kt}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (23), ϵ^G_{wt}, is mean zero.

B.2.2 Non-Labor Income

As specified by the model, three sets of non-labor income equations are estimated, depending on the marital and employment status of the individuals in the sample. The non-labor income equation for single, non-working individuals ($d^G_{snt} = 1$) is

$$y^G_{snt} = \zeta^G_{0sn} + \zeta^G_{isn} i + \zeta^G_{tsn} t + e^G_{snt}.$$

The conditional expectation of the error in the non-labor income equations for single, non-working individuals is:

$$\begin{aligned} E[e^G_{snt}|d^G_{sht} = 1] = \{&J^{G'}_{mt}E[e^G_{snt}|d^G_{sht} = 1, K^G_{mt}] \\ &+(1 - J^{G'}_{mt})E[e^G_{snt}|d^G_{1t} = 1, K^G_{st}]\}1(m^G_{t-1} = 1) \\ +\{p^G_t J^{G'}_{st}E[e^G_{snt}|d^G_{1t} = 1, K^G_{mt}] &+ (1 - p^G_t J^{G'}_{st})E[e^G_{snt}|d^G_{1t} = 1, K^G_{st}]\}1(m^G_{t-1} = 0). \end{aligned} \tag{24}$$

Using (24) above, the conditional expectation of non-labor income can be expressed as

$$E[e^G_{snt}|d^G_{snt}=1\ ]=\zeta^G_{0sn}+\zeta^G_{isn}i+\zeta^G_{tsn}t+b^G_{sh}B^G_{sht}+b^G_{mn}B^G_{mnt}+b^G_{mh}B^G_{mht},$$

where

$$B^G_{sht}=1(d^G_{snt}=1)\left[A\left(\frac{P^G_{sht}\ln P^G_{sht}}{1-P^G_{sht}}+\ln P^G_{snt}\right)+B\left(\frac{P^{*G}_{sht}\ln P^{*G}_{sht}}{1-P^{*G}_{sht}}+\ln P^{*G}_{snt}\right)\right]$$

$$B^G_{mnt}=1(d^G_{snt}=1)\left[A\left(\frac{P^G_{mnt}\ln P^G_{mnt}}{1-P^G_{mnt}}+\ln P^G_{snt}\right)\right]$$

and

$$B^G_{mht}=1(d^G_{snt}=1)\left[A\left(\frac{P^G_{mht}\ln P^G_{mht}}{1-P^G_{mht}}+\ln P^G_{snt}\right)\right].$$

The non-labor income equation to be estimated is

$$y^G_{snt}=\zeta^G_{0sn}+\zeta^G_{isn}i+\zeta^G_{tsn}t+b^G_{sh}\widehat{B}^G_{sht}+b^G_{mn}\widehat{B}^G_{mnt}+b^G_{mh}\widehat{B}^G_{mht}+\epsilon^G_{snt}, \tag{25}$$

where $\widehat{B}^G_{sht}$, $\widehat{B}^G_{mnt}$, and $\widehat{B}^G_{mht}$ are estimated by replacing the $P^{G\prime}_{kt}s$ and $P^{*G\prime}_{kt}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (25) is mean zero.

The non-labor income equations for single, working men and women can be expressed as

$$y^G_{sht}=\zeta^G_{0sh}+\zeta^G_{ish}i+\zeta^G_{tsh}t+e^G_{sht}$$

and are selection corrected to account for the bias that may be induced by estimating non-labor income on samples of single, working women and men only ($d^G_{sht}=1$). The conditional expectation of the error in the non-labor income equations for single, working individuals is:

$$\begin{aligned}E[e^G_{sht}|d^G_{sht}=1]&=\{J^{G'}_{mt}E[e^G_{sht}|d^G_{sht}=1,K^G_{mt}]\\&+(1-J^{G'}_{mt})E[e^G_{sht}|d^G_{sht}=1,K^G_{st}]\}1(m^G_{t-1}=1)\\+\{p^G_tJ^{G'}_{st}E[e^G_{sht}|d^G_{sht}=1,K^G_{mt}]&+(1-p^G_tJ^{G'}_{st})E[e^G_{sht}|d^G_{sht}=1,K^G_{st}]\}1(m^G_{t-1}=0).\end{aligned} \tag{26}$$

Using (26), the conditional expectation of non-labor income can be expressed as

$$E[e^G_{sht}|d^G_{sht} = 1\ ] = \zeta^G_{0sh} + \zeta^G_{ish}i + \zeta^G_{tsh}t + c^G_{sh}C^G_{sht} + c^G_{mn}C^G_{mnt} + c^G_{mh}C^G_{mht},$$

where

$$C^G_{sht} = 1(d^G_{sht} = 1)\left[A\left(-\frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}} - \ln P^G_{sht}\right) + B\left(-\frac{P^{*G}_{sht}\ln P^{*G}_{sht}}{1-P^{*G}_{sht}} - \ln P^{*G}_{snt}\right)\right]$$

$$C^G_{mnt} = 1(d^G_{sht} = 1)\left[A\left(\frac{P^G_{mnt}\ln P^G_{mnt}}{1-P^G_{mnt}} - \frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right) + B\left(-\frac{P^{*G}_{snt}\ln P^{*G}_{snt}}{1-P^{*G}_{snt}} - \ln P^{*G}_{sht}\right)\right]$$

and

$$C^G_{mht} = 1(d^G_{sht} = 1)\left[A\left(\frac{P^G_{mht}\ln P^G_{mht}}{1-P^G_{mht}} - \frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right) + B\left(-\frac{P^{*G}_{snt}\ln P^{*G}_{snt}}{1-P^{*G}_{snt}} - \ln P^{*G}_{sht}\right)\right].$$

The non-labor income equation to be estimated is

$$y^G_{sht} = \zeta^G_{0sh} + \zeta^G_{ish}i + \zeta^G_{tsh}t + c^G_{sh}\widehat{C}^G_{sht} + c^G_{mn}\widehat{C}^G_{mnt} + c^G_{mh}\widehat{C}^G_{mht} + \epsilon^G_{sht}, \qquad (27)$$

where $\widehat{C}^G_{sht}$, $\widehat{C}^G_{mnt}$, and $\widehat{C}^G_{mht}$ are estimated by replacing the $P^{G\prime}_{kt}s$ and $P^{*G\prime}_{kt}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (27) is mean zero.

The final non-labor income equations to be estimated are those for married couples

$$y_{mt} = \zeta^G_{0m} + \zeta^F_{im}i + \zeta^M_{jm}j + \zeta_{tm}t + e_{mt}.$$

Since data are only available on non-labor income for married couples, non-labor income is estimated on the sample of married men and women only ($d^G_{mnt} = 1$ or $d^G_{mht} = 1$) and is selection corrected accordingly. The conditional expectation of the error in the non-labor income equations for married, non-working individuals is:

$$\begin{aligned} E[e^G_{mt}|d^G_{mnt} = 1] = {} & J^{G\prime}_{mt}E[e^G_{mt}|d^G_{mnt} = 1, K^G_{mt}]1(m^G_{t-1} = 1) \\ & + p^G_t J^{G\prime}_{st}E[e^G_{mt}|d^G_{mnt} = 1, K^G_{mt}]1(m^G_{t-1} = 0) \end{aligned} \qquad (28)$$

and the conditional expectation of the error in the non-labor income equations for married, working individuals is

$$
\begin{aligned}
E[e^G_{mt}|d^G_{mht}=1] = J^{G'}_{mt}E[e^G_{mt}|d^G_{mht}=1,K^G_{mt}]1(m^G_{t-1}=1)\\
+p^G_t J^{G'}_{st}E[e^G_{mt}|d^G_{mht}=1,K^G_{mt}]1(m^G_{t-1}=0).
\end{aligned}
\tag{29}
$$

Using (28) and (29) above, the conditional expectation of non-labor income can be expressed as

$$
E[e^G_{mt}|d^G_{mnt}=1 \text{ or } d^G_{mht}=1] = \zeta_{0m}+\zeta^F_{im}i+\zeta^M_{jm}j+\zeta_{tm}t+d^G_{sh}D^G_{sht}+d^G_{mn}D^G_{mnt}+d^G_{mh}D^G_{mht},
$$

where

$$
\begin{aligned}
D^G_{sht} &= 1(d^G_{mnt}+d^G_{mht}=1)\left[A\left(\frac{P^G_{sht}\ln P^G_{sht}}{1-P^G_{sht}}-\frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right)\right]\\
D^G_{mnt} &= A1(d^G_{mnt}=1)\left(-\frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}-\ln P^G_{mnt}\right)\\
&+A1(d^G_{mht}=1)\left(-\frac{P^G_{mnt}\ln P^G_{mnt}}{1-P^G_{mnt}}-\frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right)
\end{aligned}
$$

and

$$
\begin{aligned}
D^G_{mht} &= A1(d^G_{mnt}=1)\left(\frac{P^G_{mht}\ln P^G_{mht}}{1-P^G_{mht}}-\frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}\right)\\
&+A1(d^G_{mht}=1)\left(-\frac{P^G_{snt}\ln P^G_{snt}}{1-P^G_{snt}}-\ln P^G_{mht}\right)
\end{aligned}
$$

The non-labor income equation to be estimated is thus

$$
y^G_{mt} = \zeta_{0m}+\zeta^F_{im}i+\zeta^M_{jm}j+\zeta_{tm}t+d^G_{sh}\widehat{D}^G_{sht}+d^G_{mn}\widehat{D}^G_{mnt}+d^G_{mh}\widehat{D}^G_{mht}+\epsilon^G_{mt} \tag{30}
$$

where $\widehat{D}^G_{sht}$, $\widehat{D}^G_{mnt}$, and $\widehat{D}^G_{mht}$ are estimated by replacing the $P^{G\prime}_{kt}s$ and $P^{*G\prime}_{kt}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (30) is mean zero.

B.2.3 Construction of the MDE Covariance Matrix

The derivation of the weighting matrix used to estimate the structural parameters follows directly from Hansen (1982) and van der Klaauw (1996). The estimation of the weighting matrix is based on the first order conditions satisfied by the estimators of the reduced form parameters. Denote f_j the j^{th} first order condition in the system and ψ_j the j^{th} vector of reduced form parameter estimates. Specifically, the estimators of the reduced form parameters $\psi = [\psi_1, \psi_2, ...\psi_{15}]'$ satisfy

$$\frac{1}{N}\sum f_1(\psi_1) = 0 \tag{31}$$

$$\frac{1}{N}\sum f_j(\psi_1, \psi_j) = 0,\ j = 2, ...15 \tag{32}$$

(31) represents the first order conditions satisfied by the reduced form choice and fertility probabilities. The first order conditions described by (32) correspond to the two earnings and five non-labor earnings equations from the second stage of estimation. Notice that the first order conditions for earnings and non-labor income are dependent on the reduced form choice probability parameters, which enter the selection correction terms. Hansen (1982) derives the asymptotic distribution of the reduced form parameters, where

$$\sqrt{N}(\psi - \psi^0) \rightarrow^D n[0, W]$$

where n denotes the normal distribution and

$$W^{-1} = E\left[\frac{\partial f(\psi^0)}{\partial \psi}\right]' \left[E\left[ff'\right]\right]^{-1} E\left[\frac{\partial f(\psi^0)}{\partial \psi}\right].$$

C Reduced Form Parameter Estimates

C.1 Choice Probability Parameter Estimates in the Single, Working State

	Female	Male
Northeast	0.0678	0.1214
	(0.0432)	(0.0445)
South	0.1887	0.0254
	(0.0389)	(0.0409)
West	-0.1798	-0.0563
	(0.0489)	(0.0509)
Black	-0.7892	-0.9395
	(0.0408)	(0.0422)
Education	1.8520	0.3380
	(0.0834)	(0.0508)
Child	-1.6630	0.1579
	(0.0315)	(0.0657)
Time/10	6.3800	3.1450
	(0.1367)	(0.1350)
$\text{Time}^2/100$	-2.2270	-1.2670
	(0.0814)	(0.0838)
Intercept	-3.5960	-0.2704
	(0.0962)	(0.0667)
Log likelihood	-77,179.2279	

Note: standard errors in parentheses.

C.2 Choice Probability Parameter Estimates in the Married, Not-Working State

	Female	Male
Sex ratio	-0.3979	-7.4370
	(0.1374)	(0.3377)
Northeast	0.0493	-0.5281
	(0.0592)	(0.1542)
South	0.1678	-0.7698
	(0.0484)	(0.1272)
West	-0.2682	-1.0760
	(0.0633)	(0.1467)
Black	-1.1540	0.5872
	(0.0664)	(0.1574)
Education	-0.6986	-6.3745
	(0.0294)	(0.8722)
Child	0.0148	-3.8470
	(0.0420)	(0.2107)
Time/10	-3.3340	5.3520
	(0.2670)	(0.6457)
$\text{Time}^2/100$	2.3700	-4.7800
	(0.1418)	(0.3188)
Intercept	2.3658	5.8700
	(0.1813)	(0.4933)
Education of spouse	-0.1618	3.3380
	(0.0277)	(0.2920)
Log likelihood	-77,179.2279	

Note: standard errors in parentheses.

C.3 Choice Probability Parameter Estimates in the Married, Working State

	Female	Male
Sex ratio	-1.3950	-2.2960
	(0.1097)	(0.1966)
Northeast	-0.0360	-0.4033
	(0.0529)	(0.1259)
South	0.0188	1.0920
	(0.0451)	(0.1014)
West	-0.5671	-0.3820
	(0.0572)	(0.1167)
Black	-1.6290	-3.3680
	(0.0586)	(0.1321)
Education	0.8213	1.6460
	(0.0315)	(0.1425)
Child	-1.2150	-4.3380
	(0.0370)	(0.1737)
Time/10	-0.7553	6.5420
	(0.2341)	(0.5673)
$\text{Time}^2/100$	2.0210	-4.9140
	(0.1213)	(0.2627)
Intercept	1.5880	0.7315
	(0.1597)	(0.4219)
Education of spouse	0.1556	3.6390
	(0.0200)	(0.2837)
Log likelihood	-77,179.2279	

Note: standard errors in parentheses.

C.4 Fertility and Marriage-Specific Capital

	Single Women	Single Men	Married Couples
		Fertility	
Time/10	-0.3130	-0.3664	-2.463
	(0.0829)	(0.0775)	(0.0508)
Female Education	-0.7298		0.9614
	(0.1140)		(0.0730)
Male Education		0.4008	1.4850
		(0.3408)	(0.0558)
Black	1.032	1.5330	-0.7867
	(0.0788)	(0.1751)	(0.0744)
Marital-Specific Capital			-0.0821
			(0.0098)
Northeast	-0.9066	1.1716	0.0748
	(0.1140)	(0.2570)	(0.0512)
South	-0.2769	0.8884	0.0768
	(0.0738)	(0.3230)	(0.0395)
West	-0.4766	2.367	-1.4300
	(0.1171)	(0.2830)	(0.0647)
Intercept	-2.363	-7.4540	-1.4270
	(0.1171)	(0.4322)	(0.0899)
		Marital-Specific Capital	
Women			0.1349
			(0.0079)
Men			2.2660
			(0.0879)
Log likelihood		-77,179.2279	

Note: standard errors in parentheses.

C.5 Earnings and Non-Labor Income Parameters for Females

Variable	Earnings	Non-Labor Income (sn)	Non-Labor Income (sh)
Northeast	1.933	-0.2932	-0.069
	(0.142)	(0.078)	(0.046)
South	1.340	-0.615	-0.007
	(0.113)	(0.062)	(0.044)
West	0.865	-0.152	0.017
	(0.143)	(0.079)	(0.051)
Black	-1.438	-0.018	-0.040
	(0.106)	(0.059)	(0.049)
Education	2.847	-0.222	0.084
	(0.160)	(0.057)	(0.058)
Time/10	0.877	0.983	-0.022
	(0.059)	(0.267)	(0.186)
Time^2/100	-0.015	-0.182	0.015
	(0.003)	(0.150)	(0.098)
Child		1.308	0.432
		(0.065)	(0.040)
Intercept	-0.118	1.820	0.803
	(0.242)	(0.107)	(0.095)
λ_{sh}^F	0.173	0.008	0.007
	(0.108)	(0.078)	(0.043)
λ_{mn}^F	0.200	0.909	-0.608
	(0.184)	(0.633)	(0.400)
λ_{mh}^F	0.060	-0.799	0.599
	(0.036)	(0.698)	(0.402)
Observations	19,193	4,580	5,047

Note: standard errors in parentheses. The dependent variable is measured in thousands of dollars.

C.6 Earnings and Non-Labor Income Parameters for Males

Variable	Earnings	Non-Labor Income (sn)	Non-Labor Income (sh)	Non-Labor Income (mn or mh)
Northeast	2.356	-0.056	0.028	0.053
	(0.172)	(0.090)	(0.054)	(0.026)
South	0.474	-0.172	-0.029	-0.149
	(0.157)	(0.081)	(0.057)	(0.022)
West	1.361	0.028	0.047	-0.083
	(0.192)	(0.095)	(0.062)	(0.027)
Black	-3.682	-0.095	-0.002	-0.106
	(0.211)	(0.082)	(0.078)	(0.033)
Education	4.114	0.096	-0.111	-0.141
	(0.175)	(0.081)	(0.074)	(0.026)
Time/10	0.585	0.580	-0.140	0.329
	(0.068)	(0.302)	(0.203)	(0.110)
$\text{Time}^2/100$	0.005	-0.160	0.013	-0.125
	(0.004)	(0.180)	(0.119)	(0.056)
Child		0.215	0.450	0.048
		(0.110)	(0.070)	(0.020)
Education of spouse				0.012
				(0.028)
Intercept	2.314	1.427	1.383	0.392
	(0.289)	(0.122)	(0.099)	(0.057)
λ^M_{sh}	-0.049	0.191	-0.014	-0.191
	(0.0248)	(0.138)	(0.012)	(0.609)
λ^M_{mn}	0.256	-0.998	-0.589	0.044
	(0.169)	(1.242)	(0.722)	(0.048)
λ^M_{mh}	-0.009	0.371	0.445	-0.041
	(0.006)	(1.102)	(0.644)	(0.062)
Observations	19,782	2,092	4,914	6,040

Note: standard errors in parentheses. The dependent variable is measured in thousands of dollars.

D Structural Parameter Estimates

D.1 Female Preference Parameter Estimates for Structural Model

	State		
	sh	*mn*	*mh*
Women			
Years in marriage market	5.593	-3.365	-0.329
	(0.156)	(0.263)	(0.233)
Square of years in marriage market	-2.218	2.371	2.016
	(0.082)	(0.142)	(0.121)
Education	-0.743	-0.868	1.953
	(0.204)	(0.072)	(0.224)
Spousal Education			-0.723
			(0.210)
Northeast	-1.880	0.020	1.071
	(0.155)	(0.093)	(0.161)
South	-0.179	0.165	0.210
	(0.135)	(0.054)	(0.070)
West	-1.442	-0.274	0.040
	(0.172)	(0.080)	(0.115)

Note: standard errors in parentheses.

D.2 Male Preference Parameter Estimates for Structural Model

	State		
	sh	*mn*	*mh*
Men			
Years in marriage market	2.543	4.601	5.726
	(0.168)	(0.714)	(0.584)
	(0.1371)	(0.1194)	
Square of years in marriage market	-1.272	-4.752	-4.910
	(0.084)	(0.319)	(0.263)
	(0.0830)	(0.1733)	
Education	-3.901	-1.306	-1.693
	(0.202)	(1.283)	(0.485)
	(0.0790)	(0.1572)	
Spousal Education			-2.609
			(0.202)
Northeast	-2.497	-1.150	-2.985
	(0.186)	(0.757)	(0.269)
South	-0.545	-0.436	0.750
	(0.174)	(0.244)	(0.164)
West	-1.699	-0.881	-1.811
	(0.210)	(0.506)	(0.225)

Note: standard errors in parentheses.

D.3 Earnings and Non-Labor Income Parameter Estimates for Females

Variable	Earnings	Non-Labor Income (sn)	Non-Labor Income (sh)
Northeast	1.993	-0.263	-0.045
	(0.140)	(0.083)	(0.051)
South	0.333	-0.541	0.035
	(0.119)	(0.071)	(0.050)
West	1.034	0.427	0.229
	(0.154)	(0.087)	(0.058)
Black	-11.456	0.011	0.106
	(0.111)	(0.071)	(0.064)
Education	2.842	-0.434	-0.247
	(0.169)	(0.067)	(0.078)
Time/10	0.877	-0.047	-0.090
	(0.336)	(0.046)	(0.046)
Time^2/100	-0.0147	0.007	0.005
	(0.003)	(0.002)	(0.002)
Child		2.602	1.138
		(0.153)	(0.099)
Intercept	0.845	1.281	1.337
	(0.336)	(0.133)	(0.334)
λ^F_{sh}	-0.396	-0.132	-0.093
	(0.083)	(0.164)	(0.041)
λ^F_{mn}	0.376	3.106	-0.527
	(-.114)	(0.412)	(0.351)
λ^F_{mh}	-0.075	-3.079	0.287
	(0.027)	(0.459)	(0.355)

Note: standard errors in parentheses. The dependent variable is measured in thousands of dollars.

D.4 Earnings and Non-Labor Income Parameter Estimates for Males

Variable	Earnings	Non-Labor Income (sn)	Non-Labor Income (sh)	Non-Labor Income (mn or mh)
Northeast	2.390	-0.038	0.229	0.022
	(0.168)	(0.117)	(0.066)	(0.026)
South	0.444	0.220	0.126	-0.122
	(0.155)	(0.112)	(0.068)	(0.021)
West	1.490	0.334	0.153	-0.095
	(0.189)	(0.129)	(0.077)	(0.027)
Black	-3.210	0.061	0.116	-0.188
	(0.209)	(0.118)	(0.010)	(0.032)
Education	4.326	0.538	-0.087	-0.053
	(0.173)	(0.114)	(0.091)	(0.025)
Time/10	0.585	-0.250	0.017	0.056
	(0.068)	(0.152)	(0.074)	(0.011)
Time^2/100	0.005	0.018	0.0004	-0.003
	(0.004)	(0.008)	(0.003)	(0.001)
Child		1.118	0.853	0.042
		(0.296)	(0.142)	(0.019)
Education of spouse				0.053
				(0.028)
Intercept	5.834	-0.679	0.639	0.104
	(0.380)	(0.492)	(0.788)	(0.056)
λ_{sh}^M	-0.007	-1.397	-0.0006	-1.264
	(0.017)	(0.554)	(0.010)	(0.268)
λ_{mn}^M	-2.808	5.687	-0.813	0.762
	(0.220)	(2.334)	(0.610)	(0.022)
λ_{mh}^M	0.037	-4.291	0.779	0.034
	(0.005)	(1.899)	(0.521)	(0.031)

Note: standard errors in parentheses. The dependent variable is measured in thousands of dollars.

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