Gender Differences and the Timing of First Marriages*

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December 15, 2011

Abstract

In first marriages in the United States grooms are on average 1.7 years older than their brides, the life-cycle profile of this age gap is increasing both for the grooms and for the brides, and it is steeper for the grooms. To address these issues we construct a general equilibrium model economy in which people search for spouses, and they marry because they value bearing children, sharing their income with their spouses, and companionship. A distinguishing feature of our model economy is that the age distributions of singles are endogenous. We calibrate our model economy so that it replicates some of the aggregate features of the timing of first marriages in the United States. And we find that gender differences in fecundity are essential to account for the average age gap observed in first marriages. We also find that distributions of single people that are decreasing in age and some random matching are sufficient to account for the positive slopes of the life-cycle profiles of the age gaps at first marriage; and that gender differences in fecundity account for these profiles being steeper for the grooms.

Keywords: marriage, search, age gap.

JEL Classification: J12, J16, D83

*We thank J. V. Ríos-Rull, N. Guner, and several anonymous referees for many valuable suggestions and comments. We revised this article while Giolito was visiting Duke University, and he thanks the Department of Economics for the financial support, its faculty for their hospitality, and Seth Sanders, very specially. We gratefully acknowledge the financial support of the Spanish Ministerio de Educación y Ciencia (Grants SEJ2005-05381, ECO2008-04073, BEC2006-05710, and ECO2009-11165). Please address the correspondence about this article to Eugenio Giolito at <egiolito@uahurtado.cl>.

1 Introduction

Women tend to marry older men over time and across societies. In the United States, the age gap at first marriage was 1.74 years in the year 1995. This is the first fact that we account for in this article.

Two other facts about the timing of first marriages, that are less well known, are that the life-cycle profiles of the age gaps at first marriage, defined as someone's age minus the age of his or her spouse, are increasing both for the brides and for the grooms, and that they are steeper for the grooms. In Panels A and B of Figure 1 we report these facts for the United States in 1995.[1]

Panel A shows that first time grooms marry on average to an older first time bride until about age 20. And that they marry to brides who are younger than they are after that age. It also shows that the average age gap at first marriage increases continuously with the groom's age. For example, first time grooms who are 40 years old marry on average to brides who are six years younger.

Interestingly, Panel B shows that the age gap of first time brides is also increasing. For instance, before age 20, first time brides marry to grooms who are 3 or 4 years older on average. In contrast, around age 40, first time brides marry first time grooms who are on average two years younger. In this article we account also for these two facts about the timing of first marriages.

The traditional story to account for these facts is related to gender specialization and to the role of males as "providers". It essentially describes marriage as a waiting game in which young women are scarce and choosy, and old and rich pretenders outbid the young and poor ones in their competition for young and fecund women.[2] A more recent version of this story is that marriage is an "exchange of money for beauty", which can be applied also to women who marry younger men.[3]

In this article we argue that the gender differences in the life-cycle profiles of income —and even the life-cycle profile of income itself— are unlikely explanations either of the average age gaps at first marriage, or of their increasing life-cycle profiles. Instead, we show that the age gaps at first marriage arise mostly from gender differences in fecundity. And that their increasing life-cycle profiles are essentially a general equilibrium effect generated by the age distributions of singles.[4]

The relationship between gender differences in fecundity and the age gap at marriage was first studied by Siow (1998).[5] A consequence of these differences in fecundity is that there are always

[1]Unless otherwise indicated, the data sources for all the statistics reported in this article are either the United States Census for the year 2000 (see Ruggles, Sobek et al., 2003), or the Marriage Detail File (MDF) compiled by the National Center of Health Statistics for 1995, which was the last year in which the MDF was published.

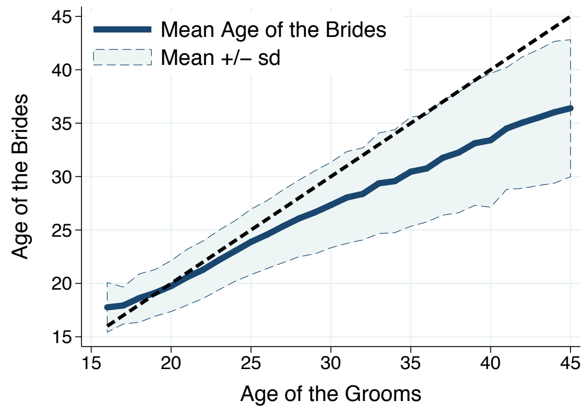
[2]See, for example, Bergstrom and Bagnoli (1993).

[3]See, for example, Coles and Francesconi (2007).

[4]This article is a completely revised version of the quantitative part of Giolito (2004), which was one of the very early attempts to endogenize the distributions of singles, and to explore role played by people's age as an explicit determinant of their marriage decisions. In a related article Seitz (2009) endogenizes the distributions of singles, but only partially. Finally, Giolito (2010) uses a version of our model economy to study the transitional dynamics of the age structure of the population and its impact on marriages in the United States since the 1940's.

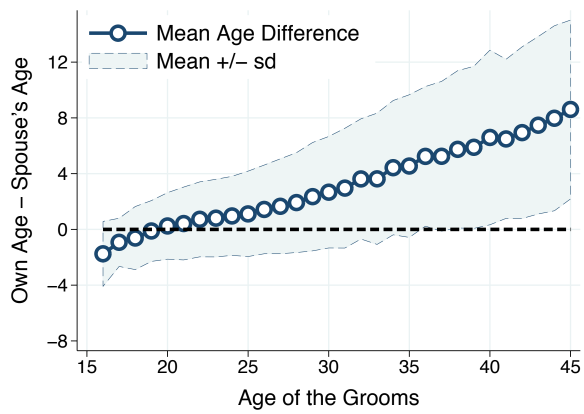
[5]In the biology camp Trivers (1972) is one of the first to study the implications of gender differences in fecundity. In the economics camp, Akerloff, Yelin and Katz (1996), Edlund (1998), and Willis (1999) study the implications of gender differences in fecundity for out of wedlock childbearing. And Siow and Zhu (1998) study its implications for gender biased parental investment in children. Another related contribution is Hamilton and Siow (2007), which uses a detailed 18th century dataset from the Quebec region to estimate the contributions of gender differences in fecundity, social heterogeneity, assortative matching, and search frictions in accounting for aggregate marriage behavior. For many other references outside economics see Betzig (1999).

Figure 1: The Timing of First Time Marriages in the United States

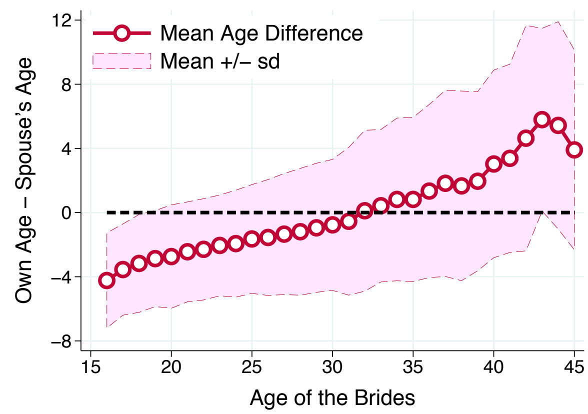


Panel A: Mean Age Profile of the Brides

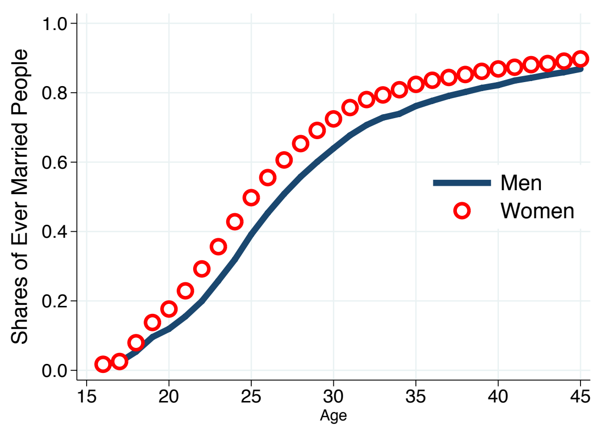
Panel B: Mean Age Profile of the Grooms



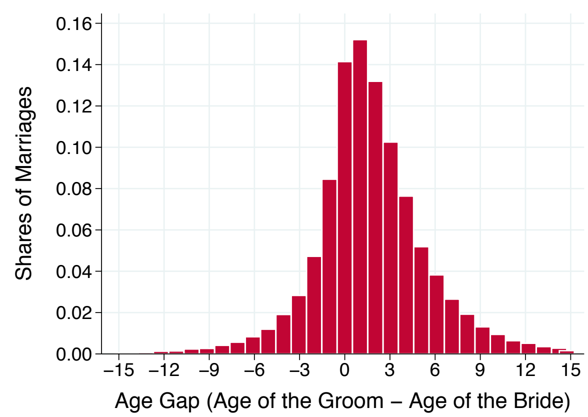
Panel C: Mean Age Gap Profile for the Grooms



Panel D: Mean Age Gap Profile for the Brides



Panel E: Shares of Ever Married People by Age



Panel F: Density Function of the Age Gap more fecund men than fecund women, and this makes the relatively abundant fecund men compete for the relatively scarce fecund women. One way to do this is through the resources that men bring to the marriage. Siow (1998) shows that this mechanism, together with the upward sloping life-cycle profile of income, leads men to delay their marriages. They do this to improve their competitive positions with respect to younger men.[6] In this article we argue that gender differences in income play a small role in accounting for the age gap at first marriage, and that gender differences in fecundity play a crucial role.

The timing of marriages is important because marriage and child-bearing are two of the key decisions that people make in their life-times. They are both extremely discrete, and they condition in important ways the education, labor, and savings decisions of adults. Moreover, the timing of marriages is a tight proxy for the age of parents at first birth, which in turn conditions the time and the resources that they invest in children.[7] In this article we do more than to provide a full account of the timing of first marriages. We also discuss who marries to whom, and we give careful accounts of the matching process, and of the demographics of single people, and of married people.

To construct our argument, we compare the steady states of several parameterizations of an overlapping generations model economy where people search for spouses. Our model economy is populated by men and women who live for many periods. They meet with each other at most once per period, and they decide whether to marry. Men and women differ in their fecundity, in their income, and in their longevity. Fecundity and income are deterministic and they depend on people's age. Longevity also depends on people's age, but it is stochastic. And women's income also depends on their marital status.

In some sense this article is an attempt to quantify the trade-offs faced by people when they decide to have children. These trade-offs are particularly severe in the case of women because the income of married women is sizably smaller than the income of single women, and this does not happen to men (see Panel C of Figure 2). Even if we ignore the psychological differences between the genders in their attitudes towards child-bearing, the shorter duration of women's fecundity makes their child-bearing decision especially pressing. To capture these trade-offs parsimoniously in our model economy, we assume that men's income is independent of their marital status, and that the income of married women grows at a lower rate than the income of single women.

In our model economy people marry because they want to have children and because they value sharing their income and keeping company with their spouses. Moreover, we assume that marriages last until "death do them part", and widows and widowers never remarry. To keep the decision problem as simple as possible, we also assume that the only economic decision that singles make is whether to marry, and that married and widowed people make no economic decisions whatsoever. We make these assumptions to show that such a simplified model world is sufficient to account for the basic features of the timing of first marriages in the United States in recent years.

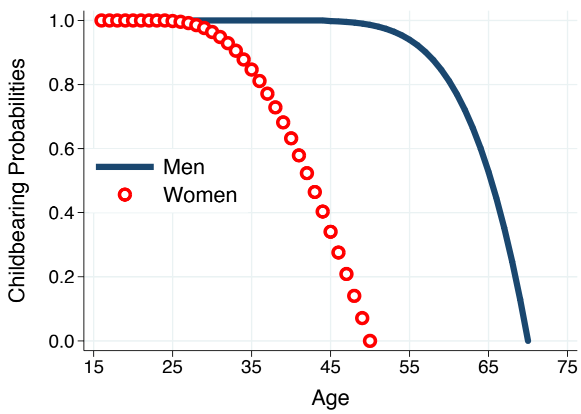
We also assume that in our model economy utility is non-transferable.[8] We make this assumption because we are not interested in the allocation of resources between spouses. Instead we assume

[6]The model economy in Siow (1998) is much richer than ours. In his analysis parental investment in children and labor markets interact with the marriage decision and determine the gender roles.

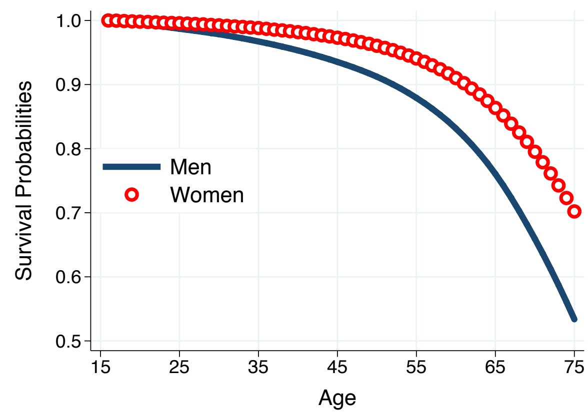
[7]In the last two decades in developed countries the timing of first births has taken precedence over fertility as a concern for both demographers and economists.

[8]Transferable utility models of marriage are part of a long and respected tradition in economics started by Becker (1973 and 1974). Some recent examples in this literature are Choo and Siow (2006 and 2007) and Chiappori, Iyigun and Weiss (2009). In contrast, Coles and Francesconi (2007) also assume that utility is non-transferable, and they use an income sharing mechanism that is similar to ours.

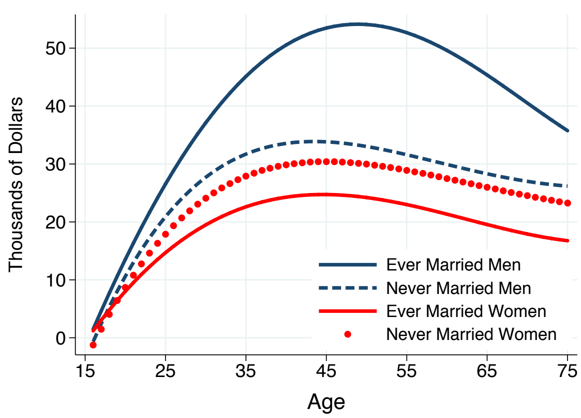
Figure 2: Gender Differences in the United States and in the Benchmark Model Economy



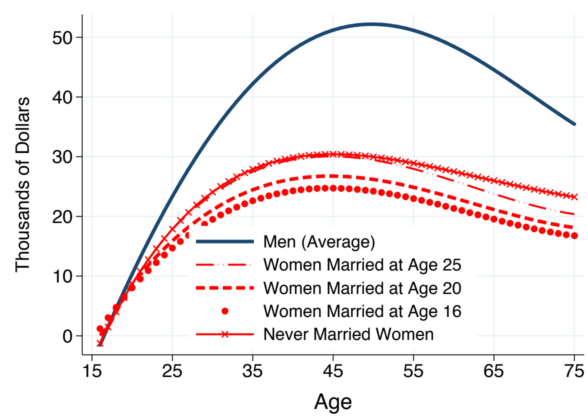
Panel A: Fecundity Profiles



Panel B: Survival Probabilities



Panel C: Income Profiles in the United States



Panel D: Income Profiles in the Model Economy that when two people marry they pool their income and that both children and consumption are public goods within the household. Our income pooling assumption plays a role that is similar to the transferable utility assumption, and it simplifies our equilibrium process

In our model economy, when two singles meet they each draw a realization from a random process that determines the value of the match for the other partner, and they ask about each other's age. This information is sufficient for both partners to compute the expected value of the marriage, and to decide whether to propose. If both partners propose, the meeting ends up in a marriage. Otherwise, they both remain single. Some of the main features that distinguish our modeling choices from those in the literature are that we consider people's age as an explicit determinant of their marriage behavior, that we endogenize the single sex ratios fully, and that we make our arguments entirely quantitative.[9]

In a model world as simple as ours, who meets with whom plays a large role in determining the timing of marriages. To capture some of the flavor of meetings of singles in the real world, we assume that singles sometimes meet other singles who belong to their same age group, and that, other times, they meet with singles whose age is completely random. Therefore, in our model economy some of the matches are assortative in age, and some of the matches are random. But, in both cases, the probabilities of the matches are a function of the appropriate sex ratios, which are endogenous.

In the benchmark parametrization of our model economy men are fecund for a longer period of their lives than women, their income is greater, and their life-expectancy is shorter. The fecundity profiles, the income profiles, and the survival probability profiles replicate the corresponding profiles in the United States, which we illustrate in the various panels of Figure 2. Naturally, the decision to propose depends crucially on the shape of the utility function, and on the utility shares of child-bearing, family income, and companionship. We lump together child-bearing and companionship, and we assume that utility function is a standard Cobb-Douglas function, and that the elasticity of substitution between its two arguments is unity.

When all is told, our benchmark model economy has four free parameters, which we calibrate using four aggregate targets that describe marriage behavior in the United States. We find that modeling the marriage decision in an extremely simple framework, like we do in this article, is sufficient to account for the main aggregate and distributional statistics that describe the timing of first marriages in the United States (see Table 1 and Figures 3 and 4, where we report our findings). And we argue that endogenizing the age distributions of singles and including a random component in our matching function play crucial roles in delivering some of these findings.

To decide whether to marry, the singles in our model economy observe each other's ages and they compute the reservation match values that make them indifferent between proposing to their current match partner or remaining single. In Section 6 we use these reservation match values to show that 20, 30, and 40 year old women are choosier than men of their same age, as long as their match partner is younger than about 38. But in meetings with older partners, it is the men who are the choosier. These findings illustrate that fecundity plays a dominant role in our model economy. When women are young and fecund, their relative scarcity allows them to play hard to get, and they are choosier than men of their same age. But, when their fecundity starts to decline, the men

[9] Some important contributions to the literature of fecundity, economic incentives, and marriage that we have not yet mentioned are Aiyagari, Greenwood, and Guner (2000), Regalia and Ríos-Rull (2001), Caucutt, Guner and Knowles (2003), and Greenwood, Guner, and Knowles (2003). These articles do not study the age gap at first marriage.

take advantage of their longer biological clocks, and it is them who become the choosier.

Next, in Section 7 we discuss the robustness of our calibration exercise to various specifications of our matching function. To that purpose, we compare our benchmark economy with two model economies that differ in their shares of random and assortative matches. In random matches the partners are drawn from the entire distribution of singles. And in assortative matches they are drawn from the distribution of people whose age difference is at most three years. We compare our benchmark model economy —where 46 percent of the matches are random and 54 percent of the matches are assortative— with two other model economies, one in which every match is random and another one in which every match is assortative. The three model economies are identical otherwise. We find that a purely random matching function exaggerates the increasing life-cycle profiles of the age gaps at first marriage. And that a purely assortative matching function underestimates the slope of these profiles. Consequently, our robustness exercise leads us to conclude that some degree of random matching is essential to replicate the profile of the age gaps that we observe in the data.

Then, in Section 8, we use our model economy to quantify the roles played by the life-cycle profiles of income and fecundity in determining the timing of first marriages. To this purpose we solve three counterfactual economies, which we label E_Y, E_P, and E_F. In model economy E_Y we assume that men and women have identical income profiles, and that these income processes are independent of their marital status. In model economy E_P we assume that the income profiles of men and women, besides being identical and independent of their marital status, are also constant over the life-cycle. And in model economy E_F we assume that men and women have identical fecundity profiles. In all other respects, the men and the women in these three model economies are identical to their counterparts in the benchmark model economy.

We find that both men and women marry somewhat earlier in model economy E_Y than in the benchmark model economy, and that the average age gap at first marriage increases by a tiny 0.08 years —from 1.73 years in the benchmark model economy, to 1.81 years in model economy E_Y. Men are less demanding with women of every age in model economy E_Y, because they now earn more income and, consequently, their value as spouses has increased. And, therefore, they marry earlier. Women marry earlier because they no longer need to delay their marriages in order to increase their income. But the interesting part of our findings is that, even though in this model economy there are no gender differences in income, the age gap at first marriages remains essentially unchanged.

Perhaps more interestingly, we find that these two results also obtain in model economy E_P, where the income profiles of men and women are both identical and flat. Since both men and women have no incentives to wait, they marry earlier. But the age gap at first marriage remains essentially unchanged at 1.77 years. We interpret this result as additional evidence in favor of the causal relationship between gender differences in fecundity and the age gap at first marriages. When the income profiles are flat, and only then, older men loose all their advantages over younger men. Yet women, pressed by their shorter biological clocks, still choose to marry at a younger age than the men of their same cohort, whose longer fecundity allows them to hold out longer and keep searching for a better match.

These results are very different when we assume that it is the the fecundity periods of men and women that are identical. Specifically, we find that both men and women marry at an older age in model economy E_F, than in the benchmark model economy. Since their increased fecundity makes women to delay their marriages by much more than men do, the age gap at first marriage falls to only 0.59 years, which is 1.14 years less than in our benchmark model economy. This is mostly because their middle aged women, who are now fully fecund, become sizably more demanding in the match quality of their prospective spouses, and this makes them delay their marriages. Consequently, the number of fecund women who are both fecund and single increases. This allows men to become more demanding and they, too, end up marrying later in life.

The comparison between our counterfactual model economies E_Y, E_P, E_F, and our benchmark model economy leads us to conclude that there is a tight causal connection between gender differences in fecundity and the timing of first marriages observed in the United States. And it also suggests that it is the gender differences in fecundity that make the life-cycle profiles of the age gaps at first marriage steeper for the grooms than for the brides. Our analysis also shows that considering the general equilibrium effects of the marriage decisions —which make the age distributions of singles endogenous and decreasing— and some random matching —which is the transmission mechanism of these general equilibrium effects— are sufficient to account for the increasing life-cycle profiles of the age gaps at first marriage observed in the United States for both sexes. And that this feature of the age gap profiles is essentially independent of gender differences in either income or fecundity.

2 The Model Economy

We study a model economy populated by a continuum of men and a continuum of women. In our model economy men and women differ in their fecundity, in their longevity, and in their income. And they derive utility from being married, from having children, and from their income, which is transformed one-to-one into consumption.

People enter our model economy as singles and we assume that the only economic decision that they make is whether to marry. To model marriage we do the following: We assume that singles meet in heterosexual pairs at most once each period. When two singles meet, each of them draws a random number which represents the value of that marriage for the other person. Based on this information and on the potential spouse's age, fecundity, and income each of them decides whether to propose. When both parties propose the meeting ends up in a marriage. When one of them does not propose, they both remain single and they continue their search for spouses in the future. Since we are interested in first marriages only, marriages in our model economy last until "death do them part", and widows and widowers never remarry. And to keep our analysis as simple as possible married people and widowed people in our model economy make no economic decisions whatsoever.

2.1 Population Dynamics

We use subindex $i=1,2$ to denote people's gender. Following the conventions of the United States Census we choose $i=1$ for men and $i=2$ for women. We use subindex $j=16,17,\ldots,T$ to denote people's age. We assume that people enter our model economy at age 16, that they are initially single, and that they live for at most T years. We also assume that they face an exogenous probability of dying each period. We denote these probabilities by δ_{ij}, and we assume that they are gender and age dependent, and time-invariant. Since people live for at most T periods, then $\delta_{1T}=\delta_{2T}=1$.

We assume that the measure of 16 year-old people that enters the economy each period is endogenous. We denote it by h_t, and we describe it in Section 2.3 below. Let parameter η denote the share of men in the measure of new-entrants. Then our assumptions imply that the gender and age distribution of people in period t, which we denote by $\{n_{ijt}\}$, is

$$n_{1,16,t} = \eta h_t \tag{1}$$

$$n_{2,16,t} = (1 - \eta) h_t \tag{2}$$

$$n_{i,j,t} = (1 - \delta_{i,j-1})\, n_{i,j-1,t-1} \text{ for } 17 \geq j \leq T \tag{3}$$

Expressions (1), (2), and (3), together with our assumptions about the probabilities of dying imply that the sex and age distribution of people in our model economy converges to a stationary distribution which depends on marriage behavior. Our assumptions also imply that the probability that an c year-old person of gender i survives until age d is

$$p_i(c, d) = \prod_{j=c}^{d-1} (1 - \delta_{i,j}) \tag{4}$$

They also imply that, when the survival probabilities of j year old men and women differ, the sex ratios of people of any age older than j differ from each other, and from the total sex ratio. In contrast, when there are no gender differences in survival probabilities, our assumptions imply that the sex ratios of people of all ages are identical, and they are equal to the sex ratio of sixteen year-olds.[10] We represent the survival probability profiles in Panel A of Figure 2 **??**.

2.2 Fecundity

Measuring fecundity in real life is hard and relating it to age is harder. According to Hassan and Killick (2003), the effect of men's age on fecundity remains uncertain. The evaluation of standard sperm and endocrine parameters for age cohorts is typically inaccurate, because these parameters do not reflect the sperm fertilizing capacity or fecundability. Experiments that study the effect of age on male fecundity have been criticized on methodological grounds because they use the subjects' age at conception and they do not take into account cofounding factors such as the age of the mother or their coital frequency. Hassan and Killick (2003) measure the time to pregnancy from the onset of the attempts to become pregnant for men of various age groups, and they find that male aging leads to a significant increase in the time to pregnancy, especially after ages 45 to 50.

Wood and Weinstein (1988) study the fecundity of women. They distinguish between "total fecundability" and "effective fecundability". Total fecundability is a woman's monthly probability of any conception, regardless of its outcome. While effective fecundability is the woman's monthly probability of a conception that results in a live birth. Therefore, effective fecundability excludes the probability that a conception will end in a miscarriage. According to Wood and Weinstein,

[10]Notice that the single sex ratios differ from the sex ratios of the total population because the former depend on marriage behavior.

total fecundability of women drops rapidly after age 40, as a result of large changes in the ovarian function. Between ages 25 and 40, total fecundability of women is remarkably constant. This finding suggests that any reduction in the physiological capacity to bear children between ages 25 and 40 is attributable to an elevation in intrauterine losses rather than to a decline in the ability to conceive. But, even accounting for intrauterine loss, the pattern of effective fecundability remains fairly flat between ages 20 and 35.

Modeling these diffuse findings is not easy. We compromise as follows: Let f_{ij} denote the time-invariant probability that a person of gender i bears children at age j. We assume that this probability is one from age 16 until that person reaches age α_i. Next, we assume that the probability of bearing children decreases exponentially between ages α_i and λ_i, and that it is zero afterwards. To model the gender differences in fecundity, we assume that the age limits vary for men and women.[11] Formally,

$$f_{ij} = \begin{cases} 1 & \text{for } 16 \leq j \leq \alpha_i \\ 1 - e^{\xi\left(\frac{\alpha_i}{j}\right)(\lambda_i - j)} & \text{for } \alpha_i < j \leq \lambda_i \\ 0 & \text{for } \lambda_i < j \leq T \end{cases} \tag{5}$$

We represent the resulting fecundity functions in Panel B of Figure 2 **??**.[12]

2.3 Fertility

In our model economy we abstract from the fertility decision. Instead we assume that when an a-year old groom marries a b-year old bride they beget instantaneously $k_{a,b}$ children at the time of marriage. To determine the value of $k_{a,b}$ we make two assumptions. First we assume that every couple wants to have the same number of children. We call this number the desired fertility parameter and we represent it by the letter μ. Then we assume that the actual fertility differs from couple to couple and that it depends on the declining fecundity of both spouses as follows:

$$k_{a,b} = \sum_{j=0}^{\mu-1} f_{1,a+2j} f_{2,b+2j}. \tag{6}$$

Expression (6) is the number of children that a couple who married when their ages were (a, b) would have had if they had attempted to have the first child during the first year of their marriage, and their next children in two-year intervals until they reached their desired fertility, assuming that the probability of success is the product of the values of the fecundity parameters of both parents at the time of child-bearing.

Suppose for example, that a 40 year-old groom marries a 36 year-old bride and that value of the desired fertility parameter is $\mu = 2$ children. The ages of the couple would have been 40 and 36 when they attempted to have their first child, and 42 and 38 when they attempted to have their second child. Therefore their total number of children is $k_{40,36} = f_{1,40} f_{2,36} + f_{1,42} f_{2,38}$. If we use the values for $f_{i,j}$ represented in Panel B of Figure 2 to compute this number, it turns out that $k_{40,36} = 1.48$. Hence, in our model economy when a 40 year old groom marries a 36 year old bride they beget 1.48 children in the period when they marry.

[11] This functional form is chosen in order to replicate the life-cycle profile of effective fecundability which Wood and Weinstein (1998) plot in Figure 5 (page 101).

[12] Notice, that in our benchmark model economy, if a woman marries a man who is under 50 and therefore fully fecund, the fertility of that marriage declines at the rate determined by the fecundity of the wife.

The desired number of children, μ, can take any value. When μ is not an integer we simply assume that in the last year of their child-bearing period couples attempt to have $1 + x$ children were x is the decimal part of μ. For example if $\mu = 2.5$, we assume that in the last year of their child-bearing period couples attempt to have 1.5 children.

Let $m_{a,b,t}$ to denote the total number of marriages that take place in our model economy between an a-year old groom and a b-year old bride in period t, then the total number of births in our model economy in period t is

$$h_t = \sum_{a=16}^{T} \sum_{b=16}^{T} \sum_{j=0}^{\mu-1} m_{a,b,t-2j} f_{1,a+2j} f_{2,b+2j} \tag{7}$$

2.4 Income

In Panel C of Figure 2 we show that in the United States marriage affects the income of men and women sizably and in different ways. Married men tend to earn more than single men —$230,000 more in present value between ages 16 and 64. And married women tend to earn less than single women —$77,000 less in present value between ages 16 and 64. The literature on marriage and on gender specialization conjectures that the causal relationship between income and marriage works in different directions for men and for women. Whereas men with high income-earning potential tend to marry earlier, women who marry early tend to earn less income. To formalize this idea, in our model economy we assume that men's income is independent of their marital status, and that the income of single and married women grows at different rates.

Specifically, we assume that singles in our model economy receive an endowment of income which depends on their gender, on their age, and on their marital status, and which we denote by, y_{ijl}. Subindex $l = s, m, w$ indicates the marital status of a person, s indicates that the person is single; m indicates that the person is married; and w indicates that the person is a widow or a widower.

We assume that the income of single and married men is the same. Therefore, for all j

$$y_{1,j,s} = y_{1,j,m} \tag{8}$$

In contrast, we assume that when women marry their income grows at a rate that is smaller than the growth rate of the income of single women. Therefore the income of a married woman who is $(b+\ell)$ years old and who married at age b is

$$y^b_{2,b+\ell,m} = y_{2,b,s} \prod_{t=a}^{j} (1 + g_{b+j}) \tag{9}$$

where g_t denotes the rate of growth of income for married women of age t.

These assumptions imply that in our model economy the income of men is completely exogenous, and that the income of women is partially endogenous. When women marry later, they increase amount of income that they bring to the marriage, and this increases their value as spouses. But this does not happen in the case of men.

Finally, we assume that survivors receive the income that they would have received if they were still married, y_{ijm}, and a gender dependent survivors pension which we denote by τ_i. Formally, the income of a j-year old widower is

$$y_{1jw} = y_{1jm} + \tau_2 \tag{10}$$

2.5 The Intangible Values of Marriage

We use a random process to model the intangible values of marriage such as companionship and sexual fulfillment. When two people meet they each draw an independent and identically distributed realization from a random process. The realization determines the value of that marriage for the potential spouse. We denote the realizations of this process by x_i, and the distribution from which they are drawn by $G(x)$.

2.6 Search

In our model economy the search for spouses is double-sided and costly. Our matching function is a convex combination of a standard random matching function, and an assortative matching function that restricts the meetings to people who belong to the same age group.

Let s_{ij} denote the number of j year-old singles of gender i, let $S_i = \sum_{j=16}^{T} s_{ij}$ denote the total number of singles of gender i, and let $\hat{S}_i(j) = \sum_{j \in \kappa(j)} s_{ij}$ denote the number of singles of gender i whose ages belong to the interval $\kappa(j) = [\max(j-z, 16), \min(j+z, T)]$, where z is a positive integer. Then the probability that an a year-old bachelor meets a b year-old single woman is

$$q_1(a,b) = \begin{cases} \pi \left[\frac{s_{2b}}{\hat{S}_2(a)} \min\left(\frac{\hat{S}_2(a)}{\hat{S}_1(b)}, 1 \right) \right] + (1-\pi) \left[\frac{s_{2b}}{S_2} \min\left(\frac{S_2}{S_1}, 1 \right) \right] & \text{if } b \in \kappa(a) \\ (1-\pi) \left[\frac{s_{2b}}{S_2} \min\left(\frac{S_2}{S_1}, 1 \right) \right] & \text{otherwise} \end{cases} \tag{11}$$

The assortative component of our matching function is the first term of the first line of expression (11), and the random component is its second term. And our matching function converges to a purely random matching function as parameter π approaches zero. Pure assortative matching means that singles only meet potential spouses who belong to the age group defined by parameter z. For example, if $z = 3$, then 25 year-old bachelors only meet single women who are between 22 and 28 years old. Pure random matching means that bachelors of every age face the same probabilities of meeting single women of any given age, and that these probabilities are determined by the age distribution of single women.

In our model economy the meeting probabilities, the utility functions, and the decision problems of single men and single women are symmetrical. For notational convenience we describe only the probabilities, functions, and problems of single men. To obtain the corresponding expressions for the probabilities, functions and problems of single women simply substitute the 1's for 2's, the 2's for 1's, the a's for b's, and the b's for a's. We use this convention throughout the article with only one exception: we use the pair (a, b) to denote the age of the groom and the age of the bride always in that order, and we never switch it it to (b, a).

2.7 Payoffs

The period utility of a j-year old single person of gender i is

$$v(y_{ijs}) = (1-\theta)\log(y_{ijs}) \tag{12}$$

Suppose that an a-year old groom married a b-year old bride whose match quality was x_2. Then, ℓ years later, the period utility of the groom is

$$u_1(x_2, y_{1,a+\ell,m}, y^b_{2,b+\ell,m}) = x_2 \left\{\theta \log(1+k_{a,b}) + (1-\theta)\log\left[\phi_{a,b}\left(y_{1,a+\ell,m} + y^b_{2,b+\ell,m}\right)\right]\right\} \tag{13}$$

In expression (13) parameter $0<\theta<1$ measures the utility share of being part of a family and bearing children with one's spouse, and parameter $0<\phi_{a,b}<1$ measures the income sharing feature of marriages. The value of parameter $\phi_{a,b}$ is determined at the time of the marriage. It is a function of the effective fertility of the couple. It never changes during the entire duration of the marriage, and we discuss it in detail in Section 4 below.

Finally, the period utility of a j-year-old survivor of gender i is

$$w(y_{ijw}) = (1-\theta)\log(y_{ijw}) \tag{14}$$

Notice that we have assumed that the utility share of income is the same for singles, married people, and survivors.

2.8 The Decision Problem of Singles

In our model economy when two singles meet, each of them compares his or her expected values of marrying their current meeting partner with his or her expected values of remaining single, and possibly meeting somebody else and getting married sometime in the future. The value of the marriage is uncertain because life-time durations, and therefore marriage durations, are uncertain. The value of remaining single is uncertain because life-time durations are uncertain, because meetings are uncertain, and because marriages and their qualities are uncertain.

2.8.1 The Probabilities of Marriages

The probability that an a-year old groom marries a b-year old bride is

$$\gamma_1(a,b) = q_1(a,b)\left\{1 - G\left[R_1(a,b)\right]\right\}\left\{1 - G\left[R_2(b,a)\right]\right\} \tag{15}$$

where $R_1(a,b)$ denotes the reservation value that a-year old bachelors require to propose to b-year old single women, and $R_2(b,a)$ is the reservation value that b-year old single women require to propose to a-year old bachelors. Variable $q_1(a,b)$ is the probability that the match takes place, the first set of curly brackets is the probability that the man proposes, and the second set of curly brackets is the probability that the woman proposes provided that the match occurs. Consequently, the probability that an a-year old groom marries a bride of any age is

$$\Gamma_{1a} = \sum_{b=16}^{T} \gamma_1(a,b) = \sum_{b=16}^{T} q_1(a,b)\left\{1 - G\left[R_1(a,b)\right]\right\}\left\{1 - G\left[R_2(b,a)\right]\right\} \tag{16}$$

which naturally depends on the reservation values of both potential spouses.

2.8.2 The Expected Values of Marriages

The value that an a-year old bachelor expects to obtain from marrying a b-year old single woman who has drawn realization x_2 and has proposed to him is

$$\begin{aligned} EM_1(a,b,x_2) = u_1(x_2, y_{1as}, y_{2bs}) + \\ \sum \beta^{\ell} \times p_1(a, a+\ell) \times p_2(b, b+\ell) \times u_1(x_2, y_{1,a+\ell,m}, y^{b}_{2,b+\ell,m}) + \\ \sum_{\ell=1}^{T-a-15} \beta^{\ell} \times p_1(a, a+\ell) \times [1 - p_2(b, b+\ell)] \times w(y_{1,a+\ell,w}) \end{aligned} \tag{17}$$

where $D = \min\{T-a-15, T-b-15\}$. The first term of expression (17) is the value of the first period of the marriage. The second term is the value of the marriage during its expected duration. And the third term is the value of widowerhood during its expected duration.

2.8.3 The Expected Value of Remaining Single

The value that an a-year old bachelor expects to obtain from remaining single is

$$\begin{aligned} ES_1(a) = v(y_{1as}) + \sum_{\ell=1}^{T-a-15} \beta^{\ell} p_1(a, a+\ell) \times \\ \left\{ \sum_{b=16}^{T} \gamma_1(a,b)\, EM_1[a,b,x_2 \mid x_2 \geq R_1(a,b)] + (1 - \Gamma_{1,a+\ell})\, v_1(y_{1,a+\ell,s}) \right\} \end{aligned} \tag{18}$$

The first term of expression (18) is the value of remaining single during the current period, the first term in the curly brackets the expected value of getting married sometime in the future before a match takes place, and the second term is the expected value of remaining single in the future.

2.8.4 The Reservation Values

The optimal reservation values that a-year old men and b-year old women require to propose to each other can be found solving the system of $2T^2$ equations in $2T^2$ unknowns that results from equating the T^2 expressions (17) and (18) for the men and the corresponding T^2 equations for the women. Formally, the $\{R_1(a,b)\}$ are the T^2 values of x_2 that solve the T^2 equations

$$EM_1(a,b,x_2) = ES_1(a) \tag{19}$$

one for each value of $a, b \in \{16, 17, \ldots, T\}$. Similarly, the $\{R_2(a,b)\}$ are the T^2 values of x_1 that solve the T^2 equations

$$EM_2(a,b,x_1) = ES_2(b). \tag{20}$$

3 Equilibrium

A steady state equilibrium for this economy is a time-invariant age distribution of people, $\{n_{ijt} = n_{ij}\}$, a time-invariant measure of singles, $\{s_{ijt} = s_{ij}\}$, a time-invariant measure of marriages between

a-year old grooms and b-year old brides, $\{m_{a,b,t} = m_{a,b}\}$, a time-invariant measure of new entrants, $h_t = h$, a matrix of the optimal reservation values that singles require to propose to each other, $\{R_1(a,b), R_2(a,b)\}$, for $i \in \{1,2\}$ and for all $a, b, j \in \{16, 17, \ldots, T\}$, and a parameter μ, such that:

(i) The invariant age distribution of the population, $\{n_{ijt} = n_{i,}\}$ satisfies expressions (1), (2), and (3).

(ii) The invariant measure of singles, $\{s_{ijt} = s_{ij}\}$, satisfies

$$s_{i,16} = n_{i,16} \text{ and} \tag{21}$$

$$s_{i,j+1} = s_{ij}\,(1 - \delta_{ij})\,(1 - \Gamma_{ij}) \;\; for\{j < 16 \leq T\} \tag{22}$$

where the Γ_{ij} are defined in expression (16)

(iii) The invariant measure of marriages between a-year old grooms and b-year old brides, $m_{a,b,t} = m_{a,b}$, satisfies

$$m_{a,b} = s_{1a}\gamma_1\,(a,b) = s_{2b}\gamma_2\,(a,b) \tag{23}$$

where the $\gamma_i(a,b)$ are defined in expression (15)

(iv) Parameter μ is such that

$$h = \sum_{a=16}^{T}\sum_{b=16}^{T} m_{a,b}k_{a,b}(\mu) = \sum_{i=1}^{2}\sum_{j=1}^{T} n_{ij}\delta_{ij}$$

(v) The reservation values $\{R_1(a,b),\, R_2(a,b)\}$ solve the decision problems of singles described in expressions (19) and (20).

4 Calibration

To calibrate our model economy we must choose the duration of the model period, a functional form for the distribution function of the match values, $G(x)$, and a value for every parameter that we have discussed above. These parameters are: the maximum life-time, T; the mortality probabilities, δ_{ij}; the share of men in the measure of new-entrants, η; the five parameters that determine the fecundity profiles, α_i, λ_i, and ξ; the desired fertility parameter, μ; the income profiles of singles, y_{ijs}; the growth rates of the income of married women, g_j; the survivors pensions, τ_i; the search function parameters, π, and z; the time discount factor, β; and the parameters that characterize the payoffs, $\phi_{a,b}$, μ, and θ.

The model period. We assume the time period in our model economy is yearly. We make this assumption to be consistent with the periodicity of our main sources of data.

The distribution of the match values. We assume that the logarithm of the distribution of match values, $G(x)$, is normally distributed with zero mean and a standard deviation σ. We choose a lognormal distribution because the match value enters multiplicatively in our utility function and, therefore, a distribution of match values with a negative support would make little sense. Moreover, lognormal distributions are fairly standard in the search literature.[13]

The maximum life-time. We assume that $T = 92$. We choose this age because the United States Census of the year 2000 supplies information on marriages up to that age only.

The mortality probabilities. We take the mortality probabilities from the Human Mortality Database for the year 2000. We represent the survival probabilities implied by these mortality probabilities in Panel A of Figure 2.[14]

The share of men in the measure of new-entrants. We choose $\eta = 0.507$. This choice implies a sex ratio of 1.028 at age 16, which approximates the corresponding value for the 16-30 age group in the United States Census for the year 2000.[15]

The fecundity profiles. To characterize the functions that determine the fecundity profiles we must choose the values of parameters α_i, λ_i, and ξ. We choose these values so that our fecundity profiles are roughly consistent with the findings of Hassan and Killick (2003) and Wood and Weinstein (1988) discussed in Section 2.2 above. We assume that the fecundity of women is one between ages 16 and 25, that it declines exponentially between ages 26 and 50, and that it zero afterwards. We use the concept of "effective fecundability" proposed by Wood and Weinstein (1988), and we choose $\alpha_2 = 25$, $\lambda_2 = 50$ and $\xi = 0.25$ to replicate their results. Similarly, we assume that the fecundity of men is one between ages 16 and 45, that it declines exponentially at rate ξ between ages 46 and 75, and that it is zero afterwards. These choices imply that $\alpha_1 = 45$, and $\lambda_1 = 75$. We represent the fecundity profiles in Panel B of Figure 2.

The desired fertility parameter. The value that we choose for the desired fertility parameter is $\mu = 2.33$. This choice implies a zero growth rate of the model economy equilibrium population. In the United States in 2000 the total fertility rate was 2.1 which is essentially the population replacement rate —that is, the rate that generates a stable population.

The income profiles. We construct the income profiles of singles, y_{ijs}, and the growth rates of the income of married women, g_j, using the the data on total personal income reported in United States Census for the year 2000 excluding from the sample people under 64 who do not work. To construct the income profiles for men, we have computed the average income by age regardless of the marital status. To construct the profiles for women, we compute the average income by age and marital status in the sample. To construct the profiles for married women, we compute the average income of the ever married women from the times of their weddings onwards. Then we fit three fourth degree polynomials through the resulting data points. Finally we use the profile for ever married women in the United States to compute the growth rates for the income of married women in the sample. We plot the polynomials for the United States in Panel C of Figure 2. In

[13] In a previous version of this paper we used a uniform distribution and the main qualitative results reported in this article remained unchanged.

[14] The Human Mortality Database is compiled by the University of California, Berkeley (USA) and the Max Planck Institute for Demographic Research (Germany). This dataset is available at www.mortality.org.

[15] In the 2000 United States Census, the sex ratio at age 16 is 1.04 and it drops fairly quickly in the early twenties. For this reason we have chosen the value of the sex ratio from an extended cohort.

our model economy the income profiles of singles are the same as in the United States. And in Panel D of Figure 2 we plot the income profile of married men —which is identical to the income profile of single men— and the income profiles of married women who marry at ages 16, 20, and 25.

The survivors' pensions. The survivors' pension of widows are 45 percent of the average total personal income of 60 year old men reported in United States Census for the year 2000. Likewise, the survivors' pension of widowers are 45 percent of the average total personal income of 60 year old women. We make this choices so that the survivors' pensions in our model economy resemble roughly the survivors' pensions in the United States.

The time discount factor. We choose $\beta = 0.96$. This choice is standard in the literature and it implies that the yearly discount rate in our model economy is four percent.

The economies of scale of marriage. We calculate the economies of scale in consumption that result from income sharing and cohabitation using the OECD modified scale. This scale was proposed by Haagenars, de Vos and Zaidi (1994). It assigns a value of 1 to the household head, a value of 0.5 to each additional adult member of the household, and a value of 0.3 to each child. Therefore, when an a year-old groom marries a b year-old bride their scale factor is $\phi_{a,b} = (1.5 + 0.3k_{a,b})^{-1}$.

Four free parameters. To complete the calibration of our benchmark model economy we are left with four free parameters: the standard deviation of the distribution of the match values, σ; the parameters that determine the age range and the share of assortative matches, z and π; and the parameter that measures utility share of being part of a family and bearing children, θ. To determine the numerical values of these four parameters, we choose four United States targets. These targets are the shares of ever married men and ever married women between ages 16 and 45, taken from the United States Census 2000; the average of the age gap at first marriage, and the share of marriages in the United States in 1995 associated with each value of z for $z = 2, 3, 4, 5, 6$.[16]

To obtain the values of these four parameters we do the following for each value of $z \in \{2, 3, 4, 5, 6\}$: First we choose a value of z. This choice defines our fourth target, which is the share of marriages in which the ages of the spouses differ in at most z years. Next we define evenly spaced grids of 50 points for θ, π, and σ. For θ and π we define the grids on the interval $[0, 1]$, and for σ on the interval $[0.1, 1]$. Then we find the values of θ, π, and σ that minimize the sum of the squared differences between outcomes in our model economy and our four United States targets. We repeat this process for each value of z, and we choose the four dimensional vector of parameters that gives us the smallest sum of squares.

The values the parameters that deliver this result are $z = 3$, $\sigma = 0.53$, $\pi = 0.56$, and $\theta = 0.74$. A value of π of 56 percent means that each single draws 56 percent of his or her meetings from the distribution of people within our chosen age range of $z = 3$ years, and that he or she draws the remaining 44 percent of the meetings from the entire distribution of singles. And a value of θ close to 75 percent means that the utility share of children and companionship in marriage, is about 3 times larger than the utility share of income.

[16]Recall that we measure the distribution of ages at first marriage for the United States using the 1995 Marriage Detail File.

5 The Timing of First Marriages

Table 1: The Timing of First Marriages in the United States and in the Benchmark Model Economy*

	United States	Benchmark	Δ
Average Age Gap at First Marriage	**1.74**	**1.73**	**0.01**
Share of Ever Married Men 16-45 (%)	**56.0**	**56.1**	**–0.1**
Share of Ever Married Women 16-45 (%)	**62.5**	**62.2**	**0.3**
Share of Assortative Marriages[a] (%)	**68.4**	**66.4**	**2.0**
Grooms' Median Age at First Marriage	26.63	26.30	0.32
Brides' Median Age at First Marriage	24.80	24.90	–0.09
Never Married Sex Ratio (Men/Women)	1.17	1.18	–0.01

*The bold-faced parameters are calibration targets and the standard face parameters are overidentifying restrictions.

[a]This is the share of marriages in which the ages of the spouses differ in three years or less.

In Table 1 we report the main statistics that describe the timing of first marriages in our benchmark model economy and we compare them with the corresponding data in the United States. Overall, we consider that our calibration exercise has been successful. The average age gap at first marriage in the model economy is only 0.01 years smaller than our United States target. The shares of ever married men, and of ever married women are also very close to their targets. The largest discrepancy between the benchmark model economy statistics and the corresponding United States targets is the two percentage points difference in the shares of assortative marriages. We consider this difference to be reasonable.

We also find that the median ages of both brides and grooms in our model economy are similar to the corresponding statistics in the United States, and that the never married sex ratio is also similar. These three statistics play the role of overidentifying restrictions since we did not target them in our calibration. And they increase our trust in our results.

Notice that the average age gap at first marriage is not equivalent to the difference between the median ages of men and women at first marriage. We compute the average age gaps directly from marriage data. The median ages are the ages at which fifty percent of the married people of a given sample were already married. They measure the timing of marriages using the stock of married people in a given sample, rather than the flow of marriages that take place during a given period.[17] We compute the aggregate statistics on the timing of marriages in the United States using the two data sources that we have described above. And we compute the corresponding statistics for our model economy using its stationary distributions.

In Figure 3 we plot the shares of ever married men and women in every age group, and the age distributions of singles in our model economy and of never married people in the United States.[18] And in Figure 4 we plot the life-cycle profiles of the age gaps at first marriage, their density function,

[17]To compute the median age at first marriage of the men, we take all the ever married men in a sample and we rank them according to their age at first marriage. The median age is the age which leaves 50 percent of the ever married men at either side. The median age at first marriage is the measure preferred by demographers because it is robust to mechanical changes in cohort sizes that affect the average age at first marriage.

[18]The shares of ever married people and the age distributions of singles are different statistics. The shares of ever married people count the shares of people of a given age who are or have ever been married. The age distributions of

and their cumulative distribution.[19]

With some exceptions, Figures 3 and 4 show that overall our benchmark model economy also does a fair job in accounting for the main distributional features of the timing of first marriages in the United States. The most important similarities between our benchmark model economy and the data are that the age gap profiles are increasing both for the brides and for the grooms, and that the slope of the age gap profile is steeper for the grooms than for the brides (see Panels A and B of Figure 4).

These features of the data have largely escaped the attention of the literature on the timing of marriages. In our model economy they are mostly general equilibrium effects, and they arise because the distributions of both single men and single women are decreasing in age. Therefore, as singles get older they are more likely to meet potential spouses who are younger. The steeper slope of the age gap profile of the grooms is a consequence of the longer duration of men's fecundity. When women reach the age in which their fecundity starts to decline, they find it progressively harder to marry men who are much younger. This is not the case for men because they are fecund for a sizably longer period. For example, 40 year-old men are acceptable spouses for women who are 10 or even 15 years younger. In contrast, 40 year-old women are approaching the end of their fecund period, and they are rejected by men who are 10 or 15 years younger. In Section 8 below, we show that the fact that the life-cycle profiles of age gaps at first marriage of both brides and grooms are increasing is essentially independent of the gender differences in income. This result contrasts with some of the accounts for the timing of marriages provided in the literature.[20]

Other similarities between the timing of first marriages in our benchmark model economy and in the United States are the following: the shares of ever married people are increasing and essentially concave both in the United States and in the benchmark model economies (see Panels A and B of Figure 3), and the age distributions of never married people are decreasing and essentially convex in both economies (see Panels C and D of Figure 3). In addition, both in the United States and in the model economy very young people marry older spouses —and therefore the age gaps at first marriage of very young people are negative— and after a certain age the age gaps at first marriage become positive. This is the case both for the brides and for the grooms (see Panels A and B of Figure 4). Finally, the age distributions of the age gaps are unimodal both in the United Stats and in the model economy (see Panel C of Figure 4).

The main differences between the timing of marriages in the benchmark model economy and in the data are the following: both men and women marry earlier in the benchmark model economy than in the data, and this creates differences in the shares of ever married people and in the age distributions of singles. This is particularly noticeable in the case on men.

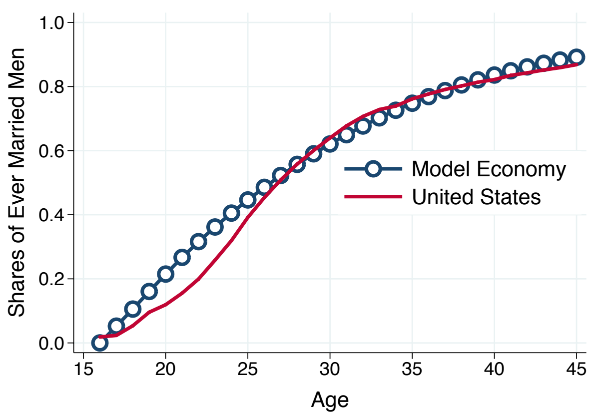
This happens essentially because in our model economy we abstract from the education decision. In our model economy earnings are an exogenous endowment. In the real world young people invest heavily in education when they are young in order to get their earnings potential to grow. And the time requirement of this investment delays the marriage decision. In the case of women, the earnings disincentive to marry young is even stronger because when a woman gets married her income starts to grow at a sizably lower rate. Hence women have stronger incentives to remain

never married people —singles in the model economy— count the single people of each age. We report them because they are an essential component of our matching function.

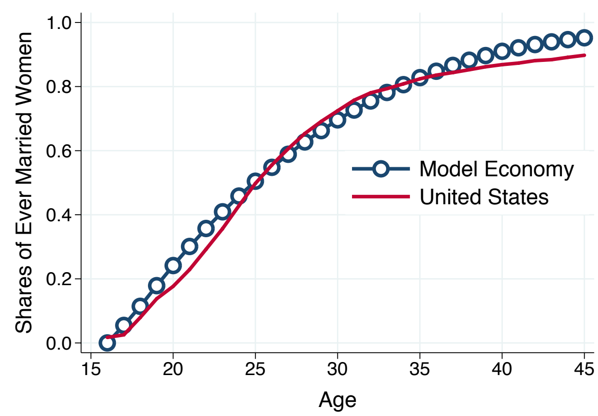
[19]Recall that the data source for the age gap at first marriage in the United States is the 1995 Marriage Detail File.

[20]See, for example, Coles and Francesconi (2007).

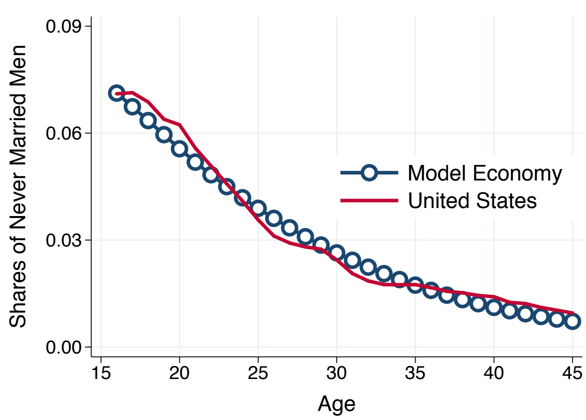
Figure 3: The Timing of Marriages in the United States and in the Benchmark Model Economy (1)



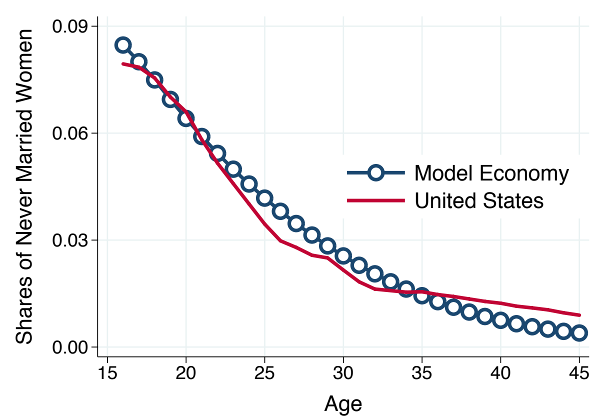
Panel A: Shares of Ever Married Men



Panel B: Shares of Ever Married Women

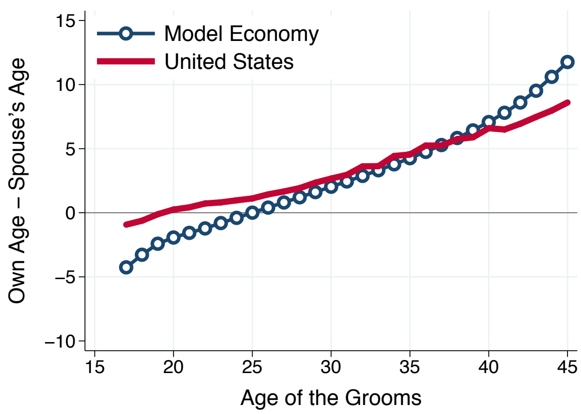


Panel C: Age Distribution of Never Married Men

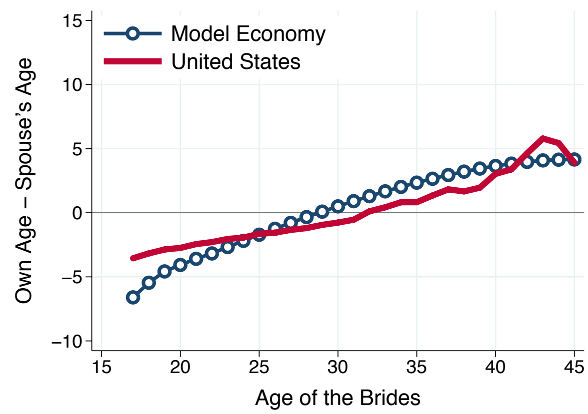


Panel D: Age Distribution of Never Married Women

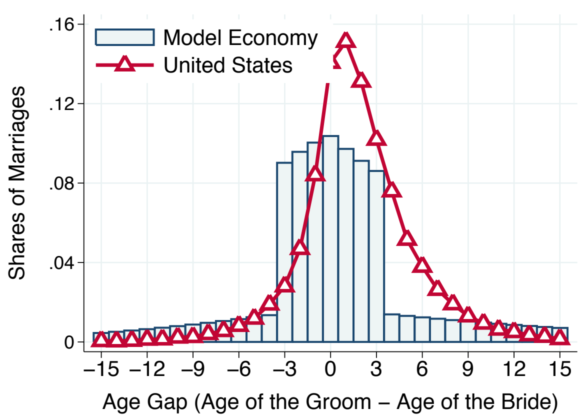
Figure 4: The Timing of Marriages in the United States and in the Benchmark Model Economy (2)



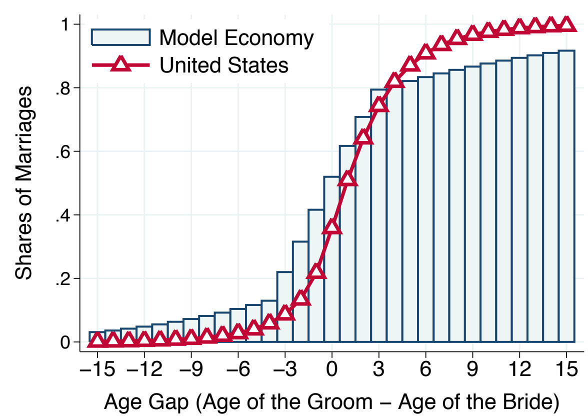
Panel A: Mean Age Gap Profile for the Grooms



Panel B: Mean Age Gap Profile for the Brides



Panel C: Densitiy Function of the Age Gap



Panel D: Cummulative Distribution of the Age Gap single, which they balance against the incentives to marry provided by the shorter duration of their fecund period.

As far as who marries with whom, we find that the sign of the age gaps at first marriage changes earlier in the United States than in our model economy for the grooms and later for the brides (see Panels A and B of Figure 4). This means that there are more marriages in which the husband is younger than the wife in our benchmark model economy than in the United States and, consequently, less in which the wife is younger than the husband.

The features of our matching function offer a partial account of these differences. The age range in the assortative part of our matching function does not change with age. And this is not the case in the real world. In the real world young people meet mostly with peers who belong essentially to their same cohorts —in other words, a large share of the meetings of young people is assortative in terms of age in the real world. This certainly happens in high school and, to a large extent, it also happens in college. In contrast, when people grow older and they move into the working place, they start meeting people of all ages. The purely random part of our matching function allows young people in our benchmark model economy to meet —and marry— people who are older than those that they would meet in the real world and, consequently, the age gaps at first marriage of young people are larger in our model economy. In spite of this limitation of our matching function, our model economy succeeds in replicating the increasing profiles of the age gaps at first marriage.

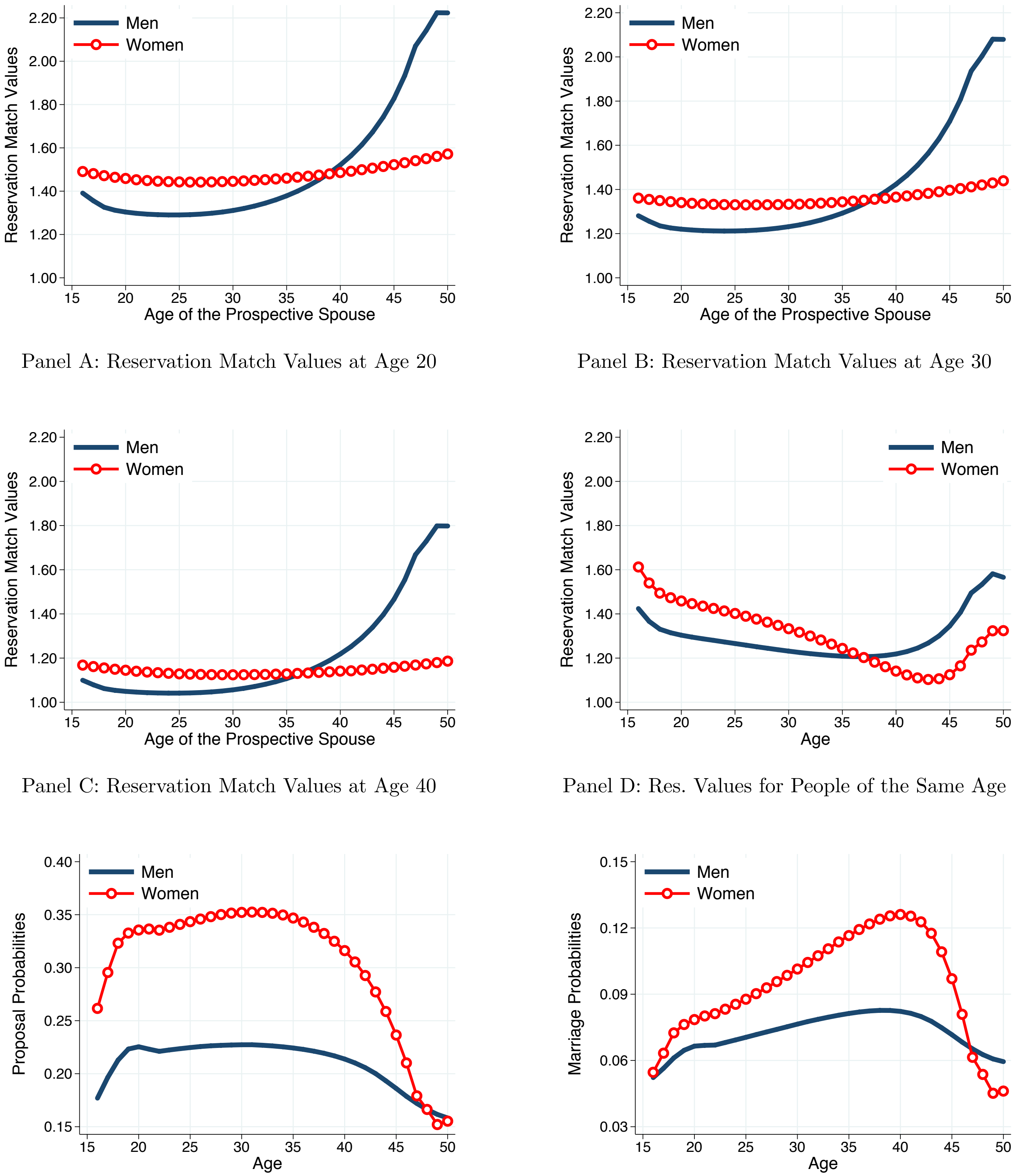
Finally, even though the density functions of the age gaps at first marriage are unimodal both in the United States and in the model economy, we find the the density function in the United States it is skewed to the right and that in the model economy it is essentially symmetrical (see Panel C of Figure 4). Once again, our matching function is partially responsible for this result, because it imposes a symmetry in the the age differences of the matches that is absent in the data.

6 Who Is the Most Choosy?

In our model economies, when two singles meet, they observe their respective ages, and they compute the reservation match values that make them indifferent between proposing to their match partners and remaining single. These reservation match values are a compact way to describe the marriage decisions in our model word, because they summarize both their individual aspects —whether is it worth it for someone to propose to his or her current match partner— and their aggregate aspects —that feed back into the marriage decision problem through the equilibrium age distributions of singles.

In Panels A, B, C, and D of Figure 5 we plot the reservation match values that singles in our benchmark model economy require to propose to partners of various ages. We find that 20, 30, and 40 year old women are choosier than men of their same age, as long as their match partner is younger than about 38. But in meetings with older partners men are the choosier. This is because in our benchmark model economy fecundity is a key consideration in the marriage decision. Young fecund women are relatively scarce, they know that their marriage probabilities are increasing until about age 40 (see Panel F of Figure 5). Therefore, they can afford to play hard to get. When women reach about age 38 their fecundity starts to decline quickly and, consequently, so does their value as spouses. This lowers their reservation values relative to those of men of their same age, whose fecundity has not yet started to decline. Consequently, at about age 38, it is the men who become the choosier.

Figure 5: Reservation Values and Matching and Marriage Probabilities in the Benchmark Model Economy



Panel A: Reservation Match Values at Age 20

Panel B: Reservation Match Values at Age 30

Panel C: Reservation Match Values at Age 40

Panel D: Res. Values for People of the Same Age

Panel E: Matching Probabilities

Panel F: Marriage Probabilities

We also find that the reservation values of both men and women are roughly convex on the age of the potential spouse, that they are flatter for women, and that they reach a minimum for potential spouses whose ages are around the mid to late twenties. At that age both men and women still have their full reproductive capacity, and the income of women has reached a level that is acceptable.

Panel D of Figure 5 summarizes these findings. It shows that women are choosier with potential spouses of their same age until about age 36 and that after that age they become less choosy than men. This panel also shows that young people up to about age 19 are very choosy, and that, after that age, they lower their reservation values progressively until about age 37 in the case of men, and until about 43 in the case of women. In both cases the fecundity of women is the binding constraint. At age 37 women start to become infecund and, consequently, men start to find them less attractive as spouses. In contrast, when women reach age 43 and child-bearing stops being and issue, they start to become more demanding about the match quality of their potential spouses.

Finally, we find that in our benchmark model economy both men and women lower their reservation values for people of their same age at about age 49. In the case of men this is because the fecundity of women becomes essentially zero when they reach age 49, and their income stops growing. Consequently, their utility as spouses becomes a function of their match values and their life-expectancies only. In the case of men, their fecundity starts to decline when they reach age 50, and young fecund women start to turn them down as spouses. This leads the men to lower their reservation values for women of their same age.

7 Random Matching and Assortative Matching

Table 2: Random Matching and Assortative Matching

	E_R^a	E_B^b	E_A^c	Δ_{RB}	Δ_{AB}
Average Age Gap at First Marriage	3.33	1.73	0.003	1.60	–1.73
Grooms' Median Age at First Marriage	26.88	26.30	25.98	0.58	–0.32
Brides' Median Age at First Marriage	24.18	24.90	25.84	–0.72	0.94
Shares of Assortative Marriages^d (%)	24.5	66.6	100.0	–42.1	33.4
Shares of Ever Married Men 16-45 (%)	53.8	56.1	57.6	–2.3	1.5
Shares of Ever Married Women 16-45 (%)	64.4	62.2	59.2	2.1	–3.0
Never Married Sex Ratio (M/W)	1.31	1.18	1.05	0.14	-0.12

$^a E_R$: The Random Matching Model Economy. In this model economy $\pi = 0.0$. Consequently, every match is drawn from the entire distribution of singles.

$^b E_B$: The Benchmark Model Economy. In this model economy $\pi = 0.56$. Consequently, 56 percent of the matches are made up of people whose ages differ in at most three years.

$^c E_A$: The Assortative Matching Model Economy economy. In this model economy $\pi = 1.0$. Consequently, every match is made up of people whose ages differ in at most three years.

^{d}This is the share of marriages in which the ages of the spouses differ in at most three years.

The matching function in our model economy plays a key role in determining the timing of marriages, because people have to be matched before they propose, and they have to propose in order to marry. To explore the relationship between the matching function and our results, in this section we discuss the robustness of our calibration exercise to various specifications of our matching function. Specifically, we compare our benchmark model economy with two model economies that differ in their shares of random and assortative matches only. As we have already mentioned, in random matches the partners are drawn from the entire distribution of singles. And in assortative matches they are drawn from the distribution of people whose ages differ in at most $z = 3$ years. In our benchmark model economy, which we label E_B, 56 percent of the matches are assortative and 44 percent of the matches are random. In model economy E_A every match is assortative. And in model economy E_R every match is random. The three model economies are identical otherwise. In Table 2 we report the aggregate statistics that describe the timing of first marriages in these three model economies.

We find that the average age gap at first marriage is much larger when matches are purely random (3.33 years) than when they are purely assortative (0.003 years). Of course, the age gap in our benchmark model economy (1.73 years) is between those two numbers. This is because, when matches are purely random, grooms marry 0.58 years later on median than in our benchmark model economy, and brides marry 0.72 years earlier. When matches are purely assortative, the signs of the age differences are reversed. Grooms marry 0.32 years earlier than in the benchmark model economy, brides marry 0.94 years later, and the average age gap at first marriage drops to a negligible 0.003 years.[21]

Part of these findings is accounted for by the different matching probabilities in the three model economies (see Equation 11 and Panels A and B of Figure 6). When every match is purely random, the matching probabilities depend exclusively on the aggregate value of the single sex ratio, which is 1.36 in model economy E_R. Consequently, the matching probabilities are constant for both sexes. And since the stock of single men is greater than the stock of single women, every single woman, and only about 74 percent (=1/1.36) of the single men are matched every period. In contrast, when every match is assortative, the matching probabilities depend on the single sex-ratios of the various assortative age groups. These ratios vary with age and, consequently, the matching probabilities are also age-dependent. Since women delay their marriages by a sizable amount in model economy E_A, the number of single women increases, and the matching probabilities for men are higher than in model economy E_R. And, logically, that the matching probabilities of fecund women are lower.

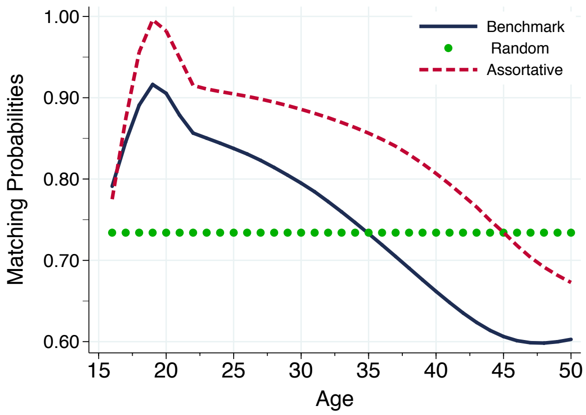
The differences in the matching functions result in sizable changes in the reservation values of both men and women (see Panels C and D of Figure 6). In model economy E_R, men become increasingly choosier with women of the same age after about age 30, and women become increasingly less choosy with men of their same age after about age 25. And exactly the opposite happens in model economy E_A. Men become less choosy with people of their same age, and women become more choosy.

This is because purely assortative matching acts as a tight constraint on the marriage decisions of older men, who do not meet, and therefore cannot marry women that are more than three years younger than themselves. Assortative matching also acts as an insurance mechanism for older women, who get more proposals and, consequently, can afford to become more demanding than when at least some of the matches are random.[22] This mechanism does not operate in the case of younger people. Before age 19, this is because the assortative matching constraint is only partially binding. And, after that age, this is because the expected values of remaining single when young are high in our three model economies.

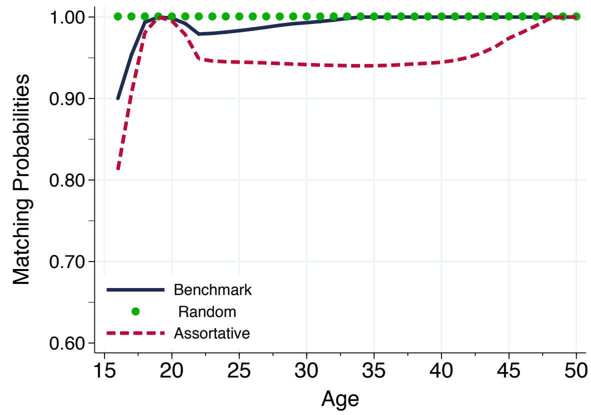
[21]In our model economies the sex ratios, the matching probabilities, the reservation match values and the marriage probabilities are all endogenous, and they are determined simultaneously. But we discuss them separately for the sake of exposition, and to gain some intuition about our results.

[22]Notice that the type of matching function would have symmetric effect on the marriage decisions of men and women, if their fecund periods were identical.

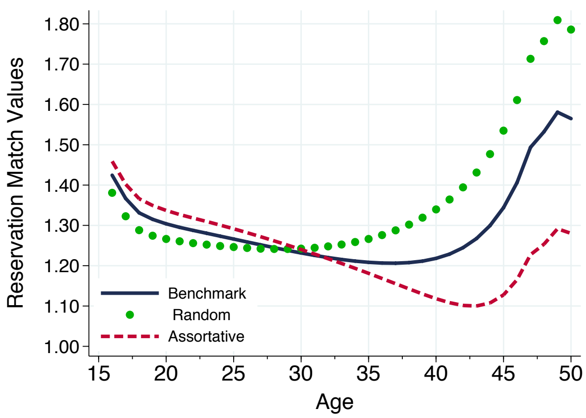
Figure 6: A Comparison Between Random and Assortative Matching Functions (1)



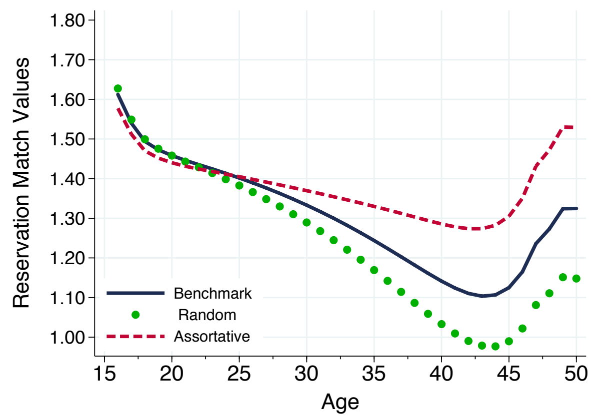
Panel A: Matching Probabilities for Men



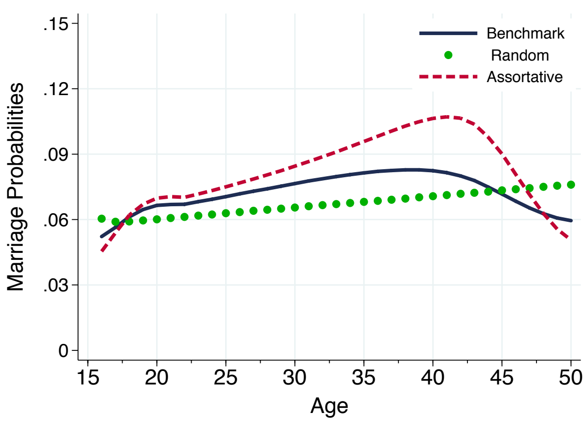
Panel B: Matching Probabilities for Women



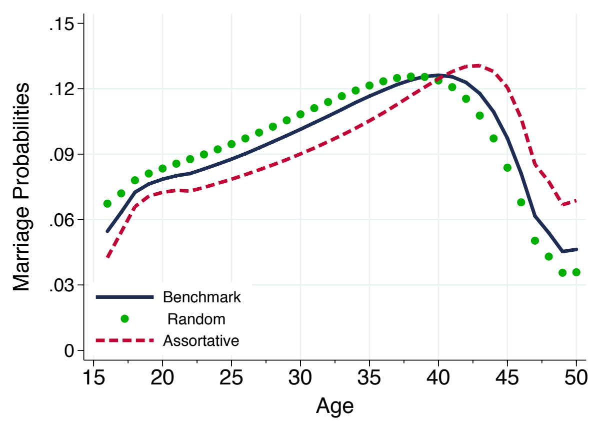
Panel C: Res. Values for Women of the Same Age



Panel D: Res. Values for Men of the Same Age

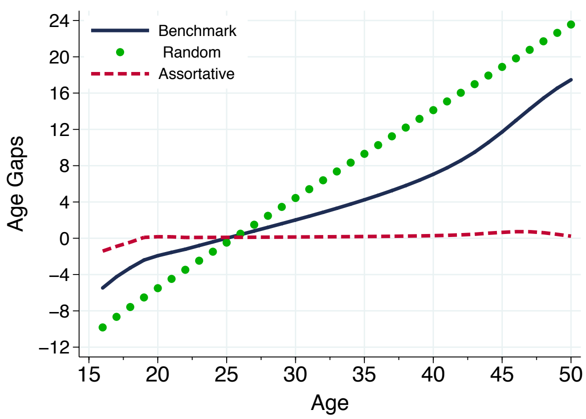


Panel E: Marriage Probabilities for Men

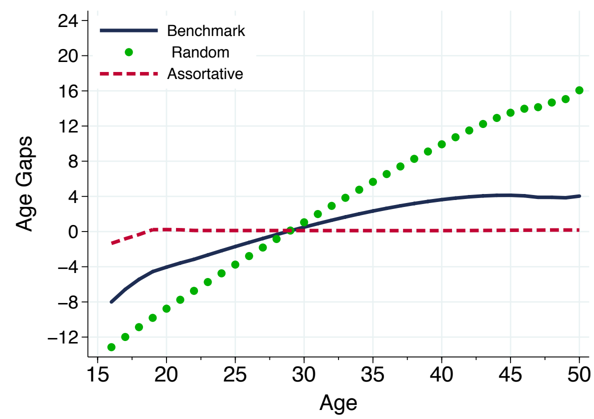


Panel F: Marriage Probabilities for Women

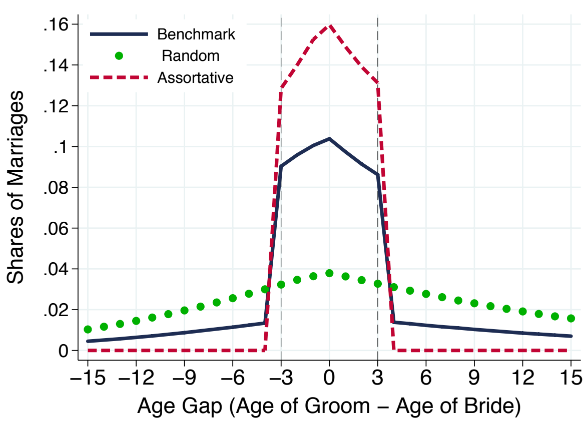
Figure 7: A Comparison Between Random and Assortative Matching Functions (2)



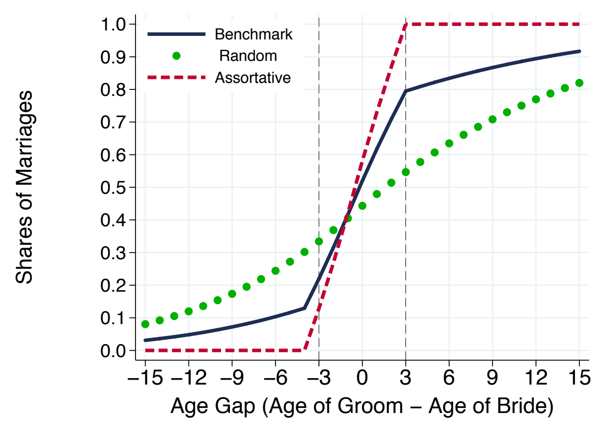
Panel A: Mean Age Gap Profile for the Grooms



Panel B: Mean Age Gap Profile for the Brides



Panel C: Densitiy Function of the Age Gap



Panel D: Cummulative Distribution of the Age Gap

Overall, these changes in the matching probabilities and in the reservation values result in marriage probabilities that are larger for young women and smaller for young men in model economy E_R, where matches are purely random, than in model economy E_A, where they are purely assortative (see Panels E and F of Figure 6). This means that the matching function effect dominates the reservation value effect for both women and men.

Perhaps the most interesting implication of the differences in matching functions can be found the life-cycle profiles of the age gaps at first marriage, that we illustrate in Panels A and B of Figure 7. It turns out that the age gaps increase with the age of the grooms at a considerably faster rate in model economy E_R, than in the benchmark model economy. This is because when every match is random, singles are always matched with singles of every age. Consequently, when people are very young they are mostly matched with people who are older. And as people age, they are increasingly matched with people who are younger.

This general equilibrium effect of aging operates both for the brides and for the grooms, and it results in age gaps at first marriage that are increasing in age for both sexes. Interestingly, the increasing profile of the age gaps persists even when we assume that income is constant over the life-cycle as we discuss in Section 8 below. This general equilibrium effect appears if and only if some of the matches are random in age, and it cannot be accounted for in model economies that abstract from this feature.

In contrast, when every match is assortative, the results are very different. In this case, the age gaps increase mechanically from age 16 to age 19 as the age ranges of the people in the meetings are expanding, and they become essentially stable after that age. This is because, in this model economy, people are matched with partners who belong to their same age group throughout their lives, and they never meet people from younger or older cohorts. Consequently, the single sex ratios are close to one for every age, and the age gaps at first marriage are small and essentially constant after age 19.

Logically, in our benchmark economy we get an intermediate solution. Even though many singles meet and marry other singles who belong to their assortative age groups, sometimes they meet and marry singles who do not belong to those age groups. Therefore, the general equilibrium effect implies that people are more likely to be matched with younger people as they age, similarly to what we observe in the data. But this is less likely to happen in the benchmark model economy, where some matches are assortative and some matches are random, than in model economy E_R, where every match is random.

Our robustness exercise leads us to conclude that a purely random matching function exaggerates the increasing life-cycle profiles of the age gaps at first marriage. But it also shows that some degree of random matching is essential to replicate the shapes of the profiles that we observe in the data.

8 Income, Fecundity, and the Timing of First Marriages

In this section we quantify the roles played by gender differences in income and in fecundity in accounting for the age gap of first marriages. We consider two possible accounts for the age gap. It can result form gender differences in income that decrease the value of young women as potential spouses, and increase the value of older men. It can result from gender differences in fecundity that increase the value of young women, and preserve the value of older men. Or, more likely, it can result from a combination of these two accounts, and from their general equilibrium consequences.

To quantify the individual roles played by these two types of gender differences, we solve three counterfactual model economies, which we label E_Y, E_P and E_F. In model economy E_Y, we assume that men and women have identical income profiles, that these profiles are independent of their marital status, and that they coincide with the income profile of men in the benchmark model economy. In model economy E_P, we assume that the income of men and women, besides being identical and independent of their marital status, is also constant over the life-cycle. And in model economy E_F, we assume than men and women have identical fecundity profiles and that they coincide with the fecundity profile of men in our benchmark model economy. In all other respects the men and the women of model economies E_Y, E_P, and E_F are identical to their counterparts in the benchmark model economy.

In Table 3 we report the aggregate statistics that describe the timing of marriages in the three counterfactual model economies and in our benchmark model economy, which we call E_B. And in the various panels of Figures 8 and 9 we plot the life-cycle profiles that illustrate various features of the timing of first time marriages in these four model worlds.

Table 3: Income, Fecundity, and the Timing of First Marriages

	E_B^a	E_Y^b	E_P^c	E_F^d	Δ_{YB}^e	Δ_{PB}^f	Δ_{FB}^g
Average Age Gap at First Marriage	1.73	1.81	1.77	0.59	0.08	0.04	–1.14
Grooms' Median Age at First Marriage	26.30	26.09	25.71	26.58	–0.21	–0.59	0.28
Brides' Median Age at First Marriage	24.90	24.62	24.34	25.85	–0.28	–0.54	0.95
Shares of Assortative Marriages^f	66.6	66.5	67.5	66.0	–0.03	0.9	–0.51
Shares of Ever-Married Men 16-45 (%)	56.1	56.5	57.5	54.4	0.38	1.4	–1.74
Shares of Ever-Married Women 16-45 (%)	62.2	62.9	63.8	57.4	0.64	1.6	–4.79
Never-Married Sex Ratio (Men/Women)	1.18	1.19	1.19	1.09	0.01	0.01	–0.09

[a] Economy E_B: The Benchmark model economy.

[b] Economy E_Y: Men and women have identical income profiles.

[c] Economy E_P: Men and women have identical and constant income profiles.

[d] Economy E_F: Men and women have identical fecundity profiles.

[e] Differences between the statistics in model economies E_Y and E_B.

[f] Differences between the statistics in model economies E_P and E_B.

[g] Differences between the statistics in model economies E_F and E_B.

[f] This is the share of marriages in which the ages of the spouses differ in at most three years.

8.1 Income

We find that both men and women marry somewhat earlier on average in model economy E_Y, where their income profiles are identical and independent of their marital status, than in the benchmark model economy.[23] Specifically, the grooms of model economy E_Y advance their median age at first marriage by 0.21 years, and the brides by 0.28 years. Since women advance their marriage age by more than men do, the age gap at first marriage increases, but not by much. In model economy E_Y it is 1.81 years, which is only 0.08 years larger than in the benchmark model economy.

[23] These findings are consistent with the previous literature on the increase in the number of single households. See for example Regalia and Ríos-Rull (2001).

Panels A and B of Figure 8 show that the matching probabilities of both men and women in model economy E_Y and in the benchmark model economy are almost the same, so we have to look for the justification of our results somewhere else. Panel C of Figure 8 shows that in model economy E_Y men of every age lower their reservation values for women of their same age. This happens because in model economy E_Y women's income is larger than in the benchmark model economy, and this increases their value as spouses regardless of their age. The differences in reservation values between the two economies are particularly large for very young women, because the income prospects of women who marry at a very young age in the benchmark model economy are worse than those of women who marry at an older age (see Panel D of Figure 2).

In contrast, Panel D of Figure 8 shows that, from age 19 onwards, the reservation values of women for men of their same age are higher in model economy E_Y than in the benchmark model economy. Once again, this is because in model economy E_Y the income of single women is sizably larger than in the benchmark model economy and, therefore, the value of being a single woman is also larger. This makes women more demanding with their prospective spouses.

Panels E and F of Figure 8 show that these changes combined with their general equilibrium effects imply that the marriage probabilities of very young men and women are higher in model economy E_Y than in the benchmark model economy, and that this situation is reversed for men over 21 and for women over 20. This implies that in model economy E_Y both brides and grooms marry on median at a younger age.

Our comparison between model economy E_Y and the benchmark model economy establishes that gender differences in income are not necessary to account for the age gap at first marriage. But it does not help us to discriminate between the traditional theory of the age gap that argues that older people marry younger people because they trade off income or wealth against youth or beauty, and the theory that we defend in this article: that it is the gender differences in fecundity the ones that play a dominant role in accounting for the the age gap at first marriage. Essentially, our story claims that, after women reach a certain age, their shorter fecundity pressures them into lowering their reservation values for everyone, and that they end up marrying the relatively abundant older men, who are still fully fecund.

Because the life-cycle profile of income is increasing, and older men are also richer than younger men, both theories could be correct, even when the profiles of men and women are identical. In order to discriminate between them, we compare the timing of first marriages in model economy E_Y and in model economy E_P, where we assume that the income of men and women, besides being identical and independent of their marital status, is also constant over the life-cycle.[24]

We report our findings for model economy E_P in the fourth and seventh columns of Table 3. We find that, when their income profiles are flat, both men and women marry earlier than they did in the benchmark model economy. Specifically, they advance their marriages by 0.59 and 0.54 years, which is sizably more than the 0.21 and 0.28 years by which they advance their marriages in model economy E_Y. These results are not surprising because both men and women gain nothing by waiting when their income profiles are flat. Instead, each year they postpone their marriages they give up the utility of child-bearing and companionship. Consequently, to compensate for these losses, both men and women reduce their reservation match values, and they end up marrying at a younger age in model economy E_P, than both in model economy E_Y and in the benchmark model

[24] Specifically, we assume that the income of men and women of every age is equal to the average present value of the income of men in the benchmark model economy and, therefore, in model economy E_Y. That is, $y_P = \sum_{j=16}^{T} \beta^{j-16} y_{1,j} / \sum_{j=16}^{T} \beta^{j-16}$.

economy (see Panels C through F of Figure 9).

But the interesting fact is that the age gap at first marriage does not disappear. In model economy E_P, it is 1.77 years, which is 0.04 years more than the age gap in the benchmark model economy, and 0.04 years less than the age gap in model economy E_Y. We interpret this result as additional evidence in favor of the causal relationship between gender differences in fecundity and the age gap at first marriages. When the income profiles are flat, and only then, older men loose all their advantages over younger men. Yet women, pressed by their shorter biological clocks, and encouraged by the fact that they receive more proposals than men do, still choose to marry at a younger age than the men of their same cohort.

8.2 Fecundity

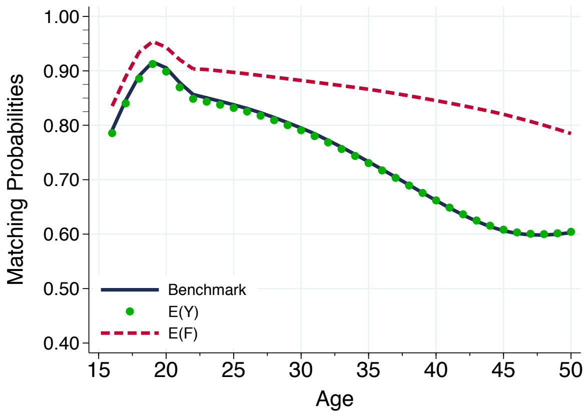
We find that both men and women marry later in model economy E_F, where the fecund periods of men and women are identical, than in the benchmark model economy. Men delay their marriages by 0.28 years in median, and women by a sizable 0.95 years. Since women delay their marriages by much more than men do, the age gap at first marriage falls to 0.59 years in model economy E_F, which is 1.14 years less than in the benchmark model economy. These findings imply that gender differences in fecundity play a much larger role than gender differences in income in accounting for the age gap at first marriage in our model world. And they help us understand why the age gap at first marriage persists in advanced economies, even though the gender income gap has become much smaller. In fact, our model economy predicts that the age gap at first marriage will persist until reproductive technologies succeed in removing the gender differences in fecundity.

That women should marry later in life in model economy E_F than in the benchmark model economy, is very intuitive. Their extended reproductive clock no longer bids them to haste. That the median age of grooms is also delayed, requires further explanation. In the benchmark model economy women hurry to get married because they want to have children, and men hurry because they may run out of fecund women to marry, if they do not hurry. In contrast, in model economy E_F the longer duration of women's fecundity increases the value of being single both for men and for women, and it allows everyone to relax. Women can relax relatively more than men can because their full fecundity now lasts for 20 years longer —from age 25 to age 45— and because their period of decreasing fecundity has increased from 25 to 30 years.

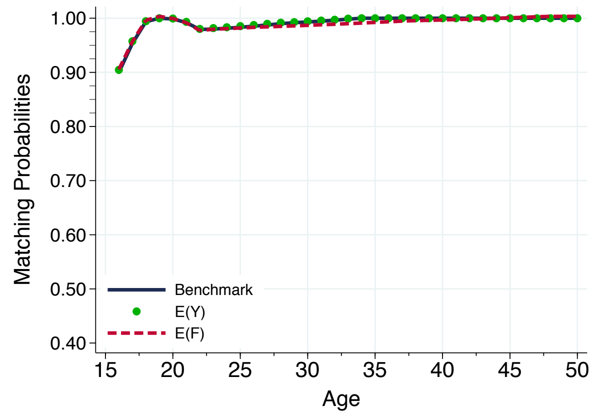
The various panels of Figure 8 help us to understand these results. In Panels A and B we represent the age profiles of the matching probabilities. In model economy E_F the single sex ratio is 1.09 and in the benchmark model economy it is 1.19. Since in both cases it is greater than one, the matching probabilities of women change by very little. But since in model economy E_F the relative number of single women is sizably higher, single men of every age are matched much more often than in the benchmark model economy.

Panel D of Figure 8 shows that the extension of their fecundity allows women increase the reservation values that they require to propose to men of their same age in a rather spectacular way, specially when they are in their middle thirties to middle forties. This results both from their extended fecundity, and from the fact that their matching probabilities remain high as we have already discussed. Panel C shows that men can also afford to become more demanding with partners of their same age in model economy E_F, until about age 40. This is essentially because the number of fecund and single women is higher in this economy than in the benchmark model economy. After

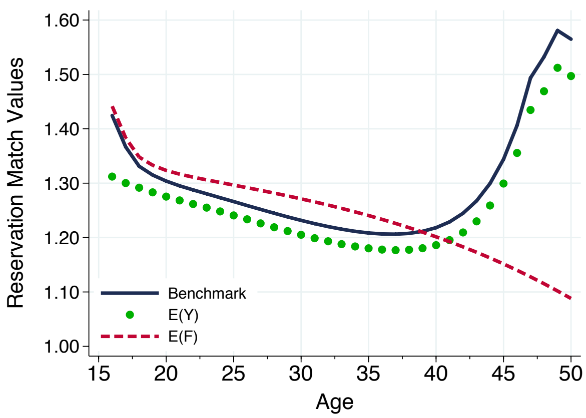
Figure 8: A Comparison of Model Economies E_Y, E_F, and E_B



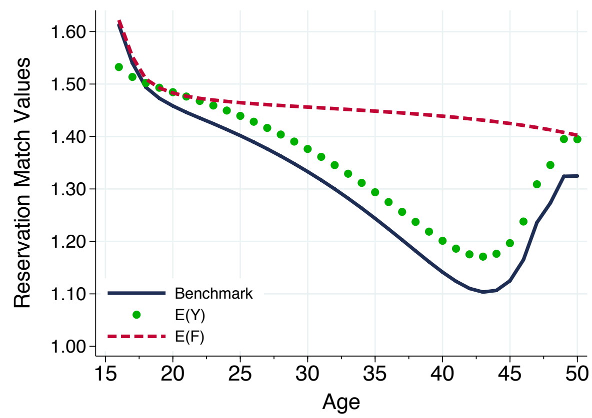
Panel A: Matching Probabilities for Men



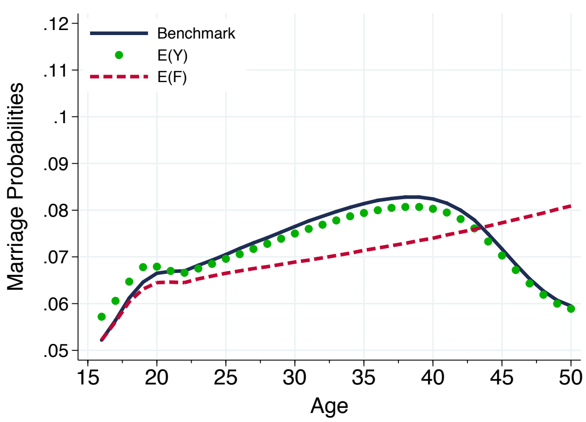
Panel B: Matching Probabilities for Women



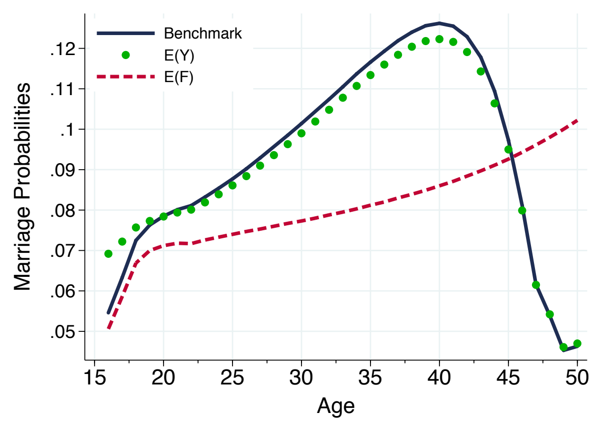
Panel C: Res. Values for Women of the Same Age



Panel D: Res. Values for Men of the Same Age

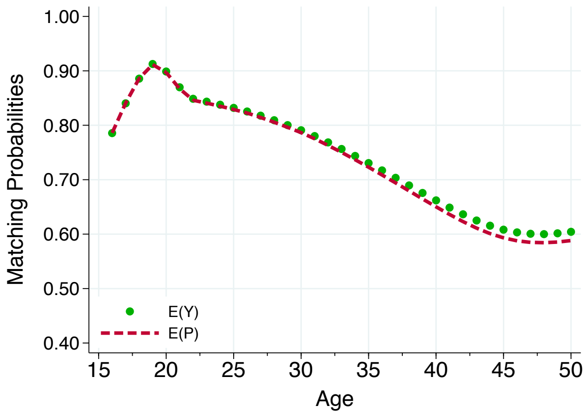


Panel E: Marriage Probabilities for Men

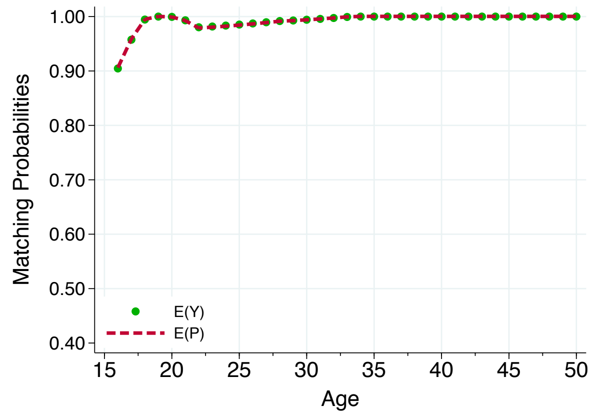


Panel F: Marriage Probabilities for Women

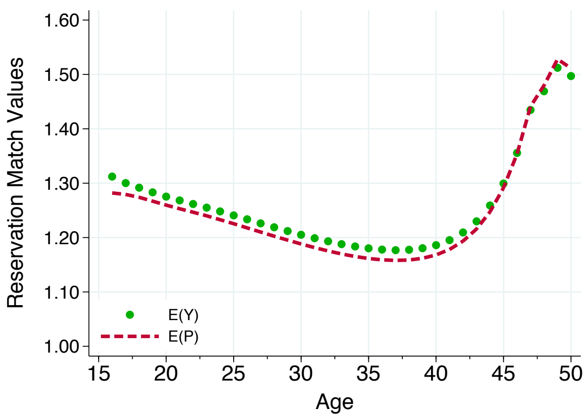
Figure 9: The Life Cycle Profile of Income: A Comparison of Model Economies E_Y and E_P



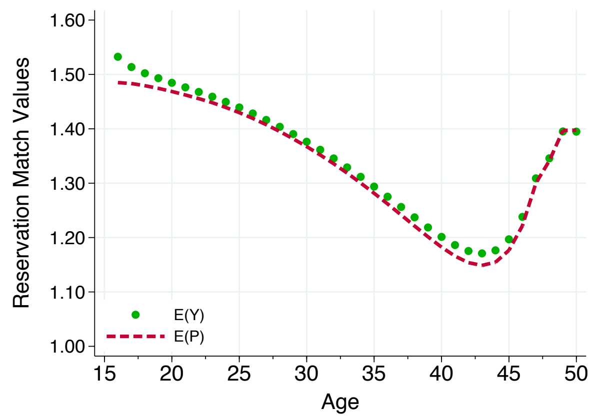
Panel A: Matching Probabilities for Men



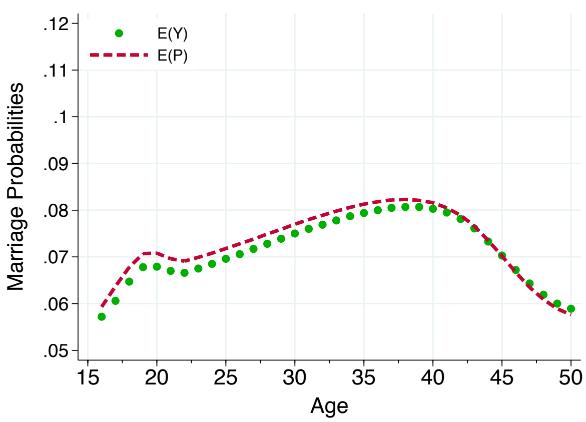
Panel B: Matching Probabilities for Women



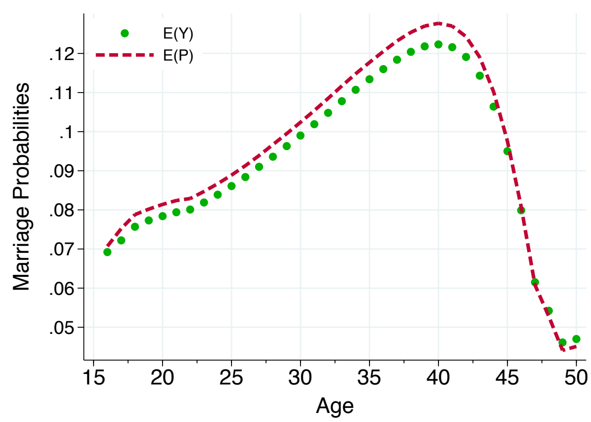
Panel C: Res. Values for Women of the Same Age



Panel D: Res. Values for Men of the Same Age



Panel E: Marriage Probabilities for Men



Panel F: Marriage Probabilities for Women

age 40, the reservation values of men are smaller in model economy E_F because women are still fully fecund, while this was not the case in the benchmark model economy.

Finally, Panels E and F illustrate the consequences of extending the fecundity of women for the probabilities of marriage. In model economy E_F they are smaller for both men and women than in the benchmark model economy until about their middle forties, and after that age they become larger. Consequently, both men and women delay their marriages. Since women do so by much more than men do, the age gap at first marriage is sizably smaller in model economy E_F than in the benchmark model economy.

Two other remarkable findings are that the profiles of the age gaps of first time brides are increasing and almost identical in all three model economies until about age 36. And that the profiles of the age gaps of first time grooms are also very similar until about that that age in the three model economies (see Panels A and B of Figure 9). From this comparison we conclude that this feature of the timing of marriages is not accounted for either by gender differences in income or by gender differences in fecundity. Instead, it is a general equilibrium effect that is accounted for jointly by the decreasing age distributions of singles, and by the random component of our matching function.

After age 36 or so, the patterns of the age gaps in model economy E_F start to diverge from those in model economy E_Y and in the benchmark model economy, but in opposing directions for each gender. For men over 36 the age gaps become smaller in E_F than in the benchmark model economy, and for women over that age they become bigger. This is due to the interaction of differential fecundity and random matching. In the benchmark model economy men over 36 still retain their full fecundity, while the fecundity of women is declining quickly. Therefore women older than 36 or so will propose to and marry men who are their seniors by quite a few years. This is not the case in model economy E_F, because women remain fully fecund for much longer. Therefore, between ages and 36 and 50 they reject most of the men who are much older than they are. Consequently, the age gap at first marriage of men increases, but only at the smooth rate implied by the endogenous dynamics of the age distribution of singles, and the random component of our matching function. And, logically, the age gap of women mirrors this behavior.

9 Concluding Comments

In this article we ask what are the contributions of gender differences in income and in fecundity to account for the timing of first marriages observed in the United States and we conclude that gender differences in fecundity play a sizably larger role. Our research also suggests that it is the gender differences in fecundity that make the life-cycle profiles of the age gaps at first marriage steeper for the grooms than for the brides, as we observe in United States data.

We also conclude that making the age distributions of singles endogenous, and therefore decreasing, and some random matching are sufficient to account for the increasing life-cycle profiles of the age gaps at first marriage observed in the United States for both sexes. And that this feature of the age gap profiles is essentially independent of gender differences in either income or fecundity.

The model economy described in this article can be extended to study the consequences for the timing of marriages of exogenous demographic shocks that alter the age structure of the population. Giolito (2010), for example, extends our framework to study the changes in the timing of marriages that resulted from the baby boom in the United States. Further research along this line could explore the consequences of making age an explicit argument in the other decisions taken within the family.

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