Accounting for Age in Marital Search Decisions

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Abstract

The quality of spouse a woman is willing to marry varies significantly over her lifecycle, first increasing rapidly then falling more slowly as she ages. Men have a similar but less pronounced pattern. We document this and other facts on the quality of chosen spouses depending on the age of marriage. We then interpret these facts in the framework of a non-stationary sequential search model, which points to declining frequency of marriage opportunities and declining utility from unmarried life as the main determinants of these patterns. For men, only the former seems to be responsible.

1 Introduction

The search for a spouse is undoubtedly influenced by many factors, including one's own qualities, the pool of potential partners, and expectations about future opportunities. Yet these factors may not stay constant over one's lifecycle; as a consequence, the quality of one's spouse could depend heavily on one's age at marriage. Worsening prospects later in life will encourage a single person to lower his or her standards over time.

In this paper, we document facts on how spouse quality changes with the age of marriage, and account for which changing factors drive the observed patterns. Using US Census data, we find consistent trends in chosen spouses. First, women married in their mid-twenties obtain the best husbands on average, where quality is measured by educational attainment.[1] Average quality rapidly increases as women age through

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[1]Income and other measures of quality produce similar trends, which we document in the appendix.

their teens, and then declines more slowly through their mid-forties. Thereafter, the average quality of husband is roughly constant. The pattern for men is similar but not as pronounced. (These facts are illustrated in Figure 2.)

Our primary goal is to understand which underlying factors are responsible for these age-dependent outcomes. To do this, we calibrate a non-stationary sequential search model (as in Wolpin, 1987; van den Berg, 1990) to replicate the observed patterns. In the model, an unmarried individual encounters a suitor with some exogenous probability, whose quality is drawn from a known distribution. Quality is measured as the sum of educational attainment and intangible qualities; the individual observes both components while the econometrician only observes the former. If the proposal is accepted, the individual perpetually enjoys utility equal to the suitor's quality. If the proposal is declined, the individual resumes searching (without recall of past suitors), receiving an interim utility for each period of single life.

Choices in this framework particularly depend on three parameters: the arrival rate of suitors, the distribution of suitors, and the utility of single life. We allow all three to differ across gender and educational attainment, as well as changing with age. To distinguish the role of each factor, we choose parameter values so that the model solution replicates observed outcomes in the quality distribution of accepted spouses and the hazard rate of marriage. In particular, we are interested in the relative changes in these parameters as the marriage candidate ages.

Our calibration provides the following insights on the marital search process. First, the distribution of potential suitors makes only a small contribution in explaining the observed trends. It is true that the average educational attainment of single individuals peaks at roughly the same age as the average quality of spouse. Yet even if the quality distribution were held constant, the resulting quality and hazard rate of marriage would be nearly the same. Arrival rates and single life utility, on the other hand, play larger roles with roughly equal importance.

This is significant, as it implies that the observed decrease in spouse quality with age is largely driven by choice, not opportunity: the individual chooses a lower reservation quality in anticipation of less favorable arrival rates or single-life utility in the future. We demonstrate this by decomposing the effects in a counterfactual experiment. That is, we ask how choices would differ if one or more parameters were held constant throughout life, leaving the others at their calibrated values.

We also examine differences across gender and educational attainment. The latter provides the largest distinction. Compared to college graduates, those who never obtain a college degree are 3 to 4 times less likely to encounter a college-educated suitor who would want to propose marriage. On the other hand, those with less education encounter marriage opportunities at a much higher rate in their teens and early twenties than those with college degrees.

More subtly, the utility from single life remains nearly constant for college educated women, while all others enjoy high utility in their early twenties, followed by a sharp drop then a steady increase through their late thirties. The latter trend seems consistent with a need for specialization in household production, particularly during childbearing years. That is, single life faces the greatest opportunity cost during the ages in which one would like to start a family. College-educated women may feel differently since specialization would typically move them out of the labor force at a critical time for career development. Both the benefits of marriage and the benefits of single life are very high in this age range.

1.1 Related Literature

There is an extensive literature, both empirical and theoretical, which tries to understand patterns in mate choice. However, these papers mostly focus on time-independent patterns, without paying specific attention to the decision of individuals through the lifecycle. This is what sets us apart from these studies.

In his seminal work, Becker (1973) presents a theory of marriage based on utility maximizing individuals and a marriage market that is in equilibrium. He shows that the gain to a man and woman from marrying (relative to remaining single) depends positively on their incomes, human capital, and relative difference in wage rates. His theory implies that men differing in physical capital, education, height, race, or many other traits will tend to marry women with similar traits, whereas the correlation between mates for wage rates or for traits of men and women that are close substitutes in household production will tend to be negative. Becker (1974) extends this analysis to include many circumstances such as caring between mates, genetic selection related to assertive mating, and separation, divorce, and remarriage.

Following Becker, the empirical literature focuses on either the time to marriage or bearing children. For example, Keeley (1979) analyzes the age pattern at first marriage. He models search as a two-stage decision process. First, a single person decides whether or not to enter the market and spend resources searching for a spouse; second, if the person enters, he/she pursues an optimal sequential search for a spouse. Age at first marriage depends on age at entry and duration of search. Boulier and Rosenzweig (1984) argue that, to test household fertility behavior and marriage theory, one has to control for heterogeneity in the personal traits of agents which are unknown to the econometrician. Spivey (2011) asks whether risk aversion plays a role in the time to marriage, because searching for a spouse involves uncertainty regarding the quality and state of marriage. Like us, she considers a partial equilibrium search model where women receive a single offer per period from the given quality distribution. Searchers are all identical but their risk-aversion varies. By estimating the model using NLSY data, she finds that more risk-averse individuals marry sooner.

Another strand of literature investigates the relationship between wage inequality and marriage and fertility decisions of women. Loughran (2002) investigates the effect of male wage inequality on female age at first marriage to explain the fact that age at first marriage increases over time. The idea is that as male wage inequality rises, it increases the reservation quality of women, thus age at first marriage increases (just like a mean-preserving spread in the wage distribution will increase search duration because it increases expected value of wage offers above the reservation wage). He also estimates a partial equilibrium search model for women. Caucutt, *et al* (2002) show how patterns of fertility timing in U.S. data can be explained by the incentives for fertility delay implied by marriage and labor markets. They find that these incentives help explain both the cross-sectional relationship between women's wages and fertility timing and the changes over the past 40 years in married women's fertility timing and labor supply.

The theoretical literature has mostly investigated marriage patterns via matching models. Results point out to assortative matching, where high types match with high types. We are taking a different approach here, by modeling the female's problem as a dynamic search problem where reservation qualities are formed at each age.

Burdett and Coles (1997) present a two-sided matching model with heterogeneous agents and non-transferrable utility. Upon meeting, a man and a woman observe the other's pizzazz. Then they both decide whether to propose or not. If they both propose, they marry. If not, they keep searching. The flow of singles is constant through time. The distribution of pizzazz among men and women is assumed to be constant through time. They solve for the reservation pizzazz for each man and woman. They study how equilibrium sorting takes place and show by examples that many equilibria exist.

Chade (2001) presents a model of two-sided search with a continuum of agents with different types in each population. Match utility is non-transferrable; agents incur a fixed cost every period. He finds that when utility functions are additively separable in types and strictly increasing in the partner's type, there is a unique equilibrium where there's perfect segregation, i.e, agents form clusters and mate within them. He also characterizes duration of search for each type.

Smith (2006) studies a heterogeneous agent matching model where the payoff of each matched individual depends on both partners' types. He finds that when finding partners requires search and individuals are impatient, matching is positively assortative (high types match with high types) when the proportionate gains from having better partners rise in one's type. He gets a "block segregation" result, which says an interval of the highest type match only with each other; the next highest match with each other, etc. After accounting for the time spent on search, to get assortative matching, one needs complementarity of log payoffs, not just complementarity of production as in Becker (1973). Shimer and Smith (2000) is similar to Smith (2006) with transferable utility rather than non-transferable utility.

We proceed as follows. Section 2 provides details of our data and presents facts on the age profile of average spouse quality, marriage hazard rates, and average quality of single individuals. Section 3 provides our non-stationary search model and outlines our calibration procedure. In Section 4, we presents our findings from the calibration and decompose the effects of each parameter. Section 5 investigates some variations on our approach as robustness checks. We conclude in Section 6. The appendix provides alternative measures of spouse quality, confirming our basic findings.

2 Empirical Facts

In this section, we document three dimensions of marriage decisions that systematically change with age of marriage: the average quality of spouse, the hazard rate of marriage, and the average quality of potential suitors. We extract these facts from the 2010 American Community Survey (ACS), retrieved from the IPUMS-USA database.

We restrict our analysis to those individuals in their first marriage[2] (or, when

[2] Beginning in 2008, the ACS introduced two new questions that allow us to identify age at first

examining the single population, those individuals who have never married). We do this for two reasons. First, one could plausibly worry that the marriage market operates differently for those who are divorced, who may differ from those never married in either their quality distribution or their desire to be (re)married. The data can speak to this issue, though, which we discuss in Section 5; in short, the differences are generally small. The other reason for excluding divorcees is that our model does not contemplate divorce; unions are permanent. Incorporating divorce would complicate both the solution and our calibration without adding significant light.

Figure 1 plots the density for age at first marriage for women (Panel a) and for men (Panel b). We observe that the density is unimodal and skewed to the left. For women, the peak age for marriage is 20, whereas for men the peak is 23. For both groups, almost all individuals are married by age 45. We restrict our analysis to marriages between age 18 to 45 for women, and age 21 to 48 for men (since the average age gap between spouses is three years).

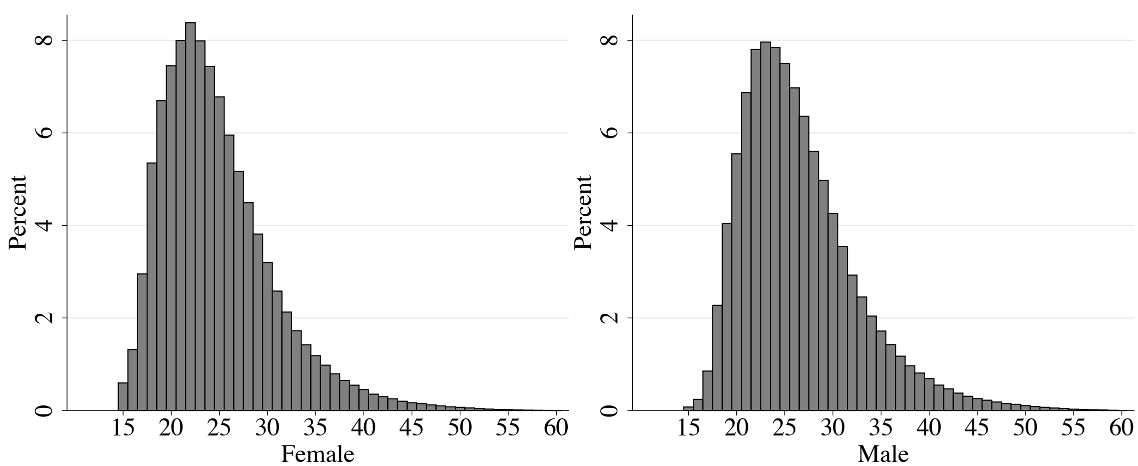

Figure 1: Histograms of age at first marriage for women (Panel A) and men (Panel B)

To be able to generate measures of spouse quality, our analysis includes only those households where both spouses were present. The respondent's spouse was matched

marriage: 1) the number of times an individual has been married, and 2) the year in which an individual was last married. To generate the *age at first marriage* variable, we restrict our analysis to those marriages where at least one spouse was still in their first, and therefore last, marriage. The age at marriage is computed by subtracting the individual's birth year from the year of marriage.

using household, family unit, subfamily unit identifiers, and year of marriage. If the year of marriage did not match, the marriage pair was dropped from the analysis. We also dropped singleton observations, same-sex marriages, or marriages with more than two spouses identified by this algorithm. After these restrictions were imposed, 838,640 marriages where at least one spouse is in his or her first marriage remained.

Our primary measure of spouse quality is educational attainment. Therefore, to allow adequate time for individuals to complete their education, we restrict our analysis to couples where both partners are currently older than 30. This resulting sample includes over 400,000 marriages; unless otherwise noted, all analysis refers to this subset of marriages. Table 1 provides the summary statistics for this ACS data on women and men in their first marriage.

Table 1: Data description

Variable	Female	Male	Difference
Age at Marriage	24.73	26.45	1.72
	[5.84]	[6.01]	[0.013]
Age	44.1	45.84	1.74
	[8.13]	[8.18]	[0.018]
Years of Education	13.74	13.65	-0.09
	[2.75]	[2.82]	[0.006]
College Degree	0.25	0.23	-0.02
	[0.43]	[0.42]	[0.001]
Total Personal Income	31860	73179	41319
	[41645]	[80127]	[135.10]
Observations	446844	446537	

Notes: Means are reported with standard deviations in parentheses for male and female; standard errors in parentheses for Male-Female difference. All differences are significant at the 1% level. Analysis restricted to individuals in their first marriage and to married couples where both spouses are between the ages of 30 and 60. Source: ACS 2010 (IPUMS).

We now examine three measures in the data that change dramatically depending on an individual's age at marriage: (1) the average quality of spouse, (2) the hazard rate of marriage, and (3) the average quality of suitors.

2.1 Average Quality of Spouse

We begin by examining the average quality of one's spouse, conditional on age of marriage. In this section and the subsequent theoretical analysis, we use a discrete measure of quality: whether the spouse eventually obtains a college degree.

Figure 2 reports the fraction of marriages to a college-educated spouse, depending on gender, own education, and own age at marriage. Note that the average quality of spouse rises rather quickly, then falls more gradually, for those who get married at older ages. For instance, a college-educated woman married at age 23 is 15 percentage points more likely to be married to a college-educated man, compared to a 19 or 45 year-old bride (solid line in the left panel).

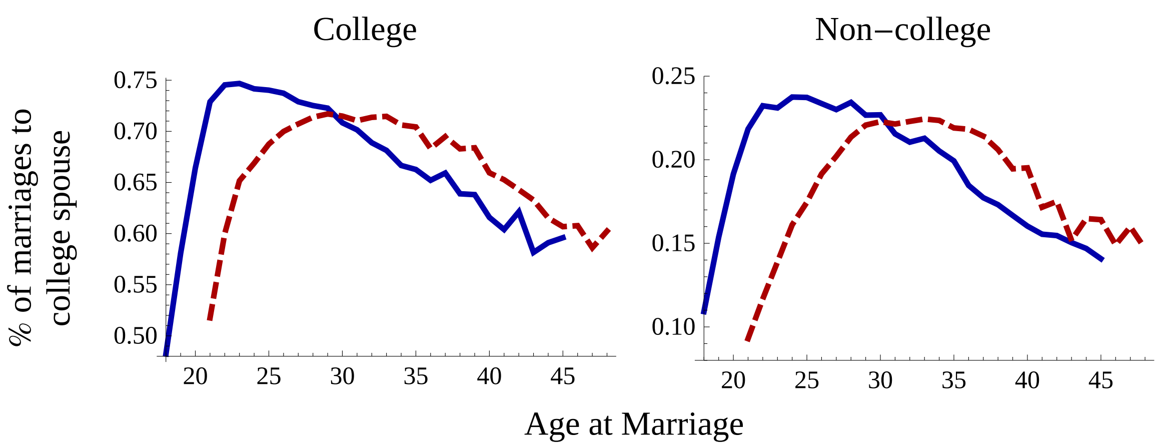

Figure 2: **Average quality of spouse**. Solid lines indicate the fraction of husbands with a college degree, depending on the woman's age at marriage and educational attainment; dashed lines do the same for wives, depending on the man's age at marriage and educational attainment.

Another clear fact is that one's own quality (educational attainment) also has a dramatic effect on the quality of spouse. For instance, at any given age, a college-educated bride is at least three times as likely as a non-college bride to be married to a college-educated husband. The same is true when comparing college and non-college grooms. This is clear evidence of assortative matching, though not with perfect segregation; a reasonable fraction (23%) of the population ends up marrying someone whose educational attainment differs from their own.

Finally, it is noteworthy that women (of either education level) reach the peak of spouse quality for marriages at about age 23, while men (of either education level) reach their peak at age 31. In addition the rise and fall in spouse quality are not as pronounced for men. This suggests that there are important differences between the genders, which we attribute to differences in their search parameters.

Of course, whether a spouse is college educated is one measure of quality, and the data offer other measures, such as income, occupation, and employment status. However, each measure produces the same trends with respect to age (which we discuss further in the appendix). Moreover, the discrete measure makes it easy to control for one's own quality and report results for each quality type.

2.2 Hazard Rate of Marriage

Our second empirical fact examines the rate at which singles get married. That is, among singles of a given age, what fraction will get married at that age? To compute this hazard rate, we consider all married people and ask what fraction were married at each age (repeating the analysis for each gender and educational attainment).[3] This unconditional probability is then used to compute the probability of getting married, conditional on reaching a given age unmarried. The result is depicted in Figure 3.

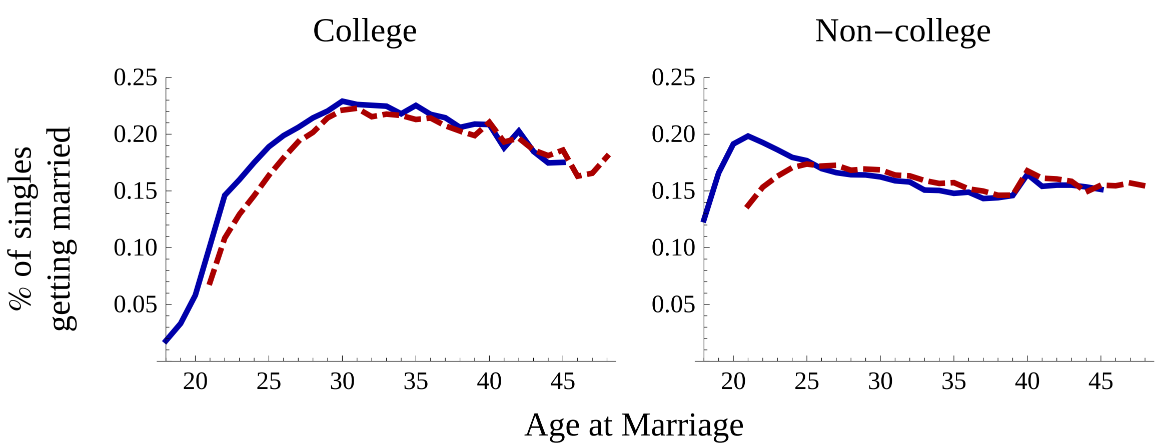

Figure 3: **Hazard rate of marriage**. Solid lines indicate the fraction of women who get married at a given age, conditional on reaching that age unmarried; dashed lines do the same for men.

[3]An alternative procedure is to compute the number of people who got married at a given age, and divide this by the total population who stayed single or got married at that age. This direct approach is complicated by the fact that we only observe singles of a given age in 2010, which may not be directly comparable to people married at that age in 1980, for instance.

Here, we see that men and women of the same educational attainment (quality) have very similar hazard rates. In contrast, the hazard rate is very different across educational attainments. Among those without a college degree, the hazard rate is nearly constant at about 16%. For the college-educated, however, the hazard rate is much lower at young ages, but reaches 22% by age 30, and then gradually declines to about 17%. As a consequence, the college-educated will tend to get married later than non-college singles (by 1.5 years).

2.3 Average Quality of Suitors

Finally, we examine the average quality of singles, in order to get a sense of how the distribution of potential mates evolves with age. Since we only consider first marriages, here we restrict our data to people who are currently single and never previously married. Again, in Section 5, we consider the minimal impact of including divorcees in among potential mates. For each gender and at each age, we compute the fraction of singles that hold a college degree.

Some additional calculation is necessary for young singles, since very few of these actually hold a college degree. Thus, we impute a probability that they eventually obtain a college degree. To do this, we compute what fraction of those who got married at age 19, for instance, obtain a degree by age 30. This is repeated for each age up to age 30, after which the measure remains fairly stable.

In general, women are more likely to hold a college degree than men. For both genders, the fraction holding a degree first increases rapidly, then falls more gradually. This observed trend is related to the hazard rates previously discussed. In particular, college-bound singles are less likely to get married in their early twenties than singles that will never obtain a college degree. Thus, the latter exit the pool of singles at a faster rate, and the concentration of the former increases. This reverses by age 25, however, and remains so until their hazard rates equalize in their mid-forties.

3 Model

Our goal is to understand which factors influence the choices of men and women to produce the preceding facts. To give structure for the analysis, we apply a non-stationary search model to our environment of search for a marriage partner.

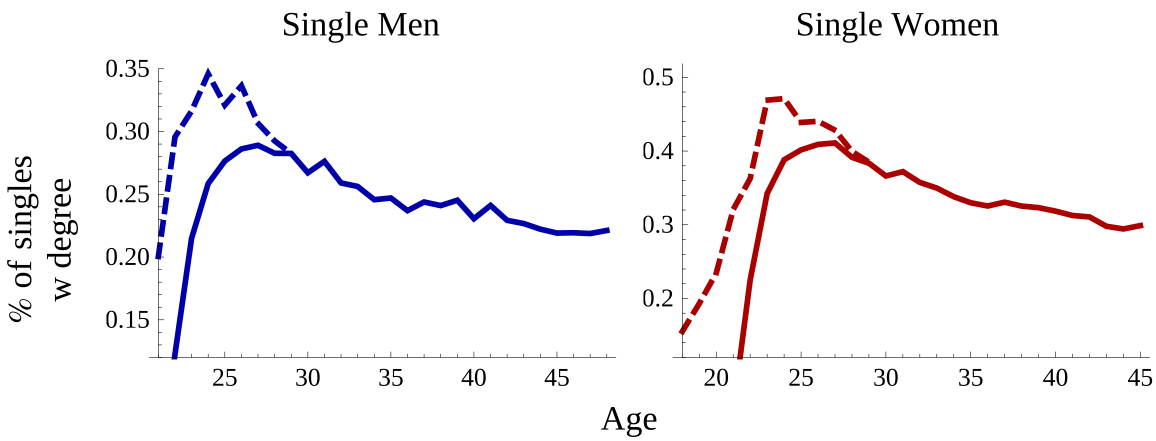

Figure 4: **Average quality of suitors**. Solid lines indicate the fraction of singles (never married) holding a college degree. Dashed lines indicate the imputed fraction who either have or will obtain a college degree by age 30. The left panel indicates the distribution of men that a single woman faces, and vice versa for the right.

Our model has much in common with that in Wolpin (1987), which employs a discrete-time search model to understand decisions to accept a first job after graduation. An important feature was that wage offers are imperfectly observed by the econometrician; without this, one would have to conclude that the lowest accepted wage is the reservation wage. We employ this concept to our quality measures; an educated woman might accept a less educated spouse even though she has a high reservation quality if he happens to be exceptional in intangible qualities. As in Wolpin's analysis, by imposing some structure on the distribution of both dimensions of quality, we can identify how underlying parameters must change to best fit observed trends.

3.1 Non-stationary Search in the Marriage Market

While our model will be applied to both genders, for expositional clarity, consider the search problem of a single woman. At a each age t, a woman randomly encounters a suitor with probability λ_t, whereupon she observes a measure q of his quality. If she marries him, she obtains utility q each period forever thereafter. Otherwise, she continues her search the next period, discounting future utility by β.

The quality measure q consists of two parts, distinguished by whether they are publicly or privately observed. The public component, a, indicates the educational attainment of the suitor, with $a = 1$ for those who are at least college educated and $a = 0$ for those with less than a college degree.[4] This quality measure is commonly agreed upon, meaning all individuals prefer a more highly-educated spouse. Let γ_t denote the probability that her suitor is college educated.

The private component, z, indicates a match-specific quality of this suitor. This captures personality and other intangible qualities (unobservable by the econometrician) that might make a particular paring better or worse than average. We assume that z is a normally distributed random variable with mean 0 and standard deviation σ, and is not persistent from one match to the next.

After observing the total quality of the suitor, $q = a + z$, the woman must decide whether to marry him. Rejection is final; she is not able to resume dating past suitors. Her decision at age t will be characterized by a reservation quality R_t, where she accepts a proposal if and only if $a + z \geq R_t$.

While single, a woman enjoys utility b_t each period. Note that this is relative to the (normalized) values of spousal quality q. Thus, $b_t = 1/2$ would provide the same annual utility as being married to a college graduate who is $1/(2\sigma)$ standard deviations below average, or to a less-educated man who is $1/(2\sigma)$ standard deviations above average. Thus, b_t represents the benefits (or disadvantages, if negative) associated with being single relative to being married.

Summarized in recursive form, a single woman's search problem is given by:

$$\begin{aligned} V_t = \max_{R_t} \quad & b_t + \frac{\beta\lambda_t}{1-\beta}\int_{R_t}^{\infty} q\left(\gamma_t\phi(q-1) + (1-\gamma_t)\phi(q)\right) dq \\ & + \beta\left(1 - \lambda_t + \lambda_t\left(\gamma_t\Phi(R_t - 1) + (1-\gamma_t)\Phi(R_t)\right)\right) V_{t+1}, \end{aligned}$$

where $\phi(z) = \frac{e^{-\frac{z^2}{2\sigma^2}}}{\sqrt{2\pi}\sigma}$ is the normal density function and $\Phi(z)$ is its cumulative density function. The reservation quality will be chosen so as to accept whenever the future flow of value from marriage exceeds the future flow of value from continued search. Thus, $R_t = (1-\beta)V_{t+1}$.

This indifference condition allows one to rewrite the Bellman function in terms of

[4] For young suitors, we assume the woman observes his *eventual* educational attainment; that is, she is able to discern whether he will eventually graduate from college.

the reservation quality function:

$$\frac{R_{t-1}}{1-\beta} = b_t + \frac{\beta\lambda_t}{1-\beta}\int_{R_t}^{\infty} q\left(\gamma_t\phi(q-1) + (1-\gamma_t)\phi(q)\right)dq \quad (1)$$
$$+\beta\left(1-\lambda_t+\lambda_t\left(\gamma_t\Phi(R_t-1)+(1-\gamma_t)\Phi(R_t)\right)\right)R_t. \quad (2)$$

We assume there exists an age T such that for all $t \geq T$, the search parameters b_t, λ_t and γ_t remain constant. Therefore, one can find the stationary solution for R_T (i.e. substitute $R_{t-1} = R_t = R_T$ into Equation 1), then solve for earlier reservation values (*e.g.* R_{T-1}) by backwards induction.

3.2 Calibration Targets

Our aim is to obtain estimates of the search model parameters, with particular interest in the movement of λ_t, γ_t, and b_t over the lifecycle, so as to deduce their relative importance in producing the trends described in Section 3. Besides separately considering the search problems of men and women, we also distinguish between those who are college- and non-college-educated in each gender. That is, we allow the search parameters to differ across these four groups, since each may face different opportunities for and different benefits from marriage.

For expositional purposes, consider the process used to calibrate these parameters for college-educated females. For each age, we can directly observe the fraction of single (never married) men who hold college degrees, which we use as our proxy for γ_t. In doing so, we assume that women marry men of about their own age (approximately three years older, according to the data).

The data also indicates the fraction of women (married at a given age) who married a college-educated man, which we denote f_t. Derived from the theory, this fraction would be:

$$f_t = \frac{\gamma_t\left(1-\Phi(R_t-1)\right)}{\gamma_t\left(1-\Phi(R_t-1)\right)+(1-\gamma_t)\left(1-\Phi(R_t)\right)}. \quad (3)$$

Note that $\Phi(R_t - 1)$ is the probability that a college-educated suitor will be rejected due to a low match-specific quality z, while $\Phi(R_t)$ is the equivalent probability for non-college-educated suitors. Thus, the fraction of college educated suitors is adjusted by the probability of rejecting each type of suitor to obtain the realized fraction of marriages to college-educated men. Since we have γ_t and f_t from the data, Equation 3 allows us to find the R_t consistent with these observed facts.

Next, from the data, we can extract the hazard rate of marriage; that is, the probability that a woman gets married at age t, conditional on being unmarried at age $t-1$. We denote this p_t, and its theoretical analog is:

$$p_t = \lambda_t \left(\gamma_t \left(1 - \Phi(R_t - 1)\right) + \left(1 - \gamma_t\right)\left(1 - \Phi(R_t)\right)\right). \tag{4}$$

Here, λ_t gives the probability of encountering a suitor, while the last term gives the probability of accepting that suitor. We use this to compute λ_t.

Finally, we use the translated Bellman function (Eq. 1) to compute b_t. At that point, the other parameters and reservation values have been found, so b_t becomes a residual, set such that R_t is optimal given λ_t and γ_t.

We use the same procedure for college-educated men. For the single man or woman who is not college-educated, however, we must adjust γ_t, since these singles would frequently be rejected by those who are college educated (over 80%, using the calibration approach above). Thus, the pool of willing suitors has fewer college grads than the overall population; for non-college females, the adjustment is made as follows:

$$\hat{\gamma}_t = \frac{\gamma_t(1 - \Phi(R_t^{mc}))}{1 - \gamma_t + \gamma_t(1 - \Phi(R_t^{mc}))}. \tag{5}$$

Here, γ_t gives the fraction of the full population of single men with a college degree, while $\Phi(R_t^{mc})$ is the probability that a college-educated male would reject a non-college educated female. Thus, $\hat{\gamma}_t$ indicates the effective population that a non-college-educated single female faces. A similar procedure is used for non-college single men.

4 Results

Having presented our dynamic search model and derived the theoretical analogs to our data targets, we now present our results. Note that three parameters contribute to determining the reservation value along the life-cycle: the utility from being single, the offer arrival rate, and the probability that a suitor is college-educated. Our goal is to account for the role of each parameter in determining a single individual's reservation quality of a mate at each age.

We begin by considering the variance in intangible qualities, σ, which we hold constant over the lifecycle. This is inherently difficult to match, since these qualities are by definition unobservable. However, this parameter essentially determines the likelihood that a non-college suitor would be judged more desirable than a college suitor. For instance, since the average college suitor has quality $q = 1$, a non-college suitor would need intangibles $z = 1$ to be judged equally desirable. Thus, only $1 - \Phi(1)$ percent of non-college suitors are more desirable than college suitors, with $\Phi(1)$ depending on the parameter σ.

To find an empirical analog to this theoretical statistic, we examine income. In our data, 4.8% of non-college graduates (over age 30) earn more than non-college graduates. This percentage is larger for workers in their early twenties, but remains fairly steady from age 30 to 60. This provides a reasonable stylized estimate for calibration, which yields $\sigma = 0.6$.

As a robustness check, we repeated our calibration using a number of alternative values for σ. A higher variance resulted in a higher estimates of single-life utility and probabilities of encountering a suitor, but retained the same overall shape.

4.1 The probability of finding a college-educated suitor

As explained in Section 4.2, we compute the probability of finding a college-educated suitor γ_t by matching it to the observed fraction of singles who have (or will obtain) a college degree. In doing this, we will assume that college-educated singles draw a suitor at random from the population of the opposite sex of appropriate age (*e.g.* adjusting for the average three-year age gap). This distribution is displayed in Figure 4. Recall that at any age, there are more college-educated single females than males, which implies that men actually face a better distribution of quality for potential spouses.

While non-college singles also draw suitors at random from the same population, they will be frequently rejected by the college educated. We account for this using Equation 5 to obtain the effective distribution $\hat{\gamma}_t$ that these less-educated singles face, namely, the distribution of those willing to accept a non-college single. Note that this calculation for a non-college women utilizes R_t^{mc}, the reservation quality of a college-educated men; thus, we complete the calibration for college-educated men first and employ it here.

The result is a dramatic reduction in average suitor quality for both genders, shown in Figure 5. Indeed, the resulting distributions are very similar across genders (with the exception of a bigger spike among single men in their mid twenties). This

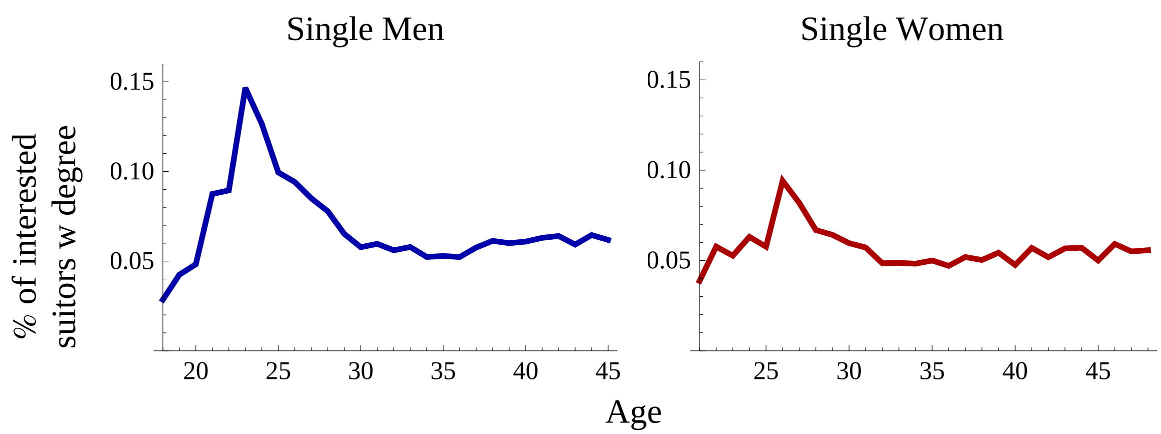

Figure 5: **Adjusted average quality of suitors**. Solid lines indicate the fraction of singles who have (or will obtain) a college degree, adjusted by the probability that the suitor is interested in marrying a non-college mate. The left panel indicates the distribution of men that a single woman faces, and vice versa for the right.

stands in contrast with the distribution faced among the college educated, where the distribution is much more favorable for men.

4.2 The benefits of single life

We continue by computing the benefits from single life, b_t, which is backed out from the Bellman Equation. The results for all four types are presented in Figure 6.

In interpreting these results, one should recall that these utilities are relative to the benefit of being married; thus a lower value over time (or across types) could reflect less enjoyment from being single, or more value on committed companionship or having children.

We also note that while estimated utilities are mostly negative, this does not mean a single person should accept the first suitor they encounter. Rather, one can think of this as a search cost. Turning down a current suitor not only delays the benefits of marriage but incurs some disutility. This can still be optimal if suitors arrive frequently and anticipates a more favorable distribution of suitors later on. (We discuss the resulting optimal reservation qualities in Section 4.4.)

To examine with greater detail, consider the utility for college-educated single women. This annual utility is estimated to be essentially flat with age (with an average of -1.15 utils). Indeed, if b_t is held constant at this value, we nearly match

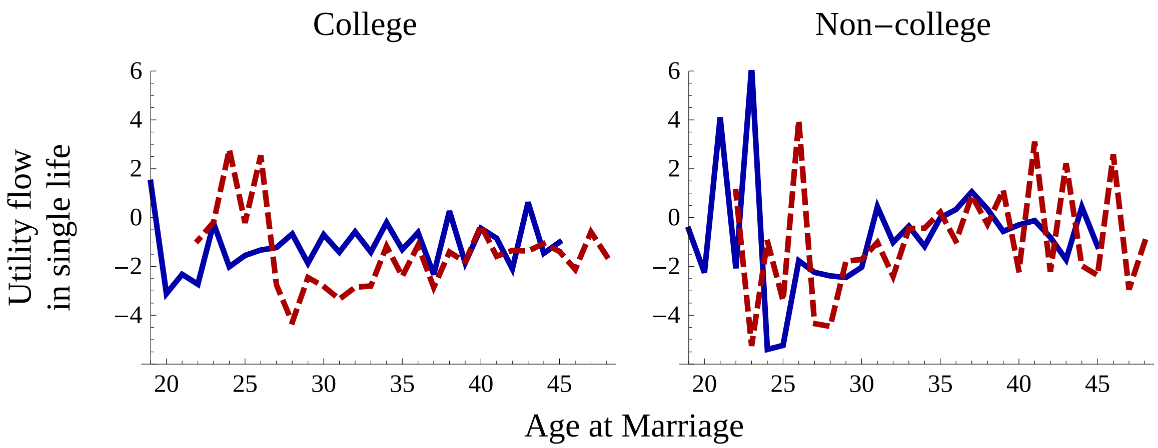

Figure 6: **Benefits of single life**. Solid lines indicate the annual flow of utility to women from single life, relative to marriage; dashed lines provide the same for men.

our calibration targets. Therefore, we conclude that the opportunity cost of marriage is fairly constant for college-educated women.

In contrast, utility varies over time for college-educated single men. From age 21 to 25, they enjoy single life more than their female counterparts,[5] and less from age 27 to 32. Thereafter, their utility remains flat and nearly identical to that of college women.

One explanation for this difference is that men (especially for the cohorts included in this sample) tend to be the primary breadwinner. College-educated men particularly benefit from marriage as it allows his wife to specialize in household production while he can specialize in market activities (consistent with Becker, 1973). At the same time, a college-educated woman is likely to reduce labor force participation after marriage, sacrificing more as she specializes in home production. These would be particularly important during the age when childrearing is most common.

On the other hand, singles without college education of either gender follow a similar path: utility rises through age 37, then slightly falls thereafter.[6] Here, the wife is more likely to remain in the labor force (to increase household income), so

[5]These changes in utility are important in explaining the observed timing and quality of marriages. If one assumes a constant flow of benefits among college men, then in their early twenties, they would marry less frequently and to higher-quality women than observed in the data. The reverse is true in the late twenties to early thirties.

[6]We also note that the estimates become very noisy among the youngest singles; this is likely due to imprecision in the estimate of quality distribution among potential suitors.

full specialization may not occur. Indeed, any benefits or sacrifice in marriage are likely to be more evenly borne, explaining why both genders experience the same trend. Moreover, these trends are fairly similar beyond the late twenties to those of college men. Again, this is consistent with joint effort being most valuable during childrearing.

Finally, it is interesting that across all four types, the utility of single life seems to equalize around -1.2 by age 40. Thus, while each may face different incentives for marriage early in life, they eventually reach similar feelings regarding single life versus marriage. Plausibly, this is because these later marriages are more likely to be motivated by a desire for companionship, making career concerns and household production second-order issues.

4.3 Suitor arrival rates

We next discuss our findings on arrival rates of potential suitors, which are illustrated in Figure 7. This indicates rather dramatic changes over a single person's life, forming a hump that peaks in the early to mid thirties for the various groups. Among the various types, college men have the most stable (though lower) arrival rate; the others experience much larger fluctuation over time.

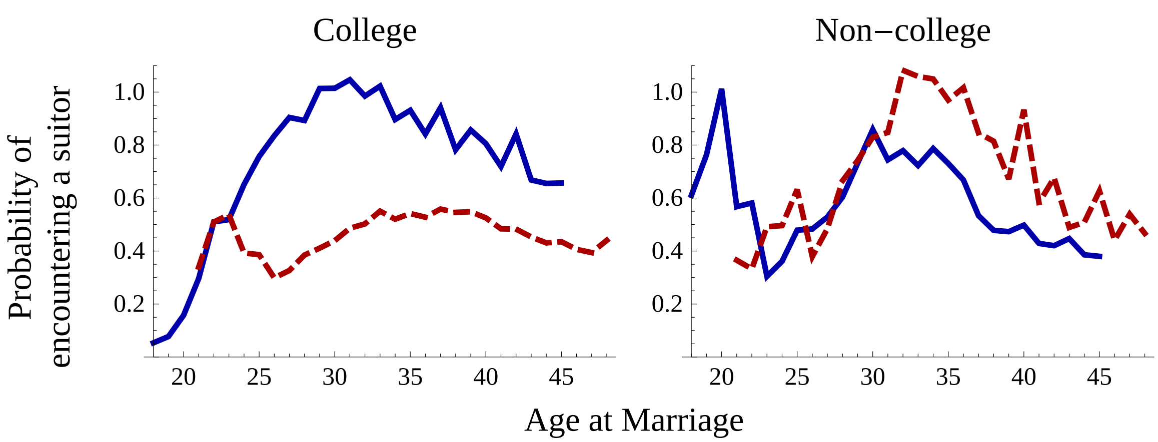

Figure 7: **Probability of Suitor Arrival**. Solid lines indicate the annual probability that a woman encounters an interested suitor; dashed lines provide the same for men.

Comparing the two types of women, we note those who obtain college degrees are far less likely to encounter suitable prospects early in life, *e.g.* while still in school.

This is a period with plentiful opportunities for women not in college, but this drops sharply in the early twenties. Thereafter, opportunities are steadily more frequent for both groups of women through age 30. This difference does not appear in comparing men; both seem to have a temporary and modest jump in opportunities early in life, followed by a steady climb through age 35.

The life-cycle profile of arrival rates suggest interesting dynamics at play. College education seems to benefit women in that it generates a higher number of offers from potential suitors; but these advantages are delayed until at least age 23. For the first half a decade, college women have much fewer opportunities. Among men, college slows the rate of opportunities. Of course, for both genders, a college education provides great advantages in other dimensions; in particular (comparing Figures 4 and 5), the probability that a given suitor has a degree is roughly four times higher if the individual also holds a degree.

This contrast between men and women might arise if men search less than women in the marriage market. For instance, college educated men may enter jobs with greater time demands, which reduce time devoted to search for a marriage partner. Similarly, women may only finish their college degree because they diverted time from marriage search. Of course, our model takes both search intensity and educational attainment as exogenous, but this provides a plausible interpretation of the arrival rate patterns needed to replicate the observed facts.

4.4 Reservation Quality

In our model, the reservation quality is an endogenous variable that depends on b, λ, and γ, along with other parameters of the model. Each individual optimally decides at each age on the lowest quality that he or she is willing to accept in a spouse, where quality is the sum of observed and intangible components. Figure 8 shows the reservation qualities implied by our calibrated model for each type of individual.

A comparison across types indicates that college women typically have the highest standards, exceeding the others by 0.1 to 0.3 units (*i.e.* up to half a standard deviation). Surprisingly, college men have remarkably low standards, on par with those of non-college men or women (except in their early twenties).

While this seems to contradict the fact that college men marry higher quality women, it actually does not, since college men draw from a much higher quality

Figure 8: **Endogenous Reservation Quality**. Solid lines indicate a woman's minimum acceptable spouse; dashed lines provide the same for men. The average college spouse has a quality of 1, while the average non-college spouse has 0.

distribution. They draw from a better pool, but are equally discriminating between college and non-college women; as a consequence, they still frequently marry college women. A non-college man, on the other hand, will encounter far more non-college women, but holds them to a fairly high standard. When he finally marries one, she must have very good intangible qualities.

For all four groups, the pattern over age moves in near lockstep with arrival rates: the singles raise their standards precisely when they are highly likely to have another suitor in the near future. This raises an interesting question of which parameters have the biggest effect in these endogenous decision of R_t. To explore this issue, we perform a counterfactual experiment, asking how the optimal reservation policy would change if b_t or λ_t were constant over the lifespan. The resulting decisions are depicted in Figure 9.

Among singles who are college educated, the calibrated benefits do not fluctuate much over the lifespan. Thus, holding benefits constant (the dashed line) results in almost no change for college women or older college men compared to the baseline calibration (the solid line). If arrival rates were also held constant (the dotted line), the reservation quality flattens out dramatically. In that scenario, only the distribution of suitors is allowed to vary; if that parameter were also held constant, the search problem would become stationary and reservation quality would be held constant at R_{45}.

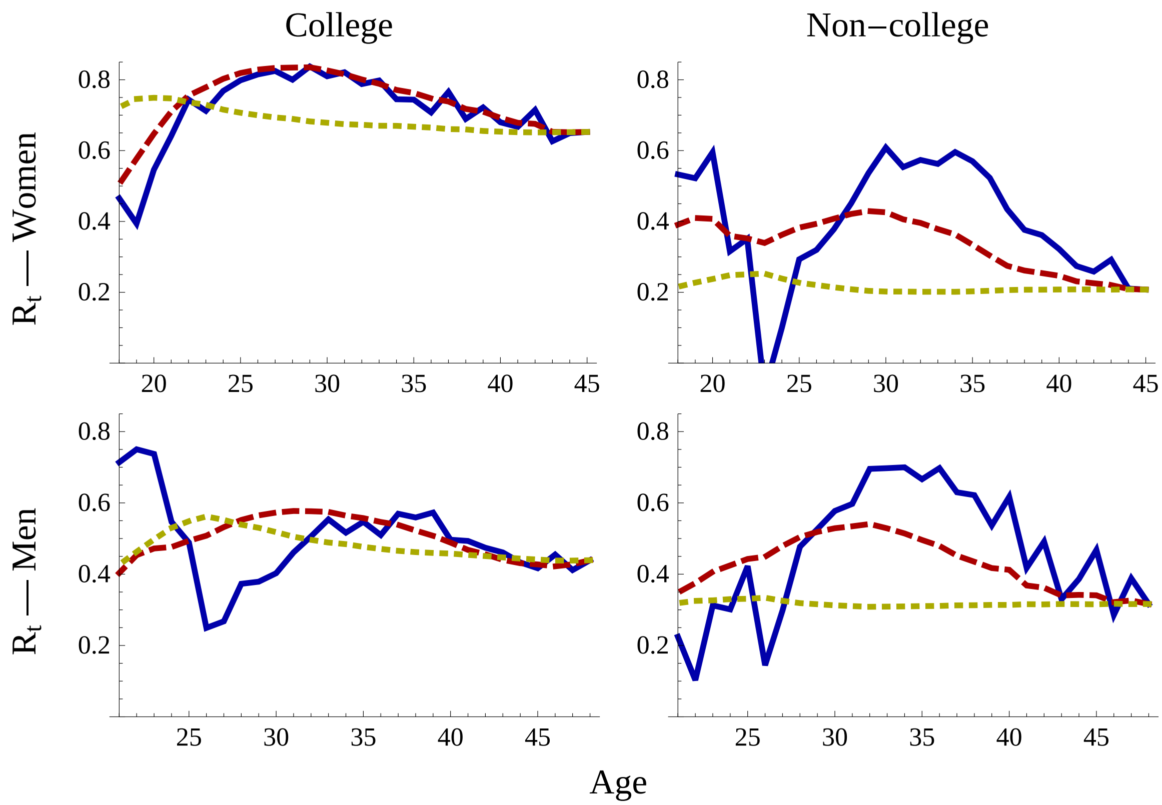

Figure 9: **Counterfactual Experiments**. Each line indicates the optimal reservation quality for each group. Solid lines are under calibrated parameters. Dashed lines use the same except holding single benefits constant at the calibrated value of b_{45}. Dotted lines also hold constant the arrival rate at λ_{45}.

Thus, we conclude that among the college educated, changes in the distribution of suitors has relatively minor impact on endogenous choices, as does benefits of single life (except among younger men). Rather, change in the arrival rate explain most of this variation in standards over time. This seems consistent with the story discussed in the previous section: the pursuit of college education has a sizable impact on the frequency of marriage prospects.

For those who do not obtain a college degree, single-life utility fluctuates more and thus plays a larger role in the choice of reservation quality. When b_t is held constant, the fluctuation in R_t is cut in half, though retaining the overall trend. When λ_t is also held constant, the remaining fluctuation is nearly eliminated. Thus, changes in the distribution of suitors have negligible effect on this endogenous choice; but single benefits and arrival rate are roughly equal in their contributions.

5 Robustness

In this section, we examine several alternatives that we could have taken in our analysis, but find that they have relatively minor impact on our analysis. First, we dropped divorced or remarried individuals from our sample. While this sample is consistent with our model (in which marriages last forever), it is easy to consider what would happen if divorcees had been included.[7] This might be of greatest importance at later ages, since the majority of singles are divorcees after age 45.

To examine the importance of divorce, here we recompute our calibration targets of spouse quality and marriage hazard rate including all marriages (where the spouse is present), and the target of suitor quality using all unmarried singles. In each case, there is virtually no change in the targets below age 25, as there are very few young divorcees. Differences, if any, slowly emerge and are most apparent by age 45.

After including single divorcees, the distribution of suitor quality falls slightly; by age 45, a randomly-drawn suitor is 3.5% less likely to be a college graduate. In other words, the population of divorcees tends to be slightly less educated than singles of the same age who have never been married.

When remarriages are included, the average quality of spouse slightly *increases* beyond age 32. In most cases, a spouse is 0.5 to 2% more likely to be college educated

[7]Divorcees constitute 32% of the single population, while 24% of marriages include a spouse who had been previously married.

when remarriages are included. The largest difference is in the spouses of non-college educated men, who after age 42, are 5% more likely to be college educated.

In contrast to these relatively minor and localized changes, the estimated hazard rates of marriage are consistently lower by 3 to 4% when divorcees are included in the calculation. This indicates that divorced individuals are less likely to (re)marry in any given year than someone of the same age who has never been married.

If this larger data set is used in the calibration process, it does very little to our estimates of γ_t or b_t; only λ_t experiences a notable decrease for most ages. This is because the first two targets experience minimal change; only hazard rates differ, which is ascribed to suitors arriving less frequently. In other words, divorcees mainly differ from never-married singles in that they are given fewer opportunities despite very similar observable qualities.

6 Conclusion

In this paper we establish facts regarding the distribution of spouse quality at first marriage as a function of age at first marriage, using the U.S. Census data. Women married in their mid-twenties obtain the best husbands on average, where quality is proxied by income or education. Average quality rapidly increases as women age through their teens, and then declines more slowly through their mid-forties. Thereafter, the average quality of husband is roughly constant. The pattern for men is similar but not as pronounced; indeed, the highest quality wives are obtained by men in their late 20s, but their average outcome is only marginally worse if married in the three decades that follow.

To explain these different experiences between men and women, we set-up a non-stationary sequential search model, a la Van den Berg (1990). In the model, a single woman encounters potential mates at an exogenous Poisson arrival rate, with the man's quality drawn from a fixed distribution. She then must either accept the man, or decline and continue her search. While searching, she receives an interim utility from single life. This model solves for the reservation quality of a woman at each age as a function of suitor arrival rates, the benefit from staying single, and the quality distribution of suitors.

Calibrating the model the US data on marriages and then solving the model, we shed light on the intrinsic choice of an individual for a mate at a given age, controlling for her education. Results indicate a dramatic change in the suitor arrival rate over a single woman's life, again forming a hump shape that peaks in the mid 20s for college-educated women, with a marriageable prospect arriving once every three years on average. This falls to once every five years by age 40, and then remains stable thereafter. The general pattern is the same for high-school-educated women, though the peak occurs earlier, and is generally lower except before age 21. The benefit of being single is also hump-shaped, increasing till mid-twenties and decreasing afterwards.

Of course, the most curious fact from the data is the fact that men do not experience significant decrease in spouse quality as they age. We attribute this to the biological clock of women, which puts bigger pressure on them to get married as they get closer to the end of child-bearing ages.

A Alternative Quality Measures

In the paper, we have relied on educational attainment as our observable measure of quality. In particular, the discrete measure of whether or not one earns a college degree greatly simplifies our model as well as the presentation of our results for individuals of different types. Even so, we could have employed a variety of other measures as a proxy for spouse quality, using the same ACS data.

In this appendix, we establish that these alternate measures follow the same trend over different ages of marriage. In principle, one could use any of these measures to calibrate an adapted version of on non-stationary search model. For each of these we have attempted, the resulting trends in single benefits b_t, arrival rate λ_t, and average suitor quality γ_t has been largely consistent with the approach presented in the text. For brevity, we do not report those results.

First, we could employ a more nuanced measure of educational attainment, such as years of education.[8] In the text, we controlled for one's own quality by computing the fraction of spouses with a college education, conditional on one's own educational attainment. Since we add more categories of educational attainment here, we instead use a regression to control for one's own years of education. In particular, we estimate the following equation (separately for men and women):

$$Y_i = \sum_{j=16}^{50} \alpha_j \cdot FM_{ij} + \beta_E \cdot YE_i + \epsilon_i. \tag{6}$$

Here Y_i represents the spouse's years of education as the dependent variable. A set of indicator variables for each value of one's own years of education is captured by YE_i. We also provide FM_{ij} as an indicator variable for each age at marriage from $j = 16$ to 50. Since age at marriage equal to 15 is the omitted category, the coefficients α_j indicate the difference in average quality if married at a later age.

Figure 10 plots the estimate α_j coefficients for women (solid line representing the change in their husband's years of education) and men (dashed line). For example, this indicates that the husband of a woman married at age 25 will have on average

[8] The ACS measure of education identifies years of education through grade 12 but shift to degree attained after grade 12. To provide a continuous measure of spousal quality, we map the ACS education variable into years of education (indicated in parentheses): 12th grade, with or without a high school diploma (12), some college but no degree (13), associate's degree (14), bachelor's degree (16), master's or professional degree (17).

0.9 more years of education than a woman married at age 15, even when both women have the same educational attainment. Note the overall trend is the same as in the text: the peak for each gender occurs at about the same age, and the decline for men in average spouse quality is not as pronounced as it is for women.

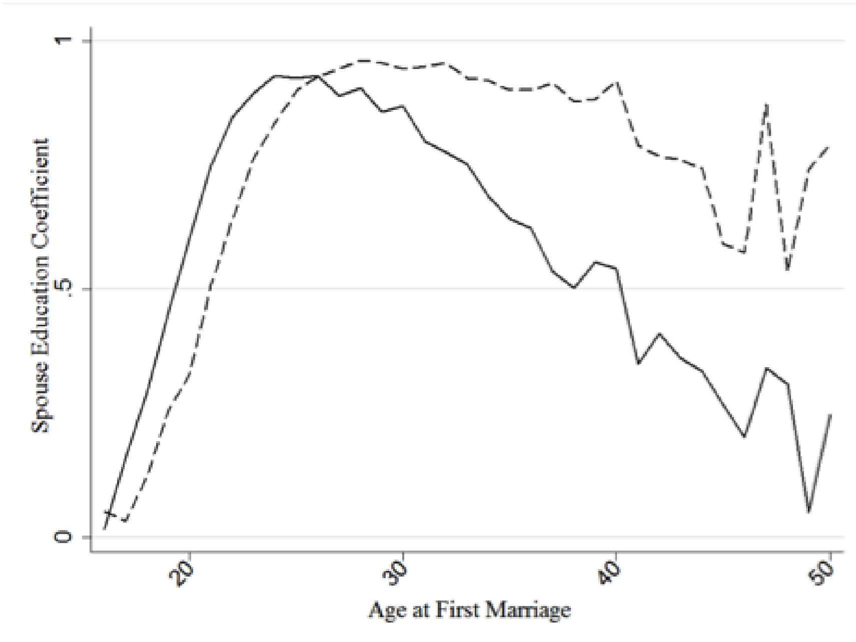

Figure 10: **Spouse Educational Attainment**. Spouse's additional years of education (relative to the spouse of a person married at age 15), depending on age of marriage, after controlling for one's own educational attainment. Husband's education (by woman's age) is represented with the solid line, with wife's education (by man's age) with the dashed line.

Another measure of spouse quality is his or her income.[9] We repeat an estimation of Equation 6, using spouse income as the dependent variable Y_i. We still use one's own educational attainment as the variable YE_i, since this provides a control for one's own quality even if not currently employed.

The estimated coefficients α_j of this regression are depicted in Figure 11. Controlling for own education, a women married at age 25 has a husband making approximately $18,000 more than a similar women (in terms of education) married at

[9]The individual respondent's income includes revenue from all source reported within the ACS, including (but not limited to) wage income, social security, business revenue, welfare receipt, retirement benefits directly attributed to the individual.

age 15. Those married after age 45, on the other hand, have husbands earning \$8,000 less. The trend for men is much less pronounced, with a peak of \$10,000 more in the mid thirties.

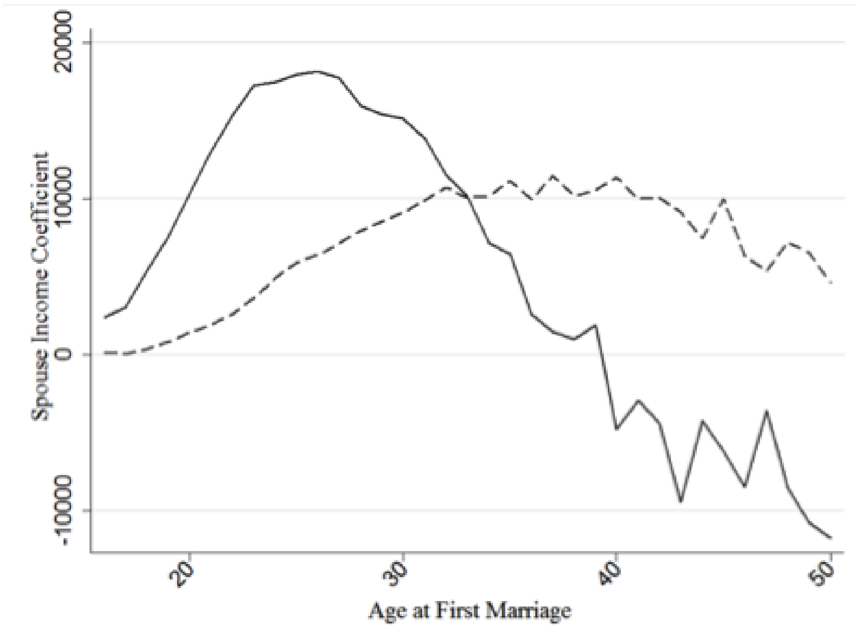

Figure 11: **Spouse Income**. Spouse's additional income (relative to the spouse of a person married at age 15), depending on age of marriage, after controlling for one's own educational attainment. Husband's income (by woman's age) is represented with the solid line, with wife's income (by man's age) with the dashed line.

Even more surprising is that the same trend persists even after controlling for all observable traits of men. That is, even when a husband is compared to men of similar age, location, and occupation, women married in their mid 20s tend to obtain men of higher income than women married earlier or later. For instance, a twenty-three year-old bride is more likely to marry a lawyer (than a forty-five year-old bride), but she is also more likely to marry one of the better-paid lawyers.

To demonstrate this, we begin with the full ACS data set (before eliminating observations based on marital status and marriage pairings) and regress each individual's income on a set of observable characteristics, separately for each gender, estimating the following equation:

$$Income_i = \sum_{j=16}^{50} \alpha_j \cdot Age_{ij} + \beta_2 \cdot X_i + \epsilon_i. \tag{7}$$

Here, Age_{ij} denotes a vector of indicator variables, equalling 1 if j is the current age of individual i and 0 otherwise. Thus, α_j is an age-specific effect on income. X_i includes all other demographic controls, including indicator variables for each value of years of education, state of residence, survey year, and 43,052 industry-occupation combinations.

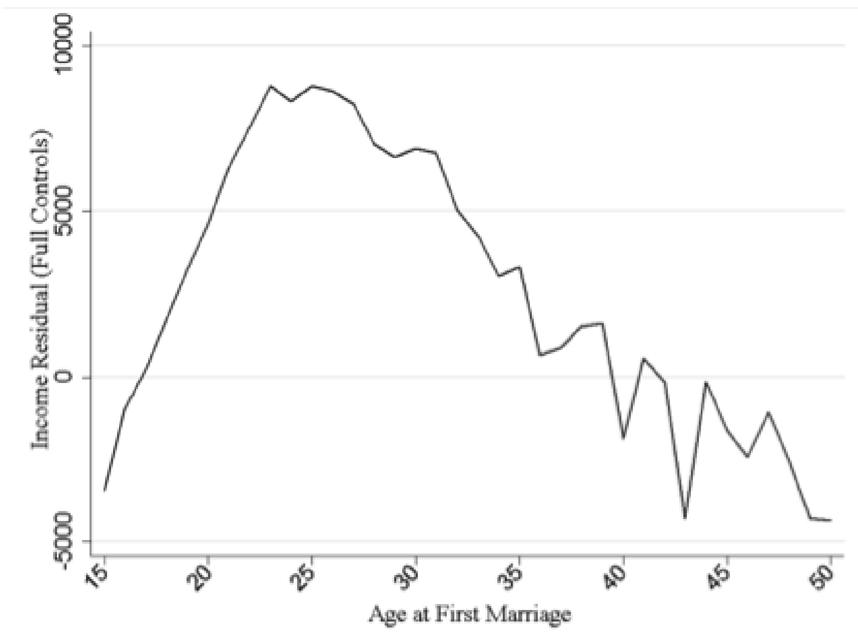

Figure 12: **Husband's Income with Controls**. Husband's additional income (relative to the average man with similar characteristics), depending on age of marriage, after controlling for the husbands other characteristics.

This regression generates a residual ϵ_i for each individual in the ACS, indicating how far his or her income deviates from the average individual of his or her type. We then restrict the data set to couples in their first marriage as before and, for women of each marriage age, compute the average residual, $\bar{\epsilon}$, of their husbands. The result is depicted in Figure 12. The same age-profile appears, though the difference from the minimum to the peak is only \$11,000 there.

A.1 Candidate Quality

The WLS follows a single cohort of 10,317 men and women who graduated from Wisconsin high schools in 1957, in repeated interviews over the following 50 years. The data provide similar measures of income and educational attainment (though all sample participants are high school graduates), but offer two additional measures: IQ and an attractiveness rating.[10] Both of these were measured in high school, so to use either as a measure of spouse quality, both members of the marriage pair must be Wisconsin graduates; this limits the sample to XX observations. Table 1 also lists the WLS summary statistics.

One potential explanation for declining husband quality for women married later in life is that this simply reflects selection. That is, the best women are taken first, and hence those married later are of lower average quality and hence can only attract lower quality spouses. While plausible, we find evidence to the contrary in WLS data. Here, we employ IQ and attractiveness ratings as our measure of quality, both of which were generated while the subject was in high school. The latter can change over time, of course, but the former is generally thought to persist throughout one's life.

In Figure 13, we indicate the average quality of women married at a given age, and similarly for men. Note that this is their own quality, rather than their spouse's quality. Due to the small sample size, these measures are noisy (especially beyond age 30); however, the story is consistent for both genders and both quality measures. The average quality remains essentially flat regardless of age of marriage. There is a minor downward trend in the attractiveness of women married at later ages, but it is not statistically different from being constant. Note the fluctuations are only a couple of IQ points for the most part; attractiveness only varies by about half a point on a 10 point scale.

This suggests that women married later in life are not observably worse than those married at young ages. Of course, we cannot rule out that they are selected on other characteristics (such as personality) that are observed by the men they encounter but not the econometrician. Barring this, it appears the pool of candidates is roughly constant at each age. That is, even though some single men and women are married each period, they are replaced by new entrants to the marriage market in equal

[10] Attractiveness was determined by a panel reviewing high school yearbook photos.

proportions to maintain a steady state distribution.

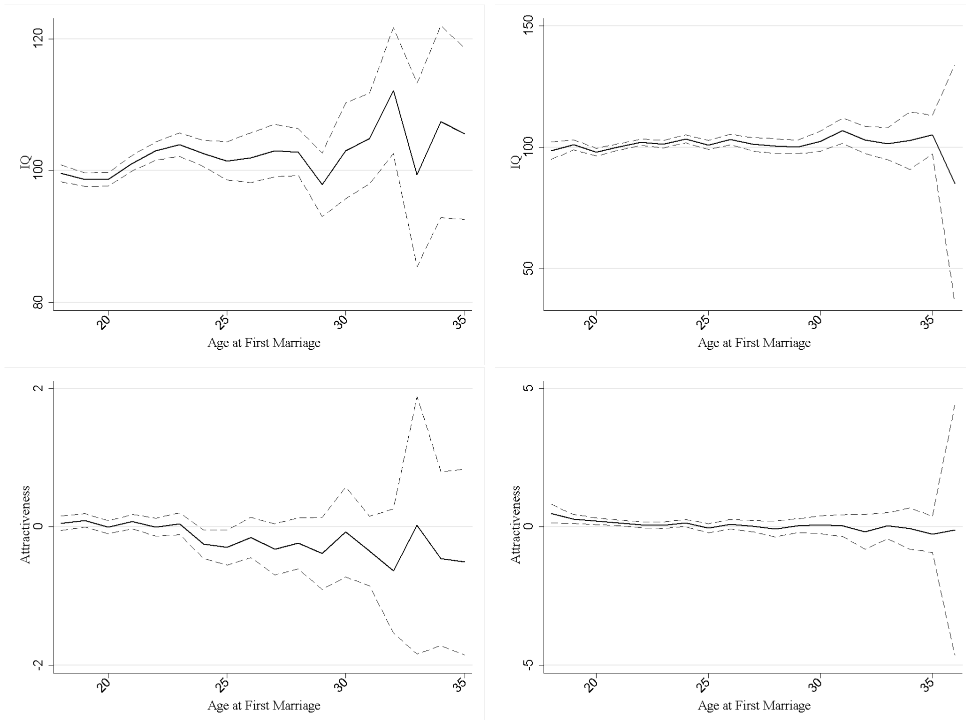

Figure 13: Average quality of women/men married at a given age. Dashed lines indicate 95% confidence intervals.

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