Cohort Size and the Marriage Market: What Explains the Negative Relationship?

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Cohort Size and the Marriage Market: What Explains the Negative Relationship?[*][†]

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Abstract

Bronson and Mazzocco (2017) document a strong and negative relationship between changes in cohort size and changes in marriage rates for both women and men. This empirical pattern is puzzling if interpreted using insights derived from the previous literature and a two-sided matching model à la Becker, which predicts that an increase in cohort size should reduce the marriage rate of women, but increase the marriage rate of men. In this paper, we investigate the mechanisms behind the negative relationship using a standard dynamic search model of the marriage market. We first show that the model we consider is rejected by the data for the same reason the Becker-style matching model is rejected: it predicts that a rise in cohort size should reduce the marriage rate of women, but increase the marriage rate of men. We then develop two variations of the search model and show that they are both able to generate the observed relationship between cohort size and marriage rates. Lastly, we derive a testable implication for the two models based on the relationship between cohort size and divorce rates and provide evidence that only one model is not rejected by the data.

1 Introduction

Since the early 1970s, both economists and sociologists have analyzed the effect of demographic changes, such as population growth and migration, on marriage decisions.[1] The

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[1]Prominent examples include Akers (1967), Becker (1973), Schoen (1983), Bergstrom and Lam (1989) and, more recently, Angrist (2002), Seitz (2009), Abramitzky, Delavande, and Vasconcelos (2011), and Knowles

insight that follows from this long-standing literature is simple. Whenever the number of men in the marriage market declines relative to the number of women, men's marriage rates should increase and women's marriage rates should decrease. When the relative number of women declines, the opposite should be true. This relationship is commonly rationalized using a matching model of the type proposed in Becker (1973)'s seminal work.

Changes in cohort size – the number of individuals from a given birth cohort – represent one of the most important sources of variation in the supply of women relative to men. Such changes may be generated, for instance, by baby booms or busts. To illustrate why changes in cohort size affect the sex composition in the marriage market, note that women marry mostly men of the same age or older men. Moreover, women and men have similar cohort sizes at birth. Thus, when the size of consecutive cohorts increases, older men become a scarce resource, leading to an increase in the share of women relative to men in the marriage market. This relationship between cohort size and the supply of men and women, combined with the insight developed in the previous literature, imply that a rise in cohort size should produce a decline in the marriage rate of women and an increase in the marriage rate of men. This result was derived formally by demographers in the 1960s and 1970s (e.g., Akers (1967), Schoen (1983)).

Bronson and Mazzocco (2017) document that in the U.S. data there is a systematic, negative relationship between changes in cohort size and changes in marriage rates for women, which is consistent with the idea made popular by the literature that studies the marriage market. But, contrary to the insight provided by this literature and the predictions of Becker's matching model, they also document the same systematic, negative relationship for men. This puzzling result has been overlooked in previous papers, which have focused primarily on women.

In this paper, we investigate theoretically and empirically the potential mechanisms behind the negative relationship between changes in cohort size and changes in marriage rates. We start by developing a dynamic search model of the marriage market. We rely on a search model instead of the standard matching model (Becker (1973)) because, as mentioned above, one of the predictions of that model is rejected by the data. In addition, the search model enables us to account for the dynamic nature of the marriage market which, we will document, is an essential part of the mechanism behind the empirical results reported in Bronson and Mazzocco (2017). Using the search model, we can account for the fact that

and Vandenbroucke (2016).

some individuals marry when young, while others marry when they are older. We can also account for the observation that age differentials between spouses adjust in response to changes in cohort size (Bergstrom and Lam (1989)).

Using the model, we derive three main results. First, we show that a simple dynamic search model of the marriage market is rejected for the same reason that a Becker-style matching model is rejected: in the search model an increase in cohort size always increases the marriage rate of men. This result has an important implication. Becker's matching model and the standard search model we develop have one common feature: changes in cohort size affect marriage rates exclusively through the number of women in the marriage market relative to the number of men and the corresponding probability of meeting a spouse. The rejection of these two models implies that changes in cohort size affect the marriage market in ways that go beyond their effect on the matching probability.

Using this insight, we develop two variations of the search model and show as a second result that they are both able to generate the negative relationship between changes in cohort size and changes in marriage rates for both women and men. In the first version, a man can undertake a pre-marital investment that increases his probability of meeting a potential spouse and, if they marry, their marital surplus. In this alternative formulation, men are more likely to invest when cohort size is decreasing because, in this case, the probability of meeting a potential spouse is generally below the optimal level for a larger fraction of them. In the second version, the model is modified to allow the value of being single to increase with cohort size. The economic idea behind this feature of the model is that it is more enjoyable to be single when cohort size is large because there are more individuals of the same age with whom to perform leisure activities.

The two versions of the search model have one common attribute. In both of them, an increase in cohort size has an additional negative effect on the marriage rate of women and men. We show that, if this additional effect is sufficiently strong, the search model can generate the observed pattern that a rise in cohort size generates a decline in the marriage rate of men. But, interestingly, the two alternative models generate this additional effect in different ways. The first version does this by increasing the marital suplus when cohort size declines, whereas the second version achieves this by increasing the value of being single when cohort size rises. This difference generates a testable implication based on the relationship between cohort size and divorce rates. The first version of the search model predicts that an increase in cohort size should generate an increase in divorce rates. The second version has the opposite prediction and generates a negative relationship between those two variables. We use this implication to test one model against the other and derive our final result. We document that, in the data, there is a strong and positive relationship between cohort size and divorce rates. We can therefore reject the model in which the value of being single increases with cohort size in favor of the investment model. This result suggests that the negative relationship between cohort size and marriage rates can be explained by changes in cohort size that simultaneously affect the relative supply of women in the marriage market and the marital surplus.

Our results have three main implications. First, in the past three decades, politicians and policy makers have proposed and implemented policies designed to raise the share of married households with the objective of reducing the fraction of family below the poverty line. Some examples of such policies are "First Things First" in Tennessee, "Healthy Marriages Grand Rapids," and the federal Temporary Assistance to Needy Families (TANF) program. Bronson and Mazzocco (2017) find that, in the medium and long run, marriage rates are determined mostly by changes in demographic variables, which are difficult to control. The marriage policies considered in the U.S. are therefore likely to produce limited results, unless they attempt to increase the pre-marital investments of young individuals.

Second, most of the literature that studies the marriage market has relied on matching models to understand changes in marriage rates. One of the first papers to analyze marriage decisions is Becker (1973)'s seminal work, in which he proposes the classical two-sided matching model. Several papers have extended, tested, and estimated that model. Angrist (2002), Choo and Siow (2006), Iyigun and Walsh (2007), Chiappori, Iyigun, and Weiss (2009), Seitz (2009), Hitsch (2010), Abramitzky, Delavande, and Vasconcelos (2011), and Cherchye et al. (2016) are examples of papers in this literature. Fewer papers have used search models to analyze the marriage market (Brien, Lillard, and Stern (2006) and Mortensen (1988) are two examples). The results presented here indicate that the standard version of the matching and search models cannot explain the relationship between cohort size and marriage rates. An additional feature must be added that increases the probability of marriage for men when cohort size declines.

Lastly, our results provide a possible explanation for an inconsistency in the literature that analyzes the relationship between sex ratios and marriage rates. Angrist (2002) and Bronson and Mazzocco (2017) find that an increase in the sex ratio – the number of women divided by the number of men in a marriage market – reduces the marriage rate of both women and men. But there is one paper, Abramitzky, Delavande, and Vasconcelos (2011), that finds that the increase reduces the marriage rate of women, but raises the marriage rate of men. Our findings indicate that the effect of changes in the sex ratio may depend on whether individuals have the incentives to undertake pre-marital investments. In the contexts studied by Angrist (2002) and Bronson and Mazzocco (2017), men exceeded women in the marriage market and, hence, had the incentives to undertake the investment, thus producing the negative relationship between changes in sex ratios and marriage rates. However, in European countries after World War II, the context analyzed by Abramitzky, Delavande, and Vasconcelos (2011), men were outnumbered by women and had no incentive to invest. The relationship between sex ratios and marriage rates was therefore positive for men.[2]

The paper proceeds as follows. In Section 2, we develop the dynamic search model. Section 3 introduces the two augmented dynamic search models. Section 4, tests the two models. Section 5 concludes.

2 A Dynamic Search Model of the Marriage Market

In this section, we develop a simple version of a dynamic search model of the marriage market that has the potential to generate the negative relationship between changes in cohort size and changes in marriage rates. This relationship is documented in Figure 1, which is the starting point of the paper by Bronson and Mazzocco (2017). The figure plots cohort size and the share never married or cohabiting by age 30 in the U.S., separately for women and men, for all cohorts born between 1914 and 1981.[3] Panels A and B describe these variables for the white and black populations, respectively. We plot the share *never* married or cohabiting because visually it is easier to detect a positive correlation between the two variables. Figure 1 documents a clear positive relationship between cohort size and the share never married or, equivalently, a negative relationship between cohort size and the share married by age 30. Similar patterns are observed in Figure 2, where we increase the age cutoff for marriage from 30 to 40. In Bronson and Mazzocco (2017), we document that a systematic relationship between changes in cohort size and marriage rates is observed not

[2] As we note later, allowing women to invest when they outnumber men would further strengthen the positive relationship between the sex ratio and men's marriage rates that Abramitzky, Delavande, and Vasconcelos (2011) find.

[3] As discussed in Bronson and Mazzocco (2017), in recent decades cohabitation has become a popular form of household formation and a close substitute for marriage. For this reason, we also consider cohabiting households in the analysis.

only over time, but also across states using cross-sectional variation.[4]

To evaluate whether a standard dynamic search model can explain the pattern displayed in Figure 1, we consider an economy populated by $T+1$ overlapping generations of men and women. In each period t a new generation, or cohort, is born and lives for $T+1$ periods. $N_{0,t}^{w}$ and $N_{0,t}^{m}$ denote the size of the new generation of women and men born in period t. We assume that women and men have the same cohort size $N_{0,t}$, which is a good approximation for the white population. In the Appendix we consider the more general case in which $N_{0,t}^{w} \neq N_{0,t}^{m}$. Men and women can be either single or married. The within-period utility of being single is denoted by δ, whereas the within-period utility of being married for the couple as a whole is denoted by η. The value of being single is constant across individuals and over time. The value of being married is drawn from a distribution $F(\eta)$, which does not vary across couples or over time. We will use interchangeably the terms within-period utility of being married and match quality to describe η.

If in period t an individual of gender i and age a is single, she or he meets a potential spouse with probability $\theta_{a,t}^{i}$. The two individuals then decide whether to marry with the objective of maximizing their lifetime utility. Once married, they make no further decision. If two potential partners decide to marry, the within-period utility they have drawn is also the utility they will experience in each period for the rest of their life or until they divorce. Divorce can occur in each period with a probability q which is independent of the within-period utility, time, and age. In the next subsection, we discuss the consequences of allowing the probability of divorce to depend on the quality of the marriage. A couple can freely divide the gains from marriage using a Nash-bargaining solution, with the parameter $\gamma \in [0,1]$ determining how the marriage surplus is divided. Future utilities are discounted at the discount factor $\beta \leq 1$.

We can now introduce the main assumption of the model. We assume that single women meet a potential spouse with a positive probability only in the first period of their life, while single men meet a possible partner with a positive probability in the first two periods of their life. Two observations form the basis for this assumption. First, women's fertile lifespan is shorter than men's period of fertility. Second, an important benefit of marriage is that it is an effective arrangement for having and raising children. These two observations imply that the value of getting married for a woman declines faster with age than the value for a

[4] Bergstrom and Lam (1989) study the effect of changes in cohort size on sex ratios and marriage behaviors of both men and women. That paper cannot explain the negative relationship between changes in cohort size and changes in marriage rates for both genders because, while it allows for age differences between spouses to vary with cohort size, it assumes that the marriage rates do not respond to changes in cohort size.

man. Our assumption that this value is zero for a woman in the second period of her adult life is a special case of this general idea.[5]

Our main assumption has two implications. First, the marriage market is populated by younger women (age 0) and younger and older men (age 0 and 1). Second, women cannot marry after the first period and men cannot marry after the second period. Allowing women to marry for more than one period with a declining value of marriage and men to marry for more than two periods makes the model more complicated without changing the qualitative nature of the results.

The solution of search models is generally provided in terms of reservation values. In our model, the relevant reservation value is the match quality η at which a pair of potential spouses is indifferent between marrying or staying single. In our context, two types of couples can form: couples in which the woman is younger than the man; and couples in which the woman and the man are both of age 0. Our model is therefore characterized by two reservation utilities.

In Appendix A.1, we show that a couple with an older man has the following reservation match quality:

$$\underline{\eta}_{1,t} = 2\delta.$$

The intuition behind this result is straightforward. Since this is the last potential spouse they meet, a woman of age 0 and a man of age 1 choose to marry if they draw a match quality η greater than the sum of their values of staying single, 2δ. The reservation value of a couple in which the woman and man are both of age 0 is slightly more complicated to derive because a man of age 0 has the option value of waiting until next period and drawing a new potential spouse. In Appendix A.1, we show that the existence of this option value generates a reservation utility for this type of couple of the following form:

$$\underline{\eta}_{0,t} = 2\delta + B\theta^m_{1,t+1}, \tag{1}$$

where $\theta^m_{1,t+1}$ is the probability that a man meets a woman when older, and B is a positive constant that depends only on the parameters of the model. The option value is included in the term $B\theta^m_{1,t+1}$, which measures the probability that a younger man will meet a woman when older multiplied by the share of the expected marital surplus he will receive times the probability he will choose to marry her. Thus, the reservation value for this type of couple

[5] This is not the first paper to use the differential fertility between women and men to develop a model of the marriage market. For instance, Siow (1998) uses a similar idea.

increases with the probability that a man meets a woman when he is older.

We will now use the derived reservation utilities to solve for the steady state equilibrium in the marriage market. We will then evaluate how a change in cohort size from its steady state level impacts marriage rates. To solve for the steady state equilibrium, we have to derive the probability that a younger man meets a woman $\theta_{0,t}^{m}$ and the corresponding probability for an older man $\theta_{1,t}^{m}$. Let $N_{a,t}^{i}$ be the number of individuals of gender i, age a, in period t who are present in the marriage market. Then, under our assumption that men and women have identical cohort size, $\theta_{0,t}^{m}$ and $\theta_{1,t}^{m}$ can be derived by noting that

$$\theta_{0,t}^{m} = \theta_{1,t}^{m} = \frac{N_{0,t}^{w}}{N_{0,t}^{m} + N_{1,t}^{m}} = \frac{N_{0,t}}{N_{0,t} + N_{1,t}^{m}}. \tag{2}$$

The probability $\theta_{0,t}^{m}$ is the correct measure in our model of the sex-ratio, defined as the number of women divided by the number of men in the marriage market. Equation (2) shows that an increase in cohort size $N_{0,t}$ increases the relative supply of women in the marriage market, as argued earlier in the paper.

The number of individuals of age 0 is exogenously given by the cohort size of a generation. However, the number of older men in the marriage market $N_{1,t}^{m}$ is endogenously determined by their decisions in the previous period as younger men. We therefore have to solve for $N_{1,t}^{m}$ to derive $\theta_{0,t}^{m}$ and $\theta_{1,t}^{m}$. The variable $N_{1,t}^{m}$ can be computed as the number of younger men who did not meet a woman at $t-1$ plus the number of younger men who met a woman at $t-1$ but drew a match quality η lower than the reservation value, i.e.

$$N_{1,t}^{m} = N_{0,t-1}\left(1 - \theta_{0,t-1}^{m}\right) + N_{0,t-1}\theta_{0,t-1}^{m}F\left(\underline{\eta}_{0,t-1}\right). \tag{3}$$

In Appendix A.2 we show that, in steady state, equation (3) simplifies to

$$N_{1}^{m} = N_{0}F\left(\underline{\eta}_{0}\right)^{\frac{1}{2}}.$$

Substituting for N_{1}^{m} in the equation defining the meeting probabilities θ_{a}^{m}, we obtain

$$\theta_{0}^{m} = \theta_{1}^{m} = \frac{N_{0}}{N_{0} + N_{0}F\left(\underline{\eta}_{0}\right)^{\frac{1}{2}}} = \frac{1}{1 + F\left(\underline{\eta}_{0}\right)^{\frac{1}{2}}}.$$

To determine the reservation value of younger men in steady state, we can substitute for θ_1^m in equation (1) and obtain

$$\underline{\eta}_{ss} = 2\delta + B \frac{1}{1 + F\left(\underline{\eta}_{ss}\right)^{\frac{1}{2}}}.$$

Note that $F(\underline{\eta})$ is monotonically increasing in $\underline{\eta}$. As a consequence, there is a unique solution for $\underline{\eta}_{ss}$ and hence a unique steady state equilibrium. Moreover, in the steady state equilibrium the reservation value is independent of cohort size N_0. The following Proposition summarizes the result.

Proposition 1 *In steady state, there is a unique reservation value for marriage $\underline{\eta}_{ss}$ and hence a unique equilibrium. Moreover, the reservation utility does not depend on cohort size.*

Now that we have characterized the steady state equilibrium we can study the effect of a change in cohort size first on the marriage rate of women and then on the marriage rate of men. We will focus on the case in which the shock to cohort size is unexpected and permanent. Similar results apply if the permanent shock is known with certainty. We consider the case of a permanent shock because in the data changes in cohort size tend to be persistent and even reinforcing.

Suppose the steady state economy is hit by a shock in period $t = \tau$ that changes permanently the cohort size from N_0 to $N_0 + \Delta$. This change affects the marriage rates by changing the probability that an individual meets a potential spouse and, hence, the reservation value of younger men. The following Proposition establishes that an increase in cohort size raises the reservation utility of younger men.

Proposition 2 *A positive and permanent shock to cohort size in period τ increases the reservation value $\underline{\eta}_{0,\tau}$. A negative shock has the opposite effect.*

Proof. See Appendix A.3. ∎

The intuition behind this result is straightforward. With a permanent increase in cohort size, men are more likely to meet a woman when older. Thus, the option value of waiting until next period for younger men goes up and with it their reservation match quality.

Using Proposition 2 we can now study the effect of a shock to cohort size on the marriage rate of women and men. The following Proposition determines the effect for women.

Proposition 3 *A positive and permanent shock to cohort size in period τ reduces the fraction of cohort τ women who get married. A negative shock in period τ has the opposite effect.*

Proof. See Appendix A.4. ■

To provide the insight behind this result, consider an increase in cohort size. This change has two effects. First, older men become a scarce resource. As a consequence, the fraction of women who marry mechanically declines because they are now less likely to meet older men, who have lower reservation utilities. Second, younger men become more selective because they will have a larger group of women to choose from when they are older. Thus, the second effect also generates a decrease in the fraction of women who marry. The total impact of an increase in cohort size is therefore a reduction in the fraction of women who marry. This result indicates that the search model developed here can explain the negative relationship observed in the data for women between cohort size and marriage rates.

The following Proposition establishes that in the search model there is a positive relationship between changes in cohort size and changes in marriage rates for men.

Proposition 4 *A positive and permanent shock to cohort size in period τ increases the fraction of cohort τ men who get married. A negative shock in period τ has the opposite effect.*

Proof. See Appendix A.5. ■

Proposition 4 contains a negative result. Since our dynamic search model generates a positive relationship for men between changes in our two main variables, it is rejected by the data. We want to point out, however, that without a formal proof this result is not obvious. To understand why, observe that an increase in cohort size has two different effects on men. First, the probability that younger and older men in a cohort meet a woman increases. Second, younger men become more selective because they will have more women to choose from when they are older. The first effect goes against our empirical findings since it implies an increase in the marriage rate of men when cohort size increases. But the second effect is in our favor and generates a decline in the marriage rate of men. Proposition 4 establishes that the first effect always dominates, therefore rejecting our search model.

The U.S. data are in conflict with the search model developed in this section. There are, however, two modified versions that can generate the two main patterns observed in the data. The next subsection develops them, derives a testable implication based on the relationship between cohort size and divorce rates, and provides evidence that only one of the two versions is consistent with that implication.

3 Two Augmented Dynamic Search Models of the Marriage Market

An important feature of the search model considered in the previous subsection is that changes in cohort size affect marriage decisions only through the probability of meeting a potential spouse. Its rejection indicates that in the data changes in cohort size affect household formation in ways that go beyond their impact on meeting probabilities.

Here we consider two approaches that can reconcile the search model with the empirical patterns documented in Bronson and Mazzocco (2017). The first approach allows men to undertake a costly investment that increases the probability of meeting a woman and the surplus generated by their future marriage. The economic insight underlying this enriched search model is that men can choose higher-paid jobs with fewer amenities or to work longer hours to increase the probability of meeting a potential spouse and their marital surplus (Peters and Siow (2002), Iyigun and Walsh (2007), and Chiappori, Iyigun, and Weiss (2009)). In the model, they are more likely to make these choices when cohort size decreases, since in this case the probability of meeting a woman is generally low. We will denote this model with the term investment-model. The alternative way of reconciling the search model with the data is to introduce a positive correlation between the value of being single δ and cohort size. The economic idea behind the positive correlation is straightforward: when cohort size increases it is more enjoyable to be single because there are more people of the same age with whom to perform different types of leisure activities. We will refer to this model as the δ-model.

In both models, changes in cohort size generate an additional negative effect on marriage rates. The additional effect strengthens the negative relationship between cohort size and marriage rates generated by the standard search model for women. It also introduces a new negative effect for men which, if strong enough, can outweigh the effects that in the standard search model produce the positive relationship between cohort size and marriage rates of men. The last consideration implies that the two models can generate the observed patterns only for some parameter choices. If the additional negative effect is not strong enough, the two models will produce the same positive relationship between cohort size and marriage rates of men that characterizes the standard search model. It is therefore not productive to search for a general proof showing that our models can produce the observed patterns for men. Instead, we will calibrate the models and evaluate whether they can match our empirical findings for a realistic set of parameters.

Before presenting the models in details, it is important to point out that they generate the additional negative effect in different ways. The investment-model achieves this by increasing the value of marriage when cohort size is low, whereas the δ-model does this by increasing the value of the outside option when cohort size is high. As a result, if the probability of divorce declines with the match quality of the marriage, our two models generate relationships between cohort size and divorce rates of opposite sign. The investment-model predicts a positive relationship between cohort size and divorce rates. When cohort size decreases, men invest more and, by doing so, they increase the match quality of their marriage. The probability of divorce will therefore decline, generating a positive relationship between cohort size and divorce rates. The δ-model has the opposite prediction. When cohort size declines, the value of being single becomes lower. As a consequence, the average match quality of formed marriages drops, which increases the probability that a marriage will end in divorce.

We will use this result to test the δ-model against the investment-model. To implement this test, we need to slightly modify the way divorce is modeled and allow its probability to depend on match quality. This change should have no effect on the rejection of the simple search model based on Proposition 4. When the probability of divorce declines with the value of marriage, younger men become more selective because the value of marrying a woman with higher match quality increases. However, this increase in reservation utilities of younger men will be similar for all cohort sizes, implying that the marriage rate of men will still rise with cohort size. We will use simulations to document that this is the case at the calibrated parameters.

We will now describe how we modify the original search model to obtain the two enriched models. In the δ-model, we simply allow the value of being single to depend on cohort size according to a function that will be specified in the next subsection. In the investment-model, men can make a decision when young to undertake an investment that increases their attractiveness in the marriage market. If they choose to invest, they pay a cost c_i, which is individual-specific. The pre-marital investment has two effects. First, it has a pay-off upon marriage, increasing the level of match quality by a positive constant K. Specifically, if a man and his potential spouse draw a match quality $\eta^{'}$, in case of investment they enjoy a within-period value of marriage $\eta = \eta^{'} + K$. The idea behind this modeling choice is that men who invest have higher income and wealth and can therefore sustain higher degrees of intra-household specialization and afford to buy more public goods if married. Second, if a young man invests, he meets a woman with probability θ_h, whereas men who do not invest meet a woman with probability θ_l, with $\theta_h > \theta_l$ in all periods. The economic insight for this feature of the model is that it is easier for men who have made the pre-marital investment to draw the attention of women.

In this version of the model, whenever cohort size increases and the probability of meeting a woman is high, men have fewer incentives to invest and investment rates are low. Since foregoing a pre-marital investment makes marriage between two potential partners less likely, the share of men who marry decreases. If sufficiently strong, this effect generates a negative relationship between changes in cohort size and marriage rates of men.

We model the investment as having two benefits instead of just one for two reasons. First, this modeling choice makes our framework logically consistent: a pre-marital investment that increases marital surplus should also be valued in the marriage market and attract more potential partners. Second, both benefits are necessary to generate the negative relationship between changes in cohort size and changes in marriage rates for men. If the investment affects only match quality but not the meeting probabilities, men would be more, rather than less, likely to invest when cohort size increases. Indeed, in those periods they would have a higher probability of meeting a woman and, hence, a higher probability of realizing a return on their pre-marital investment. This would generate a positive rather than a negative relationship between changes in cohort size and marriage rates. Alternatively, if the investment affects the meeting probabilities but not match quality, its only effect is to switch women from men who do not invest to men who invest without changing the marriage rate.

Finally, we note that it would be straightforward to add investment to the model also for women. However, since in our model the marriage market is composed of women of age 0 and men of age 0 and 1, there are always more men than women searching for a spouse. Thus, women always meet a man with probability one and, hence, their incentives to undertake a pre-marital investment would not change with cohort size.

4 Testing the Investment-Model Against the δ-model

To evaluate which of the two models is better able to explain the data, we have to make functional form assumptions and calibrate the corresponding parameters. Starting with the investment-model, we assume that the individual cost of investing c_i takes the following functional form:

$$c_i = \mu_0 + \mu_1(1 + x_i)^{\mu_2},$$

where x_i is a random variable drawn from a uniform distribution defined on the interval $[0, 1]$, which captures the heterogeneity across individuals in the cost of undertaking the investment. The cost parameters μ_0, μ_1, and μ_2 influence the distribution across cohorts of the share of men who invest. While we cannot observe such a measure directly, we use as a proxy the share of men in a cohort either working full-time and full-year or investing in an education at age 20, and calibrate the cost parameters by matching its distribution over cohorts. For this purpose, we use the U.S. Census and ACS data from 1940 to 2010. The power coefficient μ_2 is necessary to match how the share of men who invest changes with cohort size. Without this parameter, or if this parameters is too low, the model generates overly large swings in investment due to the following amplification effect. When cohort size declines and the probability of meeting a woman falls, more men choose to invest. The investment further lowers the probability of meeting a woman for the remaining men who did not invest, increasing their incentives to undertake the investment.

To calibrate the investment parameter K, we rely on the observation that K affects the share of younger men who choose to marry since, for a larger K, by not marrying they forgo a larger marital surplus in the current period. Using this idea, we calibrate K by matching the share of men in a cohort who marry when young, which we assume to be by age 30. We construct these moments using the CPS (1962-2015) and the U.S. Census (1960-1970), which has a recall variable for age at first marriage for the earliest cohorts that we study. Lastly, we assume that the probability of meeting a women in case of investment, θ_h, is equal to a constant, while θ_l is endogenous and equal to the number of younger women who did not meet a man who invested divided by the number of men who chose not to invest. In the data we do not observe the probability of meeting a woman for a man who invests. But we know that, to match the marriage patterns in the data, θ_h must be sufficiently high so that it is always larger than θ_l. If not, men would choose either not to invest or to invest in periods when cohort size is increasing and the probability of meeting a woman is high. To satisfy this restriction, we have experimented with values of θ_h that are between 0.7 and 1, obtaining similar results. The simulations presented in this paper have been generated using θ_h equal to 0.85.

To calibrate the δ-model we only have to specify the increasing function that relates the value of being single to cohort size. We assume that the function takes the following form:

$$\delta_t = \alpha_0 + \alpha_1 N_{0,t}.$$

The linear functional form has been chosen for simplicity. We have also experimented with alternative functional forms that are increasing in cohort size with similar results. The parameters α_0 and α_1 affect the share of individuals who choose to stay single. All else equal, a higher value of α_0 increases the share of people who choose to remain single independently of cohort size, whereas a higher value of α_1 raises the share of never married individuals proportionally more in larger cohorts. Using this idea, we calibrate these parameters by matching the minimum and the average share never married in the data, computed over the cohorts observed in our sample period. As before, we generate these moments using the CPS (1962-2015) and, for the earliest cohorts, the age-at-first-marriage variable available in the U.S. Census (1960-1970).

In both versions of the search model, we set the parameter γ governing how the marital surplus is allocated to 0.5, and assume that the distribution of match quality $F(\eta)$ is uniform in the interval $[0, 1]$. Finally, in both models, we allow the probability of divorce q to decline with match quality η using the following linear functional form:

$$q(\eta) = \rho_0 + \rho_1 \eta,$$

where $\rho_1 \leq 0$. The parameter ρ_0 affects the share of households who choose to divorce independently of match quality. The parameter ρ_1 influences how the share of divorces changes with match quality. In the simulations, we restrict ρ_0 and ρ_1 so that $0 \leq q(\eta) \leq 1$ for all values of η, and calibrate the two parameters by matching the minimum and the average share of individuals ever divorced, computed over the cohorts observed in our sample period. To construct these data moments, we need to observe current divorce status, as well as the number of previous marriages for all currently married individuals. The latter variable is available in the American Community Survey (ACS) for the years 2008-2013. In those years, we construct the share ever divorced for all individuals between the ages of 50 and 75, i.e. individuals who are sufficiently old to have had a chance to experience a divorce. This corresponds to cohorts born between 1933 and 1963.

Figure 3 documents the performance of the two versions of the search model by plotting cohort size and the share *never* married. Analogously to the original search model, the investment-model and δ-model replicate the negative relationship between changes in cohort size and changes in marriage rates of women. But, unlike the basic search model, the two new versions can match the negative relationship for men observed in the data. They are therefore both consistent with the empirical findings reported in Bronson and Mazzocco

(2017). In Figure 4, we document that the original search model produces a positive relationship between our two main variables for men even when the probability of divorce is a decreasing function of match quality.

Since both proposed models can match well our empirical results, we now use the testable implication based on the relationship between cohort size and divorce rates to evaluate which framework is a better characterization of the data. At the beginning of this subsection we argued that the investment-model predicts a positive relationship between cohort size and divorce rates, whereas the δ-model predicts a negative relationship. Figure 5, Panel A, reports the share of individuals in the data ever divorced for cohorts born between 1933 and 1963, the cohorts for which we have divorce data. There is a strong and positive relationship between cohort size and the share ever divorced, for both women and men. Individuals born between 1933 and the first half of the fifties experienced increasing cohort size and rising divorce rates, whereas people born in the second half of the fifties and the first half of the sixties are characterized by declining cohort size and falling divorce rates. The evidence provided in Figure 5 and the previous discussion imply that the δ-model is rejected in favor of the investment-model. Panels B and C, which report the simulated share ever divorced for the investment-model and δ-model, confirm this conclusion. The investment-model is the only framework able to generate the positive relationship between cohort size and share ever divorced. In that model, the share of women and men ever divorced peaks a bit early relative to the data, but otherwise matches well the observed patterns.

A striking feature of the data displayed in Figure 5A is that, when the time-series of cohort size starts to flatten, the share of women ever divorced crosses from below the share of men ever divorced. Interestingly, the investment-model generates the same type of crossing. To see why, recall that, all else equal, the marriages with the lowest probability of divorce in the model are those in which the man has made an investment. In the first half of the thirties, the fraction of men who invested dropped as cohort sizes began to increase, after having declined for over a decade. Correspondingly, both men's and women's divorce rates started to increase. However, women's divorce rates remained lower than men's, since a significant share of these women were married to older men, who came from smaller cohorts and had higher rates of investment. Over time, the share of women in such marriages dropped steadily. Accordingly, in Figure 5, Panel B, the difference between the probability of divorce of women and men gradually shrinks until the two variables become approximately equal for cohorts born around 1950. Cohorts born after 1950 display the opposite pattern.

Men began investing again at increasing rates as they experienced first a flattening in cohort size growth and then a significant drop. Correspondingly, divorce rates of men began to fall. Women's divorce rates did not begin to fall until later, since many of the women in these cohorts married older men from larger cohorts who had lower rates of investment. As a consequence, the share of women ever divorced stays above the share of men for the rest of the sample period.

Divorce rates start to fall earlier in our simulations than in the data. One possible explanation for the difference is that divorce laws changed significantly in the 1970s, when cohorts born in the 1950s were entering the marriage market. Since the model abstracts from this aspect of the data, it is to be expected that our simulations generate lower divorce rates for cohorts born after 1950. Nevertheless, it is remarkable that the model matches the general patterns in divorce rates using only cohort size, without incorporating the legal changes to the marriage contract taking place during our sample period.

We end by providing two additional pieces of evidence in support of the explanation developed in this section. First, using Census and ACS data from 1940 to 2010, we document the evolution of a measure of the fraction of younger men who invest: the share of men either in college or working full-time, full-year at age 20. We use this measure because it represents a proxy of the fraction of younger men who are committed to accumulating financial resources and/or human capital. This measure is plotted in Figure 6 together with the fraction of younger men who invest generated by our model. Marriage considerations are only one of several factors that explain labor supply and education decisions. Nevertheless, the model can match reasonably well the variation observed in the data, including the increase in the share investing for cohorts born at the beginning of the century, the decline for the cohort born in 1950, the rise for cohorts born in 1960 and 1970, followed by a flattening and decline for cohorts born in the last part of our sample. Only for the 1940 cohort does our model make the incorrect prediction that the share investing declined. As mentioned above, it is to be expected that the model cannot explain all the variation in the measure of investment given the complexity of the data and the simplicity of the model.

The second piece of evidence in support of the explanation proposed in this section concerns the relationship between cohort size and age differences between spouses. An implication of our search model is that the relationship should be negative.[6] Since an increase in cohort size makes older men a scare resource, women marry on average younger

[6] A similar result holds in a matching model as shown in Bergstrom and Lam (1989).

men when cohort size rises. As a result, the average age difference between spouses should decline with an increase in cohort size. To test this prediction, in Figure 7 we report the evolution of the average age difference between spouses in the data and in the investment model, and the evolution of cohort size. With the exception of the first twelve cohorts, Figure 7 indicates that there is a tight negative relationship between age difference and cohort size in the data and that our model can replicate well that pattern. When the size of a given cohort increases, the age difference between women in that cohort and their spouses becomes less negative and therefore declines in both the data and simulations. When cohort size drops, the age difference becomes more negative and therefore increases.

The results presented in this section also help explain why some researchers have found that marriage rates of men decline when the relative supply of women drops (Abramitzky, Delavande, and Vasconcelos (2011)), whereas others (Angrist (2002) and Bronson and Mazzocco (2017)) provide evidence that marriage rates of men increase. According to our findings, a decline in relative supply of women will generate an increase in marriage rates of men if they have the incentive to undertake an investment that boosts their attractiveness. This is generally the case in a marriage market in which there are more men than women: men will undertake the investment to draw the attention of the limited number of women. Since the fertility stage is shorter for women than for men and one of the main reasons for marriage is to have and raise children, in the U.S. marriage market analyzed by Bronson and Mazzocco (2017) men outnumber women in most years. Similarly, in the marriage market studied by Angrist (2002), for ethnicities with high immigration rates, men generally exceed the number of available women. In those instances, men have the right incentives to invest and one should expect a rising marriage rate for men when the relative supply of women drops, which is the finding in those two papers. By contrast, Abramitzky, Delavande, and Vasconcelos (2011) consider marriage markets in France after World War I where, due to the high mortality rate of men, in most regions women exceeded men (in some areas the sex ratio was as low as 864 men per 1,000 women). In that context, men have limited incentives to invest to attract women and their marriage rate should follow the pattern predicted by the standard matching model: it should decline with a reduction in the relative supply of women as observed in Abramitzky, Delavande, and Vasconcelos (2011). Allowing women to invest when they exceed the number of men would only make the positive relationship between the sex ratio and men's marriage rates stronger.[7]

[7] In our paper, we focus on investment by men because, as mentioned above, we consider marriage markets in the U.S. where men generally outnumber women. Pre-marital investment by women is an aspect that

To summarize, the findings of this section indicate that a simple dynamic search model with investment can generate the marriage and divorce patterns observed in the data. This is not an easy task, since some of the patterns, such as the crossing in the divorce data, are not a priori easy to explain.

In principle, it should be possible to explain the same patterns by adding investment to the standard matching model. We have used the search model instead, because it is better suited to account for how changes in cohort size affect the relative supply of women in the marriage market and, hence, marriage and divorce decisions. Our results should, therefore, not be interpreted as a rejection of the matching model in favor of the search model. They should be understood as indicating that the effects of cohort size on marriage decisions are sufficiently complicated that a standard search or matching model cannot explain them. To rationalize the data an additional mechanism must be added that increases the value of marriage when cohort size declines.

5 Conclusions

We consider possible mechanisms that can explain the negative relationship between cohort size and marriage rates observed in the data. The classic two-sided matching model used to analyze marriage behaviors (Becker (1973)) is not consistent with this pattern, since it predicts that a rise in cohort size should increase the marriage rate of men. For this reason, we propose and test a dynamic search model of the marriage market. Using this model we derive three results.

First, a standard dynamic search model is rejected by the data for the same reason the standard matching model is rejected: it predicts that a rise in cohort size should always increase the marriage rate of men. Next, we show that the two variations of the standard search model can generate the data patterns documented in Bronson and Mazzocco (2017). In the first variation, men can choose to undertake an investment that increases their probability of meeting a potential spouse and, if they marry, their marital surplus. In the second variation, the search model is modified by allowing the value of being single to be an increasing function of cohort size. As a last result, we document that the two variations of the search model imply a relationship between cohort size and divorce rates of opposite sign. Using this testable implication, we reject the second model in favor of the investment model. Interestingly, this last finding – that a model with pre-marital investment provides

should certainly be considered in markets in which women exceed men.

an excellent fit for U.S. data on marriage behaviors, including marriage rates, spousal age differences, and divorce – is in line with anthropological evidence that men invest more in economic opportunities when women are in relatively short supply (Guttentag and Secord (1983)).

Our results have have two main implications. First, the failure of standard models to fit U.S. data on marriage rates indicates that changes in cohort size affect the marriage market not only through their direct effect on matching between the sexes, but also through indirect effects that change the marriage quality.

Second, our findings have implications for policy analysis. Several policies designed to increase the marriage rate have been proposed as a way of reducing the number of family living in poverty (e.g. "First Things First" in Tennessee, "Healthy Marriages Grand Rapids," and the federal Temporary Assistance to Needy Families (TANF) program). The findings in Bronson and Mazzocco (2017) indicate that, in the medium and long run, marriage rates are determined mostly by changes in cohort size, which are difficult to control. The type of marriage policies considered by the U.S. government are therefore likely to have limited effects on the marriage market, unless they focus on increasing the pre-marital investments of young individuals, as this paper suggest.

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6 Tables and Figures

Table 1: Average Age Differences Between Spouses

Age Difference between Husband and Wife	Percent of couples, 1962-2011
Husband is more than 1 year younger	8.1%
Spouses are approximately the same age	34.4%
Husband is 2 to 4 years older	31.8%
Husband is 5 to 6 years older	10.8%
Husband is 7 to 9 years older	7.6%
Husband is 10+ years older	7.3%

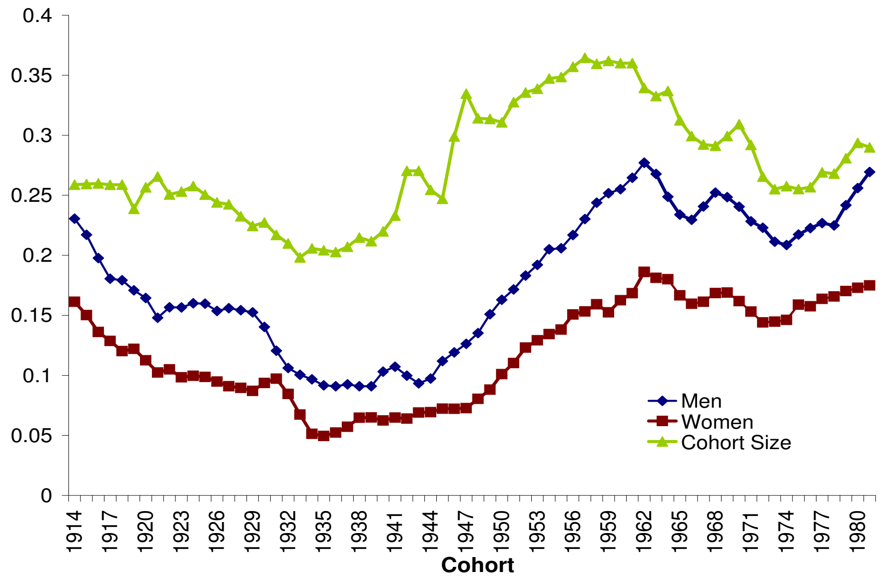
Notes: Because CPS data does not provide information about month of birth, we consider spouses to be of the same age if they are recorded to be either zero or one year apart in age in the data. Source: IPUMS CPS, 1962-2015.

Table 2: Calibrated Parameters

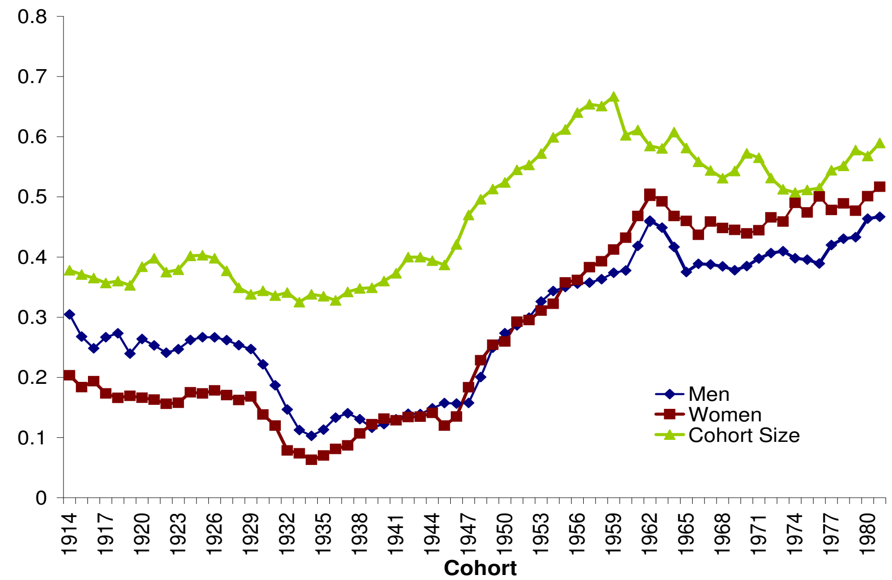
Parameter	Parameter Type	Value
Investment-Model:		
μ_0	Cost of investment	1.06
μ_1	Cost of investment	0.07
μ_2	Cost of investment	3.90
θ_h	Probability of meeting a woman	0.85
ρ_0	Probability of divorce	0.3
ρ_1	Probability of divorce	0.47
δ-Model:		
α_0	Value of being single	-0.07
α_1	Value of being single	0.50
ρ_0	Probability of divorce	-0.03
ρ_1	Probability of divorce	1.03

Figure 1: Share Never Married and Not Cohabiting By 30

(a) White



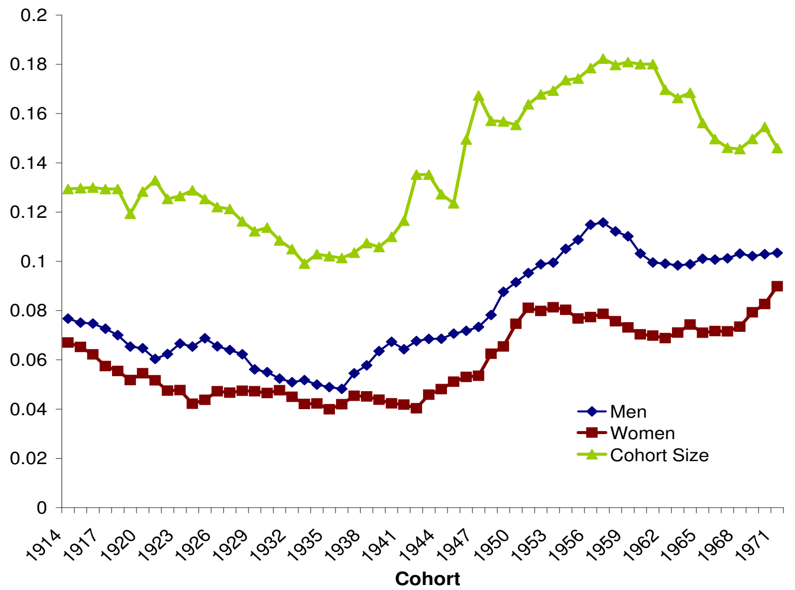
(b) Black



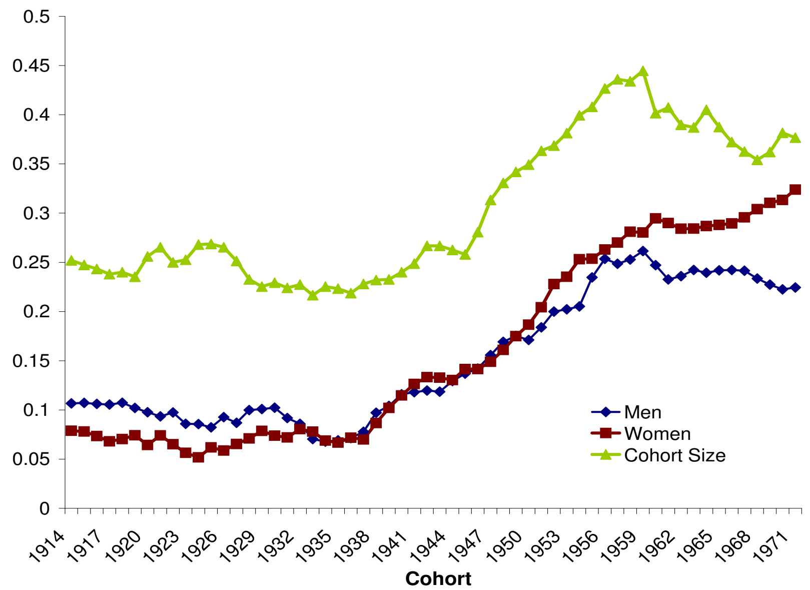
Notes: The vertical axis represents both the percentage of individuals ever married as well as normalized cohort size. In Panel A we normalize cohort size by dividing by 10,000,000; in Panel B by 1,000,000. For share ever married, we graph three-year moving averages. Sources: Vital Statistics of the United States; IPUMS CPS, 1962-2011; IPUMS USA, 1960-1970.

Figure 2: Share Never Married and Not Cohabiting By 40

(a) White



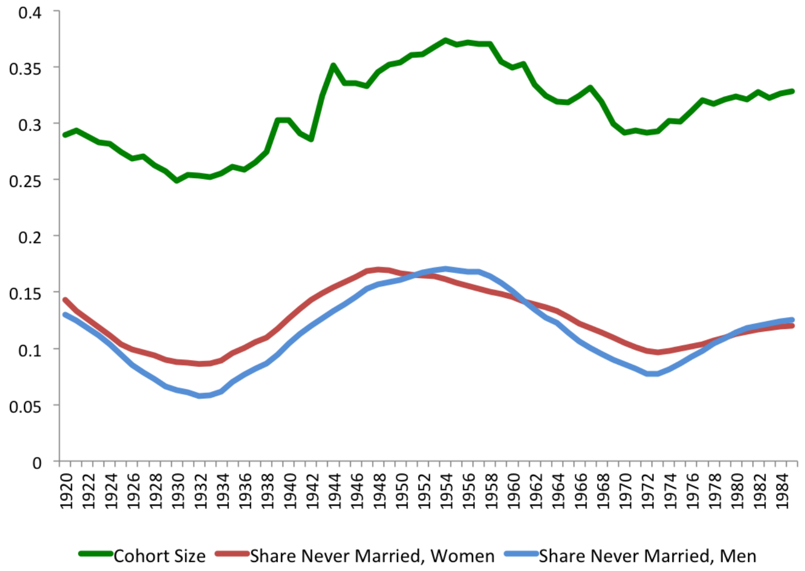
(b) Black



* See note in Figure 1 .

Figure 3: Share Never Married

A. Investment-Model



B. δ-Model

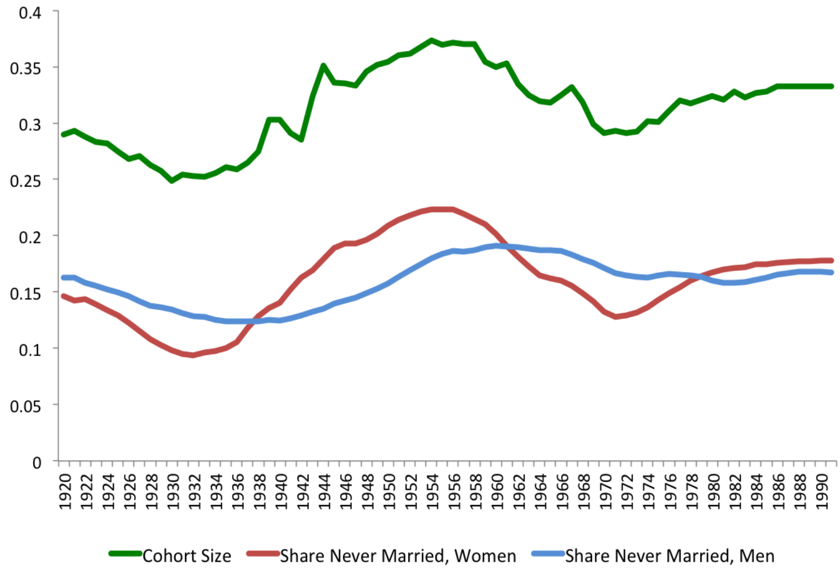


Figure 4: Share of Men and Women Never Married, Basic Search Model

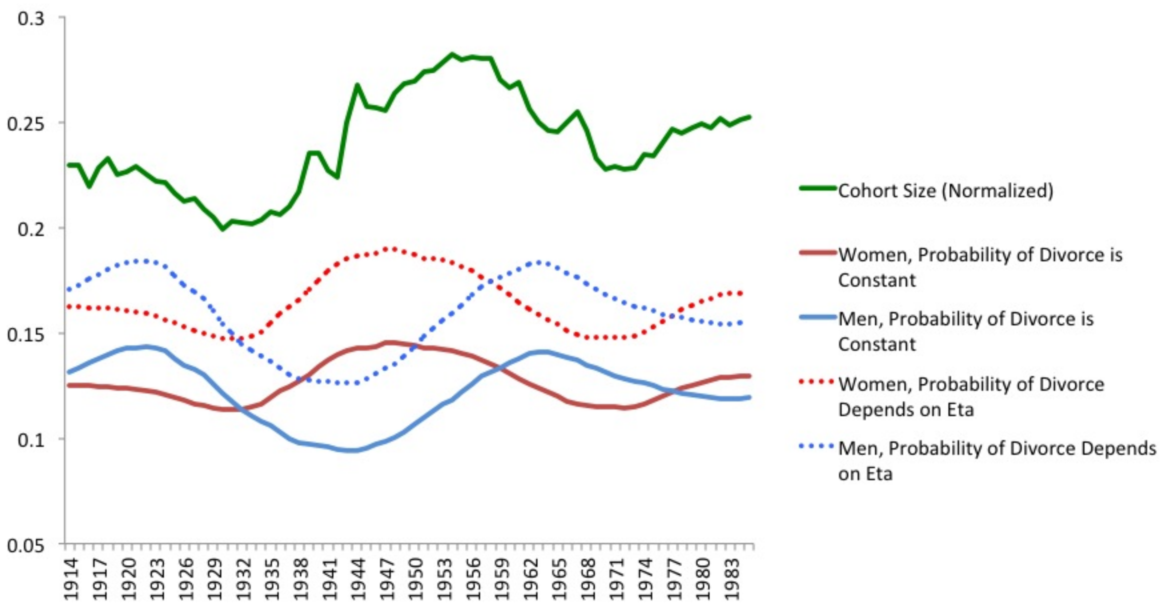


Figure 5: Share Ever Divorced

A. Data B. Investment-Model C. δ-Model

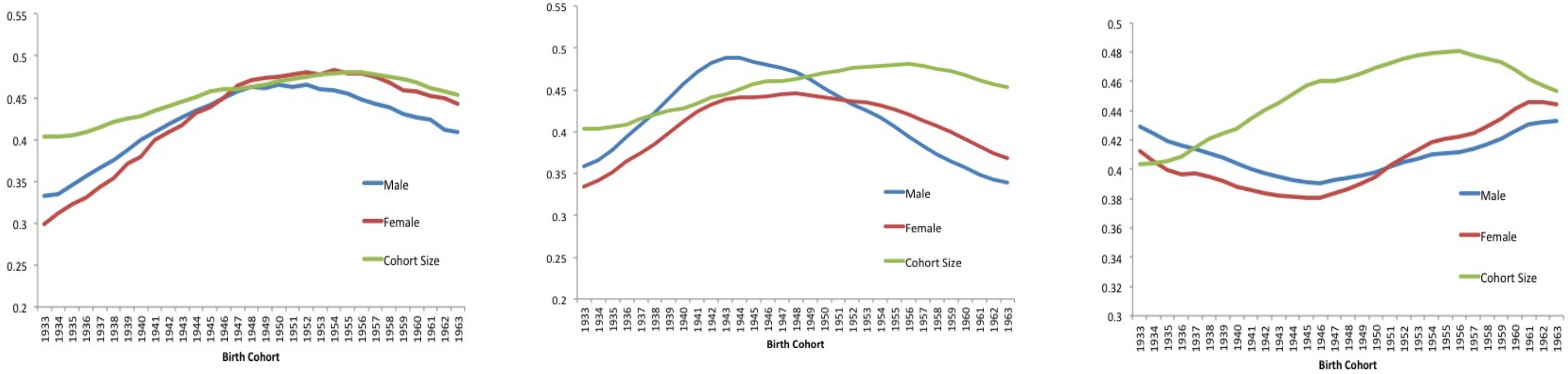
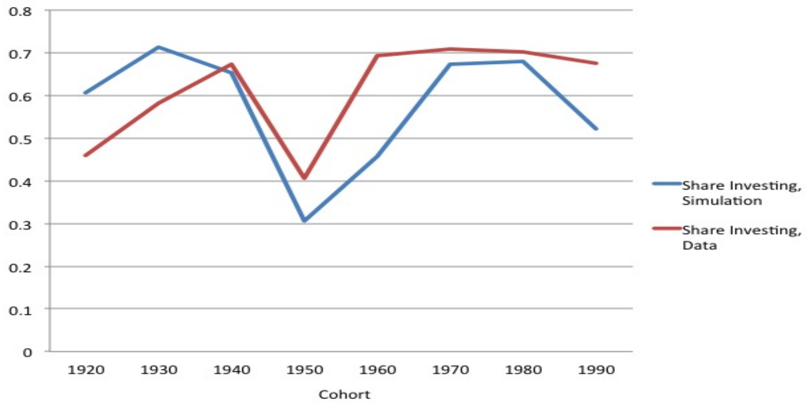
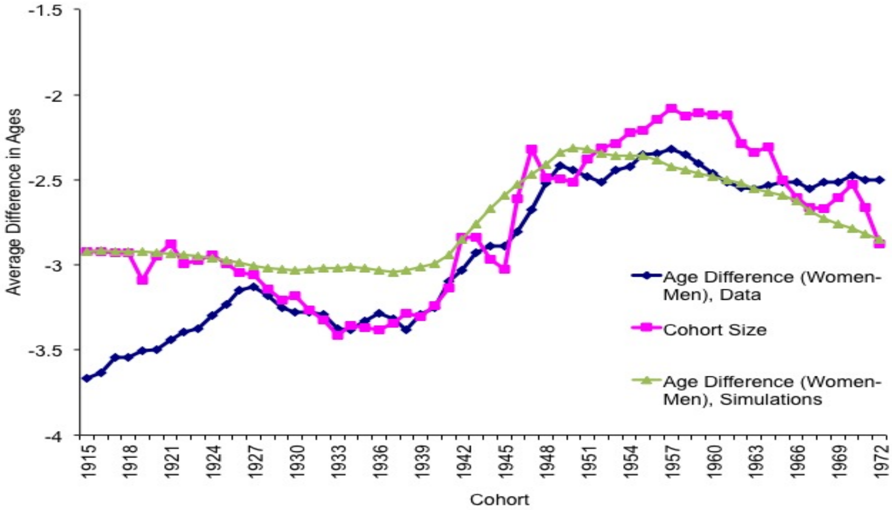


Figure 6: Fraction of Young Men Who Invest



Sources: IPUMS USA, 1940-2000; ACS, 2010. Share investing constructed for men at age 20. See main text for details.

Figure 7: Age Difference Between Spouses and Cohort Size



Sources: Vital Statistics of the United States; IPUMS CPS, 1962-2011; IPUMS USA, 1950-1960.

A Appendix: Proofs and Derivations

A.1 Reservation Values

We begin by characterizing the decisions of a man of age 1 in period t. If an old man chooses to be single in the second period, his lifetime utility takes the following form:

$$v^m_{1,t} = \sum_{t=0}^{T-1} \beta^t \delta = \frac{1-\beta^T}{1-\beta}\delta.$$

Similarly, if a woman decides to stay single in her first period of life, her lifetime welfare can be computed as follows:

$$v^w_{0,t} = \sum_{t=0}^{T} \beta^t \delta = \frac{1-\beta^{T+1}}{1-\beta}\delta = \frac{1-\beta^T}{1-\beta}\delta + \beta^T \delta.$$

If two potential partners decide to marry, the within-period utility they have drawn is also the utility they will experience in each period for the rest of their life or until they divorce. Divorce can occur each period with a probability $q = 1 - p$. If a couple divorces, each individual receives the value of being single for the remainder of their lifetime. The lifetime utility of a couple of individuals who are both of age 0 and have drawn a value η in period t can therefore be written as follows:

$$v_{0,0,t} = \eta \sum_{t=0}^{T} \beta^t p^t + 2\delta \sum_{t=1}^{T} \beta^t (1-p^t) = \eta \sum_{t=0}^{T} \beta^t p^t + 2\delta \sum_{t=1}^{T} \beta^t - 2\delta \sum_{t=1}^{T} \beta^t p^t =$$
$$\eta \sum_{t=0}^{T} \beta^t p^t + 2\delta \sum_{t=1}^{T} \beta^t + 2\delta - 2\delta \sum_{t=1}^{T} \beta^t p^t - 2\delta = \eta \sum_{t=0}^{T} \beta^t p^t + 2\delta \sum_{t=0}^{T} \beta^t - 2\delta \sum_{t=0}^{T} \beta^t p^t =$$
$$(\eta - 2\delta) \sum_{t=0}^{T} \beta^t p^t + 2\delta \sum_{t=0}^{T} \beta^t = \frac{1-(p\beta)^{T+1}}{1-p\beta}(\eta - 2\delta) + \frac{1-\beta^{T+1}}{1-\beta}2\delta,$$

where the last equality follows from the following geometric series formula:

$$\sum_{t=0}^{T} ab^t = a\frac{1-b^{T+1}}{1-b}.$$

If the couple is composed of an older man and a woman, the man will die one period earlier. As a consequence, following the same steps as in the derivation of $v_{0,0,t}$, their lifetime utility takes the following form:

$$v_{0,1,t} = \eta \sum_{t=0}^{T-1} \beta^t p^t + 2\delta \sum_{t=1}^{T-1} \beta^t (1-p^t) + \beta^T \delta = \frac{1-(p\beta)^T}{1-p\beta}(\eta - 2\delta) + \frac{1-\beta^T}{1-\beta} 2\delta + \beta^T \delta.$$

We will assume that the couple can freely divide the gains from marriage and that its lifetime utility is split between the two spouses using a Nash bargaining solution. For a couple composed of a woman of age 0 and a man of age 1, the share received by the man in period t is, therefore,

$$\begin{aligned} w_{1,t}^m(\eta) &= v_{1,t}^m + \gamma \left[v_{0,1,t} - v_{1,t}^m - v_{0,t}^w \right] \\ &= v_{1,t}^m + \gamma \left[\frac{1-(p\beta)^T}{1-p\beta}(\eta - 2\delta) + \frac{1-\beta^T}{1-\beta} 2\delta + \beta^T \delta - v_{1,t}^m - v_{0,t}^w \right], \end{aligned}$$

where the parameter $\gamma \in [0,1]$ allows for possible asymmetries in the way the marriage surplus is divided and $v_{1,t}^m$ and $v_{0,t}^w$ are the value of being single in this and future periods that were computed above. A similar equation can be derived for the woman.

We can solve the model starting with the decisions of a man of age 1 in period t. With probability $\theta_{1,t}^m$, he meets a woman and they marry if their joint lifetime utility from marrying $v_{0,1,t}$ is greater than the sum of their lifetime utilities if they choose to stay single $v_{1,t}^m + v_{0,t}^w$. As a consequence, they will marry if and only if

$$\frac{1-(p\beta)^T}{1-p\beta}(\eta - 2\delta) + \frac{1-\beta^T}{1-\beta} 2\delta + \delta\beta^T \geq \frac{1-\beta^T}{1-\beta} 2\delta + \delta\beta^T.$$

This implies that the reservation value for marriage between a woman and a man of age 1 is

$$\underline{\eta}_{1,t} = 2\delta.$$

We can now derive the expected value function for an older man before he enters the marriage market. If in period t this man meets a woman and draws a match quality η, Nash-bargaining implies that he receives the following share of the couple's lifetime utility:

$$\begin{aligned} w_{1,t}^m(\eta) &= \delta \frac{1-\beta^T}{1-\beta} + \gamma \left[\frac{1-(p\beta)^T}{1-p\beta}(\eta - 2\delta) + \frac{1-\beta^T}{1-\beta} 2\delta + \delta\beta^T - \frac{1-\beta^T}{1-\beta} 2\delta - \delta\beta^T \right] \\ &= \delta \frac{1-\beta^T}{1-\beta} + \gamma (\eta - 2\delta) \frac{1-(p\beta)^T}{1-p\beta}. \end{aligned}$$

As a consequence, the expected value function of an older man can be written in the following form:

$$v_{1,t}^{m} = \left(\delta\frac{1-\beta^{T}}{1-\beta} + E\left[\gamma\left(\eta-2\delta\right)|\eta\geq 2\delta\right]\frac{1-(p\beta)^{T}}{1-p\beta}\right)\left(1-F\left(\underline{\eta}_{1,t}\right)\right)\theta_{1,t}^{m}+$$
$$+\delta\frac{1-\beta^{T}}{1-\beta}F\left(\underline{\eta}_{1,t}\right)\theta_{1,t}^{m}+\delta\frac{1-\beta^{T}}{1-\beta}\left(1-\theta_{1,t}^{m}\right).$$

It is composed of three parts. The first term describes the value for the older man of meeting a woman with a match quality η sufficiently high that the couple will choose to marry multiplied by the corresponding probability. The second term characterizes the value of meeting a woman with a match quality η that is below the reservation value $\underline{\eta}_{1,t}$ times the probability of this event. Finally, the last term captures the value of not meeting a woman in the current period multiplied by the probability. By replacing $\underline{\eta}_{1,t} = 2\delta$ and simplifying some of the terms, we obtain the following equation for the value function:

$$v_{1,t}^{m} = \delta\frac{1-\beta^{T}}{1-\beta} + E\left[\gamma\left(\eta-2\delta\right)|\eta\geq 2\delta\right]\frac{1-(p\beta)^{T}}{1-p\beta}\left(1-F\left(2\delta\right)\right)\theta_{1,t}^{m}. \tag{4}$$

We are now in position to consider the decision of a younger man. He meets a potential spouse with probability $\theta_{0,t}^{m}$ and they marry if their joint lifetime utility is greater than the sum of their lifetime utilities if they choose to be single in this period, i.e. if

$$2\delta\frac{1-\beta^{T+1}}{1-\beta} + (\eta-2\delta)\frac{1-(p\beta)^{T+1}}{1-p\beta} \geq 2\delta + \beta v_{1,t+1}^{m} + \beta\delta\frac{1-\beta^{T}}{1-\beta},$$

where the first term on the right hand side is the joint value of being single in this period, the second term is the man's discounted expected value function for next period if he chooses to stay single today, and the third term is the woman's discounted value from next period onward if she chooses to stay single today. With this expression, we can now solve for the reservation value of a man of age 0. Substituting for the expected value function of an older man using equation (4) and simplifying some of the terms, we obtain the following equation for the reservation value of a younger man:

$$\underline{\eta}_{0,t} = 2\delta + \beta\frac{1-(p\beta)^{T}}{1-(p\beta)^{T+1}}\gamma\left\{E\left[\eta\,|\eta\geq 2\delta\right]-2\delta\right\}\left(1-F\left(2\delta\right)\right)\theta_{1,t+1}^{m}. \tag{5}$$

Using $\underline{\eta}_{0,t}$, one can derive the expected value function for a woman and a younger man. They are presented in Appendix A.6.

A.2 Steady State

In this subsection, we use the reservation values discussed above to solve for the steady state equilibrium in the marriage market. To do this, we have to derive the probability that a younger man meets a woman $\theta^m_{0,t}$ and the corresponding probability for an older man $\theta^m_{1,t}$. Let $N^i_{a,t}$ be the number of individuals of gender i, age a, and period t who are present in the marriage market. Then $\theta^m_{0,t}$ and $\theta^m_{1,t}$ can be derived by noting that

$$\theta^m_{0,t} = \theta^m_{1,t} = \frac{N^w_{0,t}}{N^m_{0,t} + N^m_{1,t}}. \tag{6}$$

The number of individuals of age 0 is exogenously given by the cohort size of a generation. However, the number of older men in the marriage market $N^m_{1,t}$ is endogenously determined by the decisions of younger men. As a consequence, to derive $\theta^m_{0,t}$ and $\theta^m_{1,t}$ we need to solve for $N^m_{1,t}$. This variable can be computed as the number of younger men who did not meet a woman at $t-1$ plus the number of younger men who met a woman at $t-1$ but draw a match quality η lower than the reservation value, i.e.

$$N^m_{1,t} = N^m_{0,t-1}\left(1-\theta^m_{0,t-1}\right) + N^m_{0,t-1}\theta^m_{0,t-1}F\left(\underline{\eta}_{0,t-1}\right) = N^m_{0,t-1}\left(1-\theta^m_{0,t-1}\left(1-F\left(\underline{\eta}_{0,t-1}\right)\right)\right). \tag{7}$$

We can now replace for $\theta^m_{0,t-1}$ using (6) and obtain the following equation for $N^m_{1,t}$:

$$\begin{aligned} N^m_{1,t} &= N^m_{0,t-1}\left(1-\frac{N^w_{0,t-1}}{N^m_{0,t-1}+N^m_{1,t-1}}\left(1-F\left(\underline{\eta}_{0,t-1}\right)\right)\right) \\ &= N^m_{0,t-1}\left(\frac{N^m_{0,t-1}+N^m_{1,t-1}-N^w_{0,t-1}\left(1-F\left(\underline{\eta}_{0,t-1}\right)\right)}{N^m_{0,t-1}+N^m_{1,t-1}}\right). \end{aligned}$$

In a steady state equilibrium, the cohort size $N^w_{0,t}$ and $N^m_{0,t}$ and the number of older men in the marriage market $N^m_{1,t}$ are constant over time. We therefore have that

$$N^m_1 = N^m_0\left(\frac{N^m_0+N^m_1-N^w_0\left(1-F\left(\underline{\eta}_0\right)\right)}{N^m_0+N^m_1}\right).$$

We can now solve for N^m_1 and obtain

$$N^m_1 = \sqrt{\left(N^m_0\right)^2 - N^m_0 N^w_0 + N^m_0 N^w_0 F\left(\underline{\eta}_0\right)}.$$

Generally, men and women have identical cohort size, i.e. $N_{0,t}^m = N_{0,t}^w = N_{0,t}$.[8] In this case the solution for N_1^m simplifies to

$$N_1^m = N_0 F\left(\underline{\eta}_0\right)^{\frac{1}{2}}.$$

If we substitute N_1^m back into θ_j^m, we have

$$\theta_0^m = \theta_1^m = \frac{N_0^w}{N_0^m + \sqrt{\left(N_0^m\right)^2 - N_0^m N_0^w + N_0^m N_0^w F\left(\underline{\eta}_0\right)}}.$$

If men and women have identical cohort size, θ_j^m simplifies to

$$\theta_0^m = \theta_1^m = \frac{N_0}{N_0 + N_0 F\left(\underline{\eta}_0\right)^{\frac{1}{2}}} = \frac{1}{1 + F\left(\underline{\eta}_0\right)^{\frac{1}{2}}}.$$

To determine the reservation value of younger men in steady state, we can substitute for θ_1^m in the equation that determines the reservation value (5). We can then derive, for the case in which $N_0^m \neq N_0^w$, the following equation for the steady state reservation value:

$$\underline{\eta}_{ss} = 2\delta + \beta \frac{1-(p\beta)^T}{1-(p\beta)^{T+1}} \gamma \left\{E\left[\eta \left|\eta \geq 2\delta\right.\right] - 2\delta\right\}\left(1 - F\left(2\delta\right)\right) \frac{N_0^w}{N_0^m + \sqrt{\left(N_0^m\right)^2 - N_0^m N_0^w + N_0^m N_0^w F\left(\underline{\eta}_{ss}\right)}},$$

If $N_0^m = N_0^w$, the equation simplifies as follows:

$$\underline{\eta}_{ss} = 2\delta + \beta \frac{1-(p\beta)^T}{1-(p\beta)^{T+1}} \gamma \left\{E\left[\eta \left|\eta \geq 2\delta\right.\right] - 2\delta\right\}\left(1 - F\left(2\delta\right)\right) \frac{1}{1 + F\left(\underline{\eta}_{ss}\right)^{\frac{1}{2}}}.$$

Note that $F\left(\underline{\eta}\right)$ is monotonically increasing in $\underline{\eta}$. As a consequence, there is a unique solution for $\underline{\eta}_{ss}$. Moreover, if men and women have identical cohort sizes, the steady state reservation value is independent of N_0^m and N_0^w.

A.3 Proof of Proposition 2 and The Effect of an Unexpected Shock to Cohort Size

Suppose the economy is in steady state when it is hit by an unexpected shock in period $t = \tau$ that changes permanently the cohort size from N_0 to $N_0 + \Delta$. According to equation

[8] This is not the case if men or women are more likely not to be in the marriage market for particular reasons. For instance, African-American men are more likely than African-American women to be incarcerated during their marriage years. As a consequence, the relevant cohort size for African-American men is smaller than the corresponding cohort size for women.

(6), the probabilities $\theta^m_{j,t}$ take the following form:

$$\theta^m_{0,t} = \theta^m_{1,t} = \frac{N_{0,t}}{N_{0,t} + N^m_{1,t}} \qquad \text{if } t < \tau$$

and

$$\theta^m_{0,t} = \theta^m_{1,t} = \frac{N_{0,t} + \Delta}{N_{0,t} + \Delta + N^m_{1,t}} \qquad \text{if } t \geq \tau.$$

Consider the period in which the shock is realized and notice that $N^m_{1,\tau}$ are the men born in period $\tau - 1$ who did not marry when younger. As a consequence, $N^m_{1,\tau}$ equals the number of older men in steady state, i.e. $N^m_{1,\tau} = N_{0,\tau-1} F(\underline{\eta}_{ss})^{\frac{1}{2}} = N_0 F(\underline{\eta}_{ss})^{\frac{1}{2}}$. Substituting for $N^m_{1,\tau}$ in the probabilities $\theta^m_{j,t}$, we have that in period τ

$$\theta^m_{0,\tau} = \theta^m_{1,\tau} = \frac{N_0 + \Delta}{N_0 + \Delta + N_0 F(\underline{\eta}_{ss})^{\frac{1}{2}}} = \frac{1}{1 + \frac{N_0}{N_0 + \Delta} F(\underline{\eta}_{ss})^{\frac{1}{2}}}.$$

The previous equation implies that a positive cohort shock Δ increases the probability that a man of any age meets a woman, whereas a negative cohort shock has the opposite effect. In our economy there are always more men than women in the marriage market. As a consequence, the probability that a woman meets a younger man, $\theta^w_t = \frac{N_{0,t}}{N_{0,t} + N^m_{1,t}}$, is equivalent to the probability that a man meets a woman. Therefore, the previous result also implies that a positive cohort shock increases the probability that a woman meets a younger man.

We can now determine the effect of a shock to cohort size on the reservation value of younger men $\underline{\eta}_{0,\tau}$. Notice that in the determination of $\underline{\eta}_{0,\tau}$ a younger man compares the value of getting married at τ with the value of waiting until next period. The value of waiting depends on the probability he will meet a woman in period $\tau + 1$. This probability depends on the number of older men at $\tau + 1$, which can be written as follows:

$$\theta^m_{0,\tau+1} = \theta^m_{1,\tau+1} = \frac{N_0 + \Delta}{N_0 + \Delta + N_{1,\tau+1}}.$$

Using equation (7), we can substitute for $N_{1,\tau+1}$ to obtain the following expression:

$$\theta^m_{0,\tau+1} = \theta^m_{1,\tau+1} = \frac{N_0 + \Delta}{N_0 + \Delta + (N_0 + \Delta)\left(1 - \theta^m_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right)\right)} = \frac{1}{1 + \left(1 - \theta^m_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right)\right)}.$$

We can now substitute for $\theta^m_{1,\tau+1}$ in the equation that determines $\underline{\eta}_{0,\tau}$ to obtain

$$\underline{\eta}_{0,\tau} = 2\delta + \beta \frac{1-(p\beta)^T}{1-(p\beta)^{T+1}} \gamma \left\{ E\left[\eta \left| \eta \geq 2\delta \right.\right] - 2\delta \right\} \left(1 - F\left(2\delta\right)\right) \frac{1}{1 + \left(1 - \theta^m_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right)\right)}. \tag{8}$$

The same equation for the reservation value in steady state can be derived as follows:

$$\underline{\eta}_{0,ss} = 2\delta + \beta \frac{1-(p\beta)^T}{1-(p\beta)^{T+1}} \gamma \left\{ E\left[\eta \left| \eta \geq 2\delta \right.\right] - 2\delta \right\} \left(1 - F\left(2\delta\right)\right) \frac{1}{1 + \left(1 - \theta^m_{0,ss}\left(1 - F\left(\underline{\eta}_{0,ss}\right)\right)\right)}. \tag{9}$$

Earlier in this section we have shown that, with a positive shock to cohort size, $\theta^m_{0,\tau} > \theta^m_{0,ss}$. As a consequence, a simple comparison of the last two equations implies that an increase in cohort size has the effect of increasing the reservation value of younger men. Specifically, by substituting $\theta^m_{0,ss}$ with $\theta^m_{0,\tau}$ and by using the result that $\theta^m_{0,\tau} > \theta^m_{0,ss}$, we obtain the following inequality:

$$\underline{\eta}_{0,ss} < 2\delta + \beta \frac{1-(p\beta)^T}{1-(p\beta)^{T+1}} \gamma \left\{ E\left[\eta \left| \eta \geq 2\delta \right.\right] - 2\delta \right\} \left(1 - F\left(2\delta\right)\right) \frac{1}{1 + \left(1 - \theta^m_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,ss}\right)\right)\right)}.$$

Since the left hand side of the inequality is increasing in $\underline{\eta}_0$ and the right hand side is decreasing in $\underline{\eta}_0$, equation (8) implies that $\underline{\eta}_{0,\tau} > \underline{\eta}_{0,ss}$.

A.4 Proof of Proposition 3

The total number of women that marry in a particular cohort is given by the total number of women in the cohort time the probability that a woman in that cohort marries. As a consequence, the fraction of women in a cohort that marries is simply the probability of marriage for those women. The probability that a woman marries can be written as the probability that she meets a younger man times the probability she marries him plus the probability she meets an older man times the probability she marries him, i.e.

$$P\left(\text{woman marries at } \tau\right) = \theta^w_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right) + \left(1 - \theta^w_{0,\tau}\right)\left(1 - F\left(2\delta\right)\right)$$

Define $1 + \lambda_\tau = \dfrac{F\left(\underline{\eta}_{0,\tau}\right)}{F\left(\underline{\eta}_{0,ss}\right)}$ and $1 + \phi_\tau = \dfrac{\theta^w_{0,\tau}}{\theta^w_{0,ss}}$, where $\lambda_\tau > 0$ and $\phi_\tau > 0$ because $\dfrac{\partial \underline{\eta}_{0,\tau}}{\partial N_0} > 0$ and $\dfrac{\partial \theta^w_{0,\tau}}{\partial N_0} > 0$. We then have

$$
\begin{aligned}
& P\left(\text{woman marries at } \tau\right) = \\
= \;& \theta^{w}_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right) + \left(1 - \theta^{w}_{0,\tau}\right)\left(1 - F\left(2\delta\right)\right) \\
= \;& \theta^{w}_{0,ss}\left(1 + \phi_{\tau}\right)\left(1 - F\left(\underline{\eta}_{0,ss}\right)\left(1 + \lambda_{\tau}\right)\right) + \left(1 - \theta^{w}_{0,ss}\left(1 + \phi_{\tau}\right)\right)\left(1 - F\left(2\delta\right)\right) \\
= \;& \theta^{w}_{0,ss}\left(1 - F\left(\underline{\eta}_{0,ss}\right)\right) + \left(1 - \theta^{w}_{0,ss}\right)\left(1 - F\left(2\delta\right)\right) - \theta^{w}_{0,ss}\lambda_{\tau}F\left(\underline{\eta}_{0,ss}\right) + \theta^{w}_{0,ss}\phi_{\tau}\left(1 - F\left(\underline{\eta}_{0,ss}\right)\left(1 + \lambda_{\tau}\right)\right) \\
& - \theta^{w}_{0,ss}\phi_{\tau}\left(1 - F\left(2\delta\right)\right) \\
= \;& P\left(\text{woman marries at } ss\right) - \theta^{w}_{0,ss}\lambda_{\tau}F\left(\underline{\eta}_{0,ss}\right) + \theta^{w}_{0,ss}\phi_{\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right) - \theta^{w}_{0,ss}\phi_{\tau}\left(1 - F\left(2\delta\right)\right) \\
< \;& P\left(\text{woman marries at } ss\right) - \theta^{w}_{0,ss}\lambda_{\tau}F\left(\underline{\eta}_{0,ss}\right) \\
< \;& P\left(\text{woman marries at } ss\right).
\end{aligned}
$$

A.5 Proof of Proposition 4

We prove the Proposition in two steps. We first prove that the probability that a man marries when younger in period t increases with cohort size. When then prove that a man marries when younger or older increases with cohort size.

First step. Let P^{ym}_{t} be the probability that a man marries when younger the period of the shock τ. Since we consider the case of a permanent shock to cohort size we have $N^{m}_{0,\tau} = N^{m}_{0,\tau+1}$. Using equation (7), we can therefore write the number of older men in period $t+1$ as follows:

$$
N^{m}_{1,\tau+1} = N^{m}_{0,\tau}\left(1 - \theta^{m}_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right)\right) = N^{m}_{0,\tau}\left(1 - P^{ym}_{\tau}\right). \tag{10}
$$

Using the previous equation and equation (8), the reservation utility of a younger man can be written in the following form:

$$
\underline{\eta}_{0,\tau} = A + B\frac{N_{0,\tau}}{N_{0,\tau} + N_{0,\tau}\left(1 - \theta^{m}_{0,\tau}\left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right)\right)} = A + B\frac{1}{1 + \left(1 - P^{ym}_{\tau}\right)} = A + B\frac{1}{2 - P^{ym}_{\tau}}.
$$

Proposition 2 establishes that $\underline{\eta}_{0,ss} < \underline{\eta}_{0,\tau}$. Hence,

$$
\underline{\eta}_{0,ss} = A + B\frac{1}{2 - P^{ym}_{ss}} < A + B\frac{1}{2 - P^{ym}_{\tau}} = \underline{\eta}_{0,\tau}.
$$

The inequality implies that $P^{ym}_{\tau} > P^{ym}_{ss}$. We can therefore conclude that an increase in cohort size increases the probability that a man marries when younger.

Second step. The probability that a man marries when younger or older P_τ^m can be written as the probability that a man married when younger in period τ plus the probability that the same man marries when older in period $\tau+1$, i.e.

$$P_\tau^m = \theta_{0,\tau}^m \left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right) + \left(1 - \theta_{0,\tau}^m \left(1 - F\left(\underline{\eta}_{0,\tau}\right)\right)\right) \theta_{1,\tau+1}^m \left(1 - F\left(2\delta\right)\right). \tag{11}$$

The first part of the right hand side is the probability that a younger man meets a woman and marries her in period τ, which we denoted with P_τ^{ym}. The second part is the probability that a younger man does not marry in period τ, $1 - P_\tau^{ym}$, meets a woman in period $\tau+1$, and marries her. Using equation (10), the probability that an older men meets a woman can be written as follows:

$$\theta_{1,\tau+1}^m = \frac{N_{0,\tau+1}^m}{N_{0,\tau+1}^m + N_{1,\tau+1}^m} = \frac{1}{2 - P_\tau^{ym}}.$$

As a consequence, equation (11) can be written as follows:

$$P_\tau^m = P_\tau^{ym} + \frac{\left(1 - P_\tau^{ym}\right)}{2 - P_\tau^{ym}} \left(1 - F\left(2\delta\right)\right).$$

Taking the derivative with respect to cohort size N of both size and rearranging terms, we have,

$$\frac{\partial P_\tau^m}{\partial N} = \frac{\partial P_\tau^{ym}}{\partial N} \left[1 - \frac{1 - F\left(2\delta\right)}{\left(2 - P_\tau^{ym}\right)^2}\right] > \frac{\partial P_\tau^{ym}}{\partial N} F\left(2\delta\right) > 0,$$

where the first inequality follows from $\left(2 - P_\tau^{ym}\right)^2 > 1$ and the second from the first step of the proof. Hence, an increase in cohort size increases the probability that a man marries.

A.6 Expected Value Functions

For completeness, in this appendix we derive the expected values for younger men and women. The expected value of a younger man takes the following form:

$$\begin{aligned} v_{0,t}^m = {} & \theta_{0,t}^m \left(1 - F\left(\underline{\eta}_{1,t}\right)\right) \left\{\delta + \beta v_{1,t}^m + \gamma \left\{2\delta \frac{1 - \beta^{T+1}}{1 - \beta} + \frac{1 - (p\beta)^{T+1}}{1 - (p\beta)} E\left[\eta - 2\delta \left| \eta \geq \underline{\eta}_{0,t}\right.\right] - \right.\right. \\ & \left.\left. - \left(\delta + \beta v_{1,t}^m\right) - \frac{1 - \beta^{T+1}}{1 - \beta}\delta\right\}\right\} + \theta_{0,t}^m F\left(\underline{\eta}_{0,t}\right) \left(\delta + \beta v_{1,t}^m\right) + \left(1 - \theta_{0,t}^m\right) \left(\delta + \beta v_{1,t}^m\right). \end{aligned}$$

The first term represents the value of meeting a woman with a match quality η higher than the reservation value times the probability of this event. The second term describes the value of meeting a woman characterized by an η lower than the reservation value multiplied by the corresponding probability. The third term measures the value of not meeting a woman when younger times the probability.

To derive the woman's expected value function we have to take into account that she can meet both younger and older men. As a consequence, it takes the following more complex form:

$$v_{0,t}^{w} = \theta_{0,t}^{m}\left(1 - F\left(\underline{\eta}_{0,t}\right)\right)\left\{\frac{1-\beta^{T+1}}{1-\beta}\delta + (1-\gamma)\left\{2\delta\frac{1-\beta^{T+1}}{1-\beta} + \frac{1-(p\beta)^{T+1}}{1-(p\beta)}E\left[\eta - 2\delta\left|\eta \geq \underline{\eta}_{0,t}\right.\right] - \right.\right.$$
$$\left.\left. - \left(\delta + \beta v_{1,t}^{m}\right) - \frac{1-\beta^{T+1}}{1-\beta}\delta\right\}\right\} + \theta_{0,t}^{m}F\left(\underline{\eta}_{0,t}\right)\frac{1-\beta^{T+1}}{1-\beta}\delta +$$
$$+ \theta_{1,t}^{m}\left(1 - F\left(2\delta\right)\right)\left\{\frac{1-\beta^{T+1}}{1-\beta}\delta + (1-\gamma)\left\{2\delta\frac{1-\beta^{T}}{1-\beta} + \frac{1-(p\beta)^{T}}{1-p\beta}E\left[\eta - 2\delta\left|\eta \geq 2\delta\right.\right] + \beta^{T}\delta - \right.\right.$$
$$\left.\left. - v_{1,t}^{m} - \frac{1-\beta^{T+1}}{1-\beta}\delta\right\}\right\} + \theta_{1,t}^{m}F\left(2\delta\right)\frac{1-\beta^{T+1}}{1-\beta}\delta$$

The first term measures the value of meeting a younger man with an η higher than the reservation value times the corresponding probability. The second term is the value of meeting a younger man whom it is optimal not to marry times the probability of this event. The third and fourth terms describe the same values of meeting an older man.

A.7 Basic Search Model with Divorce

In Figure 4, we show simulation results for the basic search model, under two different assumptions about the probability with which a divorce may occur. Under the first assumption, the probability that a divorce occurs is constant. Under the second assumption, the probability of divorce is modeled as a decreasing function of match quality of the form $q(\eta) = \gamma_0 + \gamma_1\eta$. As Figure 4 shows, under both assumptions, the share never married changes in opposite directions for men and women, in contrast to the patterns observed in the data. Additionally, as discussed in the paper, the share never married is higher for all cohorts when the probability of divorce is decreasing in the value of marriage since younger men become more selective and increase their reservation utility.