What Women See in Men and Viceversa: Estimates Based on Sex Ratios and Marriage Patterns*

José-Víctor Ríos-Rull
University of Pennsylvania,
UCL, CAERP, CEPR, and NBER

Shannon Seitz
Analysis Group

Satoshi Tanaka†
University of Queensland

Thursday 25th July, 2024

Abstract

We exploit the variation in the sex and age composition of the U.S. population in the last 100 plus years to estimate the marriage preferences of each sex for the other at different ages, the specificities of personal attraction, how much it varies and how much it persists, and the costs of marriage and divorce. We find that males and females like prime age most, especially men; that prime age is a bit shorter (28% percent) for women than for men; that love is very important, and that if survives a rocky start it becomes hard to beat; that getting married is costly (3 years of a good marriage) and divorce even more so (up to 4.4 years of a good marriage). People born in the 1950's have similar preferences than those born in the 1870's. The parents of the baby boom (born in the 1930's), however, seem to be quite different with a much larger and durable appreciation of marriage.

Keywords: Demographic Transition, Sex Ratio, Marriage and Divorce, Two-Sided Search

JEL Classification: J10, J11, J12

*We would like to thank Aspen Gorri for his discussion, participants at the 2005 Wharton Macro Lunch Group and CMSG Conference, the 2011 Conference on Cultural Change and Economic Growth, Southern Workshop in Macroeconomics 2013, the Workshop on Macroeconomic Dynamics in Australia 2013, the Society for Economic Dynamics Annual Meeting 2013, the Income Dynamics and the Family Workshop at the 2022 Barcelona School of Economics Summer Forum, the 2024 University of Georgia Macro Workshop and attendants at seminars in the University of Western Ontario, the Federal Reserve Bank of St. Louis, and Monash University for helpful comments. RíÂos-Rull thanks the National Science Foundation and Seitz thanks the Social Sciences and Humanities Research Council of Canada for financial support.

†vr0j@upenn.edu, sseitz@analysisgroup.com, s.tanaka@uq.edu.au.

1. Introduction

There are consistent patterns across time in the way people organize their lives: most persons get married while being young adults, men a little older than their spouses, and occasionally they divorce, and some also remarry. In this paper we pursue answers to what is it that compels people to marry, and to do so in the particular ways they do it. Specifically, we want to measure how valuable is to live with a different sex person of a particular age, how special is one's specific partner relative to another, how likely is this enthusiasm to last, and how costly is to set up marriages and to break them.[1] Moreover, we are interested in the extent to which preferences are gender specific. It has been pointed out (Siow (1998)) that the biological clock of females, by having a shorter span of time where they are able to reproduce, restricts the way women are attractive for marriage purposes. Our work sheds light on this issue.

There has been a very large variation in the ratio of men to women (sex ratio) over time in the U.S. due to changing patterns in mortality and immigration by sex. The cohort born in the 1870's had a sex ratio of 0.94 women per man on average, while the cohort born in the 1950's, the latest cohort that has almost completed the marriage process, has a ratio of 1.04 women per men. These imbalances, which are greatly amplified if we look only at single people, dramatically change the availability of prospective patterns and may lead people of both genders to exhibit different amounts of pickiness when assessing the suitability of a prospective partner for marriage. A consequence is that marriage patterns may have changed in response to these differential assessments even in the absence of changes in preferences.

We take advantage of the variation in sex ratios to infer how preferences are shaped by the age and specificity of a particular partner. With *preferences* we mean what is age by the eyes of the partner? what is too young? what is prime age? what is old? How much does this age matter. Are men and women different in this regard as Siow (1998) (and possibly many others) suspect? We also mean by *preferences*, how much better is to be married? How different is a good partner from a mediocre or even a bad one? How persistent are these attributes? How volatile they are? Finally, we also want to know how easy is to change status, how expensive (or cheap) is to get married? What about divorce?

To learn about these matters we pose and estimate a dynamic equilibrium model of marriage and divorce where the availability of patterns is different for different cohorts: women were scarce for the earlier cohorts while men are less available in the different cohorts. These advantages results in the ability to pick more suitable partners by the gender in short supply. In our framework, we abstract from all differences besides age. We see the role of children and earnings as partly subsumed in the age of the partner as they are clearly age related. But age is also relevant because it affects other concerns of

[1] Throughout the paper we only consider heterogeneous couples. A sign of the times that this paper refers to.

people such as expected survival, divorce, and their own attractiveness. The aggregation of all these features, allows for compact modeling that facilitates the identification and estimation of parameters that relate age, specificity and attractiveness. The patterns of marriage by age and partner turnover in the face of very different opportunities as determined by the sex ratios is what carries the information about the relative suitability of some individuals versus others.

Our approach allows us to learn what is it that people like in their partners when we assume that preferences are unchanged over time. In order to do this we pose a two-sex demographic model with exogenous fertility and mortality, where agents that are subject to some frictions in meeting each other choose to marry and divorce taking into account the availability of prospective partners. We then pose various specifications The logic is to pose various versions of the model that share (at least some properties of) preferences but with variation in the fertility and mortality regimes. We then infer the parameters of each version of the model using a minimum distance estimator between the properties of marriages for each of the cohorts and the moments generated by the model. This requires that we treat the demographic environments in which the agents live as stationary. We estimate various specifications that differ in what are the parameters shared by agents of each of the time periods that we look at. Each specification differs in the patterns of inflow (fertility and immigration) and outflow (mortality) of agents that generates the differential sex ratios and life expectancies faced by all cohorts.

The main findings about what people like derive from the estimates in the third column of Table 3 (which is our favorite specification because the only change across cohorts of preferences is the divorce cost, which greatly improves the quality of the fit). Recall that the value of a match is the sum of a component that depends on age, another that is Markovian that is person specific and yet another that is temporary. Agents meet with a zero initial value of the Markovian component. As a result, Agents upon meeting want to marry if the temporary value is high enough with the threshold being highest for the old, then the youngest then the adult. To understand the units of the estimates, we normalize the utility of being single to 0, the mean to the temporary value of a match to 0, and more importantly its standard deviation to 1. The findings can be summarized as

1. Good (the high Markovian component) marriages are very valuable. The flow value of a good marriage with an adult about the same as one standard deviation of the temporary value of the match.

2. Upon marrying partners have a 45% chance of becoming good in a year and 60% in two years. It also has a 25% chance of becoming bad. Once it is good, it remains good for the duration.[2]

[2] The persistence of bad partners is imprecisely estimated as it is very unlikely for bad partners not to divorce.

3. With respect to the role of age,[3] we see that for women, an adolescent male is very unattractive, they would rather be single today than having one 1.3 standard deviations better than average adolescent husband. Old husbands are worse than adult husbands but only 12% of a standard deviation of the temporary shock. Males really dislike adolescent girls, they like young females more than females like young males and like less old females than females like males. Still old partners are clearly better than being single.

4. Women's prime age, as perceived by men, is a 9 years and 4 months span starting at 17.8 and going until 27.1 years of age. Men's prime age, as perceived by women, is longer (13 years) starting 5 months before women's and lasting until 3 years and for months after the age at which women lose their prime.

   Figure 1 displays them these properties of attractiveness which confirm the intuition of Siow (1998) and others.

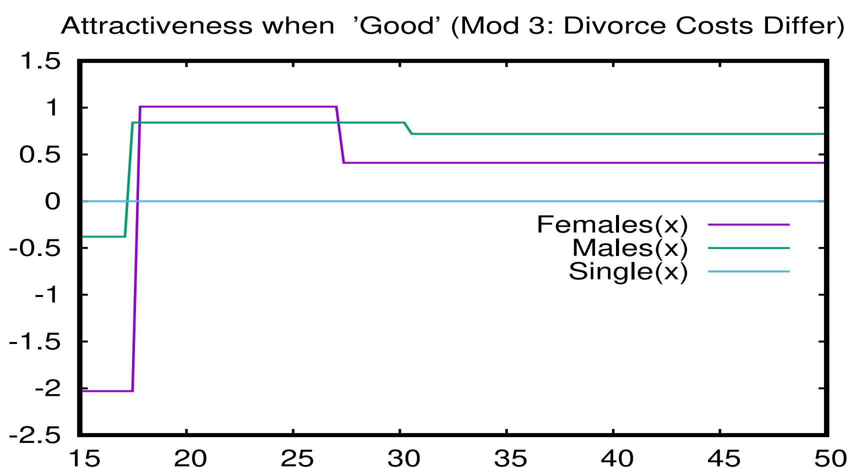

Figure 1. Attractiveness when Good partners in the Baseline Model

5. The (permanent) value of a good partner is 1.25 times the standard deviation of the temporary quality of the match shock.[4]

6. Both men and women severely dislike adolescent partners. Note that marriages have a high probability of becoming good long term bets and an early marriage could payoff as an investment

[3] The fact that the values are all negative has to do with our normalization of the values to 1 being the standard deviation of the temporary shock.

[4] We assume the value of a bad partner to be minus the value of a good partner. Again, the scarcity of observable instances would have made this hard to estimate and any large negative value is consistent with the rest of the estimation.

while waiting for the spouse to become an adult. That this does not happen very often in any of the demographic regimes indicates that the utility flow of those marriages is quite low. Men dislike adolescent women more (-4.) than women dislike adolescent men (-2.).

7. The permanent value of an adult or new partner is close to zero for both men (-.06) and for women (-.23).

   These estimates mean that overall a random partner, even if at peak adult age, is ex-ante worse in flow terms than remaining single. However, both the temporary shocks and the high likelihood of the random partner becoming a good partner makes marriage worthwhile.

8. When the partner becomes old there is a deterioration of the quality of the marriage. For men it reduces about half of the value of a good marriage while for women it reduces one third.

   Overall we see that women both have a shorter interval of being of prime age and that the value of their own age is more important than that of men, albeit not so much.

9. Marriage and divorce are very costly. The cost of marriage is equal to about two and a half years of a marriage to a good partner. The cost of divorce (that is the only thing that varies between the two time periods) is even higher. It goes from more than four years of marriage bliss for the earlier cohorts to just about two and a half years for the 1950 cohort.

We can also glimpse at what has changed over time by estimating various forms of cohort dependent parameters. A surprising sharp finding emerges: there are almost no changes between what people born in the 1870's and what people born in the 1950's liked. The estimates are very similar for these two cohorts. The 1930 cohort, the parents of the baby boomers, are however quite different, and can be summarized that for the 1930 cohort the gains from marriage are clearly larger. Going into more detail, we find that:

10. Women of the 1930's cohort had a stronger dislike for adolescents, and a much stronger liking of both adults and older males than women in the other cohorts. Men of the 1930's cohort also like adults and elderly women more than the other cohorts.

11. The cohort born in 1930 has a stronger appreciation of a good partner (10% more), especially relative to the earlier cohort, and the probability of becoming a good partner is relatively higher for them.

12. Adult age, when people are perceived as more attractive, lasts longer for the 1930 cohort. Women are thought of as prime age for more than six extra years (starting almost a year earlier and and

ending two and a half years later than the other cohorts). Men are thought of as primed age also for a much longer period by the women born in the 1930's. The interval of age attractiveness is the only relevant difference for the estimates of the 1870 and the 1950 cohort. In the latter, men adulthood is earlier and shorter (it starts about a year earlier and ends four years earlier).

Our work is related to various strands of literature. There is a vast body of work that highlights the relationship between sex ratios, marriage and divorce (Becker (1981); Wilson and Neckerman (1986); Brien (1997); Seitz (2009); Choo et al. (2008); Knowles and Vandenbroucke (2019)). A recent empirical subset of this literature has documented significant effects of the sex ratio on marriage patterns. Abramitzky et al. (2011) using the French sex imbalance after World War I and Angrist (2002) using data from the second generation of immigrants to the U.S. show significant effects of the sex ratios on people's marriage prospects. Other researchers have explored the effects of the sex ratio imbalance on various economic outcomes: Wei and Zhang (2011) on saving motives, Du and Wei (2011) on the exchange rate and Edlund et al. (2013) on crime. That biological constraints such as gender differences in fertility horizons may play a significant role in determining the timing of marriage was pioneered by Siow (1998). Díaz-Giménez and Giolito (2013) shows that it is sex differences in fecundity and not in income what accounts for the age gap at first marriage and for its increasing size by age.

Many theories have been proposed to explain the delay in marriage and the rise in divorce, observed in the last forty years. The most prominent explanations for the delay in marriage points to a fall in the gains to marriage. According to Greenwood and Güner (2009), technological innovations in home production reduced the gains to specialization within marriage. Goldin and Katz (2002) suggest the introduction of the birth control pill reduced the gains to marriage as pre-marital sex became less costly. Santos and Weiss (2012) give an explanation that the rise in labor income volatility makes marriage less attractive as marriage involves consumption commitment. Regalia et al. (2013) argue that it is the reduction in the wage gender gap what is mostly behind the reduction in marriage. All these mechanisms are consistent with the delay and the decline in marriage happened in the last few decades but do not consider that earlier cohorts did marry earlier. In our work, marriage is delayed until the temporary valu of marriage becomes sufficiently high, and the delayed in marriage of the 1950's cohort relative to the 1930's is the result of special preferences of the 1930's cohort. Our model is capable of accounting for a much larger set of marriage and divorce facts than the mere delay in marriage age.

The model we adopt here is similar in spirit to recent equilibrium marriage models used to study marriage and divorce (Aiyagari et al. (2000)), single motherhood (Regalia et al. (2013)), and marital sorting (Fernandez et al. (2005); Choo and Siow (2006); Greenwood et al. (2012)). It is much simpler than Shephard (2019) who analyzes household formation allowing for marriage accross age groups. His model includes time allocation, labor market earnings risk, human capital accumulation, home production activities and fertility. Our work is also related, albeit less so, to the literature that examines the economic implications of demographic change (De Nardi et al. (1999), Ríos-Rull (2001), Attanasio and Violante (2005)).

Section 2 discusses the historical properties of the sex ratio and the moments that we use for the estimation. Section 3 has the model. Section 4 contains the empirical analisys. We estimate various alternative specifications varying mainly in what group of parameters we keep constant across economies and which ones we vary. We start by imposing that all parameters are the same across cohorts including the demographic parameters. We then vary only the demographic parameters. We then explore various combinations of features common and separate across cohorts, while also looking for what made the cohort of 1930 or baby-boom cohort special (Section 5). Section 6 concludes.

2. Data Properties and the Logic of the Estimation

Over the last hundred plus years there have been large differences in the age and sex structure of the U.S. population, mostly due to a huge increase of life expectancy, especially for women who, in addition to increased survival at older ages, have also experienced a dramatic reduction in the mortality associated to child bearing. Immigration has also played a part as it has varied over time while being more male intensive in the earlier period. As a result of these changes, there has been a large switch in the sex ratio of adults (which we take to be those over 15). It went from 1.040 males to females for the cohort born in the decade starting in 1870, to 0.997 for the cohort born in the 1930's, to 0.939 for the cohort born in the 1950's (top panel of Table 1).

Some marriage patterns have been consistent over this period (e.g. that most people marry, that men marry older, that divorce is much rarer than marriage). Yet, some other marriage patterns have experienced large changes (bottom panel of Table 1). Among those that affected both sexes similarly were the noticeable increase in the fraction of people married[5] (those never married by age 50 shrunk by over 25%), the enormous increase in divorce (the divorce rate went from less than 1‰ to over 5‰, and, most interestingly for our purposes, there was an asymmetric change in the age at first marriage that increased by 1 year for women and shrunk by 1.2 years for men.

We exploit the link between sex ratios and age of marriage that this table suggests. In particular, we take advantage of finer information about age specific patterns and hence we use age-specific marriage and divorce rates experienced by a subset of the cohorts born since 1870.[6] Table 2 displays those rates

[5] The increase in the relative number of women to men make the increase of incidence asymmtric: the fraction married increased very little for women (59.7% to 60.8%) while it increased dramatically for men (50.8% to 56.1%).

[6] We choose cohorts as far away as possible because we want to avoid overlapping of people between our analysis. We

Table 1. Trends in Demographics and Marital Statistics, 1870-1950

	Birth Cohort 1870	1930	1950	% Change in the Data
Demographics				
Sex ratio	1.040	0.997	0.939	-9.7
Life expectancy from 15 (female)	43.4	55.0	60.4	37.8
Life expectancy from 15 (male)	43.9	51.4	54.4	25.3
Some Marriage Properties				
Age at first marriage				
Females	21.9	20.3	22.0	0.5
Men	25.9	22.8	24.7	-4.6
Married as a Percentage of those aged 16 to 49				
Females	59.7	75.4	60.8	1.8
Men	50.8	69.4	56.1	10.4
Divorce rate, per 1,000 people	0.7	2.2	5.2	642.9

in addition to the incidence of marriage (the fraction to ever marry or its complement, those that never married) and the average age at first marriage. There some properties common to all cohorts. Marriage rates rise then fall with age, peaking between the ages of 20 to 24 both for males and females. Despite the fact that marriage rates for males and females peak during the same age range, males' rates are low relative to those of females before the age of 25, and high relative to females' rates after the age of 25. These patterns are consistent with the well documented fact that males tend to marry younger females. For both males and females, the divorce rates are highest at the youngest ages and decrease (almost) monotonically after that. The data on the never-married implies that males have both higher rates of entry-into and exit-from marriage (especially given the low sex ratio of the 1950 birth cohort). Finally, age at marriage is lower for females than males.

There are other notable differences across cohorts that are not monotonic in the sex ratio. Between the first and the last cohort there is

- A large (30%) reduction in the never married.
- An enormous (sevenfold) increase in divorce.

  As a consequence ot the previous two, there is a large increase of marriage rates.
- In the recent cohort women marry less in their early thirties and a bit more in their late thirties

added the 1930 cohort because of the large variation in marriage behavior that it experienced.

Table 2. Marital Statistics Target: 1870, 1930 and 1950 Birth Cohorts

	1870 Birth Cohort		1930 Birth Cohort		1950 Birth Cohort	
	Female	Male	Female	Male	Female	Male
Marriage Rate						
16-19	97.8	20.5	151	48	123.1	58.7
20-24	120.0	97.7	216	181	170.3	148.7
25-29	89.5	90.9	114	137	95.6	111.7
30-34	65.4	70.2	44	80	46.4	55.8
35-40	28.2	42.7	21	31	32.1	39.2
40-44	24.6	48.7	21	42	16.0	24.6
Divorce Rate						
16-19	2.6	2.6	12.9	11.7	16.4	18.5
20-24	1.8	1.6	8.8	9.2	25.5	23.6
25-29	1.4	0.6	4.6	4.3	16.0	17.0
30-34	1.4	1.1	5.4	4.1	16.7	14.8
35-40	0.3	0.6	3.8	3.0	16.2	14.2
40-44	0.2	1.2	08.1	7.1	7.6	7.9
Never-Married by Age 50	11.3	13.0	4.5	6.0	7.6	9.3
Age at First Marriage	21.9	25.9	20.3	22.8	22.0	24.7

Sources: various Census. for how we construct the targets while men marry less after thirty.

- The age at first marriage went down one year for men and none for women.

While there are substantial differences between the marriage patterns of the first and the last cohorts, they are dwarfed by the differences of these two cohorts with the 1930 cohort:

- The number of never married was less than two thirds of those of 1950.
- The average age at first marriage was very low, over a year and a half less than any other cohort.
- Marriage concentrated on the earlier ages much more than the other cohorts.
- Only divorce rates where in between those of the other two cohorts.

Given these changes in behavior and associated changes in fundamental demographics, we follow the strategy of posing and estimating a dynamic equilibrium model of marriage and divorce. We take the model to confront the data from each of the three cohorts as different steady states of environments with different sex ratios and age compositions. To assess the contribution of the different demographics, we start by posing common demographics and report how would the model try to account for the three sets of data, obviously an impossible task. We then confront the model with each of the cohorts noting how each cohort has a different demographics but identical preferences. We then look at how the fit may improve by allowing some properties of preferences to change.

3. The Model

3.1. Model Ingredients

We pose a very simple multiple-age model where there is a role to marry and divorce. We abstract from additional attributes of agents (education, income, wealth, parental status) implicitly assuming that those variables have not experienced a change in their relative distribution large enough to matter. To model age as perceived by the other gender, we pose an model with 3 ages and exponential aging where the estimated aging parameters imply a change of how much a partner is liked. Further, we assume that mortality is age-independent which makes the stationary population of the environment consist of only three age-groups (and 42 groups when we consider all possible individual states). Consequently, current age only matters through the eyes of possible partners and we typically refer to it as maturity. Finally, the analysis is under the conditions of a stationary population which is what allows us to estimate the model (the demographic details including the sex ratio variation are in Section 3.2).

Every period agents may die, but if they survive, they choose whether to marry or not, if single and matched, and whether to divorce or not, if married (details in Section 3.3). It takes both CLagents to agree for marriage to occur, but it only takes one to want to to divorce. Both marriage and divorce carry costs when they happen and there are frictions in matching as every period (a year) there is at most a match with one other person, with the odds depending on the relative supplies of unmarried males and females (outlined in Section 3.5 after taking care of record keeping the agents' types in Section 3.4). Combined with the differential life expectancies of males and females, the relative abundance of agents of each sex allows us to capture gender differences in the incentives to delay marriage and to divorce. Being married yields utility (or disutility) that depends on the maturity of the spouse and on a Markovian idiosyncratic *quality of the match* shock. In addition, both being single or married has an individual associated temporary shock of the extreme value variety. Preferences and individual's decisions are in Sections 3.6 and 3.7, respectively). Section 3.8 defines the steady-state equilibrium.

3.2. Demographics

Agents differ in sex (male and female), $g \in \{m, f\}$, and maturity (adolescent, young, and old), $i \in \{a, y, o\}$, beginning their lives as adolescents. While sex is a permanent fixture of agents, an individual's maturity switches forward stochastically with transition probabilities $\Gamma^g_{i,i'}$, and, importantly, differently for males and females. Obviously, agents also differ in how long they have been alive, their age (a backward notion), which is relevant for record keeping, but not for the determination of behavior. Agents of any maturity can make contacts and form matches. Maturity (adolescent, young, or old) is not observed in the data, where only age in years is recorded, but it is observed by the agents in a match, partially determining how attractive each one of them is. Death happens with constant, gender-specific probability π^g.

The measure of females is normalized to 1, and we denote the total number of males by x^m. To keep the population stationary, each period there is an inflow of single adolescent females n^f, that equals the outflow of females through death. We pose a constant measure of new adolescent males that may differ to that of females which we attribute to net migration[7] and that allows for the sex ratio to differ from the one implied by differences in life expectancy. The measure of new adolescent single females that keeps the population constant is

$$n^f = \frac{\left[1 - \Gamma^f_{a,a}(1-\pi^f)\right]\left[1 - \Gamma^f_{y,y}(1-\pi^f)\right]\pi^f}{\left[1 - \Gamma^f_{y,y}(1-\pi^f) + \Gamma^f_{a,y}(1-\pi^f)\right]\pi^f + \Gamma^f_{a,y}(1-\pi^f)\Gamma^f_{y,o}(1-\pi^f)}. \quad (1)$$

[7] While a few more males than females are born (with small variations across space and time), the higher mortality of males implies that by the time adolescence arrives the numbers are very similar.

3.3. Match Quality

At the beginning of each period an agent can be in one of three marital states: single unmatched ($z = 0$), single matched, ($z = 1$), and married ($z = 2$). All couples must date before becoming married. Singles include those never married, divorced, and widows. Matched and married agents draw their own assessment of the match quality, q, that has two components, a Markov component and an i.i.d. component, $q = \mu + \epsilon$. These two variables are different for each member of the couple. The Markov component, $\mu \in \{\mu_L, \mu_M, \mu_H\}$, is initially drawn from $\Lambda_0(\mu)$ and has transition $\Lambda_{\mu,\mu'}$ (throught the paper, primes denote next period values, while asterisks, *, denote the associated variable of the "other" —the agent matched with— as is customary in international economics). The transitory component, ϵ^1, follows a type 1 extreme value distribution with mean zero and scale paramter 1. That the variance of ϵ is 1 is not a constraint, but a normalization, given the unrestricted nature of the values of μ.

3.4. States and Aggregates

An agent is characterized by its sex and maturity, $\{g, i\}$ as well as by whether it is single unmatched, single matched, or married, z, and if so, what is the maturity of the partner, i^* and the quality of the match as assessed by itself q, and its partner q^*. It is more convenient to keep track of the state before realization of the extreme value shocks ϵ. We separate the state into purely exogenous variables (sex and maturity) that we write as super-indices and those that partly depend on choices that we denote s, so when matched or married we have $s = \{z, i^*, \mu, \mu^*\}$ for an agent and $s^*(s) = \{z, i, \mu^*, \mu\}$ for its partner while when unmatched we write $s = 0$. We have then that $x^{g,i}(z, i^*, \mu, \mu^*)$ is the measure of agents of sex g and maturity i that are matched in a type z relationship with a partner of maturity i^*, and assessments of the quality of the match μ and μ^*. Since every matched male must be matched with a matched female, we have that

$$x^{f,i}(z, i^*, \mu, \mu^*) = x^{m,i^*}(z, i, \mu^*, \mu), \qquad \forall\, z \in \{1, 2\}, i, i^*, \mu, \mu^*. \tag{2}$$

Aggregation over ages yields $x^g(z, i^*, \mu, \mu^*) = x^{g,a}(z, i^*, \mu, \mu^*) + x^{g,y}(z, i^*, \mu, \mu^*) + x^{g,o}(z, i^*, \mu, \mu^*)$ and $x^g(0) = x^{g,a}(0) + x^{g,y}(0) + x^{g,o}(0)$.

3.5. Matching Technology

Matching depends on the sex ratio of available agents, the ratio of potential spouses to potential competitors. In particular, those of the sex in short supply meets a potential spouse with certainty, while those of the opposite sex are rationed. Consequently, single agents, (the newborn, and those surviving and either previously unmatched, or previously matched who did not marry, or previously married and divorced), meet a partner with probabilities given by

$$\psi^f = \min\left\{1, \frac{x^m(0)+x^m(1,.)}{x^f(0)+x^f(1,.)}\right\}, \tag{3}$$

$$\psi^m = \min\left\{1, \frac{x^f(0)+x^f(1,.)}{x^m(0)+x^m(1,.)}\right\}. \tag{4}$$

The measures of singles $\{x^f(0), x^m(0)\}$ and matched $\{x^f(z,i^*,\mu,\mu^*), x^m(z,i^*,\mu,\mu^*)\}$ refer to the situation after the matches have occurred which we take to be at the beginning of the period. Note that for simplicity we assume that there is no bias towards matching within the same maturity.

3.6. Preferences

Preferences differ by gender and marital status. Single agents get zero utility (a normalization). Married agents that did not change marital status get utility based on their own gender's assessment of the maturity of the spouse and on their own assessment of the match quality, $\alpha^g_{i^*}+\mu$. Change of marital status is costly (or rewarding). An agent that gets married this period gets disutility c^m, while one that gets divorced gets disutility c^d. We write $u^{g,i}(s,z') = \alpha^g_{i^*}+\mu-c^m$ when $z=1$, $z'=2$ and $u^{g,i}(s,z') = -c^d$ when $z=2$, and $z'=1$, and $u^{g,i}(s) = \alpha^g_{i^*}+\mu$ when $z=z'$. Agents discount the future at rate β. In addition agents are hit by a pair of Gumbel shocks $\{\epsilon^1,\epsilon^2\}$, with location parameter 0 and scale parameter 1 that add to the value of being single or married.

3.7. Value Functions

The value for a single unmatched agent of gender g and maturity i is

$$\Omega^{g,i}(0,0) = \beta\ (1-\pi^g) \sum_{i'} \Gamma^g_{i,i'} \Bigg\{ (1-\psi^g)\ V^{g,i'}(0) + \psi^g \sum_{i^*,\mu,\mu^*} \frac{x^{g^*,i^*}(1,.)}{x^{g^*}(1,.)} \Lambda_0(\mu)\ \Lambda_0(\mu^*)\ V^{g,i'}(1,i^*,\mu,\mu^*) \Bigg\}. \tag{5}$$

The expected value of entering the next period unmarried, involves the consideration of whether the subsequent period will be matched or unmatched. In the last term, $\frac{x^{g^*,i^*}(1,.)}{x^{g^*}(1,.)}$ is the probability of drawing a maturity i^* partner conditional on matching which follows from our assumption of non-own-maturity bias in matching. Note also that because of the zero expected value of the extreme value shocks the expected value of being single is also $V^{g,i}(0)$.

The values for matched agents depend on the actions of both members of the couple. Not only the agent has to know what it likes, but also the circumstances under which the agent with whom it is matched will be willing to become or remain married. The value that the agent gets conditional on being or becoming married is in addition to the extreme value shock

$$\Omega^{g,i}(s,1) = u^{g,i}(s,2) \; + \; \beta\,(1-\pi^{g}) \left[(1-\pi^{g^*}) \sum_{i',i^{*\prime},\mu',\mu^{*\prime}} \Gamma^{g}_{i,i'} \Gamma^{g^*}_{i^*,i^*} \Lambda^{i'}_{\mu,\mu'} \Lambda^{i^{*\prime}}_{\mu^*,\mu^{*\prime}} \; V^{g,i'}(2, i^{*\prime}, \mu', \mu^{*\prime}) \right.$$
$$\left. + \, \pi^{g^*} \sum_{i'} \Gamma^{g}_{i,i'} \Big((1-\psi^{g}) V^{g,i'}(0) + \psi^{g} \sum_{i^{*\prime},\mu,\mu^*} p^{g}(i^{*\prime}) \Lambda_0(\mu) \Lambda_0(\mu^*) V^{g,i'}(1, i^{*\prime}, \mu, \mu^*) \Big) \right]. \quad (6)$$

Some discussion is needed. The first line of this expression includes the current utility and the part of the continuation value that involves remaining married. It requires survival, and it takes the expectation over future ages and assessments of the quality of the marriages of both partners including their persistence. The second line involves the utility that ensues if becoming a widow with its subsequent possibilities of being matched or not.

If a matched agent gets divorced, its value in addition to the extreme value shock associated with being single is

$$\Omega^{g,i}(s,0) = \Omega^{g,i}(0,0) - \; c^{d}. \quad (7)$$

This is, it gets the cost of divorcing today and the value of being single. The agent will like to choose the solution to

$$\max \quad \left\{ \Omega^{g,i}(s,2) + \epsilon^2, V^{g}(0) - \; c^{d} + \; \epsilon^1 \right\}. \quad (8)$$

A matched agent has a say on its marital status only if the other agent in the match is willing to be married, otherwise it will become single. The properties of extreme value shocks imply that the probability that an $\{i, g, s\}$ agent prefers to be married is

$$p^{g,i}(s) = \frac{\exp\left[\Omega^{g,i}(s,1)\right]}{\exp\left[\Omega^{g,i}(s,0) + \Omega^{g,i}(s,1)\right]\right]} \quad (9)$$

We can now obtain the beginning of period value for matched or married (given the decision rule of the partner if any) $s = \{z, i^*, \mu, \mu^*\}$ using again the convenient extreme value formula

$$V^{g,i}(s) = \ln\left[\exp\Omega^{g,i}(s,1) + \exp\Omega^{g,i}(s,0)\right] p^{g^*,i^*}(s^*(s)) + \Omega^{g,i}(s,0)\left[1 - p^{g^*,i^*}(s^*(s))\right], \quad (10)$$

where obviously $p^{i,g}(0) = 0$.

3.8. Steady State Equilibrium

A steady state is just a set of measures $x^{g,i}(s)$, values $V^{g,i}(s)$, and choices $p^{g,i}(s)$ such that agents choose optimally, and their choices both generate the value functions and yield the measures as steady state distributions of agents. It is standard, so no need of further formality.

4. Estimation

We estimate the model using the method of moments. We take each cohort (sufficiently separated from each other) to be in a stationary equilibrium with the life expectancy and sex ratios described in Table 1. We assume that each cohort lives under a different demographic regime that shapes the relative availability by age of men and women. These regimes are determined by a combination of mortality and fertility/immigration that differs by age. Demographics properties (mortalities and sex ratios) are the only features that are directly observable and vary across cohorts and, consequently, they play a central role in our analysis. We then estimate different versions of the model varying which elements are commons across cohorts using data for all cohorts.

In our setup, a model period corresponds to one year. We assume both men and females enter the economy at age 15, and we track their calendar age in order to calculate the marital status targets.[8] Mortality determines the exit of agents in the model and it plays three roles in the analysis. *(i)* A fall in mortality rates for the opposite sex implies an increase in the expected future value of marriage, as the probability of remaining married in the future increases. *(ii)* Mortality affects the marriage opportunities for males versus females through the sex ratio. That is, if mortality rates fall to a greater extent for females than for males, as we observe in the data, then males are predicted to experience an improvement in marriage market conditions. Thus, we expect the fall in mortality to benefit males more than females along two dimensions: the value of marriage increases because one's current spouse is more likely to survive and the value of being single increases as one's marriage market improves. *(iii)* The age composition of the population is determined by mortality rates, where a fall in mortality rates is consistent with an increase in the average age in the population.

Fertility/immigration determines the entry of agents in the model. As we are only interested in adults, it is not necessary to distinguish between the two forms of arrival of new agents. We just set

[8] Remember that agents' maturity ($i \in \{a, y, o\}$) changes stochastically over their life-cycle. Therefore, individuals at the same calender age could differ in their maturity. The distributions of the adolescent, the prime, and the old at certain age are determined by the transition probabilities, $\{\Gamma^f_{a,y}, \Gamma^f_{y,o}, \Gamma^m_{a,y}, \Gamma^m_{y,o}\}$. We estimate the transition probability parameters so that the model can fit the marriage and divorce rates by age group.

the initial number of males to be such that given mortality patterns, the sex ratio of the stationary population is the one of each cohort. An increase in the immigration rate serves two roles in the model, similar to the effect of a fall in the male mortality rate. *(i)* Marriage market conditions for females improve as immigration for males increases, as more potential husbands become available. *(ii)* An increase in the immigration rate results in a decrease in the average age of men in the model.

We select in Section 4.1 the functional forms and we list the parameters that we need to estimate. Section 4.2 discusses the set of moments that we use in the estimation. The technical details of the estimation are in Section 4.3.

4.1. Parameters

For a given cohort there are 20 parameters in addition to the discount factor which we set equal to 0.96 annually. We divide those parameters into six groups: A) demographic parameters, B) divorce cost parameter, C) preference parameters, D) the parameters for aging process, E) the parameters for match quality process, F) marriage cost parameter. The A parameters that determine the initial sex ratio and the mortality rates are determined outside the model as they are assumed to not depend on marriage patterns. Each set of parameters is discussed in turn below.

A. Demographics (3 parameters) There are 2 mortality parameters that determine life expectancy of each sex , $\left\{\pi^f, \pi^m\right\}$. There is also the number of new male adolescents in each cohort which together with the differential mortality determines the sex ratio for the cohort: $\left\{i^m\right\}$.

B. Cost of Divorce (1 parameter) We assume that the cost of divorce is symmetric for males and females which adds one parameter c^d.

C. Preferences (6 parameters) The current period utility function takes the form: $u^g(j) = \alpha_j^g + q$ for married males and females and $u^g(0) = 0$ for singles. Preferences for a matched agent depend on gender and on the age of the agent's spouse and match quality. Therefore, there are 6 preference parameters to be determined: $\left\{\alpha_a^f, \alpha_y^f, \alpha_o^f, \alpha_a^m, \alpha_y^m, \alpha_o^m\right\}$.

D. Aging Process (4 parameters) Recall that we assume all males and females start out adolescent and age stochastically over time and that they may age at different speeds. As a result, there are 4 parameters governing the aging process $\left\{\Gamma_{a,y}^f, \Gamma_{y,o}^f, \Gamma_{a,y}^m, \Gamma_{y,o}^m\right\}$.

E. Match Quality Process (5 parameters) Agents decide whether they get married or not after observing the realization of match quality. As stated, match quality consists of two parts, a Markov chain and an i.i.d. component. We pose a three state Markov chain with an initial distribution where everybody starts in the middle state when a couple meets for the first time (thus, $\Lambda_0(\mu_M) = 1$, and $\Lambda_0(\mu_L) = \Lambda_0(\mu_H) = 0$). If a couple decides to continue marriage, the Markov component of their match quality evolves according to a common transition matrix even though future realizations across sexes may vary:

$$\begin{pmatrix} \Lambda_{HH} & 1-\Lambda_{HH} & 0 \\ \Lambda_{MH} & 1-\Lambda_{MH}-\Lambda_{ML} & \Lambda_{ML} \\ 0 & 1-\Lambda_{LL} & \Lambda_{LL} \end{pmatrix}.$$

We also assume that the gain from marriage of the Markov component is symmetric with mean zero; $\mu_H = -\mu_L = \theta$ with $\theta \geq 0$, and $\mu_M = 0$. The temporary shocks are also specific to each member of the couple and are type 1 extreme value with zero mean and standard deviation equal to 1. Notice that the values for age specific attractiveness and the Markovian high quality makes this choice a normalization rather than a restriction on parameter values. Thus, there are 5 parameters involved in the match quality process $\{\theta, \Lambda_{HH}, \Lambda_{MH}, \Lambda_{ML}, \Lambda_{LL}\}$.

F. Cost of Marriage (1 parameter) We assume the cost of marriage is the same for both sexes. Therefore, there is 1 parameter which governs the cost of marriage, c^m.

4.2. Targets

We have 93 targets or moments overall (31 per cohort). Of those, 9 targets (3 per cohort), (those in the top panel of Table 1), describe the sex and age composition of the population and are used to determine the demographic parameters of the economy without solving the model (A parameters).

The other 84 targets (28 per cohort) summarize detailed marriage and divorce behavior by age and sec as well as the incidence of marriage and the average age of first marriage are shown in Table 2. They are used to estimate the rest of the parameters. We pose various specifications of the model that differ in what are the features, as described by sets of parameters, that are shared by the various cohorts.

Demographics (3) We want to highlight the different sex ratio across cohorts of people 15 and older, and because of changes in life expectancy, we want the sex ratio to be consistent with the different life expectancy at 15 that men and women had in each cohort. The details of the data sources and how we obtain these statistics are in Appendix A. The values of the demographic targets are in the first three lines of Table 1.

Marital Statistics (28) We summarize the marriage and divorce patterns for each cohort with 28 statistics. First, we use the marriage rates at different ages. Therefore, we target the marriage rates for the relevant unmarried population for six age groups for each sex for each birth cohort (12 targets). Next, we target the divorce rates of the married couples for six age groups (12 targets). The third set of targets involve the incidence of marriage. We target the fraction of males and females who never marry by the age of 50 (2 targets). Finally, we also target the average age at first marriage for each sex (2 targets). Again, Appendix A describes the data sources and the details of how we obtained the target values. The actual values for the marital statistics targets are inTable 2.

4.3. Estimation

It is important to note that it is impossible to match all the moments with our model, even if it perfectly described the preferences of agents. The reason is that simply, the U.S. population is not in a stationary state and the realized marriage rates by age cannot consistent with the marriage stocks of the stationary population. We think that proceeding with the estimation of the model under the assumption that the U.S. data is generated by the model is not very productive. This said, we want to find the parameters that do the best job in accounting for the realized marriage rates of each cohort. Consequently, we proceed by obtaining parameters via a minimum distance estimator and using the sum of the squares of the deviations of model generated data and U.S. data as a measure of goodness of fit.

The actual estimation consists of two steps. In the first step, we determine the values of the demographic parameters (the A parameters) that generate the observed sex ratios and life expectancies. This does not require solving the model, in fact it is just a simple system of 3 equations and 3 unknowns (except for an introductory estimation that poses a common demographic structure for all cohorts) implying that in this step parameters are exactly identified. For introductory estimation that poses a common demographic structure for all cohorts we just choose parameters to minimize the sum of the square of the residuals of sex ratios and life expectancies for the three cohorts.

In the second step, we estimate the remaining parameters by the Minimum Distance Estimation Method targeting the moments described above. The idea is as follows: given an arbitrary set of parameter values and the predetermined demographic parameters, we solve the equilibriumfor the demographic structure associated to each cohort. Once the equilibria are solved, we calculate the model's counterparts of the marital statistics targets and compute the square of the differences between the moments in the data and in the model. The function that we minimize is a weighted sum of these squared differences, which typically involve thousands of computations of equilibria given the large number of parameter values that we have. We choose the weighting matrix, $\mathbf{W}$, as a diagonal matrix where each diagonal has a weight for each target. We didn't use an identity matrix, which tends to overemphasize targets that are larger in absolute value. We set the weight for each of marriage rates equal to 1, the one for each of divorce rates equal to 10, the one for each of age at first marriage equal to 10^{-2}, and the one for each of the fraction of the never-married by age 50 equal to 10. Our way of weighting takes into account the size of their absolute values as in Altonji and Segal (1996).

5. Findings

To see what the model can achieve, we estimate all cohorts under the assumption that the demographic structure is common and the data come from different realizations of the model (Section 5.1). The theoretical justification of this exercise is to view the various cohorts as different contexts of non-stationary population structures with the same fundamental demographics (initial populations and mortailities). We then proceed to estimate the model assuming that all parameters of preferences and technology (we refer here to marriage and divorce costs) (Section 5.2). The resulting improvement in the fit over the previous estimate indicates that demographic expectations matter in matching the data. We next turn to what is our baseline estimate, which is to only vary the divorce costs across cohorts (Section 5.3). The seven-fold increase in divorce rates over time clearly indicates that this is something that has happened and it is outside the scope of the model to explore the reasons why. Now the improvement of fit is dramatic (44.4% reduction in the sum of weighted errors to the first estimation exercise. We then go on reestimating versions of the model where certain elements of preferences change but not all (Section 5.4).

5.1. Estimates under Common Preferences and Common Demographics

This version of the model assumes a common demographic process that poses the average sex ratio found for all three cohorts as well as the average life expectancies across the three cohorts. The estimates are in column (None) of Table 3. Here, we are not using demographic variation for our estimates, so we should interpret these estimates as the best job that the model could do to minimize the distance between the model moments and the average of the corresponding moments accross the three cohorts.

Already these estimates show some properties that are present in all estimates: both sexes like the young more than both the adolescents and the old and the dislike of adolescents is much higher than that of the old. In addition, both for males and for females,newly met young partners give the same utility than being single. However, the newly met partner will become good with probability 0.5 next year (and 15% in two periods) in which case the gain is more than one standard deviation of the temporary shock. With this logic in mind, way more than half of the choices would be acceptable,

Table 3. Estimated Parameters for Various Specifications 1, 1870-1930-1950

Version of the Model Parameters that Differ Across Cohorts	(1) (None)		(2) (A)			(3, Baseline) (A+B)			(4) (A+B+C)			(5) (A+B+D)	
Cohort	All	1870	1930	1950	1870	1930	1950	1870	1930	1950	1870	1930	1950
(A) Demographics													
i^m Sex ratio	0.992	1.040	0.997	0.939	1.040	0.997	0.939	1.040	0.997	0.939	1.040	0.997	0.939
π^f Life expectancy (female)	52.9	43.4	54.9	60.4	43.4	54.9	60.4	43.4	54.9	60.4	43.4	54.9	60.4
π^m Life expectancy (male)	42.9	43.9	51.4	54.4	43.9	51.4	54.4	43.9	51.4	54.4	43.9	51.4	54.4
(B) c^d Divorce cost	2.58		2.42		4.30	4.20	2.49	4.38	4.26	2.50	4.38	4.20	2.43
(C) Preferences													
α_a^f Females liking of adolescent males	-1.34		-3.47			-1.48		-1.65	-2.15	-1.39		-1.47	
α_y^f Females liking of young males	-0.01		0.08			-0.26		-0.49	0.09	-0.43		-0.15	
α_o^f Females liking of old males	-0.46		-0.12			-0.38		-0.48	-0.31	-0.55		-0.39	
α_a^m Males liking of adolescent females	-4.25		-4.51			-3.13		-3.68	-3.55	-3.13		-3.13	
α_y^m Males liking of young females	0.01		-0.15			-0.09		-0.09	0.04	-0.16		0.13	
α_o^m Males liking of old females	-0.61		-0.38			-0.69		-0.45	-0.39	-0.52		-0.52	
(D) Aging process													
Females													
Γ_{ay}^f Age of becoming young adult	17.9		17.8			17.8			17.7		17.5	17.4	17.5
Γ_{yo}^f Age of becoming old	28.7		28.5			27.1			29.5		27.1	29.8	27.5
Males													
Γ_{ay}^m Age of becoming young adult	18.5		17.5			17.4			17.5		17.1	17.5	17.1
Γ_{yo}^m Age of becoming old	31.5		31.2			30.4			30.6		30.1	31.2	30.6
(E) Love shock process													
θ Gain in H-state	1.21		0.63			1.10			1.09			1.02	
Λ_{HH} Prob. H-state to H-state	1.00		1.00			1.00			1.00			1.00	
Λ_{MH} Prob. M-state to H-state	0.50		0.51			0.45			0.45			0.45	
Λ_{ML} Prob. M-state to L-state	0.20		0.23			0.25			0.25			0.25	
Λ_{LL} Prob. L-state to L-state	0.75		0.70			0.70			0.70			0.70	
(F) c^m Marriage cost	2.50		2.26			2.88			2.89			2.88	
Weighted Sum of Squared Errors (WSSE): E_i	0.160		0.133			0.089			0.041			0.060	
WSSE$*$(Number of Parameters)/16	0.166		0.166			0.100			0.077			0.097	
Measure of Fit: $1-(E_i/E_1)$	0.000		0.169			0.444			0.744			0.625	

even if we take into account the cost of marriage which amounts to two years of a good marriage. Adolescents and the old have to overcome some barriers to become attractive. Adolescents are quite unattractive (especially females) but they have the advantage that they will become adults soon. Marrying the old are worse than being single in the first period but within a year half of them are about half as good as a good young partner. In addition to these features, there is an opportunity cost which is that the following period agents can match with a young adult which is clearly preferred. This logic only works for young adults themselves who can be quite optimistic about being acceptable for prospective partners, adolescents and the old do not have this assurance, although adolescents can be quite optimistic about their prospects as singles as they soon will become young adults.

With respect to the aging process (when do adolescents mature into young and the young become old) we see females are considered young age between the ages of 17.9 and 28.7 while males are young between 18.5 and 31.5, this is for a lot longer and starting slightly later.

With respect to the process for love, we see that after marriage one half of all marriages become good at the eyes of at least one of the two partners, and a quarter of the marriages to both partners. Only a fifth become unattractive to at least one partner. The gain when happens is large: equal in a year to half of the cost of marriage or about two times and a bit more times the expected temporary bliss.

We also find that changing marriage status is very costly, and it is symmetric both to create it and to destroy it.

In the last 3 rows of Table 3 we show our measure of fit which is the sum of the weighted square errors of the differences between the moments in the model and in the data (first row or WSSE). The measure by itself does not tell us much, but it is very useful when we differentiate the demographics in the model. The second row reports the measure of fit penalizing over paramaterization while the third row, the most important of them reports the reduction in the measure of fit of a particular specification relative to this one that does not include any parametric variation in the fundamental demograpchics (hence the zero value for this version of the model).

5.2. Different Demographics and Common Preferences and Marriage and Divorce Costs

Column (A) of Table 3 displays the estimates of a model where all preference parameters are constant across cohorts and only the demographic properties differ. In a sense it is the simplest specification that carries out the ideas in this paper. Under this specification, agents see different odds of meeting over time and are also aware that so do their prospective partners which induces different behavior in them. The first thing to point out is that there is a 17% improvement in the goodness of fit (reduction of the sum of weighted squared errors) without any change in the number of parameters, pointing to the importance in the fundamental importance of the underlying demographics. With respect to the the estimates themselves, they are quite similar (except for a lower value of a good marriage which is now one half of what it was in model (A)) and do not merit special comments given that we do not take them to be our baseline specification. Still, the demographic variation in the model across cohorts cannot replicate the dramatic increase in divorce over time that has occurred in the U.S. Because of this, we specify the Baselilne version of the model with divorce costs moving over time and we turn to it next.

5.3. Different Demographics; Common Preferences, Varying Divorce Costs (Baseline)

As stated, the worse part of the performance of the model is because of divorce. Models (None) and (A) have too much divorce for the earlier cohorts and too little for the later cohort. Clearly, something is going on outside the realm of this paper. For whatever reasons, divorce is easier than it used to be. To accommodate this feature we specify a model where different cohorts not only face different demographic regimes, but also different divorce costs. This adds 2 parameters to the estimation.

The results are in column (A+B). There is now a tremendous improvement in the measure of fit which is now 44% lower than in the (None) model and a full third lower than in (A). Clearly, the estimates of the divorce costs are responsible for the majority of the improvement. They are decreasing over time, but curiously larger than in model (A). Divorce costs for the later cohort are less than 60% those of the earlier costs, a dramatic reduction. Interestingly, the permanent high quality value of the match is again large even if slightly less likely to be achieved. The intervals of youth become more asymmetric: females last less than 10 years as young while males last 13 and start slightly earlier. There is also a much larger premium for youth in females than in males. For instance the difference in the liking by a female of young male versus an adult male is only 12% of the standard deviation of the temporary shock, while males like young females 60% of the standard deviation of the temporary shock. A large difference. The rest of the parameters are quite similar to our previous findings.

It is for this estimation that we briefly discuss the goodness of fit. Figures 2 and 3 show the marriage and divorce rates for both data and this model. We can see how the model capture both the levels and most of the patterns associated to different age groups. Only the higher divorce rate of the 20-24 in the later cohort is a bit off, a consequence, probably, of the simplified age structure that the model has.

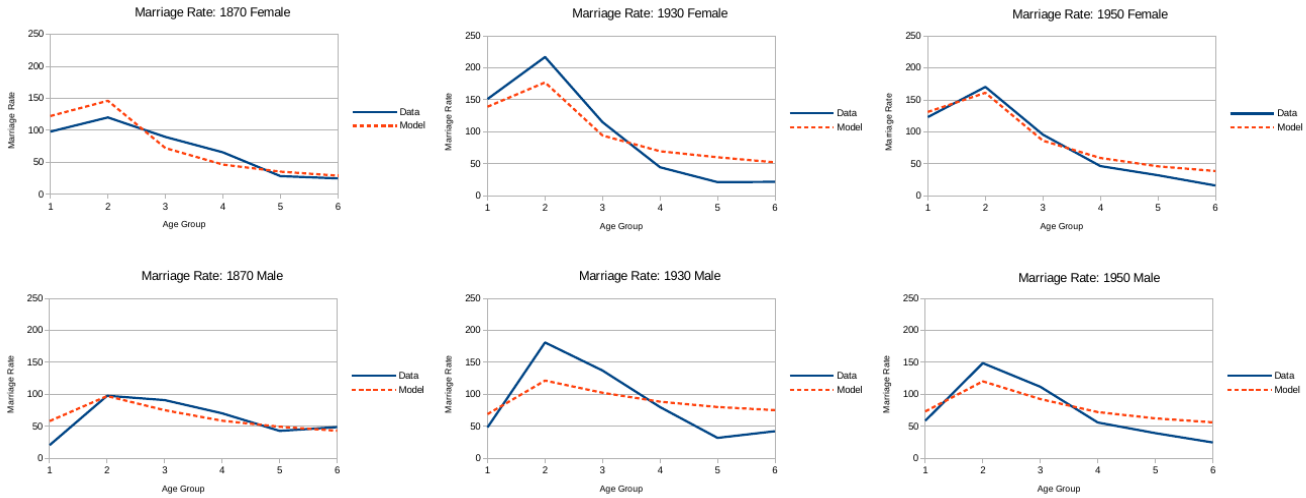

Figure 2. Marriage Rates in Data and Baseline Model

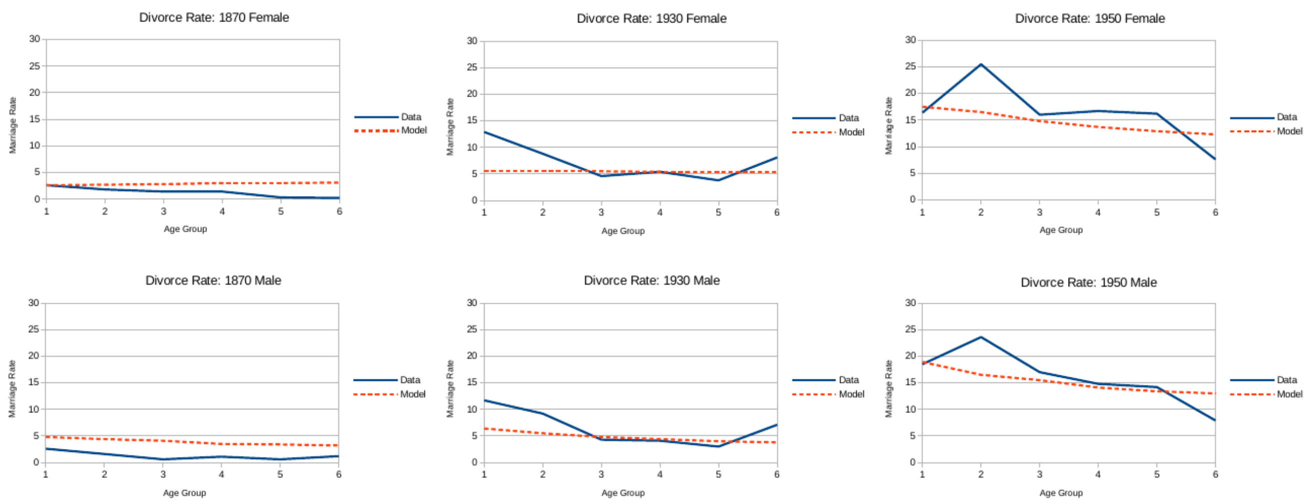

Figure 3. Divorce Rates in Data and Baseline Model

5.4. Are there Differences in Preferences across Cohorts?

We now turn to ask whether our model can identify differences between cohorts other than the divorce costs. To what extent are we different than our ancestors? To this end we proceed to estimate versions of the model with some subset of preferences differing across cohorts. This step involves estimating more parameters in each case.

5.4.1. Cohort Differences in Preferences over Maturities

We start looking at differences in the preference over maturities in column (A+B+C). Again, we see a dramatic improvement in the goodness of fit, we are now reducing the weighted sum of the errors of the economy with all cohorts assumed identical by a whopping 74%. Two changes in parameter values are behind this improvement. First with respect to common parameters there is a delaying of over two years of the age at which females became old. But, what really stands out is that the cohort of 1930 seems to appreciate marriage to adults a lot more than the earlier and later cohorts. Recall that this is the cohort of the baby boom, the cohort with a very high incidence of marriage and the highest fraction that is married between 16 and 49 (more than three quarters for females and more than two thirds for males). For this cohort, being married to an adult is very rewarding, much more than for the other two cohorts. Females in this cohort value being married to a young adult male one half of the standard deviation of the temporary shock more than females in the other cohorts, while being married to an old male is about 20% of the standard deviation more rewarding than for the females of the other cohorts. The differences in males tastes are smallre: they value 20% of the standard deviation of the temporary shock being married to young and 10% being married to old than males in the other cohorts. Between the first and the third cohort, it seems that females in the latter cohort find age more important than in the first cohort but no real difference for males.

5.4.2. Cohort Differences in Perceived Maturities

When we assume that preferences over maturities are common across cohorts but the definition of maturities is different (column (A+B+D)), the improvement in the fit is still substantial relative to the Baseline but smaller relative to differences in the age premium. In this case, the higher marriage proclivity of the 1930 cohort is achieved by a longer duration of female young adulthood which extends more than two years longer than for the other cohorts. For males, interstingly, the differences are quite small.

5.4.3. Cohort Differences in the Evolution of Match Quality

Turning to the differences in the process for the permanent component of match quality, (that are in Table 4, column (A+B+E)) we see that again, there is a large improvement over the Baseline but smaller than in the previous two models. Now the higher marriage rates of the 1930's cohort is achieved by a larger gain of a permanently good marriage. The transition differences are mixed, for the 1930 improvements are slightly less like upon marriage but so is deterioration allowing mediocre marriages to continue longer.

5.4.4. Cohort Differences in Marriage Costs

If we let marriage costs to difer by cohort as we show in column (A+B+F) which only requires two additional parameters relative to the Baseline, we see that a very large reduction of the weighted sum

Table 4. Estimated Parameters for Various Specifications 2, 1870-1930-1950

Version of the Model		(6)			(7)			(8)			(9)	
Parameters that Differ Across Cohorts		(A+B+E)			(A+B+F)			(A+B+C+D)			(All)	
Cohort	1870	1930	1950	1870	1930	1950	1870	1930	1950	1870	1930	1950
(A) Demographics												
Sex ratio	1.040	0.997	0.939	1.040	0.997	0.939	1.040	0.997	0.939	1.040	0.997	0.939
Life expectancy (female)	43.41	54.97	60.45	43.41	54.97	60.45	43.41	54.97	60.45	43.41	54.97	60.45
Life expectancy (male)	43.93	51.43	54.43	43.93	51.43	54.43	43.93	51.43	54.43	43.93	51.43	54.43
(B) Divorce cost	4.29	4.14	2.54	4.76	3.40	1.72	4.39	3.38	2.46	5.20	3.95	2.50
(C) Preference												
α_a^f Females liking of adolescent males		-1.57			-3.56		-1.86	-2.54	-1.48	-2.09	-3.72	-1.56
α_y^f Females liking of young males		-0.25			-0.35		-0.27	0.22	-0.	-0.24	0.52	-0.10
α_o^f Females liking of old males		-0.43			-0.52		-0.46	-0.24	-0.44	-0.44	-0.12	-0.47
α_a^m Males liking of adolescent females		-3.56			-5.48		-3.66	-4.84	-3.91	-3.73	-5.09	-3.81
α_y^m Males liking of young females		-0.16			-0.30		-0.04	-0.10	-0.02	0.27	-0.04	0.09
α_o^m Males liking of old females		-0.59			-0.62		-0.52	-0.60 -	0.51	-0.46	-0.68	-0.55
(D) Aging process												
Female												
Age of becoming young		17.34			17.10		17.43	17.41	17.98	17.25	17.03	17.98
Age of becoming old		27.76			29.98		28.58	30.67	28.76	29.91	35.01	28.87
Male												
Age of becoming young		17.76			17.66		19.12	17.76	18.28	19.51	17.65	18.45
Age of becoming old		28.81			31.25		31.43	31.42	28.56	34.12	37.68	28.93
(E) Love shock process												
Gain in H-state (θ)	1.01	1.10	1.03		1.02			0.97		0.88	0.98	0.98
Prob. H-state to H-state	1.00	1.00	1.00		1.00			1.00		1.00	1.00	1.00
Prob. M-state to H-state	0.43	0.39	0.42		0.47			0.44		0.48	0.56	0.48
Prob. M-state to L-state	0.21	0.18	0.22		0.13			0.15		0.18	0.18	0.18
Prob. L-state to L-state	0.69	0.72	0.69		0.71			0.71		0.73	0.76	0.73
(F) Marriage cost		2.45		2.50	2.09	2.62		2.42		2.33	2.29	2.28
Weighted Sum Squared Errors, WSSE: E_i		0.062			0.050			0.033			0.028	
WSSE∗(Number of Parameters)/16		0.108			0.062			0.078			0.088	
Measure of Fit: $1-(E_i/E_1)$		0.613			0.688			0.794			0.825	

of squared errors can be achieved with a large reduction in marriage costs for the 1930's cohort. In fact, we could have considered this version the Baseline as it is the one with the lowest weighted sum of squared errors normalized by he number of parameters. Here the mechanism that ensures the higher engagement in marriages of the 1930's cohort is both a lower divorce cost than the earlier cohort and a much lower marriage cost. This feature together with some subtle differences with the Baseline estimates (the cost of divorce, the gains from a good marriage and the youth premium from the point of view of males are all a bit smaller here) suffice to get a much smaller weighted sum of squared residuals.

5.5. Cohorts Differ in All or Almost All Margins

We conclude our estimation allowing for differences between cohorts in all margins. Column (A+B+C+D) allows for differences in divorce costs and the timing and size of how age affects preferences (39 parameters), while column (All) allows everything to be cohort dependent (51 parameters). Obviously, the fit improves reducing the residuals by 80%. To account for the more pervasive marriages in the 1930 cohort, Model (A+B+C+D) displays again a monotonically lower divorce cost over time, larger age premia amd larger gains from marriage for the 1930's cohort. However, the duration of adulthood is barely longer youth for males. Economy (All) has also monotonically lower divorce cost over time, large age premia, longer duration of youth, slightly better outlook for marriages but not much lower costs of marriage.

6. Conclusion

In this paper, we have used the tremendous variation in sex ratios and age composition of various cohorts to shed light in what are the gains from marriage and the role played by the age of the partner. To this end we posed and estimated a general equilibrium structural model of age and divorce using such demographic variation. We show that the fit is quite good and that demographic variation plays an important role. The findings are sharp: There are large gains from marriage. Age matters. The variation of the attractiveness by age is larger for females than for males and the duration of their peak is shorter by about two years. We also find that once marriages improve (which happens with high probability) they are very stable. Getting married or divorced is very costly. We also found that the cohort born in 1930 experienced more gains from marriage. While the precise details of the differences depend on the specification, they can be summarized by experiencing lower costs in getting married.

References

Abramitzky, R., A. Delavande, and L. Vasconcelos (2011): "Marrying Up: The Role of Sex Ratio in Assortative Matching," *American Economic Journal: Applied Economics*, 3, 124–157.

Aiyagari, S. R., J. Greenwood, and N. Güner (2000): "On the State of the Union," *Journal of Political Economy*, 108, 213–244.

Altonji, J. G. and L. M. Segal (1996): "Small-Sample Bias in GMM Estimation of Covariance Structures," *Journal of Business & Economic Statistics*, 14, 353–366.

Angrist, J. (2002): "How Do Sex Ratios Affect Marriage and Labor Markets? Evidence from America's Second Generation," *The Quarterly Journal of Economics*, 117, 997–1038.

Arias, E. (2008): "United States Life Table, 2008," *National Vital Statistics Reports*, national Center for Health Statistics.

Attanasio, O. and G. L. Violante (2005): "The Demographic Transition in Closed and Open Economy: A Tale of Two Regions," Mimeo, University College, London.

Becker, G. S. (1981): *A Treatise on the Family*, no. beck81-1 in NBER Books, National Bureau of Economic Research, Inc.

Brien, M. J. (1997): "Racial Differences in Marriage and the Role of Marriage Markets," *Journal of Human Resources*, 32, 741–778.

Choo, E., S. Seitz, and A. Siow (2008): "Marriage Matching, Risk Sharing and Spousal Labor Supplies," Mimeo, University of Toronto.

Choo, E. and A. Siow (2006): "Who Marries Whom and Why," *Journal of Political Economy*, 114, 175–201.

Clarke, S. C. (1995): "Advance Report of Final Divorce Statistics, 1989 and 1990," *Monthly Vital Statistics Report*, 43, national Center for Health Statistics.

De Nardi, M., S. İmrohoroğlu, and T. J. Sargent (1999): "Projected US Demographics and Social Security," *Review of Economic Dynamics*, 2, 575–615.

Díaz-Giménez, J. and E. Giolito (2013): "Accounting For The Timing Of First Marriage," *International Economic Review*, 54, 135–158.

Du, Q. and S.-J. Wei (2011): “A Darwinian Perspective on” Exchange Rate Undervaluation”,” Tech. rep., National Bureau of Economic Research.

Edlund, L., H. Li, J. Yi, and J. Zhang (2013): “Sex Ratios and Crime: Evidence from China,” *Review of Economics and Statistics*, forthcoming.

Fernandez, R., N. Guner, and J. Knowles (2005): “Love and Money: A Theoretical and Empirical Analysis of Household Sorting and Inequality,” *Quarterly Journal of Economics*, 120, 273–344.

Goldin, C. and L. F. Katz (2002): “The Power of the Pill: Oral Contraceptives and Women’s Career and Marriage Decisions,” *Journal of Political Economy*, 110.

Greenwood, J. and N. Güner (2009): “Marriage and Divorce Since World War II: Analyzing the Role of Technological Progress on the Formation of Households,” *NBER Macroeconomics Annual 2005*.

Greenwood, J., N. Guner, G. Kocharkov, and C. Santos (2012): “Technology and the Changing Family: A Unified Model of Marriage, Divorce, Educational Attainment and Married Female Labor-Force Participation,” Tech. rep., National Bureau of Economic Research.

Haines, M. R. (1998): “Estimated Life Tables for the United States, 1850–1910,” *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, 31, 149–169.

Knowles, J. (2013): “Why are Married Men Working So Much?” *Review of Economic Studies*, 80, 1055–1085.

Knowles, J. and G. Vandenbroucke (2019): “Fertility Shocks And Equilibrium Marriage-Rate Dynamics,” *International Economic Review*, 60, 1505–1537.

Plateris, A. A. (1973): “100 Years of Marriage and Divorce Statistics, United States, 1867 - 1967,” *Vital and Health Statistics*, 21, national Center for Health Statistics.

Regalia, F., J.-V. Ríos-Rull, and J. Short (2013): “What Accounts for the Increase in Single Households and for the Properties of Fertility?” Mimeo, University of Minnesota. First version, 1998.

Ríos-Rull, J.-V. (2001): “Population Changes and Capital Accumulation: The Aging of the Baby Boom,” *Advances in Macroeconomics*, 1, article 7.

Ruggles, S., J. T. Alexander, K. Genadek, R. Goeken, M. B. Schroeder, and M. Sobek (2010): "Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]," Minneapolis: University of Minnesota.

Santos, C. and D. Weiss (2012): "Why Not Settle Down Already? A Quantitative Analysis of the Delay in Marriage," Mimeo, University of Pennsylvania.

Seitz, S. (2009): "Accounting for Racial Differences in Marriage and Employment," *Journal of Labor Economics*, 27, 385–437.

Shephard, A. (2019): "Marriage Market Dynamics, Gender, and the Age Gap," PIER Working Paper No. 19-003.

Siow, A. (1998): "Differential Fecundity, Markets, and Gender Roles," *Journal of Political Economy*, 106, 334–354.

Wei, S.-J. and X. Zhang (2011): "The Competitive Saving Motive: Evidence from Rising Sex Ratios and Savings Rates in China," *Journal of Political Economy*, 119, 511–564.

Wilson, W. and K. Neckerman (1986): "Poverty and family structure: the widening gap between evidence and public policy issues," in *Fighting Poverty. What works and what doesn't*, ed. by D. S. and D. Weinberg, Cambridge: Harvard University press.

Appendix

A. Data Construction and Sources

In this appendix, we describe how we construct marriage and divorce rates (flow variables) from the fractions of the population by age and marital status (stock variables). We observe only stock variables in the U.S. Census data, while we use flow variables in our estimation.[9] In this appendix, we also list all the data sources in for the variables we use in our estimation.

A.1. Constructing Marriage and Divorce Rate from the Census Data

Denote the stock of females at calendar age t who are never-married, married, divorced, and widowed by S_t^f, M_t^f, D_t^f, and W_t^f, respectively. Denote $p_{m,t}^f$ the probability a single female of calendar age t gets married, and $p_{d,t}^f$ the probability a married female of calendar age t gets divorced. Then, the stocks in each marital state evolve over time according to the following equations:

$$S_{t+1}^f = S_t^f \left(1 - p_{m,t}^f\right)\left(1 - \pi_t^f\right), \tag{11}$$

$$M_{t+1}^f = M_t^f \left(1 - p_{d,t}^f\right)\left(1 - \pi_t^m\right)\left(1 - \pi_t^f\right) + \left(S_t^f + D_t^f + W_t^f\right) p_{m,t}^f, \tag{12}$$

$$D_{t+1}^f = M_t^f \left(1 - \pi_t^f\right)\left(1 - \pi_t^m\right) p_{d,t}^f + D_t^f \left(1 - \pi_t^f\right)\left(1 - p_{m,t}^f\right), \tag{13}$$

$$W_{t+1}^f = M_t^f \pi_t^m \left(1 - \pi_t^f\right) + W_t^f \left(1 - \pi_t^f\right)\left(1 - p_{m,t}^f\right). \tag{14}$$

To obtain marriage and divorce rates for five-year age groups,[10] we make an assumption that marriage and divorce rates are the same within each age group. That is, if age t and $t+4$ are the youngest and the oldest ages within the same five-year age group, we set

$$p_{m,t}^f = p_{m,t+1}^f = \cdots = p_{m,t+4}^f.$$

Then, from Equation (11), we can derive

$$S_{t+5}^f = S_t^f \left(1 - p_{m,t}^f\right)^5 \left(\prod_{s=0}^{4} \left(1 - \pi_{t+s}^f\right)\right).$$

We are able to solve the above equation for $p_{m,t}^f$ as a function of the stock of the never-married and

[9] Using stock variables to construct flow variables is common in the marriage literature. For example, Knowles (2013) uses stock variables from the Current Population Survey (CPS) to construct annual marriage and divorce rates.

[10] The five-year age groups are 16-19, 20-24, 25-29, 30-34, 35-39, and 40-44 years old.

age-specific mortality rates as

$$p^f_{m,t} = f\left(S^f_t, S^f_{t+5}, \left\{\pi^f_{t+s}\right\}^4_{s=0}\right). \tag{15}$$

Once the marriage rate, $p^f_{m,t}$, is determined in the above equation, we can compute divorce rates from Equation (11) through (14). The divorce rate is a function of all the stock variables and age-specific mortality rates as

$$p^f_{d,t} = g\left(S^f_t, S^f_{t+5}, M^f_t, M^f_{t+5}, D^f_t, D^f_{t+5}, W^f_t, W^f_{t+5}, \left\{\pi^f_{t+s}\right\}^4_{s=0}\right). \tag{16}$$

Equation (15) and (16) show that we need the number of individuals by age and marital status (stock variables) for every five years, and age-specific mortality rates for each cohort, to calculate marriage and divorce rates by five-year age groups.

For the number of individuals by age and marital status, we don't use the data directly. To obtain the number of individuals by age and marital status that are consistent with the age-specific mortality rates, we first calcualte the fraction of females and males in each age and marital status (denoted as s^g_t , m^g_t, d^g_t, w^g_t where $g \in \{f, m\}$) for every five years from the U.S. Census data. Because the U.S. Census data is only available for every 10 years, we compute the equally-weighted average for the mid point of each decade. Also, we obtain estimates of the mortality rates π^f_t and π^m_t for females and males at each age (see Appendix B.2 for the data sources). After normalizing the total stock of females at age 15 equal to 1 and that of males to $1 + i^m$, we calculate the number of the never-married by

$$S^f_t = s^f_t\left(\prod_{\tau=15}^{t}(1-\pi^f_\tau)\right), \quad t > 15$$

and likewise for M^f_t, D^f_t, and W^f_t.[11] By doing so, we could compute the number of individuals by age and marital status that are consistent with the age-specific mortality rates. Finally, we use Equation (15) and (16) to compute marriage and divorce rates for five year age groups.

Here, we describe the case for the 1950 birth cohort as an example. For the 1950 birth cohort, we use the Census data in 1960, 1970, 1980, 1990, and 2000. From the data, we can compute the fraction of each marital status by gender, $\left\{s^f_t, m^f_t, d^f_t, w^f_t, s^m_t, m^m_t, d^m_t, w^m_t\right\}$, for the ages 20. 30, 40, or 50. Furthermore, by taking the equally-weighted average, we are able to compute the fraction of each marital status for the ages, 15, 25, 35, and 45.[12] Once we obtain those fractions, we can compute

[11] We calibrate the migration rate i^m so that the sex ratio of the population at age 15 above in each cohort becomes equal to that of the data.

[12] For example, we calculate the fractions of the people at age 15 by marital status in 1965 by combining the samples

$\{S_t^f, M_t^f, D_t^f, W_t^f, S_t^m, M_t^m, D_t^m, W_t^m\}$ for five-year age intervals, which allows us to use Equation (15) and (16) to compute marriage and divorce rates for five year age groups. Thus, marriage and divorce rate for the ages between 15 and 50 are able to be constructed.

A.2. Data Sources for Demographic Statistics

- *Sex Ratio of the Population at Age 15 and Above (1870 through 1950 Birth Cohort):* We calculate the sex ratio of the population at age 15 and above from the IPUMS Census data (Ruggles et al., 2010). For each cohort, we assign the value that is 10-years-after their birth. That is, we used the sex ratio of the population at age 15 and above in the 1880 data for the 1870 birth cohort.
- *Sex Ratio by Age (1870 through 1950 Birth Cohort):* We calculate the sex ratio by age from the IPUMS Census data (Ruggles et al., 2010). We track the 1870, 1930, and 1950 birth cohort to calculate the sex ratio at different ages. We present this statistics in Table XXXX **??** to show significant variations in the sex ratio across cohorts for those who are at prime age in marriage markets (e.g. 20 to 30 years-old).
- *Life Expectancy at Age 15 (1870 through 1950 Birth Cohort):* There are two data sources for the life expectancy at age 15. For the years, 1880 through 1890, the data is from Haines (1998). For the years, 1900 through 1960, we used the data from Arias (2008). For each cohort, we assign the value that is 10-years-after their birth. That is, we used the life expectancy at age 15 in the 1880 data for the 1870 birth cohort.
- *Age-Specific Mortality Rate (1870, 1930, and 1950 Birth Cohort):* Age-specific mortality rates are used to calculate the marriage and divorce rates as described in Appendix B.1. Those mortality rates are from the National Center for Health Statistic's United States Decennial Life Tables.

A.3. Data Sources for Marital Statistics

- *Marriage and Divorce Rate by Age Group (1870, 1930, and 1950 Birth Cohort):* Marriage and divorce rate by age group are calculated from the IPUMS Census data (Ruggles et al., 2010) by using the method described in Appendix B.1. Since the 1890 data is missing in the U.S. Census, we compute them by taking the average of the 1880 and 2000 data. Also, for the year 1980, the fraction of the divorced is unusually high because the year is right after the changes in the divorce law in many states. Therefore, we compute the fraction of the divorced by taking the average of the 1970 and 1990 data, and rescale other statistics in 1980 so that they sum up to

at age 15 in 1960 and those in 1970 putting an equal weight to each group.

1. Table 5 lists the number of samples in the U.S. Census data used to calculate the marriage and divorce rates.

Table 5. The Number of Samples Used for the Calculation of Marriage and Divorce Rate

	1870 Birth Cohort		1930 Birth Cohort		1950 Birth Cohort	
Age	Female	Male	Female	Male	Female	Male
15 years old	54567, 38492*	54969, 39162*	12915, 17288*	13005, 17680*	13645, 39623*	14198, 41259*
20 years old	71149, 40341¶	61185, 37431¶	13498	12862	35054	32381
25 years old	63252, 37729*	62015, 37190*	15162, 13697*	11194, 10626*	28009, 102997*♢	26541, 101241*♢
30 years old	35242	38984	11806	11527	94059♢	91647♢
35 years old	27185, 7350*	30840, 8202*	12969, 22808*	12256, 21563*	73559, 107343*♢	71077, 104748*♢
40 years old	7187	8149	24966	23349	99267	94891
45 years old	5076, 6537*	6007, 7366*	25420, 57261*	23761, 53703*	77202, 109433*	74027, 106694*
50 years old	6225	6920	60922	56503	97207	93223

For the cells marked by *, we calculate the fraction of individuals by marital status by taking an equally-weighted average from two years (thus, the number of the samples in each year is listed). The cells marked by ¶ corresponds to the year, 1890, which we don't have data in the Census. Thus, we combine the two years, 1880 and 1900, to compute the fractions. For the cells marked by ♢, the fraction of the divorced in 1980 is replaced by the equally-weighted average of the ones in 1970 and 1990 when we are calculating the marital statistics.

- *Age at First Marriage (1870 through 1950 Birth Cohort):* For the age at first marriage, we use the median[13] age at first marriage provided by U.S. Census Bureau. They estimate it from the Current Population Survey for the years after 1947. For the years prior to 1947, they estimate it from the decennial censuses.[14] For each cohort, we assign the value which is in the year 30-years-after their birth. That is, we used the age at first marriage in the 1900 data for the 1870 birth cohort.

- *Fraction of the Never-Married by Age 50 (1870 through 1950 Birth Cohort):* The fraction of the never-married by age 50 is calculate from the IPUMS Census data (Ruggles et al., 2010) for each cohort.

- *Fraction of the Married Aged 16 to 49 (1870 through 1950 Birth Cohort):* The fraction of the married aged 16 to 49 is calculated from the IPUMS Census data (Ruggles et al., 2010). For

[13] We also estimated the 'mean' age at first marriage from the IPUMS Census data, and conducted the benchmark analysis. However, our results didn't significantly change.

[14] U.S. Census Bureau, Current Population Survey, March and Annual Social and Economic Supplements.

each cohort, we assign the value which is in the year 30-years-after their birth. That is, we use the fraction of the married aged 16 to 49 in the 1900 data for the 1870 birth cohort.

- *Divorce Rate per 1,000 of the Population (1870 through 1950 Birth Cohort):* The data for the divorce rate is from Clarke (1995) for the period 1940 to 1990, and Plateris (1973) for the period earlier than 1940. For each cohort, we assign the rate which is in the year 30-years-after their birth. That is, we used the divorce rate in the 1900 data for the 1870 birth cohort.