The Interrelation between Educational Homogamy and Racial Endogamy in Marriage Markets: A Search Model

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Preliminary Draft

Abstract

Numerous empirical studies have found a tendency for people to choose marriage partners of similar educational attainment. Current Population Survey data from 1964 to 2009 indicate that educational assortative mating is evident either among whites or blacks when they are considered separately. However, in a structure of the marriage market consisting of both blacks and whites, the barrier to intermarriage across the education groups of whites persists while that of blacks disappears. Furthermore, at least in the last two decades, the proportion of those who have never been married among people aged 40 to 49 is higher in the black population, especially for those without a college diploma. This paper proposes a comprehensive explanation of these empirical observations by adopting a search and matching model in the presence of racial prejudice.

1 Introduction

Reflecting both socioeconomic status and cultural capital, education is especially meaningful when one looks for his/her spouse in the marriage market. As studied in previous research (e.g., Kalmijn, 1991; Lewis and Oppenheimer, 2000; Mare, 1991; Qian and Preston, 1993), educational assortative mating is significantly pervasive and has increased in the past several decades. Meanwhile, another line of research focusing on black/white interracial marriage in the U.S. (e.g., Batson et al., 2006; Fu, 2001; Kalmijn, 1993; Qian, 1997)

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has attracted increased attention, partly because it is commonly regarded as an indicator of race relations and improving race relations is socially desirable. However, recent evidence shows that the black/white color line remains strong relative to other traditional group boundaries in the marriage market (e.g., Qian, 1997; Wong, 2003). Can it come from racial differences in educational attianments, limited opportunities of interracial contacts owing to residential and school segregation, or a high degree of racial prejudice? Wong (2003) adopts a random matching model with a mating taboo to implement an empirical analysis, concluding that the mating taboo can explain 74% of the significantly low intermarriage rate of black males in the U.S.

This paper is motivated by some empirical findings obtained from the 1964–2009 March CPS data. To calculate the black/white interracial marriage rate, I include married couples of which either the husband or the wife is aged 40-49 at the time of each survey and each of them must be either black or white. In addition, the percentage of those who have never been married will be computed, for which the base is composed of all black or white individuals aged 40-49. The sample selection intends to ensure that most potential marriages have been completed, although some couples may have experienced a divorce and remarriage. Both blacks and whites are divided into two classes: a high-type and a low-type, depending on whether they have a college diploma or not. Then there will be four groups in total: high-type whites (HW), low-type whites (LW), high-type blacks (HB), and low-type blacks (LB).

An examination of married couples' education levels and races reveals (1) that educational assortative mating is evident either among whites or blacks when they are considered separately, and (2) that, in a marriage market structure consisting of both blacks and whites, the interracial marriage rate is significantly low and the educational homogamy in blacks disappears. Furthermore, an investigation of marital status concludes that (3) the percentage of those who have never married is getting higher for blacks, especially for those without a college diploma. To indicate whether the actual marriage rate is high or low, it is compared with the random marriage/encounter rate which corresponds to the rate at which there is no barrier to intermarriage across education or racial groups.

When only white couples are investigated, the educational homogamy can be found. As illustrated in Figure 1, the actual marriage rates (thick lines) are consistently higher than the random marriage rates (thin lines) in panel (A) among high-type whites and in panel (B) among low-type whites from 1964 through 2009. By contrast, the actual rates between HW and LW are lower than the random rates in panel (C), indicating there must be some barriers to intermarriage across education groups. Similar evidence is found in panels (D), (E), and (F), indicating that the educational assortative mating also exists when only black couples are examined. Such findings might be somewhat misleading because it is as if we make the extreme assumption that blacks and whites live in two perfectly segregated worlds.

Another extreme case would be a situation in which blacks and whites were randomly assigned to their district of residence. As illustrated in Figure 2, there can be ten possible combinations for marriage among the aforementioned four groups of people. As the reader can see, the actual marriage rates are higher than the random marriage rates in panels (A), (B), (C), (D), and (F), but lower in others. It is not unexpected to see a lower actual marriage rate in panels (G), (H), (I), and (J) which reflects the well-known racial endogamy. However, the significantly high actual marriage rate in panel (F) can be surprising. Although there cannot be no evidence of segregation between blacks and whites at all in the real world, such findings still deserve some explanations, just as economists pay a lot of attention to perfectly competitive markets.

As can be seen in Figure 3, the percentage of those who have never married has been growing for blacks, at least in recent years. In 2009, for example, the percentage of those who have never married is about 30% for LB, 20% for HB, and 10% for both HW and LW. Such differences are also worth an explanation.

This paper proposes a search and matching model similar to that in Wong (2003),

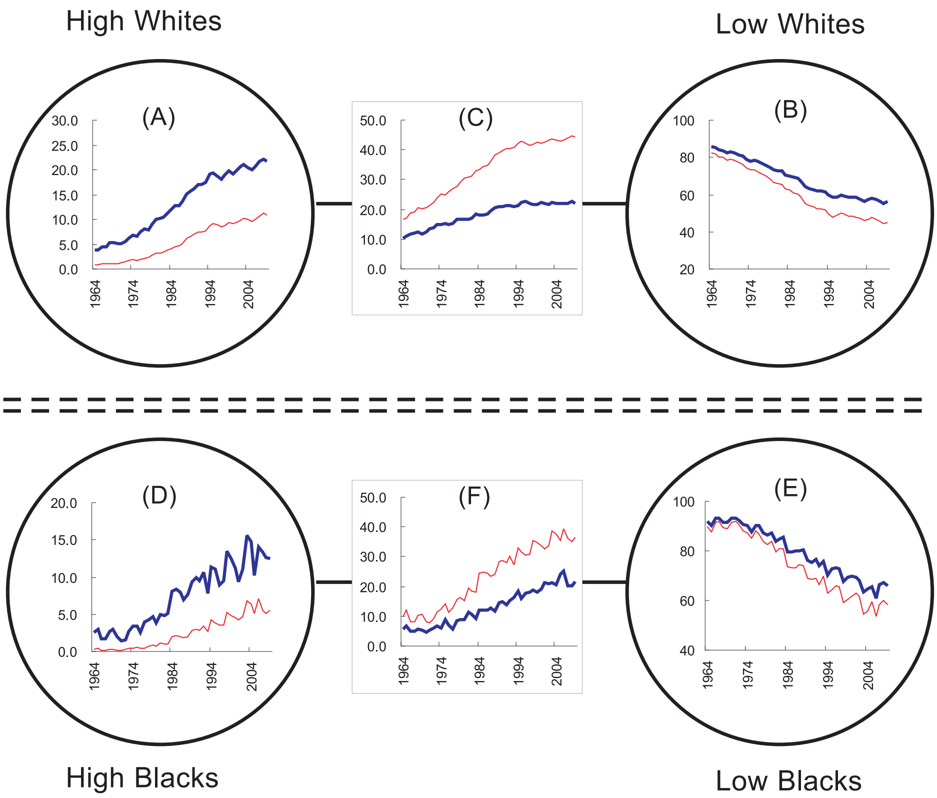


Figure 1. Actual and Random Marriage Rates in Perfectly Segregated Markets for People Aged 40–49 in the U.S. (1964–2009)

Note: In each panel, thick lines represent the actual marriage rates, while thin lines represent the random marriage rates.

Source: Computed by the author from 1964–2009 March CPS data.

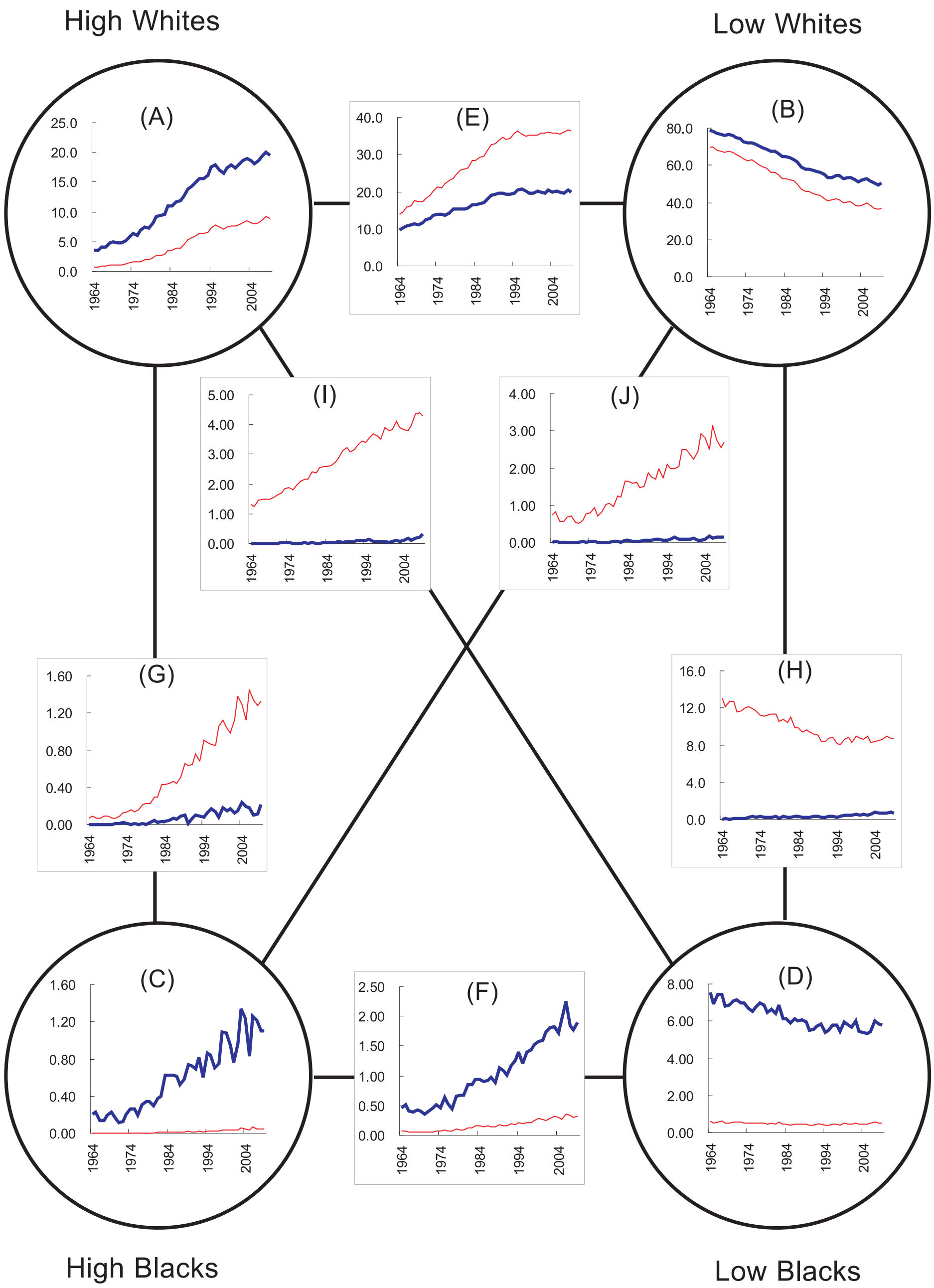


Figure 2. Actual and Random Marriage Rates in Markets Without Segregation for People Aged 40–49 in the U.S. (1964–2009)

Note: In each panel, thick lines represent the actual marriage rates, while thin lines represent the random marriage rates.

Source: Computed by the author from 1964–2009 March CPS data.

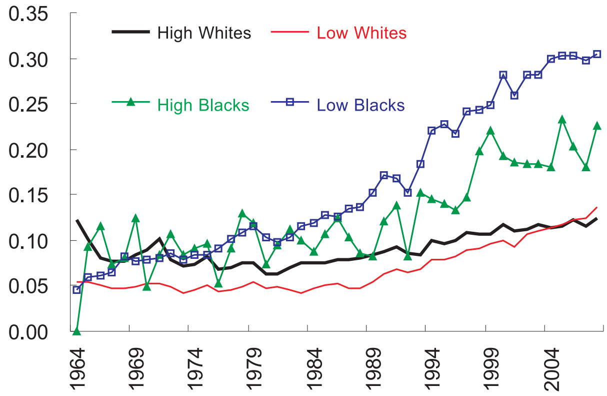


Figure 3. Percentage of People Who Have Never Married Aged 40–49 in the U.S. (1964–2009): by Races and Types

Source: Computed by the author from 1964–2009 March CPS data.

except that I adopt a two-type rather than a continuum-type setting and add two more possible specifications of racial prejudice, to help understand the observed evidence mentioned in Figures 2 and 3. The remainder of this paper is organized as follows. Section 2 describes the theoretical framework. Marriage strategies for agents of the four groups and the Nash equilibrium outcomes will be included in Section 3. Section 4 concludes.

2 The Framework

Consider a stylized world in which single people look for their spouses of the opposite sex.[1] When one meets a potential agent, he/she has to decide whether to make a marriage proposal to and whether to accept the proposal (if any) from the agent. Like barter, marriage requires a double coincidence of wants.

[1] Homosexual marriage is not considered in this paper for simplicity.

2.1 The Environment

Suppose that a large and equal number of infinitely lived single men and women participate in a marriage market. Each individual meets others according to a Poisson process with a constant parameter α (i.e., the arrival rate of single agents of the opposite sex faced by a single agent), and discounts the future at rate $r > 0$. When two singles meet and both agree to form a marriage, they leave the single pool forever.[2] In the meantime, there will be two identical singles entering the marriage market to keep it stationary.[3] Otherwise, they continue to look for partners.

Assume that each individual's characteristics (*excluding race*), which make him/her more or less desirable in the market, can be mapped into a real number X, the individual's type. All people agree on how to rank one another, and their types are revealed upon meeting each other. To keep things simple, assume that there are only two types: high X_H and low X_L, where $X_H > X_L > 0$.

Since this paper focuses on black/white interracial marriage, we further divide people into two race groups: whites W and blacks B. As a consequence, the marriage market consists of four groups defined by type and race, including high-type whites, low-type whites, high-type blacks, and low-type blacks. Let $\Pi = \{HW, LW, HB, LB\}$ be the set of groups and λ_i be the exogenous proportions of group i in the population, where $\sum_{i \in \Pi} \lambda_i = 1$. Note that $X_{HW} = X_{HB} = X_H$ and $X_{LW} = X_{LB} = X_L$. Without loss of generality, we assume that the proportion of high-type people is less than that of low-type people for both races, i.e., $\lambda_{HW} < \lambda_{LW}$ and $\lambda_{HB} < \lambda_{LB}$. For simplicity, we will not investigate any difference between genders in this study. The distribution of type and race is thus assumed to be the same for both sexes, so that men and women are restricted

[2] One can of course assume a positive probability that the marriage could dissolve subsequently, but it can be verified that including a divorce rate in the model is in effect equivalent to inflating the discount rate r.

[3] We adopt this clone specification for tractability so that a Nash equilibrium (where all agents use optimal matching strategies) will also be a steady-state one.

to using symmetric strategies.

In a world without prejudice, assume that the flow value an agent receives from a match is exactly the type of his/her partner. In other words, when a type X_i agent matches with a type X_j agent, the former receives a nontransferable flow value X_j and the latter receives X_i. While unmatched, an agent enjoys a utility flow normalized to zero so that being matched yields a higher flow payoff than being unmatched. In the presence of prejudice, however, assume that an agent receives another lump-sum disutility flow Δ when he/she has a (negative) prejudice against the agent he/she marries. In sum, if a type X_i agent marries a type X_j agent, the expected discounted lifetime utility he/she obtains will be

$$V_i^M(X_j) = \frac{X_j + z_{ij}\Delta}{r}, \quad i, j \in \Pi \tag{1}$$

where

$$z_{ij} = \begin{cases} 0, & \text{if an } X_i \text{ has no prejudice toward marrying an } X_j; \\ -1, & \text{if an } X_i \text{ has a prejudice against marrying an } X_j. \end{cases}$$

2.2 Matching Strategy

For an agent of group i, the value of being single V_i^S can be derived as follows. First, he/she meets a potential partner with probability α; more specifically, $\alpha\lambda_j$ if that person is of group j. Next, a marriage proposal may or may not be offered by this group j person, which can be represented by an indicator variable y_{ji} that takes on a value of 1 if a group j agent is willing to marry a group i agent and 0 if not. So the derived indicator variables y_{ji}, $j \in \Pi$ can be used to define the opportunity set of a group i agent. Given $y_{ji} = 1$, a group i agent will accept the proposal (i.e., $y_{ij} = 1$) if the value of being married to that person $V_i^M(X_j)$ is at least as great as V_i^S. However, if $y_{ji} = 0$, or if $y_{ji} = 1$ while $V_i^M(X_j) < V_i^S$ such that $y_{ij} = 0$, he/she remains single and continues to search in the marriage market. As a consequence,

$$V_i^S = \frac{(1-\alpha)V_i^S + \alpha \sum_{j\in\Pi} \lambda_j \max\{y_{ji} V_i^M(X_j), V_i^S\}}{1+r}, \quad i \in \Pi. \tag{2}$$

Substituting for $V_i^M(X_j)$ from Equation (1), Equation (2) can be rearranged in terms of the flow value of search as:

$$R_i^S \equiv r V_i^S = \frac{\alpha \sum_{j\in\Pi} \lambda_j y_{ij} y_{ji} \left(X_j + z_{ij}\Delta\right)}{r + \alpha \sum_{j\in\Pi} \lambda_j y_{ij} y_{ji}}, \quad i \in \Pi. \tag{3}$$

Note that $y_{ij} y_{ji} = 1$ holds only when there is a double coincidence of wants between group i agents and group j agents.

Given a set of exogenous values for the arrival rate α, the proportions λ_j, the types X_j, the sorts of prejudice z_{ij}, and the utility flow due to prejudice Δ, one can utilize Equation (3) to seek the solution values of y_{ij} for all i, $j \in \Pi$ and thereby obtain the equilibrium outcome. Note that y_{ij} and y_{ji} are interrelated and must be reflectively balanced: group i agents decide whether to accept the marriage proposal from group j agents based on their opportunity set (partially) defined by y_{ji}, and the decision y_{ij} conversely (partially) defines the opportunity set of group j agents. Here is the analytical method adopted throughout the paper. By equating flow values of search in each pair of comparable situations, a demarcation line that divides the X_H - X_L space into two regions — $y_{ij} = 1$ and $y_{ij} = 0$ — can be derived. Agents of group i use such lines as their strategies in deciding whether to accept agents of group j on the premise that group j agents are willing to marry them (i.e., $y_{ji} = 1$). On the contrary, if $y_{ji} = 0$ for some j, one can then save time that would be spent deriving related demarcation lines for agents of group i since the "double coincidence of wants" requirement must not be met.

We also introduce two intuitive principles that can help in the derivation of equilibrium outcomes. For agents having the same marriage evaluations $V^M(X_j)$ as defined in Equation (1),

- a marriage proposal accepted by those with a larger opportunity set will be accepted by those with a smaller one (Principle 1);

- identical strategies will be adopted by those who have the same opportunity set (Principle 2).

Based on Principle 1, one should put the analysis of high-type people's strategies before that of low-type people's strategies since high-type people cannot have a smaller opportunity set than low-type people.

2.3 Nash Equilibrium Outcomes: Marriage Without Prejudice

Before proceeding to the model discussing marriage in the presence of prejudice, we first utilize a simple case which has been studied in Burdett and Coles (1997, 1999) and Ermisch (2003, Ch. 7) to exemplify the use of our analytical method.

Suppose that there is no prejudice at all (i.e., $z_{ij} = 0, \ \forall\, i, j \in \Pi$) so that all single individuals share the same marriage evaluations. As a consequence, marrying a high-type white is identical to marrying a high-type black, and marrying a low-type white is identical to marrying a low-type black as well. Because everyone in the marriage market wants to marry a high-type person (i.e., $y_{ji} = 1$ for $i = HW, HB$ and $j \in \Pi$) in order to obtain the highest expected discounted lifetime utility X_H/r, the opportunity sets of HW and of HB are both the largest (i.e., Π) so that they will adopt the same strategies (by Principle 2). The only issue in this case is whether a high-type person is willing to marry a low-type person (i.e., whether $y_{ij} = 1$ when $i = HW, HB$ and $j = LW, LB$). Equating the flow value of search for high-type people if they accept low-type people

$$R_H^{\text{accept}} = \frac{\alpha[(\lambda_{HW} + \lambda_{HB})X_H + (\lambda_{LW} + \lambda_{LB})X_L]}{r + \alpha(\lambda_{HW} + \lambda_{HB} + \lambda_{LW} + \lambda_{LB})}$$

and the flow value of search if they reject them

$$R_H^{\text{reject}} = \frac{\alpha(\lambda_{HW} + \lambda_{HB})X_H}{r + \alpha(\lambda_{HW} + \lambda_{HB})}$$

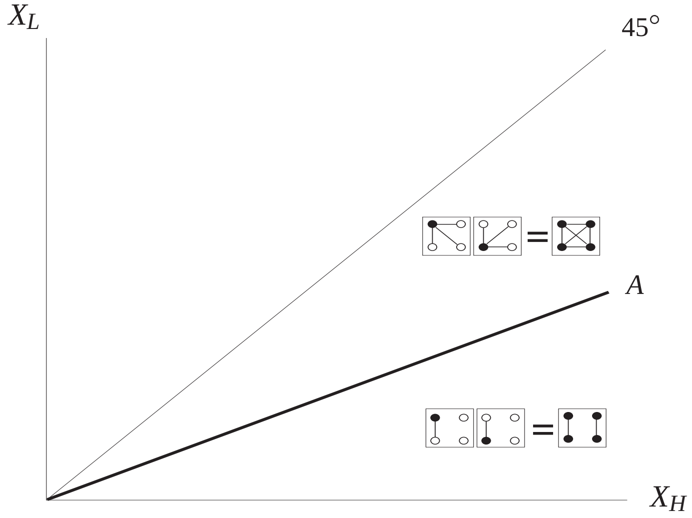


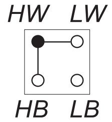
Figure 4. Matching Strategies of High-Type People and Marriage Equilibrium Outcomes: Without Prejudice

yields a demarcation line

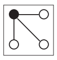
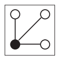
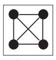
$$X_L = \frac{\alpha(\lambda_{HW} + \lambda_{HB})}{r + \alpha(\lambda_{HW} + \lambda_{HB})} X_H \qquad \text{(Line } A\text{)}$$

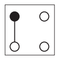
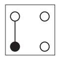
passing through the origin and being flatter than the 45-degree line, as depicted in Figure 4. Note that only the region below the 45-degree line will be analyzed since $X_H > X_L$.

Let us digress for a while to introduce the specific expression adopted throughout this paper in identifying people's marriage decisions and the consequential equilibrium outcomes — a square configuration with four circles. Each circle represents a group of agents: *HW* (the upper-left), *LW* (the upper-right), *HB* (the lower-left), and *LB* (the lower-right). When the focus is on the marriage decisions of agents of a particular group, the corresponding circle will be filled and the other three circles will be left empty. Line segments connecting circles stand for their willingness to marry people within those groups. For example,

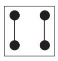


indicates that high-type whites are willing to marry low-type whites and high-type blacks but not low-type blacks. Although there is no line segment connecting the filled circle itself, this configuration also concludes that high-type whites accept themselves. In case an agent does not accept people within his/her group, we will use an X symbol to replace the filled circle. For all similar configurations in the remainder of this paper, the assignment of each circle to a group is set in stone so that we can omit corresponding group symbols for simplicity. Furthermore, a Nash equilibrium outcome will be denoted by a square configuration with four filled circles.

Back to the discussion. In the region above Line A where $R_H^{\text{reject}} < R_H^{\text{accept}}$, high-type people ($HW$ and HB) will accept low-type people regardless of their race; their decisions can thus be illustrated by  and . Because the opportunity set of LW (LB) can never be larger than that of HW (HB), low-type people will accept themselves (by Principle 1), have Π as their opportunity sets, and follow the same strategies as high-type people to accept everyone in the marriage market (by Principle 2). The equilibrium outcome is illustrated by . Every single individual in the marriage market obtains a flow value of search R_H^{accept}.

By contrast, in the region below Line A where $R_H^{\text{reject}} > R_H^{\text{accept}}$, high-type people will refuse low-type people and accept themselves only, as illustrated by  and . They obtain a flow value of search R_H^{reject}. As a consequence, low-type people can marry within their own group only and obtain the following flow value of search

$$\frac{\alpha(\lambda_{LW} + \lambda_{LB})}{r + \alpha(\lambda_{LW} + \lambda_{LB})} X_L .$$

The equilibrium outcome is illustrated by .

Apparently, both equilibrium outcomes are inconsistent with the empirical observations proposed in the Introduction. Some specifications of racial prejudice will be added to the framework.

3 Marriage with Prejudice

In this section, we add some further assumptions concerning the racial prejudice attitudes of people in the marriage market. Specifically, we assume that

Table 1. Flow Evaluations on Marriage by Agents in the Market

		Flow values of marrying			
Agents	Proportions	*HW*	*LW*	*HB*	*LB*
Whites	$\lambda_{HW} + \lambda_{LW}$	X_H	X_L	$X_H - \Delta$	$X_L - \Delta$
Blacks					
subgroup 1	$\phi_1 \lambda_{HB} + \mu_1 \lambda_{LB}$	X_H	X_L	X_H	X_L
subgroup 2	$\phi_2 \lambda_{HB} + \mu_2 \lambda_{LB}$	$X_H - \Delta$	$X_L - \Delta$	X_H	X_L
subgroup 3	$\phi_3 \lambda_{HB} + \mu_3 \lambda_{LB}$	X_H	X_L	$X_H - \Delta$	$X_L - \Delta$

1. all whites have a prejudice against marrying blacks but have no prejudice toward marrying amongst themselves;

2. blacks are diversified in their racial prejudice attitudes and can be divided into three subgroups: (1) those having no prejudice toward marrying anyone, (2) those having a prejudice against marrying whites but no prejudice toward marrying amongst themselves, and (3) those having no prejudice toward marrying whites but a prejudice against marrying blacks. Let ϕ_i and μ_i be the fractions of subgroup i for high-type and low-type blacks, respectively. $\phi_1 + \phi_2 + \phi_3 = 1$ and $\mu_1 + \mu_2 + \mu_3 = 1$.

Table 1 summarizes the composition of single people in the marriage market and their corresponding flow values in terms of marrying other individuals in the presence of prejudice. Note that if all blacks assume the attitude of the second subgroup (i.e., $\phi_2 = \mu_2 = 1$), then the framework becomes exactly the mating taboo case as discussed in Wong (2003), except that we adopt a two-type rather than a continuum-type setting.

As indicated by Table 1, an *HW* agent is considered to be the most popular potential mate for most single people, except for blacks in subgroup 2, because marrying him/her yields a flow value of X_H. Therefore, we proceed with the discussion based on the analysis of *HW* people's matching strategies, deriving their related demarcation lines in deciding whether to marry people within a particular group. These strategies then become crucial

Table 2. Five Situations for HW People

Situations	A/R Decisions* toward HW	HB	LW	LB	HW People's Flow Values of Search
I	A	A	A	A	$\frac{\alpha\left[\lambda_{HW}X_H+\lambda_{HB}(X_H-\Delta)+\lambda_{LW}X_L+\lambda_{LB}(X_L-\Delta)\right]}{r+\alpha(\lambda_{HW}+\lambda_{HB}+\lambda_{LW}+\lambda_{LB})}$
II	A	A	A	R	$\frac{\alpha\left[\lambda_{HW}X_H+\lambda_{HB}(X_H-\Delta)+\lambda_{LW}X_L\right]}{r+\alpha(\lambda_{HW}+\lambda_{HB}+\lambda_{LW})}$
III	A	A	R	R	$\frac{\alpha\left[\lambda_{HW}X_H+\lambda_{HB}(X_H-\Delta)\right]}{r+\alpha(\lambda_{HW}+\lambda_{HB})}$
IV	A	R	A	R	$\frac{\alpha\left[\lambda_{HW}X_H+\lambda_{LW}X_L\right]}{r+\alpha(\lambda_{HW}+\lambda_{LW})}$
V	A	R	R	R	$\frac{\alpha\left[\lambda_{HW}X_H\right]}{r+\alpha(\lambda_{HW})}$

* A=Accept; R=Reject.

to forming environments for people in other groups to make their decisions.

3.1 *HW* People's Matching Strategies

Suppose that all single individuals in the marriage market would accept HW people as their mates, so that HW people have Π as their opportunity set. From the viewpoint of an HW agent, if he/she considers rejecting some people from a specific group, LB agents will be the first since marrying them yields the least flow value $X_L-\Delta$. The next group to reject can be either HB or LW, depending on the relative magnitudes of prejudice Δ and the type differential $X_H - X_L$. There are in total five possible situations that result from HW people's Accept/Reject decisions. Table 2 exhibits these decisions and their corresponding flow values of search as well.

By equating flow values of search in each pair of comparable situations (such as I vs. II, II vs. III, and so on), five related demarcation lines (as drawn in Figure 5) are derived, including:

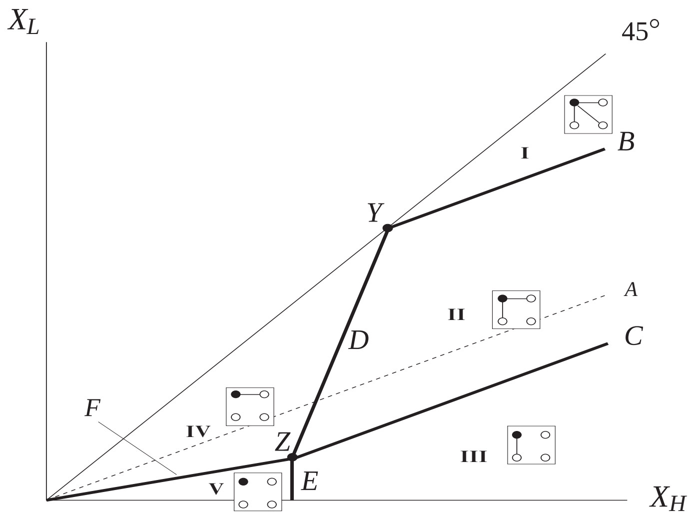


Figure 5. Matching Strategies of *HW* People: With Prejudice

$$X_L = \frac{r + \alpha(\lambda_{HW} + \lambda_{LW})}{r + \alpha(\lambda_{HW} + \lambda_{HB})}\Delta + \frac{\alpha(\lambda_{HW} + \lambda_{HB})}{r + \alpha(\lambda_{HW} + \lambda_{HB})} X_H \qquad \text{(Line } B\text{)}$$

$$X_L = -\frac{\alpha\lambda_{HB}}{r + \alpha(\lambda_{HW} + \lambda_{HB})}\Delta + \frac{\alpha(\lambda_{HW} + \lambda_{HB})}{r + \alpha(\lambda_{HW} + \lambda_{HB})} X_H \qquad \text{(Line } C\text{)}$$

$$X_L = -\frac{r + \alpha(\lambda_{HW} + \lambda_{LW})}{\alpha\lambda_{LW}}\Delta + \frac{r + \alpha\lambda_{LW}}{\alpha\lambda_{LW}} X_H \qquad \text{(Line } D\text{)}$$

$$X_H = \frac{r + \alpha\lambda_{HW}}{r}\Delta \qquad \text{(Line } E\text{)}$$

$$X_L = \frac{\alpha\lambda_{HW}}{r + \alpha\lambda_{HW}} X_H \qquad \text{(Line } F\text{)}$$

where Lines B, D, and the 45-degree line intersect at

$$\left(\frac{r + \alpha(\lambda_{HW} + \lambda_{LW})}{r}\Delta, \frac{r + \alpha(\lambda_{HW} + \lambda_{LW})}{r}\Delta\right) \qquad \text{(Point } Y\text{)}$$

and Lines C, D, E, and F intersect at

$$\left(\frac{r + \alpha\lambda_{HW}}{r}\Delta, \frac{\alpha\lambda_{HW}}{r}\Delta\right). \qquad \text{(Point } Z\text{)}$$

In Figure 5, Line A is also drawn for reference to reveal how the presence of a prejudice against blacks affects *HW* people's strategies.

Recall that without prejudice HW always accept high-type people and utilize Line A to decide whether to accept low-type people. But now Lines D and E emerge as the criteria of whether to accept HB, Line B shifts upward from Line A as the criterion of whether to accept LB, and Lines C and F move downward from Line A as the criterion of whether to accept LW. In other words, they become more picky in accepting blacks as their mates at the expense of being more tolerant toward LW, exhibiting the substitution effect owing to the change in relative prices in mating blacks and whites.[4]

Can the assumption made at the very beginning of this subsection that all single individuals in the marriage market would accept HW as their mates be violated? More specifically, will the analysis in this subsection be valid if the blacks of subgroup 2 reject HW as their mates under some conditions? It can be shown that as long as the proportions λ_i match the nationally representative ones so that $\lambda_{HB} < \lambda_{LB} < \lambda_{HW} < \lambda_{LW}$, Regions I, II, and III in Figure 5 satisfy the "double coincidence of wants" requirement between HW and the high-type blacks of subgroup 2. As for Regions IV and V, HW always reject blacks regardless of whether blacks accept them or not. As a consequence, the analysis in this subsection is valid regardless of others' strategies.[5]

3.2 HB and LW People's Strategies

After investigating how HW people decide whom to marry, we now turn to the analysis of HB and LW people's marriage decisions, in both environments of being accepted and rejected by HW.

[4]This point is similar to that mentioned in Wong (2003, Lemma 1).

[5]In the case where $\lambda_{HB} < \lambda_{LB} < \lambda_{HW} < \lambda_{LW}$ does not hold, there may be a little but not substantial change in the analysis.

3.2.1 Being Accepted by *HW*

In Regions I, II, and III where HW accept HB, all HB agents can make marriage decisions as freely as they wish since all agents will accept them.[6] Because HB of subgroup 1 are color neutral, they utilize Line A in deciding whether to accept low-type people. By Principle 2, HB of subgroup 3 will just follow HW's strategies in adopting Line B (Line C) as the criterion of whether to accept LB (LW). As for HB of subgroup 2, they utilize

$$X_L = \frac{r + \alpha(\lambda_{HB} + \lambda_{LB})}{r + \alpha(\lambda_{HW} + \lambda_{HB})}\Delta + \frac{\alpha(\lambda_{HW} + \lambda_{HB})}{r + \alpha(\lambda_{HW} + \lambda_{HB})}X_H \qquad \text{(Line } B'\text{)}$$

in deciding whether to accept LW and

$$X_L = -\frac{\alpha\lambda_{HW}}{r + \alpha(\lambda_{HW} + \lambda_{HB})}\Delta + \frac{\alpha(\lambda_{HW} + \lambda_{HB})}{r + \alpha(\lambda_{HW} + \lambda_{HB})}X_H \qquad \text{(Line } C'\text{)}$$

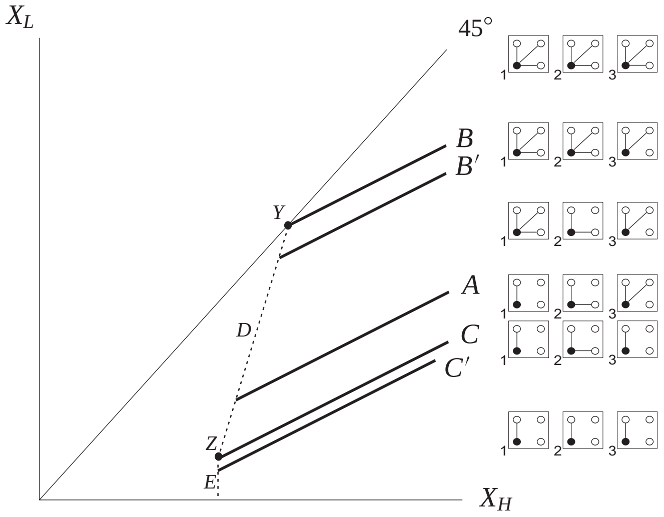
in deciding whether to accept LB. As depicted in Figure 6(a), these five parallel demarcation lines divide Regions I, II, and III into six subregions, each corresponding to a set of three decision configurations by the high-type blacks of subgroups 1, 2, and 3.

In Regions I, II, and IV where HW accept LW, although LW and the blacks of subgroup 3 will follow HW to accept LW (by Principle 1), the blacks of subgroups 1 and 2 have their own strategies in deciding whether to accept LW. Therefore, the case is somewhat complicated for LW; they have to derive different criteria according to the variable opportunity set. As depicted in Figure 6(b), it can be verified that LW always utilize Line D in deciding whether to accept HB, regardless of whether all HB accept them or not. To the right of Line D, LW follow HW to adopt Line B in deciding whether to accept LB in the region above Line B' where the opportunity set is also Π (by Principle 2). They adopt

$$X_L = \frac{r + \alpha(\lambda_{HW} + \lambda_{LW})}{r + \alpha[\lambda_{HW} + (\phi_1 + \phi_3)\lambda_{HB}]}\Delta + \frac{\alpha[\lambda_{HW} + (\phi_1 + \phi_3)\lambda_{HB}]}{r + \alpha[\lambda_{HW} + (\phi_1 + \phi_3)\lambda_{HB}]}X_H \quad \text{(Line } G\text{)}$$

[6] Blacks of subgroups 1 and 2 evaluate HB as the most popular. In the meantime, LW and blacks of subgroup 3 just follow HW to accept HB (by Principle 1).

(a) *HB*'s strategies in Regions I, II, and III



(b) *LW*'s strategies in Regions I, II, and IV

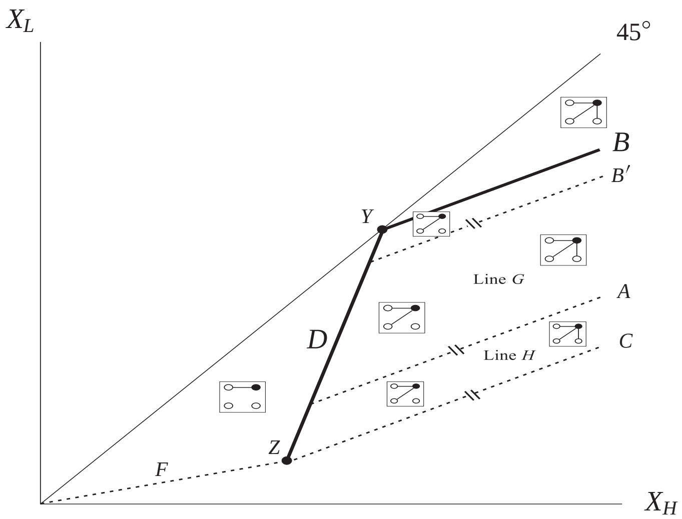
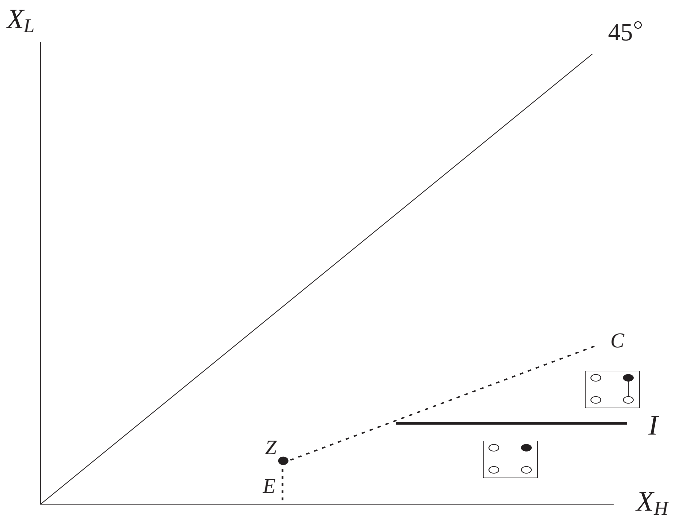


Figure 6. Matching Strategies of *HB* and *LW* People: With Prejudice

(c) *LW*'s strategies in Region III



(d) *HB*'s strategies in Region IV

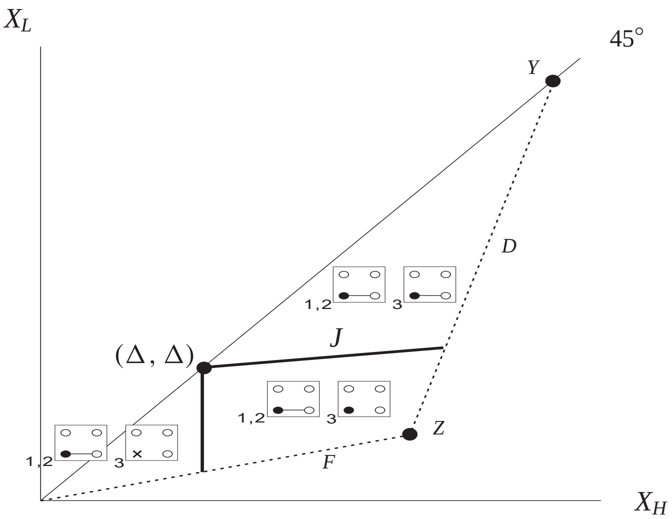


Figure 6. Matching Strategies of *HB* and *LW* People: With Prejudice (Cont.)

(e) HB's and LW's strategies in Region V

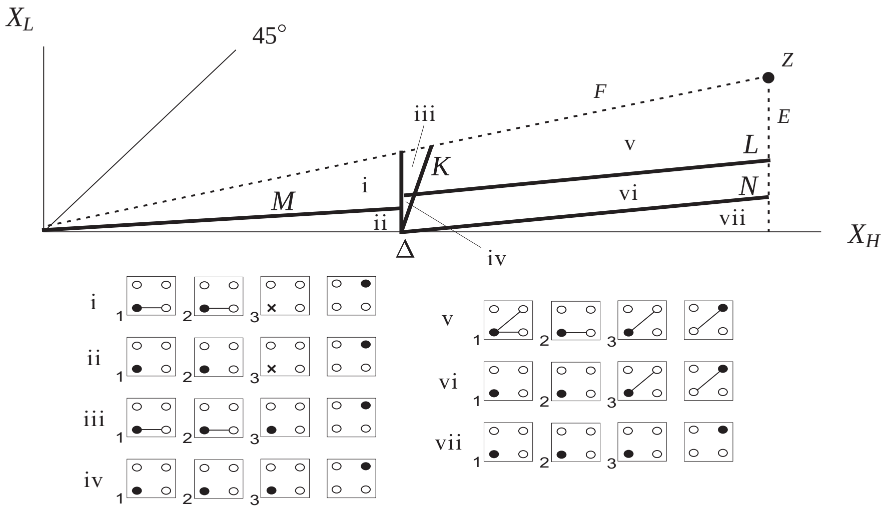


Figure 6. Matching Strategies of HB and LW People: With Prejudice (Cont.)

in deciding whether to accept LB in the region between Lines B' and A where HB of subgroup 2 move out of the opportunity set, and adopt

$$X_L = \frac{r + \alpha(\lambda_{HW} + \lambda_{LW})}{r + \alpha(\lambda_{HW} + \phi_3\lambda_{HB})}\Delta + \frac{\alpha(\lambda_{HW} + \phi_3\lambda_{HB})}{r + \alpha(\lambda_{HW} + \phi_3\lambda_{HB})}X_H \qquad \text{(Line } H\text{)}$$

in deciding whether to accept LB in the region between Lines A and C where HB of both subgroups 1 and 2 are not available. Note that we do not draw Lines G and H explicitly in Figure 6(b) for it is hard to do so; both lines pass through Point Y and their slopes are between that of Line B and that of Line F.

3.2.2 Being Rejected by *HW*

In Region III where LW are rejected by both HW and HB, low-type whites have to decide whether to accept LB. They adopt the horizontal line

$$X_L = \frac{r + \alpha\lambda_{LW}}{r}\Delta \qquad \text{(Line } I\text{)}$$

as the criterion, as depicted in Figure 6(c).

In Region IV where HB are rejected by both HW and LW, high-type blacks have to decide whether to accept themselves and LB. As depicted in Figure 6(d), high-type blacks in groups 1 and 2 always accept themselves and decide to accept LB based on a criterion outside Region IV. By contrast, HB of group 3 accept themselves only when $X_H > \Delta$, and utilize

$$X_L = \frac{r}{r + \alpha\lambda_{HB}}\Delta + \frac{\alpha\lambda_{HB}}{r + \alpha\lambda_{HB}} X_H \qquad \text{(Line } J\text{)}$$

in deciding whether to accept LB.

In Region V there is no shortcut to simplify the analysis since neither HB nor LW are accepted by HW, and so looking for the "double coincidence of wants" region for HB and LW is then helpful.[7] As depicted in Figure 6(e), an LW agent adopts

$$X_L = \frac{r + \alpha\lambda_{LW}}{\alpha\lambda_{LW}}(X_H - \Delta) \qquad \text{(Line } K\text{)}$$

as the criterion of whether to accept HB and rejects LB based on some criteria outside Region V. By contrast, HB of subgroup 1 utilize

$$X_L = \frac{\alpha\lambda_{HB}}{r + \alpha\lambda_{HB}} X_H \qquad \text{(Line } L\text{)}$$

and

$$X_L = \frac{\alpha(\phi_1 + \phi_2)\lambda_{HB}}{r + \alpha(\phi_1 + \phi_2)\lambda_{HB}} X_H \qquad \text{(Line } M\text{)}$$

in deciding whether to accept all low-type people. HB of subgroup 2 use Lines L and M as the criteria of whether to accept LB and reject LW based on a criterion outside Region V. As for HB of subgroup 3, they reject themselves if $X_H < \Delta$, adopt

$$X_L = \frac{\alpha\lambda_{HB}}{r + \alpha\lambda_{HB}}(X_H - \Delta) \qquad \text{(Line } N\text{)}$$

[7] HB derive their criterion of whether to accept LW by presuming that LW are available, and LW derive theirs vice versa. The intersection of these two acceptance regions is thus the "double coincidence of wants" region.

as the criterion of whether to accept LW, and reject LB based on Line J outside Region V. These demarcation lines divide Region V into seven subregions. As can be seen in Figure 6(e), a "double coincidence of wants" between LW and some HB occurs only in Subregions v and vi.

3.3 LB People's Strategies

Strategies adopted by people other than LB constitute the environments for LB people to make their decisions. For LB of subgroup 1, all marriage proposals are simply accepted since they have no prejudice against anyone. For LB of subgroup 2, the only proposal they need to consider whether to accept is from LW; all proposals from blacks and HW will be accepted at once.[8] In fact, LB accept LW in most cases whenever LW make marriage proposals to them. The only exception is in the region between Lines C and C', in which case LB's strategy depends on the relative magnitudes of some parameters. For LB of subgroup 3, they accept all proposals from whites (if any) but reject those from blacks whenever the types are less than Δ.

3.4 Nash Equilibrium Outcomes: Marriage With Prejudice

Having examined all the strategies adopted by agents of the four groups in the marriage market, Nash equilibrium outcomes can be derived directly. There are, however, numerous equilibrium outcomes in the X_H - X_L space, and it is fruitless to inspect them one by one. To focus on explaining the empirical findings as exhibited in Figures 2 and 3, only the most related outcome(s) will be investigated in this subsection.

In Regions I, II, and III, all equilibrium outcomes have a common characteristic that HW and HB accept each other, which is inconsistent with what we see in Figure 2. Similarly, equilibrium outcomes in Region IV share a common characteristic that HW and

[8] LB of subgroup 2 accept blacks because they have no prejudice against blacks. Besides, they accept HW because HB of subgroup 2 accept HW, as discussed in the last paragraph in Subsection 3.1.

LW accept each other, which is also contradictory to what we see in Figure 2. As a consequence, the equilibrium outcome that coincides with the empirical findings can only exist in Region V where HW reject both HB and LW.

Among the seven subregions as divided in Figure 6(e), only Subregion i can fully explain the empirical findings. The corresponding equilibrium outcome consists of

1. the HW accept themselves only;

2. the LW accept themselves only;

3. all agents who are either HB of subgroups 1 and 2 or LB of subgroups 1 and 2 accept each other;

4. the HB of subgroup 3 (with proportion $\phi_3\lambda_{HB}$) and LB of subgroup 3 (with proportion $\mu_3\lambda_{LB}$) stay single.

Because Subregion 1 is bounded by Lines F, M, and $X_H = \Delta$, we can conclude that, according to their formulae, a higher proportion of high-type whites in the market λ_{HW}, a lower proportion of high-type blacks of subgroups 1 and 2 $(\phi_1 + \phi_2)\lambda_{HB}$, and a higher prejudice Δ all make it more possible for the equilibrium outcome to exist. It is interesting that blacks of subgroups 1 and 2 look the same in equilibrium, although they adopt different strategies.

The corresponding flow values of search are $\dfrac{\alpha\lambda_{HW}X_H}{r+\alpha\lambda_{HW}}$ for HW, $\dfrac{\alpha\lambda_{LW}X_L}{r+\alpha\lambda_{LW}}$ for LW, $\dfrac{\alpha[(\phi_1+\phi_2)\lambda_{HB}X_H + (\mu_1+\mu_2)\lambda_{LB}X_L]}{r+\alpha[(\phi_1+\phi_2)\lambda_{HB} + (\mu_1+\mu_2)\lambda_{LB}]}$ for blacks of subgroups 1 and 2, and zero for blacks of subgroup 3. Comparing these values of search with those in the same region when there is no prejudice (as illustrated in Figure 5 and discussed in Subsection 2.3), we can examine the changes in welfare levels due to the presence of racial prejudice. It can be directly verified that HW and LW become worse off for

$$\frac{\alpha\lambda_{HW}X_H}{r+\alpha\lambda_{HW}} < \frac{\alpha(\lambda_{HW}+\lambda_{HB})X_H}{r+\alpha(\lambda_{HW}+\lambda_{HB})}$$

and

$$\frac{\alpha\lambda_{LW}X_L}{r+\alpha\lambda_{LW}} < \frac{\alpha(\lambda_{LW}+\lambda_{LB})X_L}{r+\alpha(\lambda_{LW}+\lambda_{LB})}.$$

These results are intuitive since giving up the opportunity of marrying people of the same type but from the other race is in effect reducing the arrival rate of an acceptable mate. In addition, HB of subgroups 1 and 2 become worse off because they have no opportunities to marry HW and are thus forced to accept low-type blacks whom they would not accept otherwise.[9] As for LB of subgroups 1 and 2, they could be either worse off or better off. On the one hand, they can mate with high-type people of the same race instead of low-type people from the other. On the other hand, however, the relative proportion of HB is smaller than that of LW, which reduces the arrival rate of a mate. These two opposite

[9]The mathematical inference is somewhat indirect. In Subregion i, inequalities

$$\frac{\alpha(\phi_1+\phi_2)\lambda_{HB}X_H}{r+\alpha(\phi_1+\phi_2)\lambda_{HB}} \le X_L < \frac{\alpha(\lambda_{HW}+\lambda_{HB})X_H}{r+\alpha(\lambda_{HW}+\lambda_{HB})}$$

must hold since the region lies between Lines A and M. From the first inequality we can derive

$$\frac{\alpha[(\phi_1+\phi_2)\lambda_{HB}X_H+(\mu_1+\mu_2)\lambda_{LB}X_L]}{r+\alpha[(\phi_1+\phi_2)\lambda_{HB}+(\mu_1+\mu_2)\lambda_{LB}]} \le X_L,$$

and therefore

$$\frac{\alpha[(\phi_1+\phi_2)\lambda_{HB}X_H+(\mu_1+\mu_2)\lambda_{LB}X_L]}{r+\alpha[(\phi_1+\phi_2)\lambda_{HB}+(\mu_1+\mu_2)\lambda_{LB}]} < \frac{\alpha(\lambda_{HW}+\lambda_{HB})X_H}{r+\alpha(\lambda_{HW}+\lambda_{HB})},$$

which completes the inference.

forces make the direction of the change in welfare levels indeterminate.[10] Without doubt, blacks of subgroup 3 will be definitely worse off since they get nothing in the presence of prejudice.

4 Conclusion

In this article, I formulate a search and matching model in the presence of race prejudice to propose a comprehensive explanation of some empirical findings: (1) that the interracial marriage rate is significantly low and the barrier to intermarriage across education groups for blacks does not exist, and (2) that the percentage of those who have never married is getting higher for blacks, especially for those without a college diploma.

The equilibrium outcome shows: (1) that a higher proportion of high-type whites, a lower proportion of high-type blacks who do not hate themselves, and a higher degree of prejudice all provide support for the empirical findings; (2) that the specification of prejudice can be distinct from the mating taboo setting adopted in Wong (2003); and (3) that people except for some low-type blacks are worse off in the presence of prejudice. While this theoretical work might overlook some of the real features of a U.S. society, it can still provide important insights in devising an empirical model for future research.

[10] One can reorganize the flow value of search in the presence of prejudice for LB of subgroups 1 and 2 as

$$\frac{\alpha[(\phi_1+\phi_2)\lambda_{HB}X_H+(\mu_1+\mu_2)\lambda_{LB}X_L]}{r+\alpha[(\phi_1+\phi_2)\lambda_{HB}+(\mu_1+\mu_2)\lambda_{LB}]}=sX_H+(1-s)\frac{\alpha(\mu_1+\mu_2)\lambda_{LB}X_L}{r+\alpha(\mu_1+\mu_2)\lambda_{LB}},$$

where $s=\dfrac{\alpha[(\phi_1+\phi_2)\lambda_{HB}]}{r+\alpha[(\phi_1+\phi_2)\lambda_{HB}+(\mu_1+\mu_2)\lambda_{LB}]}$. In addition, one can reorganize the flow value of search without prejudice for LB of subgroups 1 and 2 as

$$\frac{\alpha(\lambda_{LW}+\lambda_{LB})X_L}{r+\alpha(\lambda_{LW}+\lambda_{LB})}=tX_L+(1-t)\frac{\alpha(\mu_1+\mu_2)\lambda_{LB}X_L}{r+\alpha(\mu_1+\mu_2)\lambda_{LB}},$$

where $t=\dfrac{\alpha(\lambda_{LW}+\mu_3\lambda_{LB})}{r+\alpha(\lambda_{LW}+\lambda_{LB})}$. Although $X_H>X_L$ makes the flow value of search in the presence of prejudice higher, $s<t$ forms an opposite force driving it lower; the change in welfare levels for LB is thus indeterminate.

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