

# Racial Sorting in the US Marriage Market: Evolution and Welfare Implications

Yu Kyung Koh\*

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## Abstract

Interracial marriage has steadily increased in the US, indicating positive progress toward social integration. Nevertheless, this progress has been uneven across different social groups, with notable gender disparities among Blacks and Asians. This paper analyzes how changing marital gains and changing population supplies have shaped the interracial marriage pattern and the marital welfare of each social group in the US. Using a structural model of marriage market equilibrium, I first show that marital gains from interracial marriage have improved only for some pairs, revealing substantial gender and education gaps. I then show that these disparities in marital gains, along with the demographic composition, have improved marriage prospects and welfare for some groups (e.g. college-educated Black men) while limiting others' (e.g. Black women). Using the estimated model, I uncover the complex ways through which changing marital gains and population have shaped uneven marital welfare through equilibrium channels. In particular, I find that the evolving gender disparities in marital surplus associated with interracial marriage contributed to the gender gaps in marital welfare among Black men and women. In contrast, the sex ratio imbalances played a more substantial role for White men's and women's marital welfare.

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\*Department of Economics, McGill University. Email: [yu.koh@mcgill.ca](mailto:yu.koh@mcgill.ca). I am grateful to Pierre-André Chiappori, Bernard Salanié, and Brendan O'Flaherty for their guidance and support throughout this project. I also thank So Yoon Ahn, Amanda Awadey, Sandra Black, Martsella Davitaya, Paul Koh, Rodrigo Soares, Krzysztof Zaremba, and the participants at Columbia Applied Microeconomic Theory colloquium, Southern Economic Association Annual Meeting, and various seminars for their helpful comments. All errors are my own.

# 1 Introduction

Since 1967 *Loving v. Virginia* decision removed all legal barriers, the overall interracial marriage rate has steadily increased in the US, indicating progress toward social integration. Nevertheless, this progress has been uneven across different social groups, with notable gender disparities among Blacks and Asians.<sup>1</sup> These gender disparities indicate that certain social groups may have disproportionately more limited marital prospects relative to the gender that engages more in interracial marriage. This is particularly concerning for Black women who already face documented challenges in finding eligible partners *within* their racial group, due to the high incarceration and unemployment of Black men (Charles and Luoh, 2010; Caucutt et al., 2021; Liu, 2020). The gender gap in interracial marriage among Black people can further limit the marital prospects for Black women, as discussed in Banks (2012). Despite this potential concern, we know little about how these gender asymmetries have evolved and shaped the distribution of welfare in the marriage market.

Marriage patterns are determined by both the structure of marital gains<sup>2</sup> and population supplies. Conceptually, shifts in marital gains and population composition can change the marital prospects of various social groups, potentially favoring some while disadvantaging others. While marital gains are unobserved, we can expect that marital gains associated with interracial marriage can change over time due to shifting marital preferences and social acceptance. If there exists a gender disparity in this shift – for instance, if Black men’s interracial marriages have a greater increase in marital gains compared to Black women’s – then Black men’s interracial marriages become systematically easier to form than Black women’s. This can result in unfavorable marital prospects for Black women by heightening marriage competition, potentially reducing their marital welfare. Similarly, demographic shifts can skew the marriage pool comprised of different-race potential partners, favoring one gender’s marital prospects over another. A relevant example is the rising number of women obtaining college degrees compared to men, across all races, as highlighted in Goldin et al. (2006). The essential point is that the disparities in marital gains and population and their evolutions can lead to uneven marital prospects and welfare across social groups.

In this paper, I comprehensively analyze how changing marital gains and changing populations have shaped the interracial marriage patterns and marital welfare of each social group in the US. As suggested by the interracial marriage patterns, marital gains across interracial marriage

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<sup>1</sup>For example, according to the American Community Survey, 19.2% of married Black men aged 35-44 were interracially married in 2019. In contrast, only 8.6% of married Black women were interracially married.

<sup>2</sup>Marital gains, also known as marital surplus, can be conceptualized as the additional well-being derived from each type of marriage compared to staying single. The exact nature of marital gains is complicated. As discussed in Chiappori (2020), marital gains encompass (i) economic gains from marriage and (ii) nonmonetary aspects, including love and social stigma. The latter can be important in the case of interracial marriage.

types likely have not evolved in the same way, and population composition has also been changing over time. However, it is not well understood *how* these changes have shaped each social group's marital prospects and *which* particular changes have driven the uneven marital welfare associated with interracial marriage. While existing literature on interracial marriage has focused on measuring the preferences for marrying same-race partners, which is often called the preferences for "racial endogamy" (Qian and Lichter, 2011; Ciscato and Weber, 2020; Anderberg and Vickery, 2021), these measures are not gender-specific<sup>3</sup> and do not provide insight into the gender-based disparities we see in interracial marriage patterns. This paper seeks to fill this gap in the literature.

Specifically, I contribute to the literature by addressing the following questions: First, how have marital gains evolved for different interracial unions depending on one's own and spouse's characteristics? Second, which groups have benefitted from the changing structure of marital gains associated with interracial marriage and population composition, and by how much? Third, which particular shifts in marital gains and population composition contributed the most to shaping uneven marital welfare across social groups? Fourth, what would happen if there were no gender disparities in marital gains associated with interracial marriage?

I answer these questions using a structural model of marriage market equilibrium. I first show that there are substantial gender- and education-based gaps in the evolution of marital gains across interracial marriage types. I then show that these disparities in marital gains, along with the demographic composition, have improved marriage prospects for some groups (e.g. college-educated Black men) while limiting others' (e.g. Black women). Through decomposition analyses, I identify that both (1) increasing sex ratio imbalance and (2) evolving gender disparities in marital gains associated with interracial marriage contributed to the gender gaps in marital welfare. Finally, I show that in the absence of gender disparities in marital gains associated with interracial marriage, especially towards stronger racial integration, marital welfare for all would improve.

It is worth emphasizing that distinct from previous literature that has examined the effects of *overall* changes in marital preferences on sorting pattern (Brandt et al., 2016; Chiappori et al., 2020; Ciscato and Weber, 2020)<sup>4</sup>, my decomposition analyses take a step further and identify *which* particular changes in marital gains and population played the biggest role in shaping uneven marital welfare. Examining the equilibrium impacts of each change in marital surplus and population is crucial to uncover the complex ways through which various changes shape the disparities in marital welfare.

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<sup>3</sup>To elaborate, these measures are informative in understanding, for example, whether Black people have increasingly weaker preferences to marry within race. However, the preference for racial endogamy is not gender-specific.

<sup>4</sup>These papers have computed counterfactual marriage patterns by substituting actual marital gains with counterfactual marital gains measured for different birth cohorts. This exercise is useful in understanding how *overall* changes in marital preferences have affected the sorting patterns. However, this exercise cannot uncover *which* particular changes in marital preferences and population supplies have been most important in shaping each social group's marriage prospects.

To establish these findings, I proceed with the analysis in the following steps. To address the first research question, I estimate the evolution of marital gains from 1980 to 2019 using a transferable utility matching model in the spirit of [Choo and Siow \(2006\)](#). This is a parsimonious model where the structure of marital surplus and the population composition endogenously determine equilibrium marriage patterns and the distribution of marital welfare. This model allows me to disentangle marital gains, which are distinguished from population composition effects, as well as to investigate their impact on each social group's marital welfare. Using the US Census data, I estimate how marital surpluses have changed, based on the husband's and wife's race/ethnicity<sup>5</sup> and education.

While the estimated marital surplus by itself does not unveil its determinants, it helps us understand which types of interracial marriages have become more attractive and easier to form than others, shedding light on the progress of social integration across various social groups. Moreover, irrespective of the specific reasons behind why certain marital surpluses are higher than others (e.g. social stigma, economic consideration, friction, etc.), the overall structure of marital surplus itself, together with population composition, determines who marries whom and who remains single. Therefore, the structure of marital surplus helps us better understand interracial marriage patterns as well as singlehood.

The estimates show substantial disparities in the evolution of marital gains across interracial marriage types, indicating that social integration is stronger among some groups than others. For example, the marital surpluses for interracial marriages involving college-educated pairs have increased over time, but not for non-college-educated pairs. This indicates that interracial marriages have become more attractive and easier to form among college graduates, aligning with survey results indicating higher acceptance of interracial marriage among more educated people ([Pew Research Center, 2017](#)). Moreover, even conditional on education, there remains a large variation in marital surpluses depending on one's gender and race, suggesting that the attractiveness of interracial marriage differs widely across social groups. Notably, interracial marriages involving Black men persistently have higher marital gains than those involving Black women. This leads to a concern that Black women face double-sided challenges in finding same-race *and* different-race partners, which could lower their marriage prospects and marital welfare.

Next, I proceed to understand how these disparities in marital surpluses, as well as in population composition, have impacted each group's marital prospects in equilibrium. To this end, I compare each social group's marital utility – which, in the model I use, corresponds to one's likelihood of getting married – between the actual marriage market and a counterfactual racially segre-

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<sup>5</sup>I include four major races/ethnicities in the US, which are non-Hispanic White, Black, Hispanic, and Asian. Note that Hispanic is an *ethnicity* – a social group that shares a common and distinctive culture, religion, and/or language – which is distinct from race.

gated marriage market. I call this measure “individual gains from interracial marriage.”<sup>6</sup> Comparing to the racial segregation benchmark helps us understand the extent to which each social group has benefitted (or not) from access to interracial marriage, taking into account all the existing disparities in the marriage market. For example, due to the aforementioned gender disparities in marital surplus and sex ratio imbalance, we expect that Black men would have a higher likelihood of getting married when they can marry other races, relative to the complete racial segregation benchmark. This may not be true for Black women. My approach systematically quantifies the distributional impacts of the existing disparities related to interracial marriages.

Although my estimation includes all four racial/ethnic groups, I focus on describing the individual gains from interracial marriage for Black and White people because these two groups have experienced substantial increases in interracial marriage rates over the past four decades, unlike Hispanics and Asians, whose interracial marriage rates have remained relatively constant.<sup>7</sup> Moreover, Hispanics and Asians are largely comprised of immigrants, and different generations of immigrants may have systematically different preferences for same-race marriage (Lichter et al., 2011; Furtado, 2015). It is outside the scope of this paper to investigate individual gains for Hispanics and Asians who exhibit markedly different interracial marriage trends and immigration trends.

I show that the disparities in marital gains associated with interracial marriage, along with the demographic composition, have improved marital prospects for some groups, but not for others. Among Black people, college-educated Black men gained the most from interracial marriage, and their gains have shown the most pronounced increase over time. For example, access to interracial marriage has reduced their probability of remaining unmarried by 17.5% compared to a complete segregation benchmark in 2019. In contrast, Black women have not gained at all from interracial marriage, regardless of their education level, across all years. Despite having a larger and racially diverse pool of potential partners in the actual marriage market, Black women’s marriage probability is the same as the complete racial segregation scenario. Results for other racial groups also show education- and gender-based gaps in the evolution of individual gains from interracial marriage.

What specific changes in the marital surplus and the population composition have played the biggest role in shaping these uneven individual gains from interracial marriage? To better understand this, I perform decomposition analyses utilizing the system of equilibrium matching functions. When examining the effects of the marriage market changes, it is crucial to acknowledge that *any* change in the marital surplus and population supplies affects some groups favorably

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<sup>6</sup>For clarification, individual gains defined here differ from marital gains from interracial marriage. “Marital gain” is a *marriage-level* concept, capturing the overall benefit each type of marriage generates. In contrast, “individual gain” from interracial marriage is an *individual-level* concept, capturing the degree to which access to interracial marriage has improved each individual’s marital welfare.

<sup>7</sup>Appendix Figure A2 shows interracial marriage trends by race/ethnicity.

while affecting others negatively.<sup>8</sup> The decomposition method, which directly uses the equilibrium relationships between the sorting patterns and marriage market conditions, accounts for the equilibrium nature of the marriage market changes and systematically summarizes the impact of each change on the distribution of marital welfare.

Results from the decomposition analyses show that both (1) gender gaps in marital gains across interracial marriage types and (2) sex ratio imbalance within the population contributed to the gender disparities in marital prospects, but differently for different racial groups. Among Black people, changing marital gains played a more significant role. Specifically, I find that college-educated Black men substantially gained from the rise in the marital surplus associated with marrying college-educated White and Hispanic women. Importantly, these gains are large enough to render other negative forces negligible for college-educated Black men. To elaborate, one example of an unfavorable change for Black men's marriage prospects is the rise in the marital surplus for (White man, Black woman) marriages, which intensifies marriage competition for Black men. However, this adverse impact was not large enough to cancel out the positive impacts of marital surplus changes that favored college-educated Black men. Conversely, Black women's marital prospects have not improved as much from the marital surplus changes.<sup>9</sup> These findings suggest that, among Black people, the structure of marital surplus has evolved in a way that is most favorable to the most educated Black men.

In contrast, population changes – particularly the growing sex imbalance among college graduates – played a greater role in shaping marital prospects among White people. I find that college-educated White men derived the largest benefit from the expanded marriage pool, particularly due to the increase in the number of college-educated Asian and Hispanic women. In contrast, college-educated White women's marriage prospects were weakened by this growing sex imbalance among Asian and Hispanic college graduates.

Finally, I consider two sets of counterfactual scenarios. The first aims to simulate the marriage patterns in the absence of gender disparities in marital surplus associated with interracial marriage for Black people. There are two different ways of simulating the absence of such gender gaps: one is to *increase* the marital surplus associated with Black women's interracial marriages to the Black men's level, and the other is to *decrease* the marital surplus associated with Black men's interracial marriages to the Black women's level. I find that these two approaches have different im-

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<sup>8</sup>To better understand this, consider a population change where the number of college-educated White women increases. All else equal, this is a favorable change for all groups of men, as they have a larger marriage pool. However, this population change lowers the marriage probabilities of all other women due to increased marriage competition.

<sup>9</sup>To elaborate, the results show that college-educated Black women also gained from the increase in the joint surplus from marriage with college-educated White men. However, this gain is partly canceled out by the increase in marital surplus for Black men and White women marriages, among other forces that adversely impact Black women's marriage prospects. Eventually, combining all the effects coming from changing marital gains, college-educated Black women did not gain from interracial marriage as much as college-educated Black men did.

pacts on marital outcomes for each social group. Elevating the marital surplus for Black women's interracial marriages substantially enhances their marriage prospects without significantly compromising those of Black men or other racial groups. Conversely, reducing the marital surplus for Black men's interracial marriages does not notably enhance Black women's marital prospects and significantly diminishes Black men's marriage rates. Therefore, these results imply that it would be socially beneficial for everyone's marital prospects if Black women's interracial marriages become as easy to form as Black men's interracial marriages.

The second counterfactual exercise is to more generally predict marriage patterns as race becomes less important in marriage-matching. I find that progress toward complete racial integration in the marriage market would significantly reduce the proportion of unmarried Black men and women, as well as for all other minority groups. Furthermore, racial integration would not affect the proportion of unmarried White men and women. Overall, my counterfactual exercises imply that it would be beneficial for everyone's marital prospects when interracial marriages become more attractive for currently segregated social groups in the marriage market, such as Black women.

This paper contributes to several strands of literature. First, I contribute to the literature examining the marital preferences concerning race. Several studies have examined interracial marriages across groups and over time using descriptive statistics (Fryer, 2007; Pew Research Center, 2017). Other studies have made further progress by disentangling the changing racial preferences in marriage and changing population supplies (Fu and Heaton, 2008; Qian and Lichter, 2011; Ciscato and Weber, 2020; Anderberg and Vickery, 2021). However, while these measures of racial endogamy provide insight into overall trends in racial preference in marriage, they are not gender-specific. Some studies, including Fisman et al. (2008) and Hitsch et al. (2010), utilize speed dating experiments and online dating data to uncover the gender gaps in preferences for partners of different races. Nonetheless, these datasets do not reveal the actual matches formed in the marriage market, and they only consider one time period, lacking an examination of how marital preferences have evolved over time. My paper contributes to this literature by investigating the evolution of the gender disparities in marital surplus associated with interracial marriages and their consequences on each social group's marital welfare.

More generally, my paper relates to the literature that investigates marital sorting using the transferable utility (TU) matching framework. Since Choo and Siow (2006) provided a benchmark framework for empirically implementing the TU matching model, it has been implemented to investigate marital sorting on a variety of dimensions, including education (Chiappori et al., 2017, 2020), physical and personality traits (Dupuy and Galichon, 2014; Chiappori et al., 2023), income (Chiappori et al., 2022), behavioral traits and risk attitude (Chiappori et al., 2023), and same-sex marriage (Ciscato et al., 2020). My paper adds to the literature by investigating racial sorting in the

marriage market, along with the aforementioned [Ciscato and Weber \(2020\)](#) and [Anderberg and Vickery \(2021\)](#). Distinct from these studies that mostly focus on understanding the preferences for marrying someone with similar traits using the TU framework, my paper focuses on understanding the welfare effects of evolving disparities in marital gains across interracial marriage types and changing population supplies, shedding light on intricate ways through which marriage market changes shape uneven marital welfare.

My study also relates to the literature on how the costs associated with particular marriages affect marriage sorting and welfare. The notion of such costs reflects the reality that certain types of marriages can be more difficult to form than others. For example, cross-border marriages can be costly due to legal issues, long distance, and cultural differences. [Ahn \(2023\)](#) studies how changes in the costs of cross-border marriages affect marriage patterns and intra-household allocation. In a similar vein, marriage between immigrants and natives can be more difficult to form. [Adda et al. \(2022\)](#) studies how granting legal access to migrants, which alters the attractiveness of cross-cultural marriages, affects marital sorting. My paper adds to the literature by investigating the costs associated with the formation of different types of interracial marriage. Specifically, this paper empirically demonstrates that if some types of interracial marriages (e.g. Black men's interracial marriage) are relatively easier to form than others (e.g. Black women's interracial marriage), then these disparities can lead to uneven marital welfare.

Lastly, I add to the literature on the causes of the diverging patterns in marriage. As reviewed in [Lundberg et al. \(2016\)](#), marriage rates in the US have declined faster for high school graduates than college graduates and for Blacks than Whites. Most of the existing studies have examined the causes *within* each race, such as the rising incarceration of Black men ([Charles and Luoh, 2010](#); [Liu, 2020](#); [Caucutt et al., 2021](#)) and the decline in employment prospects for low-skilled male workers who are heavily represented in minorities ([Autor et al., 2019](#)). However, marriage *across* races have rarely been examined, although interracial marriage has become more prevalent and important. I add to this literature by studying how gender gaps in interracial marriage shape the disparities in each social group's marriage probability.

The rest of the paper is organized as follows. Section 2 documents motivating trends that highlight difficulties in interpreting the interracial marriage patterns. Section 3 describes the data and the sample selection for model estimation. Section 4 presents the matching model and explains the estimation of the marital surplus and expected utilities. Section 5 explains the method to measure the individual gains from interracial marriage and presents the results. Section 6 presents the decomposition method and the results. Section 7 performs counterfactual simulations. Section 8 concludes.



## 2 Interracial Marriage Trends

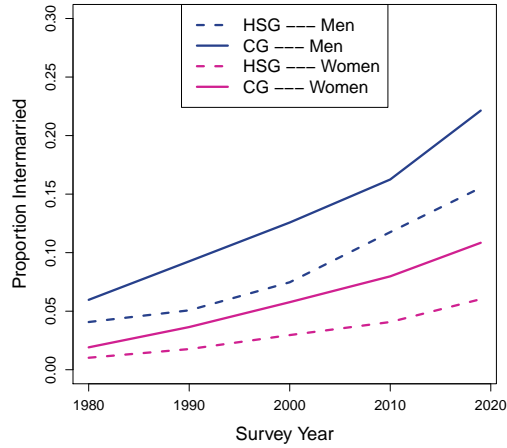
In this section, I document the interracial marriage patterns and relevant demographic changes in the US, which motivate the analyses in this paper. Interracial marriage rates have not evolved in the same way across gender and education groups. Figure 1a shows that Black men with four-year college degrees are substantially more likely to marry out than their female counterparts and their high school graduate male counterparts. Notably, even high school graduate Black men are more likely to marry out than college-educated Black women. Similarly, Figure 1b shows that college-educated White men marry out more than their lower-educated male counterparts and their female counterparts, although this gender difference is less stark than for Black people. Furthermore, Asians have also experienced a persistent gender gap in interracial marriage, as shown in Appendix Figure A3.

The gender gaps in interracial marriage are potentially concerning. For instance, the gender gap in interracial marriage among Black people may disproportionately deplete the marriage pool for Black women, who already face well-documented challenges in finding partners within race due to the high incarceration and unemployment rates of young Black men (Charles and Luoh, 2010; Mechoulan, 2011; Liu, 2020; Caucutt et al., 2021). Therefore, it is important to understand the magnitude of consequences of these gender disparities on each social group's marital prospects.

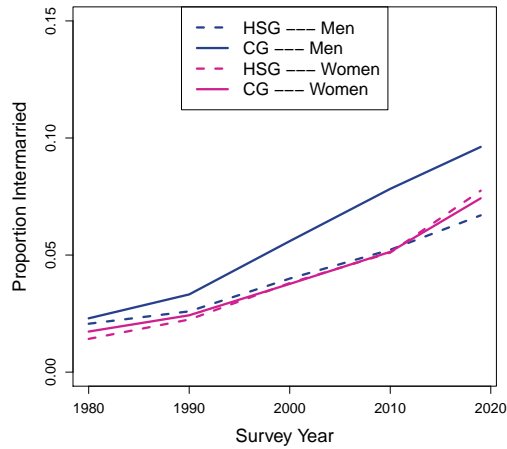
What drives these gender disparities? As emphasized throughout the literature on marriage markets (Chiappori and Salanié, 2016; Schwartz, 2013), it is not straightforward to distinguish the roles of marital gains and population supplies from marriage rates alone. While it may be tempting to think that the disparities in interracial marriage rates simply reflect the varying marital gains across interracial marriage types (potentially due to varying stigma or other preference factors), population supplies also can shape the marriage patterns. For example, rising sex imbalances across racial groups may increase interracial marriage rates for one gender by broadening the marriage pool with different-race potential partners while reducing interracial marriage rates for the other gender.

An example of the increasing sex ratio imbalance in the US is observed among college graduates. There has been a reversal of the gender gap in college education: while more men used to earn college degrees than women in the past, the opposite is true now. While this is a well-documented trend (Goldin et al., 2006; Chiappori et al., 2009; Chuan and Zhang, 2022), I additionally show in Figure 2 that this reversal in the gender gap is observed for *all* racial/ethnic groups. This implies that there are now a larger number of potential college-educated partners, across all racial/ethnic groups, for men than for women among college graduates. Therefore, the gender differences in interracial marriage shown in Figure 1 could be the consequence of the reversal of the gender gap in higher education, rather than the consequence of the gender differences in the

Figure 1: Interracial Marriage Rates Among Blacks and Whites



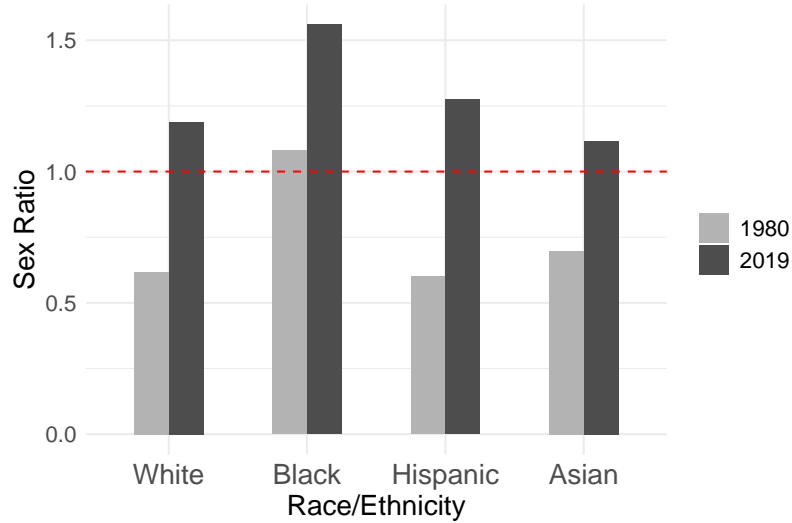
(a) Blacks



(b) Whites

Note: This figure shows the proportion of those who married out of their race among married individuals of the specified group aged 35-44 in each survey year. "HSG" refers to high school graduation or the equivalent GED. "CG" refers to the four-year college degree or above. Data sources for this figure are: 1980 5% sample Census, 1990 5% sample Census, 2000 5% sample Census, 2010 5% sample American Community Survey (2006-2010 5 year pooled sample), 2019 5% sample American Community Survey (2005-2019 5 year pooled sample). Survey weight is applied.

Figure 2: Female-to-Male Sex Ratio, Among 4-Year College Graduates, Age 35-44



Note: This figure shows sex ratio (female-to-male) among college graduates aged 35-44 for each race/ethnicity in 1980 and in 2019, respectively. Data sources for this figure are: 1980 5% sample Census microdata and 2019 5% sample American Community Survey (2015-2019 5-year pooled sample). Survey weight is applied.

marital gains associated with interracial marriage. It is also possible that different effects are at play for different social groups. Without a clear framework, it is challenging to disentangle the effects of changing marital gains associated with interracial marriage and the effects of changing demographics.

To better understand these disparities in interracial marriage patterns and their welfare implication, I proceed by building a structural matching model in Section 4. This model will allow me (i) to estimate how the marital gains from interracial marriage have changed over time depending on one's own and spouse's characteristics, (ii) how the disparities in marital surplus have shaped each group's marital prospects, and (iii) disentangle the effects of changing population and changing marital gains associated with interracial marriage.

### 3 Data

I begin by describing the data used for estimating the marriage matching model for each year spanning from 1980 to 2019. I use the US Decennial Census for years 1980, 1990, and 2000, and I use the 5-Year American Community Survey sample for the years 2010 and 2019, all of which are extracted from IPUMS (Ruggles et al., 2022).<sup>10</sup> The reason I start from year 1980 is because the

<sup>10</sup>All data are 5-in-100 national sample of the population for the corresponding year.

census question on the Hispanic origin was added in 1980.<sup>11</sup> For the previous years, the Hispanic origin of each respondent is imputed by the IPUMS based on several criteria including one's and family's birthplace, surname, and family relationship, among others. However, it is problematic to use the imputed Hispanic variable, because interracial/interethnic marriages involving Hispanics are not well-identified.<sup>12</sup>

I impose the following sample restriction for estimation. For *each* survey year, I first select the sample of currently married couples where the wife is aged 35-44 and the husband is aged 37-46. The lower bound of this age range is selected to exclude people who may marry in the future. The upper bound of the age range is selected to keep the age distribution across different calendar years comparable.<sup>13</sup> Two years of an age gap between the husband's age group and the wife's age group reflects the fact that men tend to marry younger women, and the most common spousal age differences in the data are 1 and 2 years.<sup>14</sup> I focus on heterosexual married couples as same-sex marriage was only legalized nationwide in 2015.

To the sample of married couples, I add the sample of never-married single men and women who are in the same corresponding age groups. I do not include divorced people in the single sample to abstract away from the issues of selection into divorce. Institutionalized individuals are excluded from the estimation sample, as they are unlikely to be participating in the marriage market. Never-married singles in the estimation sample include those living with unmarried partners.<sup>15</sup> As shown in the Table A2, cohabitation among the sample of singles has increased from 11.3% in 1980 to 24.6% in 2019. I later perform sensitivity checks in Appendix A.3 and confirm that excluding cohabiting singles do not affect the main results.

I now describe the definition of "type" of men and women that is used for the estimation. I consider 4 races/ethnicities in my estimation, which are non-Hispanic Whites, Black/African Americans, Hispanics, and Asians<sup>16</sup>, which is denoted as  $\mathcal{R} \equiv \{White, Black, Hispanic, Asian\}$ . I exclude other races, including mixed races because their sample size is too small; Appendix Table A1 shows that other races, which include Native Americans, Alaska Indians, and other races, are less than 1% of the population of interest each year; and people who reported to be mixed race, an option available from 2000 onward, make up less than 3% for each available year. For ed-

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<sup>11</sup>In fact, as discussed in O'Flaherty (2015), "Hispanic" only gained meaning around 1970 in the US.

<sup>12</sup>Specifically, the occurrences of marriages between non-Hispanic whites and Hispanics are recorded to be zero in 1960 and 1970. This is because spouse's race is one of the criteria to impute the Hispanic origin of individuals for 1960 and 1970 Decennial Censuses.

<sup>13</sup>The choice of age range 35-44 is common in the marriage literature (e.g. Chiappori et al. (2020), Bertrand et al. (2021)).

<sup>14</sup>Note that this age restriction only includes individuals who have partners within the specified age range. For example, age 35 women married to age 33 men are excluded from the sample. This age restriction is necessary to properly estimate the marital surplus and perform counterfactual analyses.

<sup>15</sup>From 1990 Census and onwards, "unmarried partner" living with the head of household can be identified.

<sup>16</sup>"Asian" include Chinese, Japanese, and other Asians or pacific islanders.

education, I consider four levels of educational attainment:  $\mathcal{E} \equiv \{HSD, HSG, SC, CG\}$ , where *HSD*: high school dropout, *HSG*: high school graduate or GED with no college education, *SC*: less than 4 years of college education, and *CG*: 4 years of college education or more. Hence, the type I consider for the estimation is a combination of one's race and education:  $\mathcal{R} \times \mathcal{E}$ , which consists of 16 different types. Specifically,  $\mathcal{R} \times \mathcal{E} = \{WhiteHSD, WhiteHSG, WhiteSC, WhiteCG, \dots, AsianHSD, AsianHSG, AsianSC, AsianCG\}$ .

## 4 Marriage Matching Model

In this section, I present the matching model that serves as the building block for the analyses of interracial marriage throughout this paper. Building on [Choo and Siow \(2006\)](#), I construct a frictionless matching framework with perfectly transferable utility (TU) and random preferences. This framework allows me to (i) estimate the marital gains from any race-education matching in the marriage market, (ii) quantify each social group's marital welfare, and (iii) perform counterfactual analyses and decomposition analyses to understand how changing marital gains and changing population composition affects equilibrium sorting pattern and distribution of marital welfare.

### 4.1 The Setting

In this setting, each man or woman has two traits that are observed by the analyst: race and education.<sup>17</sup> Each man  $i$  belongs to a type  $I = (R_i, E_i) \in \mathcal{M} \equiv \mathcal{R} \times \mathcal{E}$ , where  $\mathcal{R}$  and  $\mathcal{E}$  denote the type spaces for race and for education, respectively. Similarly, each woman  $j$  belongs to a type  $J = (R_j, E_j) \in \mathcal{F} \equiv \mathcal{R} \times \mathcal{E}$ . In addition, each individual has other traits that are unobservable to the analyst but are observable to all men and women.<sup>18</sup>

A *matching* indicates who marries whom, including the option of singlehood. I augment the type spaces for men and women to allow for singlehood:  $\tilde{\mathcal{M}} := \mathcal{M} \cup \{\emptyset\}$  and  $\tilde{\mathcal{F}} := \mathcal{F} \cup \{\emptyset\}$ , where  $\{\emptyset\}$  means no partner. Feasible matching must satisfy the population constraints, which simply means that the number of unmarried and married people of each type should match the total

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<sup>17</sup>I only focus on these two traits as they are likely to be determined before marriage. Other observable characteristics from the census data, such as the current wage and hours of work, are not used because they can be the outcomes that are endogenously determined by marriage.

<sup>18</sup>The unobservable heterogeneity allows for richer matching patterns, which is otherwise not possible with a deterministic matching model. As discussed throughout the matching literature ([Chiappori and Salanié, 2016](#); [Chiappori, 2017](#); [Galichon and Salanié, 2022](#)), the uni-dimensional deterministic matching model with positive complementarities gives a stark prediction that matching is perfectly assortative, which is obviously unrealistic in the real world.

number of people in the marriage market for that type. Formally, the feasibility constraint is:

$$n^I = \mu^{I\phi} + \sum_J \mu^{IJ} \quad \forall I \quad (1)$$

$$m^J = \mu^{\phi J} + \sum_I \mu^{IJ} \quad \forall J \quad (2)$$

where  $n^I$  is the number of type  $I$  men and  $m^J$  the number of type  $J$  women available in the marriage market.  $\mu^{IJ}$  denotes the number of  $(I, J)$  marriages,  $\mu^{I\phi}$  the number of single  $I$  men,  $\mu^{\phi J}$  the number of single  $J$  women.

In a perfectly transferable utility framework, a matching also indicates how marital surplus  $z_{ij}$  generated by  $(i, j)$  marriage is divided between the couple. The formal definition of the marital surplus is the total utility man  $i$  and woman  $j$  get when married together minus the sum of utilities man  $i$  and woman  $j$  get when remaining single. It should be noted that marital surplus encompasses both husband's and wife's gains from each marriage. In essence, marital surplus includes all economic and non-economic gains derived from the corresponding marriage, *relative to* singlehood.<sup>19</sup> Hence, the exact nature of marital surplus is complicated and can encompass various factors. In the next subsection, I discuss the implications of marital surplus in the context of interracial marriage.

Marital surplus is expressed as a sum of two components:

$$z_{ij} = Z^{IJ} + \varepsilon_{ij} \quad (3)$$

where  $Z^{IJ}$  is a deterministic part of the surplus that depends only on *observed* types of spouses, and  $\varepsilon_{ij}$  is an idiosyncratic part of the surplus that reflects *unobserved* heterogeneity in marital preferences.

When Mr.  $i$  and Ms.  $j$  marry each other, the joint surplus  $z_{ij}$  is divided between them. This is expressed as  $z_{ij} = u_i + v_j$ , where  $u_i$  is the payoff for Mr.  $i$  and  $v_j$  is the payoff for Ms.  $j$ . While marital surplus is considered given in the model, how it is divided between the couple is *endogenously* determined by marriage market equilibrium. For example, if one possesses a desirable trait (e.g. high education), and if that trait is scarce in the market, we expect that such a person would extract a large share of marital surplus due to the high demand for such partners. This rationale is reflected in the equilibrium division of marital surplus between spouses.

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<sup>19</sup>The relative nature of the marital surplus is important, because the analyst cannot separately identify the utilities from marriage and the utilities from singlehood, from the marriage patterns alone. It is only possible to identify the relative utilities that a couple gets, *relative to* singlehood, from the marriage patterns.

Similarly, the utility of singles is expressed as:

$$\begin{aligned} z_{i\phi} &= Z^{I\phi} + \varepsilon_{i\phi} \\ z_{\phi j} &= Z^{\phi J} + \varepsilon_{\phi j} \end{aligned}$$

Without loss of generality, I normalize  $Z^{I\phi}$  and  $Z^{\phi J}$  to zero.

A matching equilibrium is achieved when (i) no Mr.  $i$  or Ms.  $j$  who is currently married would rather be single and (ii) no Mr.  $i$  or Ms.  $j$  who are not currently married together would both rather be married together than remain in their current situation. This equilibrium condition results from stability, and the stable matching is generally unique (Gale and Shapley, 1962; Shapley and Shubik, 1971).

## 4.2 Identification of Marital Surplus and Expected Utility

One of the main goals of this paper is to understand the disparities in marital gains across interracial marriage types and their evolution. Hence, I need to recover the marital surplus (Equation (3)) from the observed marriage patterns. As discussed and proved in previous literature (Choo and Siow, 2006; Chiappori and Salanié, 2016; Galichon and Salanié, 2022), it is not possible to identify the marital surplus without further imposing a structure on the idiosyncratic terms. This is because the analyst cannot observe how people match based on traits that are not observed in the data, such as personalities or hobbies. Following Choo and Siow (2006), I impose the separability assumption, which restricts matching on unobserved traits:

**Assumption 1 (Separability).** *The joint surplus from a marriage between a type  $I$  man and a type  $J$  woman is of the form*

$$z_{ij} = Z^{IJ} + \alpha_i^J + \beta_j^I. \quad (4)$$

Separability allows for matching on unobservable traits, but in a restrictive way – which is conditional on the observed types of both spouses. For example,  $\alpha_i^J$  reflects that a marriage between Mr.  $i \in I$  and Ms.  $j \in J$  may occur because Mr.  $i$  has unobservable traits (e.g. a certain hobby) that type  $J$  women value when choosing a partner. Moreover,  $\alpha_i^J$  can also reflect that Mr.  $i$  has idiosyncratic preferences for type  $J$  women. Similar implications hold for  $\beta_j^I$ . However, the separability assumption does not allow the matching on unobserved traits of both spouses.

The separability assumption leads to the following property, which is crucial for identification:

**Proposition 1 (Choo and Siow, 2006; Chiappori et al., 2017).** *For any stable matching, there exists values  $U^{IJ}$  and  $V^{IJ}$  satisfying the following property:*

- Each man  $i$  will match with a woman of type  $J$  that maximizes  $U^{IJ} + \alpha_i^J$  over  $\tilde{\mathcal{F}}$
- Each woman  $j$  will match with a man of type  $I$  that maximizes  $V^{IJ} + \beta_j^I$  over  $\tilde{\mathcal{M}}$ .
- $U^{I\phi}$  and  $V^{\phi J}$  are normalized to be zero.
- $U^{IJ} + V^{IJ} = Z^{IJ}$  if  $(I, J)$  match exists.

*Proof.* See [Chiappori et al. \(2017\)](#).

$U^{IJ}$  (resp.  $V^{IJ}$ ) can be interpreted as the husband's (resp. wife's) portion of the deterministic part of the joint marital surplus that is shared between the spouses. An important consequence of Proposition 1 is that the separability assumption simplifies the two-sided matching problem by turning it into a series of discrete choice problems. The husband's share of the surplus, which is  $U^{IJ}$ , can be obtained from a man  $i$ 's problem of choosing a partner type (or choosing not to marry) that maximizes his utility – i.e. a maximization of  $U^{IJ} + \alpha_i^J$  over  $\tilde{\mathcal{F}}$ . Given  $U^{IJ}$ , wife's share of the surplus is written as  $V^{IJ} = Z^{IJ} - U^{IJ}$ . This can be similarly obtained through a woman  $j$ 's problem of choosing a partner type (or choosing not to marry) that maximizes her utility, *taking into account* the surplus the husband takes from each type of marriage – i.e. a maximization of  $Z^{IJ} - U^{IJ} + \beta_j^I$  over  $\tilde{\mathcal{M}}$  given all  $U^{IJ}$ . Then, we can identify the marital surplus  $Z^{IJ}$ , which is simply the sum of  $U^{IJ}$  and  $V^{IJ}$ .

**Marital Surplus:** Marital surplus can be identified using Proposition 1 and an assumption on the distribution of unobserved preferences. Following a common practice in the literature, I assume that the unobserved heterogeneities  $\alpha_i^J$  and  $\beta_j^I$  are distributed as standard type-I extreme values.<sup>20</sup> Then, solving the model in a standard way ([Choo and Siow, 2006](#)), I get the following formula for marital surplus  $Z^{IJ}$  for husband's type  $I$  and wife's type  $J$ :

$$Z^{IJ} = \ln\left(\frac{(\mu^{IJ})^2}{\mu^{I\phi}\mu^{\phi J}}\right) \quad (5)$$

Because  $Z^{IJ}$  is a function of the number of married and singles, the marital surplus can be recovered from the observed matching patterns. Note that, unlike the raw marriage rate, the above measure of marital surplus controls for the effects of demographic composition, by scaling the proportion of  $I, J$  marriages by the geometric average of the proportion of unmarrieds of those racial groups.

**Discussion of Marital Surplus:** Before highlighting why marital surplus is useful in understanding interracial marriage patterns, I discuss its limitations. First, we cannot know which party drives the value of the marital surplus. For example, if the marriage between a Black man and a White

<sup>20</sup>[Galichon and Salanié \(2022\)](#) show that any distributions for the random terms can be used to identify the marital surplus, as long as these distributions are known ex ante.



woman has a high value of marital surplus, we cannot distinguish whether it is because Black men value marriage with White women more or it is because White women value marriage with Black men more. Second, without further specification, marital surplus does not tell us the specific reasons behind its value. It encompasses any economic, social, or other benefits associated with  $(I, J)$  marriage. For instance, a high marital surplus for certain interracial marriages may be due to low social stigma, economic consideration, or other preference factors. Furthermore, because the model does not consider friction in finding a partner, the marital surpluses that differ across marriage types may reflect varying levels of difficulty in finding a partner across social groups.

Despite these limitations of marital surplus, it is informative for the following reasons. First, it helps us understand which types of interracial marriages have become more attractive and easier to form than others, shedding light on the progress of social integration across various social groups. Second, although we cannot reveal the specific reasons behind the marital surpluses, the overall structure of marital surplus itself is important as it determines who marries whom and who remains single. Therefore, the structure of marital surplus sheds light on why some demographic groups intermarry less than others and why some demographic groups remain more unmarried.

**Expected utilities:** Another important concept, which will be used throughout this paper, is each social group's expected utilities from the marriage market. It is crucial to note that while the marital surplus is a *couple-level* gain, the expected utility is an *individual-level* welfare from the marriage market. I use the notion of expected utilities in the next sections to understand who benefitted from access to interracial marriage and by how much.

Each social group's expected utility can also be easily identified and estimated in this framework. As shown in [Choo and Siow \(2006\)](#), the expected utility from the marriage market for male type  $I$  is the following:

$$\bar{u}^I = E \left[ \max_j (U^{IJ} + \alpha_i^J) \right] = \ln \left( \sum_j \exp(U^{IJ}) + 1 \right) = -\ln(\Pr(\text{single} | I)) \quad (6)$$

The above equation shows that the expected utility of type  $I$  men can be fully expressed by their probability of being single, which is a well-established property of assuming Gumbel distributed idiosyncratic terms in a discrete choice framework.<sup>21</sup> In other words, high expected utility indicates a high likelihood of marriage for a social group in this framework. A similar result applies to the female type  $J$ , and I denote  $\bar{v}^J$  the expected utility of women of type  $J$ .

One remark is that the expected utility that each group gets from the marriage market can be interpreted as their *price* in the marriage market.  $\bar{u}^I$  is the expected price that a woman has

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<sup>21</sup>Note that this correspondence is only true when assuming the Gumbel distributed random terms. [Galichon and Salanié \(2022\)](#) shows that one can use any stochastic distribution and compute the corresponding "generalized entropy" function.

to pay to marry a type  $I$  man; after paying the price, she keeps what is left of the joint surplus from marrying that man. Similarly,  $\bar{v}^J$  is the expected price that a man has to pay to marry type  $J$  women. Like the usual prices in any type of market, these expected utilities play an important role that equates demand and supply for each type of partner in the marriage market.

### 4.3 The System of Equilibrium Matching Functions

Lastly, I highlight that the matching model yields a system of equilibrium matching functions. This system enables us to explicitly link population distribution and marital surplus to equilibrium matching patterns and distribution of welfare. In other words, it allows us to explore how the changes in population or marital surplus affect who marries whom and who remains single, as well as the marital welfare of each social group. These functions are useful as they allow counterfactual simulations and decomposition analyses, which will be conducted in Section 5 and Section 6.

To obtain this system of matching functions, I begin by re-arranging the marital surplus formula (Equation (5)) as the following:

$$\mu^{IJ} = \exp\left(\frac{Z^{IJ}}{2}\right) \sqrt{\mu^{I\phi} \mu^{\phi J}} \quad (7)$$

Next, I plug the above expression into the feasibility constraints (Equations (1) and (2)) to obtain:

$$n^I = \mu^{I\phi} + \sum_J \exp\left(\frac{Z^{IJ}}{2}\right) \sqrt{\mu^{I\phi} \mu^{\phi J}} \quad \forall I \quad (8)$$

$$m^J = \mu^{\phi J} + \sum_I \exp\left(\frac{Z^{IJ}}{2}\right) \sqrt{\mu^{I\phi} \mu^{\phi J}} \quad \forall J \quad (9)$$

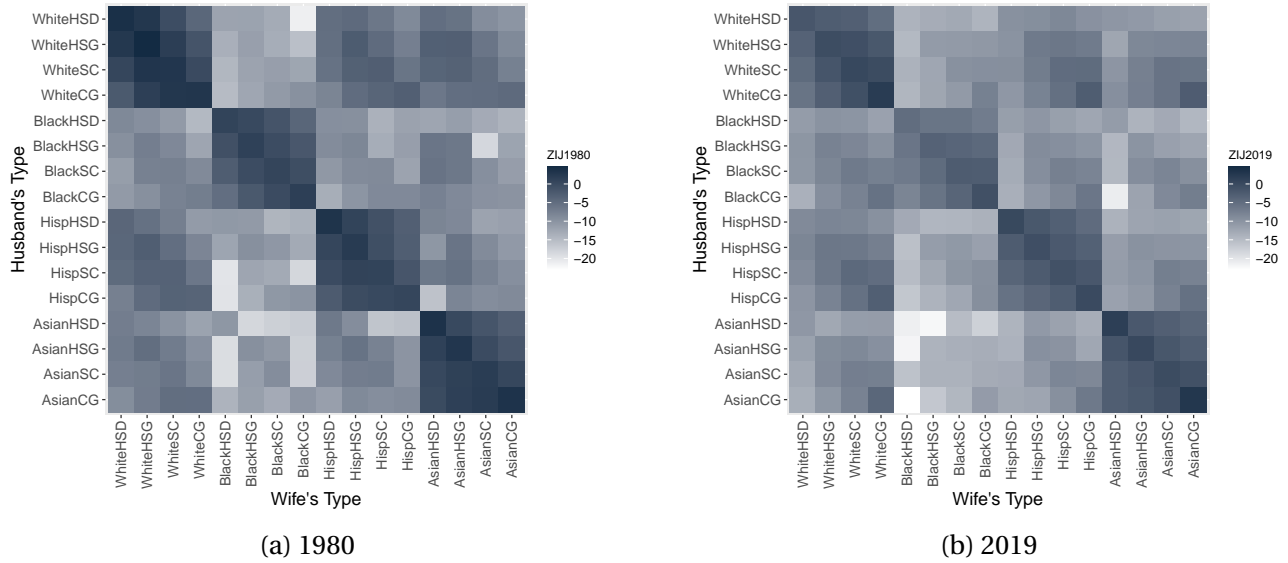
Let  $K$  be the total number of types for  $I$  and  $J$ , respectively. Then, Equations (8) and (9) define a system of  $2K$  matching equations with  $2K$  unknowns, which are the number of single men of each type ( $\mu^{I\phi}$ ) and the number of single women of each type ( $\mu^{\phi J}$ ) for all  $I, J$ .

The counterfactual simulations can be performed using the system of Equations (7), (8), and (9) with any counterfactual population distribution and/or marital surplus matrix. These simulations derive counterfactual marriage patterns under any different structure of population and marital surplus. Moreover, another interesting but unexplored feature of this system of matching functions is that it can be used to quantify the effects of changing population and changing marital surplus on marital sorting and welfare. I demonstrate how this can be done in Section 6.

## 4.4 Estimated Marital Surplus

How have marital gains evolved for different interracial unions depending on one's own and spouse's characteristics? In this section, I present descriptive statistics of the estimated marital surplus  $\hat{Z}_t$  using the data described in Section 3. I document how the evolution of marital gains differs across interracial marriage types to understand which types of interracial marriage have become more attractive and easier to form than others.

Figure 3: Estimated Marital Surplus Matrix  $\hat{Z}_t$ , 1980 vs 2019



Note: This figure shows a heatmap for estimated marital surplus  $\hat{Z}_t^{IJ}$  for the survey year 1980 (Panel (a)) and the survey year 2019 (Panel (b)), respectively.  $I$  refers to husband's type (Row) and  $J$  refers to wife's type (Column). *HSD*: high school dropout, *HSG*: high school graduate with no college education, *SC*: less than 4 years of college education, and *CG*: 4 years of college education or more.

**Overall changes in marital surplus:** Figure 3 shows the heatmaps of the marital surplus for the survey years 1980 and 2019.<sup>22</sup> Panel (a) confirms that in 1980 the US marriage market was largely segregated by race: for all races, same-race marriages exhibit the highest values of marital surplus.

Panel (b) shows several notable patterns for the year 2019. First, compared to 1980, the values of marital surplus have generally gone down for most marriages in 2019, especially for marriages involving lower-educated people. This reflects a well-known retreat from marriage in the US (Lundberg et al., 2016). Second, in 2019, the marriage market is still largely segregated by race; the same-race marriages still exhibit the highest values of marital surplus across all races. Third,

<sup>22</sup>Specific values of the marital surplus are presented in Appendix Figure A4 for the year 1980 and Appendix Figure A5 for the year 2019.

within each block of interracial marriages, the values of marital surplus are highest for college graduates in 2019.

**Further investigations into the evolution of marital surplus:** To further understand how the marital surpluses from interracial marriage have changed, I investigate selected marital surpluses and their corresponding changes over the 1980-2019 period. Table 1 reports selected  $\hat{Z}_t^{IJ}$  for marriages involving a White spouse, and Table 2 reports selected  $\hat{Z}_t^{IJ}$  for marriages involving a Black spouse. When describing the changes in marital surplus below, I focus on the sign of the changes rather than on the magnitude of the changes. This is because marital surplus is a *non-linear* function of quantities of marriages and singles, as shown in Equation (5), which makes it difficult to directly compare the levels of the changes in  $\hat{Z}_t^{IJ}$  across marital surpluses with differing starting values.

Table 1: Selected Marital Surplus Involving **White Spouse**

		Panel A: Marital surplus for CG couple			Panel B: Marital surplus for HSG couple			
		1980	2019	$\Delta^{2019-1980}$	1980	2019	$\Delta^{2019-1980}$	
White-White	$Z^{WhiteCG,WhiteCG}$	3.01	2.13	-	$Z^{WhiteHSG,WhiteHSG}$	4.74	-0.38	-
White-Black	$Z^{WhiteCG,BlackCG}$	-9.58	-7.48	+	$Z^{WhiteHSG,BlackHSG}$	-11.47	-10.84	+
	$Z^{BlackCG,WhiteCG}$	-7.08	-5.55	+	$Z^{BlackHSG,WhiteHSG}$	-7.21	-7.67	-
White-Hispanic	$Z^{WhiteCG,HispCG}$	-3.01	-2.61	+	$Z^{WhiteHSG,HispHSG}$	-2.46	-6.64	-
	$Z^{HispCG,WhiteCG}$	-3.59	-2.92	+	$Z^{HispHSG,WhiteHSG}$	-2.79	-6.24	-
White-Asian	$Z^{WhiteCG,AsianCG}$	-4.50	-2.59	+	$Z^{WhiteHSG,AsianHSG}$	-2.99	-8.43	-
	$Z^{AsianCG,WhiteCG}$	-5.07	-4.07	+	$Z^{AsianHSG,WhiteHSG}$	-5.00	-9.06	-

Notes: This table reports selected marital surplus for marriages involving at least one White spouse. Panel A reports marital surplus for marriages where both spouses are college graduates. Panel B reports marital surplus for marriages where both spouses are high school graduates. For  $Z^{IJ}$ ,  $I$  refers to husband's type and  $J$  refers to wife's type.  $\Delta^{2019-1980}$  denotes the change in corresponding marital surplus from 1980 to 2019. CG refers to 4-year college graduates, and HSG refers to high school graduates or equivalent GED.

Table 1 reveals several implications about the evolution of the gains to interracial marriage. First, it has become more attractive and easier to interracially marry for college graduates, but not for high school graduates. For example, Panel A shows that the marital surpluses of all interracial marriages involving a college-educated White spouse have increased over the past four decades.<sup>23</sup> In contrast, Panel B shows that the marital surpluses have gone down for most interracial and same-race marriages involving a White spouse with only high school degree, and the magnitude of the decline is substantial for most marriages. These differing trends by education in the marital surplus are consistent with the findings that education is becoming increasingly more important than race in marriage (Kalmijn, 1991; Schwartz, 2013), and that college graduates are more open to interracial marriage (Pew Research Center, 2017).

<sup>23</sup>Notably, same-race marriages between college-educated White men and women has experienced decreasing marital surplus, which reflects the overall declining value of marriages as noted by the literature Lundberg et al. (2016)

Second, there are gender- and race-based gaps in the marital gains associated with interracial marriage. Among all interracial marriages involving a White spouse, Black-White marriages exhibit the lowest marital gains. Among Black-White marriages, marriages between Black men and White women have higher joint surplus than marriages between White men and Black women, both in 1980 and in 2019. This confirms that Black-White marriages are more difficult to form than other types of interracial marriages, especially for marriages involving Black women, as widely conjectured (Fryer, 2007; O’Flaherty, 2015). There are also gender gaps in gains to White-Asian marriages: marriages between White men and Asian women have a higher surplus than marriages between Asian men and White women. These findings are consistent with the prior evidence on racial preferences in the dating market. For example, both Hitsch et al. (2010) and Lin and Lundquist (2013) show using data from online dating that Black women and Asian men are the groups that are least likely to send to or receive messages from dating candidates outside their race. This is also consistent with the anecdotal evidence that Black women experience higher social pressures than Black men to marry within-race (Banks, 2012) and that they face more discrimination in the dating market (Stewart, 2020).

Table 2: Selected Marital Surplus Involving **Black Spouse**

		Panel A: Marital surplus for CG couple			Panel B: Marital surplus for HSG couple			
		1980	2019	$\Delta^{2019-1980}$	1980	2019	$\Delta^{2019-1980}$	
Black-Black	$Z^{BlackCG,BlackCG}$	1.63	-0.86	-	$Z^{BlackHSG,BlackHSG}$	1.33	-3.40	-
Black-White	$Z^{BlackCG,WhiteCG}$	-7.08	-5.55	+	$Z^{BlackHSG,WhiteHSG}$	-7.21	-7.67	-
	$Z^{WhiteCG,BlackCG}$	-9.58	-7.48	+	$Z^{WhiteHSG,BlackHSG}$	-11.47	-10.84	+
Black-Hispanic	$Z^{BlackCG,HispCG}$	-8.65	-6.10	+	$Z^{BlackHSG,HispHSG}$	-8.30	-8.97	-
	$Z^{HispCG,BlackCG}$	-9.99	-9.32	+	$Z^{HispHSG,BlackHSG}$	-9.45	-11.12	-
Black-Asian	$Z^{BlackCG,AsianCG}$	-9.90	-7.14	+	$Z^{BlackHSG,AsianHSG}$	-6.35	-9.95	-
	$Z^{AsianCG,BlackCG}$	-10.17	-10.96	-	$Z^{AsianHSG,BlackHSG}$	-9.50	-13.87	-

Notes: This table reports selected marital surplus for marriages involving at least one Black spouse. Panel A reports marital surplus for marriages where both spouses are college graduates. Panel B reports marital surplus for marriages where both spouses are high school graduates. For  $Z^{I,J}$ ,  $I$  refers to husband’s type and  $J$  refers to wife’s type.  $\Delta^{2019-1980}$  denotes the change in corresponding marital surplus from 1980 to 2019. CG refers to 4-year college graduates, and HSG refers to high school graduates or equivalent GED.

Table 2 also confirms that the gains from interracial marriage involving a Black spouse have only increased for the college-educated. Moreover, the marital gains from interracial marriages among minorities (e.g. Black-Hispanic marriages and Black-Asian marriages) are lower than the gains from Black-White marriages in both years. The estimates again confirm that interracial marriages involving Black women have a lower surplus than interracial marriages involving Black men for all cases.

The gender disparities in marital gains across interracial marriage types, particularly among

Blacks and Asians, suggest that social groups like Black women and Asian men experience unfavorable marriage market conditions relative to their opposite-gender counterparts. For example, as Black men's interracial marriages have persistently higher gains and hence are easier to form than Black women's interracial marriages, Black women face *double-sided* challenges in the marriage market: On the one hand, Black women would face difficulties marrying a *Black* male partner, due to heightened competition from non-Black women. On the other hand, Black women would still not marry a *non-Black* male partner, due to the low marital surplus. Consequently, Black women may have lower marital welfare relative to Black men because of the unfavorable marriage market conditions. This motivates my next analysis, which is to investigate how these gender asymmetries in marital gains across interracial marriage types have impacted each social group's marital prospects and welfare.

## 5 Individual Gains from Interracial Marriage

How have the *differing* gains across interracial marriage types, as documented in Section 4.4 shaped each social group's marital prospects in equilibrium? The structure of marital surplus, as well as population composition, may favor the marital prospects of certain groups while disadvantaging others. In this section, I examine who has benefitted from interracial marriage and by how much, while considering all the disparities in marital gains and population composition.

To this end, I compare each social group's marital utility between the actual marriage market and a counterfactual racially segregated marriage market. Note that, in the model, the marital utility for each social group is fully summarized by their probability of remaining unmarried, or conversely, their probability of getting married (Equation 6). Having this benchmark and comparing it to the current marriage market helps us understand how much each group has benefitted from access to interracial marriage, considering all the disparities in marital gains and population composition. I call this measure "individual gains from interracial marriage."

To better understand this welfare measure, consider the example of Black men and Black women. As documented in Section 4.4, Black men's interracial marriages constantly have higher marital gains than Black women's interracial marriages. This means that Black men's interracial marriages are easier to form, which essentially creates a larger marriage pool for Black men than for Black women. Additionally, due to an imbalanced sex ratio among college graduates documented in Section 2, college-educated Black men have a larger marriage pool even in terms of quantities of different-race potential partners, relative to college-educated Black women. Therefore, we expect that Black men are likely to have higher chances of marriage and higher marital welfare when there is access to interracial marriage, relative to a complete racial segregation benchmark. Conversely, it is unclear if Black women would have higher chances of getting mar-

ried in the actual marriage market, even though they have a larger and more racially diverse marriage pool than the segregation benchmark. My estimation approach allows me to understand the distributional impacts of the existing disparities in the marriage market.

## 5.1 Estimation Strategy

**Counterfactual simulation for a complete segregation benchmark:** I describe the steps to compute the counterfactual equilibrium marriage patterns for the counterfactual scenario of complete racial segregation.

- **Step 1:** For each survey year  $t$ , I take the marital surplus matrix  $\hat{\mathbf{Z}}_t$  that is estimated in Section 4.4.
- **Step 2:** For each  $\hat{\mathbf{Z}}_t$ , I replace  $\hat{Z}_t^{IJ}$  by  $-\infty$  for all  $(I, J)$  that correspond to interracial marriage ( $R_i \neq R_j$ ).<sup>24</sup> This guarantees that interracial marriages do not happen in the segregated marriage market. I keep the marital surpluses for all same-race marriage at their corresponding values in  $\hat{\mathbf{Z}}_t$ . I denote  $\hat{\mathbf{Z}}_t^{Segregated}$  the resulting counterfactual marital surplus matrix for complete racial segregation.
- **Step 3:** I compute the counterfactual marriage patterns for each survey year  $t$ , using  $\hat{\mathbf{Z}}_t^{Segregated}$  and the observed population vectors  $\mathbf{n}_t$  and  $\mathbf{m}_t$ . This is done by applying the Iterative Projection Fitting Procedure (IPFP) on the system of matching functions represented by Equations (8) and (9) in Section 4.3.<sup>25</sup>

Through the above procedures, I obtain the counterfactual equilibrium quantities of single men and women of each type for each survey year.

**Individual gains from (access to) interracial marriage:** Using the counterfactual sorting patterns, I define and estimate “individual gains from interracial marriage.” This measure captures the additional welfare – which also corresponds to additional marriage probability in the specified model – each group receives in the actual marriage market over what they would get in a completely racially segregated marriage market.

<sup>24</sup>Full racial segregation can be represented by *any* marital surplus matrix where the entries for interracial marriages have infinitely negative values. However, because the objective is to only capture the changes in sorting patterns due to changes in the marital gains associated with interracial marriage, I choose the values of same-race marriages in  $\hat{\mathbf{Z}}_t^{Segregated}$  to be same as their values in  $\hat{\mathbf{Z}}_t$ .

<sup>25</sup>Galichon and Salanié (2022) explain that IPFP is an efficient and fast way to solve for the stable matching. This algorithm solves the system of equations defined by Equations (8) and (9) iteratively, starting from the vector of arbitrary guesses  $\mu_{(0)}^I$  and  $\mu_{(0)}^J$ . The intuition behind this algorithm is that the average utilities ( $\bar{u}^I$  and  $\bar{v}^J$ ) of each type of men and women act as *prices* in the marriage market that equate demand and supply of partners. Hence, the algorithm adjusts the prices alternatively on each side of the market until it reaches the stable matching.

Formally, the individual gains from interracial marriage for each man type  $I$  are defined as the following:

$$Gain_{m,t}^I = \bar{u}_t^{I,Actual} - \bar{u}_t^{I,Segregated} \quad (10)$$

where  $\bar{u}_t^{I,Actual}$  is the expected utility for each race-education-gender group in the actual marriage market and  $\bar{u}_t^{I,Segregated}$  is the corresponding expected utility in the racially segregated marriage market in year  $t$ . Analogously, for each woman type  $J$ , the individual gains from interracial marriage are:

$$Gain_{f,t}^J = \bar{v}_t^{J,Actual} - \bar{v}_t^{J,Segregated} \quad (11)$$

For ease of interpretation, I rescale the welfare gains to represent the percentage change in the single rate that would occur when the marriage market is completely segregated. To explain, note that  $Gain_{m,t}^I$  can be re-written as:

$$\begin{aligned} Gain_{m,t}^I &= \ln\left(\Pr(Single | I, t, Segregated)\right) - \ln\left(\Pr(Single | I, t, Actual)\right) \\ &\approx \frac{\Pr(Single | I, t, Segregated) - \Pr(Single | I, t, Actual)}{\Pr(Single | I, t, Actual)} \end{aligned}$$

Therefore, the welfare gain multiplied by 100 can be interpreted as the percentage change in the single rate of type  $I$  men that would occur if we move from the current state to complete segregation in each year  $t$ .

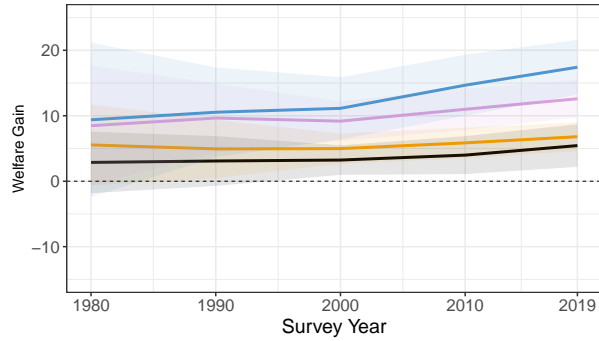
It should be noted that this welfare gain measure is silent about the specific mechanisms that have driven the individual gains from interracial marriage. A positive individual gain *only captures* the fact that the single rate of a given type is lower in the actual world than in the completely racially segregated world. It does not tell us which parts of marital surplus or the population distribution drive the gains. In Section 6, I investigate which changes in marital surplus and population composition have driven the uneven gains from interracial marriage.

## 5.2 Results

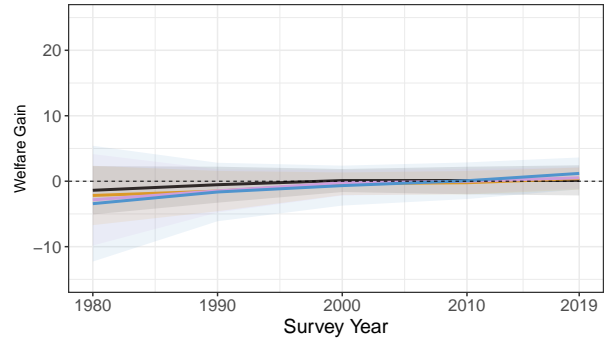
**Results for Black people:** Figure 4 shows clear gender- and education-based gaps in the evolution of individual gains for Black men and women. Even as early as in 1980, Black men gained from access to interracial marriage as shown in Figure 4a, although these positive gains were not significantly different from zero. Over the years, the most educated Black men experienced the highest increase in welfare gains. In 2019, the magnitude of the welfare gains for college-educated Black



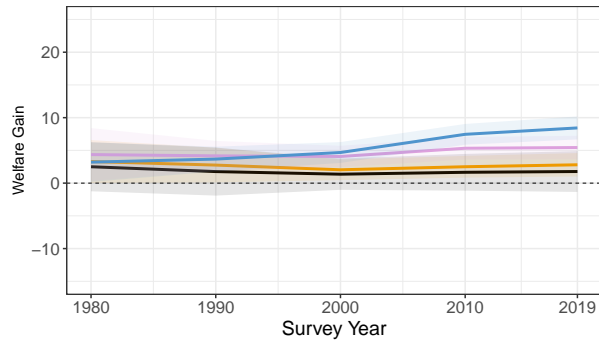
Figure 4: Individual Gains from Interracial Marriage



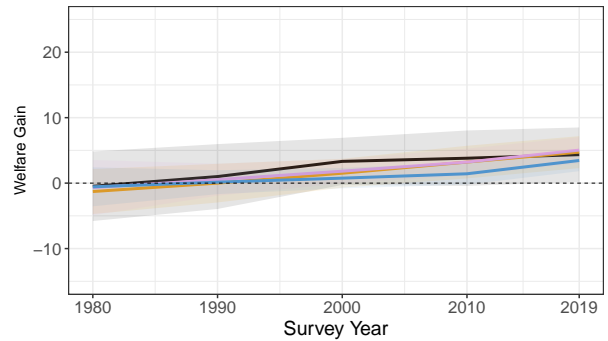
(a) Black Men



(b) Black Women



(c) White Men



(d) White Women

**Note:** These figures plot the welfare gain from interracial marriage as defined by Equation (10) and Equation (11) for each specified type of men and women. Note that welfare gain can be thought of as a change in marriage probability due to access to interracial marriage, as explained in the text. Data used to calculate the gains are: 1980-2000 Decennial Census, 2010 and 2019 5-Year ACS. I focus on age 37-46 men and age 35-44 women for each survey year. Further details on the sample restriction are described in Section 3. Shade for each line refers to the 95% confidence interval. Standard errors are calculated from the sampling variation in the data. *HSD*: high school dropout, *HSG*: high school graduate with no college education, *SC*: less than 4 years of college education, and *CG*: 4 years of college education or more.

men is substantial: in the absence of access to interracial marriage, the probability of being single would be on average 17.5% higher for the college-educated Black men. Across all years, there is a clear positive relationship between Black men's education level and the individual gains from interracial marriage.

In contrast, Figure 4b shows that Black women did not gain from interracial marriage across all years. While the welfare gain for college-educated Black women increased over time from the negative mean value in 1980, this increase is not as large as what their male counterpart has experienced. This reveals a less-discussed aspect of the currently low marriage rates of Black women. Previous literature has focused on the explanations related to the within-race marriage market; the low marriage rate of Black women is typically attributed to the lack of marriageable Black men (Charles and Luoh, 2010; Liu, 2020; Caucutt et al., 2021). Figure 4b provides an explanation pertaining to the across-race marriage market. Given the existing structure of marital surplus and population supplies, Black women do not benefit from access to interracial marriage at all, which further contributes to their low marriage rates.

**Results for White people:** Figure 4c shows that college-educated White men experienced a larger increase in welfare gains than their less-educated counterparts: in 2019, interracial marriage led to a reduction in their probability of being single by 8% compared to the complete segregation scenario. In contrast, non-college-educated White men experienced a slight decrease in welfare gains over time. From 2000 onward, there is a clear positive relationship between White men's education level and the welfare gains they receive from access to interracial marriages.

Welfare gains for White women show different patterns. While all White women did not gain at all from interracial marriage in 1980, they increasingly gained more over time. Notably, there is no clear education difference in the trends, unlike the case of White men. In 2019, access to interracial marriage reduced the probability of being single for White women, across all education levels, by 3 ~ 5% relative to the complete segregation scenario.

## 6 Decomposition

What drove the uneven individual welfare gains from interracial marriage? *Any* change in the marital surplus and population supplies affects certain groups favorably while affecting others negatively. Hence, it is important to comprehensively examine the effects of all changes in the marriage market to uncover the intricate ways through which changing marital gains and population supplies have shaped the uneven gains from interracial marriage. Using a decomposition method based on the matching model, I identify which changes have been most important to each social group's marital prospects.

To better illustrate the equilibrium effects of each marriage market change, I consider two examples: one related to marital surplus and the other to population supplies. First, consider an increase in the marital surplus associated with (Black man, White woman) marriages. This change favors Black men's marital prospects: although the number of women in the market remains constant, this change essentially expands the marriage pool for Black men, as marriages with White women have become more attractive. However, all else equal, this is an unfavorable change to Black women's and White men's marital prospects, because they would experience heightened marriage competition. Furthermore, other racial groups' marital prospects – such as Hispanics and Asians' – can also be affected by this marriage market change.

Similar logic applies to the following example of a population change. Suppose that the number of White women in the marriage market has increased. All else equal, this would increase Black men's gains from access to interracial marriage by expanding their marriage pool, while reducing the marital prospects of Black women, as well as other women's. Therefore, when examining any marriage market change, we need to take into account how it would impact *everyone's* marital prospects.

The matching model outlined in Section 4 enables me to account for the equilibrium nature of marriage market changes, by tracking how *each* marriage market change can impact *all* participants. The decomposition method effectively summarizes the equilibrium effects of a large number of marriage market changes that happened in the US over the past several decades. By doing so, it helps us identify the most important changes that explain the gender gaps in marital prospects for each racial group.

## 6.1 Overview of the Method

In this section, I explain each step I conduct to perform decomposition analyses. The idea is to use the system of equilibrium matching functions in Section 4 to track the impacts of changing marital surplus and changing population. To accomplish this, I combine the implicit function theorem (IFT) and a fine-tuning method. While the application of IFT to the matching model has previously been suggested (Choo and Siow, 2006; Galichon and Salanie, 2017), to the best of my knowledge, this method has not yet been empirically implemented in the literature. I demonstrate how this can be done.

**Implicit differentiation.** It is worth mentioning that the equilibrium matching functions (Equations (8) and (9)) are interdependent on one another, specifying how any given marital surplus and population supply relates to the marriage pattern for all. Hence, applying IFT to the whole system of matching functions enables me to estimate how any small change in the marriage market affects the equilibrium sorting patterns.

To facilitate the application of IFT, I start by applying the following changes of variables:  $\tilde{Z}_t^{IJ} = \exp\left(\frac{Z_t^{IJ}}{2}\right)$  and  $s_t^{I\phi} = \sqrt{\mu_t^{I\phi}}$  and  $s_t^{\phi J} = \sqrt{\mu_t^{\phi J}}$ . I use  $\tilde{\theta}_t = (\mathbf{n}_t, \mathbf{m}_t, \tilde{\mathbf{Z}}_t)$  to denote a vector of all components of marital surplus and population supplies.<sup>26</sup> Then, Equations (8) and (9) are re-written as:

$$F^I(\tilde{\theta}_t) = (s_t^{I\phi})^2 + \sum_J \tilde{Z}_t^{IJ} s_t^{I\phi} s_t^{\phi J} - n_t^I = 0 \quad \forall I \quad (12)$$

$$G^J(\tilde{\theta}_t) = (s_t^{\phi J})^2 + \sum_I \tilde{Z}_t^{IJ} s_t^{I\phi} s_t^{\phi J} - m_t^J = 0 \quad \forall J \quad (13)$$

Applying IFT on the whole system of equations (12) and (13) leads to the following Jacobian matrix, which summarizes the impact of each marriage market change on the number of unmarried people in each social group.

$$\begin{bmatrix} \frac{\partial \mathbf{s}_t}{\partial \tilde{\theta}_t} \end{bmatrix}_{(2K) \times (2K+K^2)} = - \begin{bmatrix} \frac{\partial \mathbf{F}}{\partial \mathbf{s}_t} \\ \frac{\partial \mathbf{G}}{\partial \mathbf{s}_t} \end{bmatrix}_{(2K) \times (2K)}^{-1} \begin{bmatrix} \frac{\partial \mathbf{F}}{\partial \tilde{\theta}_t} \\ \frac{\partial \mathbf{G}}{\partial \tilde{\theta}_t} \end{bmatrix}_{(2K) \times (2K+K^2)} \quad (14)$$

For the brevity of notation, I use  $\mathbf{s} = (s^{1\phi}, \dots, s^{K\phi}, s^{\phi 1}, \dots, s^{\phi K})$  to denote a vector of the square roots of the number of unmarried people in each social group.  $\mathbf{F}$  is a vector for  $F^I$  and  $\mathbf{G}$  is a vector for  $G^J$ . The full solution for the partial derivatives is presented in Appendix B.1.

**Linking the Jacobian to welfare gains from interracial marriage.** Recall from Section 5 that the individual gain from interracial marriage compares each social group's singlehood rate in the current marriage market versus that in a complete racial segregation scenario. In other words, individual gain is a function of each group's singlehood rates, as shown in Equations (10) and (11). Therefore, it is straightforward to use the Jacobian matrix (Equation (14)) to understand how a small change in marital surplus and population supplies affects the individual gains from interracial marriage.

To demonstrate, consider the expected utility for type  $I$  men. Recall that this expected utility takes the following form:  $\bar{u}_t^I = -\ln(\Pr(\text{single} | I, t)) = -\ln\left(\frac{\mu_t^{I\phi}}{n_t^I}\right)$  and  $\mu_t^{I\phi} = (s_t^{I\phi})^2$ . Then, the total

<sup>26</sup>Full expansion of  $\tilde{\theta}_t$  is  $\tilde{\theta}_t = (n_t^1, \dots, n_t^K, m_t^1, \dots, m_t^K, \tilde{Z}_t^{11}, \tilde{Z}_t^{12}, \dots, \tilde{Z}_t^{KK})$ . This vector has  $2K + K^2$  components; because  $K = 16$  in my setting,  $\tilde{\theta}_t$  has 288 components.

differential of  $\bar{u}_t^I$  is:

$$\underbrace{d\bar{u}_t^I}_{\text{Change in marital utility of type I men}} = \underbrace{\frac{1}{n_t^I} dn^I}_{\text{Contribution from the change in \# of type I men}} - \underbrace{\frac{2}{s_t^{I\phi}} \left( \frac{\partial s_t^{I\phi}}{\partial \tilde{\theta}_t} d\tilde{\theta}_t \right)}_{\text{A combination of contributions from each market change}} \quad (15)$$

where the partial derivative  $\frac{\partial s_t^{I\phi}}{\partial \tilde{\theta}_t}$  is from the Jacobian matrix shown in Equation (14).

Note that the right-hand side of Equation (15) can be *linearly* decomposed into parts that are attributed by each change in the marital surplus and population supplies,  $d\tilde{\theta}_t^k$ . This is the key feature that allows the decomposition of the change in each social group's gain from interracial marriage *into* contributions made by each change in the population distribution and the marital surplus. This will be further explained in the next steps.

Because the welfare gain from interracial marriage is the difference between each social group's expected utility in the actual world and the expected utility in the completely segregated world, this can be expressed analogously using Equation (15).

**Fine-tuning method to link four decades of changes in  $\tilde{\theta}$ .** The implicit function theorem approach only applies to small changes in the model primitives. However, the objective is to understand the effects of four decades of changes in population and in marital surplus on welfare gains. Using the implicit function approach for such large changes may led to an incorrect decomposition.

To deal with this issue and better approximate the effects of changes in marital surplus and population supplies that happened over the past four decades, I implement a fine-tuning method following Judd (1998). This method decomposes the large changes in the marriage market into a series of infinitesimal changes. Using this method, I evaluate the differentials for each infinitesimal change and update the approximation along the path of infinitesimal changes. I apply this method for each decade within the 1980-2019 period, based on available survey years.

For a better understanding of this method, I illustrate using the following example. Consider the changes in the marriage market from 1980 to 1990. I denote 1980 as  $\tau = 0$  and 1990 as  $\tau = 1$ . Then  $\tilde{\theta}_0$  (resp.  $\tilde{\theta}_1$ ) is the vector of marital surplus and population supplies in 1980 (resp. in 1990). Consider the homotopy:

$$\tilde{\theta}_\tau = \tau \tilde{\theta}_1 + (1 - \tau) \tilde{\theta}_0, \quad \tau \in [0, 1]$$

which defines a series of intermediate values of marital surplus and population supplies with interval  $d\tau$  between observed values at  $\tau = 0$  and  $\tau = 1$ . Because the vector of marital surplus and

population  $\tilde{\theta}_\tau$  is now a function of  $\tau$ , Equation (15) is re-written as:

$$d\bar{u}_\tau^I = \frac{1}{n_\tau^I} (n_1^I - n_0^I) d\tau - \frac{2}{s_\tau^{I\phi}} \left( \frac{\partial s_\tau^{I\phi}}{\partial \tilde{\theta}_\tau} (\tilde{\theta}_1 - \tilde{\theta}_0) d\tau \right) \quad (16)$$

Using the above specification, I can use infinitesimal change  $d\tau$  in marital surplus and population to evaluate and decompose the infinitesimal changes in  $\bar{u}_\tau^I$  between the years 1980 and 1990. In practice, I specify  $d\tau = 0.001$  when estimating Equation (16) for each decade. Summing the decompositions of infinitesimal changes of the expected utility over the 1980-1990 period gives a better approximation of  $\Delta \bar{u}_\tau^I$  than directly using the observed 10-year changes in model primitives to evaluate Equation (15).

Application to the four decades of changes in individual gains from access to interracial marriage is done analogously. Further details on this method are provided in Appendix B.2.

**Decomposition.** The steps outlined above result in a linear decomposition of four decades of changes in individual gains, which are shown in Section 5, into contributions from changes in population and marital surplus. For instance, the welfare gain from access to interracial marriage for type  $I$  man between 1980 to 2019 are decomposed into the following:

$$\begin{aligned} \Delta^{2019-1980} \text{Gain}^I &= (\text{Contribution by } \Delta n^1) + \dots + (\text{Contribution by } \Delta n^K) \\ &+ (\text{Contribution by } \Delta m^1) + \dots + (\text{Contribution by } \Delta m^K) \\ &+ (\text{Contribution by } \Delta Z^{11}) + \dots + (\text{Contribution by } \Delta Z^{KK}) \end{aligned} \quad (17)$$

As shown in Equation (17), this method can summarize a large number of the contributions from various market-level changes. Therefore, this allows me to identify which changes have driven the individual gain from interracial marriage for each group of men and women over the past four decades.

I evaluate the validity of the decomposition method by comparing the estimated changes in welfare gains from the data (using Equations (10) and (11)) and the estimated welfare gains using the IFT approach. The latter is simply the total sum of contributions for each group, as represented by the right-hand side of Equation (17). Table 3 shows that the estimates based on the method closely match those based on the data for each group of man and woman, confirming the validity of the method.

Table 3: Data vs. IFT: 1980-2019 Changes in Welfare Gains from Interracial Marriage

Type	Men		Women	
	Data	IFT	Data	IFT
WhiteHSD	-0.728	-0.730	4.826	4.827
WhiteHSG	-0.492	-0.494	6.018	6.021
WhiteSC	1.076	1.074	5.727	5.729
WhiteCG	5.231	5.230	4.020	4.021
BlackHSD	2.566	2.567	1.515	1.516
BlackHSG	1.254	1.255	2.575	2.576
BlackSC	4.114	4.115	3.366	3.366
BlackCG	8.028	8.027	4.635	4.637

Notes: This table reports the changes in (i) welfare gain from access to interracial marriage of each group over the 1980-2019 period that is estimated from data and (ii) the corresponding changes estimated from the IFP method. "Data" column refers to the estimated change from the data, and "IFT" column refers to estimated changes using IFT according to Equation (17).  $d\tau = 0.001$  is used when applying the fine-tuning method.

## 6.2 Decomposition Results

Although my decomposition analyses encompass estimating the effects of *all* changes in the marriage market on each social group, I prioritize discussing the most significant impacts that contributed to the gender gaps in marital welfare for Black people and White people, respectively. For ease of exposition, I use abbreviations to denote various education levels, as outlined in Section 3.

### 6.2.1 Role of gender gap in marital surplus: A case for Black men and women

I describe how the evolving gender gap in marital surplus associated with interracial marriage has intensified the gender gap in marital welfare for Black men and women. Table 4 shows that the gender gap in marital gains for BlackCG men and BlackCG women was largely shaped by shifts in marital surplus. Specifically, for BlackCG men, combined changes in marital surplus substantially improved their gains from interracial marriage, surpassing the gains received by any other group from the same changes. In contrast, population changes only played a minor (and negative) role in the overall increase in their welfare gains from interracial marriage.

Table 4: Decomposition of the 1980-2019 Changes in the Welfare Gain from Interracial Marriage

Type	$\Delta^{2019-1980}Gain$	Total Contribution from the Changes in:	
		Population	Marital Surplus
BlackCG Men	8.0	-2.5	10.6
BlackHSG Men	1.3	-3.1	4.3
BlackCG Women	4.6	0.8	3.8
BlackHSG Women	2.6	1.0	1.6

Notes: This table presents the decomposition of the 1980-2019 changes in the welfare gains from interracial marriage for the specified group.  $\Delta^{2019-1980}Gains$  is the change in the welfare gains for the specified group over the 1980-2019 period. "Population" Column shows the summation of all contributions by changes in population over the 1980-2019 period. "Marital Surplus" Column shows the summation of all contributions by changes in marital surplus over the 1980-2019 period..

To understand which specific shifts in marital surplus played the most important role, I document the top three positive and negative contributions from the marital surplus changes for BlackCG men and BlackCG women, respectively. Panel A in Table 5 shows that BlackCG men have benefitted the most from the increases in marital surplus associated with interracially/inter-ethnically marrying WhiteCG and HispanicCG women. These changes amount to 77.5% of their total welfare gain from interracial marriage over the analysis period ( $\Delta Gain = 8.0$ ).

Importantly, these positive contributions are large enough to render other negative forces negligible for BlackCG men. For instance, an increase in marital surplus for (WhiteCG men, BlackCG women) marriage is an *unfavorable* change for BlackCG men's marital prospects, as it would intensify marriage competition for them. However, as shown in Table 5, the negative contribution from this unfavorable change was negligible (-0.6), relative to the positive contributions (4.7+1.5) from the increases in marital surplus for BlackCG men's interracial marriages.

In contrast, Panel B in Table 5 shows that the marital surplus changes associated with BlackCG women's interracial marriage had much smaller positive effects for BlackCG women. Specifically, although BlackCG women's marital prospects were improved due to the rise in marital surplus associated with interracially marrying WhiteCG men, this gain is much smaller – less than half – of what BlackCG men gained from marrying WhiteCG women. Furthermore, the second row of Panel B shows that about half of this gain for BlackCG women is offset by an *unfavorable* change for BlackCG women's marital prospects, which is the increase in marital surplus for (BlackCG men, WhiteCG women) marriages.



Table 5: Decomposition: Top three contribution from changes in  $Z$ , Black College Graduates

A. Decomposition for BlackCG Men's $\Delta$ Welfare Gain ( $\Delta Gain = 8.0$ )				
Contribution	Top (+)	4.7	1.8	1.5
		$\uparrow Z^{BlackCG, WhiteCG}$	$\downarrow Z^{BlackCG, BlackSC}$	$\uparrow Z^{BlackCG, HispCG}$
	Top (-)	-0.6	-0.6	-0.4
		$\uparrow Z^{WhiteCG, BlackCG}$	$\downarrow Z^{BlackSC, BlackCG}$	$\downarrow Z^{BlackCG, AsianHSD}$
B. Decomposition for BlackCG Women's $\Delta$ Welfare Gain ( $\Delta Gain = 4.6$ )				
Contribution	Top (+)	2.0	1.9	1.2
		$\uparrow Z^{WhiteCG, BlackCG}$	$\downarrow Z^{BlackCG, BlackCG}$	$\downarrow Z^{BlackSC, BlackCG}$
	Top (-)	-1.0	-0.9	-0.5
		$\downarrow Z^{BlackCG, BlackSC}$	$\uparrow Z^{BlackCG, WhiteCG}$	$\downarrow Z^{BlackCG, BlackHSG}$

Notes: This table presents the top three positive and negative contributions from marital surplus to the 1980-2019 changes in the welfare gains from interracial marriage for Black college graduate men (Panel A) and Black college graduate women (Panel B). For marital surplus  $Z^{IJ}$ ,  $I$  refers to husband's type and  $J$  refers to wife's type. Upward arrow ( $\uparrow$ ) indicates that the corresponding marital surplus has increased over the analysis period, and downward arrow ( $\downarrow$ ) indicates that it has decreased over the analysis period.

Therefore, the decomposition results imply that the gender disparities in marital surpluses associated with Black people's interracial marriages played an important role in creating a gender gap in their marital prospects. For lower-educated Black people, I show in Appendix Table A3 that none of the changes in marital surplus associated with their interracial marriages had a significant impact on their marital welfare. All in all, my results show that the marital surplus associated with interracial marriage has evolved in a way that is most favorable to the most educated Black men among Black people.

### 6.2.2 Role of sex ratio imbalance: A case for White men and women

In this section, I describe how the growing sex ratio imbalance has contributed to the gender gap in marital welfare. Table 6 shows that population changes played a substantial role in driving up the welfare gains that WhiteCG men received from access to interracial marriage. This is unlike the case of BlackCG men, who mostly benefitted from marital surplus changes. In contrast, for White women, population changes had overall negative effects on their marital welfare.

Table 6: Decomposition of the 1980-2019 Changes in the Welfare Gain from Interracial Marriage

Type	$\Delta^{2019-1980}Gain$	Total Contribution from the Changes in:	
		Population	Marital Surplus
WhiteCG Men	5.2	6.8	-1.6
WhiteHSG Men	-0.5	5.4	-5.8
WhiteCG Women	4.0	-1.2	5.2
WhiteHSG Women	6.0	-0.7	6.7

Notes: This table presents the decomposition of the 1980-2019 changes in the welfare gains from interracial marriage for the specified group.  $\Delta^{2019-1980}Gains$  is the change in the welfare gains for the specified group over the 1980-2019 period. "Population" Column shows the summation of all contributions by changes in population over the 1980-2019 period. "Marital Surplus" Column shows the summation of all contributions by changes in marital surplus over the 1980-2019 period..

To further decompose the effects of changing population composition, I start by showing in Table 7 that the overall changes in the non-White population have had varying impacts on WhiteCG men and WhiteCG women. Panel A shows that WhiteCG men benefitted from the overall increase in the non-White female population. This positive contribution is large enough to completely offset the impact from unfavorable marriage market changes for them – which is the increase in the non-White male population, which intensifies marriage competition for WhiteCG men.

In contrast, the marital prospects of WhiteCG women were diminished by the overall changes in the non-White population. Specifically, the increase in the non-White female population, which is an unfavorable marriage market change for White women, completely offset the positive contribution from an increase in the non-White male population.

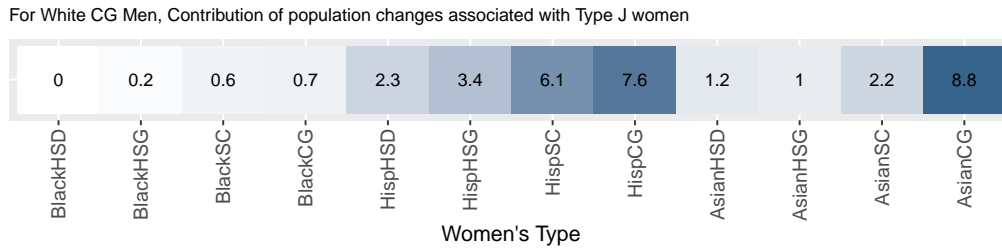
I further investigate which non-White populations have driven these gender differences in marital gains from interracial marriage. As shown in Figure 5, WhiteCG men’s rising welfare gains have been largely driven by the growing AsianCG women and HispanicCG women population. Conversely, these population changes diminished WhiteCG women’s marital prospects by heightening marriage competition. Appendix Figure A12 further demonstrates that for WhiteCG men, the positive effects from the rise in the female college graduate population were large enough to completely offset the negative impacts of the increases in the non-White male population. In contrast, for WhiteCG women, the positive impacts of the rising Asian and Hispanic male population were insufficient to offset the negative impacts of female population changes. All in all, these results imply that the growing sex ratio imbalance among college graduates across all races, as documented in Section 2, played an important role in shaping the gender gap in marital prospects for White men and women.

Table 7: Contributions from population changes to welfare gains for White college graduates

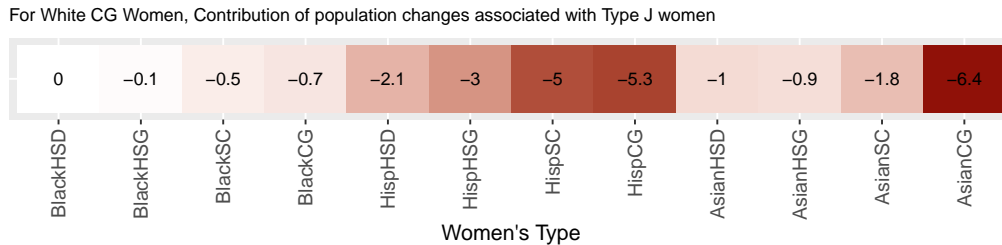
	Population Changes 1980-2019			
	Non-White Female	Non-White Male	White Female	White Male
A. Decomposition for WhiteCG Men's $\Delta$ Welfare Gain ( $\Delta Gain = 5.2$ )				
Contribution	34.1	-26.3	-5.0	4.0
B. Decomposition for WhiteCG Women's $\Delta$ Welfare Gain ( $\Delta Gain = 4.0$ )				
Contribution	-26.8	25.7	5.5	-4.5

Notes: This table presents the decomposition of the 1980-2019 changes in the welfare gains from access to interracial marriages for WhiteCG men and WhiteCG women. This table focuses on the contributions from the population changes. Each column shows the summation of all contributions made by populations corresponding to the label.

Figure 5: Details on the contributions from the changes in non-White population



(a) Decomposition for WhiteCG Men's Welfare Gains



(b) Decomposition for WhiteCG Women's Welfare Gains

Note: This figure presents the decomposition of the 1980-2019 changes in the welfare gains from interracial marriage for WhiteCG men and WhiteCG women. This figure focuses on the contributions of the changes in different-race populations. Each column shows the contribution made by the change in the corresponding population.

## 7 Counterfactual Exercises

So far, I have shown how the disparities in marital surplus and population composition have led to uneven benefits from access to interracial marriage. Notably, for Black people, gender disparities in marital surplus from interracial marriage have played a crucial role in creating gender gaps in marital welfare.

What would happen if there were no gender gaps in marital gains from interracial marriage for Black people? Furthermore, what will happen if race is no longer a factor considered in marriage matching? In this section, I simulate counterfactual marriage patterns using alternative marital surplus associated with interracial marriages and investigate their impacts on the marital welfare of each social group.

### 7.1 Counterfactual: Removing the gender gap in the marital surplus

I begin by considering the absence of the gender gaps in the marital surplus from interracial marriage. I focus on the case of interracial marriages involving Black men and women. The goal here is to understand if the absence of such a gender gap would improve Black women's marriage probabilities without harming all other groups' marriage probabilities.

There are two different ways of modeling the absence of such gender gaps in marital surplus. The first way is to elevate the marital gains associated with *Black women's* interracial marriages to match those associated with *Black men's* interracial marriages. Before formally describing this scenario, I rewrite the marital surplus  $Z^{IJ}$  as  $Z^{(R_i, E_i), (R_j, E_j)}$ , where  $R_i$  (resp.  $R_j$ ) denotes husband's (resp. wife's) race and  $E_i$  (resp.  $E_j$ ) denotes husband's (resp. wife's) education. Let  $\tilde{Z}$  denote the counterfactual marital surplus and  $Z$  denote the actual marital surplus. Then, I can express this counterfactual scenario as the following:

**Counterfactual 1:** *Increase the marital surplus associated with Black women's interracial marriage to be the same as those of Black men:*

$$\tilde{Z}^{(R_i, E_i), (Black_j, E_j)} = Z^{(Black_i, E_i), (R_j, E_j)} \quad (18)$$

where  $R_i \neq Black_i$  and  $R_j \neq Black_j$ . All other  $Z$ s remain the same as the actual values.

For example, the marriage between a BlackCG woman and a WhiteCG man would now have the same surplus as the marriage between a BlackCG man and a WhiteCG woman. Counterfactual 1 is equivalent to increasing the attractiveness of interracial marriage associated with Black women, hence moving towards stronger racial integration. This can be thought of as the reduced stigma associated with Black women's interracial marriages, or as higher marital preferences associated

with those marriages.

Alternatively, the second way of modeling the absence of gender disparities is to reduce the marital gains associated with *Black men's* interracial marriages to match those associated with *Black women's* interracial marriages. Specifically,

**Counterfactual 2:** *Decrease the marital surplus associated with Black men's interracial marriages to be the same as those of Black women:*

$$\tilde{Z}^{(Black_i, E_i), (R_j, E_j)} = Z^{(R_i, E_i), (Black_j, E_j)} \quad (19)$$

where  $R_i \neq Black_i$  and  $R_j \neq Black_j$ . All other  $Z$ s remain the same as the actual values.

This is equivalent to the reduced attractiveness of interracial marriages associated with Black men.

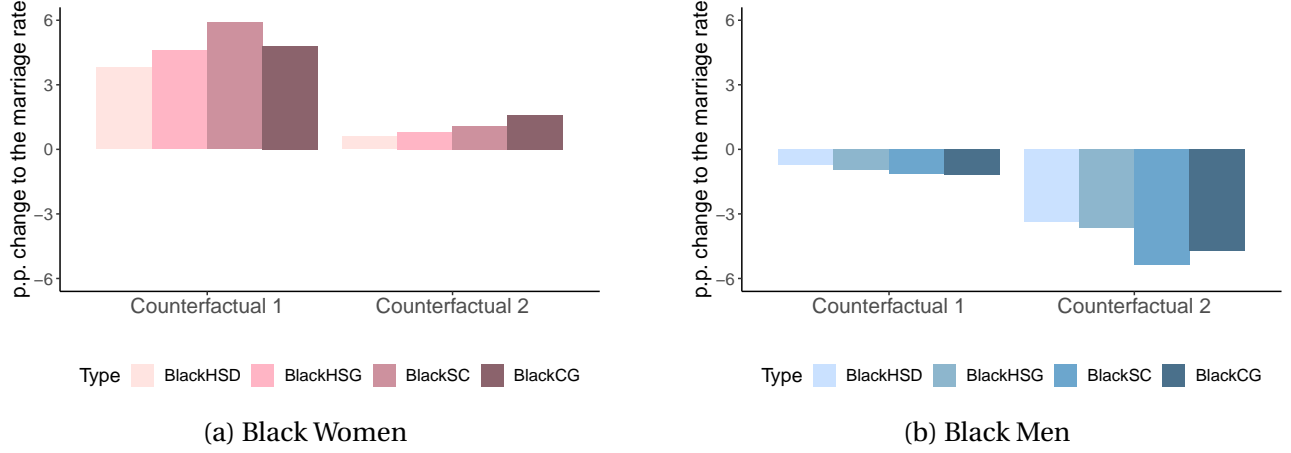
Using the estimated marital surplus for the year 2019, I construct the counterfactual marital surplus matrices corresponding to the first and second scenarios, respectively. I simulate counterfactual marriage rates in each scenario and compare them to the actual marriage rates for each social group.

Figure 6 shows that the first counterfactual substantially improves Black women's marriage probabilities without compromising Black men's. In Panel (a) of Figure 6, I show that elevating the marital surplus for Black women's interracial marriages to the levels of Black men's (Counterfactual 1) improves Black women's marriage rates by 4.0 ~ 5.9 p.p. In contrast, reducing the marital surplus for Black men's interracial marriages to the levels of Black women's (Counterfactual 2) does not lead to much improvement in Black women's marriage probabilities.

Similarly for Black men, Panel (b) of Figure 6 indicates that while the reductions in their marriage rates in Counterfactual 1 are small (ranging from -0.7 ~ -1.2 p.p.), the adverse effects are substantial in Counterfactual 2 (ranging from -3.4 ~ -5.4 p.p.). In the Appendix, I additionally show the impacts of each counterfactual on the marriage rates of other racial groups. Appendix Figures A7 and A8 show that both counterfactual scenarios only have small negative impacts on women of other racial groups. Furthermore, the first counterfactual leads to stronger improvements in marriage rates of men of other racial groups.

The overall implication of the above results is that in the absence of the gender gap in marital surplus, particularly *in the direction of* higher surplus for Black women's interracial marriage, Black women's marriage rates would improve without compromising the marriage rates of any other social groups. Conversely, if the surplus of Black men's interracial marriage becomes as low as Black women's, the overall marital welfare would be lower than that of the observed marriage market.

Figure 6: Percentage Point Changes in Marriage Rates after Removing Gender Gap in  $Z^{interracial}$ , Year 2019



Note: This figure plots the percentage point differences in marriage rate between actual marriage rates and counterfactual marriage rates for each group: (Counterfactual marriage rate - Actual marriage rate). Counterfactuals consider two different scenarios of removing the gender gap in the marital surplus from interracial marriage for Black people. As described in 7.1, **Counterfactual 1** sets the marital surpluses of *Black women's* interracial marriages the same as those of *Black men's* interracial marriages (Equation 18). Alternatively, **Counterfactual 2** sets the marital surpluses of *Black men's* interracial marriages the same as those of *Black women's* interracial marriages (Equation 19).

## 7.2 Counterfactual: Complete racial integration

Lastly, I predict how the marriage patterns would change if race becomes less important in marriage matching, extrapolating from the observed trends from the previous decades. I start by constructing a marital surplus matrix for complete racial integration, which is a scenario where race is no longer a factor considered in marriage matching. Note that, by definition, any matrix that does not depend on the race of each spouse can reflect complete racial integration. In practice, I choose a marital surplus matrix that (i) only depends on the education of both spouses and that (ii) minimizes the weighted Euclidean distance from the estimated  $\hat{Z}_t$ . The marital surplus for each education pair is constructed as the weighted average of estimated  $\hat{Z}_t^{IJ}$  from the data, conditional on the education levels of both spouses:

$$\hat{Z}_t^{E_i, E_j} = \sum_{R_i, R_j} \widehat{Pr}(R_i, R_j | E_i, E_j, t) \hat{Z}_t^{(E_i, R_i), (E_j, R_j)} \quad (20)$$

The marital surplus matrix for complete integration, denoted by  $\tilde{Z}_t^{Integrated}$ , is constructed by simply replacing all  $\hat{Z}_t^{(R_i, E_i), (R_j, E_j)}$  in  $\hat{Z}_t$  with the corresponding  $\hat{Z}_t^{E_i, E_j}$ . Appendix Figure A9 visualizes the differences between the counterfactual marital surplus and the actual marital surplus.

To construct a trajectory toward the complete integration, I take the following convex combination of the marital surplus matrices:

$$\hat{\mathbf{Z}}_t^{Simulated}(p) = (1 - p)\hat{\mathbf{Z}}_t^{Actual} + p\hat{\mathbf{Z}}_t^{Integrated} \quad (21)$$

where  $p \in [0, 1]$ . When  $p$  is closer to 1, the counterfactual marital surplus is closer to the case of complete racial integration.

Figure 7 shows that, based on the 2019 data, if race becomes less important in marriage matching, there will be fewer single Black men and women. For instance, when  $p = 0.5$ , the single rate of Black high school graduate women would decrease by 17 p.p. and the single rate of Black college-educated women would decrease by 20 p.p. Further progress toward racial integration not only closes the racial gap in marriage but also makes Blacks marry more than Whites. Appendix Figure A10 also demonstrates that other racial/ethnic minority groups would observe higher marriage rates in the complete racial integration scenario. For Whites, I find that racial integration would not change their marriage rates. Overall, the results show that racial minorities would substantially benefit when race is no longer relevant in marriage matching, as it significantly expands their potential pool of partners.

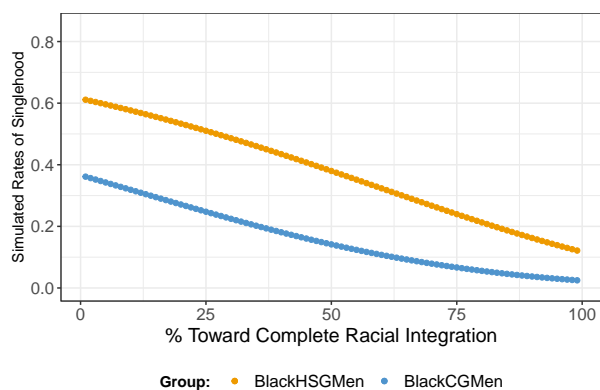
## 8 Conclusion

Although still largely segregated by race, the US marriage market has experienced an overall steady increase in interracial marriage. While this indicates positive progress towards social integration, the disparities in interracial marriage rates, especially the gender gap, suggests that some social group's marital prospects may be more limited than others.

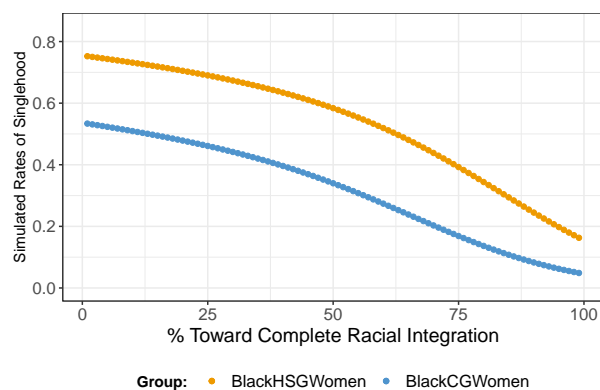
This paper investigates the evolution and welfare implications of the disparities in interracial marriage patterns using a structural model of marriage market equilibrium. I show that there have been wide disparities in marital gains across interracial marriage types. Due to these disparities in marital gains and population composition, certain groups, such as college-educated Black men, have experienced significant improvements in marital prospects from access to interracial marriages, while others, like Black women, have not.

Using a decomposition method that comprehensively examines how each marriage market change affected all social groups, I find that the (i) evolving gender gap in marital surplus associated with interracial marriage and (ii) increasing sex ratio imbalance both played a role, albeit in different ways for various groups. For Black men and women, I find that the gender gap in the marital surplus from interracial marriages played a bigger role in shaping the gender gap in marital prospects. In contrast, the increasingly imbalanced sex ratio among college graduates has bene-

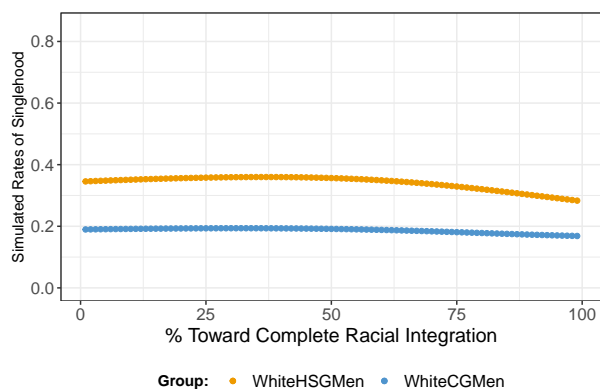
Figure 7: Simulated Rate of Singlehood for Varying Degree of Racial Integration



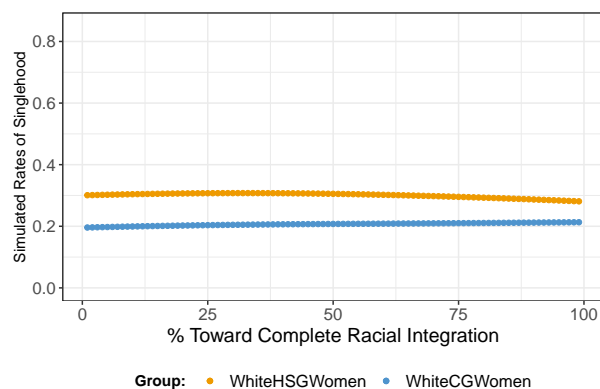
(a) Black Men



(b) Black Women



(c) White Men



(d) White Women

**Note:** This figure plots the simulated rate of singlehood at each % of racial integration (rescaled  $p$ ) for the specified group. “% Toward Complete Racial Integration” describes how close the counterfactual marital surplus is to the complete integration case. Estimation is done using the 2019 Census data. I focus on age 37-46 men and age 35-44 women. Further details on the sample restriction are described in Section 3.



fitted the marriage prospects of White men, while diminishing the marriage prospects of White women.

Simulation results show that in the absence of the gender gap in marital surplus associated with Black people's interracial marriage, particularly in the direction of stronger social integration, Black women's marital prospects and welfare would improve without compromising others'. More generally, I predict that as race becomes less important in marriage matching, the marriage probabilities among minorities would substantially improve without reducing those of Whites.

My findings suggest two main avenues for future research. First, it is important to understand the determinants behind varying marital surpluses across interracial marriages. The current estimates only reveal the extent to which marital gains differ, but not why. For example, the matching model cannot distinguish why the marital surplus between Black men and White women is higher than the marital surplus between White men and Black women. It would be fruitful to investigate whether these gender differences in marital surplus are affected by economic conditions, residential locations, or other social and cultural factors. Second, the question of which policies can promote interracial marriage needs to be further studied. [Merlino et al. \(2019\)](#) show that greater racial diversity in high school increases interracial dating as adults. It would be important to study whether the policies that encourage diversity in other settings would also promote interracial marriage and foster social integration.

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## A Appendix: Tables and Figures

### A.1 Additional Tables

Table A1: Percentage of Other Race and Mixed Races in Each Census Year, Female Aged 35-44, Male Aged 37-46

Year	Other Race	Mixed Race
1980	0.71%	N/A
1990	0.78%	N/A
2000	0.88%	2.12%
2010	0.92%	1.65%
2019	0.89%	2.55%

Notes: This table presents the proportion of people who reported Other Race (which includes "American Indian or Alaska Native" and "Other race") and Mixed Race among women aged 35-44 and men aged 37-46 for each survey year. A response option of mixed race was added from the 2000 census and onwards. Data sources for this table are: 1960 5% sample Census, 1970 1% sample Census, 1980 5% sample Census, 1990 5% sample Census, 2000 5% sample Census, 2010 5% sample American Community Survey (2006-2010 5 year pooled sample), 2019 5% sample American Community Survey (2005-2019 5 year pooled sample). Survey weight is applied.

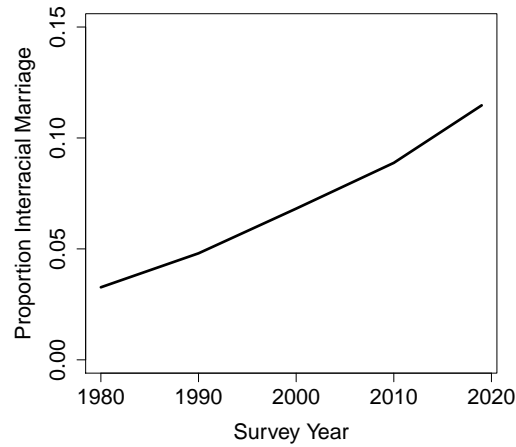
Table A2: Percentage of Never Married Singles who Cohabit in Each Census Year, Female Aged 35-44, Male Aged 37-46

Year	% Cohabiting
1990	11.3%
2000	17.7%
2010	21.3%
2019	24.6%

Notes: This table presents the proportion of respondents who reported to have cohabiting partners among never-married single women aged 35-44 and never-married single men aged 37-46 for each survey year. A response option for a cohabiting partner was added from the 1990 census and onwards. Data sources for this table are: 1990 5% sample Census, 2000 5% sample Census, 2010 5% sample American Community Survey (2006-2010 5 year pooled sample), 2019 5% sample American Community Survey (2005-2019 5 year pooled sample).

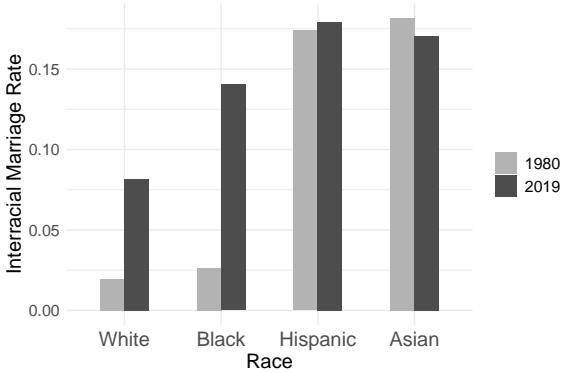
## A.2 Additional Figures

Figure A1: Interracial Marriage Rate, Among Married, Age 35-44



Note: This figure shows the proportion of interracial marriage among married men and women aged 35-44 for each survey year. Data sources for this figure are: 1960 5% sample Census, 1970 1% sample Census, 1980 5% sample Census, 1990 5% sample Census, 2000 5% sample Census, 2010 5% sample American Community Survey (2006-2010 5 year pooled sample), 2019 5% sample American Community Survey (2005-2019 5 year pooled sample). For Hispanics, 1960 and 1970 are excluded as the Hispanic identification is imputed by the IPUMS and does not properly capture the interracial marriage with non-Hispanic whites. Survey weight is applied.

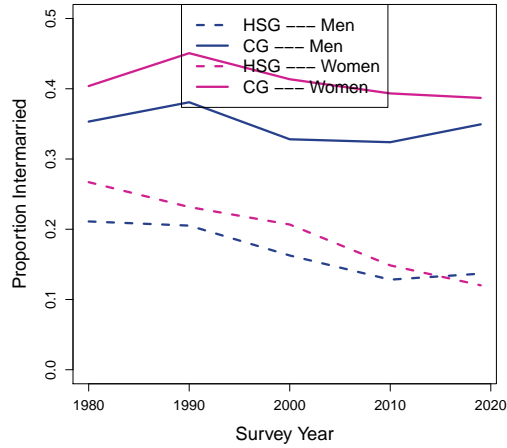
Figure A2: Interracial/Interethnic Marriage For Each Race/Ethnicity, Among Married, Age 35-44



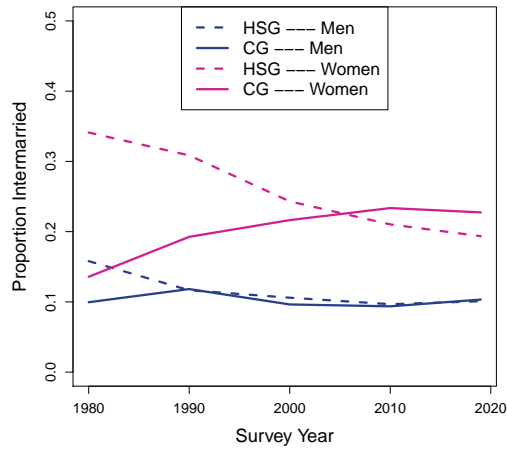
Note: This figure shows the proportion of those who married out of their race/ethnicity among married men and women aged 35-44 in 1980 and in 2019, respectively. Data sources for this figure are: 1980 5% sample Census microdata and 2019 5% sample American Community Survey (2015-2019 5-year pooled sample). Survey weight is applied.



Figure A3: Interracial/Interethnic Marriage Rates Among Hispanics and Asians



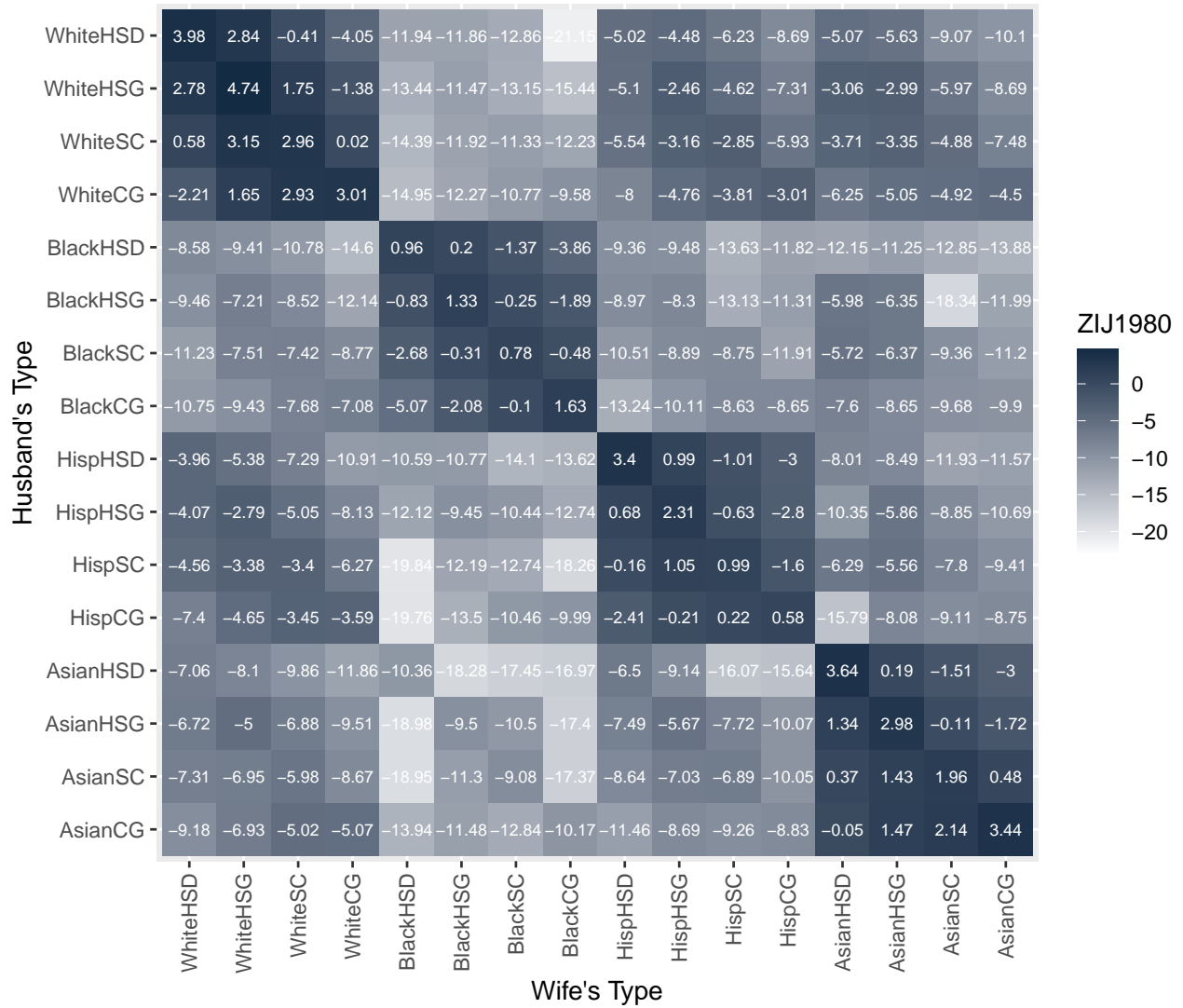
(a) Hispanics



(b) Asian

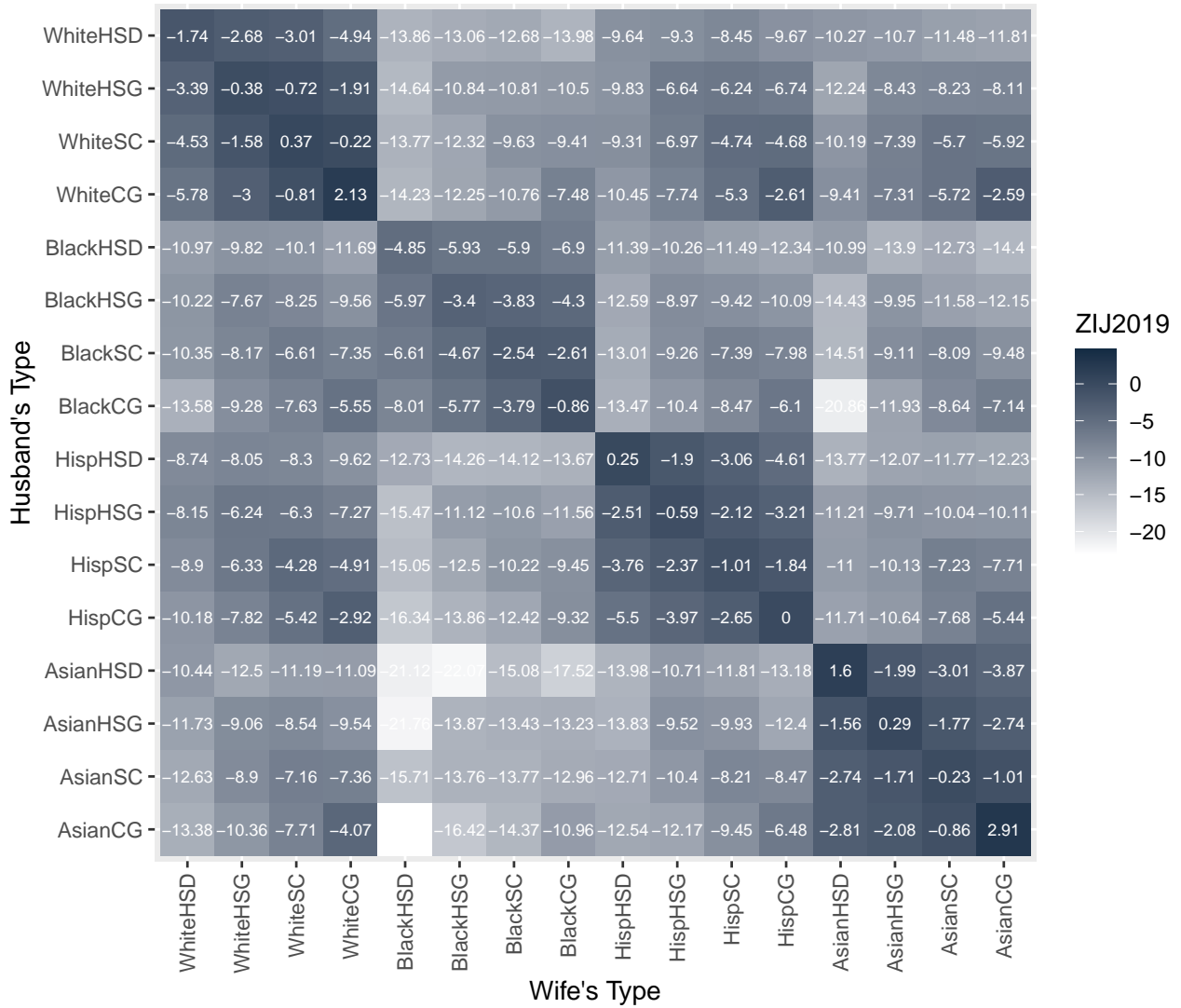
Note: This figure shows the proportion of those who married out of their race/ethnicity among married individuals of the specified group aged 35-44 in each survey year. “HSG” refers to high school graduation or the equivalent GED. “CG” refers to the four-year college degree or above. Data sources for this figure are: 1980 5% sample Census, 1990 5% sample Census, 2000 5% sample Census, 2010 5% sample American Community Survey (2006-2010 5 year pooled sample), 2019 5% sample American Community Survey (2005-2019 5 year pooled sample). Survey weight is applied.

Figure A4: Marital Surplus  $Z^{IJ}$ , 1980



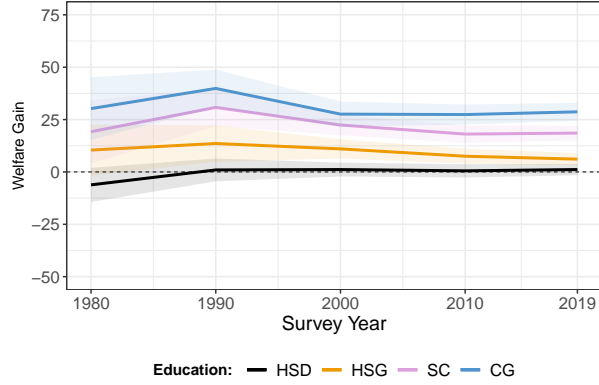
Note: This figure shows the heatmap for estimated marital surplus  $\hat{Z}_t^{IJ}$  for the survey year 1980. Data used to estimate this matrix is described in Section 3.  $I$  refers to husband's type (Row) and  $J$  refers to wife's type (Column).

Figure A5: Marital Surplus  $Z^{IJ}$ , 2019

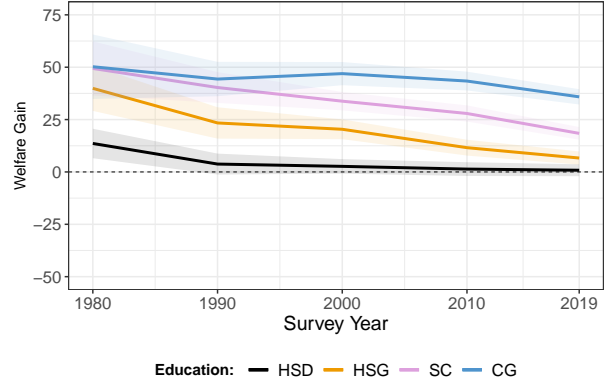


Note: This figure shows the heatmap for estimated marital surplus  $\hat{Z}_t^{IJ}$  for the survey year 2019. Data used to estimate this matrix is described in Section 3.  $I$  refers to husband's type (Row) and  $J$  refers to wife's type (Column).

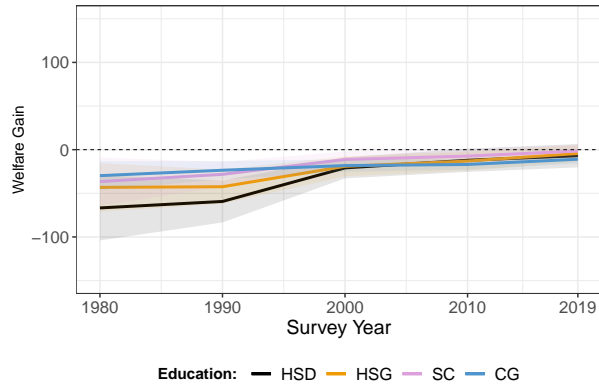
Figure A6: Individual Gains from Interracial Marriage



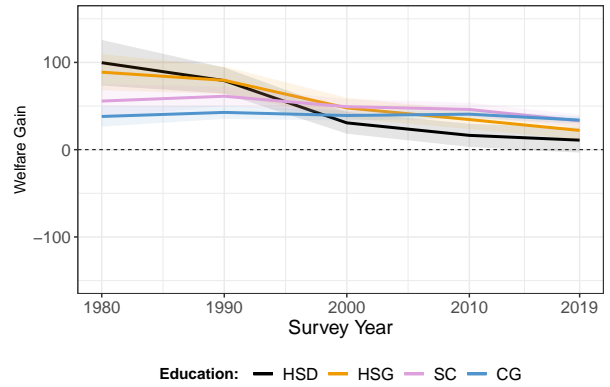
(a) Hispanic Men



(b) Hispanic Women



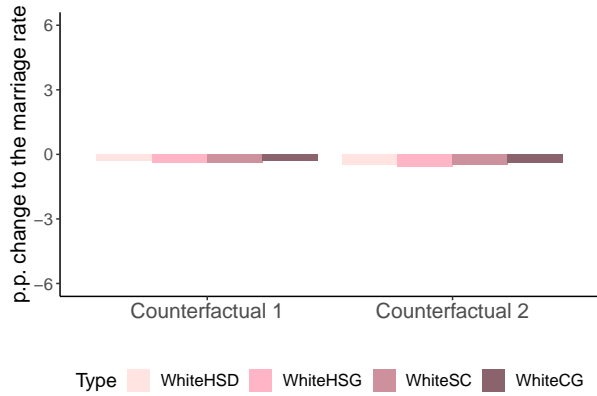
(c) Asian Men



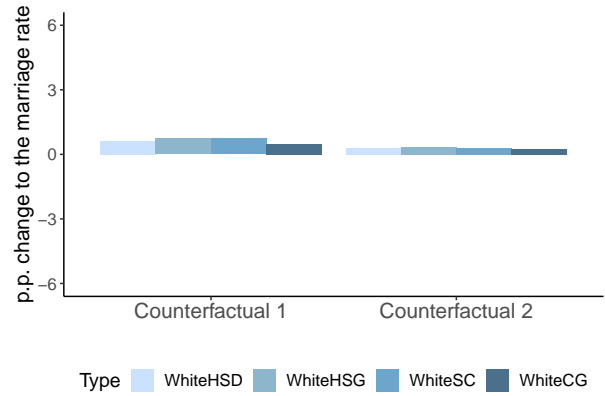
(d) Asian Women

**Note:** These figures plot the welfare gain from interracial marriage as defined by Equation (10) and Equation (11) for each specified type of men and women. Data used to calculate the gains are: 1980-2000 Decennial Census, 2010 and 2019 5-Year ACS. I focus on age 37-46 men and age 35-44 women for each survey year. Further details on the sample restriction are described in Section 3. Shade for each line refers to the 95% confidence interval. Standard errors are calculated from the sampling variation in the data. *HSD*: high school dropout, *HSG*: high school graduate with no college education, *SC*: less than 4 years of college education, and *CG*: 4 years of college education or more.

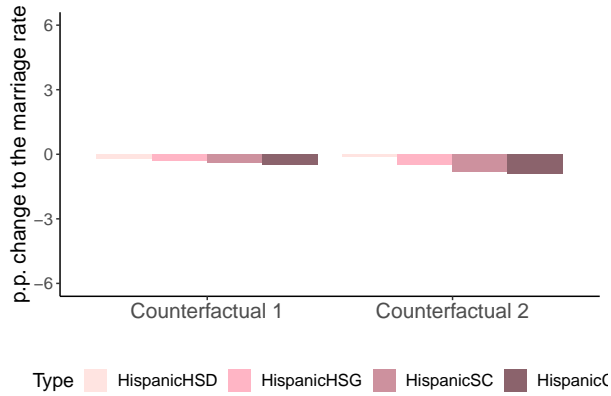
Figure A7: Percentage Point Changes in Marriage Rates after Removing Gender Gap in  $Z^{interracial}$  for Black People, Year 2019



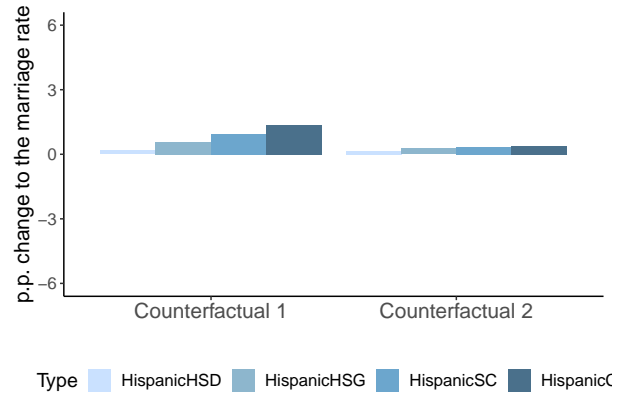
(a) White Women



(b) White Men



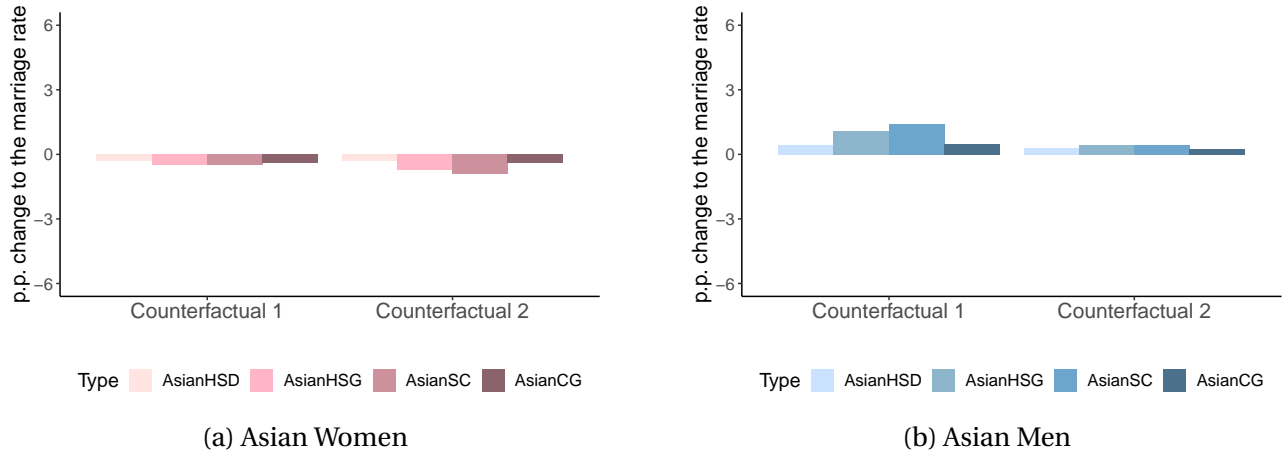
(c) Hispanic Women



(d) Hispanic Men

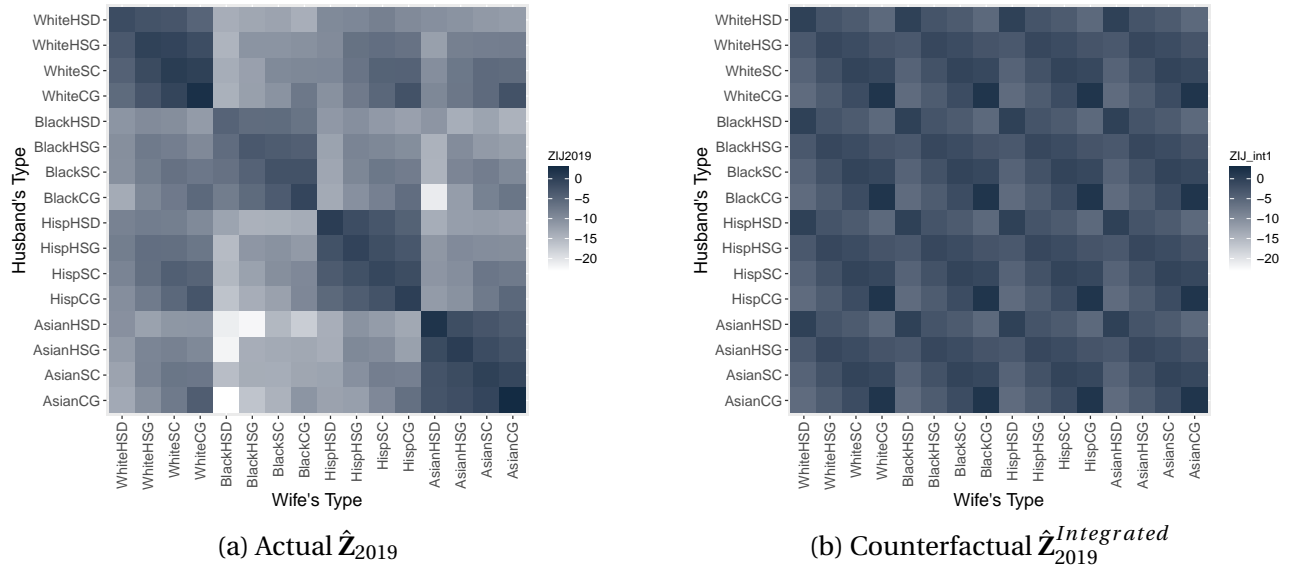
Note: This figure plots the percentage point differences in marriage rate between actual marriage rates and counterfactual marriage rates for each group: (Counterfactual marriage rate - Actual marriage rate). Counterfactuals consider two different scenarios of removing the gender gap in the marital surplus from interracial marriage for Black people. As described in 7.1, **Counterfactual 1** sets the marital surpluses of *Black women's* interracial marriages the same as those of *Black men's* interracial marriages (Equation 18). Alternatively, **Counterfactual 2** sets the marital surpluses of *Black men's* interracial marriages the same as those of *Black women's* interracial marriages (Equation 19).

Figure A8: Percentage Point Changes in Marriage Rates after Removing Gender Gap in  $Z^{interracial}$  for Black People, Year 2019 (Continued)



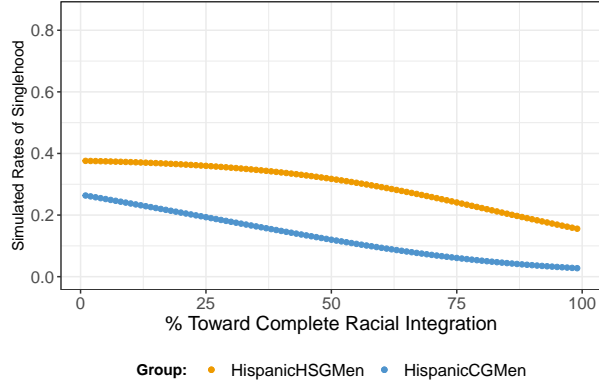
Note: This figure plots the percentage point differences in marriage rate between actual marriage rates and counterfactual marriage rates for each group: (Counterfactual marriage rate - Actual marriage rate). Counterfactuals consider two different scenarios of removing the gender gap in the marital surplus from interracial marriage for Black people. As described in 7.1, **Counterfactual 1** sets the marital surpluses of *Black women's* interracial marriages the same as those of *Black men's* interracial marriages (Equation 18). Alternatively, **Counterfactual 2** sets the marital surpluses of *Black men's* interracial marriages the same as those of *Black women's* interracial marriages (Equation 19).

Figure A9: Marital Surplus Matrix in 2019, Actual vs. Complete Integration

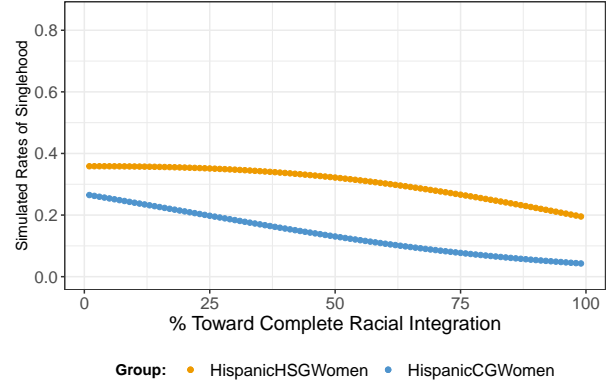


Note: This figure shows heatmap of the marital surplus  $Z_{2019}^{IJ}$  for the actual values that is estimated from data (Panel (a)) and the counterfactual values with complete integration (Panel (b)) and respectively.  $I$  refers to husband's type (Row) and  $J$  refers to wife's type (Column).

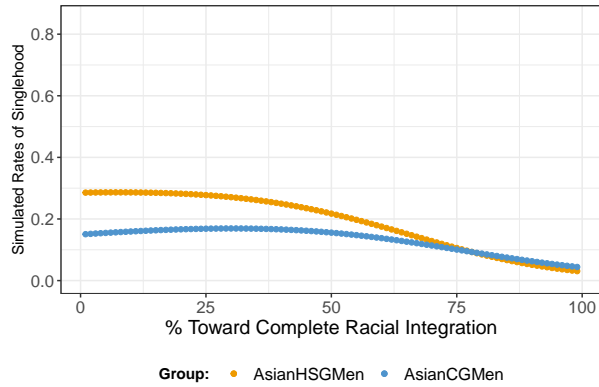
Figure A10: Simulated Rate of Singlehood for Varying Degree of Racial/Ethnic Integration



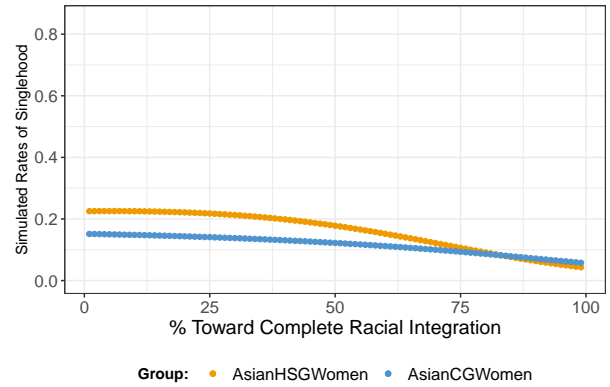
(a) Hispanic Men



(b) Hispanic Women



(c) Asian Men



(d) Asian Women

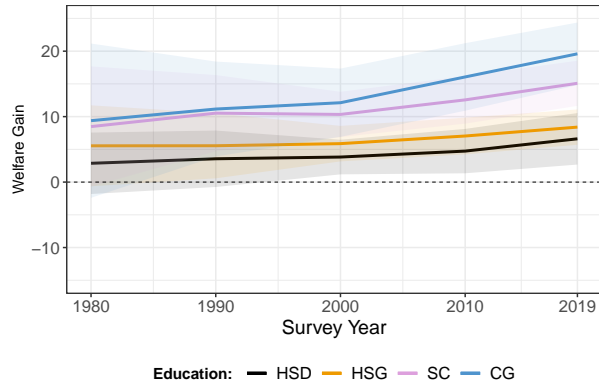
Note: This figure plots the simulated rate of singlehood at each % of ethnic/racial integration (rescaled  $p$ ) for the specified group. “% % Toward Complete Racial Integration” describes how close the counterfactual marital surplus is to the complete integration case. Estimation is done using the 2019 Census data. I focus on age 37-46 men and age 35-44 women. Further details on the sample restriction are described in Section 3.

### A.3 Sensitivity Check: Excluding Cohabiting Singles

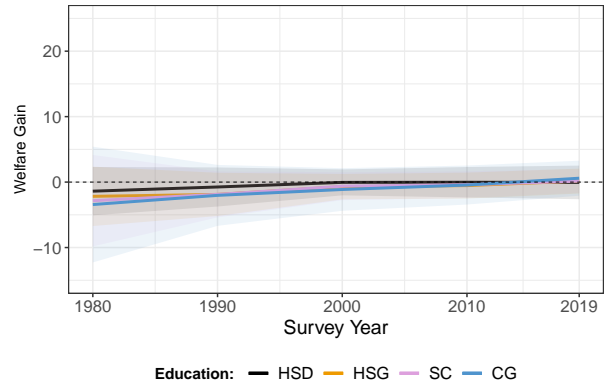
As shown in Table A2, the proportion of never-married singles who cohabit with a partner has increased over time. To see how the cohabiting singles affect the results, I perform sensitivity analyses that exclude cohabiting singles from the single population. I re-estimate the welfare gains from marital desegregation for each group, which is presented in Figure A11. The results confirm that excluding cohabiting singles do not affect the results for welfare gain from marital desegregation.



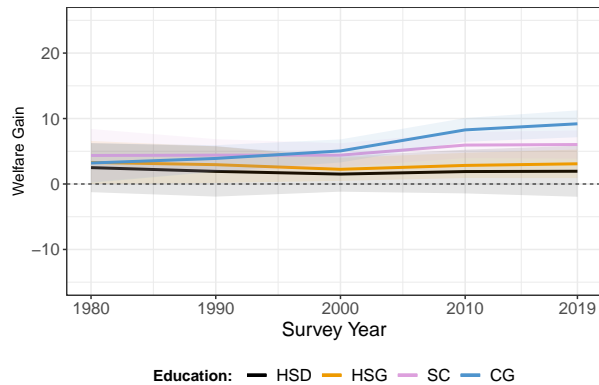
Figure A11: Individual Gains from Interracial Marriage, Excluding Cohabiting Singles



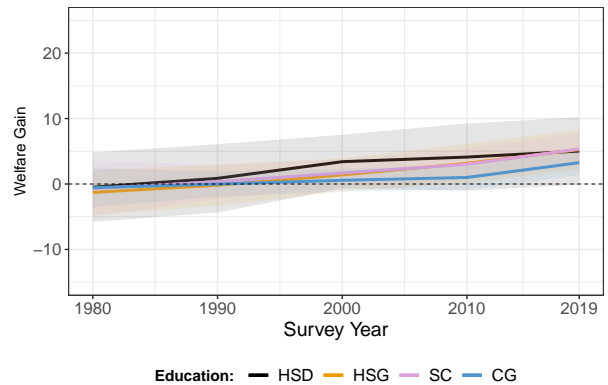
(a) Black Men



(b) Black Women



(c) White Men



(d) White Women

**Note:** These figures plot the individual gains from interracial marriage as defined by Equation (10) and Equation (11) for each specified type of men and women. Data used to calculate the gains are: 1980-2000 Decennial Census, 2010 and 2019 5-Year ACS. I focus on age 37-46 men and age 35-44 women for each survey year. Further details on the sample restriction are described in Section 3. I exclude cohabiting singles from the estimation sample. Shade for each line refers to the 95% confidence interval. Standard errors are calculated from the sampling variation in the data.

## B Appendix: Decomposition

### B.1 Full Solution of IFT Partial

**Full solution for the IFT partials:** Full solution for the Jacobian matrix (Equation 14) is as follows:

$$\begin{bmatrix} \frac{\partial \mathbf{s}}{\partial \tilde{\boldsymbol{\theta}}} \end{bmatrix}_{(2K) \times (2K+K^2)} = - \underbrace{\begin{bmatrix} \frac{\partial \mathbf{F}}{\partial \mathbf{s}} \\ \frac{\partial \mathbf{G}}{\partial \mathbf{s}} \end{bmatrix}}_{[A]}_{(2K) \times (2K)}^{-1} \underbrace{\begin{bmatrix} \frac{\partial \mathbf{F}}{\partial \tilde{\boldsymbol{\theta}}} \\ \frac{\partial \mathbf{G}}{\partial \tilde{\boldsymbol{\theta}}} \end{bmatrix}}_{[B]}_{(2K) \times (2K+K^2)}$$

where

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$$[A] = \begin{bmatrix} 2s_{1\phi} + \sum_J \tilde{Z}_{1J} s_{\phi J} & 0 & \cdots & 0 & \tilde{Z}_{11} s_{1\phi} & \tilde{Z}_{12} s_{1\phi} & \cdots & \tilde{Z}_{1K} s_{1\phi} \\ 0 & 2s_{2\phi} + \sum_J \tilde{Z}_{2J} s_{\phi J} & \cdots & 0 & \tilde{Z}_{21} s_{2\phi} & \tilde{Z}_{22} s_{2\phi} & \cdots & \tilde{Z}_{2K} s_{2\phi} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & 2s_{K\phi} + \sum_J \tilde{Z}_{KJ} s_{\phi J} & \tilde{Z}_{K1} s_{K\phi} & \tilde{Z}_{K2} s_{K\phi} & \cdots & \tilde{Z}_{KK} s_{K\phi} \\ \tilde{Z}_{11} s_{\phi 1} & \tilde{Z}_{21} s_{\phi 1} & \cdots & \tilde{Z}_{K1} s_{\phi 1} & 2s_{\phi 1} + \sum_I \tilde{Z}_{I1} s_{I\phi} & 0 & \cdots & 0 \\ \tilde{Z}_{12} s_{\phi 2} & \tilde{Z}_{22} s_{\phi 2} & \cdots & \tilde{Z}_{K2} s_{\phi 2} & 0 & 2s_{\phi 2} + \sum_I \tilde{Z}_{I2} s_{I\phi} & \cdots & 0 \\ \vdots & \vdots & & \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{Z}_{1K} s_{\phi K} & \tilde{Z}_{2K} s_{\phi K} & \cdots & \tilde{Z}_{KK} s_{\phi K} & 0 & 0 & \cdots & 2s_{\phi K} + \sum_I \tilde{Z}_{IK} s_{I\phi} \end{bmatrix}^{-1}$$

and

$$[B] = \begin{bmatrix} -1 & 0 & \cdots & 0 & 0 & 0 & \cdots & 0 & s_{1\phi} s_{\phi 1} & s_{1\phi} s_{\phi 2} & \cdots & s_{1\phi} s_{\phi K} & 0 & 0 & \cdots & 0 & \cdots & 0 & 0 & \cdots & 0 \\ 0 & -1 & \cdots & 0 & 0 & 0 & \cdots & 0 & 0 & 0 & \cdots & 0 & s_{2\phi} s_{\phi 1} & s_{2\phi} s_{\phi 2} & \cdots & s_{2\phi} s_{\phi K} & \cdots & 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots & & \vdots & \vdots & \vdots & & \vdots & & \vdots & \vdots & & \vdots \\ 0 & 0 & \cdots & -1 & 0 & 0 & \cdots & 0 & 0 & 0 & \cdots & 0 & \cdots & 0 & 0 & 0 & \cdots & s_{K\phi} s_{\phi 1} & s_{K\phi} s_{\phi 2} & \cdots & s_{K\phi} s_{\phi K} \\ 0 & 0 & \cdots & 0 & -1 & 0 & \cdots & 0 & s_{1\phi} s_{\phi 1} & 0 & \cdots & 0 & s_{2\phi} s_{\phi 1} & 0 & \cdots & 0 & \cdots & s_{K\phi} s_{\phi 1} & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 & 0 & -1 & \cdots & 0 & 0 & s_{1\phi} s_{\phi 2} & \cdots & 0 & 0 & s_{2\phi} s_{\phi 2} & \cdots & 0 & \cdots & 0 & s_{K\phi} s_{\phi 2} & \cdots & 0 \\ \vdots & \vdots & & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 & 0 & 0 & \cdots & -1 & 0 & 0 & \cdots & s_{1\phi} s_{\phi K} & 0 & 0 & \cdots & s_{2\phi} s_{\phi K} & \cdots & 0 & 0 & \cdots & s_{K\phi} s_{\phi K} \end{bmatrix}$$

Estimation of the Jacobian matrix is done by combining [A] and [B] using matrix multiplication.

## B.2 Details on Decomposition Procedures

In this section, I describe the estimation steps to decompose the expected utility of type  $I$  men. The application to the individual welfare gain from access to interracial marriage, which is a function of expected utilities, can be done analogously.

**STEP 1:** First, to link the change in the expected utility to the IFT partials, I take the total differential of the expected utility:

$$d\bar{u}^I = \frac{1}{n^I} dn^I - \frac{2}{s^{I\phi}} \underbrace{\left( \frac{\partial s^{I\phi}}{\partial \tilde{\theta}} \right)}_{\text{From IFT}} d\tilde{\theta} \quad (22)$$

**STEP 2:** A naive way of expressing the changes in  $\bar{u}^I$  from year 1980 to 2019 using Equation (15) is the following:

$$\Delta^{2019-1980} \bar{u}^I = \frac{1}{n^I} \Delta^{2019-1980} n^I - \frac{2}{s^{I\phi}} \left( \frac{\partial s^{I\phi}}{\partial \tilde{\theta}} \Delta^{2019-1980} \tilde{\theta} \right)$$

where  $\Delta^{2019-1980} y$  refers to change in  $y$  from 1980 to 2019. However, this is problematic because the implicit function theorem and the total differentials only give good approximations for *very small* changes in the model primitives. US has experienced large changes in population distribution over the past four decades. Moreover, marital surplus  $Z$  also has experienced changes over time. Hence, it is improper to use 40 years of changes to evaluate Equation (22).

A better, but still not ideal, approach is to divide the time period into smaller time periods based on available survey years. Because I use the census data with 10-year intervals,  $\Delta^{2019-1980} \bar{u}_t^I$  can be decomposed into:

$$\Delta^{2019-1980} \bar{u}^I = \Delta^{1990-1980} \bar{u}^I + \Delta^{2000-1990} \bar{u}^I + \Delta^{2010-2000} \bar{u}^I + \Delta^{2019-2010} \bar{u}^I$$

However, changes in model primitives over each decade may still be considered large.

In order to better approximate the effect of changes in model primitives on  $d\bar{u}_t^I$ , I implement the homotopy method following Judd (1998). This method decomposes the large changes in the model primitives into a series of infinitesimal changes. I apply this method for each decade based on the available survey years: 1980 to 1990, 1990 to 2000, 2000 to 2010, and 2010 to 2019.

To give a concrete example, I consider the changes from 1980 to 1990. Let me denote 1980 as  $\tau = 0$  and 1990 as  $\tau = 1$ . Then  $\tilde{\theta}_0$  (resp.  $\tilde{\theta}_1$ ) is the vector of the values of model primitives in 1980

(resp. in 1990). Then I consider the homotopy:

$$\tilde{\theta}_\tau = \tau \tilde{\theta}_1 + (1 - \tau) \tilde{\theta}_0, \quad \tau \in [0, 1]$$

which defines a series of intermediate values of the model primitives with interval  $d\tau$  between observed values at  $\tau = 0$  and  $\tau = 1$ . Because  $\tilde{\theta}_\tau$  is now a function of  $\tau$  as defined above,  $d\tilde{\theta}_\tau$  becomes  $d\tilde{\theta}_\tau = (\tilde{\theta}_1 - \tilde{\theta}_0)d\tau$ . Then, applying the homotopy to Equation (22),

$$d\bar{u}^I = \frac{1}{n_\tau^I} (n_1^I - n_0^I) d\tau - \frac{2}{s^{I\phi}} \left( \left[ \frac{\partial s^{I\phi}}{\partial \tilde{\theta}_\tau} \right]_\tau (\tilde{\theta}_1 - \tilde{\theta}_0) d\tau \right) \quad (23)$$

where  $\left[ \frac{\partial s^{I\phi}}{\partial \tilde{\theta}_\tau} \right]_\tau$  means that this partial is evaluated at each  $\tau$ . Note that  $s_\tau^{I\phi}$  is updated as  $\tau$  progresses with interval  $d\tau$ .

I use Equation (23) to estimate  $d\bar{u}^I$  for each decade and to decompose  $d\bar{u}^I$  into contributions by change in each of the model primitives. With the homotopy method, I can use infinitesimal change  $d\tau$  to evaluate and decompose  $\Delta^{(\tau+d\tau)-\tau} \bar{u}^I$  for  $\tau \in [0, 1]$ . I specify  $d\tau = 0.001$  when estimating Equation (23) for each decade. Summing  $\Delta^{(\tau+d\tau)-\tau} \bar{u}^I$  over all  $\tau \in [0, 1]$  gives better approximation of  $\Delta \bar{u}^I$  than using the observed 10-year changes of model primitives to evaluate Equation (22).

For a more concrete illustration, I describe in detail how I perform first few steps for this fine-tuning method:

- **STEP 2.1:** From  $\tau = 0 \rightarrow \tau = 0.001$

The goal is to estimate  $\bar{u}_{0.001}^I$ . Starting from  $\bar{u}_0^I$ ,

$$\bar{u}_{0.001}^I = \bar{u}_0^I + d\bar{u}_0^I$$

Using the fine-tuning method,  $d\bar{u}_0^I$  is expressed as:

$$d\bar{u}_0^I = \frac{1}{n_0^I} (n_1^I - n_0^I) \cdot 0.001 - \frac{2}{s_0^{I\phi}} \frac{\partial s_0^{I\phi}}{\partial \tilde{\theta}_\tau} (\tilde{\theta}_1 - \tilde{\theta}_0) \cdot 0.001$$

Note that  $\frac{\partial s_0^{I\phi}}{\partial \tilde{\theta}_\tau}$  is a function of  $s_0^{I\phi}$ ,  $s_0^{\phi J}$ ,  $Z_0^{IJ}$ , all of which are evaluated at  $\tau = 0$ .

In this step, I also need to compute  $s_{0.001}^{I\phi}$  and  $s_{0.001}^{\phi J}$ , because these will be used in the next

step. For example,

$$\begin{aligned} s_{0.001}^{I\phi} &= s_0^{I\phi} + ds_0^{I\phi} \\ &= s_0^{I\phi} + \frac{\partial s_0^{I\phi}}{\partial \tilde{\theta}_\tau} (\tilde{\theta}_1 - \tilde{\theta}_0) \cdot 0.001 \end{aligned}$$

- **STEP 2.2:** From  $\tau = 0.001 \rightarrow \tau = 0.002$ .

The goal is to estimate  $\bar{u}_{0.002}^I$ . Starting from  $\bar{u}_{0.001}^I$ ,

$$\bar{u}_{0.002}^I = \bar{u}_{0.001}^I + d\bar{u}_{0.001}^I$$

Using the fine-tuning method,  $d\bar{u}_{0.001}^I$  is expressed as:

$$d\bar{u}_{0.001}^I = \frac{1}{n_{0.001}^I} (n_1^I - n_0^I) \cdot 0.001 - \frac{2}{s_{0.001}^{I\phi}} \frac{\partial s_{0.001}^{I\phi}}{\partial \tilde{\theta}_\tau} (\tilde{\theta}_1 - \tilde{\theta}_0) \cdot 0.001$$

where  $n_{0.001}^I = 0.001n_1^I + 0.999n_0^I$ .

Note that  $\frac{\partial s_{0.001}^{I\phi}}{\partial \tilde{\theta}_\tau}$  is a function of  $s_{0.001}^{I\phi}$ ,  $s_{0.001}^{\phi J}$ , and  $Z_{0.001}^{IJ}$ . I have already estimated  $s_{0.001}^{I\phi}$  and  $s_{0.001}^{\phi J}$  from the previous step, and  $Z_{0.001}^{IJ} = 0.001Z_1^{IJ} + 0.999Z_0^{IJ}$ .

In this step, I also need to compute  $s_{0.002}^{I\phi}$  and  $s_{0.002}^{\phi J}$ , because these will be used in the next step. For example,

$$\begin{aligned} s_{0.002}^{I\phi} &= s_{0.001}^{I\phi} + ds_{0.001}^{I\phi} \\ &= s_{0.001}^{I\phi} + \frac{\partial s_{0.001}^{I\phi}}{\partial \tilde{\theta}_\tau} (\tilde{\theta}_1 - \tilde{\theta}_0) \cdot 0.001 \end{aligned}$$

- **STEP 2.3 and above:** The rest of the estimation proceeds analogously until  $\tau$  reaches 1.

**STEP 3:** I now explain how to decompose the changes from 1980 to 2019 in individual expected utilities  $\bar{u}^I$  into contributions by each model primitive. As an example, let's consider how  $\Delta^{1990-1980} \bar{u}^I$  is estimated according to Equation (23):

$$\Delta^{1990-1980} \bar{u}^I = \sum_{\tau \in [0,1], d\tau=0.001} \frac{1}{n_\tau^I} (n_1^I - n_0^I) d\tau - \frac{2}{s^{I\phi}} \left( \left[ \frac{\partial s^{I\phi}}{\partial \tilde{\theta}_\tau} \right]_\tau (\tilde{\theta}_1 - \tilde{\theta}_0) d\tau \right)$$

where  $\tau = 0$  refers to year 1980 and  $\tau = 1$  refers to year 1990.

Because  $\Delta^{1990-1980} \bar{u}^I$  is a linear function in  $(\tilde{\theta}_1 - \tilde{\theta}_0)$ , it can be linearly decomposed into parts

that are attributed to each model primitive  $\theta^k$ .<sup>27</sup> I call this the **contribution** of  $\theta^k$  to  $\Delta^{1990-1980} \bar{u}^I$ . The contribution of  $\theta^k$  is essentially the change in  $\theta^k$  from 1980 to 1990 multiplied by a multiplier that measures how sensitive  $\bar{u}^I$  is with respect to the change in  $\theta^k$ . Because summing up all contributions of the model primitives leads to  $\Delta^{1990-1980} \bar{u}^I$ , each contribution can be thought of as a portion of the changes in the expected utilities that is attributed to  $\theta^k$ . In order to decompose changes in  $\bar{u}^I$  over a longer time frame from 1980 to 2019, I simply sum up all four decade-by-decade contributions of each model primitive.

While I only described the decomposition steps for  $\bar{u}^I$  for the illustration purpose, the decomposition for the welfare gains, which is  $\bar{u}^{I,actual} - \bar{u}^{I,counterfactual}$ , is straightforward.

### B.3 Additional Decomposition Results

Table A3: Decomposition: Top three contribution from changes in **Z**, Black College Graduates

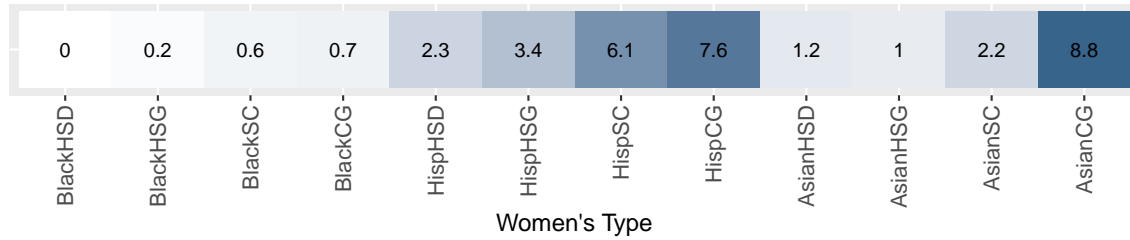
A. Decomposition for BlackHSG Men's $\Delta$ Welfare Gain ( $\Delta Gain = 1.3$ )			
Contribution	Top (+)	1.1	0.7
		$\downarrow Z^{WhiteHSG,WhiteHSG}$	$\uparrow Z^{BlackHSG,WhiteCG}$
			$\downarrow Z^{WhiteSC,WhiteHSG}$
	Top (-)	-0.6	-0.4
		$\downarrow Z^{BlackHSG,AsianHSD}$	$\downarrow Z^{BlackHSG,WhiteHSG}$
			$\downarrow Z^{BlackHSG,HispHSD}$
B. Decomposition for BlackHSG Women's $\Delta$ Welfare Gain ( $\Delta Gain = 2.6$ )			
Contribution	Top (+)	1.5	1.2
		$\downarrow Z^{BlackHSG,BlackHSG}$	$\downarrow Z^{BlackSC,BlackHSG}$
			$\downarrow Z^{BlackHSD,BlackHSG}$
	Top (-)	-0.2	-0.2
		$\downarrow Z^{WhiteCG,WhiteSC}$	$\downarrow Z^{BlackHSG,BlackHSD}$
			$\downarrow Z^{BlackSC,BlackSC}$

**Notes:** This table presents the top three positive and negative contributions from marital surplus to the 1980-2019 changes in the welfare gains from interracial marriage for Black high school graduate men (Panel A) and Black high school graduate women (Panel B). For marital surplus  $Z^{IJ}$ ,  $I$  refers to husband's type and  $J$  refers to wife's type. Upward arrow ( $\uparrow$ ) indicates that the corresponding marital surplus has increased over the analysis period, and downward arrow ( $\downarrow$ ) indicates that it has decreased over the analysis period.

<sup>27</sup>For example, the part of  $\Delta^{1990-1980} \bar{u}^I$  that is contributed by the number of *WhiteHSG* women is  $\sum_{\tau \in [0,1], d\tau=0.001} -\frac{2}{s^I \phi} \left( \left[ \frac{\partial s^I \phi}{\partial m_1^{WhiteHSG}} \right]_{\tau} (m_1^{WhiteHSG} - m_0^{WhiteHSG}) d\tau \right)$ .

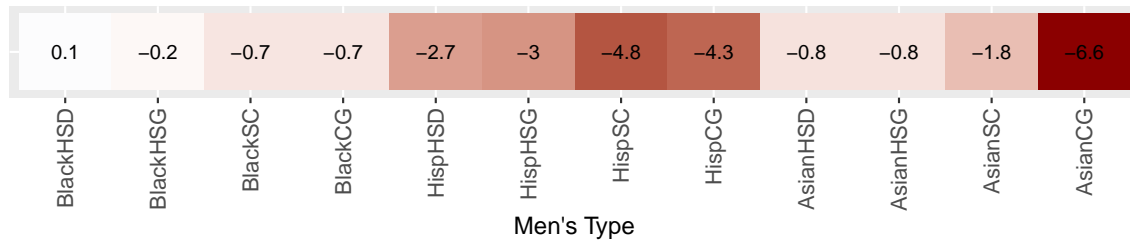
Figure A12: Details on the contributions from the changes in non-White population

For White CG Men, Contribution of population changes associated with Type J women



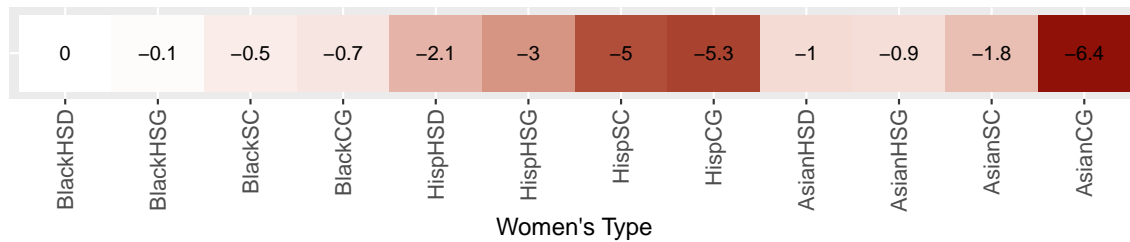
(a) For WhiteCG Men's Welfare Gains: Role of Female Population Changes

For White CG Men, Contribution of population changes associated with Type I men



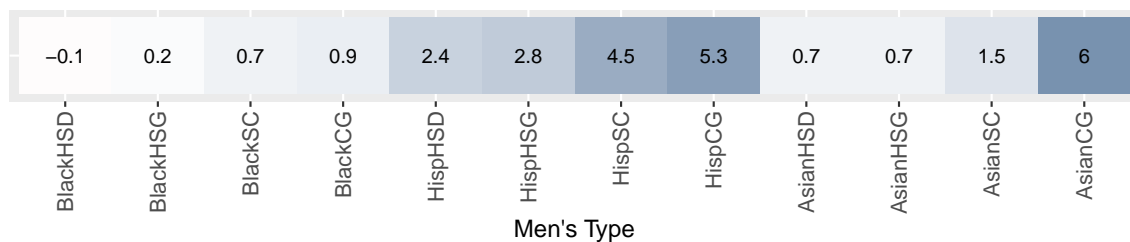
(b) For WhiteCG Men's Welfare Gains: Role of Male Population Changes

For White CG Women, Contribution of population changes associated with Type J women



(c) For WhiteCG Women's Welfare Gains: Role of Female Population Changes

For White CG Women, Contribution of population changes associated with Type I men



(d) For WhiteCG Women's Welfare Gains: Role of Male Population Changes

Note: This figure presents the decomposition of the 1980-2019 changes in the welfare gains from interracial marriage for WhiteCG men and WhiteCG women. This figure focuses on the contributions of the changes in different-race populations. Each column shows the contribution made by the change in the corresponding population.