Accounting for Age in Marital Search Decisions

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Abstract

The average quality of spouse an individual marries varies significantly with age at marriage, peaking in the mid-twenties, then declining through the mid-forties, as does the hazard rate of marriage. Using a non-stationary sequential search model, we identify the search frictions that generate these age-dependent marriage outcomes. We find that the arrival rate of suitors is the dominant friction, responsible for 80% of hazard rate variation and 49% of spouse quality variation. Surprisingly, the distribution of suitor quality is a lower-order concern. Also, individual choice, rather than worsening frictions, is responsible for most of the decline in spouse quality.

JEL Classifications: C81, D83, J12

Keywords: Marriage market frictions, spouse quality, reservation quality over the life-cycle, non-stationary search

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1 Introduction

The search for a spouse is undoubtedly influenced by many factors, including one’s own qualities, the availability and the quality of suitors, expectations about future opportunities as well as the expected benefits obtained from marriage. 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. For example, worsening prospects or higher utility from marriage later in life will encourage a single person to lower his or her standards over time. But which factors are changing significantly, and how consequential are they to marriage outcomes?

The American Community Survey data (between 2008 and 2010) illuminate these questions: the average spouse quality (measured by educational attainment) is hump shaped relative to an individual’s age of marriage. For women, spouse quality peaks at 24, then falls steadily through age 40. A parallel trend occurs for men, however there is a significant distinction: over the life-cycle, average spouse quality at marriage is higher for men relative to women. These facts are illustrated in Figure 2 on page 11. Similar trends emerge using income and other measures of quality, as we document in the appendix.

In this paper, we present a quantitative exercise to measure the size and importance of key frictions in the marriage market along an individual’s life cycle. To this end, we first document important facts on how spouse quality, hazard rate of marriage and divorce, and the quality distribution of suitors change with the age of marriage. Using the equilibrium conditions of a sequential search model (as in Wolpin, 1987; van den Berg, 1990) of marriage together with these facts from the data, we measure the size of each time-varying search friction. As in Chari, Kehoe, and McGrattan (2006), we then feed these measured frictions back into our model to understand the contribution of each friction (or a combination of them) in explaining the observed quality outcomes. We then ask how much of the observed decline in spouse quality is due to changes in an individual’s reservation value (choice) or due to exogenous factors in the marriage market (luck), in order to assess the degree to which individual choice magnifies or moderates the exogenous frictions.\footnote{Krusell, et al. (2010) makes a similar distinction between choice and luck in the labor market and accounts for the importance of each factor in determining the unemployment rate.}

The model depicts dynamic choices in discrete time periods, each lasting two
years. In each period, an unmarried individual encounters a suitor with some ex-
genous probability. A suitor’s total quality is measured as the sum of educational
attainment and intangible qualities. Both are drawn from an exogenous distribution;
the individual observes both components while the econometrician only observes the
former. If the proposal is accepted, the individual enjoys utility equal to the suitor’s
quality each period they are married. Marriages dissolve at an exogenous rate. If the
proposal is declined, the individual resumes searching (without recall of past suitors),
receiving an interim utility for each period of single life.

We restrict our analysis to marriages that occur between ages 22 and 42. This
accounts for 69% of those who eventually get married in our data. Our analysis
does not apply to earlier marriages, which may be motivated by other considerations
beyond the scope of our model, such as religious preferences or out-of-wedlock births.
We allow search parameters to vary each period, but assume stationarity beyond age
42. The data is roughly consistent with this assumption; average spouse quality is
stable (though noisy) through age 60. This stationarity also simplifies the analysis,
allowing us to solve the model by backwards induction. In this partial equilibrium
framework, we do not explicitly model how the distribution of suitor quality arises,
but take the distribution as exogenously given.

Our results provide crucial insights on the magnitude of frictions that affect the
marital search process. We find that the arrival rate of suitors is primarily responsi-
ble for the observed age-trends in marriage outcomes. According to our calibration,
suitors are increasingly plentiful, roughly doubling from age 22 to 30; but these op-
opportunities return to their original frequency by age 40. This motivates singles to
first raise, then lower, their selectivity (i.e. reservation quality) in choosing a spouse.

We also find variation in the utility from single life (relative to marriage) along
the lifecycle. Single life becomes steadily more enjoyable with age for women; for
men, it initially declines, then follows a similar trajectory to women. At each age,
single life utility is higher for women than men. As we discuss in the calibration,
this trend is broadly consistent with marriage being largely motivated by the desire
at younger ages to raise children or enable within-family specialization over market
and non-market production. Increasing single life utility would typically motivate an
individual to raise his reservation quality over time; however, this effect is dominated
by the declining arrival rate of suitors.

We quantify the contribution of each friction by comparing how choices and out-
comes would have differed if a given friction had been held constant throughout the lifespan. This allows us to compare observed fluctuation to fluctuation in this hypothetical market with more stable frictions. We find that changes in the arrival rate of suitors are responsible for 80% of the fluctuation in marriage hazard rates for both genders, while changes in single life utility account for all but 1% of the remainder. For age-trends in average spouse quality, the quality of the pool of suitors also contributes; yet arrival rate fluctuations are still the dominant friction. Indeed, these cause more than the observed fluctuation in average spouse quality, accounting for 108% of the trend for women (135% for men). Changes in suitor quality exacerbate the fluctuations in the same direction by another 52% for both genders; while rising single-life utility offsets these trends by the remaining 60% (or 87% for men).

Regarding reservation quality, we also find that there is a dramatic change over the lifecycle. This is significant because it suggests that individual choice plays an important role in the outcomes as opposed to just lucky circumstances. To illustrate this, we compute what would have occurred had singles held their reservation quality constant throughout their life. Any remaining variation in outcomes is therefore attributed to the changing exogenous parameters, which is to say, luck. Particularly in their thirties, we see little change due to luck, meaning most of the decline in quality is by choice, out of concern for future opportunities.

Our work offers an important foundation for policy-relevant empirical investigations. Many government programs distort the benefits of marriage, but perhaps not evenly over the lifecycle. Child tax credits have greatest value to those married earlier in life, as they are likely to have more children. The presence of such programs could contribute to one of our findings, that marriage has the greatest benefits relative to single-life before age 30, and falling thereafter. On the other hand, eliminating the marriage tax (where married couples pay a higher marginal rate than if they had been taxed as singles) would have a broader impact across all ages. These and similar policies could easily sway the timing of marriage and thus affect the quality of spouse.

1.1 Related Literature

An extensive literature, both empirical and theoretical, investigates patterns in mate choice. However, most of these papers focus on time-independent patterns, without
paying specific attention to the decision of individuals through the lifecycle, which separates our work from previous 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. ²

More recent theoretical literature has investigated marriage patterns in two-sided matching models. Burdett and Coles (1997), Shimer and Smith (2000), Chade (2001), and Smith (2006) each examine heterogeneous agents who face a stationary search problem. Upon meeting, both members of a pair must accept the other to marry; otherwise, they continue searching. A key assumption is whether match utility is transferrable (via side-payments between spouses); we follow Burdett and Coles (1997), Chade (2001), and Smith (2006) in assuming it is not.

Burdett and Coles (1997) show by examples that multiple equilibria can exist. By assuming utility is additively separable and strictly increasing in the partner’s type, Chade (2001) shows a unique equilibrium occurs with perfect assortative mating. Smith (2006) gets a similar result by assuming the proportionate gains from having a better partner rise in one’s type. Uniqueness is a trivial concern in our partial equilibrium setting. Our main distinction is in modeling an individual’s decisions as a dynamic search process, where search frictions change deterministically with age and a reservation quality threshold is formed at each age. In this framework, assortative mating is more subtle; even though the quality of a person does not change, the type of mate he will accept may change in response to an evolving search environment.

In this regard, Fernandez and Wong (2011) bears greatest resemblance to our attention the lifecycle dimension of choices. They build a partial equilibrium dynamic lifecycle model to quantitatively evaluate why the labor force participation of women age 30 to 40 doubled between cohorts born in the 1930s and the 1950s. They find that both the higher probability of divorce and the rise in wages are independently able to explain about 60% of the rise in women’s labor force participation.

Several other papers consider how dynamic lifetime decisions affect marriage out-

²Becker (1974) extends this analysis to include many circumstances such as caring between mates, genetic selection related to assortative mating, and separation, divorce, and remarriage.
comes, but these have primarily focused on the timing of marriage or the age gap between partners. Bergstrom and Bagnoli (1993) and Coles and Francesconi (2011) each investigate the effects of asymmetric career opportunities in generating marriages where one spouse is older than the other. In the latter model, decaying fitness and dwindling career opportunities motivate individuals to marry earlier. Siow (1998) and Diaz-Gimenez and Giolito (2012) study how differential fecundity between men and women generates a competition for younger women by young and old men. The latter finds that the age gap is primarily explained by differences in reproductive potential and earnings differences matter only little. They also find that some degree of randomness in matching is necessary to explain the life-cycle profile of marriages.

In our analysis, the offer arrival rate, the distribution of suitors, the benefits of single life, and the probability of divorce are all age-dependent. These frictions are calibrated so that the output of our dynamic search theoretical model replicates the observed trends in the data. In contrast to the preceding four papers, we take the average age difference in marriage as given; rather, our aim is to carefully account for the factors that determine the observed quality of spouse at each age of marriage. As in Diaz-Gimenez and Giolito, our agents differ in age, education, and sex. In addition, we allow for a random quality component (unobserved to the econometrician) of utility from marriage, above and beyond the observed characteristics of the spouse.

A broader quantitative literature focuses on factors which determine the timing of marriage (Keeley, 1979; Spivey, 2011), including how this is interrelated with wages and fertility decisions. Among those, Boulier and Rosenzweig (1984) emphasize the need to control for unobserved heterogeneity in the personal traits of agents, which is an important feature of our model. In a partial equilibrium search model for women, Loughran (2002) shows that increasing inequality in male wages can lead females to get married at later ages. 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. Rotz (2011) also works with a model of the marriage market similar to ours (but without the life cycle dimension) to understand how increases in age at marriage after the 1980s affect the decrease in the divorce rates over the same time period.

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 present 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 facts on four dimensions of marriage decisions that systematically change with age of marriage: the average educational attainment of spouse, the average educational attainment of potential suitors (or singles), and the hazard rates of marriage and divorce. We extract these facts from the 2008 through 2010 American Community Survey (ACS), retrieved from the IPUMS-USA database. We use educational attainment as a proxy for tangible qualities of an individual, and thus use the two terms interchangeably.

Our analysis is restricted to those households where both spouses were present in the sample, thereby allowing us to observe spouse characteristics. The respondent’s spouse was matched 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, over 1.6 million couples remained.

We further restrict our sample to couples where both partners are currently older than 30. This allows adequate time for individuals to complete their education and thus gives a stable measure of quality. We also drop couples where either partner is older than 60, so as to preserve a more homogeneous cohort born between 1950 and 1980.

Our analysis is all done in terms of the individual’s age at time of marriage, which has rich variation in the data, as illustrated in Figure 1. The left panel plots the distribution of ages at which college-educated women entered their current marriage; the density is unimodal and skewed to the left, with the peak at age 24. The distribution for college-educated men (not pictured) is very similar, though shifted two years higher. Indeed, husbands are on average two years older than their wives, with a

\[3^3\]For those currently married but previously divorced, we only observe the characteristics of their current spouse.
Figure 1: Age at marriage. The left panel indicates the fraction of marriages at each age for college women; light bars indicate ages that are excluded from our analysis. The right panel indicates the fraction of marriages for each difference in age between college man and his wife.

standard deviation of four years. The variation in this age gap is depicted in the right panel of Figure 1. This distribution is close to normal, and is fairly stable regardless of the age at marriage. For convenience, we plot all figures in terms of the woman’s age at marriage — that is, a plot for women can be read literally, while a plot for men is shifted two years earlier to match the age of the woman he will typically marry.

One readily notes that the overwhelming majority of marriages take place between ages 22 and 42 (shaded with darker bars). Only 1.5% of marriages take place after older ages, making estimates for these ages highly noisy. On the other hand, 14% of marriages take place before age 22; for these we have sufficient data, but are less confident of the applicability of our model to their marriage decisions. At such young ages, the final educational attainment of a potential mate is still uncertain; our model assumes this quality is perfectly known. Furthermore, early marriages could also be influenced by factors outside the model, such as religious preferences or out-of-wedlock conception. Thus, we limit our analysis to marriages where the woman was between age 22 and 42 and the man was between age 24 and 44, leaving 781,267 couples.

Table 1 provides descriptive statistics for our sample of married couples, separated by gender. Note that these include all those currently married, even if they have previously been divorced. In most aspects, the genders are fairly similar, though men
Table 1: Summary Statistics: Married Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Female</th>
<th>Male</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>Age</td>
<td>43.04</td>
<td>45.00</td>
</tr>
<tr>
<td></td>
<td>[7.77]</td>
<td>[7.79]</td>
</tr>
<tr>
<td>Years of Education</td>
<td>14.21</td>
<td>14.04</td>
</tr>
<tr>
<td></td>
<td>[2.61]</td>
<td>[2.70]</td>
</tr>
<tr>
<td>College Degree</td>
<td>.48</td>
<td>.46</td>
</tr>
<tr>
<td></td>
<td>[.50]</td>
<td>[.50]</td>
</tr>
<tr>
<td>Total Personal Income</td>
<td>35562.30</td>
<td>76692.30</td>
</tr>
<tr>
<td></td>
<td>[45807.10]</td>
<td>[84130.10]</td>
</tr>
<tr>
<td>Age at Marriage</td>
<td>28.07</td>
<td>30.53</td>
</tr>
<tr>
<td></td>
<td>[4.61]</td>
<td>[4.60]</td>
</tr>
<tr>
<td>First Marriage</td>
<td>.85</td>
<td>.84</td>
</tr>
<tr>
<td></td>
<td>[.36]</td>
<td>[.36]</td>
</tr>
<tr>
<td>Observations</td>
<td>781,267</td>
<td>781,267</td>
</tr>
</tbody>
</table>

Notes: Means are reported with standard deviations in brackets, by gender. A couple is included in the sample if both spouses are currently between age 30 and 60. Also, the woman must have been married between age 22 and 42, and the man between age 24 and 44. Source: ACS 2008-2010 (IPUMS).

have much higher income, largely due to higher labor force participation.

Our analysis also requires information regarding the single population in order to determine the rate at which marriages and divorces occur, and the distribution of educational attainment among this pool of potential suitors. This sample is also drawn from the ACS, which distinguishes the single population between those that have never been married and those that are currently divorced. In Table 2, we report summary statistics for both groups. Note that the ages of those in this sample need to be comparable to the age of marriage for the married sample; thus, we restrict our single sample to women whose current age is between 22 and 42, and men between 24 and 44. Relative to our married sample, singles are on average less educated and have lower income. Also the disparity in income between genders is less pronounced due to more equal labor force participation.

Throughout the paper, we focus our attention on the choices of individuals who obtained a four-year college degree. The model seems most applicable to a highly-educated population, as they can afford to be more selective in who they choose to marry, yet a sizable fraction still marry less educated spouses. With this variation, our
Table 2: Summary Statistics: Single Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Never Married</th>
<th></th>
<th>Divorced</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Age</td>
<td>28.83</td>
<td>31.25</td>
<td>35.29</td>
<td>37.14</td>
</tr>
<tr>
<td></td>
<td>[5.74]</td>
<td>[5.94]</td>
<td>[5.14]</td>
<td>[5.22]</td>
</tr>
<tr>
<td>Years of Education</td>
<td>13.65</td>
<td>12.97</td>
<td>13.24</td>
<td>12.74</td>
</tr>
<tr>
<td></td>
<td>[2.82]</td>
<td>[2.99]</td>
<td>[2.47]</td>
<td>[2.44]</td>
</tr>
<tr>
<td>College Degree</td>
<td>.35</td>
<td>.26</td>
<td>.23</td>
<td>.17</td>
</tr>
<tr>
<td></td>
<td>[.48]</td>
<td>[.44]</td>
<td>[.42]</td>
<td>[.37]</td>
</tr>
<tr>
<td>Total Personal Income</td>
<td>24712.60</td>
<td>29820.80</td>
<td>31376.20</td>
<td>38758.30</td>
</tr>
<tr>
<td></td>
<td>[27910.30]</td>
<td>[36839.40]</td>
<td>[31643.00]</td>
<td>[43762.90]</td>
</tr>
<tr>
<td>Observations</td>
<td>379,866</td>
<td>400,128</td>
<td>96,898</td>
<td>87,102</td>
</tr>
</tbody>
</table>

Notes: Means are reported with standard deviations in brackets, by gender and marital status. Sample is limited to women age 22 to 42, and men age 24 to 44. Source: ACS 2008-2010 (IPUMS).

The model can distinguish the extent to which this mismatch of education type is driven by external circumstances (luck) or personal decisions (choice). In our technical appendix, we extend the analysis to those without a college education.

2.1 Average Quality

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. For brevity, we refer to high-quality individuals as a college man or college woman. Of course, the data offer other measures, such as income, occupation, and employment status; yet each measure produces similar trends with respect to age (as documented in the appendix).

Figure 2 reports the average quality of spouse (left panel) and of potential suitors (right panel); that is, the percentage who hold a college degree. We compute this for each gender and age. In order to obtain smoother estimates, we categorize age using two-year intervals. As previously noted, all plots from the man’s perspective (dashed lines) are shifted two years earlier to match the age of the women they typically marry.
Figure 2: **Average Quality.** In the left panel, the solid line indicates the fraction of husbands with a college degree, depending on the college woman’s age at marriage; the dashed line does the same for wives. In the right panel, the solid line depicts the fraction of single men holding a college degree; the dashed does the same for women.

In the left panel, we ask what fraction of college graduates marry a college graduate, depending on the age at which they were married. For instance, 76% of college men married at age 24 marry a college woman. This percentage falls steadily over the next two decades to only 66% at age 44. For college women, the decline is a bit steeper, and they are 3-7% less likely to marry a college man throughout.

We next consider the average quality of singles, in order to get a sense of how the distribution of potential mates evolves with age. While one could literally take the fraction of singles with a degree at each age, this would be biased downwards for young singles, since some of these are still in the process of obtaining a college degree. Instead, we use the following reasonable imputation.

We begin by looking at the fraction of the population (married and single) holding a degree at the oldest age of 42. Then, we renormalize the populations at each age so as to maintain that fraction over the lifespan; for younger ages where this fraction would be lower, college graduates (both single and married) are given additional weight. Effectively, this extrapolates how many will eventually become college graduates and accounts for them moving across marital statuses.

In the right panel of Figure 2, we report the percentage of college-educated singles for each gender and age. We use the term *single* to include all those who are not
currently married, including divorcees. Single women are more likely (consistently by 5-6% at each age) to hold a college degree than single men. For both genders, the fraction holding a degree declines by about 10% over a decade, then leveling off in the early thirties.

In comparing the two panels, one immediately takes note of the high degree of assortative matching. If matches were simply random, the college educated individuals would marry college graduates in the same proportion as they occur in the full population. Instead, the fractions on the left are at least double those on the right at every age. At the same time, the assortative matching is not perfectly segregated, nor is it constant with age.

The comparison of these figures may also tempt one to ascribe the decline in spouse quality to the decline in suitor quality. However, even on its face this cannot be the whole story. Note that spouse quality continues to decline throughout the thirties, even after the single population has leveled off. While the quality of potential suitors is undoubtedly important to the analysis, it cannot in isolation explain the quality decline.

### 2.2 Hazard Rates

We next consider the frequency of transitions into and out of marriage, which we compute in terms of hazard rates. The ACS reports those who were married within the last year; we divide the number of newly-married college men of a given age by the sum of newly-married and single college men of that same age. The same is repeated for women. The left panel of Figure 3 reports the resulting hazard rates of marriage.

The rate rapidly increases by 10 percentage points over six years. At its peak, over a quarter of single 28 year-old college women will be married before reaching 30. Thereafter, the marriage rate falls 15 percentage points over the next twelve years. This pattern is virtually identical across genders.

The likelihood of divorce may also affect marriage decisions. The ACS data identify whether an individual is newly divorced within the past year, so we follow the same procedure as described above for marriage rates. The right panel of Figure 3 reports the resulting hazard rate of divorce.

The divorce rate rises from age 22 to 26; this is to be expected, since it may take a couple years for couple to realize incompatibilities. Thereafter, the divorce rate
Figure 3: **Hazard Rates.** In the right panel, the solid line indicates the fraction of women who get married at a given age, conditional on reaching that age unmarried; dashed lines do the same for men. The left panel indicates the fraction who are divorced, conditional on reaching that age married.

remains somewhat steady. The data also indicates that, at each age, college women are more likely (by 0.5%) to have a divorce than college men. This difference is likely because college women marry more non-college men, who have higher divorce rates than college men.

In the preceding analysis, we have categorized those never married together with single divorcees, and those currently married for the first time together with in a second or later marriage. In our data, divorcees constitute 32% of the overall single population, while 24% of marriages include a spouse who had been previously married. Any of the facts computed in Figures 2 and 3 can be computed conditional on the number of prior marriages; the resulting figures are available in our Technical Appendix.

In many aspects, divorced singles behave similarly to never-married singles of the same age. If remarried after age thirty, their average spouse quality is nearly the same as those entering their first marriage at that age; for earlier remarriages, the average spouse quality tends to be lower. Divorcees tend to be somewhat less educated; and their hazard rate of marriage is generally 2-3% higher, but follows the same shape as those entering their first marriage. The biggest distinction is in their hazard rate of divorce, which is at least twice as high at each age.
In our model and calibration, we do not distinguish between divorcees and never-married singles. Doing so adds significant clutter to the calibration process without shedding much additional light. Indeed, our calibration was not very sensitive to the divorce rate, which is the largest point of distinction between the two groups. In both the model and data, we categorize marital status based on its current state, and ignore the past history of marriages.

3 Model

Our goal is to quantify the search frictions that govern the observed choices of men and women in the marriage market. To give structure for the analysis, we use a non-stationary model of search for a marriage partner.

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 has exceptional 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 evolve with age to best fit observed trends.

A minor difference in our model is that a single person potentially encounters several suitors in a given period (according to a Poisson distribution), rather than at most one. Each suitor must be rejected before others are encountered, though. This has several purposes. First, it captures some of the uncertainty as to how frequently another opportunity will arise — indeed, several opportunities might arise before any significant change in circumstances due to age. In a continuous time model, this is reflected in the Poisson arrival rate.

The other advantage is that we can lengthen a period (to two years). Some serious relationships are nevertheless quite brief, while others end up lasting several years before concluding in marriage or break up; our Poisson distribution of dating opportunities seems to be consistent with the variation in relationship duration. Empirically, these longer periods allow us to smooth our calibration targets over several years.
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. During a period $t$, a woman randomly encounters suitors sequentially according to a Poisson distribution with parameter $\lambda_t$. That is, with probability $\lambda_t$ she encounters a first suitor. If he is rejected, she has probability $\lambda_t$ of encountering a second suitor. If she ever fails to encounter a suitor, she has no more marriage opportunities for that period, with utility from the next period discounted by factor $\beta$.

Upon encountering a suitor, she observes a measure $q$ of his quality. If she rejects the current suitor, she continues her search that period, finding another suitor with probability $\lambda_t$. If she marries the current suitor, she obtains utility $q$ each period thereafter so long as the marriage remains intact, which imposes that utility is nontransferable. Divorce occurs at the end of each period with probability $\delta_t$, with divorcees returning to the single population.

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. This quality measure is commonly agreed upon, meaning all individuals prefer a more highly-educated spouse. Let $\gamma_t$ 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 $\sigma$, 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 $t$ is 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 $b_t$ from each attempt at dating that period. If negative, this can be thought of as the monetary and emotional cost of dating; if positive, it indicates the net benefit of the social scene of single life. In either case, $b_t$ is measured relative to the (normalized) values of spousal quality $q$. Thus, $b_t = 0$ would provide the same annual utility as being married to a college graduate who
is $1/\sigma$ standard deviations below average, or to a less-educated man who is exactly average. Thus, $b_t$ represents the benefits (or disadvantages, if negative) associated with being single relative to being married.

As in Wolpin (1987) or van den Berg (1990), we assume there exists an age $T$ such that for all $t \geq T$, all search frictions ($b_t$, $\lambda_t$, $\gamma_t$, and $\delta_t$ in particular) remain constant.

Let $V_t$ denote the present expected value of utility for a single woman at age $t$, and let $W_t(q)$ denote the same for a woman married to a man of quality $q$. The search problem can be summarized in recursive form as follows:

$$V_t = \max_{R_t} b_t + \lambda_t \int_{R_t}^{\infty} W_t(q) \left( \gamma_t \phi(q - 1) + (1 - \gamma_t) \phi(q) \right) dq$$

$$+ \lambda_t (\gamma_t \Phi(R_t - 1) + (1 - \gamma_t) \Phi(R_t)) V_t + \beta (1 - \lambda_t) V_{t+1},$$

where $\phi(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{z^2}{2\sigma^2}}$ is the normal density function and $\Phi(z)$ is its cumulative density function. Note in the first term of the second line that if she rejects a suitor (whose quality lies below $R_t$), then she remains in period $t$ and potentially may meet another suitor. She only moves to the next period (the last term) once she fails to meet a suitor. This allows for ex-post heterogeneity in the number of opportunities the woman may receive in a given period.

We also allow the single woman to skip search if it is not expected to be productive; that is, search only occurs if:

$$\int_{R_t}^{\infty} W_t(q) \left( \gamma_t \phi(q - 1) + (1 - \gamma_t) \phi(q) \right) dq + (\gamma_t \Phi(R_t - 1) + (1 - \gamma_t) \Phi(R_t)) V_t > \beta V_{t+1}. \quad (2)$$

The married woman has no choices to make, as separation occurs exogenously. Her expected utility is depicted as:

$$W_t(q) = q + \beta (\delta_t V_{t+1} + (1 - \delta_t) W_{t+1}(q)). \quad (3)$$

The reservation quality will be chosen so as to accept whenever the flow of value from marriage exceeds the flow of value from continued search. In particular, turning down an offer $q$ during period $t$ sacrifices $W_t(q)$ in favor of $V_t$. The reservation quality must make the single person indifferent; hence,

$$V_t = W_t(R_t). \quad (4)$$
Note that if couples could also voluntarily separate, this would only occur if and only if $V_{t+1} > W_{t+1}(q)$. Thus, if $R_s \geq R_t$ for all $s < t$, there would be no prior marriages that would prefer separation. On the other hand, if $R_s < R_t$ for some $s < t$, some marriages agreed to at $s$ would be preferred to terminate at $t$ in favor of further search.

Equations 1 through 4 can be jointly solved to get $R_t$, $V_t$, and $W_t$ for all $t$. In particular, the search problem is stationary for $t > T$, so one can replace both $t$ and $t + 1$ with $T$ in all three equations; the latter two can be substituted into the first to get a single equation in terms of $R_T$, which is relatively simple to solve numerically. From there, earlier reservation values (e.g. $R_{T-1}$) are found by backwards induction.

The effect of parameters on search decisions are mostly intuitive. The single person benefits from higher search utility ($b_t$), a greater proportion of college graduates in the pool ($\gamma_t$), or more frequent arrival of suitors ($\lambda_t$). Furthermore, anything that raises the expected utility of current singles will lead them to raise their reservation quality.

In this regard, changes in the divorce rate are slightly more subtle. A lower divorce rate helps anyone who prefers their current match over re-entering the search market; but if reservation qualities rise over time, some people marry early to a low-quality match and would prefer a new search later on. Since we assume separation is exogenous, a lower divorce rate would harm someone in that situation. Thus, a sufficient condition is that reservation qualities are declining with age.

**Proposition 1.** In a given period $t$, if $b_t$, $\gamma_t$, or $\lambda_t$ increase, all else equal, then $R_s$ will increase in all periods $s \leq t$. A decrease in $\delta_t$ will increase $R_t$; it will also increase $R_s$ for $s < t$ so long as $R_{s'} \geq R_{s'+1}$ for all $s' \in [s, t-1]$.

Strictly speaking, the preceding result discusses the change of a single parameter at a single point in time. However, the result easily generalizes to changing a whole path of a parameter, particularly when the path consistently changes in the same direction. For instance, suppose we start with the stationary problem in which all parameters are held constant at their period $T$ values. If for some $s < T$, $\gamma_t$ is increased by the same amount for all $t \leq s$, then not only does $R_t$ increase, but $R_{t-1} > R_t$ for all $t \leq s$. One can see this in the proof of Proposition 1 by noting that the direct effect of $\gamma_t$ will be felt in all $t$, not just period $s$, but the indirect effect in $W_t(q)$ moves in the same direction and affects all earlier periods. More generally, if
\( \gamma_t \) is falling with age (and other parameters were held constant), then \( R_t \) would also necessarily fall with age, or similarly for the other parameters.

### 3.2 Calibration Targets

Our aim is to obtain estimates of the search model frictions, with particular interest in the movement of \( \lambda_t, \gamma_t, \) and \( b_t \) over the lifecycle, so as to deduce their relative importance in producing the trends described in Section 2. We allow the search parameters to differ across genders, since each may face different opportunities for and different benefits from marriage. These parameters are chosen so as to replicate the basic facts in our data, as presented in Figures 2 and 3.

For expositional purposes, consider the process used to calibrate these parameters for college-educated women. The data (Figure 2, right panel, solid line) reports the fraction of single men of age \( t \) who hold degrees, which we use as our proxy for \( \gamma_t \). The data (left panel, solid line) also indicates at each age the fraction of women married to a college man, which we denote \( f_t \). Derived from the theory, this fraction would be:

\[
f_t = \frac{\gamma_t (1 - \Phi(R_t - 1))}{\gamma_t (1 - \Phi(R_t - 1)) + (1 - \gamma_t) (1 - \Phi(R_t))}.
\] (5)

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. Since we have \( \gamma_t \) and \( f_t \) from the data, Equation 5 allows us to find the \( R_t \) consistent with these observed facts. This process exploits any difference between \( \gamma_t \) and \( f_t \); a wider gap between these is consistent with being more selective and hence employing a higher reservation quality.

Next, the data (Figure 3, left panel, solid line) provides the hazard rate of marriage, which we denote \( p_t \); that is, the probability that a woman gets married at age \( t \), conditional on being unmarried at age \( t - 1 \). This depends both on the arrival rate of suitors, \( \lambda_t \), as well as the probability that a given suitor exceeds the woman’s reservation quality. We denote the latter as \( A_t \equiv (\gamma_t (1 - \Phi(R_t - 1)) + (1 - \gamma_t) (1 - \Phi(R_t))) \).

The probability that a single woman meets and accepts a suitor in period \( t \) is given by:

\[
p_t = \sum_{s=0}^{\infty} \lambda_t A_t (\lambda_t (1 - A_t))^s = \frac{\lambda_t A_t}{1 - \lambda_t + \lambda_t A_t}.
\] (6)

Here, \( s \) indicates the number of suitors that were encountered but turned down before
finally accepting the $s + 1^{\text{th}}$ suitor. Having observed $p_t$ in the data and inferred $R_t$ from Equation 5, we can use Equation 6 compute $\lambda_t$.

Finally, we use the 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 $\lambda_t$, $\gamma_t$, and $\delta_t$. We use $\beta = 0.95^2$ as each period in the model is two years.

4 Results

Having presented our dynamic search model and derived the theoretical analogs to our data targets, we now present our results. Note that four parameters contribute to determining the reservation value along the life-cycle: the utility from being single, the offer arrival rate, the divorce rate, and the probability that a suitor is college-educated. Our goal is to account for the role of each search friction in determining a single individual’s reservation quality of a mate at each age. The last two are directly derived from the data (and presented in the left panels of Figures 2 and 3, respectively). The former two are calibrated as described in the preceding section, and depicted below. We also report and interpret the resulting path of reservation quality with respect to age.

4.1 Calibrated Frictions

Variance of Intangible Qualities. To begin, we must set the variance in intangible qualities, $\sigma$, 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 $\sigma$.

To find an empirical analog to this statistic, we examine other factors reported in the data that may contribute towards desirability, beginning with total income. Clearly incomes are strongly correlated with holding a college degree, but even after controlling for education, a wide variation in incomes remains. In our data on single
men, 7.2% of non-college graduates (over age 30) earn more than the average college graduate. This percentage is larger for women (7.8%), and for younger singles, but for each gender the fraction remains fairly steady from age 30 to 60. This provides a reasonable estimate for calibration, yielding $\sigma = 0.69$ for men, and $\sigma = 0.71$ for women.

One concern in exclusively using income is that labor force participation is lower among women; for them, income may not provide as much insight into intangible quality. However, the data provide factors that are potentially relevant to desirability, including labor force participation, employment status, marital history, age, and income. We add these factors to the previous procedure by first determining how they are correlated with holding a college degree via a linear probability model (separately for each gender with the same sample of 30 to 60 year-old singles). A probit estimation yielded similar results. The details of these regressions are provided in Appendix C.

We use the estimated regression coefficients to compute each individual’s predicted probability of having a college degree. This essentially creates an index of quality. For example, suppose two men both lack a college degree, so the realized value of $\text{HasDeg}$ is 0 for both. If the predicted probability is higher for one of these men, then his labor and demographic characteristics are more similar to those of the typical college graduate, which should make him more desirable as a spouse. We then compute the average predicted probabilities among those who actually obtained college degrees, and ask what fraction of non-college singles have a higher predicted probability than the average college single. This produces very similar estimates: 7.5% for men and 7.9% for women, which translate to $\sigma = 0.70$ and 0.71, respectively.

We thus use $\sigma = 0.7$ for the remainder of the paper. As a robustness check, we have recomputed our results with alternate values ranging from 0.4 to 1.0, but the effect on our remaining calibrations and results was minimal. As $\sigma$ increases, the probability of encountering a suitor and single-life utility are pushed to higher levels, but their shape with respect to age is virtually identical. This is reassuring, since our primary objective is to identify these relative changes in the calibrated parameters (rather than their absolute levels).

**Arrival Rates.** We next examine arrival rates of potential suitors, reported in Figure 4. Both genders see a rapid increase in marriage opportunities through twenties, followed by a similar decline after age 30. For instance, a 22 year-old college
A woman encounters an average of $\frac{1}{1-0.4} \approx 1.7$ suitors over two years, but this rises to 4.3 suitors by age 30, then returns to 1.6 suitors by age 42.\footnote{In interpreting these arrival rates, we do not consider “potential suitor” to be synonymous with “serious relationship,” but rather an opportunity for starting a relationship. This explains why our arrival rate is higher than in Rotz (2011), where marriage proposals are calibrated to arrive once every three years.} The peak level is only slightly lower for men.

Figure 4: Arrival rate of suitors. The solid line indicates the arrival rate of suitors for women; the dashed line does the same for men.

These patterns have plausible explanations in typical career dynamics. At younger ages, these college-educated singles are mostly focused on their schooling. While college provides a rich social environment, this social network is drawn on more heavily for marriage prospects in the years that follow. As one settles into a career, social circles from college decay, and are replaced by smaller circles of co-workers.

**Single-life Benefits.** The benefits from single life, $b_t$, are computed as a residual from the Bellman Equation, and are presented in Figure 5. In interpreting these results, one should recall that these utilities are relative to the benefit of being married. Thus, a higher $b_t$ could reflect more enjoyment from being single, or less value placed on marriage (for instance, lower importance on committed companionship or having children).
Figure 5: **Single-life Benefits.** The solid line indicates the utility an unmarried woman receives from each iteration of dating, relative to 0, the benefits of marrying an average non-college man. The dashed line does the same for unmarried men.

We also note that while estimated utilities are sometimes 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 can cause some disutility. This can still be optimal if suitors arrive frequently and if the distribution promises much better opportunities than the current match. Indeed, the participation constraint in Equation 2 never binds under these parameters; every opportunity to search is gladly welcomed.

For women, $b_t$ improves somewhat steadily with age. Again, this could also indicate that single life is getting better with age, or that the benefits of marriage are declining.\(^5\) This trend could arise from several plausible sources. Fertility generally declines with age; thus, early marriages could yield higher utility than those later in life, even if to the same quality man. Alternatively, at older ages, a single person has a more developed career and hence more to lose if marriage necessitates employment changes for relocation or family care.

\(^5\)This finding is contrary to the theory of marriage as a risk-sharing arrangement (as in Kotlikoff and Spivak, 1981), which posits that older people benefit from marriage more, because they reap the benefits of sharing the spouse’s income if, for example, health shocks take away their own income.
The search utility of men follows a similar overall trend, with two exceptions: utility rapidly declines in their early twenties, then remain lower than women’s utility for most of the remaining years. On its face, this indicates that men get greater benefits from marriage than 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 ages when childrearing is most common.

4.2 Reservation Quality

Finally, we examine the path of reservation quality chosen by singles in response to these frictions, depicted in Figure 6. Both genders become increasingly selective through age 32, followed by a similar decline thereafter. This rise and fall is more pronounced for women than men.

Remember that these are indexed relative to the average non-college single, who has mean quality \(0\) with a standard deviation of \(\sigma = 0.6\). Thus, when women choose \(R_{22} = 0.9\), for instance, this means she is willing to accept \(1 - \Phi(R_{22}) \approx 10\%\) of non-college men, and \(1 - \Phi(R_{22} - 1) \approx 56\%\) of college men. This is a much lower standard than women at age 32, who accept only 4% of non-college men and 40% of college men.

We can interpret these reservation qualities on two levels. The first is mechanical, which is to say, what features of the observed data determine \(R_t\). This computation is driven by the comparison of \(f_t\) and \(\gamma_t\). If people simply married anyone they encountered, these fractions would equate. To obtain a larger gap between the average quality of spouse, \(f_t\), and the average quality of suitor, \(\gamma_t\), people must be more selective, turning down a higher fraction of non-college suitors than college suitors. The precise relation is dictated by Eq. 5. Our computed reservation values indicate that women are more selective than men between ages 24 and 34, and that both genders rise then fall in their selectivity.

The alternative interpretation method is to ask which of the imputed search fric-
Figure 6: Reservation Quality. The solid line indicates a woman’s optimal reservation quality at each age; the dashed line does the same for men.

tions are driving these optimal decisions. To assess each parameter’s impact, we determine how choices and outcomes would have differed if the parameter had stayed constant throughout their life. As our starting point, we use our calibrated parameter values. Single individuals use the reservation qualities in Figure 6, which are repeated in the solid lines of the top row of Figure 7. We also report the average quality of spouse $f_t$ (middle row) and hazard rate of marriage $p_t$ (bottom row); under the calibrated frictions (solid lines), these necessarily match the observed data.

We then consider what would have occurred if suitor arrival rates had been constant over the lifespan, specifically at $\lambda_{42}$, the same value used in the stationary search problem beyond age 42. Other frictions remain as in the calibration. We recompute the optimal reservation quality and expected marriage outcomes under this set of frictions and report them with long dashed lines in Figure 7. The gap between the solid and long dashed lines would thus indicate the marginal contribution of changes in the arrival rate to marriage choices and outcomes.

We continue this decomposition of the marginal effects by holding $\lambda$ and $\gamma$ constant at their age 42 values; the resulting reservation quality and expected marriage outcomes are reported in the short dashed lines of Figure 7. Thus, the gap between the long and short dashed lines indicates the marginal contribution of changes in the
Figure 7: Marginal Effect of Each Friction. These graphs report the reservation quality, average spouse quality, and marriage hazard rate (for college women on the left, college men on the right) under various search frictions. For the solid lines, the calibrated frictions are used, thus replicating the observed data. For the remaining lines, the same frictions are used, except that noted parameters are held constant at their age 42 value.
distribution of suitors to marriage choices and outcomes.

Finally, we hold $\lambda$, $\gamma$, and $b$ constant at their age 42 values, reporting the consequences in the dotted lines of Figure 7. The gap between the short dashed and dotted lines indicates the marginal contribution of changes in single-life utility to marriage choices and outcomes.

We now consider the role each friction plays in turn. First, we note that in all four specifications, we still allow divorce rate $\delta$ to vary as in the data, but this has only a minor upward drift as people age. This has practically no effect on the equilibrium behavior or outcomes, which are nearly constant when the other three frictions are constant (dotted lines).

One might naturally suspect that the friction of greatest concern is the quality of the pool of candidates, but that does not seem to be the case. In the top and bottom rows of Figure 7, note that the marginal impact of $\gamma$ (long versus short dashed lines) is quite minor.$^6$ This is despite a rather significant decline by over ten percentage points from age 22 to 32. The only substantial impact is on average spouse quality, where $\gamma$ plays a direct role. In short, the candidate pool has little sway over the choices of singles or their timing of marriage, but makes a difference in who they end up marrying.

The benefits of single life $b_t$ rise substantially from age 26 through 40; on its own, this would lead to rising selectivity throughout. This marginal contribution is evident in comparing $R_t$ in the short dashed and dotted lines of the top row of Figure 7. Through its indirect effect on selectivity, rising $b_t$ also leads to increasing spouse quality and a decreasing hazard rate of marriage across the whole age range. Since these trends do not match the data, clearly another friction is in play.

The marginal impact of the arrival rate $\lambda_t$ (solid vs. long dashed lines) is of first-order importance in both choices and outcomes. Without the hump-shaped arrival rate, reservation quality would be substantially lower and strictly increasing. The average spouse quality would be lower and somewhat steady with age. The timing of marriage would also be much smoother, dropping as much as 15 percentage points. Note that the calibrated arrival rate nearly mirrors the changes in reservation quality for both genders; both rise together initially and then fall together in the end, with

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$^6$We also note that $R_t$ is increasing when $\gamma_t$ is decreasing. If suitor quality were the only effect, exactly the opposite would occur, using the comparative statics in Proposition 1. Moreover, the distribution remains more or less constant during the thirties, while the reservation quality falls.
the peak occurring two years later in $R_t$ than in $\lambda_t$.

In sum, only declining marriage opportunities can explain declining selectivity in the late thirties; the pool of suitors is not changing, and the benefits of marriage are generally increasing in that age range. During the twenties, marriage opportunities become more plentiful with age and single-life benefits are rising for the most part; these more than offset the falling quality of the pool of suitors to produce rising selectivity.

Indeed, one way to quantify these marginal effects is to compute what percentage of the total change (the absolute value of the area between the solid and dotted lines) is generated by variation in $\lambda$ (the absolute value of the area between the solid and long dashed lines). By this measure, 80% of the change in women’s or men’s marriage hazard rate comes from their arrival rate fluctuations; only 1% of the variation is due to changes in the distribution of suitor quality, with the rest from changes in single-life utility. Moreover, arrival rate fluctuations cause 49% than the observed fluctuation in average spouse quality for each gender. Declining quality of potential suitors contributes 24% of the fluctuation for women and 19% for men, with the remainder from rising single-life utility.

Our initial facts showed that men and women married in their early twenties obtain better outcomes than those married later, but this was only based on the observed educational attainment. One virtue of calibrating our search model is the ability to infer what intangible traits must have been in order to generate the observed behavior. In particular, a woman at age $t$ will only accept a man if his total quality exceeds her reservation value: $q = a + z > R_t$. Recall that intangible qualities $z$ are normally distributed, but the distribution of accepted qualities will be truncated at $R_t$. We determine average accepted total quality, $Q_t$, at age $t$ as follows:

$$
Q_t = \frac{\int_{R_t}^{\infty} q \left( \gamma_t \phi(q - 1) + (1 - \gamma_t) \phi(q) \right) dq}{\int_{R_t}^{\infty} \left( \gamma_t \phi(q - 1) + (1 - \gamma_t) \phi(q) \right) dq}.
$$

(7)

The numerator computes the expected quality $q$ for values greater than $R_t$, while the denominator rescales this by the probability of observing a $q$ greater than $R_t$.

While one might expect this to simply track parallel to $f_t$, the average educational attainment $a$ of spouses, it does not. The difference is driven by the changing selectivity reflected in $R_t$. In their twenties, college singles become more selective with age; in other words, $z$ must be higher even for a college-educated suitor to be acceptable.
Figure 8: **Average Observed vs. Total Quality.** In the left panel, the solid line indicates the fraction of husbands with a college degree, depending on the college woman’s age at marriage; the dashed line does the same for wives. In the right panel, the solid line indicates the average total quality (educational attainment plus intangible qualities) of husbands; the dashed line does the same for wives.

The net effect is illustrated in Figure 8. The left panel is the average educational attainment \( a \) of marriage partners, as observed in the data and previously reported in the left panel of Figure 2. The right panel is the average total quality \( q \) of marriage partners, as computed in \( \bar{Q}_t \). Note that the latter increases through age 32, while the former only increases through age 24. Those who get married in their early twenties encounter many college-graduate suitors but have somewhat low selectivity. As they age, fewer of their suitors will be college graduates, but they also raise their standards, meaning they only accept suitors with exceptionally great personalities, attractiveness, etc. On net, the increased selectivity dominates in regards to average total quality, but does not in regards to average educational quality.

### 4.3 Choice versus Luck

For both genders, the observable quality of spouse falls when married at older ages, and the preceding analysis identifies key factors leading to these trends. Of course, the exogenous changes are not the whole story; in response to these external pressures, singles also adjust their search strategy, captured in \( R_t \). We may therefore ask how much of the observed outcomes are due to choice, with the remainder ascribed to
Figure 9: **Choice versus Luck: Timing of Marriage.** The solid and dashed lines report the observed hazard rate of marriage, conditional on age. The dotted lines indicate the hazard rate that would have been realized had the reservation quality been held at $R_{22}$. The gap between them reflects the role of choice in observed outcomes.

random factors beyond one’s control, *i.e.* luck.

To assess this, given our computed frictions, we ask what would have occurred if the individual applied the same reservation quality $R_{22}$ throughout his or her life span. Of course, these are not the optimal reservation values (effectively ignoring $b_t$), but this counterfactual experiment allows us to see what would have occurred if choice is removed from consideration; all remaining effects arise due to external changes in $\gamma_t$, $\lambda_t$, and $\delta_t$.

We begin by assessing the impact of choice on when people get married, depicted in Figure 9. The solid and dashed lines are the observed hazard rate, repeated from the left panel of Figure 3; the dotted lines indicate the counterfactual hazard rate using a constant reservation quality. For both genders, the hazard rate of marriage retains its shape but increases by as much as 11 percentage points. In other words, because singles raise then reduce their selectivity, they tend to get married somewhat later than they would with a constant degree of selectivity.

On the other hand, changes in $R_t$ have a far more significant impact on *who* individuals marry. In Figure 10, the solid and dashed lines depict the observed quality of spouses, repeated the left panel of Figure 2; the dotted lines report the counterfactual quality of spouses under a constant reservation quality. When choice is removed from
Figure 10: **Choice versus Luck: Quality of Spouse.** The solid and dashed lines report the observed average quality of spouse, conditional on the age of marriage. The dotted lines indicate what the quality that would have been realized had the reservation quality been held at $R_{22}$. The gap between them reflects the role of choice in observed outcomes.

The outcome (dotted lines), the average quality falls earlier, then levels out after age 30. Note that this path is nearly identical to that of average suitor quality (right panel, Figure 2). By becoming more selective with age, an additional 10% of thirty-year-old college women marry college men; an additional 4% of thirty-year-old college men marry college women.

For both genders, note that the dotted lines decline steadily through age 35, then remain mostly flat. This indicates that external circumstance (luck) is worsening at first but leveling off thereafter. Beyond age 35, declining selectivity (choice) is almost entirely responsible for observed declining quality. At early ages, both choice and luck play a significant role. One distinction between the genders is that at younger ages (before 26), observed husband quality rises mostly due to choice, while observed wife quality declines a little, mostly due to luck.

### 4.4 Selection

While our model provides one explanation for why spouse quality declines with age (namely, changing utility and/or worsening prospects), another potential explanation is that this is a consequence of selection. That is, all the best candidates marry...
Figure 11: **Spouse Education by Age of Marriage.** The solid line in the left panel depicts the average years of education completed by a husband, conditional on the college woman’s age at marriage. The dashed line in the right panel does the same for wives. Dotted lines indicate 95% confidence intervals.

early, so those who marry late are less desirable themselves, and hence match with less desirable spouses. Of course, we have controlled for one dimension of candidate quality (*i.e.* own educational attainment); so this selection would have to take place on intangible qualities.\(^7\)

To address this concern, we look to another data set which can shed additional light on intangible qualities: the Wisconsin Longitudinal Survey (WLS). 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, but offer two additional measures: IQ and an attractiveness rating.\(^8\) Both measures 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.

First, we note that the relationship between spouse quality and age at marriage

\(^7\)For instance, this could be introduced in our model by allowing the mean of \(z\) to fall with age, rather than remain constant at 0.

\(^8\)Attractiveness was determined by a panel of six men and six women of similar age to the studied cohort. Each panelist was asked to rate the high school yearbook photos on an 11-point scale. Each panelist’s attractiveness ratings were normalized to mean zero. We present the average of those scores across all twelve judges.
Figure 12: **Own Attractiveness by age of marriage.** Average attractiveness rating (measured from -5 to 5) of women (left) or men (right) depending of the age at which they first married. Dotted lines indicate 95% confidence intervals.

still holds among this sample, particularly among women. In Figure 11, we restrict ourselves to the 3,553 college graduates in the sample and compute the average years of education completed by the respondent’s spouse. The hump-shape seems to be present, though the smaller sample generates much greater noise, particularly above age 30 (as indicated by the confidence intervals).

We then examine how age of marriage is correlated to one’s *own* quality, to see if there is any evidence that early brides or grooms are systematically more attractive or intelligent than those married later in life. The results are depicted in Figures 12 and 13; both indicate essentially constant quality with respect to one’s own age at marriage.

In Figure 12, we see a slight decline (for women, less than half a point on an 11-point scale) for both men and women. In both cases, the difference from 0 (the average attractiveness rating) is not statistically significant. Too few marriages occur after age 35 to make any useful inference.

In Figure 13, we see that average IQ fluctuates by about 5 points over the various ages at which people are married, but not with a clear trend in either direction. Again, confidence intervals indicate that for the most part, these fluctuations are not significantly different from the average IQ of 102.

This suggests that individuals married later in life are not less attractive or intel-
Figure 13: **Own IQ by age of marriage.** Average IQ score of women (left) or men (right) depending of the age at which they first married. Dotted lines indicate 95% confidence intervals.

...ligent 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 potential suitors but not the econometrician. If tastes are idiosyncratic regarding personality, then this component would be match-specific (as our model assumes) anyhow: some people may bristle at a particular sense of humor that others will find delightsome. Thus, we can plausibly conclude that $z$ maintains the same mean throughout life; intangible qualities do not seem to be worsening with age.

## 5 Conclusion

In this paper we establish facts regarding the distribution of spouse quality as a function of age at marriage, using the American Community Survey data. Women married in their mid-twenties obtain the best husbands on average, where quality is proxied by income or education. Average quality declines steadily through age 40. The pattern for men is roughly parallel though higher at each age.

To explain these different experiences between men and women, we set-up a non-stationary sequential search model, in the spirit of Wolpin (1987), which is then calibrated to US data on marriages. This process reveals the underlying search frictions which lead to the observed marriage choices. The most consequential friction is
the arrival rate of marriage prospects, which forms a hump shape, peaking at age 30.

Surprisingly, the declining quality of potential suitors is not as pivotal as one might expect. Indeed, during their twenties, singles become more selective even as the pool of potential suitors worsens. In their thirties, they become less selective though the pool of suitors is roughly unchanged. In the early years, the net effect of increasing selectivity and decreasing quality of suitors yields the observed decline in observable spouse quality, but an increase in total spouse quality.

Our analysis also indicates that the benefits from marriage are typically greater for college men than college women, and are greater for both in their younger years. This is consistent with marriage providing its greatest value as an institution for raising children and for specialization between spouses across market and non-market production.

More broadly, we demonstrate that the observed decline in spouse quality is not merely a consequence of worsening circumstances in the marriage market. Individual choice plays at least as big a role, with singles changing their selectivity over the course of their lifespan. This conclusion is particularly important when considering how public policy might affect the timing and quality of marriages. Tax or welfare benefits can easily impact the perceived utility of remaining single versus getting married; our work indicates a reasonably high degree of elasticity to such incentives.
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 among women, these alternate quality measures follow the same trend with respect to the age of marriage, with women married at age 24 obtaining the highest quality husbands. For men, spouse quality is much flatter under the alternate measures, and generally peaks in the late thirties. Due to this late peak for men, we examine a wider range of marriage ages (18 to 54) than in the main text.

First, we could employ a more nuanced measure of educational attainment, such as years of education. In the text, we use college graduation as a discrete measure of quality, and control for one’s own quality by only examining college graduates. Since we add more categories of educational attainment here, we use a regression to control for one’s own years of education. In particular, we estimate the following equation (separately for men and women):

\[ Y_i = \sum_{j=19}^{52} \alpha_j \cdot M_{ij} + \beta E \cdot YE_i + \epsilon_i. \]  

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 \( M_{ij} \) as an indicator variable for each age at marriage from \( j = 19 \) to 52. Since age at marriage equal to 18 is the omitted category, the coefficients \( \alpha_j \) indicate the relative difference in average quality if married at a later age.

Figure 14 plots the estimate \( \alpha_j \) coefficients for women (solid line) and men (dashed line). For example, this indicates that the husband of a woman married at age 25 will have on average 0.6 more years of education than that of a woman married at age 18.

\[ \text{The ACS measure of education identifies years of education through grade 12 but shift to degree attained after grade 12. To provide a continuous measure of spousal quality, we map the ACS education variable into years of education (indicated in parentheses): 12th grade, with or without a high school diploma (12), some college but no degree (13), associate’s degree (14), bachelor’s degree (16), master’s or professional degree (17).} \]
Figure 14: Spouse Educational Attainment. Spouse’s additional years of education (relative to the spouse of a person married at age 18), depending on age of marriage, after controlling for one’s own educational attainment.

18 or at age 45, even when the women have the same educational attainment. Note the overall trend is the same as in the text, peaking at age 24. For men, the trend is essentially flat between 27 and 37, though it does decline noticeably thereafter.

Another measure of spouse quality is his or her income.\textsuperscript{10} We repeat an estimation of Equation 8, 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 $\alpha_j$ of this regression are depicted in Figure 15. Controlling for own education, a women married at age 24 has a husband making approximately $12,000 more than a similar woman (in terms of education) married at age

\textsuperscript{10}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.
Figure 15: Spouse Income. Spouse’s additional income (relative to the spouse of a person married at age 18), depending on age of marriage, after controlling for one’s own educational attainment.

18. Those married after age 44, on the other hand, have husbands earning $12,000 less. For men, the trend is again much flatter, with a peak of $10,000 more for those married at age 35.

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-five 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,
Figure 16: **Spouse Income with Controls.** Spouse’s additional income (relative to the average person with similar age and demographic characteristics), depending on age of marriage.

estimating the following equation:

\[ Income_i = \sum_{j=19}^{52} \alpha_j \cdot Age_{ij} + \beta_2 \cdot X_i + \epsilon_i. \]  

(9)

Here, \( Age_{ij} \) denotes a vector of indicator variables, equalling 1 if \( j \) is the current age of individual \( i \) and 0 otherwise. Thus, \( \alpha_j \) 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.

This regression generates a residual \( \epsilon_i \) 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 married couples and, for each gender and each age of
marriage, we compute the average residual, $\overline{\epsilon}$, of the spouse. The result is depicted in Figure 16. For women, the same age-profile appears, though the magnitudes are 35 to 50% smaller than in Figure 15, where we do not control for demographic attributes of the spouse. For men, the wife’s average income residual is increasing through age 35; thereafter, the trend is essentially flat. This lacks the subsequent decline seen in other measures, but the likely cause is that women married at older ages are much more likely to participate in the labor force. The same is not true of men married at older ages.

B Proof of Proposition 1

Proof. First, note this change has no effect on any period $s > t$; thus, $V_s$ and $W_s(q)$ are unchanged. Also, from Eq. 3, this means $W_t(q)$ is unchanged.

To show the effect on period $t$, let

$$
\Delta_t \equiv V_t - b_t - \lambda_t \int_{R_t}^{\infty} W_t(q) \left( \gamma_t \phi(q-1) + (1 - \gamma_t) \phi(q) \right) dq
- \lambda_t \left( \gamma_t \Phi(R_t - 1) + (1 - \gamma_t) \Phi(R_t) \right) V_t - \beta (1 - \lambda_t) V_{t+1},
$$

which is a rewriting of Eq. 1 assuming the optimal $R_t$. We use implicit differentiation to show that $V_t$ and $R_t$ must increase.

First, any of the listed parameter changes yields a decrease in $\Delta_t$. This is obvious for $b_t$, since $\partial \Delta_s / \partial b_t = -1$. The derivative w.r.t. $\lambda_t$ simply yields the search participation constraint in Eq. 2 with all terms moved to the r.h.s. Thus, $\partial \Delta_s / \partial \lambda_t < 0$ whenever search would occur and is equal to 0 otherwise. For $\gamma_t$, we get:

$$
\frac{\partial \Delta_t}{\partial \gamma_t} = -\lambda_t \int_{R_t}^{\infty} W_t(q) \left( \phi(q-1) - \phi(q) \right) dq - \lambda_t \left( \Phi(R_t - 1) - \Phi(R_t) \right) V_t < 0.
$$

The inequality holds because $\Phi(R_t - 1) > \Phi(R_t)$ and $\phi(q-1)$ first-order stochastically dominates $\phi(q)$.

This decrease in $\Delta_t$ must be offset by some other increase. As noted above, $V_{t+1}$ and $W_t(q)$ are unaffected by the parameter change, and all other parameters are assumed unchanged. Thus, only $V_t$ and/or $R_t$ remain. For the former, we obtain:

$$
\frac{\partial \Delta_t}{\partial V_t} = 1 - \lambda_t \left( \gamma_t \Phi(R_t - 1) + (1 - \gamma_t) \Phi(R_t) \right) > 0.
$$
For the latter, we obtain:

\[
\frac{\partial \Delta_t}{\partial R_t} = \lambda_t \left( V_t - W_t(R_t) \right) (\gamma_t \phi(R_t - 1) + (1 - \gamma_t) \phi(R_t)) = 0.
\]

The equality holds because of Eq. 4. Hence, as \( R_t \) increases, it has no direct effect on \( \Delta_t \).

Thus we conclude that \( V_t \) must increase in response to the parameter increase to restore \( \Delta_t = 0 \). At the same time, since \( W_t(q) \) is unchanged, Eq. 4 indicates that \( V_t \) increases if and only if \( R_t \) does.

Next, consider period \( s = t - 1 \). The parameters of \( \Delta_s \) are unchanged by assumption, but \( V_t \) and \( W_s \) have each increased. Note that \( \partial \Delta_s / \partial V_t = -\beta (1 - \lambda_t) < 0 \). The value \( W_s(q) \) increases for each \( q \), which guarantees the integral will evaluate to a larger number which is then multiplied by \(-\lambda_s\), so \( \partial \Delta_s / \partial W_s < 0 \) as well. Again, the response must be that \( V_s \) increases to restore \( \Delta_s = 0 \), and \( R_s \) will increase with it (having no direct impact on \( \Delta_s \)). This paragraph applies identically to all preceding periods.

To consider the effect of changes in the divorce rate, note that \( \partial W_t(q) / \partial \delta_t = \beta \left( V_{t+1} - W_{t+1}(q) \right) \). Since \( W_{t+1}(R_{t+1}) = V_{t+1} \), this will be negative for all \( q \geq R_{t+1} \). So if \( \delta_t \) is decreased, then \( W_t(q) \) increases, which causes the integral in \( \Delta_t \) to increase. That is multiplied by \(-\lambda_t\), so \( \Delta_t \) falls, and as before, \( V_t \) and \( R_t \) must increase to offset the change.

As we consider period \( s = t - 1 \) (assuming that earlier parameters are unchanged), note that \( V_t \) has increased, as has \( W_t(q) \) for \( q \geq R_t \). If \( R_s \geq R_t \), then \( W_t \) is only evaluated for \( q \geq R_s \geq R_t \), hence we can be sure that \( W_s(q) \) will increase. The preceding analysis thus holds so that \( V_s \) and \( R_s \) will be higher. This paragraphs can be repeated so long as \( R_s' \geq R_{s'+1} \) in each successive step.

\[\square\]

\section*{C \hspace{1em} Calibration of \( \sigma \)}

As described in the text, in order to calibrate \( \sigma \), we consider variation in other factors that may influence the desirability of a potential suitor, after controlling for their direct effect on holding a college degree. In particular, we estimate the following
Table 3: Linear Probability and Probit estimation on $HasDeg$

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<th>Probit</th>
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<td>$R^2$</td>
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Notes: Sample includes singles between age 30 and 60. Negative and unreported incomes are set equal to 0. All coefficients are statistically significant, with t-stats of 15.01 or greater.

linear probability model:

$$
HasDeg_i = \beta_1 + \beta_2 NLF_i + \beta_3 Unemp_i + \beta_4 IncTot_i + \beta_5 Age_i \\
+ \beta_6 Age^2_i + \beta_7 Divorce + \beta_8 Black + \epsilon_i
$$  \hspace{1cm} (11)

Our dependent variable, $HasDeg$, is binary, indicating whether the individual has a college degree or not. Thus, the $\beta$ coefficients can be interpreted as the marginal impact of each factor on the probability that the individual will have a college degree. Our independent variables include: an indicator variable for individuals not in the labor force ($NLF$), an indicator variable for those unemployed ($Unemp$), the individual’s total income ($IncTot$), the individual’s age and age-squared, an indicator for divorced individuals ($Divorce$), and an indicator for race ($Black$). These results are reported in Table 3.

After obtaining the regression results, we then compute for each individual the predicted probability of holding a college degree, $pDeg_i$ (that is, the right-hand-side of Equation 11, without $\epsilon_i$). Consider two individuals who have no degree. The individual with a larger $pDeg_i$ must have labor and demographic variables that are correlated with better educational outcomes. Since the actual educational attainment was the same, we interpret the difference in the prediction as indicating better
intangible qualities.

Our ultimate interest is only in how these compare between college and non-college singles. Thus, we compute the mean $pDeg$ among singles with a college degree (0.34 for men and 0.41 for women); we then ask what fraction of non-college singles have a $pDeg$ that exceeds this average (7.5% for men and 7.9% for women). We also estimated $pDeg$ with a probit model; this yielded only slightly higher fractions of non-college singles who are better than the average college single (7.9% for men and 8.4% for women), which raises $\sigma$ by 0.015.

In sum, this procedure determines the correlation of these other factors with education and in the process, creates a single index of total quality. After controlling for realized education, we use the variation in this index to find a reasonable estimate for $\sigma$. 
References


