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Author(s): Shannon Seitz
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Accounting for Racial Differences in Marriage and Employment

Shannon Seitz, *Boston College and Queen's University*

What can account for the differences in marriage and employment decisions across blacks and whites? To answer this question, I develop a dynamic, equilibrium model of marriage. Two explanations for the racial differences in behavior are considered: differences in population supplies and wages. Black-white differences in population supplies explain one-fifth of the difference in marriage rates and between one-fifth and one-third of the differences in employment rates across race. Removing the racial gap in wages eliminates the differences in employment but increases the differences in marriage rates.

I. Introduction

A large literature has documented the stark differences in family structure and socioeconomic outcomes between blacks and whites in the United States. Consider the following set of stylized facts:

1. Blacks are less likely to marry than whites (Ellwood and Crane 1990; Saluter 1994; Brien 1997).
2. Age at first marriage is higher for blacks than for whites (DaVanzo and Rahman 1993).
3. Blacks are twice as likely to divorce than whites (Ellwood and Crane 1990).

In addition, several striking racial differences in employment rates also

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Table 1
Employment Rates by Race and Marital Status, 1996 Cross Section

	White	Black
Men:		
Single	.9091	.6917
Married	.9486	.9052
Women:		
Single	.7751	.6696
Married	.6806	.7713

Source.—1996 National Longitudinal Survey of Youth, 1979 cohort.
Note.—Sample of women ages 32–36 and men ages 34–38 in 1996. Employment status is an indicator equal to one if the respondent worked at least 775 hours in the interview year and zero otherwise.

emerge from the data. Table 1 presents employment statistics from the 1996 wave of the National Longitudinal Survey of Youth. The data indicate that

4. Black males have lower employment rates than white males.
5. The employment rate for black married women is higher than that of white married women.
6. Married black women are more likely to work than their single counterparts, while the converse is true for whites.

The goal of this study is to determine the importance of two potential explanations for these stylized facts. The first is differences in the population supplies of women and men across race. The ratio of men to women has been consistently lower for blacks than for whites throughout recent history for many reasons, including racial differences in the sex ratio at birth. These initial differences tend to widen further as individuals age due to differences in homicide and accident rates (Guttentag and Secord 1983; Espenshade 1985).[1] The second explanation is that there are sizable racial wage gaps for recent cohorts (Neal and Johnson 1996; Black et al. 2006) due to premarket factors, discrimination, and a host of other factors.

To understand how both explanations might account for the racial differences in behavior, I construct and estimate a dynamic model of the joint marriage and employment decisions of men and women. Individuals are assumed to match in marriage markets that are segmented by age,

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

region, and race.[2] Differences across marriage markets in the population supplies of men and women and in earnings drive marriage and employment decisions through two channels. First, the rate at which women and men meet is a function of the ratio of single men to women, analogous to the meeting rate between workers and firms in the model of Pissarides (1985). When the sex ratio is below one, for example, men are in excess demand and meet potential wives with relative ease. Since it is easy to meet potential wives, men can also become more choosy when deciding when to marry and whether to divorce. Second, spouses can make income transfers to each other that depend on the earnings potential of each spouse and on the sex ratio.

I estimate the parameters of the dynamic model using a sample of men and women from the National Longitudinal Survey of Youth 1979 cohort (NLSY79) under the assumption that agents have perfect foresight regarding the evolution of the sex ratio over time. The time period in this article (1979–94) is characterized by substantial variation in the sex ratio and in employment and marriage rates across race, region, and time. Several results are worth highlighting. First, an increase in the ratio of single men to single women translates into increased income transfers to wives. One implication of this finding is that black women, who are in excess supply, are predicted to work more because they receive lower transfers from their spouses. This result is consistent with the high employment rates of black women relative to white women and the 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 nonlabor income in the household. One implication of this finding is that marriage may be less desirable for those with low labor market earnings, in particular black males. As a result, differences in premarket factors across race or discrimination in the labor market affect the outcomes of black men in both the labor and marriage markets. Together, these results provide insight into the causes and consequences of the racial differences in employment and marriage behavior observed in the data. The model also allows preferences for marriage and employment to differ by race and gender. For women, significant differences in preferences remain after accounting for differences in sex ratios and wages. However, the estimates suggest that there are no significant differences in preferences across race for men. Observed differences in sex ratios and wage gaps can explain most of the racial differences in behavior for men but not for women.

I conduct several counterfactual experiments to further explore the

[2] Recent economic literature includes studies of the decision to match across age or racial groups. See, e.g., Wong (2003), Giolito (2005), Tertilt (2005), and Giolito and Toledo (2006).

implications of the model. In the first experiment, it is assumed that the stocks of black men and women, by age, education, and year, are the same as they are for whites. Such a change reduces the racial gap in marriage by 19% for black women. This experiment also has important implications for employment behavior: the racial gaps in employment fall by 34% for men and 22% for women. Differences in population supplies across race are thus an important contributor to the black-white differences in behavior but are not the entire story.

In the second experiment, the black-white gap in earnings is eliminated. This experiment results in a rise in employment for black men, a fall in employment for black married women, and a rise for single black women so that the employment behavior of blacks now more closely resembles that of whites. However, the elimination of the racial gap in earnings also serves to increase the gender gap in earnings for blacks, which reduces the gains to marriage and leads to a decline in marriage and a rise in divorce.

This study builds upon several existing studies on racial differences in behavior. Wilson's (1987) hypothesis, that a shortage of marriageable men is behind the low marriage rates of black women, has been tested extensively in the partial equilibrium empirical literature, for example, in 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). These studies focus almost exclusively on racial differences in marriage and are silent regarding the determinants of the black-white differences in employment.

In contrast to the existing empirical literature on black-white differences in behavior, I construct and estimate a dynamic structural model to study racial differences in marriage and employment. There are two reasons a structural model may be useful in studying this question. The first is that the model allows one to study the mechanisms (search frictions and income transfers within the household) through which the distribution of men and women across race and education affect behavior. The second reason a structural model is a useful tool in this instance is that the model can be used to conduct counterfactual experiments to try and assess the potential for policy to influence the racial differences in behavior. As an illustration, a counterfactual experiment akin to reducing the generosity of welfare shows that reducing the nonlabor income of single, nonworking women increases marriage rates as well as employment rates for men: as women find marriage more attractive, men are willing to increase their labor supply within marriage. The counterfactual experiment illustrates the potential for social and labor market policies to simultaneously influence family structure as well as employment behavior, and it highlights the importance of treating marriage and employment as joint decisions.

This study also builds on recent work that estimates dynamic structural models of employment and marriage. In particular, van der Klaauw (1996) estimates a dynamic model of marriage and employment on a sample of women. Keane and Wolpin (2006) extend the choice set to include schooling, fertility, and welfare participation to study racial differences in behavior. All of the above studies are partial equilibrium in nature. The current study extends van der Klaauw's partial equilibrium model to an equilibrium setting and applies the model to the study of racial differences in behavior. The use of a dynamic, two-sided model of marriage and employment is particularly important if one is to consider the implications of policies that change the desirability of marriage.[3] Any policy change that alters marriage rates today will have implications for marriage, divorce, and employment behavior in future periods. Furthermore, policies that target labor market outcomes may also have feedback effects on the marriage market that cannot be captured if marriage and employment are not treated as joint decisions.

The current article also contributes to a recent literature that considers other market-wide effects of marriage. Drewianka (2003) finds that marriage rates are decreasing in the fraction of the population that is single. Loughran (2002) and Gould and Paserman (2003) examine the effect of male wage inequality on marriage rates. Choo and Siow (2006) develop and estimate an equilibrium nonparametric marriage model with marriage market spillover effects. The current study develops and estimates a model of marriage and employment within which spillover effects from both the labor market and the marriage market can be studied.

Finally, this study builds on the quantitative equilibrium marriage models in the macroeconomics literature. Aiyagari, Greenwood, and Güner (2000) build and calibrate a model with marriage, divorce, and investment in the human capital of children to study intergenerational mobility. Greenwood, Güner, and Knowles (2003) calibrate a model of marriage, fertility, and employment to study the implications of "family" policies for the income distribution. The model estimated in the current article is similar in spirit to these papers, but it abstracts in large part from decisions regarding fertility and focuses instead on the implications of differences in the supplies of men and women across race for marriage and employment behavior.

The remainder of the article proceeds as follows. Section II describes the data and the stylized facts in more detail. Section III contains the theoretical model, constructed to account for the joint patterns of em-

[3] Angrist (2002) uses changes in immigration policy in the United States as a source of exogenous variation in his study of marriage rates and sex ratios but does not consider the equilibrium effects of an exogenous shock to the marriage market on future behavior.

ployment and marriage behavior across race and gender. The estimation technique is outlined in Section IV. In Section V, the estimation results and model fit are presented. Section VI contains three model simulations that further illustrate the implications of the model and parameter estimates. Section VII concludes.

II. Data

The NLSY79, a sample of 12,686 men and women who were between the ages of 14 and 22 in 1979, is used in the empirical analysis outlined below. 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.[4] 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 nonlabor 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.[5] As a result, some spells may be missed, and the length of some spells may be measured inaccurately.[6] In particular, individuals who report being married or in common-law relationships 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 definition 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

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

[5] 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. Information on the starting date of cohabitations, on whether individuals lived with their spouses before marriage, and on whether the respondent lived with their spouse continuously before marriage is available only in 1990 and 1992–96. In the remaining years, information on current cohabitation status, but not on changes in status between interviews, is available in every year.

[6] It is assumed that 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 that this assumption only affects a small number of matches.

one marriage from one interview date to the next over the 1979–96 sample period.[7]

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.[8] Earnings are measured as annual income from wages, salaries, and tips.[9] Nonlabor 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 Supplemental Security Income (SSI) is also included in nonlabor income. In addition, income from other persons, veterans pay, workers compensation, and disability benefits are included in nonlabor income. The aforementioned sources of income are all included in order to maintain consistency over the sample period, as nonlabor income is grouped in wide categories in the early years of the sample.[10] Earnings and nonlabor income are subsequently converted to real terms, where 1981 is the base year. Educational attainment is measured by an indicator equal to one if respondents have at least a high school education and zero otherwise. Regional indicators for the northeast, south, and western portions of the United States are defined.[11] An indicator equal to one when children are present and zero 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 is equal to one if the respondent is black and zero if white is constructed.

Table 2 contains sample statistics by race and sex for selected years in the panel. The data illustrate several interesting patterns. Marriage rates tend to differ widely across race: the fraction of married men and women

[7] It is important to emphasize that this figure includes cohabitations at, but not between, interview dates. It is likely that 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 (2006) 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.

[8] 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.

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

[10] 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.

[11] The appendix contains a detailed definition of each regional indicator.

Table 2
Sample Statistics by Race and Sex (Selected Years)

	Black		White	
Variable	Men	Women	Men	Women
1979:				
Married	.0465	.0372	.0825	.0902
Working	.4210	.1180	.6251	.2541
Children	.0413	.1479	.0398	.0531
High school diploma	.4247	.2152	.5856	.2871
Nonlabor income	252.37	221.93	325.48	135.40
Earnings	6,781.28	4,620.12	7,845.96	4,629.34
1985:				
Married	.2773	.2632	.4815	.5366
Working	.7508	.4896	.8908	.6990
Children	.2696	.6028	.3140	.3455
High school diploma	.8073	.8132	.8448	.8610
Nonlabor income	541.05	1,440.42	737.82	693.08
Earnings	10,916.63	7,679.74	14,491.13	8,867.56
1996:				
Married	.4979	.3981	.7127	.7630
Working	.7980	.7101	.9372	.7030
Children	.6361	.8050	.7043	.7529
High school diploma	.8652	.8475	.8636	.8869
Nonlabor 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. Sample is restricted to women ages 15–19 and men ages 17–21 in 1979.

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 that 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.

Racial differences along other dimensions also exist. Starting with the empirical evidence regarding children, black women are more likely than white women to report an early birth. 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 nonlabor income in the latter years in the sample, which is likely due to the high participation rates in social assistance programs of black women relative to white women.

In constructing sex ratios for the empirical analysis, an individual's "marriage market" is limited to same-race individuals that live in the same region and are in the same age cohort.[12] With regard to age, data from the NLSY79 suggest that men tend to be older than their spouses by 2–3 years on average, with 90% marrying women who are less than 3 years older and 7 years younger. It should be noted the average age difference between husbands and wives narrowed slightly over the same period the sex ratio declined. The median age at marriage in 1950 was 23 for men and 20 for women; in 1990 the median age at marriage was 26 for men and 24 for women. The age cohort to be considered in estimation is thus limited to women ages 15–19 in 1979 and men ages 17–21 in that year so that the behavior of a single cohort can be followed over time.[13]

Data from the Census indicate the strong presence of sorting on race: in 1980, 0.2% of all marriages in the United States were between black men and white women and 0.1% were between white men and black women.[14] It would have been possible to include blacks and whites in the same marriage market and allow individuals to have preferences over the race of their spouse in a manner analogous to the "mating taboo" of Wong (2003). Wong (2003) finds that neither improving the endowments of black males nor increasing the rate at which black males meet white females increases the interracial marriage rate. Thus, the substantive implications of a model with interracial marriage are likely to be similar. Measures of the marriage market are also limited to single agents, as is consistent with the model outlined below.

Once the marriage market is defined by age, region, and race, I reweight 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.[15] The NLSY79 sampling weights are reweighted 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 because attrition in the NLSY79 may result in mismeasurement of the stocks of single men and women over time. In contrast to previous

[12] Most marriages occur between women and men within categories defined by the interaction of race, age, and state of residence (Laumann, Gagnon, and Michael 1994; Charles and Luoh 2005).

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

[14] U.S. Bureau of the Census, Current Population Report, Series P20–509, "Household Characteristics: March 1997," and earlier reports.

[15] 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.

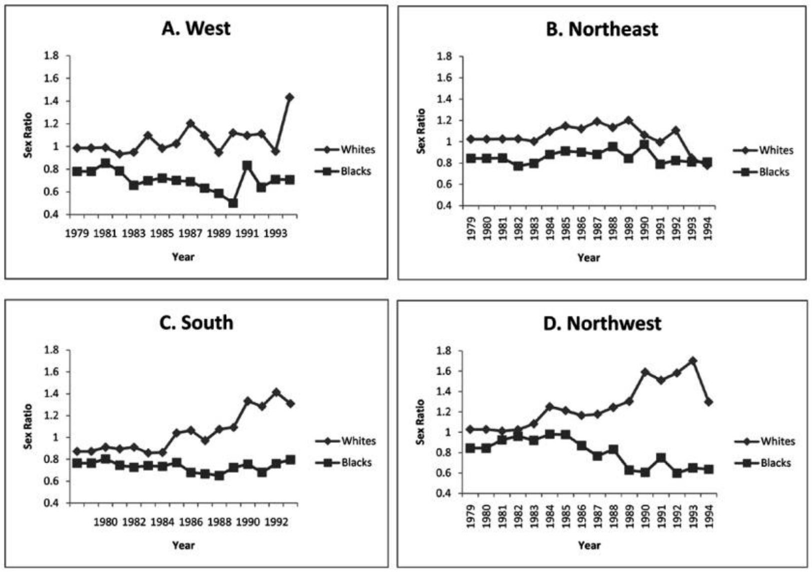

Fig. 1.—Sex ratios by race and region. The sex ratio is defined as the ratio of single men to single women in the NLSY, by age, race, region, and year. The NLSY data are reweighted to match the population supplies in the CPS. A definition of region is in Sec. I of the appendix.

studies, which generally construct state-specific sex ratios, 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.[16]

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 0.8 for blacks. The exception is the southern United States, 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

[16] Unfortunately, the CPS cannot be used directly to calculate the stocks. The individual-level marriage transitions in the NLSY79 (i.e., the flows) must be completely consistent with the sex ratio (i.e., the stocks) in the equilibrium policy experiments. To maintain this consistency, the stocks must be constructed directly from the NLSY79 data.

women. For whites, the increase in the sex ratio is due in part to the larger influx of male immigrants to the United States as compared to females within recent decades.[17]

III. The Model

The model builds on the work of Becker (1973), van der Klaauw (1996), and Chiappori, Fortin, and Lacroix (2002), 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 work either 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 that only single individuals are in the marriage market and that marriage opportunities may not be available in every period.[18] 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 reenter the marriage market. The model abstracts from the process by which agents sort in the marriage market and assumes that individuals randomly meet within marriage markets segmented by known, 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 (c_t) in the household, 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

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

[18] This assumption is consistent with other models of matching in marriage markets (Aiyagari et al. 2000; Drewianka 2003; Brien et al. 2006).

the current period. Third, the utility from each state may also differ for individuals depending on their fixed exogenous individual characteristics (i), summarized by I possible types, where the type of one's spouse is denoted i'. Individual types are assumed to be constant over time. Fourth, married individuals derive utility from match-specific marital capital L_t, which accumulates within but not across marriages, 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 is

$$u_k^G(x_t, c_t, i, L_t) = \gamma_k^G + \gamma_{xk}^G x_t + \gamma_{ck}^G c_t + \gamma_{ik}^G i + \gamma_L^G L_t, \tag{1}$$

where $k \in \{K_s, K_m\}$, $i \in I$. The budget constraint is a function of two potential sources of income in the current period, labor market earnings (w_t) and nonlabor 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 independent and identically distributed (i.i.d.) idiosyncratic component (e_t^G), where the shocks to current period earnings are observed by agents before they make their employment and marriage decisions in each period:

$$\begin{aligned} w_t = {} & [(w^F(i) + e_t^F) \cdot 1(G = F) + (w^M(i) + e_t^M) \cdot 1(G = M)] \\ & \cdot 1(k \in \{sh, mh\}). \end{aligned} \tag{3}$$

Nonlabor income differs depending on the current marital state to capture the notion that different sources of nonlabor income may be available to individuals depending on their current marital status. If single, nonlabor income may also differ depending on whether the individual is working or not working. If married, the couple receives total nonlabor income that is a function of exogenous characteristics of both partners in the marriage. In each instance, nonlabor income is also a function of i.i.d. idiosyncratic components (ν_{kt}^G) observed by agents before they make their employment and marriage decisions in each period.

Nonlabor income for married couples is divided among the partners for personal consumption according to an income transfer that depends on the current sex ratio and on the potential earnings of each partner ($\bar{w}^G$), as in the collective model of Chiappori et al. (2002). In contrast to Chiappori et al. (2002), household allocations are not Pareto efficient in this model. The income transfer function is assumed to be exogenous and known at the time individuals make marriage and employment decisions. This function allows the model to capture the idea that the allocation of resources in the household may depend on the availability of spouses (through the sex ratio) and the quality of both spouses (through earnings potential), albeit in a limited way. 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 intrahousehold allocations through their effect on an individual's opportunities outside the current marriage. From the perspective of the wife, the transfer for a married couple with a type i wife and a type i' husband in period t can therefore be expressed as

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

Nonlabor income for type i females and type i' males can therefore be defined as

$$\begin{aligned} y_t = {} & [(y^F(i, 0, c_t) + \nu_{kt}^F) \cdot 1(G = F) + (y^M(i', 0, c_t) + \nu_{kt}^M) \\ & \cdot 1(G = M)] \cdot 1(k \in K_s) \\ & + [(\phi^R R_t + \phi^F \bar{w}^F(i) + \phi^M \bar{w}^M(i')) \cdot 1(G = F) \\ & + (y^M(i, i', c_t) + \nu_{kt}^M - \phi^R R_t - \phi^F \bar{w}^F(i) - \phi^M \bar{w}^M(i')) \\ & \cdot 1(G = M)] \cdot 1(k \in K_m). \end{aligned} \tag{4}$$

The sex ratio (R_t) affects current period employment decisions directly through its effect on the intrahousehold allocation of income for married couples. Through the intrahousehold allocation process, the sex ratio also influences the behavior of single agents. In particular, movements in the sex ratio alter the intrahousehold transfers single agents face should they decide to marry and therefore alter the desirability of marriage.

A. Fertility

Children are not treated as choice variables in the model due to the added complexity of modeling 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 that 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 that $c_t = 1$ 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:

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

$$\Gamma_s^G(c_t = 1|c_{t-1} = 1) = 1,$$

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

$$\Gamma_s^G(c_t = 0|c_{t-1} = 1) = 0.$$

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 born in the current marriage. Further, it is assumed that individuals do not receive utility from stepchildren and that stepchildren do not prevent the arrival of children in the current marriage if one of the spouses does not have children of his or her 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

$$\Gamma_m(c_t = 1, c_t' = 1|c_{t-1} = 0, c_{t-1}' = 1) = B_m(i,j,t,L_{t-1}),$$

$$\Gamma_m(c_t = 1, c_t' = 1|c_{t-1} = 0, c_{t-1}' = 0) = B_m(i,j,t,L_{t-1}),$$

$$\Gamma_m(c_t = 0, c_t'|c_{t-1} = 0, c_{t-1}') = 1 - B_m(i,j,t,L_{t-1}),$$

$$\Gamma_m(c_t = 1, c_t' = 1|c_{t-1} = 1, c_{t-1}' = 1) = 1,$$

$$\Gamma_m(c_t = 0, c_t'|c_{t-1} = 1, c_t') = 0.$$

B. Search 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 as in 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 single women (S_t^F) in the current period. It is assumed that 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 that women are contacted in the marriage market is proportional to the probability that 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 i', $i' \in \{1, 2, \ldots, I\}$, 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 i' and fertility status c' in period t is denoted $q_s^{G'}(i', c_t')$ and is simply the fraction of potential spouses of type i' and fertility status c' in the marriage market in period t. The probability of contacting a potential spouse of type i' and fertility status c' can then be expressed as

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

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

C. Value Functions

For ease of exposition, preferences are expressed in terms of the reduced form utility corresponding to each state in the following sections.[19] The reduced form utility for 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

$$U_k^G(i, c_t) + \varepsilon_{kt}^G = \begin{cases} \tilde{U}_k^G(i, c_t) + \varepsilon_{kt}^G & \text{if } k \in K_s \\ \tilde{U}_k^G(i, i', c_t, R_t, L_t) + \varepsilon_{kt}^G & \text{if } k \in K_m \end{cases}, \tag{7}$$

[19] The appendix contains further details on the reduced form representation of the model.

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 nonlabor income.

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 (or potential spouse's) type and fertility status, and the current sex ratio and the stochastic components of utility in reduced form. Define the value function to be the maximal expected present value of lifetime utility in period t, denoted $V_t^G(\Omega_t, i, c_t)$. The value function can be expressed as the maximum over the choice-specific value functions and satisfies the Bellman equation

$$V_t^G(\Omega_t, i, c_t) = \max_{k \in K} \{V_{kt}^G(\Omega_t, i, c_t)\}, \tag{8}$$

where

$$V_{kt}^G(\Omega_t, i, c_t) = \begin{cases} \tilde{V}_{kt}^G(\Omega_t, i, c_t) & \text{if } k \in K_s \\ \tilde{V}_{kt}^G(\Omega_t, i, i', c_t) & \text{if } k \in K_m \end{cases}, \tag{9}$$

and where the discount factor is denoted β. The choice-specific value function for single agents of type i and fertility status c is

$$\tilde{V}_{kt}^G(\Omega_t, i, c_t) = \tilde{U}_k^G(i, c_t) + \varepsilon_{kt}^G + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) | k_t \in K_s], \tag{10}$$

and the value function for an agent of type i and fertility status c, married to a spouse of type i' is

$$\begin{aligned} \tilde{V}_{kt}^G(\Omega_t, i, i', c_t) = {} & \tilde{U}_k^G(i, i', c_t, R_t, L_t) + \varepsilon_{kt}^G \\ & + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) | k_t \in K_m]. \end{aligned} \tag{11}$$

The expectations in (10) and (11) 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

$$v_{t+1}^G(\Omega_{t+1}, i, c_{t+1}) = \begin{cases} V_{t+1}^G(\Omega_{t+1}, i, 1) & \text{if } \quad c_t = 1 \\ B^G(i,t) V_{t+1}^G(\Omega_{t+1}, i, 1) & \\ +(1 - B^G(i,t)) V_{t+1}^G(\Omega_{t+1}, i, 0) & \text{if } \quad c_t = 0 \end{cases}, \tag{12}$$

and

$$B^G(i,t) = \begin{cases} B_s^G(i,t) & \text{if } \quad k_{t-1} \in K_s \\ B_m(i, i', t, L_t) & \text{if } \quad k_{t-1} \in K_m \end{cases}.$$

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

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

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

$$\tilde{V}_{mt}^{G}(\Omega_t, i, i', c_t) = \max_{k \in K_m} \{\tilde{V}_{kt}^{G}(\Omega_t, i, i', c_t)\}.$$

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 one if an agent of type i wants to marry a spouse of type i' in period t. In particular,

$$J_t^{G}(i, i', c_t) = \begin{cases} 1 & \text{if} \quad \tilde{V}_{mt}^{G}(\Omega_t, i, i', c_t) \geq \tilde{V}_{st}^{G}(\Omega_t, i, c_t) \\ 0 & \text{otherwise} \end{cases}, \tag{13}$$

which yields a more explicit form for the value functions on the right-hand side of (10) and (11) 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 who 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:

$$\begin{aligned} E[V_{t+1}^{G}(\Omega_{t+1}, i, c_{t+1}) | k_t \in K_s] = {} & p_{t+1}^{G} \Big[\sum_{j} \sum_{c'} q_s^{G'}(i', c'_{t+1}) J_t^{G'}(i', i, c'_{t+1}) \\ & E_{\varepsilon_{t+1}} \max \{\tilde{V}_{st+1}^{G}(\Omega_{t+1}, i, c_{t+1}), \tilde{V}_{mt+1}^{G}(\Omega_{t+1}, i, i', c_{t+1})\} \Big] \\ & + \Big[1 - p_{t+1}^{G} \Big(\sum_{i'} \sum_{c'} q_s^{G'}(i', c'_{t+1}) J_t^{G'}(i', i, c'_{t+1}) \Big) E_{\varepsilon_{t+1}} [\tilde{V}_{st+1}^{G}(\Omega_{t+1}, i, c_{t+1})] \Big]. \end{aligned}$$

Agents of type i who chose to be married in t are not in the marriage market in $t + 1$. If their type i' 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:

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

D. 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 nonlabor 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 forms 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 zero otherwise; ε^{G*}_{kt} is the value such that

$$U^G_k(i, c_t) + \beta E[v^G_{t+1}(\Omega_{t+1}, i, c_{t+1})|d^G_{kt} = 1]$$
$$= U^G_{sn}(i, c_t) + \beta E[v^G_{t+1}(\Omega_{t+1}, i, c_{t+1})|d^G_{snt} = 1] + \varepsilon^{G*}_{kt}. \tag{14}$$

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:

$$V^G_{kt}(\Omega_t, i, c_t) \geq V^G_{lt}(\Omega_t, i, c_t) \Leftrightarrow$$
$$U^G_k(i, c_t) + \varepsilon^G_{kt} + \beta E[v^G_{t+1}(\Omega_{t+1}, i, c_{t+1})|d_{kt} = 1] \tag{15}$$
$$\geq U^G_l(i, c_t) + \varepsilon^G_{lt} + \beta E[v^G_{t+1}(\Omega_{t+1}, i, c_{t+1})|d_{lt} = 1].$$

The latter can be rewritten in terms of the reservation and realized values for the composite errors, using (14) and (15). The state yielding the highest level of utility satisfies

$$\varepsilon^G_{kt} - \varepsilon^G_{lt} \geq \varepsilon^{G*}_{lt} - \varepsilon^{G*}_{kt}.$$

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

$$d_{kt}^{G} = \begin{cases} 1 & \text{if} \quad \varepsilon_{kt}^{G} - \varepsilon_{lt}^{G} \geq \varepsilon_{lt}^{G*} - \varepsilon_{kt}^{G*}, \ \forall\, l \in K_t \\ 0 & \text{otherwise} \end{cases}. \tag{16}$$

E. 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 who 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

$$\begin{aligned} S_{t+1}^{G}(i, c_{t+1}) = {} & \sum_{c}\Big[1 - p_t^{G}\Big(\sum_{j}\sum_{c'} q_s^{G'}(i', c_t')J_t^{G}(i, i', c_t)J_t^{G'}(i', i, c_t')\Big)\Big] \\ & \cdot\ S_t^{G}(i, c_t)\Gamma_s^{G}(c_{t+1}|c_t) \\ & +\ \sum_{c}\sum_{c'}\Big[1 - \Big(\sum_{i'} q_m^{G}(i, i', c_t, c_t')J_t^{G}(i, i', c_t)J_t^{G'}(i', i, c_t')\Big)\Big] \\ & \cdot\ M_t^{G}(i, i', c_t, c_t')\Gamma_m(c_{t+1}, c_{t+1}'|c_t, c_t') + \Delta_s^{G}(i, c_t), \end{aligned} \tag{17}$$

where $i, i' \in \{1, 2, \ldots, I\}$ and $c, c' \in \{0, 1\}$. The stock of married couples with exogenous types i, i' and fertility status c, c' in t is denoted $M_t(i, i', c_t, c_t')$ and $q_m(i, i', c_t, c_t')$ is the exogenous fraction of individuals of type i and fertility status c married to spouses of type i' and fertility status c' in period t, $\sum_i \sum_{i'} \sum_c \sum_{c'} q_m^{G}(i, i', c_t, c_t') = 1$. 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

$$M_{t+1}(i,i',c_{t+1},c'_{t+1}) =$$

$$\sum_c \sum_{c'} \left[J_t^G(i,i',c_t) J_t^{G'}(i',i,c'_t) \cdot M_t(i,i',c_t,c'_t) \Gamma_m(c_{t+1},c'_{t+1}|c_t,c'_t) \right] \tag{18}$$

$$+ p_t^G \Big[\sum_c \sum_{c'} q_s^G(i,c_t) q_s^{G'}(j,c'_t) \cdot J_t^G(i,i',c_t) J_t^{G'}(i',i,c'_t) \Gamma_s^G(c_{t+1}|c_t) \Gamma_s^{G'}(c'_{t+1}|c'_t) C_t \Big].$$

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

$$S_{t+1}^G = \sum_i \sum_c S_{t+1}^G(i,c_{t+1}), \tag{19}$$

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

$$q_s^G(i,c_{t+1}) = \frac{S_{t+1}^G(i,c_{t+1})}{S_{t+1}^G} \tag{20}$$

and

$$q_m(i,i',c_{t+1},c'_{t+1}) = \frac{M_{t+1}(i,i',c_{t+1},c'_{t+1})}{\sum_j \sum_{j'} \sum_l \sum_{l'} M_{t+1}(j,j',l_{t+1},l'_{t+1})}, \tag{21}$$

respectively, where $j,j' \in \{1,2,\ldots\ I\}$ and $l,l' \in \{0,1\}$. Finally, the sex ratio in period $t+1$ is defined as the ratio of single men to single women in the marriage market:

$$R_{t+1} = \frac{S_{t+1}^M}{S_{t+1}^F}. \tag{22}$$

The above relations describe the manner in which the marriage market evolves over time. The equilibrium can then be defined as follows.

Definition 1. An equilibrium is a distribution of the population by gender, type, fertility status, marital status, and spousal type, and a set of value functions such that:

1. The value functions satisfy (8)–(11).
2. The rejection and acceptance choices of spouses and potential spouses are described by (13).
3. The choices of agents yield the sequence of stocks described by (17) and (19), the sequence of sex ratios described by (22), and the sequences of type probabilities described by (20) and (21).

In equilibrium, it must be the case that the stocks and sex ratio described by (17), (19), and (22), along with the type probabilities (20) and (21) 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}, $q_s^G(i, c_{t+1})$, and $q_m(i, i', c_{t+1}, c'_{t+1})$ that are consistent with the marital status decisions made by all men and women today.

Given a set of parameter values and initial distributions for the singles and married couples, the model is solved according to the following two-step algorithm:

> *Step 1:* A sequence of composite errors is drawn for every person in the sample. Conditional on this sequence of errors, each individual's finite horizon problem can be solved by backwards recursion. This generates a sequence of marriage and employment decisions for each individual.
>
> *Step 2:* The sequence of marriage choices from the first stage is used to recompute the distributions of singles, married couples, and the sex ratio for every period. Conditional on the updated distributions and the sex ratio, steps 1 and 2 are repeated until the distributions converge.

IV. Econometric Specification

The main objective of estimation is to find the set of parameters that maximizes the likelihood of the observed sequence of marriage and employment decisions for each individual in the data. I estimate the structural parameters of the model using the three-stage estimation procedure of van der Klaauw (1996). In van der Klaauw's approach, 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 first stage. In the second stage, an earnings equation for each gender, nonlabor income equations in the single, not-working and single, working states for each gender and a nonlabor income equation for married couples are estimated.[20] 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 nonlabor income equations using a minimum distance estimator.

The primary advantage of van der Klaauw's method is the computational ease with which earnings and nonlabor income are incorporated in estimation. It is necessary to estimate earnings and nonlabor 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 that the idiosyncratic components of earnings (e_{wt}^G) and nonlabor income (ν_{kt}^G) are linear in the reduced form choice probability

[20] The earnings and nonlabor income equations are a function of education, age, region, race, and the presence of children.

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 nonlabor income and earnings equations, the two fertility probabilities for individuals, and the choice probability errors.

The equilibrium conditions are not imposed during estimation because of the large computational costs imposed by doing so. Estimation will involve only step 1 of the above algorithm. The distribution of singles and married couples used to compute the value functions in step 1 are the empirical distributions of singles and married couples computed from the NLSY data. The additional special assumption implied by this simplification is that agents have perfect foresight about the evolution of the sex ratio over time and the sex ratio is treated as exogenous by individuals in estimation. This assumption ignores the fact that the same parameters that determine the evolution of the sex ratio also determine the individual marriage and employment choices. The cost, in terms of estimation, will be a loss in efficiency (as I am not imposing all of the restrictions of the model in estimation). Note, however, that this procedure will not result in biased parameter estimates if the marriage market is sufficiently large so that the marriage decision of any one agent has a negligible effect on the sex ratio itself. However, when policy experiments are conducted using the model, the equilibrium conditions are imposed.

The reduced form choice probabilities are estimated according to the optimal policy described by (16). Assuming the composite errors in period t are distributed i.i.d. extreme value,[22] the probability of choosing state k, conditional on choice set K_t, for 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

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

[22] 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 Rust (1987) and van der Klaauw (1996). This assumption does not allow preferences for work or marriage to be correlated across choices. Ignoring such a correlation could induce bias in the parameter estimates. In an expanded version of the model, one could allow for unobserved heterogeneity in preferences for work and marriage that are correlated across choices. Section III of the appendix describes the expressions relating the composite errors to the underlying shocks to utility, earnings, and nonlabor income.

if married are the exogenous or predetermined variables on the right-hand side of 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

$$\Pr(J_t^G(i, i', c_t) = 1)$$
$$= \frac{\sum_{k \in \{K_m\}} \exp\{U_k^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1})|d_{kt}^G = 1]\}}{\sum_{l \in \{K_s \cup K_m\}} \{U_l^G(i, c_t) + \beta E[v_{t+1}^G(\Omega_{t+1}, i, c_{t+1})|d_{lt}^G = 1]\}},$$

where from (12)

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

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.[23]

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 utility from children and first birth arrivals captures, albeit in a limited way, the notion that fertility and marital status decisions are interrelated. Annual data on the presence of children are 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

$$B_m(i, i', t, L_{t-1}) = \frac{\exp(\lambda_{0m} + \lambda_{im} i + \lambda_{i'm} i' + \lambda_{tm} t + \lambda_L L_{t-1})}{1 + \exp(\lambda_{0m} + \lambda_{im} i + \lambda_{i'm} i' + \lambda_{tm} t + \lambda_L L_{t-1})}$$

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

[23] 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 stepchildren.

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

$$\Pr(d_{kt}^{G} = 1|i, c_t) =$$

$$p_t^G\Big(\sum_{i'}\sum_{c'} q_s^{G'}(i', c_t')\Pr(J_t^{G'}(i', i, c_t') = 1)\Big)\Pr(d_{kt}^G = 1|k \in \{K_s \cup K_m\}, i, c_t)$$

$$+ \Big[1 - p_t^G\Big(\sum_{i'}\sum_{c'} q_s^{G'}(i', c_t')\Pr(J_t^{G'}(i', i, c_t') = 1)\Big)\Big]\Pr(d_{kt}^G = 1|k \in K_s, i, c_t)$$

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

$$\Pr(d_{kt}^{G} = 1|i, c_t) =$$

$$J_t^{G'}(i', i, c_{t+1}')\Pr(d_{kt}^G = 1|k \in \{K_s \cup K_m\}, i, c_t)$$

$$+ [1 - J_t^{G'}(i', i, c_{t+1}')]\Pr(d_{kt}^G = 1|k \in K_s, i, c_t)$$

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

The likelihood function for the N individuals in the sample is

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

$$\ldots \Pr[d_{k2}^i|d_{k1}^i, i, \Theta] \cdot \Pr[d_{k1}^i|i, \Theta],$$

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

Full details on the estimation of the earnings and nonlabor income equations and the estimation of the structural parameters follow directly from van der Klaauw.[24]

V. Results

A. Parameter Estimates

The model presented above is estimated for the time period covering 1979–94,[25] under the assumption that the discount factor is equal to 0.95 so as to capture the forward-looking behavior of agents.[26] The estimated parameters determining the size of the intrahousehold transfer are presented in table 3. The results predict that an increase of $1.00 in the

[24] Details are presented in Sec. IV of the appendix.

[25] For the purposes of this study, 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.

[26] The estimates did not converge when attempts were made to estimate the discount factor. Parameter estimates from the reduced form models are presented in Sec. V of the appendix.

Table 3
Sharing Rule Parameters and Intrahousehold Transfers

Sharing Rule	Parameter
ϕ^R	2.296
	(.059)
ϕ^F	−.344
	(.048)
ϕ^M	.216
	(.094)
	Average Intrahousehold Transfer
Black women	1,945.76
White women	2,150.93
Black men	−1,298.89
White men	−1,204.53

NOTE.—Standard errors are in parentheses.

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.

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 that matches between spouses with low potential earnings and high potential earnings are less likely to form.

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 nonlabor marital income. This result is consistent with the interpretation that more opportunities to marry 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.

These estimates imply that the average married black male transfers 35% more labor income to his spouse than a white married man and provides one explanation for the lower marriage rates in the black pop-

Table 4
Contact and Estimated Acceptance Rates

	Contact Rate	Acceptance Rate (Single)
Black females	.814	.574
White females	.887	.655
Black males	.999	.749
White males	.858	.873

ulation relative to the white population.[27] 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 nonlabor income and spousal labor market earnings, as average transfers to married women exceed total nonlabor income by $1,299 and $1,204 for black and white men, respectively.[28] 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 is sufficiently low. The latter is also 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 gender and race in the data.

The low sex ratio faced by black women relative to white women also implies that black women find it more difficult to contact a spouse than white women. The average contact probabilities over the sample period are constructed from the stocks of single males and females in the CPS according to (5) and (6) and are presented in table 4. There is a larger spread in contact rates across sex for blacks than for whites, and it is predicted that 20% of single black women are unable to make a contact in the marriage market over the course of a year.

The main goal of this study is to determine the extent to which observed differences in population supplies and earnings can account for observed differences in marriage and employment rates across race. To this end, I allow for preferences over marriage and employment to differ by race. If the preference parameters are significantly different from zero, then observed differences in characteristics are not able to explain all of the racial differences in marriage and employment rates. The results in table 5 suggest that black women receive significantly less utility from marriage than

[27] Intrahousehold transfers are equal to roughly 19% of earnings for both black and white women.

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

Table 5
Preference Parameters

	State		
	sh	*mn*	*mh*
Women:			
Intercept	−5.777	2.533	2.689
	(.484)	(.175)	(.342)
Black	.561	−1.187	−2.630
	(.135)	(.056)	(.183)
Children	−2.801	.015	−1.215
	(.104)	(.042)	(.037)
Consumption	.001	−.00017	−.00061
		(.00007)	(.00008)
Marital-specific capital		.135	.135
		(.008)	(.008)
Men:			
Intercept	−6.744	8.669	−4.239
	(.877)	(1.939)	(.812)
Black	2.153	.577	−.162
	(.235)	(1.037)	(.389)
Children	−.695	−3.982	−4.380
	(.157)	(.220)	(.175)
Consumption	.001	.0032	.001
		(.00218)	
Marital-specific capital		2.266	2.266
		(.088)	(.088)

NOTE.—Standard errors are in parentheses.

white women. This result is consistent with previous studies that consider racial differences in marital behavior (Brien 1997; Brien et al. 2006) and suggests that factors in addition to those considered here explain part of the racial differences across women. 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 earnings and population supplies.[29]

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

[29] The parameter estimates for region, year, and education are presented in Sec. V of the appendix.

Table 6
First Birth Probability Estimates

	Single Females	Single Males	Married Couples
Years in marriage market	−.313	−.366	−2.463
	(.065)	(.010)	(.056)
Education of female	−.730		.961
	(.083)		(.051)
Education of male		.401	1.485
		(.078)	(.283)
Black	1.032	1.533	−.787
	(.114)	(.341)	(.073)
Northeast	−.907	1.716	.074
	(.117)	(.432)	(.090)
South	−.277	.888	.077
	(.114)	(.257)	(.051)
West	−.477	2.367	−1.430
	(.074)	(.323)	(.040)
Marital-specific capital			−.0821
			(.0558)
Intercept	−2.363	−7.454	−1.427
	(.079)	(.175)	(.074)

NOTE.—Standard errors are in parentheses.

can choose whether to specialize in home versus market production. It is worth noting that intrahousehold transfers might differ across race as well, but it is not possible to separately identify the effect of race on preferences from the effect of race on intrahousehold transfers in this framework. Thus, the differences in preferences reported here could partially reflect lower intrahousehold transfers paid to black women.

Turning to the preference parameters for children, single working men and women receive less utility from children relative to the single, nonworking 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 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.

B. 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

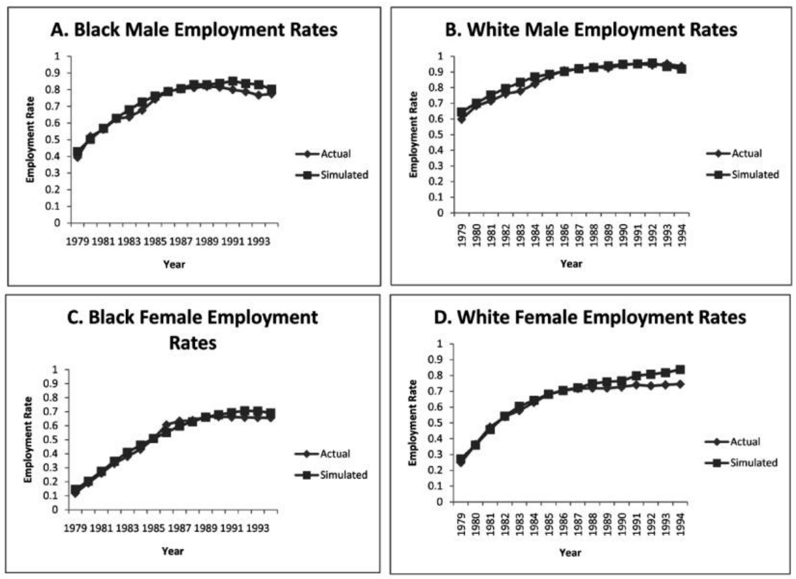

FIG. 2.—Comparison of actual and simulated employment rates. Employment status is an indicator equal to one if the respondent worked at least 775 hours per year. Simulated employment rates are computed from a sample of 5,000 individuals using the estimated model.

sex are compared in figures 2 and 3. As mentioned above, the equilibrium conditions were not imposed in estimation. As such, the model simulations presented in figures 2 and 3 do not impose the equilibrium conditions either. 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 overpredicts 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 overpredict the marriage rates for blacks over the entire sample period, suggesting that 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

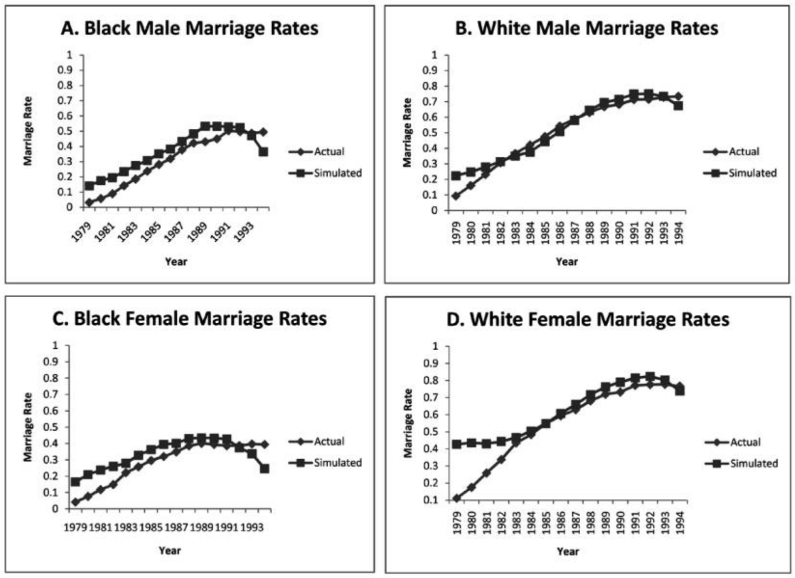

FIG. 3.—Comparison of actual and simulated marriage rates. Actual marriage rates are calculated for the sample of women ages 15–19 and men ages 17–21 in 1979. Simulated marriage rates are computed from a sample of 5,000 individuals using the estimated model.

of the model in this respect. First, education is measured as an indicator equal to one if individuals attained at least a high school education. As indicated in table 2, the high school completion rates for blacks and whites are roughly equal by 1996. However, the proportion of individuals with some postsecondary education is substantially higher for whites than for blacks. In particular, the fraction of women (men) with some postsecondary 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 that 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 im-

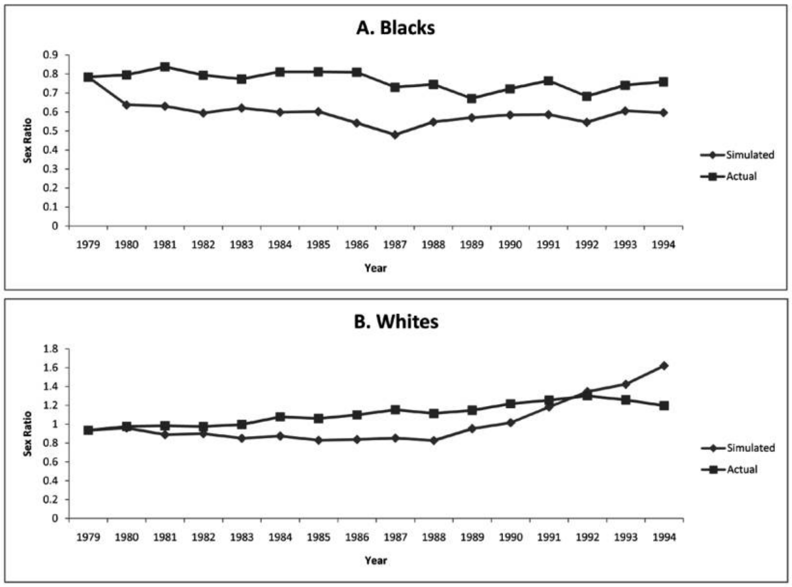

FIG. 4.—Comparison of actual and simulated sex ratios, by race. Simulated sex ratios are computed from a sample of 5,000 individuals using the estimated model.

prove 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 4 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 overpredicts 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 overpredicts marriage rates to roughly the same extent for black men and women over the entire sample period.

VI. Counterfactual Experiments

In what follows, several simulations are performed to further explore the implications of the model. It should be emphasized that the simulations are equilibrium 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 (17)–(22), are endogenous in each of the simulations presented below.

Table 7
Model Simulation: Blacks Have Same Population Supplies as Whites

	Baseline	Experiment	Percentage Change
% of single women that are employed	50.96	47.97	−5.87
% of married women that are employed	83.19	80.67	−3.03
% of single men that are employed	61.47	64.45	4.85
% of married men that are employed	74.48	92.69	24.45
Fraction of women that are married	32.22	39.16	21.54
Divorce rate	12.89	15.41	19.55
Intrahousehold transfers	1,945	1,940	−.26

A. The Wilson Hypothesis

As mentioned in the introduction, a hypothesis raised by Wilson and Neckerman (1985) and Wilson (1987) 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 education, that limit their desirability as spouses. Combined with the higher mortality and incarceration rates for black males than for other groups in the population, marriageable black men are in excess demand. If the stocks of black men and women were the same as those of whites, would the marriage and employment rates of blacks resemble those of whites?

To answer this question, the following experiment is performed. The black population is given the same stocks of men and women, by age and education, as in the white population. Although the characteristics of blacks change in the experiment, the black preference parameters and the parameters in the earnings equation remain as in the baseline economy. The results of this experiment are presented in table 7. Two findings are of particular interest. The first is that the higher sex ratio for blacks implies less search friction for black women who are searching in the marriage market.[30] As a result, there is a 24% increase in marriage rates and a 20% rise in the divorce rate as women become choosier.

Second, the employment rates for single women, single men, and married women change only slightly after the simulation, despite the fact that the characteristics and opportunities of women change dramatically. What accounts for this finding? There is virtually no change in the income available to married women as compared to single, not-working women. The nonlabor income available to single mothers is not affected by the policy change. Furthermore, since the characteristics of both men and

[30] The average contact rate for black women becomes 0.887 and for men becomes 0.858.

Table 8
Model Simulation: Eliminate the Racial Gap in Earnings

	Baseline	Experiment	Percentage Change
% of single women that are employed	50.96	83.50	63.85
% of married women that are employed	83.19	55.59	−33.18
% of single men that are employed	61.47	99.46	61.80
% of married men that are employed	74.48	99.77	33.96
Fraction of women that are married	32.22	28.49	−11.58
Divorce rate	12.89	17.78	37.94
Intrahousehold transfers	1,945	2,137	9.87

women improve after the policy change, intrahousehold transfers are not affected to a large degree: despite the fall in the sex ratio, intrahousehold transfers decrease only slightly after the experiment because of the increase in earnings potential for women relative to men. However, the employment rates for married men still increase by 24% after the policy change.

B. 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.[31] The relatively low labor market return for black males may serve a deterrent to marriage and employment, as black men have lower incentives to work and may be less attractive in the marriage market. If blacks with the same observed characteristics as whites received the same earnings, what would happen to marriage and employment rates? In this counterfactual experiment, on a simulated sample of 5,000 black men and women, the composition of the black population remains the same as in the baseline specification, but the earnings profiles are constrained to be the same for blacks as for whites. This experiment is implemented by setting the black indicators in the earnings equation to zero for men and women. The results of this simulation are presented in table 8.

The most striking change is the large rise in employment rates for single men and women, over 60% in both cases. The employment rate for married men also increases substantially. In fact, the vast majority of men are working full-time after the policy change. As men experience larger increases in their earnings than women when the racial gap is eliminated, intrahousehold transfers to black women increase. The employment patterns across marital status for black women now closely resemble the patterns for whites, as documented in table 1. As a result, married women

[31] The parameter estimates for the earnings equations are presented in Sec. V of the appendix.

Table 9
Fraction of Racial Differences Explained by Population Supplies and the Wage Gap

	% Change in Racial Gap Due to	
	Wilson Experiment	Eliminating Wage Gap
% of women that are married	−18.63	10.01
% of men that are working	−33.33	−1,635.67
% of women that are working	−21.61	−109.55

are the only group that are less likely to work after the experiment is introduced in the model. Despite the fact that women receive larger transfers in marriage, the fraction of marriages in the black population falls and the divorce rate rises. The explanation for this finding is that removing the racial gap in earnings also serves to increase the gender gap in earnings within black households. The sharing rule estimates indicate that the potential earnings of the husband and wife have opposing effects on intrahousehold transfers, as is consistent with positive sorting on wages. Thus, the probability that a match forms is decreasing in the gender earnings gap. This experiment illustrates the importance of looking at both sides of the marriage market when evaluating the effects of policy on marriage behavior. Policies that prohibit discrimination, for example, may have very different effects on the earnings of men and women.

In table 9, the marriage and employment rates for blacks and whites in the baseline are compared to the marriage and employment rates following the simulated change. The statistics in table 9 indicate that almost 20% of the racial gap in marriage rates for women can be explained by the differences in population supplies and the racial earnings gaps. In regard to employment, providing blacks with the marriage market conditions of whites accounts for 22% and 34% of the racial gap in employment for women and men, respectively. The results thus indicate that differences in marriage market conditions are able to explain some but not all of the racial differences in behavior that are observed in the data. Eliminating racial differences in the wage gaps can explain all of the difference in employment rates across white and black women but predicts that black men have higher employment rates than white males and a counterfactual decline in the black marriage rate.

C. Welfare Policy

Some have argued that generous welfare benefits serve to remove incentives to marriage, as the welfare program may serve as a substitute to marriage. The final simulation I consider is one that makes the welfare

Table 10
Reduce Nonlabor Income for Single, Nonworking Women by $1,000

	Baseline	Experiment	Percentage Change
% of single women that are employed	50.96	50.33	−1.24
% of married women that are employed	83.19	83.01	−.22
% of single men that are employed	61.47	38.20	−37.86
% of married men that are employed	74.48	81.67	9.67
Fraction of women that are married	32.07	34.86	8.70
Divorce rate	12.89	13.80	7.06
Intrahousehold transfers	1,945	1,945	.00

program less attractive.[32] This policy is implemented within the model by reducing annual nonlabor income for single, nonworking women by $1,000. The experiment is conducted on a simulated sample of 5,000 men and women and compared to the baseline specification for blacks. The results of this policy change are presented in table 10. This experiment has a direct effect on the trade-off between marriage and being single for nonworking women without changing the average potential intrahousehold transfer and the contact rates. As a result, the number of married couples increases. It is also interesting to observe that the decline in nonlabor income for single women results in a rise in employment for married men. Women are more willing to marry men with lower earnings potential than before. In turn, married men with low earnings potential are more likely to work, as the incentives to work are greater for married men than single men.

VII. Conclusion

This article provides new insight into the causes and consequences of the dramatic differences in family structure and employment across blacks and whites in recent U.S. history. The model is consistent with many of the stylized facts on the joint patterns of marriage and employment, 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 differences in population supplies in particular play a role in explaining the observed differences in behavior across blacks and whites. Simulation results suggest that racial differences in marriage market conditions can account for one-fifth of the difference in marriage rates across blacks and whites and one-third of

[32] Note that the model was estimated before the large-scale welfare reforms of the 1990s came into effect.

racial differences in employment for men. Thus, the Wilson hypothesis explains some, but not all, of the racial differences in marriage and employment. Differences in labor market earnings across race can account for the differences in employment rates for women but have counterfactual effects on the racial gaps in marriage rates and the gap in employment rates for men.

The policy experiments presented here make two important points. First, any policy that affects household formation decisions in the current period directly influences future conditions in the marriage market by changing the distribution 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. For example, reducing the attractiveness of welfare has the potential to increase marriage rates for women and employment rates for men. Such findings might have important implications for the outcomes of children: approximately 61% of black children are born to unmarried mothers, while only 16% of white children are born out of wedlock (Ellwood and Crane 1990). It is well known that children of single parents are more likely to become teenage mothers and are less likely to complete high school (e.g., McLanahan and Sandefur 1994). An, Haveman, and Wolfe (1993) report that the children of women who are welfare recipients are more likely to collect welfare themselves. Extending the model to incorporate fertility and investments in children is an important extension for future work.

Appendix

I. Definition of Region Indicators

West:	Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming
Northeast:	Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont
South:	Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia
Northwest:	Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin

II. Reduced Form Representation of the Model

A. Earnings and Nonlabor Income Equations

The reduced form representation of the model can be derived from the structural model by substituting the budget constraint into the utility function, where the nonstochastic component of the earnings equations is specified as

$$w^G(i) = \alpha_0^G + \alpha_i^G i \tag{A1}$$

and that of the nonlabor income equations as

$$y_{kt}^G(i, i', c_t) = \zeta_{0k}^G + \zeta_{ik}^G i + \zeta_{i'k}^G i_t' + \zeta_{ck}^G c_t, \tag{A2}$$

where i' is zero for single individuals.

B. Reduced Form Utility Functions

The nonstochastic component of reduced form utility corresponding to each state can be written as:
Single, not working ($k = sn$):

$$\begin{aligned} U_{sn}^G(i, c_t) &= \gamma_{sn}^G + \gamma_{xsn}^G(\zeta_{0sn}^G + \zeta_{isn}^G i) + \gamma_{csn}^G c_t + \gamma_{isn}^G i \\ &= \gamma_{sn}^G + \gamma_{xsn}^G \zeta_{0sn}^G + (\gamma_{xsn}^G \zeta_{isn}^G + \gamma_{isn}^G) i + \gamma_{csn}^G c_t \end{aligned} \tag{A3}$$

Single, working ($k = sh$):

$$\begin{aligned} U_{sh}^G(i, c_t) &= \gamma_{sh}^G + \gamma_{xsh}^G(\zeta_{0sh}^G + \zeta_{ish}^G i + \alpha_0^G + \alpha_i^G i) + \gamma_{csh}^G c_t + \gamma_{ish}^G i \\ &= [\gamma_{sh}^G + \gamma_{xsh}^G(\alpha_0^G + \zeta_{0sh}^G)] + [\gamma_{xsh}^G(\zeta_{ish}^G + \alpha_i^G) + \gamma_{ish}^G] i + \gamma_{csh}^G c_t \end{aligned} \tag{A4}$$

Married, not working ($k = mn$):
Females:

$$\begin{aligned} U_{mn}^F(i, c_t) &= \gamma_{mn}^F + \gamma_{xmn}^F(\phi^R R_t + \phi^F \bar{w}^F(i) + \phi^M \bar{w}^M(i')) \\ &\quad + \gamma_{cmn}^F c_t + \gamma_{imn}^F i + \gamma_L^F L_t \\ &= \gamma_{mn}^F + \gamma_{xmn}^F \phi^R R_t + \gamma_{xmn}^F \phi^F \bar{w}^F(i) \\ &\quad + \gamma_{xmn}^F \phi^M \bar{w}^M(i') + \gamma_{cmn}^F c_t + \gamma_{imn}^F i + \gamma_L^F L_t \end{aligned} \tag{A5}$$

Males:

$$
\begin{aligned}
U^M_{mn}(i', c_t) &= \gamma^M_{mn} \\
&\quad + \gamma^M_{xmn}(\zeta^M_{0mn} + \zeta^M_{imn} i + \zeta^M_{i'mn} i'_t + \zeta^M_{cmn} c_t \\
&\qquad - \phi^R R_t - \phi^F \bar{w}^F(i) - \phi^M \bar{w}^M(i')) \\
&\quad + \gamma^M_{cmn} c_t + \gamma^M_{i'mn} i' + \gamma^M_L L_t \qquad \text{(A6)} \\
&= (\gamma^M_{mn} + \gamma^M_{xmn}\zeta^M_{0mn}) + (\gamma^M_{xmn}\zeta^M_{i'mn} + \gamma^M_{i'mn}) i' \\
&\quad + \gamma^M_{xmn}\zeta^M_{imn} i - \gamma^M_{xmn}\phi^R R_t - \gamma^M_{xmn}\phi^F \bar{w}^F(i) \\
&\quad - \gamma^M_{xmn}\phi^M \bar{w}^M(i') + (\gamma^M_{cmn} + \zeta^M_{cmn}) c_t + \gamma^M_L L_t
\end{aligned}
$$

Married, working ($k = mh$):
Females:

$$
\begin{aligned}
U^F_{mh}(i, c_t) &= \gamma^F_{mh} + \gamma^F_{xmh}(\alpha^F_0 + \alpha^F_i i + \phi^R R_t + \phi^F \bar{w}^F(i) + \phi^M \bar{w}^M(i')) \\
&\quad + \gamma^F_{cmh} c_t + \gamma^F_{imh} i + \gamma^F_L L_t \\
&= (\gamma^F_{mh} + \gamma^F_{xmh}\alpha^F_0) + \gamma^F_{xmh}\phi^R R_t + \gamma^F_{xmh}\phi^F \bar{w}^F(i) \qquad \text{(A7)} \\
&\quad + \gamma^F_{xmh}\phi^M \bar{w}^M(i') + \gamma^F_{cmh} c_t + (\gamma^F_{imh} + \gamma^F_{xmh}\alpha^F_i) i + \gamma^F_L L_t
\end{aligned}
$$

Males:

$$
\begin{aligned}
U^M_{mh}(i', c_t) &= \gamma^M_{mh} \\
&\quad + \gamma^M_{xmh}(\alpha^M_0 + \alpha^M_{i'} i' + \zeta^M_{0mh} + \zeta^M_{imh} i + \zeta^M_{i'mh} i'_t \\
&\qquad + \zeta^M_{cmh} c_t - \phi^R R_t - \phi^F \bar{w}^F(i) - \phi^M \bar{w}^M(i')) \\
&\quad + \gamma^M_{cmh} c_t + \gamma^M_{i'mh} i' + \gamma^M_L L_t \\
&= [\gamma^M_{mh} + \gamma^M_{xmh}(\alpha^M_0 + \zeta^M_{0mh})] \qquad \text{(A8)} \\
&\quad + [\gamma^M_{xmh}(\alpha^M_{i'} + \zeta^M_{i'mh}) + \gamma^M_{i'mh}] i' \\
&\quad + \gamma^M_{xmh}\zeta^M_{imh} i - \gamma^M_{xmh}\phi^R R_t - \gamma^M_{xmh}\phi^F \bar{w}^F(i) \\
&\quad - \gamma^M_{xmh}\phi^M \bar{w}^M(i') + (\zeta^M_{cmh} + \gamma^M_{cmh}) c_t + \gamma^M_L L_t
\end{aligned}
$$

It is not possible to recover all of the structural parameters from the reduced form; thus the following identifying assumptions are imposed:

$$\gamma^G_{xsn} = \gamma^G_{xsh} = 1,$$

$$\gamma^G_{sn} = \gamma^F_{isn} = \gamma^M_{i'sn} = \gamma^G_{csn} = 0.$$

The first restriction normalizes the marginal utility from consumption for singles to one. The second restriction normalizes the remaining preference parameters in the single, not-working state to zero. Thus, preferences are identified relative to the single, not-working state. After imposing the above identifying restrictions, equations (A3) through (A8) become

$$U_{sn}^{G}(i, c_t) = \zeta_{0sn}^{G} + \zeta_{isn}^{G} i, \tag{A9}$$

$$U_{sh}^{G}(i, c_t) = [\gamma_{sh}^{G} + \alpha_0^{G} + \zeta_{0sh}^{G}] + [\zeta_{ish}^{G} + \alpha_i^{G} + \gamma_{ish}^{G}]i + \gamma_{csh}^{G} c_t, \tag{A10}$$

$$\begin{aligned} U_{mn}^{F}(i, c_t) = {} & \gamma_{mn}^{F} + \gamma_{xmn}^{F}\phi^{R}R_t + \gamma_{xmn}^{F}\phi^{F}\bar{w}^{F}(i) + \gamma_{xmn}^{F}\phi^{M}\bar{w}^{M}(i') \\ & + \gamma_{cmn}^{F}c_t + \gamma_{imn}^{F}i + \gamma_{L}^{F}L_t, \end{aligned} \tag{A11}$$

$$\begin{aligned} U_{mn}^{M}(i', c_t) = {} & (\gamma_{mn}^{M} + \gamma_{xmn}^{M}\zeta_{0mn}^{M}) + (\gamma_{xmn}^{M}\zeta_{i'mn}^{M} + \gamma_{i'mn}^{M})i' + \gamma_{xmn}^{M}\zeta_{imn}^{M} i \\ & - \gamma_{xmn}^{M}\phi^{R}R_t - \gamma_{xmn}^{M}\phi^{F}\bar{w}^{F}(i) - \gamma_{xmn}^{M}\phi^{M}\bar{w}^{M}(i') \\ & + (\gamma_{cmn}^{M} + \zeta_{cmn}^{M})c_t + \gamma_{L}^{M}L_t, \end{aligned} \tag{A12}$$

$$\begin{aligned} U_{mh}^{F}(i, c_t) = {} & (\gamma_{mh}^{F} + \gamma_{xmh}^{F}\alpha_0^{F}) + \gamma_{xmh}^{F}\phi^{R}R_t \\ & + \gamma_{xmh}^{F}\phi^{F}\bar{w}^{F}(i) + \gamma_{xmh}^{F}\phi^{M}\bar{w}^{M}(i') \\ & + \gamma_{cmh}^{F}c_t + (\gamma_{imh}^{F} + \gamma_{xmh}^{F}\alpha_i^{F})i + \gamma_{L}^{F}L_t, \end{aligned} \tag{A13}$$

$$\begin{aligned} U_{mh}^{M}(i', c_t) = {} & \left[\gamma_{mh}^{M} + \gamma_{xmh}^{M}(\alpha_0^{M} + \zeta_{0mh}^{M})\right] + \left[\gamma_{xmh}^{M}(\alpha_{i'}^{M} + \zeta_{i'mh}^{M}) + \gamma_{i'mh}^{M}\right]i' \\ & + \gamma_{xmh}^{M}\zeta_{imh}^{M} i - \gamma_{xmh}^{M}\phi^{R}R_t - \gamma_{xmh}^{M}\phi^{F}\bar{w}^{F}(i) - \gamma_{xmh}^{M}\phi^{M}\bar{w}^{M}(i') \\ & + (\zeta_{cmh}^{M} + \gamma_{cmh}^{M})c_t + \gamma_{L}^{M}L_t. \end{aligned} \tag{A14}$$

All of the remaining preference parameters can be identified. The preference parameters in the wage and nonlabor income equations can be identified from equations (A1) and (A2). The wife's characteristics only affect the husband's marriage choice through nonlabor income, which identifies γ_{xmn}^{M} in equation (A11). Identification of ϕ^{R}, ϕ^{F}, and ϕ^{M} and the remaining structural parameters follows immediately.

III. Composite Errors

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

$$\varepsilon_{snt}^{F} = \epsilon_{snt}^{F} + \nu_{snt}^{F},$$

$$\varepsilon^F_{sht} = \epsilon^F_{sht} + \nu^F_{sht} + e^F_t,$$

$$\varepsilon^F_{mnt} = \epsilon^F_{mnt},$$

$$\varepsilon^F_{mht} = \epsilon^F_{mht} + \gamma^F_{xmh} e^F_t,$$

for women and

$$\varepsilon^M_{snt} = \epsilon^M_{snt} + \nu^M_{snt},$$

$$\varepsilon^M_{sht} = \epsilon^M_{sht} + \nu^M_{sht} + e^M_t,$$

$$\varepsilon^M_{mnt} = \epsilon^M_{mnt} + \gamma^M_{xmn} \nu^M_{mnt},$$

$$\varepsilon^M_{mht} = \epsilon^M_{mht} + \gamma^M_{xmh}(\nu^M_{mht} + e^M_t),$$

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 nonlabor income equations are allowed to vary across gender. Second, the budget constraints for married men and women differ due to the presence of intrahousehold transfers and the assumption that women receive transfers and men consume the couple's remaining marital nonlabor income.

IV. Econometric Specification

A. 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:

$$\begin{aligned} &E[v^G_{t+1}(\Omega^G_{t+1}), i, c_{t+1} | d^G_{lt} = 1] \\ &= E_{\varepsilon^G_{kt+1}}\{\max_{k \in K_{t+1}} U^G_k(i, c_{t+1}) + \beta E[v^G_{t+2}(\Omega^G_{t+2}, i, c_{t+2}) | d^G_{kt+1} = 1] + \varepsilon^G_{kt+1}\} \\ &= \ln \sum_{k \in K_{t+1}} \exp\left[U^G_k(i, c_{t+1}) + \beta E[v^G_{t+2}(\Omega^G_{t+2}, i, c_{t+2}) | d^G_{kt+1} = 1]\right]. \end{aligned}$$

B. Estimation of Earnings and Nonlabor Income

Earnings and nonlabor income are estimated on nonrandom 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 nonlabor income equations can be calculated in the final stage of estimation as outlined in Section IV of the text.

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. Recall the earnings equation

$$w_t^G = \alpha_0^G + \alpha_i^G i + e_t^G,$$

estimated separately for men and for women, that 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 $E[e_t^G|\varepsilon_{snt}^G, \varepsilon_{sht}^G, \varepsilon_{mnt}^G, \varepsilon_{mht}^G] = \sum_k r_k^G \varepsilon_{kt}^G$ with $\sum_k r_k^G = 0$ if the conditional expectation of e_t^G is linear in the $\varepsilon_{kt}^{G'}s$, then

$$E[e_t^G|d_{kt}^G = 1] = \sum_{j \in K_t^G, j \neq k} r_k^G \left[\frac{P_{jt}^G \ln P_{jt}^G}{1 - P_{jt}^G} + \ln P_{jt}^G\right],$$

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

$$\begin{aligned} E[e_t^G|d_{sht}^G = 1] &= \{J_{mt}^{G'} E[e_t^G|d_{sht}^G = 1] \\ &+ (1 - J_{mt}^{G'}) E[e_t^G|d_{sht}^G = 1]\} 1(d_{mnt-1}^G + d_{mht-1}^G = 1) \\ &+ \{p_t^G J_{st}^{G'} E[e_t^G|d_{sht}^G = 1] + (1 - p_t^G J_{st}^{G'}) E[e_t^G|d_{sht}^G = 1]\} 1(d_{mnt-1}^G + d_{mht-1}^G = 0), \end{aligned} \tag{A15}$$

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

$$\begin{aligned} E[e_t^G|d_{mht}^G = 1] &= J_{mt}^{G'} E[e_t^G|d_{mht}^G = 1] 1(d_{mnt-1}^G + d_{mht-1} = 1) \\ &+ p_t^G J_{st}^{G'} E[e_t^G|d_{mht}^G = 1] 1(d_{mnt-1}^G + d_{mht-1}^G = 0). \end{aligned} \tag{A16}$$

Using (A15) and (A16) above, the conditional expectation of earnings can be expressed as

$$E[w_t^G|d_{sht}^G = 1 \text{ or } d_{mht}^G = 1] = \alpha_0^G + \alpha_i^G i + r_{sh}^G R_{sht}^G + r_{mn}^G R_{mnt}^G + r_{mh}^G R_{mht}^G.$$

Define the terms A and B as

$$A = (1(d^G_{mnt-1} + d^G_{mht-1} = 1)J^{G'}_{mt} + 1(d^G_{mnt-1} + d^G_{mht-1} = 0)p^G_t J^{G'}_{st})$$

and

$$B = \big(1(d^G_{mnt-1} + d^G_{mht-1} = 1)(1 - J^{G'}_{mt}) \\ + 1(d^G_{mnt-1} + d^G_{mht-1} = 0)(1 - p^G_t J^G_{st})\big),$$

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

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

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

and

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

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

$$w^G_t = \alpha^G_0 + \alpha^G_i i + r^G_{sh}\hat{R}^G_{sht} + r^G_{mn}\hat{R}^G_{mnt} + r^G_{mh}\hat{R}^G_{mht} + \xi^G_{wt}, \tag{A17}$$

where $\hat{R}^G_{sht}$, $\hat{R}^G_{mnt}$, and $\hat{R}^G_{mht}$ are estimated by replacing the $P^{G'}_{kt}s$ and $P^{*G'}_{kt}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (A17), ξ^G_{wt}, is mean zero.

2. *Nonlabor Income*

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

$$y^G_{snt} = \zeta^G_{0sn} + \zeta^G_{isn} i + \zeta^G_{csn} c_t + \nu^G_{snt}.$$

The conditional expectation of the error in the nonlabor income equations for single, nonworking individuals is

$$
\begin{aligned}
E[\nu^G_{snt}|d^G_{sht}=1] &= \{J^{G'}_{mt}E[\nu^G_{snt}|d^G_{sht}=1] \\
&+ (1-J^{G'}_{mt})E[\nu^G_{snt}|d^G_{1t}=1]\}1(d^G_{mnt-1}+d^G_{mht-1}=1) \qquad \text{(A18)} \\
&+ \{p^G_t J^{G'}_{st}E[\nu^G_{snt}|d^G_{1t}=1] + (1-p^G_t J^{G'}_{st})E[\nu^G_{snt}|d^G_{1t}=1]\}1(d^G_{mnt-1}+d^G_{mht-1}=0).
\end{aligned}
$$

Using (A18) above, the conditional expectation of nonlabor income can be expressed as

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

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 nonlabor income equation to be estimated is

$$y^G_{snt} = \zeta^G_{0sn} + \zeta^G_{isn}i + \zeta^G_{csn}c_t + b^G_{sh}\hat{B}^G_{sht} + b^G_{mn}\hat{B}^G_{mnt} + b^G_{mh}\hat{B}^G_{mht} + \xi^G_{snt}, \qquad \text{(A19)}$$

where $\hat{B}^G_{sht}$, $\hat{B}^G_{mnt}$, and $\hat{B}^G_{mht}$ are estimated by replacing the $P^{G'}_{kt}s$ and $P^{*G'}_{kt}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (A19) is mean zero.

The nonlabor income equations for single, working men and women can be expressed as

$$y^G_{sht} = \zeta^G_{0sh} + \zeta^G_{ish}i + \zeta^G_{csh}c_t + \nu^G_{sht}$$

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

$$
\begin{aligned}
E[\nu^G_{sht}|d^G_{sht}=1] &= \{J^{G'}_{mt}E[\nu^G_{sht}|d^G_{sht}=1] \\
&+ (1-J^{G'}_{mt})E[\nu^G_{sht}|d^G_{sht}=1]\}1(d^G_{mnt-1}+d^G_{mht-1}=1) \qquad \text{(A20)} \\
&+ \{p^G_t J^{G'}_{st}E[\nu^G_{sht}|d^G_{sht}=1] + (1-p^G_t J^{G'}_{st})E[\nu^G_{sht}|d^G_{sht}=1]\}1(d^G_{mnt-1}+d^G_{mht-1}=0).
\end{aligned}
$$

Using (A20), the conditional expectation of nonlabor income can be expressed as

$$E[\nu_{sht}^G | d_{sht}^G = 1] = \zeta_{0sh}^G + \zeta_{ish}^G i + \zeta_{csh}^G c_t c_{sh}^G C_{sht}^G + c_{mn}^G C_{mnt}^G + c_{mh}^G C_{mht}^G,$$

where

$$C_{sht}^G = 1(d_{sht}^G = 1)\left[A\left(-\frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G} - \ln P_{sht}^G\right) + B\left(-\frac{P_{sht}^{*G} \ln P_{sht}^{*G}}{1 - P_{sht}^{*G}} - \ln P_{snt}^{*G}\right)\right],$$

$$C_{mnt}^G = 1(d_{sht}^G = 1) \cdot \left[A\left(\frac{P_{mnt}^G \ln P_{mnt}^G}{1 - P_{mnt}^G} - \frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G}\right) + B\left(-\frac{P_{snt}^{*G} \ln P_{snt}^{*G}}{1 - P_{snt}^{*G}} - \ln P_{sht}^{*G}\right)\right],$$

and

$$C_{mht}^G = 1(d_{sht}^G = 1) \cdot \left[A\left(\frac{P_{mht}^G \ln P_{mht}^G}{1 - P_{mht}^G} - \frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G}\right) + B\left(-\frac{P_{snt}^{*G} \ln P_{snt}^{*G}}{1 - P_{snt}^{*G}} - \ln P_{sht}^{*G}\right)\right].$$

The nonlabor income equation to be estimated is

$$y_{sht}^G = \zeta_{0sh}^G + \zeta_{ish}^G i + \zeta_{csh}^G c_t + c_{sh}^G \hat{C}_{sht}^G + c_{mn}^G \hat{C}_{mnt}^G + c_{mh}^G \hat{C}_{mht}^G + \varepsilon_{sht}^G, \quad \text{(A21)}$$

where $\hat{C}_{sht}^G$, $\hat{C}_{mnt}^G$, and $\hat{C}_{mht}^G$ are estimated by replacing the $P_{kt}^{G'}s$ and $P_{kt}^{*G'}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (A21) is mean zero.

The final nonlabor income equation to be estimated is for married couples

$$y_{mt} = \zeta_{0m}^G + \zeta_{im}^G i + \zeta_{i'm}^G i' + \zeta_{cm}^G c_{mt} + \nu_{mt}.$$

Since data are only available on nonlabor income for married couples, nonlabor income is estimated on the sample of married men and women only ($d_{mnt}^G = 1$ or $d_{mht}^G = 1$) and is selection corrected accordingly. The conditional expectation of the error in the nonlabor income equations for married, nonworking individuals is

$$\begin{aligned} E[\nu_{mt}^G | d_{mnt}^G = 1] &= J_{mt}^{G'} E[\nu_{mt}^G | d_{mnt}^G = 1] 1(d_{mnt-1}^G + d_{mht-1}^G = 1) \\ &\quad + p_t^G J_{st}^{G'} E[\nu_{mt}^G | d_{mnt}^G = 1] 1(d_{mnt-1}^G + d_{mht-1}^G = 0), \quad \text{(A22)} \end{aligned}$$

and the conditional expectation of the error in the nonlabor income equations for married, working individuals is

$$E[\nu_{mt}^G | d_{mht}^G = 1] = J_{mt}^{G'} E[\nu_{mt}^G | d_{mht}^G = 1] 1(d_{mnt-1}^G + d_{mht-1}^G = 1) + p_t^G J_{st}^{G'} E[\nu_{mt}^G | d_{mht}^G = 1] 1(d_{mnt-1}^G + d_{mht-1}^G = 0). \quad \text{(A23)}$$

Using (A22) and (A23) above, the conditional expectation of nonlabor income can be expressed as

$$E[\nu_{mt}^G | d_{mnt}^G = 1 \text{ or } d_{mht}^G = 1] = \zeta_{m0}^G + \zeta_{im}^G i + \zeta_{i'm}^G i' + \zeta_{cm}^G c_t + d_{sh}^G D_{sht}^G + d_{mn}^G D_{mnt}^G + d_{mh}^G D_{mht}^G,$$

where

$$D_{sht}^G = 1(d_{mnt}^G + d_{mht}^G = 1)\left[A\left(\frac{P_{sht}^G \ln P_{sht}^G}{1 - P_{sht}^G} - \frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G}\right)\right],$$

$$D_{mnt}^G = A1(d_{mnt}^G = 1)\left(-\frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G} - \ln P_{mnt}^G\right) + A1(d_{mht}^G = 1)\left(-\frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G} - \ln P_{mht}^G\right),$$

and

$$D_{mht}^G = A1(d_{mnt}^G = 1)\left(\frac{P_{mht}^G \ln P_{mht}^G}{1 - P_{mht}^G} - \frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G}\right) + A1(d_{mht}^G = 1)\left(-\frac{P_{snt}^G \ln P_{snt}^G}{1 - P_{snt}^G} - \ln P_{mht}^G\right).$$

The nonlabor income equation to be estimated is thus

$$y_{mt}^G = \zeta_{0m}^G + \zeta_{im}^G i + \zeta_{i'm}^G i' + \zeta_{cm}^G c_t + d_{sh}^G \hat{D}_{sht}^G + d_{mn}^G \hat{D}_{mnt}^G + d_{mh}^G \hat{D}_{mht}^G + \xi_{mt}^G, \quad \text{(A24)}$$

where $\hat{D}_{sht}^G$, $\hat{D}_{mnt}^G$, and $\hat{D}_{mht}^G$ are estimated by replacing the $P_{mt}^{G'}s$ and $P_{mt}^{*G'}s$ by their predicted values following estimation of the reduced form choice probabilities. The error term in (A24) is mean zero.

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 jth first-order condition in the system and ψ_j the jth vector of reduced form parameter estimates. Specifically, the estimators of the reduced form parameters $\psi = [\psi_1, \psi_2, \ldots \ \psi_{15}]'$ satisfy

$$\frac{1}{N}\sum f_1(\psi_1) = 0, \tag{A25}$$

$$\frac{1}{N}\sum f_j(\psi_1, \psi_j) = 0, j = 2, \ldots \ 15. \tag{A26}$$

Equation (A25) represents the first-order conditions satisfied by the reduced form choice and fertility probabilities. The first-order conditions described by (A26) correspond to the two earnings and five nonlabor earnings equations from the second stage of estimation. Note that the first-order conditions for earnings and nonlabor 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

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

where n denotes the normal distribution and

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

V. Parameter Estimates

Table A1
Choice Probability Parameter Estimates in the Single, Working State

	Female	Male
Northeast	.2834	.0420
	(.1296)	(.1023)
South	.2977	.2177
	(.1094)	(.0986)
West	.2822	.5342
	(.1338)	(.1083)
Black	−1.0763	−.5341
	(.1069)	(.0735)
Education	1.6596	.5031
	(.1075)	(.0847)
Child	−.4123	−.8786
	(.0687)	(.0945)
Time/10	3.5281	.8394
	(.4310)	(.0618)
$\text{Time}^2/100$	−1.4881	.9894
	(.3404)	(.0772)
Intercept	−2.1828	−.2995
	(.1320)	(.0775)
β	.95	
Log likelihood	−5,983.3410	

Note.—Standard errors are in parentheses.

Table A2
Choice Probability Parameter Estimates in the Married, Not-Working State

	Female	Male
Sex ratio	2.1331	−2.0768
	(.1356)	(.3548)
Northeast	.0511	.9727
	(.0706)	(.2469)
South	.3672	−1.1895
	(.0768)	(.3106)
West	.0190	.7183
	(.0653)	(.1753)
Black	.3058	−.7106
	(.0670)	(.2804)
Education	.4159	−6.3745
	(.0952)	(.8722)
Child	1.3890	4.2768
	(.0754)	(.6763)
Time/10	.5032	5.2552
	(.1392)	(.8962)
$\text{Time}^2/100$	2.2950	−2.6021
	(.2010)	(.2963)
Intercept	1.8608	.5831
	(.1280)	(.1021)
Education of spouse	.7805	−.2530
	(.0407)	(.2208)
β	.95	
Log likelihood	−5,983.3410	

Note.—Standard errors are in parentheses.

Table A3
Choice Probability Parameter Estimates in the Married, Working State

	Female	Male
Sex ratio	1.2846	1.5383
	(.1208)	(.1905)
Northeast	.3348	1.6246
	(.0724)	(.2205)
South	.7062	.3481
	(.0707)	(.2944)
West	.6119	.4255
	(.0558)	(.1317)
Black	−.1886	−1.4076
	(.0661)	(.2027)
Education	2.1223	−5.5512
	(.0945)	(.8141)
Child	.1643	4.1568
	(.0810)	(.6706)
Time/10	2.9531	−3.1227
	(.2260)	(.5645)
$\text{Time}^2/100$	1.5703	5.2554
	(.1400)	(.7757)
Intercept	.7209	−.2676
	(.1005)	(.1608)
Education of spouse	.9786	.9358
	(.0420)	(.1461)
β	.95	
Log likelihood	−5,983.3410	

NOTE.—Standard errors are in parentheses.

Table A4
Fertility

	Female	Male
Time/10	−1.7506	7.8914
	(.1319)	(1.2739)
$\text{Time}^2/100$	.6812	−5.6529
	(.1132)	(.8822)
Education	.0092	1.1218
	(.1248)	(.3212)
Black	1.2505	−.4842
	(.1749)	(.2563)
Married in previous period	2.5683	−3.4848
	(.1485)	(.1467)
Intercept	−3.0641	−1.3667
	(.1713)	(.5053)
β	.95	
Log likelihood	−5,983.3410	

NOTE.—Standard errors are in parentheses.

Table A5
Earnings and Nonlabor Income Parameters for Females

Variable	Earnings	Nonlabor Income (*sn*)	Nonlabor Income (*sh*)
Northeast	736.85	268.98	212.84
	(482.11)	(123.69)	(109.50)
South	346.87	−484.63	220.44
	(383.71)	(95.53)	(97.87)
West	1,038.90	162.25	8.09
	(452.72)	(123.51)	(112.27)
Black	−2,015.77	415.41	75.61
	(496.10)	(100.92)	(110.43)
Education	2,817.94	−159.04	98.44
	(572.69)	(121.76)	(163.28)
Time/10	8,568.24	1,529.42	−333.46
	(2,468.37)	(568.22)	(597.92)
$Time^2/100$	−444.36	−908.32	547.54
	(1,695.68)	(431.67)	(429.50)
Child		2,567.80	690.20
		(116.11)	(118.05)
Intercept	−42.41	85.02	264.45
	(1,024.87)	(219.11)	(311.41)
λ^F_{sh}	40.92	−68.51	2.94
	(22.62)	(46.20)	(6.88)
λ^F_{mn}	278.89	518.42	133.12
	(141.13)	(276.06)	(311.81)
λ^F_{mh}	27.94	−463.02	128.41
	(21.95)	(287.39)	(311.55)
Observations	1,431	959	910

NOTE.—Standard errors are in parentheses.

Table A6
Earnings and Nonlabor Income Parameters for Males

Variable	Earnings	Nonlabor Income (*sn*)	Nonlabor Income (*sh*)	Nonlabor Income (*mn* or *mh*)
Northeast	2,213.85	−235.47	65.58	−517.84
	(583.63)	(214.83)	(109.53)	(175.65)
South	1,300.43	−807.02	−149.30	−488.19
	(584.68)	(228.45)	(116.79)	(180.24)
West	3,919.87	−750.75	−247.39	−317.36
	(634.25)	(262.56)	(120.86)	(189.04)
Black	−3,554.72	112.79	−294.79	−317.64
	(831.07)	(232.53)	(146.85)	(257.39)
Education	3,414.94	687.46	318.67	−54.86
	(670.15)	(200.32)	(123.23)	(234.46)
Time/10	5,112.96	1,942.25	375.26	881.08
	(3,001.48)	(1,163.02)	(529.80)	(1,148.62)
$Time^2/100$	3,656.38	−1,420.32	−150.97	−661.54
	(2,131.55)	(1,067.05)	(435.89)	(752.89)
Child		1,284.08	153.45	−2.27
		(346.68)	(171.51)	(138.36)
Education of spouse				−28.17
				(218.82)
Intercept	6,045.32	88.06	588.84	1,009.04
	(1,103.99)	(498.11)	(296.39)	(434.01)
λ^M_{sh}	−163.14	−49.78	−24.99	−234.08
	(42.61)	(261.09)	(14.81)	(3,871.13)
λ^M_{mn}	−1,615.56	−95.47	−44.69	1,187.79
	(245.27)	(276.06)	(381.47)	(250.08)
λ^M_{mh}	235.51	120.73	262.84	−1,650.61
	(43.42)	(287.39)	(466.40)	(760.18)
Observations	1,521	455	922	667

NOTE.—Standard errors are in parentheses.

Table A7
Preference Parameters for Region

	Females	Males
Northeast:		
γ^G_{NEsh}	.5670	−.3550
	(.1371)	(.1194)
γ^G_{NEmn}	−.2627	.2613
	(.0830)	(.1733)
γ^G_{NEmh}	.4606	−.3067
	(.0790)	(.1572)
South:		
γ^G_{Ssh}	.1387	.1924
	(.1160)	(.1156)
γ^G_{Smn}	.2165	1.6927
	(.0689)	(.1285)
γ^G_{Smh}	−.3648	.8949
	(.0660)	(.2383)
West:		
γ^G_{Wsh}	.4335	−.1688
	(.1408)	(.1264)
γ^G_{Wmn}	−.2157	−.2850
	(.0861)	(.1866)
γ^G_{Wmh}	−.7539	−1.2647
	(.0875)	(.1218)

Note.—Standard errors are in parentheses.

Table A8
Preference Parameters for Time and Education

	Females	Males
Education:		
γ^G_{Esh}	.9323	.3849
	(.1100)	(.1097)
γ^G_{Emn}	−.6082	1.0323
	(.1201)	(.1526)
γ^G_{Emh}	−.0259	1.7166
	(.1255)	(.1439)
Time:		
γ^G_{Tsh}	−2.6910	.5595
	(.2984)	(.3306)
γ^G_{Tmn}	1.6965	−.1489
	(.4353)	(.5279)
γ^G_{Tmh}	−2.2516	.2581
	(.4452)	(.4599)
Time^2:		
$\gamma^G_{T^2sh}$	2.5730	.6854
	(.2242)	(.2535)
$\gamma^G_{T^2mn}$	−.2888	.3778
	(.0585)	(.2329)
$\gamma^G_{T^2mh}$	−.9841	.5195
	(.1553)	(.2608)

Note.—Standard errors are in parentheses.

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