A "Reproductive Capital" Model of Marriage Market Matching

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August 17, 2019

We often consider the toll the ticking biological clock takes on women, but not the *economic* loss it causes via its impact on marriage market prospects. I use an incentive-compatible experiment to show that age has a causal negative impact on women's marriage market value. For every year a woman ages beyond 30, she must earn an extra $7,000 a year to remain equally attractive to potential partners. I then provide a matching model of the marriage market where women's human capital investments impact a second dimension, "reproductive capital," to study the implications for aggregate matching patterns. The model predicts that when the fertility loss from investment is large relative to the income gains, the top-earning men may not match with the top-earning women, and that women's spousal income may in fact be non-monotonic in their own human capital. These predictions match patterns in historical data that I document for the first time.

JEL Codes: C78, D10, I26, J12, J13, J16

1 Introduction

The ticking biological clock is often viewed as a central driver of women's decision-making. But, just as a woman's human capital is valued on the labor market, her fertility may have value on the marriage market: men marry partly to have children, and marriages tend to improve the economic circumstances of women.[1] Therefore, women whose human capital investments limit their fertility may experience not just a personal loss, but an *economic* one. This paper introduces the concept of fertility as "reproductive capital," and examines the economic impacts of its depreciation for women. I first provide a causal measurement of men's preference for fertility, using an incentivized experiment, and then use a marriage matching model to understand the implications of this preference for measurement and human capital investment.

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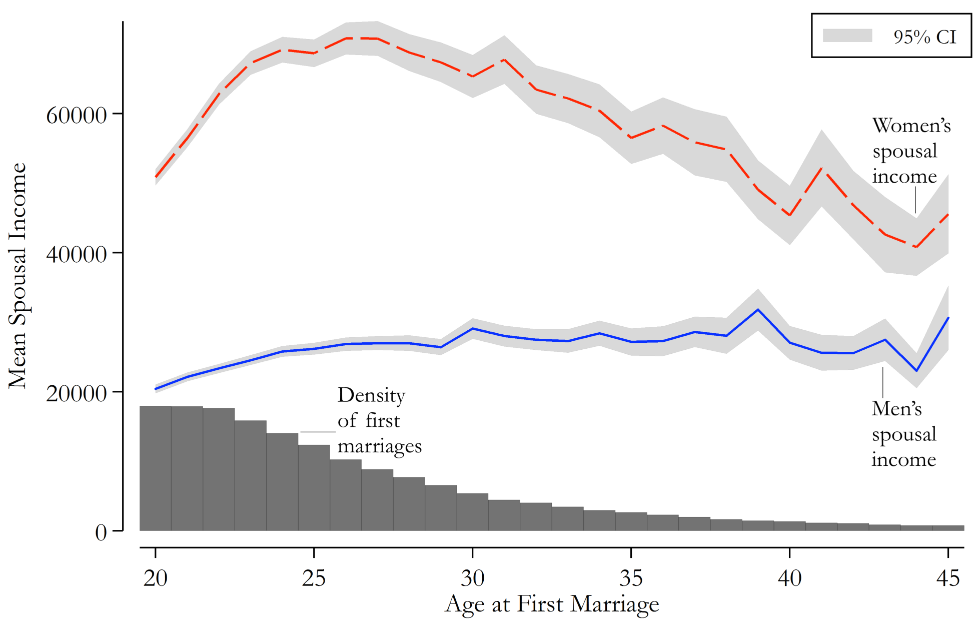
[1] Marriage has economic value to both men and women, through the production of public goods and returns to scale, but may especially improve women's economic circumstances via hypergamy [Edlund and Pande, 2002].

Whereas men's reproductive systems age at the same rate as other bodily systems, women experience sharply declining fecundity beginning in their mid-thirties, and ending in menopause. Mirroring this asymmetric biological pattern is a social one: Women who marry later (past their mid-twenties) marry poorer men with each passing year, whereas for men later marriage is associated with richer partners. Figure 1 shows that women who are older at the time of first marriage (beyond age 30) tend to marry lower-income spouses. In contrast, men's age is slightly positively correlated with spousal income.[2] This negative relationship between women's age and spousal income is non-causal, but given that individuals who marry later tend to be positively selected, it is suggestive of a negative impact of age on marriage market outcomes.[3]

Figure 1: Spousal Income by Age at Marriage



Notes: Lines represent the average spousal income for first marriages by age at marriage for women versus men. Bars represent the portion of all women's marriages occurring at that age, to check whether selection is driving the effect. Source: 2010 American Community Survey (1 percent sample) marital histories for white men and women, 46-55 years old.

[2]Appendix Figure A3 shows that in addition to the average pattern, at each level of women's own income, marrying older is linked to marrying a poorer spouse for women (but not for men).

[3]One might worries the pattern stems from unobservable selection, if women who marry later are "leftover". However, the pattern of marriage volume makes this unlikely, since the bulk of marriages—and thus the largest possible sorting—occurs before the decline in husband's income begins. Zhang [2017a] additionally notes that the selection of men who marry late tends to be negative, which could make availability of mates a contributing factor. However, the selection he outlines still depends on differential fecundity.

Of course, it is difficult to separate age from other factors. Thus, I use a unique incentivized experiment to measure the causal impact of age on marriage market value. In the experiment, real online daters rate dating profiles with age and income randomly assigned. They are incentivized to provide honest responses by receiving customized advice to attract who they are interested in based on their ratings in the study, and no other compensation. The experiment finds that for every year a woman ages beyond 30, she must earn an extra $7,000 a year to remain equally attractive to potential partners, with no such preference from women for men. This aging penalty is driven by men who have no children currently, indicating its connection to fertility. When age is isolated from other factors, men who already have children do not penalize older partners, while men looking to become fathers do.

The experiment indicates that men also hear the ticking of the biological clock. Seeking to marry and have children, they naturally prefer more fertile partners. Women thus face a tradeoff: human capital investments increase earnings, but take up crucial time during the reproductive years, as it is difficult to co-process career investments and family formation [Michael and Willis, 1976, Goldin and Katz, 2002, Bailey, 2006, Bailey et al., 2012, Adda et al., 2017, Kleven et al., Forthcoming]. This loss of reproductive capital may cost them real economic returns on the marriage market, despite human capital itself being a positive trait. If additional years of investment might be linked to marrying a poorer partner, a woman could risk actually reducing her total household income, even as she raises her own earnings.

To formally model the consequences of depreciating "reproductive capital," I add fertility as a second dimension to a standard transferable utility matching model. Despite starting from a surplus function that typically predicts assortative matching on income, I find that when fertility is introduced, and human capital investments are time-costly, the richest men do not always marry the richest women. In fact, the model produces the simple prediction that for any set of parameters, it is always possible to find a man rich enough such that he would choose a partner with a little extra fertility over one with a little extra income.

This marriage market response to skill investments in turn increases the cost of such investments to women, by adding a marriage market cost to the personal utility loss of lower fertility. This marriage market effect means that even if a woman placed no value on children personally, she would still experience a "tax" on her human capital investments via the marriage market equilibrium. However, despite this tax, I show it is still possible to sustain an equilibrium where the women who value human capital investments most make these investments, despite losing out on the "best" partners on the marriage market.

Reproductive capital helps bridge the gap between the overwhelming evidence that matching tends to be basically assortative, and anomalies where men *appear* to dislike high-earning female partners (e.g., Bertrand et al. [2015].) The model predicts that matching will be assortative whenever women differ only by income, but need not be when both income and fertility change. This means that the model is able to match a puzzling fact in US Census data that I document for the first time: until recently, women with graduate degrees married significantly poorer spouses than women with college degrees, despite every other educational level yielding richer partners. In other words, there was a *non-monotonic* relationship between women's education and spousal income.

This fact cannot be explained by existing models of household formation. If households specialize between market and non-market work, then negative assortative matching is expected, with high earning men choosing lower human capital women who have lower opportunity costs of time. Similarly so if female education is somehow a "bad," because it yields additional bargaining power for the female partner or creates greater intra-household conflict. Conversely, if marriage is taste-based, or there are consumption complementarities with one's spouse, or there are convex returns to investments in children, positive assortative matching is predicted. There is no current model that can simultaneously explain the positive relationship between education and spousal income for those with less than a college degree, and the negative relationship for those with college degrees and higher.[4]

The model additionally explains the more recent changes in marriage prospects for women with graduate degrees, as matching has become more assortative for women in the top tier of human capital accumulation. If the labor market return on investment rises or the fertility cost falls sufficiently (due to improved technology or reduced family size desires),[5] the highest-earning women may be able to compensate their partners for forgone fertility, and thus match assortatively. This partial elimination of the "graduate marriage-market penalty" may have amplified the effects of increasing labor market returns to education, helping to explain the dramatic rise in women pursuing higher education [Goldin et al., 2006]. That the rates of women attending higher education have increased to such an extent (despite labor market returns apparently being higher for men)

[4]If tastes vary with income or education in such a way that optimal matching patterns change, it would be more likely for the pattern to flip in the opposite direction, with poorer individuals preferring more "traditional" households, while wealthier individuals matched more assortatively.

[5]Family size desires transitioned rapidly from 4 to 2 during the 1970s [Livingston et al., 2010], shown in Figure 7, perhaps due to a substitution between child quantity and quality.

has led to speculation that it must be the *marriage* market returns to education that are on the rise for women [Chiappori et al., 2009, Ge, 2011], a phenomenon my model explains. I also show that while women with only college degrees have actually always married at rates similar to women of other educational levels, graduate educated women had previously married at substantially lower rates. Marriage rates for graduate women have risen and divorce rates have fallen in the last 30 years, creating a recently noted "reversal of fortune" for educated women on the marriage market [Fry, 2010], but driven entirely by women with graduate degrees.

This paper makes three key contributions. First, I use a novel experimental method to provide well-identified evidence of men's preference for partner age, and thus the causal negative impact for women of aging on marriage market. By separating age itself from physical attractiveness, my experiment adds to literature suggesting age and fertility are important marriage market traits [Edlund, 2006, Edlund and Korn, 2002, Edlund et al., 2009, Grossbard-Shechtman, 1986, Arunachalam and Naidu, 2006][6] and evidence from dating markets that shows men's preference for age [Fisman et al., 2006, Hitsch et al., 2010, Belot and Francesconi, 2013]. In addition to the evidence itself, this paper contributes a new, incentive compatible experimental methodology that can be applied to settings where one wants to measure preferences over individual characteristics without deception. This method has since been applied by Kessler et al. [Forthcoming] to elicit employer preferences in lieu of a resume audit study.

Second, I use a bi-dimensional matching model to formally model the impact of reduced fertility on the marriage market matching equilibrium, contributing to a body of literature examining the implications of older women's lower marriage market appeal [Siow, 1998, Dessy and Djebbari, 2010, Bronson and Mazzocco, 2012, Zhang, 2017b, Díaz-Giménez and Giolito, 2013, Shephard, 2019]. I demonstrate that the time-cost of large career investments can result in a non-monotonic matching patterns by building on a standard model of the household that would typically result in assortative mating. Whereas multi-dimensional characteristics have typically been handled by collapsing to an index of overall desirability, this paper adds to a growing literature studying cases where multiple dimensions cannot be collapsed (e.g., Chiappori et al. [2017a], where smokers do not mind if their partners smoke, whereas non-smokers do), and the potential of multidimensional models to make more complex predictions that may better match empirical data [Galichon and Salanié, 2015, Lindenlaub and Postel-Vinay, 2017, Dupuy and Galichon, 2014, Galichon et al., 2017, Coles and

[6] It is taken as a given in other disciplines such as evolutionary biology [Trivers, 1972], anthropology [Bell and Song, 1994], and sociology [Hakim, 2010]

Francesconi, 2017]. This paper contributes to this literature an application where adding a second dimension to the model is crucial to match basic stylized facts in data. Moreover, fertility is a trait that naturally creates a non-index model, since it *interacts* with the household's other means of creating surplus. I also examine the impact of the model's bidimensionality on investments that affect both dimensions, adding to the literature on premarital investments [Lafortune, 2013, Iyigun and Walsh, 2007, Dizdar, 2013, Mailath et al., 2013, Cole et al., 2001, Nöldeke and Samuelson, 2015, Mailath et al., 2017].

Third, I show that this model can help explain historical patterns in educated women's marriage market success, which I document for the first time. This builds on literature noting improved marriage outcomes for college educated women [Rose, 2005, Isen and Stevenson, 2010, Bertrand et al., 2016, Fry, 2010], as well as increases in assortative mating [Chiappori et al., 2017b, Hurder, 2013, Greenwood et al., 2016, 2014, Fernandez et al., 2005, Schwartz and Mare, 2005],[7] by showing the unique pattern in graduate educated women's outcomes, which is not easily explained by existing theories.

The understanding of reproductive capital as a marriage market asset, and one that often co-moves with income, is crucial to understanding surprising marriage market patterns. My model shows that men's micro preferences for more fertile partners, shown via experimental data, drive real matching patterns that result in the highest-educated women being paired with lower income spouses than women with less human capital, shown via decades of nationwide Census data. While we may presume that women value fertility and consider it in their career decisions, demonstrating its effect on the marriage market allows us to measure its economic impact: women essentially experience a "tax" in terms of their husbands' earnings for their additional education. As "reproductive capital" happens to depreciate in value at a similar time in the life cycle to when human capital for high-skilled workers appreciates most rapidly, its marriage market impacts are likely to be extremely salient in human capital investment decisions, especially at the top of the distribution. Individuals, policymakers, and firms may be able to use a better understanding of this tradeoff to blunt the impact of reproductive capital's decline.

The remainder of the paper proceeds as follows: Section 2 demonstrates the causal impact of aging for women through an experiment, Section 3 develops a model that incorporates fertility in

[7] Note that Gihleb and Lang [2016] find that there is not necessarily an increase in assortativeness, depending on measurement techniques, while Eika et al. [2014] look at assortativeness within education categories, and find the increase has been mostly among less educated groups.

the marital surplus function, Section 4 establishes the model's relevance to historical Census data, and Section 5 concludes.

2 Experiment

Aging affects men's and women's ability to have children drastically differently. Whereas men experience a reproductive decline with age that is proportional to the decline in other bodily systems, women experience a separate process—menopause—where reproductive capacity declines non-linearly to zero [Frank et al., 1994].[8]

Given that having children may be one reason that people marry, it is natural to think that this might affect women's marriage market appeal. While a large amount of anecdotal evidence suggests that men prefer younger women on the dating market, there is less evidence on the source of this preference. For instance, dating website OK Cupid has published data showing that men list their preferred age ranges for women as much younger than themselves, and target their messaging at the younger end of that range.[9] This pattern has also been documented by sociologists England and McClintock [2009], who find that the age gap between spouses is increasing in the man's age at marriage. A 30-year-old man may marry a woman only a couple years younger than himself, whereas a 50-year-old man will, on average, marry a woman ten years younger.

However, since individuals' incomes, lifestyles, and appearances also change with age, it is difficult to establish whether fecundity plays a role in these preferences. Men may simply have tastes for women who *look* younger, which is then correlated with actual age. This preference may nonetheless be rooted in an evolutionary-driven desire for fertility, but the policy implications for a conscious preference for fertility, versus an instinctive one, differ.[10] The age "penalty" could also

[8] The exact date of this decline may be difficult to pinpoint, but a collage of evidence points to pregnancies being rarer [Menken et al., 1986], more likely to end in miscarriage [Andersen et al., 2000], and more likely to result in fetal abnormalities [Hook et al., 1983] later in life. Women lose 97% of eggs by age 40 [Kelsey and Wallace, 2010], while remaining egg quality declines [Toner, 2003]. To help disentangle the co-movement of fecundity and fertility choice, such as the use of contraceptives, some literature uses couples in traditional societies that do not use birth control. Although these measures may suffer from downward bias due to potentially declining rates of intercourse with age, and lower overall health and access to medical care in societies without contraceptive use, more recent prospective studies also show an accelerating decline in fecundity by age 40 for women, whereas men's fertility is relatively stable. For example, Rothman et al. [2013], in a prospective study of 2,820 Danish women trying to conceive, find that women 35-40 years old will become pregnant 77% as frequently as women age 20-24, whereas for men this ratio is 95%.

[9] OK Trends, "The Case for an Older Woman," February 16th, 2010.

[10] If a true preference for fertility underlies the preference for younger women, then policies promoting access to assisted reproductive technology could help alleviate the marriage-market penalty to delayed marriage. If the preference for youth is exclusively a preference for younger looks, though, such policies would be ineffective (and the government may want to consider subsidies for Botox instead).

result from social norms or meeting opportunities, rather than men's preferences.

To determine whether there is indeed a causal impact of age on women's marriage market value, and quantify its impact, I implement an incentive compatible online experiment in which age is randomly assigned to dating profiles. That is, in the experiment two subjects will see the same picture, but each with a different assigned age. The random variation in age isolates it from other factors that may be correlated with it, such as physical attractiveness. Income is also randomly assigned to the profiles, providing a "numeraire" by which to quantify the preference for age. I then connect these results to an underlying preference for fertility by examining the heterogeneity in male raters' tastes.

2.1 Methodology

The methodology I use isolates age from other factors, while incentivizing participants to give honest responses. Respondents were recruited online to rate dating profiles, with each respondent rating 40 profiles. All characteristics on these (hypothetical) profiles were fixed, except for age and income, which were randomly assigned as the profile was viewed.

In order for the online experiment data to be valid, subjects must rate the profiles according to their own preferences. Yet, unlike in most traditional economics experiments, there is no clear way to incentivize truthful reporting in rating dating profiles. If the profiles were presented as real, in the context of a dating site or speed dating exercise, deception would be involved (since at least some portion of the profile, the exogenously assigned age and income, must be fake), which makes the experiment not truly incentive compatible. In order to elicit honest responses without deception, I introduce a novel strategy of providing non-monetary compensation whose value is tied to honest ratings in the study. Participants were offered free customized advice on their own online dating profiles to attract the type of people they were interested in *based on their answers to the experimental questions.* The customized advice was provided by a dating coach hired for this purpose.

Because participants are recruited using advertising for this compensation, and spend their time on the study in expectation of receiving it, I can assume participants place value on the advice and therefore want to increase its quality. The way to maximize the value of the compensation is to respond truthfully in the study, increasing the accuracy of the advice, just as in a traditional experiment the way to maximize one's payoff is by exerting effort in the game.[11]

[11]This type of non-monetary incentive structure for rating hypothetical objects has been expanded to study em-

For the initial sample, subjects were recruited using online ads, placed on dating sites or linked to searches of dating-related keywords. A sample Google ad is shown below:

A Better Dating Profile

Single & 30-40? Take this survey &

get expert dating profile advice!

www.columbiadatingstudy.com

Following the implementation of this initial experiment, I conducted a second, similar experiment in order to test for heterogeneity in men's preferences for age. Because this required a larger sample, I enlisted a survey firm, Qualtrics, to recruit respondents. These respondents were recruited through Qualtrics' relationship with marketing partners, which offer survey opportunities to their mailing lists in exchange for incentives (e.g., frequent flyer miles, gift certificates). As this second population was provided with other incentives in addition to the date coaching (which was still provided), the date coaching incentive could have been less powerful in eliciting truthful responses. However, because these respondents were not primarily interested in receiving dating advice, they may also be a more general population than my initial sample, thus providing some check on the original experiment's external validity. It is reassuring that the estimated effects are nearly identical between the two samples.

To generate the hypothetical dating profiles, a stock photo was randomly combined with a user name, height, and interests, which remained fixed to the profile (and are therefore absorbed by a profile fixed effect). Age (between 30 and 40) and income were randomly generated and assigned to profiles at the rater-profile level, in real time as they clicked through the survey tool. For additional details on the experimental methodology, as well as data summary statistics, see Appendix A.1.

2.2 Men's Preferences Over Age

I identify the effect of randomly assigned ages on ratings for men-rating-women and women-rating-men, using the specification:

$$Rating_{ij} = \beta_0 + \beta_1 age_{ij} + \beta_2 income_{ij} + \alpha_i + \theta_j + u_{ij},$$

ployer preferences in Kessler et al. [Forthcoming].

where $Rating_{ij}$ is the rating on a 1-10 scale that individual i gives profile j. Age and income are assigned at the rater–profile level. Because each individual rates 40 profiles, and each profile is seen by multiple individuals, I can include both rater, α_i, and profile, θ_j, fixed effects.[12]

Table 1 shows results for those who meet my sample requirements (of being between 30 and 40 and white), as well as all data collected (including incomplete responses).[13]

Table 1: Age-Rating Relationship for Men vs. Women

	Dependent variable: Profile rating			
	Male Raters		Female Raters	
	In Sample	All	In Sample	All
	(1)	(2)	(3)	(4)
Age	-0.044***	-0.024**	0.131***	0.079***
	(0.015)	(0.010)	(0.015)	(0.010)
Income ($0,000s)	0.061***	0.023**	0.134***	0.147***
	(0.016)	(0.011)	(0.016)	(0.011)
Constant	6.252***	5.811***	-0.160	4.493***
	(0.662)	(0.467)	(0.692)	(0.457)
Observations	1440	3752	1800	4220
R-Squared	0.471	0.487	0.394	0.452

Notes: Regression of profile rating on randomly assigned age and income, for men-rating-women in columns 1 and 2 and women-rating men in columns 3 and 4. Columns 1 and 3 are restricted to white individuals between 30 and 40. Columns 2 and 4 includes all data collected, including incomplete responses where not all profiles were rated. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

These results show that men rate women lower when the profile is presented with a higher age, whereas women rate men more highly when a higher age is shown. This lower rating is stronger for the targeted group of white men between the ages of 30 and 40, potentially because restricting in this way excludes individuals who were much older than the targeted age range, and may have less intense age preferences. The reduction in rating for an additional year of age is 0.044 points, on a scale from 1 to 10. Thus, if a woman is 10 years older, she will be rated 0.4 points lower on average. A woman who is $10,000 poorer is rated 0.06 points lower; thus to make up for each additional year of age, a woman must earn $7,000 more.

The contrasting results for men versus women demonstrate that the negative relationship be-

[12] In this section, I present heteroskedasticity-robust standard errors. Although errors may be correlated within an individual's responses, the "group" status, the individual, is not correlated with the x variable of interest, age, since it is orthogonally assigned within subject's rankings, and thus the criterion for requiring a cluster correction is not met. When examining heterogeneity among respondents in subsequent sections, I cluster results at the respondent level. See: Angrist and Pischke [2008], page 311.

[13] The considerable difference in observations between those specifications is because the complete dataset includes some individuals who did not complete the entire survey, and thus I lack information on their race or ethnicity.

tween a female profile's listed age and the rating cannot only be a "lemons" effect, where older women still on the market are judged to be less appealing. If this were entirely the channel of this negative preference, women rating men should show a similar aversion to age, although potentially less intense because men marry later. Instead, women show the opposite reaction to age.

Table 2 shows the results for men with several robustness checks. First, I restrict the analysis to only those who completed and submitted the survey, as those who did not may not have been incentivized to provide accurate data, since they did not claim the compensation. Then, I exclude subjects who opted out of the compensation, which happened in a small number of cases.[14] I next exclude individuals who have a low correlation between their "rate" responses and their "rank" responses, since this may indicate low attention. Next, I exclude the small number of individuals who took the survey prior to the implementation of a one-second load delay on the photographs, so that individuals would read the profile information more carefully before responding to the photo alone. None of these changes significantly alter the results.

Finally, I check whether photographic appearance versus reported age may be influencing the results. Photos likely *look* a certain age, and so when these photos are paired with higher ages, the person looks "good for their age," whereas when paired with lower ages the person looks "bad for their age." When the interaction between visual age (calculated by having 120 undergraduates guess the age of the person in each photo) and age is controlled for, the penalty for age, if anything, gets larger, although neither coefficient is significant.[15]

The experimental results show that men have a robust preference for younger partners, even when beauty is controlled for by exogenously assigning age to fixed profiles of potential partners. The remaining question is whether this preference is actually driven by a preference for fertility, and whether some of this preference operates on a conscious level.

2.3 Drivers of Preference

To understand the drivers of men's preferences for younger partners, I conducted a second experiment to examine how raters' characteristics interact with profile age. Because this requires looking at heterogeneity among respondents, rater-profile observations cannot be treated as independent, and thus a larger sample size is required (in this section, results are clustered at the rater level when

[14] As the compensation involved the sharing of individual data with a third party, human subjects considerations required I provide the option to opt out.

[15] "Visual age" itself is already controlled for through profile fixed effects. The interaction checks whether this element of the profile interacts with the assigned age, leading to a spurious age effect.

Table 2: Robustness Checks

	Dependent variable: Profile rating (Male raters)				
	Finished	No Opt Out	High Corr	Load Delay	Visual Age Control
	(1)	(2)	(3)	(4)	(5)
Age	-0.040**	-0.049***	-0.045***	-0.044***	-0.119
	(0.018)	(0.016)	(0.016)	(0.016)	(0.183)
Income ($0,000s)	0.066***	0.069***	0.062***	0.051***	0.061***
	(0.018)	(0.018)	(0.017)	(0.017)	(0.016)
Visual age × age					0.002
					(0.005)
Observations	1120	1280	1360	1320	1440
R-Squared	0.435	0.460	0.465	0.465	0.471

Notes: Regression of profile rating on randomly assigned age and income, for men-rating-women. Column 1 restricts to individuals who finished and submitted the survey, column 2 restricts to those who did not opt out of compensation, column 3 restricts to those with a high correlation in the two rating measures (to assure attention), column 4 excludes individuals taking the survey before a load delay in photos was implemented, and column 5 controls for the visual age of the photo (guessed by 120 undergraduates) interacted with actual age. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

rater characteristics are interacted with profile characteristics). For this experiment, I gathered a sample of 200 men through the survey firm Qualtrics, over-sampling high-income men in order to better match the distribution of respondents recruited through Google ads. I also collected data on 100 women to help confirm that the earlier results hold in this sample (and thus that the different recruitment mode did not alter the experiment's validity).

The basic age-rating analysis performed with Qualtrics data is shown in Table 3, confirming that this sample exhibits the same tradeoff between age and rating for male respondents, despite the different recruitment technique. In fact, the coefficient on age as a factor in male preferences has a remarkably similar coefficient between the two samples. The contrasting positive coefficient for women is also present in this sample.

As a first check on mechanisms driving preferences, I examine whether taste for similarly aged partners may affect the relationship between age and ratings, in Table 4. Is it possible men prefer not younger women, but rather similarly aged women, or women who are *slightly* younger only? To test for this, I control for the age difference squared, or the taste for similarity. I also perform a rescaling, where the independent variable is input as the age difference minus two, squared, for men and plus two, squared, for women—the "ideal" age difference.[16] This is essentially the same regression, but removes two years of age difference from the coefficient on age. Neither the addition

[16]There is some evidence of tastes for partner age taking this form, e.g., Hitsch et al. [2010], Choo and Siow [2006], Buss et al. [2000].

Table 3: Age-Rating Relationship for Men vs. Women: Qualtrics Sample

	Dependent variable: Profile rating		
	Male Raters		
	With Oversample	Natural sample	Female Raters
	(1)	(2)	(3)
Age	-0.043***	-0.062***	0.028***
	(0.006)	(0.009)	(0.010)
Income ($0,000s)	0.032***	0.007	0.036***
	(0.007)	(0.009)	(0.010)
Constant	9.768***	7.475***	3.340***
	(0.271)	(0.426)	(0.552)
Observations	8080	4040	4040
R-Squared	0.490	0.479	0.463

Notes: Regression of profile rating on randomly assigned age and income, for men-rating-women (columns 1 and 2) and women-rating-men (column 3), from the second sample collected via Qualtrics. High-income men were oversampled and are included in column 1, whereas column 2 restricts to the "natural" sample only. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

of age difference squared nor the adjustment for the ideal age difference eliminates men's preference for younger partners.

One of the surprising results in the experimental data is that women appear to have a *positive* preference for age. This positive preference indicates something residual besides fertility being captured by the age variable. Yet, when the distance from the two year "ideal" age difference is controlled for in the case of female raters, this apparent preference over age disappears (column 4). Thus, this apparent preference for older men is really a preference for men two years older than oneself. This is in contrast to the results for men, where a significant secular age preference is still present even after controlling for the two-year age difference.

I now turn to establishing the true drivers behind men's preferences for age, by interacting age with rater characteristics that may make men care more or less about fertility, in Table 5 . In each case, men's characteristics that indicate a preference for fertility result in a bigger rating penalty to women's age. The characteristics examined are wanting to get married, *Want marr*, wanting kids, *Want kids*, having no children, *No kids*, and having accurate knowledge of the age–fertility tradeoff, *Knowledge*.[17] Each of these are interacted with the main explanatory variable, *Age*, while the main effect for each rater characteristic is absorbed by the rater fixed effects.

When women's age is interacted with the rater wanting to get married, the main effect of age becomes smaller, while the interaction is negative and significant (although only at the 10% level).

[17] Measured as an indicator for awareness that fertility decreases for women before age 45.

Table 4: Controlling for Age Difference as Preference Channel: Qualtrics Sample

	Dependent variable: Profile rating			
	Male Raters		Female Raters	
	Age Diff Control	"Ideal" Age Diff	Age Diff Control	"Ideal" Age Diff
	(1)	(2)	(3)	(4)
Age	-0.040***	-0.024**	0.036**	0.004
	(0.009)	(0.010)	(0.015)	(0.012)
Income ($0,000s)	0.032***	0.032***	0.035**	0.035**
	(0.009)	(0.009)	(0.014)	(0.014)
(Age diff)^2	-0.004***		-0.008***	
	(0.001)		(0.002)	
(Age diff − "ideal")^2		-0.004***		-0.008***
		(0.001)		(0.002)
Observations	8080	8080	4040	4040
R-Squared	0.491	0.491	0.468	0.468

Notes: Regression of profile rating on randomly assigned age and income for men-rating-women (columns 1 and 2) and women-rating-men (columns 3 and 4), from the second sample collected via Qualtrics. Columns 1 and 3 controls for the age difference between the rater and the profile squared. Columns 2 and 4 control for the "ideal" age difference of the rater being two years older than the profile for male raters and the rater being two years younger for female raters. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses, clustered at the rater level.
*** p<0.01, ** p<0.05, * p<0.1

This means that men who want to get married dislike age *more* than men who may be looking for more casual relationships. This provides our first evidence that fertility may be driving the preference, because if it were a preference for the amenity value of younger women, we may expect men who *do not* want to get married to value it more. In the third column, we can see that men who want children soon also demonstrate a stronger preference for younger partners.

In the fourth column, I look at whether men already have children, as having no children currently may be a stronger indicator of seeking the option value to have kids than stated preferences. As expected, men with no kids have a very strong preference for younger women. In fact, with this interaction term inserted, the main effect of age becomes zero, indicating that men who already have children have *no preference* over randomly assigned age. This provides strong evidence that the preference being identified is really a preference over fertility, as other possible residual factors would be unlikely to diverge so strongly between men who have children and those who do not.

The final column interacts age with knowledge about fertility. The variable "Knowledge" represents the rater being aware that women's fertility begins to decline by age 45 (asked in the post-survey as "at what age does it become biologically difficult for a woman to conceive?"). For men who lack such knowledge, there is again *no preference* over age—the main effect is statistically zero—whereas for the knowledgeable men the negative perception of age is much stronger. Taken together, this table shows that the age preference found by this experiment is driven by men who have reason to care about fertility and have the knowledge to connect age to fertility.[18]

Table 5: Fertility Mediators: Qualtrics Sample

	Dependent variable: Profile rating (Male raters)				
	Base	Want marr	Want kids	No kids	Knowledge
	(1)	(2)	(3)	(4)	(5)
Age	-0.043***	-0.028**	-0.033***	0.002	-0.007
	(0.006)	(0.011)	(0.009)	(0.019)	(0.010)
Income ($0,000s)	0.032***	0.032***	0.032***	0.032***	0.032***
	(0.007)	(0.009)	(0.009)	(0.009)	(0.010)
Want marr × age		-0.032*			
		(0.019)			
Want kids × age			-0.055*		
			(0.032)		
No kids × age				-0.055**	
				(0.021)	
Knowledge × age					-0.057***
					(0.017)
Observations	8080	8080	8080	8080	7800
R-Squared	0.490	0.490	0.491	0.491	0.488

Notes: Regression of profile rating on randomly assigned age and income for men-rating-women, from the second sample collected via Qualtrics. Column 2 interacts profile age with whether the rater wants to get married. Column 3 interacts age with whether the rater wants kids. Column 4 interacts age with whether the rater currently has no children currently. Column 5 interacts age with whether the rater is aware that fertility declines before for women before age 45. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses, clustered at the rater level in columns 2 – 5

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

These results suggest that at least some of the observed preference for younger partners stems from preferences for fertility. If the negative coefficient on age instead captured a latent preference for attractiveness or other youthful qualities, whether or not the man wants to have children or knows about the age-fertility relationship should have no bearing on the strength of his preference. Moreover, it is reassuring that these different cuts of the data do not all capture the same characteristic—for example, one might think more mature men would have less preference over age, but the men who have children already are older, on average, than men without.

Tthese findings are consistent with a model of agents rationally maximizing utility: those with stronger preferences for children and more knowledge to act on these preferences penalize older

[18] Appendix A.3 further exploits the individual beliefs about when female fertility starts to decline to look for non-linearity in preferences over age as it relates to fertility. If the preference for age is really a preference for fertility, not all years should be the same: years closer to the fertility decline should affect dating market appeal much more than additional years very far from the fertility decline, or after the fertility decline, when there will be little marginal change to fertility. Table A4 shows that preferences indeed take this shape: additional years close to a rater's perceived fertility cutoff have a much greater impact on rating than age changes more than 10 years before the perceived cutoff or after the cutoff.

partners more. In other words, instinctive forces connecting age to beauty are not all that are at play. Thus, it is possible for fertility to impact men's preferences on the dating market, and therefore affect equilibrium matches, which I will explore in the next section.

3 A Theory of the Marriage Market with Reproductive Capital

If men value women's fertility, and human capital investments tend to impact both earnings and fertility (via age), it will have consequences for matching patterns, as well as women's willingness to invest in human capital. This section studies these effects using a bi-dimensional, transferable utility matching model.

Transferable utility matching models derive matching patterns from the efficient creation and division of surplus [Shapley and Shubik, 1971, Becker, 1973]. The equilibrium payoff of each individual in a marriage is set by the market as "offers" where both spouses are able to attract one another, essentially acting as prices based on the contribution of an individual's traits to the joint surplus and the scarcity of those traits on the market. Thus, the model simply requires assumptions on the form of the marital surplus to establish equilibrium matching patterns and resulting utilities. Moreover, we can then use the resulting utilities to gain insight into women's willingness to invest in human capital under different conditions.

Because we know that matching is generally assortative in income, and that a large driver of this is the presence of children as public goods in the household [Lam, 1988], I will start with a basic surplus function that is supermodular in male and female incomes, thus resulting in a prediction of assortative matching. To this surplus function, I will add the impact of biological fecundity: that children only occur with some probability. I will then show that when there are women who have both higher human capital and a lower probability of successfully conceiving, matching will not necessarily be assortative in income, and can in fact be non-monotonic. The predictions resulting from the matching equilibrium will then be used to consider women's willingness to invest in human capital in the first place.

3.1 Setup

In this model, career investments yield earnings gains, but delay marriage and childbearing. This is intended to capture the impact for women of large, lumpy career investments such as medical school plus residency, pursuing partnership at a law firm, or a PhD and the academic tenure track.

Men are characterized by just income, y_m, and women are characterized by both income, y_w, and fertility, p_w. How the surplus function responds to these characteristics will determine who should be matched with whom in equilibrium.

3.1.1 Household Problem

To produce a surplus function that is supermodular in incomes, which would lead to assortative matching in a unidimensional model, I start with utility functions where men and women each value private consumption, q, and children as a public good, Q, as discussed in Lam [1988]. With a single public good, the necessary and sufficient condition for transferable utility is generalized quasi-linear (GQL) utility [Bergstrom and Cornes, 1983, Chiappori and Gugl, 2014]. The simplest form of GQL is simple Cobb-Douglas utility, or "qQ" utility, which is discussed in depth in Chiappori [2017], and used, for example, in Chiappori et al. [2017b]. I make the minor adjustment of including $Q+1$ so that the couple cares about private consumption even if no children are realized. The utilities are thus:

$$u_m = q_m(Q+1)$$
$$u_w = q_w(Q+1).$$

The complementarity between investments in children and private consumption can be thought of as the human tendency to want our children to have similar levels of consumption as we enjoy: you value eating steak less if your children are eating porridge.

Because utility is fully transferable with these utilities, the allocation of income between children and private consumption can be found by maximizing the sum of utilities subject to the budget constraint. Assuming they have children, the couple's problem, once married, is thus:

$$\max_{q,Q} q(Q+1)$$
$$\text{s.t.} \quad q+Q = y_m + y_w.$$

Accordingly, the utility maximizing level of Q and the sum of private consumptions, q, is given by:

$$q^* = \frac{y_m + y_w + 1}{2}$$
$$Q^* = \frac{y_m + y_w - 1}{2}$$

as long as the sum of incomes is greater than 1 (which I will assume in the distribution of men's and women's incomes, for simplicity).

We now turn to my key addition to a standard framework: because children are only realized with probability p_w, we must consider the case where the couple is restricted to private consumption only, in case they fail to have children. Thus, the joint expected utility from marriage, T, is a weighted average between the optimal joint utility if a child is born and the fallback position of allocating all income to private consumption:

$$T(y_m, y_w, p_w) = p_w \frac{(y_m + y_w + 1)^2}{4} + (1 - p_w)(y_m + y_w).$$

If individuals remain single, they also simply consume their incomes, and so the surplus from marriage, $s(y_m, y_w, p_w)$, is:

$$s(y_m, y_w, p_w) = p_w \frac{(y_m + y_w + 1)^2}{4} + (1 - p_w)(y_m + y_w) - y_m - y_w.$$

Thus, the household surplus function is:

$$s(y_m, y_w, p_w) = \frac{1}{4} p_w (y_m + y_w - 1)^2. \tag{1}$$

3.1.2 Defining stable match

A matching is defined as the probabilities over the distribution of y_m types for matching with each (y_w, p_w) type, and value functions $u(y_m)$ and $v(y_w, p_w)$ such that for each matched pair:

$$u(y_m) + v(y_w, p_w) = s(y_m + y_w, p_w).$$

That is, their individual surplus shares add up to the joint surplus created by a match.

A matching is stable if two conditions hold:

$$u(y_m) + v(y_w, p_w) \geq s(y_m + y_w, p_w)$$

for all individuals in the marketplace, and

$$u(y_m) \geq 0$$
$$v(y_w, p_w) \geq 0$$

for all individuals matched in equilibrium.

That is, the utility received by any two individuals in their current matches must be jointly higher than the surplus they could create by matching together (the equation holds with equality if the pair is married to each other) and all individuals receive a positive benefit to marriage. In other words, there must be no pairings that create more utility for both people than the pair they are already in, meaning there are no "blocking pairs" for the match, and there are no matched individuals who wish to remain unmatched.

In this way, the surplus shares can be thought of as prices that clear the market for marriage partners. Thus, just like in a market with goods and prices, there exists the equivalent of the first welfare theorem: any stable match must maximize the aggregate marital surplus over all possible assignments [Shapley and Shubik, 1971]. That is, the stable match will be the decentralized enactment of the socially optimal equilibrium.

Thus, we can think about the form of the stable match by thinking about maximizing total welfare. Via total surplus maximization, supermodular surplus functions naturally lead to assortative mating in models with a single characteristic on each side of the market. However, in this market with two characteristics on the women's side, we will not necessarily observe assortative mating in equilibrium if there is negative co-movement between the woman's two characteristics.

3.1.3 Properties of the surplus function

The household surplus function given in equation (1) is supermodular in incomes, and is also supermodular in income and fertility. The key trait that will produce non-assortative matching is that the value of fertility *relative* to income increases in income.

If couples with richer men value fertility less relative to income, then there is no tradeoff in matching the richest, and least fertile, women with the richest men. However, if couples with richer men value fertility more relative to income, there is a fertility–income tradeoff that may make matching non-assortative on income.

To see this tradeoff mathematically, we can examine the change in surplus with regard to women's income compared to the change in surplus with regard to fertility. This ratio is essentially a marginal rate of substitution between the two traits in the surplus function.

$$
\begin{aligned}
MRS &= \frac{\frac{\partial s}{\partial y_w}}{\frac{\partial s}{\partial p_w}} \\
&= \frac{\frac{1}{2}p_w(y_m + y_w - 1)}{\frac{1}{4}(y_m + y_w - 1)^2} \\
&= \frac{2p_w}{y_m + y_w - 1}.
\end{aligned}
$$

Next, we need to examine how this rate of substitution changes in men's income:

$$\frac{\partial(MRS)}{\partial y_m} = -\frac{2p_w}{(y_m + y_w - 1)^2} < 0.$$

So, the richer the husband is, the more valuable fertility is relative to wife's income. This will create a counter-pressure on the force of supermodularity leading to assortative matching, and, if women with higher income have lower fertility, could yield non-assortative stable matches in equilibrium.

3.1.4 Distribution of Types

A key feature of biological fertility is that it does not decline linearly with age, but rather declines precipitously beginning in a woman's mid-thirties. As a result, this means the human capital - reproductive capital tradeoff is also not linear. Some amount of human capital can be acquired without incurring reproductive capital losses, but larger human capital investments will incur a reproductive capital penalty. To illustrate this fact, as well as the key feature of this model, that it allows assortative matching when fertility is held constant, but will lend itself to non-assortative matching when there is an income–fertility tradeoff, let there be three types of women: low income and high fertility, L, medium income and high fertility, M, and finally high income and low fertility, H.

Roughly, you can think of the three types as being high school, college, and graduate-educated women. The results produced by this three-type model are qualitatively similar to a model with continuous income and discrete fertility, see Low [2014], but have the added advantage of mapping well onto empirical exercises, where women's education is typically used as the underlying "type," since income is chosen endogenously post-marriage. The mass of the three types of women will for now be exogenously given, as g^K, where $K \in L, M, H$.

The three types of women have the following income–fertility pairs:

	y_w	p_w
$L:$	$\gamma - \mu_\gamma$	$\pi + \delta_\pi$
$M:$	γ	$\pi + \delta_\pi$
$H:$	$\gamma + \delta_\gamma$	π

In other words, δ_γ is the income premium to being the high type (versus medium), and δ_π is the fertility penalty. μ_γ is the income premium to being the medium versus low type.

Men will be characterized by a continuous income variable, $y_m \sim f$.

3.2 Matching Equilibrium

Because the stable match will also be surplus maximizing, we can determine the properties of the stable match by looking at the relative benefit men of different incomes receive by matching with the three types of women. Making the types explicit, in other words, allows the translation of the properties of the surplus functions into the difference in surplus received by men of different types from "switching" between different types of women. This relative, rather than absolute, benefit is key for stability because if any man receives a higher relative benefit to, say, a H versus M woman than a man currently matched with a H woman, he would be willing to trade partners and offer a higher share of the resulting surplus to the H woman, creating a blocking pair.

The three relative surplus differences are as follows.

Medium versus low:

$$\begin{aligned}\Delta^{M-L}(y_m) &= s\left(y_m, \gamma, \pi + \delta_\pi\right) - s\left(y_m, \gamma - \mu_\gamma, \pi + \delta_\pi\right) \\ &= \frac{1}{4}(\pi + \delta_\pi)\mu_\gamma\left(2y_m + 2\gamma - \mu_\gamma - 2\right).\end{aligned}$$

High versus medium:

$$\Delta^{H-M}(y_m) = s(y_m, \gamma + \delta_\gamma, \pi) - s(y_m, \gamma, \pi + \delta_\pi)$$
$$= \frac{1}{4}\pi\delta_\gamma(2y_m + 2\gamma + \delta_\gamma - 2) - \frac{1}{4}\delta_\pi(y_m + \gamma - 1)^2.$$

High versus low:

$$\Delta^{H-L}(y_m) = \Delta^{H-M}(y_m) + \Delta^{M-L}(y_m).$$

$\Delta^{M-L}(y_m)$ is linear, and monotonically increasing in men's income. Thus, there is always a higher surplus benefit from pairing a higher income man with a higher-income-type woman, corresponding to the supermodularity in the surplus function. Thus, any stable match must match M women with higher income men than L women.

Δ^{H-M} is quadratic, giving it a unique maximum. The implication of this is that there is a single interval of men that it is maximally beneficial to pair with high-income women. However, this interval may not be the richest men. Note that even when $\Delta^{H-M}(y_m)$ is positive over the full range of y_m, indicating that all men prefer H women to M women, the richest men may not be matched with the richest women, because they do not value the match sufficiently to pay the "price" these women command. This quadratic form is related to the tension between the supermodularity of the surplus function and the decreasing marginal rate of substitution between income and fertility.

$\Delta^{H-L}(y_m)$ is also quadratic, implying that there is a unique interval of men that should be matched with H versus L women, when relevant.

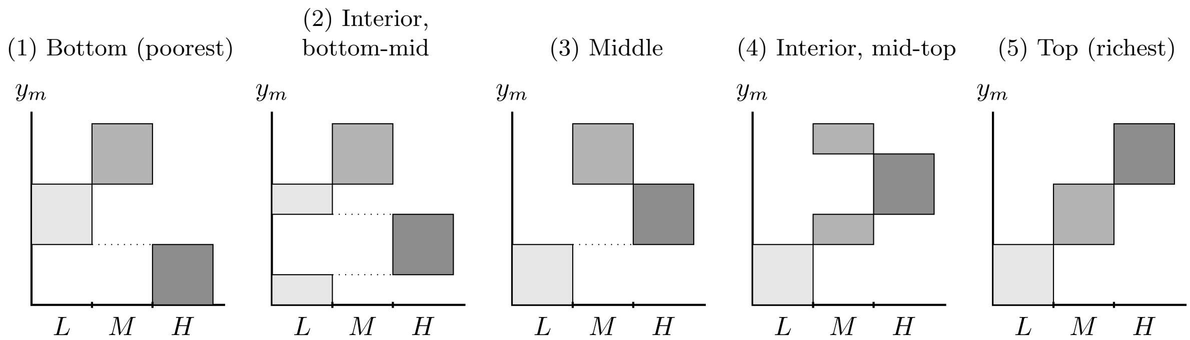
From this we can derive the following lemma.

Lemma 1. *Any stable matching will exhibit the following three characteristics:*

1. *All matched men will be higher income than all unmatched men.*
2. *All men matched with M women must be higher income than all men matched with L women.*
3. *The set of men matched with H women must be continuous.*

Proof. Item (1) follows from the fact that the surplus function is monotonically increasing in men's income, regardless of the partner, as long as the total household income exceeds 1 (which was assumed). Item (2) follows from the fact that the benefit to matching with a medium type versus

Figure 2: Possible matches: H women match with...



a low type is monotonically increasing in income. Item (3) follows from the fact that the benefit of matching with a high type versus medium or low type is single-peaked: If there is a gap in the men who are matched with H women, then the men in the gap must be matched with L or M women. But, as the benefit to matching with H women over L or M women is single-peaked, it cannot simultaneously be better to be matched with H women on both sides of the gap than in the gap. □

The options for the match that meet these criteria are illustrated in Figure 2. To think about the possible matches, imagine lining up men in order of income. Starting from the richest man, pair men with M type women until there are no M women left. Then pair men with L women until there are no L women left. Finally, pair men with H women until there are no H women left. This is equilibrium type 1. Next, move the segment of men who match with H women up one man at a time, replacing the partners of the men formerly matched with H women by L women. There will now be men matched with L women on either side of the men matched with H women—this is equilibrium type 2. When there are no L women left, the segment of men matching with H women will lie directly between those matching with L and those matching with M women—this is equilibrium type 3. If we continue to move the segment up one man at a time, we will need to replace H partners with M partners, leading to equilibrium type 4, where there are men matched with M women on either side of the segment of men matching with H women. Finally, if we continue to move the segment up until there are no more M women, H women will be matched with the richest men, which is equilibrium type 5.

In all options except for the final one, the match features non-monotonicity in income-matching. *Some* richer men are matched with richer women than some poorer men, while other still richer men are matched with poorer women. These options show the strong tendency of the model to produce non-monotonic matches when the highest income women also have low fertility.

Note that even when the highest income men create the highest surplus from matching with high-income women, they may still match with lower-income women because the relative benefit of high versus medium women is not as high for them, and thus they are not willing to "pay" as much for these matches. Again, this is because even though higher income men value income more, they value fertility more relative to income.

Which form of the equilibrium match will be the stable match depends on the parameter values. The rules for the match outlined in Lemma 1 allow me to reduce the surplus maximization problem to determine the form of the stable match to a single-variable optimization problem, where the only unknown is the income of the bottom man who receives an H match.

The next section demonstrates the precise form of the stable, surplus maximizing, match for any parameter values, and shows that the equilibrium will move from (1) to (5) as either the fertility penalty from investing falls or the income gain rises.

3.2.1 Stability of Different Match Types

To write down the maximization problem to find the stable match for any parameter set, we need a bit of additional notation.

As previously mentioned, the mass of each female type is g^K, where $g^L + g^M + g^H = 1$. Because there is measure 1 of women, only measure 1 of men can be matched, and so define $F(y_m)$ as a CDF of men, ranging from y_0 for the poorest man who receives a match ($F(y_0) = 0$) to Y for the richest man who exists ($F(Y) = 1$).

Because the question is where to place the segment of men matching with H type women, we need to define the boundary men for each possibility:

- If we pair all H type women with the poorest men, as in equilibrium 1, call the top man in this segment $y_{\underline{H}}$ (the bottom man is y_0.) Note that $y_{\underline{H}} = F^{-1}(g^H)$.
- If H type women are paired with the middle men (above those matched with L women and below those matched with M), as in equilibrium 3, call the bottom man in this segment $y_{\underline{L}}$ and the top man $y_{\bar{M}}$, where $y_{\underline{L}} = F^{-1}(g^L)$ and $y_{\bar{M}} = F^{-1}(1 - g^M)$.
- If H type women are paired with the richest men, as in equilibrium 5, call the bottom man

in this segment $y_{\bar{H}}$ (the top man will be Y), where $y_{\bar{H}} = F^{-1}(1 - g^H)$

Let the bottom man matched with a type H woman be $\underline{y}$ and the top man be $\bar{y}$, where $\bar{y} = F^{-1}(F(\bar{y}) + g^H)$. Finally, let $s^K(y_m)$ represent the surplus obtained from a match with a man of income y_m and a woman of type $K \in L, M, H$.

We can now write down the single variable optimization problem to maximize the total surplus by choosing $\underline{y}$, the bottom of the range of men to be matched with H women:

$$\max_{\underline{y} \in y_0, y_{\bar{H}}} \begin{cases} \max\limits_{\underline{y} \in y_0, y_{\underline{L}}} \int_{y_0}^{\underline{y}} s^L(y) f(y)\, \mathrm{d}y + \int_{\underline{y}}^{\bar{y}} s^H(y) f(y)\, \mathrm{d}y + \int_{\bar{y}}^{y_{\bar{M}}} s^L(y) f(y)\, \mathrm{d}y + \int_{y_{\bar{M}}}^{Y} s^M(y) f(y)\, \mathrm{d}y, \\ \max\limits_{\underline{y} \in y_{\underline{L}}, y_{\bar{H}}} \int_{y_0}^{y_{\underline{L}}} s^L(y) f(y)\, \mathrm{d}y + \int_{y_{\underline{L}}}^{\underline{y}} s^M(y) f(y)\, \mathrm{d}y + \int_{\underline{y}}^{\bar{y}} s^H(y) f(y)\, \mathrm{d}y + \int_{\bar{y}}^{Y} s^M(y) f(y)\, \mathrm{d}y. \end{cases}$$

The first order conditions of this problem reduce to setting the relative surplus gain from matching with a high type for $\underline{y}$ equal to those for $\bar{y}$. In other words, for the first case, where the men matching with H women split the men matching with L women, $\Delta^{H-L}(\underline{y}) = \Delta^{H-L}(\bar{y})$. When there is a corner solution such that $\underline{y}^* < y_0$, equilibrium 1 is the stable match. When there is an interior solution, equilibrium 2 is the stable match. When there is a corner solution such that $\underline{y}^* > y_{\underline{L}}$, we check the solution for the second case. The first order condition of the second case, where the men matching with H women split the men matching with M women, will be $\Delta^{H-M}(\underline{y}) = \Delta^{H-M}(\bar{y})$. If there is a corner solution to this second problem, where $\underline{y}^* < y_{\underline{L}}$, then equilibrium 3 is the stable match (both objective functions are maximized by $y_{\underline{L}}$). If there is an interior solution, equilibrium 4 is the stable match. And finally, if there is a corner solution where $\underline{y}^* > y_{\bar{H}}$, equilibrium 5 is the stable match.

This leads us to the following proposition for when the match will take each form, which is illustrated in Figure 3.

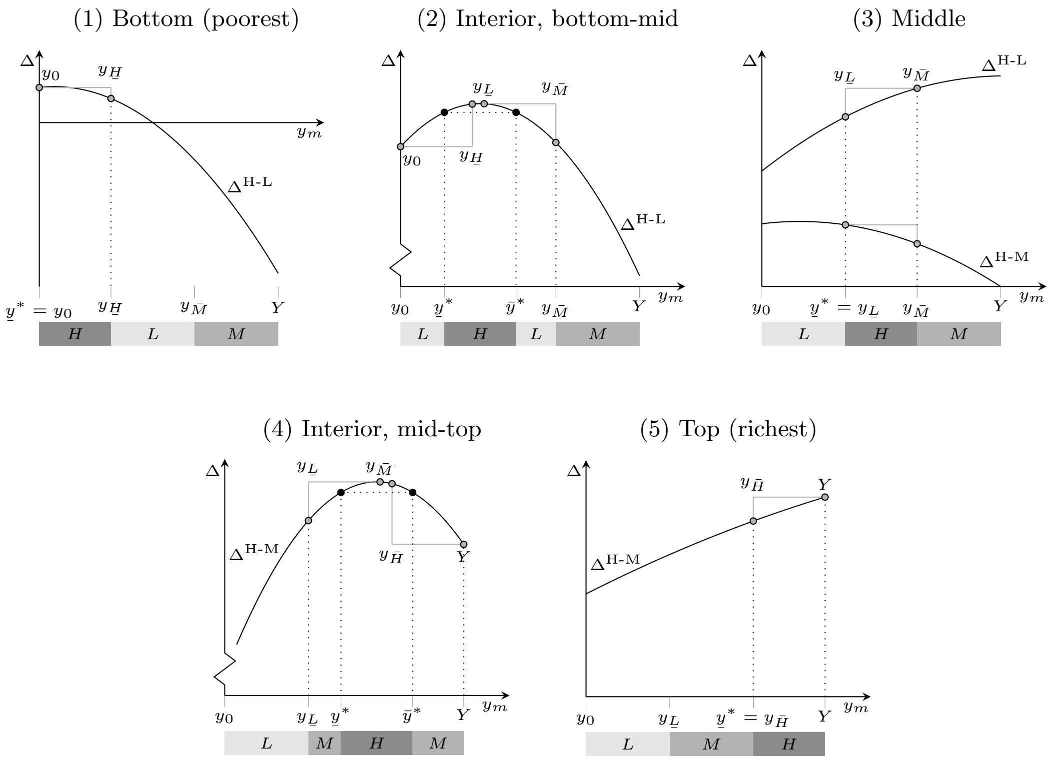
Proposition 1. *The unique stable match is fully characterized by Lemma 1 and the following conditions:*

- *If* $\Delta^{H-L}(y_{\underline{H}}) \leq \Delta^{H-L}(y_0)$,

  H women match with poorest men, from y_0 to $y_{\underline{H}}$.

- *If* $\Delta^{H-L}(y_{\bar{M}}) < \Delta^{H-L}(y_{\underline{L}})$ *and* $\Delta^{H-L}(y_{\underline{H}}) > \Delta^{H-L}(y_0)$,

Figure 3: Illustration of surplus difference conditions for different matching equilibria



Notes: δ_π and δ_γ vary by panel as follows. 1: $\delta_\pi = 0.65$, $\delta_\gamma = 1.0$; 2: $\delta_\pi = 0.4$, $\delta_\gamma = 2.0$, 3: $\delta_\pi = 0.19$, $\delta_\gamma = 2.5$, 4: $\delta_\pi = 0.11$, $\delta_\gamma = 2.5$, 5: $\delta_\pi = 0.05$, $\delta_\gamma = 3.0$. Women's medium-type income is 4, low-type is 2. Baseline fertility is a 0.3 chance of conceiving. Men's income ranges uniformly from 0 to 6 (total mass of 1), and for women there is a mass of 0.35 low types, and 0.35 medium types, and 0.3 high types. This means $y_{\underline{H}}$ is 1.8, $y_{\underline{L}}$ is 2.1, $y_{\bar{M}}$ is 3.9, and $y_{\bar{H}}$ is 4.2.

H women match with men interior to the set matching with L women, where $\Delta^{H-L}(\underline{y}^*) = \Delta^{H-L}(\bar{y}^*)$.

- *If $\Delta^{H-L}(y_{\bar{M}}) \geq \Delta^{H-L}(y_{\underline{L}})$ and $\Delta^{H-M}(y_{\bar{M}}) \leq \Delta^{H-M}(y_{\underline{L}})$,*

  H women match with middle men, from $y_{\underline{L}}$ to $y_{\bar{M}}$.

- *If $\Delta^{H-M}(Y) < \Delta^{H-M}(y_{\bar{H}})$ and $\Delta^{H-M}(y_{\bar{M}}) > \Delta^{H-M}(y_{\underline{L}})$,*

  H women match with men interior to the set matching with M women, where $\Delta^{H-M}(\underline{y}^*) = \Delta^{H-M}(\bar{y}^*)$.

- *If $\Delta^{H-M}(Y) \geq \Delta^{H-M}(y_{\bar{H}})$,*

  H women match with richest men, from $y_{\bar{H}}$ to Y.

Proof. The conditions in Lemma 1 create a single-variable maximization problem that has a unique solution for any given parameters. The solution is found through the first-order conditions of the problem, and the cutoffs for each equilibrium type is found through the boundaries for corner solutions. □

The intuition for these conditions can be seen by imagining in Figure 3 that one is sliding the segment of men matching with H women around. Whenever the gain to matching with an H woman from the bottom end of the segment exceeds the gain from the top end, the segment should be "slid" down. When the gain from the top end exceeds the gain from bottom end, the segment should be "slid" up. When the H segment is exactly between the L and M segments, sliding it down requires comparing the benefit to an L versus H type, while sliding it up requires comparing the benefit to an M versus H type, so this equilibrium will occur over a range of parameters.

Note that these cutoffs are simply conditions on the underlying parameters. For example, the condition for assortative matching to occur, as in equilibrium 5, is as follows:

$$\frac{\pi}{\delta_\pi}\delta_\gamma \geq \frac{1}{2}(Y + y_{\bar{H}}) + \gamma - 1.$$

Thus, the condition of assortative matching relies on the impact of investment on income and fertility relative to men's highest possible income, the number of women who invest, and women's baseline income.[19]

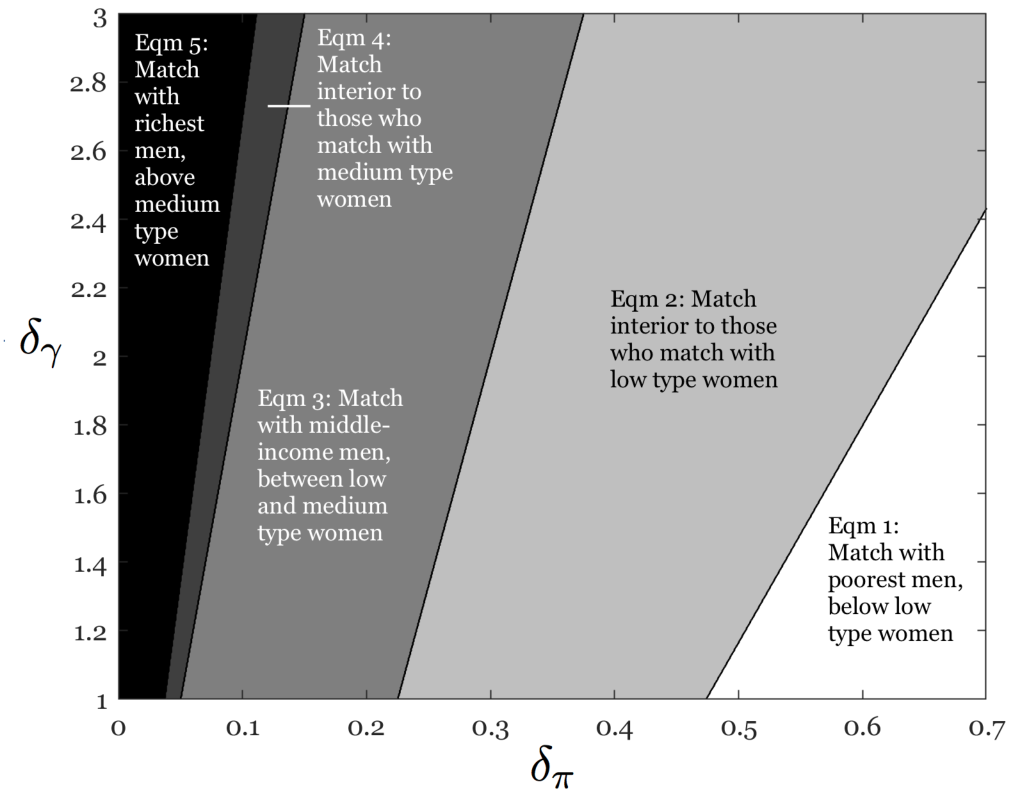
Figure 4 illustrates the boundary conditions with a uniform distribution and some parameters fixed, showing the range of δ_γ, the financial return to investment, and δ_π, the fertility penalty, that support different equilibria types. As δ_γ/δ_π increases, the equilibrium progresses to assortative matching.

As previously noted, the non-monotonicity present in all but the final equilibrium is an inherent product of the surplus function, specifically the combination of supermodularity and a decreasing marginal rate of substitution between income and fertility. In fact, for any set of parameters a non-monotonic equilibrium will arise as long as the richest man is "rich enough."

Proposition 2. *Let Y represent the income of the richest man. For any set of parameters, it is possible to find a Y large enough such that the equilibrium match is non-monotonic in income.*

[19] All conditions with Δ^{H-M} will be of the same form. Conditions with Δ^{H-L}, for example for H women to marry the poorest men, will be of the form $\frac{\pi}{\delta_\pi}(\delta_\gamma + \delta_\mu) \leq \frac{1}{2}(y_0 + y_{\underline{H}}) + \gamma - \mu_\gamma - 1$.

Figure 4: Returns to investment and fertility penalties that support different equilibria



Notes: Men's income ranges uniformly from 0 to 6 (total mass of 1), and for women there is a mass of 0.35 low types, and 0.35 medium types, and 0.3 high types. Women's medium-type income is 4, low-type is 2. Baseline fertility is a 0.3 chance of conceiving.

Proof. Suppose not. Then, all H women must be matched with richer men than all M women. For this match to be stable, it must be that $\Delta^{H-M}(Y) \geq \Delta^{H-M}(y_{\bar{H}})$, since otherwise men in the neighborhood of $y_{\bar{H}}$ would be able to form a blocking coalition with H women, since they receive more benefit from matching with H types than men in the neighborhood of Y, and thus could offer a greater share of the surplus. Given that $\Delta^{H-M}(y_m)$ is quadratic, though, it is possible to make Y sufficiently larger such that $\Delta^{H-M}(Y) < \Delta^{H-M}(y_{\bar{H}})$, in which case the total surplus could be increased by matching mean near $y_{\bar{H}}$ with H women and men near Y with M women, in which case the match would not be assortative everywhere. In fact, the match can be improved by lowering the segment of men matched with H women until the benefit to the first man matched with an H woman is equal to the benefit to the last man matched with an H woman, creating a non-monotonic match where richer men match with richer women until the segment of the richest men who match with M women while poorer men match with H women. $\square$

Intuitively, we can also see that because the condition for assortative mating relies on Y, ($\frac{\pi}{\delta_\pi}\delta_\gamma \geq \frac{1}{2}(Y + y_{\bar{H}}) + \gamma - 1$), it is possible to increase Y sufficiently such that the condition is never met, for any parameters.

3.3 Endogenous Human Capital Investment

The fact that the highest human capital women will not necessarily match with the richest men may influence women's ability to invest in human capital in the first place. In fact, the marriage market creates a "tax" on women's human capital investments, as men's preference for fertility reduces the marriage market returns to intensive human capital investments. However, this does not necessarily mean women will not invest in human capital.

Recall that even when H women are not matched with the richest men, it is because they can command a higher surplus share by matching with poorer men, because the relative benefit is higher for poorer men. Thus, it is possible for H women to still receive greater utility in equilibrium than M women even if they are not matched with the highest-income men. In other words, if investment decisions were made endogenously, women could willingly become the H type, despite "losing out" on the best men on the marriage market. Although they may not match with the best men, they receive a higher surplus share from the somewhat lower income men, with whom they generate more *relative* surplus. This section discusses women's equilibrium surplus shares and investment decisions concretely.

3.3.1 Equilibrium utilities

I first describe the process for calculating the equilibrium utilities, which are needed to back out the payoff to women of investing in human capital. Because the stable match results from a competitive market, we can recover these utilities as the "prices" associated with each individual. That is, we can calculate the surplus share each individual receives, or the utility over and above their counterfactual single utility.

Because at the stable match the sum of any two individuals' utilities must be greater than or equal to the surplus they could create from marrying one another, we can imagine the matching process as each spouse choosing the partner that maximizes his or her own share of the surplus conditional on keeping his or her spouse happy. That is, for women:

$$v(y_w, p_w) = \max_{y_m}\{s(y_m, y_w, p_w) - u(y_m)\}.$$

The first order condition of this problem dictates that the slope of the husband's value function must equal the slope of his contribution to the surplus:

$$\begin{aligned} u'(y_m) &= \frac{\partial s(y_m, y_w, p_w)}{\partial y_m} \\ &= \frac{1}{2} p_w (y_m + y_w - 1). \end{aligned}$$

Because men's partner type does not change locally with their income except at the "boundaries" of a given female type, we can ignore the woman's type and integrate this function to pin the utility down to an additive constant. Then, we know what men's surplus share will be when matched with each of the three types of women:

$$u^K(y_m) = \frac{1}{4} p_w^K y_m (y_m + 2y_w^K - 2) + \mu^K$$

where $K \in L, M, H$, and p_w^K and y_w^K refer to the fertility and income of a K type woman.

Women's surplus shares will be a constant for each type, v^K. We can solve for each of the constants and the woman's surplus shares using two sets of restrictions. First, that for each couple the two surplus shares must add up to the surplus produced by the match, and second, that for each male type at a "boundary" between two female types, the utility achieved through each match must be the same. This pins down all values except for the division of surplus between the poorest man and his wife.

Assuming initially that there are more men than women in the market provides this restriction, and allows us to assume the poorest man receives no surplus (since otherwise the unmatched men would compete to take his place), and thus $u(y_0) = 0$ (with his total utility simply equaling y_0).

I will now go through an example of this process for equilibrium 3, where high-income women are matched with the middle income men, from $y_{\underline{L}}$ to $y_{\bar{M}}$.

The two "boundary" men, $y_{\underline{L}}$ and $y_{\bar{M}}$, must be indifferent between their possible partners, as otherwise the match will not be stable. Thus we know $u^L(y_{\underline{L}}) = u^H(y_{\underline{L}})$ and $u^M(y_{\bar{M}}) = u^H(y_{\bar{M}})$. This allows us to pin down the constants μ^M and μ^H relative to μ^L (as a function of $y_{\underline{L}}$ and $y_{\bar{M}}$, but recall these are simple functions of the densities of female types, g^K). To pin down μ^L, we use the assumption that there are more men than women, and thus the lowest-income man earns 0 surplus, and thus $u^L(y_0) = 0$.

From here, we can solve for the female surplus shares in each pairing, which will each be a constant simply using the total surplus restriction:

$$v^K = s^K(y_m) - u^K(y_m).$$

We then have a full characterization of women's and men's surplus shares from marriage, and can further characterize their full utility based on their single utility plus the surplus share, i.e., for men $y_m + u^K(y_m)$ and for women $y_w^K + v^K$.

Note that a woman's value function responds to fecundity loss through two channels. First, even if the woman's consumption level stayed constant, her utility would be reduced through the lower probability of conceiving, since children directly impact her utility. However, her consumption will also be reduced via the marriage market equilibrium, given that lower fecundity also lowers her husband's utility, and thus he requires a greater share of the available consumption in order to agree to the match.

3.3.2 Investment Decision

Having the utilities fully characterized allows us to consider what women would choose if educational investment were endogenous. For this illustration, we will keep the distribution of low and medium types as exogenous, but let medium types be able to choose to make a human capital investment to become the high type.

Within a type, all women receive the same marital surplus, v^K, in addition to the income associated with their type. In other words, women's total utility is:

$$\begin{aligned}
U^H &= \gamma + \delta_\gamma + v^H \\
U^M &= \gamma + v^M \\
U^L &= \gamma - \delta_\mu + v^L.
\end{aligned}$$

Thus, women will invest in becoming the high type when:

$$c_i \leq v^H - v^M + \delta_\gamma$$

The mass of high types will now be endogenously determined as a function of the underlying density of c_i. This mass affects the value functions for men and women through its impact on the y_m at the boundary between different wife-types. If there are very few high-type women, the conditions for an assortative equilibria may be met under different conditions than if there are many high-type women.

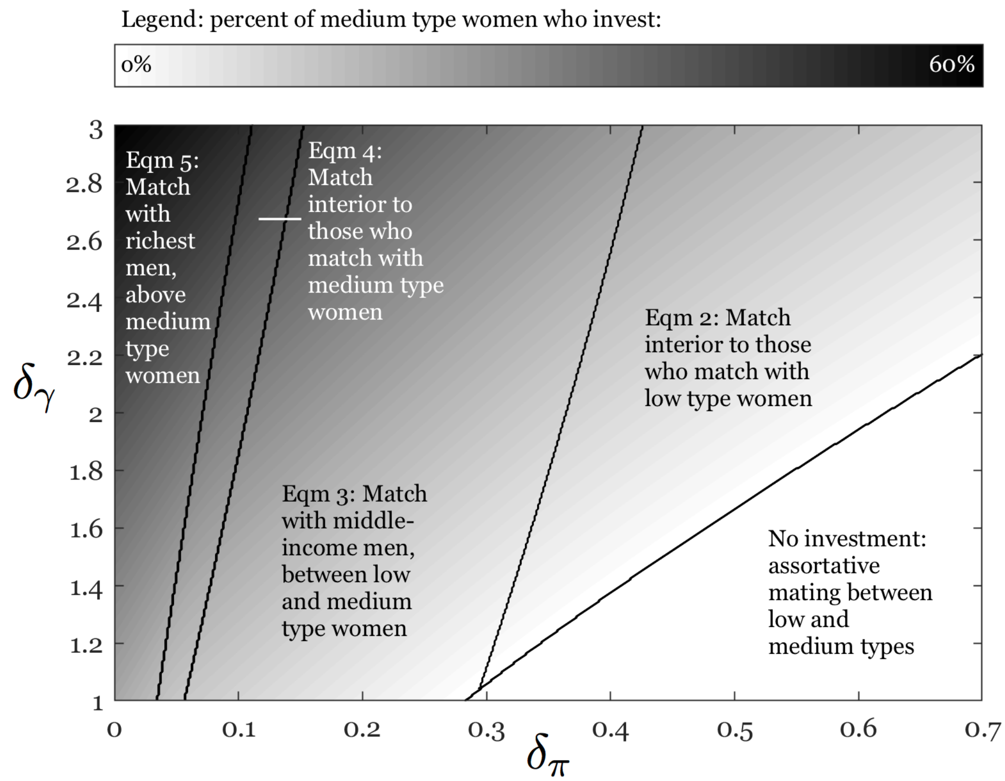
Thus, the cutoffs for women investing can be solved for as a fixed point of $c_i = v^H(c_i) - v^M(c_i) + \delta_\gamma$. Call the solution to this equation $\hat{c}$. There will be a unique equilibrium where all women with costs below $\hat{c}$ invest in becoming the high type, and then match according to Proposition 1. If no women invest, the matching will be assortative between low and medium types. The threshold cost for investment $\hat{c}$ is decreasing in δ_π (fewer women invest as the fertility cost rises) and increasing in δ_γ (more women invest as the income premium rises).

Figure 5 illustrates the portion of women that invest for a simple example, where the costs of investment range uniformly from 0 to $2Y$. The figure illustrates the interesting difference in the forces driving women's investment decision versus the marriage market equilibrium. As the figure shows, women's investment changes more in δ_γ, the financial return to investment, while the marriage market equilibrium is more influenced by δ_π the fertility penalty. This is because women get the financial benefit of their investment in addition to the marriage market payoff, and thus receive an extra financial incentive to invest that does not appear in the marital surplus, which is what influences the matching equilibrium.

3.4 Empirical predictions

Non-monotonic matching The first empirical prediction of the model is that we may not expect the matching relationship between men's and women's income to be monotonic. If income and fertility are negatively related in the distribution of women, the richest men will not be matched with the richest women. We can think of the groups as being different education levels. As long as the education levels affect primarily human capital, and not reproductive capital, we expect that matching will be assortative—as women's education increases, their spouses' incomes will also increase. However, for education levels associated with a loss of reproductive capital, husband's income may decrease.

Figure 5: PORTION OF WOMEN WHO INVEST AND THE MATCHING EQUILIBRIUM OVER δ_γ AND δ_π



Notes: Men's income ranges uniformly from 0 to 6 (total mass of 1), and for women there is a mass of 0.35 low types, and 0.65 medium types who have the option to invest. Women's medium-type income is 4, low-type is 2. Baseline fertility is a 0.3 chance of conceiving. The cost of investment ranges from 0 to 12–thus, when half of women invest, women with a cost up to 6 invest.

Trend toward increased assortative matching The model predicts that if either δ_π, the fertility penalty to investment, falls, or δ_γ, the income premium, rises, women will both experience better matches and invest more in higher education. An increase in δ_γ is natural to think about, as women may experience less discrimination in high-earning professions, and the returns to skill on the labor market are rising.

δ_π is also likely to be rising over time, first, due to increased availability of assisted reproductive technologies and secondly due to smaller desired family sizes over time (see "quantity–quality trade-off," below), which makes the time impact of women's investments less costly from a reproductive perspective.

As a result of these changes, we would expect matching to become more assortative on income. Moreover, more women would make time-costly educational and career investments.

Changes in marriage and divorce rates By extending the model a bit, we can make a further prediction. In the model everyone marries deterministically. But, if we imagine there is a stochastic taste for marriage that is a simple utility bonus or cost to being married versus single, some individuals may choose to stay single. And, if we further imagine that this shock can be redrawn after marriage, some individuals may divorce.

Importantly, recall that a high type woman's total utility if married is $U^H = \gamma + \delta_\gamma + v^H$. The "marital premium," v^H, is a function of both δ_γ and δ_π. If she is unmarried, her utility is simply $\gamma + \delta_\gamma$. In other words, when unmarried, she is unaffected by δ_π, whereas she still gets the benefit of her investment through her own income. So, as technology improves or desired family size falls, we expect marriage rates to rise and divorce rates to fall for type H women, as marriage will provide a larger benefit over and above singlehood.

Quantity–quality tradeoff Currently the model assumes that investments in children, Q, encompass investments in both the number and quality of children. However, we know that economic development tends to be accompanied by a substitution of child quality for child quantity (see, e.g., Doepke [2015]), which has implications for the penalty to aging on the marriage market.

If the desired quantity of children falls, and quality increases, later-life fertility becomes less of an issue, since fewer children can be had earlier in life. At the same time, the benefits of women's education for children's quality increases. We can think of this as a fall in δ_π (as well as other potential shifts in the surplus function increasing the value of women's human capital, see Footnote 24). Thus, if desired child quantity falls, we expect an increase in assortative mating, and an increase in marriage and fall in divorce rates for the highest educated women, who previously experienced a reproductive decline.

I now turn to discussing empirical evidence of these patterns in US Census data..

4 Model Relevance to Historical Data

4.1 New Stylized Facts

The model suggests that time-consuming human capital investments represent a double-edged sword: on the one hand, human capital is generally considered a positive marriage market trait, and likely to help attract a high-income spouse. On the other hand, income-increasing investments take time, decreasing what could be another valuable asset on the marriage market, reproductive capital.

This means that not all human capital investments are created equal; those that take place later in life and take longer are more likely to carry potentially negative marriage market effects, whereas short investments before childbearing years, such as earning a college degree, would be unambiguously positive. To see if there is support for the marriage market reproductive capital–human capital tradeoff in the data, I examine how the marriage outcomes of women with graduate degrees compare to those of women with college degrees.[20]

Essentially, I consider women with college degrees "type M" women, since they increase their earning potential without substantially affecting their reproductive capital, and women with graduate degrees (MAs, MDs, JDs, PhDs, MBAs, etc.) "type H" women, since these investments likely affect both traits.

Note that I do not mean to imply that getting a graduate degree is the only path to making a time-intensive human capital investment, nor that all of these women have necessarily delayed marriage to the point of interfering with fertility. Rather, the presence of a graduate degree provides an easy way to identify in data a group of women that *on average* marries later and earns more than college educated women.[21] Some of these women are likely to have made additional on-the-job career investments that may further delay childbearing, such as joining the partner or tenure track.

Looking at spousal income by women's education category provides empirical support for the non-monotonic matching pattern suggested by the model. In Figure 6, we see that in the 1970, 1980, and 1990 census, college educated women were married to richer spouses than non-college-educated women, but graduate educated women were married to *poorer spouses* than college-educated women.[22]

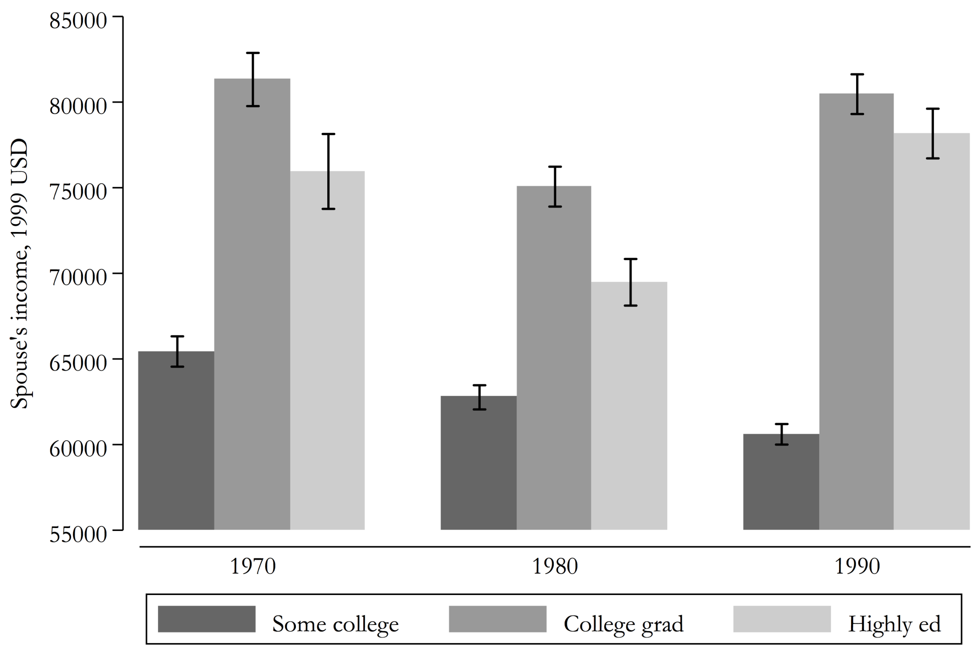
This "penalty" to graduate education is significant in all three decades, although somewhat dissipating by 1990, and is also present in the 1960 data, although very few women received graduate

[20] Much empirical work categorizes all women with college degrees as "college plus." However, the "reproductive capital" hypothesis suggests women with college degrees and graduate degrees may have very different marriage market outcomes, since women with college degrees only could still marry quite young and have large families.

[21] Data from the US Census shows that graduate educated women in the 2010 Census had married about one year later and earned $16,000 more than college educated women, shown in Table 6.

[22] For empirical results in this section: US Census and ACS sample is restricted to white individuals in their 40s, so that the vast majority of first marriage matching activity and educational investments have already taken place by the time they are observed. I analyze each ten-year cohort in a single Census year, rather than analyzing multiple groups retrospectively, which allows greater homogeneity of current life situation, since most variables, such as income, are reported for the present time only. I restrict to first marriages when showing results for only 1980 and 2010, but use all marriages when showing results across Census years, to allow for comparability with 1990 and 2000 data, which do not contain a variable for marriage number.

Figure 6: Non-monotonicity in spousal income by wife's education level



Notes: Income of spouse based on wife's education level, with "highly educated" constituting all formal education beyond a college degree. Difference between college and highly educated women's spousal earnings is significant in all three samples. 95% confidence interval shown by black lines. Source: 1 percent Census data from 1970, 1980, and 1990. Sample consists of white women, ages 41-50 years old.

degrees at the time.[23] Although women who earned graduate degrees in prior decades may have indeed pursued less lucrative degrees and careers than women who earn them today, these women always earned substantially more than their college-educated counterparts (see Table 6), and yet their spouses earned substantially less.

Standard models fail to match this non-monotonicity. Division of labor, and thus substitutability between men's and women's incomes, could explain the negative relationship between education and spouse's income for college and graduate educated women, but not the positive relationship at other education levels. Complementarity in spouse's incomes, social class, or education (whether because of consumption complementarities, or convex returns to certain investments) could explain the positive relationship in most of the data, but not the apparent "penalty" to graduate education.

A model with reproductive capital can account for this non-monotonic matching. The model

[23] Appendix figure A1 shows the pattern remains when restricting to first marriages in 1970 and 1980–number of marriages is not available for 1990.

also predicts that if either the returns to time-costly investments have risen or the reproductive costs have fallen, this matching will realign toward assortativeness. Market opportunities for women have naturally risen dramatically in the past 50 years [Hsieh et al., 2013]. However, a more dramatic shift might come from changes in the fertility penalty associated with investment. One reason would be changing technology, in terms of increased technological assistance for reproduction, including fertility drugs, in vitro fertilization, surrogacy, egg donation, and egg freezing [Gershoni and Low, 2019a,b]. Second, there is the decrease in family sizes, likely driven by a substitution from child quantity to child quality [Doepke and Tertilt, 2009, Gould et al., 2008, Isen and Stevenson, 2010, Preston and Hartnett, 2010]. Not only did actual family sizes fall, but *desired* family sizes have fallen substantially. During the 1970s there was a rapid transition from "four or more" as the modal answer for ideal family size to "two" [Livingston et al., 2010], shown in Figure 7. If couples wish to have four children, graduate education may significantly interfere with the probability of reaching this desired family size. With a desire for fewer children, longer delays are possible with less of an impact on reproductive success. One can think of this as a fall in δ_π, the fertility penalty to investment, which will drive the model toward more assortative equilibria.[24]

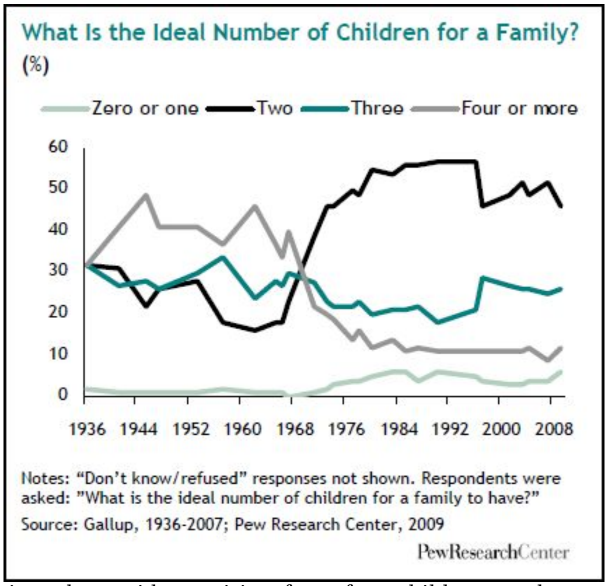
Figure 8 graphs the movement of spousal income by wife's educational level over time, to see whether there has been an increase in assortative matching for highly educated women. Indeed, the graph shows that the non-monotonic matching previously shown disappeared by the time of the 2000 Census (as the women in the graph are 41-50, this is for marriages 10-20 years earlier than the Census year).[25] By separating the "college plus" category into college educated versus graduate educated, we can see that the reversal in marriage outcomes for educated women that has been noted elsewhere was really driven by highly educated women.

Strikingly, the alignment of spousal income to every other educational level remained constant over this period. The spousal incomes of lower education levels are largely parallel. There is some growth in the incomes of college-educated women's spouses relative to other educational levels, consistent with increasing inequality and returns to skill during this period, but this cannot explain the crossing in college versus graduate women's marriage outcomes.

[24]A substitution toward child quality, in addition to lowering the δ_π, might also change the surplus function by making women's human capital a more important input into the utility received from children, as suggested by [Chiappori et al., 2017b]. This is outside the scope of the current paper, but would be a fruitful direction for future research.

[25]This is also evident in a regression with dummies for each cohort, as shown in Appendix Table A7. Appendix figure A2 also shows this pattern for first marriages only, excluding 1980 and 1990 when number of marriages is not available.

Figure 7: Desired family size transition



Notes: Figure depicts the rapid transition from four children as the modal desired family size to two children, as evidenced by Gallup polls of men and women. As published in: Pew Center, The New Demography of American Motherhood, August 2010

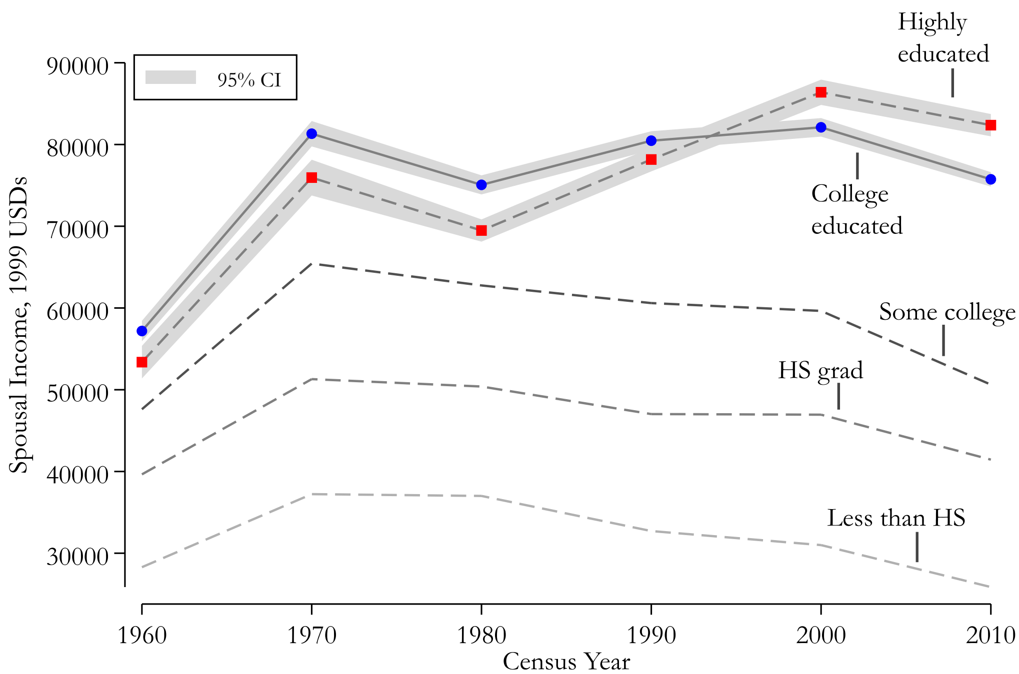
Over the same period, highly educated women's marriage rates rose precipitously, while divorce rates fell, shown in Figure 9, another measure of an increasing marriage market premium for highly educated women. Conventional wisdom holds that too-educated, too-high-earning women are punished on the marriage market. However, Figure 9 panel (a) demonstrates that *college* educated women actually always married at rates close to all other educational categories. It is only *highly* educated women who previously had comparatively low rates of marriage, and have now experienced substantial gains.[26] Similarly, as shown in panel (b), college educated women's divorce rates were almost identical to all other educational categories, whereas highly educated women's were notably higher. College educated women's divorce rates have leveled off recently, while those of other educational categories have risen, but highly educated women's divorce rates have actually fallen.

4.2 Alternative explanations and discussion

These findings are consistent with the improvement in educated women's marriage outcomes that has been noted by several authors [Rose, 2005, Isen and Stevenson, 2010, Bertrand et al., 2016, Fry,

[26]The figures shows the percent of women ages 41-50 who ever married by a given Census year.

Figure 8: Spousal income by wife's education level



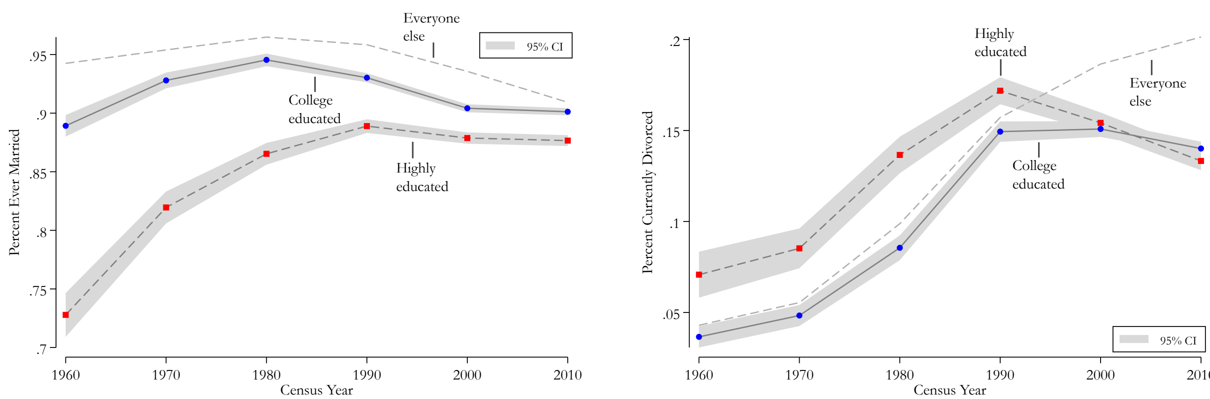
Notes: Income of spouse based on wife's education level, with "highly educated" constituting all formal education beyond a college degree. Source: 1 percent Census data from 1960, 1970, 1980, and 1990, and American Community Survey from 2000 and 2010. Sample consists of white women, ages 41-50 years old.

2010], as well as increases in assortative mating over time [Chiappori et al., 2017b, Hurder, 2013, Greenwood et al., 2016, 2014, Fernandez et al., 2005, Schwartz and Mare, 2005]. However, existing explanations in the literature for the overall increasing marital assortativeness do not explain the different trajectories seen for graduate versus college educated women.

One could imagine this realignment simply stem from a transition from Beckerian-style division of labor [Becker, 1973, 1974, 1981], and hence negative assortative matching, to a dual earner model. Stevenson and Wolfers [2007] note that consumption complementarities are likely to overtake the traditional Beckerian household model as women enter the labor force and household work becomes more easily substituted by technology. The "Engines of Liberation" [Greenwood et al., 2005] such as dishwashers (or infant formula, as in Albanesi and Olivetti [2016]) have also been noted as a possible driver of increased assortativeness by Greenwood et al. [2016], in addition to the skill premium. However, as Figure 6 highlights, matches during the period of Becker's work were not

Figure 9: Marriage and divorce rates by education level

(a) Marriage (b) Divorce



Notes: Ever married and currently divorced rates by ages 41-50, for women, based on education level, with "highly educated" constituting all formal education beyond a college degree. Ever divorced rates show a similar pattern, but are not available in all years. Source: 1 percent Census data from 1960, 1970, 1980, and 1990, and American Community Survey from 2000 and 2010. Sample consists of white women, ages 41-50 years old.

negative assortative, but rather *non-monotonic*, and the data shows a crossing between the spousal incomes of college versus graduate educated women. The increase in the skill premium noted as a driver of increasing assortativeness in Fernandez et al. [2005] would similarly be expected to increase marital outcomes, and marriage rates, for college educated women as well as graduate-educated women.

Another possible explanation for these patterns is that the selection of women into post-bachelor's education has changed in a way that could align with the observed matching patterns. For example, if women previously selected into post-bachelor's education after receiving a signal that they had a low chance of success on the marriage market, whereas in later years women have sought further education due to having higher marginal career returns.[27] Two facts appear to counter this story, however. First, the same selection forces may have also applied to college-educated women in earlier cohorts, since college education was still somewhat rare at that time (in the 1960 Census, 6.5% of women had a college-or-greater degree). Second, as shown in Figure 10, the spousal income gap between college and graduate-educated women does not respond to the percentage of women earning graduate degrees. Between the 1970 and 1980 Census, the number of

[27]It also could be that highly educated women are unobservably better along some dimension than college educated women, especially those highly educated women who managed to pursue such education at a time when it was rare for women, making the result of college educated women matching with "better" men at some point all the more striking.

women who achieved post-bachelor's education approximately doubled (thus drastically affecting selection effects, if they were present), while the "penalty" in spousal income compared to college education remained unchanged. From 1990 to 2000 the increase as a percent of the base is much slower, and thus the "pool" of women with graduate degrees cannot have changed substantially, whereas the spousal income gap showed a rapid reversal.[28] Rather, Figure 10 is more consistent with the predictions of the model, where as the reproductive costs of investment fall and career returns rise, women first become more willing to pursue graduate education despite the marriage market costs, and then the marriage gap closes, reinforcing this trend.

These patterns are also unlikely to be driven by high-earning women having different tastes for partners. Matching could potentially be non-assortative if high-earning women prefer lower-earning partners either because of income effects or a preference for partners who are more likely to be able to spend time at home (although, such preferences in traditional models would tend to predict negative assortative matching, rather than non-monotonic matching). However, both of these forces would strengthen, rather than weaken, as female earning power at the top grows, failing to predict the reversal in marriage market outcomes for the "top" women in recent years.[29] Bertrand et al. [2016] offers gender norms against career women as a possible explanation, suggesting these norms may have dissipated in recent years. My model demonstrates, though, that such a norm shift could at least partly be driven by economic fundamentals.

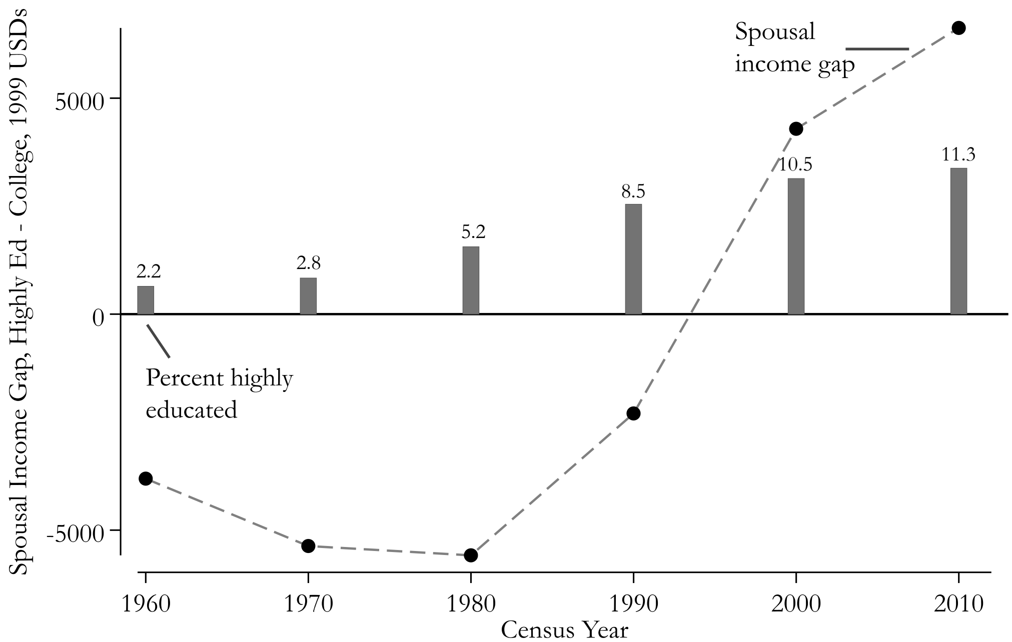
Table 6 examines the differences between women with college and graduate degrees in 1980, when there was a "penalty" to being highly educated, and 2010, when there was a premium. The shift in spousal matching might be expected if graduate education previously offered little earnings benefit. However, table 6 shows that even in the 1980 Census, highly educated women earned substantially more than college educated women, with annual income almost 50% higher.[30] This

[28] I perform an additional check using data from the National Longitudinal Surveys (NLS) to explicitly examine whether there has been an increasing skill premium among women who attain post-bachelor's education. If women were previously selecting into post-bachelor's education due to negative selection in other areas, they may be expected to be less positively selected on intelligence and academic potential. Appendix table A6 examines this, using data from aptitude scores and educational attainment of three NLS cohorts—the 1968 Young Women panel, the 1979 Youth panel, and the 1997 Youth panel. (Unfortunately, the earliest cohort with the necessary test score information only captures the tail end of the non-assortative matching group, but nonetheless, the trend should be informative about whether there are large shifts occurring in underlying selection factors.) The data shows that highly educated women indeed had substantially higher aptitude scores on average than college educated women even in the earliest cohort, and that the two numbers are not systematically diverging (which would indicate greater skill-driven selection).

[29] Moreover, in appendix A.2, I use data from the dating experiment to test for whether male income is less important for high-income women in evaluating potential partners, and find that high-income women actually care *more* about income.

[30] Women's own income in all years, with no crossing, is shown in Appendix Figure A4. This means that the results are also unlikely to be driven by measurement error in classifying women as highly educated, as noted by Kominski

Figure 10: Rates of women's graduate education versus the spousal income gap



Notes: "Highly educated" constitutes all formal education beyond a college degree. "Spousal income gap" is defined as the average spousal income for highly educated women minus the average spousal income for college educated women. Source: 1 percent Census data from 1970, 1980, and 1990. Sample consists of white women, ages 41-50 years old.

table also shows the impact of graduate education on delaying marriage and decreasing the number of children. In the 1980 as well as 2010 data, women with graduate degrees married almost a year later than women with college degrees on average, meaning some women may have delayed substantially.

This data further suggests that falling family sizes may indeed help explain the transition to more assortative matching. In 1980, women with college degrees had households with about 0.5 fewer children than women with graduate degrees. This difference dissipated substantially in 2010, but driven entirely by falling family sizes among the college educated, while graduate educated women's family sizes stayed largely constant.[31] This is consistent with the idea that while graduate educated women continued to delay marriage, falling family size desires meant this delay was less

and Siegel [1993], since the income gap between "highly educated" and college educated has remained relatively constant over time.

[31]Consistent with the finding of Hazan and Zoabi [2015] that highly educated women have had larger families recently.

Table 6: Income, age at marriage, and children by education

	1980			2010		
	College Ed.	Highly Ed.	Difference	College Ed.	Highly Ed.	Difference
Income	$18,462	$28,653	$10,190***	$32,326	$48,030	$15,703***
AFM	23.01	23.75	0.73***	26.28	27.23	0.95***
Children	1.98	1.46	-0.52***	1.64	1.52	-0.12***

Notes: "Highly Educated" constitutes all formal education beyond a college degree. Income in 1999 USD. Children measured as children in household (this may be downward biased by older children leaving the household, but this bias will be stronger for college educated women, who have children younger. Children ever born is available for 1980 only, and shows the same pattern, with a difference of 0.50 between college and highly educated). Source: 1 percent samples of 1980 US Census and 2010 American Community Survey. Sample consists of white women, age 36-45, with children in household measured for age 36-40 (to avoid children leaving) and age at first marriage measured for ages 41-45, to ensure most marriages are complete.
*** p<0.01, ** p<0.05, * p<0.1

costly in terms of realized fertility.

Despite this elimination of the penalty to graduate education, the experiment highlights that the *age* penalty still exists, it is just that graduate-educated women have sufficiently high incomes to compensate partners for their higher age. Moreover, the income-age tradeoff between college and graduate educated women aligns well with the penalty to aging found in the experiment. Today, women with graduate degrees marry richer spouses than women with college degrees, but they also earn $16,000 more while only marrying on average 1 year later, as shown in Table 6. The experiment suggests that each year older requires an additional $7,000 of annual income, so graduate educated women's extra earning more than makes up for their later marriage. Women who make even more time consuming investments, such that fertility is reduced even for a smaller family size, may still experience worse matching outcomes. Thus, reproductive capital might help explain the lack of women in top executive positions (women make up just 4% of Fortune 500 CEOs), or certain fields with rapid human capital depreciation (tech) or heavy on-the-job training requirements (surgery). Future research may want to examine investments of different lengths, rather than the binary investment modeled here.

5 Conclusion

From Hollywood films to online dating sites, it seems evident that men prefer younger women, yet the economic cost of this preference to women has not been modeled or measured. If, indeed, younger partners are preferred by men, then time-consuming career investments carry an additional price to women. By bringing together theory and experimental evidence, this paper demonstrate the dollars-and-cents cost of depreciating reproductive capital to women's economic well-being, and shows how understanding this force sheds light on historical patterns.

This paper treats women's decisions as a tradeoff between two assets: human capital, which grows based on investment, and reproductive capital, which depreciates with time. I document that later age at first marriage is linked to lower income spouses for women, but not men. For reproductive capital to matter financially to women, as this paper hypothesizes, men must value fertility in partners. I provide the first causal evidence of this through a novel online experiment.

The experiment aims to separately identify the impact of aging from other factors, such as beauty, by randomly assigning age to dating profiles, and using a new incentive mechanism to elicit truthful assessments from male raters. I show that men, but not women, have preferences over partner age, particularly when they have no children currently and are aware of the age-fertility tradeoff.

To explore the consequences of this human capital–reproductive capital tradeoff, I develop a bi-dimensional marriage matching model where women's career investments affect both human and reproductive capital. Matching is predicted to be non-monotonic when the fertility cost of career investments are large relative to the income gains. In this case, since skilled women are most likely to make career investments, they are passed over as spouses by the highest earning men, who prefer poorer, more fertile women. This adds a second cost to women considering time-consuming career investments—not only do they themselves potentially lose out on fertility, but they experience a "tax" on the marriage market as well. This equilibrium effect means that even if a woman herself wants no children, her human capital investments will still carry additional costs versus men's. This fact is essential to understand why women may make time-consuming career investments at lower rates than men, and also which policies are likely to support greater investments by women.

I demonstrate in US Census data that until recently marriage matching followed the non-monotonic pattern predicted by the model. Women with college degrees matched with richer spouses than those without, but women with even more education, graduate degrees, matched with poorer spouses than those with college degrees. In line with the model's prediction that as the reproductive cost of investment falls highly educated women's marriage fortunes should improve, I document an improvement in educated women's marriage rates and spousal quality, driven by graduate educated women only. College-educated women always enjoyed good marriage market outcomes, whereas graduate educated women previously married less and divorced more, in addition to matching with lower-income spouses. These facts indicate there are multiple dimensions to education on the marriage market: on the one hand, it increases human capital, on the other hand, it requires time, which reduces reproductive capital.

The concept of reproductive capital suggests substantial welfare effects of aging for women, or to the premature loss of fertility (as may be experienced by women in developing countries facing illness or childbirth-related infertility). The lower are the returns to female skill, e.g., due to labor market discrimination, the more such losses of reproductive capital will limit a woman's overall well-being; the higher the reproductive costs of career investment, the more high human capital women will be penalized on the marriage market. Thus, evaluating women's labor market opportunities together with the reproductive costs of capitalizing on such opportunities provides a more complete picture of women's economic well-being.

The reproductive capital framework may also provide useful insights to firms interested in attracting and retaining top female talent. Optimal contracts for women may be very different from those that have evolved in a historically male-dominated workforce. For example, firms may wish to adjust women's compensation nonlinearly to reflect the ever-increasing opportunity cost of career investment as reproductive capital depreciates. Creating greater flexibility to allow women to marry and start families while still making career investments, or easing re-entry into the workforce once they have already had children, would also lower the reproductive cost of "on the job" investments. Policy-makers could utilize a better understanding of reproductive capital to inform efforts to promote women's human capital accumulation, such as parental leave policies and workforce re-entry programs, and calculate the welfare effects of such policies. Moreover, government policies that ease access to infertility treatments may have spillover impacts on human capital decisions (see Gershoni and Low [2019a,b], Buckles [2007] for example). When viewed through this framework, insurance coverage of infertility treatments becomes a question of not just health policy, but also labor and economic policy.

This paper shows that incorporating reproductive capital into models of women's decisions may be crucial to understanding not just historical marriage patterns, but also women's current human capital investment decisions. This fundamental reproductive capital–human capital tradeoff shows the unique costs to women of large human capital investments within the framework of a rational economic model. Crucially, this takes the form of a financial penalty—even if women themselves do not desire children, they will experience a material loss from lower fertility via the marriage market. This casts a new light on policies that alleviate the work-family tradeoff or extend reproductive time horizons.

References

Jerome Adda, Christian Dustmann, and Katrien Stevens. The career costs of children. *Journal of Political Economy*, 125(2):293–337, 2017.

Stefania Albanesi and Claudia Olivetti. Gender roles and medical progress. *Journal of Political Economy*, 124(3):650–695, 2016.

Anne-Marie Nybo Andersen, Jan Wohlfahrt, Peter Christens, Jorn Olsen, and Mads Melbye. Maternal age and fetal loss: population based register linkage study. *British Medical Journal*, 320: 1708–1712, June 2000.

Joshua D. Angrist and Jörn-Steffen Pischke. *Mostly Harmless Econometrics An Empiricist's Companion*. Princeton University Press, 2008.

Raj Arunachalam and Suresh Naidu. The price of fertility: Marriage markets and family planning in bangladesh. *University of California, Berkeley*, Jan 2006.

Martha J Bailey. More power to the pill: the impact of contraceptive freedom on women's life cycle labor supply. *The Quarterly Journal of Economics*, 121(1):289–320, 2006.

Martha J Bailey, Brad Hershbein, and Amalia R Miller. The opt-in revolution? contraception and the gender gap in wages. *American Economic Journal: Applied Economics*, 4(3):225–254, 2012.

Gary Becker. *A treatise on the family*. Harvard University Press, Cambridge, MA, 1981.

Gary S Becker. A theory of marriage: Part i. *The Journal of Political Economy*, pages 813–846, 1973.

Gary S Becker. A theory of marriage: Part ii. *Journal of political Economy*, 82(2, Part 2):S11–S26, 1974.

Duran Bell and Shunfeng Song. Explaining the level of bridewealth. *Current Anthropology*, 35(3): 311–316, Jan 1994.

Michèle Belot and Marco Francesconi. Dating preferences and meeting opportunities in mate choice decisions. *Journal of Human Resources*, 48(2):474–508, 2013.

Theodore C Bergstrom and Richard C Cornes. Independence of allocative efficiency from distribution in the theory of public goods. *Econometrica: Journal of the Econometric Society*, 51(6): 1753–1765, 1983.

Marianne Bertrand, Emir Kamenica, and Jessica Pan. Gender identity and relative income within households. *The Quarterly Journal of Economics*, 130(2):571–614, 2015.

Marianne Bertrand, Patricia Cortés, Claudia Olivetti, and Jessica Pan. Social norms, labor market opportunities, and the marriage gap for skilled women. Technical report, National Bureau of Economic Research, 2016.

Mary Ann Bronson and Maurizio Mazzocco. Cohort size and the marriage market: Explaining nearly a century of changes in us marriage rates. *UCLA CCPR Population Working Papers*, 2012.

Kasey Buckles. Stopping the biological clock: Infertility treatments and the career-family tradeoff. 2007.

David M Buss, Todd K Shackelford, and Gregory J LeBlanc. Number of children desired and preferred spousal age difference: context-specific mate preference patterns across 37 cultures. *Evolution and Human Behavior*, 21(5):323–331, 2000.

Pierre-André Chiappori. *Matching with transfers: The economics of love and marriage*. Princeton University Press, 2017.

Pierre-André Chiappori and Elisabeth Gugl. Necessary and sufficient conditions for transferable utility. Technical report, Mimeo, Columbia University, 2014.

Pierre-André Chiappori, Murat Iyigun, and Yoram Weiss. Investment in schooling and the marriage market. *The American Economic Review*, pages 1689–1713, 2009.

Pierre-André Chiappori, Sonia Oreffice, and Climent Quintana-Domeque. Bidimensional matching with heterogeneous preferences: education and smoking in the marriage market. *Journal of the European Economic Association*, 16(1):161–198, 2017a.

Pierre-André Chiappori, Bernard Salanié, and Yoram Weiss. Partner choice, investment in children, and the marital college premium. *American Economic Review*, 107(8), 2017b.

Eugene Choo and Aloysius Siow. Who marries whom and why. *Journal of Political Economy*, 114 (1):175–201, 2006.

Harold L Cole, George J Mailath, and Andrew Postlewaite. Efficient non-contractible investments in large economies. *Journal of Economic Theory*, 101(2):333–373, 2001.

Melvyn G Coles and Marco Francesconi. Equilibrium search and the impact of equal opportunities for women. *IZA Discussion Papers*, (10827), 2017.

Sylvain Dessy and Habiba Djebbari. High-powered careers and marriage: Can women have it all? *The BE Journal of Economic Analysis & Policy*, 10(1):1–33, 2010.

Javier Díaz-Giménez and Eugenio Giolito. Accounting for the timing of first marriage. *International Economic Review*, 54(1):135–158, 2013.

Deniz Dizdar. Two-sided investments and matching with multi-dimensional types and attributes.

Technical report, Mimeo, University of Bonn, Oct 2013.

Matthias Doepke. Gary becker on the quantity and quality of children. *Journal of Demographic Economics*, 81(1):59–66, 2015.

Matthias Doepke and Michele Tertilt. Women's liberation: What's in it for men? *The Quarterly Journal of Economics*, 124(4):1541–1591, 2009.

Arnaud Dupuy and Alfred Galichon. Personality traits and the marriage market. *Journal of Political Economy*, 122(6):1271–1319, 2014.

Lena Edlund. Marriage: past, present, future? *CESifo Economic Studies*, 52(4):621–639, Jan 2006.

Lena Edlund and Evelyn Korn. A theory of prostitution. *Journal of Political Economy*, 110(1): 181–214, Jan 2002.

Lena Edlund and Rohini Pande. Why have women become left-wing? the political gender gap and the decline in marriage*. *The Quarterly Journal of Economics*, 117(3):917–961, 2002.

Lena Edlund, Joseph Engelberg, and Christopher Parsons. The wages of sin. Technical report, Mimeo, Columbia University, 2009.

Lasse Eika, Magne Mogstad, and Basit Zafar. Educational assortative mating and household income inequality. Technical report, National Bureau of Economic Research, 2014.

Paula England and Elizabeth Aura McClintock. The gendered double standard of aging in us marriage markets. *Population and Development Review*, 35(4):797–816, 2009.

Raquel Fernandez, Nezih Guner, and John Knowles. Love and money: A theoretical and empirical analysis of household sorting and inequality. *The Quarterly Journal of Economics*, 120(1):273–344, 2005.

Raymond Fisman, Sheena S Iyengar, Emir Kamenica, and Itamar Simonson. Gender differences in mate selection: Evidence from a speed dating experiment. *The Quarterly Journal of Economics*, 121(2):673–697, 2006.

Odile Frank, P Grace Bianchi, and Aldo Campana. The end of fertility: age, fecundity, and fecundibility in women. *Journal of Biosocial Science*, 26(3):349–368, July 1994.

Richard Fry. The reversal of the college marriage gap. Technical report, Pew Research Center, 2010.

Alfred Galichon and Bernard Salanié. Cupid's invisible hand: social surplus and identification in matching models. Technical report, 2015.

Alfred Galichon, Scott Duke Kominers, and Simon Weber. Costly concessions: An empirical framework for matching with imperfectly transferable utility. *Centre for Economic Policy Research*

Discussion Papers, (12455), 2017.

Suqin Ge. Women's college decisions: How much does marriage matter? *Journal of Labor Economics*, 29(4):773–818, 2011.

Naomi Gershoni and Corinne Low. Older yet fairer: How extended reproductive time horizons reshaped marriage patterns in israel. Technical report, Mimeo, University of Pennsylvania, 2019a.

Naomi Gershoni and Corinne Low. The impact of extended reproductive time horizons on women's human capital investments. Technical report, Mimeo, University of Pennsylvania, 2019b.

Rania Gihleb and Kevin Lang. Educational homogamy and assortative mating have not increased. Technical report, National Bureau of Economic Research, 2016.

Claudia Goldin and Lawrence F Katz. The power of the pill: Oral contraceptives and women's career and marriage decisions. *Journal of Political Economy*, 110(4):730–770, 2002.

Claudia Goldin, Lawrence F. Katz, and Ilyana Kuziemko. The homecoming of american college women: The reversal of the college gender gap. *The Journal of Economic Perspectives*, 20(4): 133–156, 2006.

Eric D Gould, Omer Moav, and Avi Simhon. The mystery of monogamy. *American Economic Review*, 98(1):333–57, 2008.

Jeremy Greenwood, Ananth Seshadri, and Mehmet Yorukoglu. Engines of liberation. *The Review of Economic Studies*, 72(1):109–133, 2005.

Jeremy Greenwood, Nezih Guner, Georgi Kocharkov, and Cezar Santos. Marry your like: Assortative mating and income inequality. *The American Economic Review*, 104(5):348–353, 2014.

Jeremy Greenwood, Nezih Guner, Georgi Kocharkov, and Cezar Santos. Technology and the changing family: A unified model of marriage, divorce, educational attainment, and married female labor-force participation. *American Economic Journal: Macroeconomics*, 8(1):1–41, 2016.

Amyra Grossbard-Shechtman. Economic behavior, marriage and fertility: Two lessons from polygyny. *Journal of economic behavior & organization*, 7(4):415–424, 1986.

Catherine Hakim. Erotic capital. *European Sociological Review*, 26(5):499–518, Jan 2010.

Moshe Hazan and Hosny Zoabi. Do highly educated women choose smaller families? *The Economic Journal*, 125(587):1191–1226, 2015.

Günter J Hitsch, Ali Hortaçsu, and Dan Ariely. Matching and sorting in online dating. *The American Economic Review*, 100(1):130–163, 2010.

Ernest B Hook, Philip K Cross, and Dina M Schreinemachers. Chromosomal abnormality rates at amniocentesis and in live-born infants. *JAMA: the journal of the American Medical Association*, 249(15):2034–2038, 1983.

Chang-Tai Hsieh, Erik Hurst, Charles I Jones, and Peter J Klenow. The allocation of talent and us economic growth. Technical report, National Bureau of Economic Research, 2013.

Stephanie Hurder. An integrated model of occupation choice, spouse choice, and family labor. Technical report, Mimeo, Harvard University, 2013.

Adam Isen and Betsey Stevenson. Women's education and family behavior: Trends in marriage, divorce and fertility. In John B Shoven, editor, *Demography and the Economy*, pages 107–140. University of Chicago Press, 2010.

Murat Iyigun and P Randall Walsh. Building the family nest: Premarital investments, marriage markets, and spousal allocations. *The Review of Economic Studies*, 74(2):507–535, 2007.

Thomas W Kelsey and W. Hamish B. Wallace. Human ovarian reserve from conception to the menopause. *PLoS One*, 5, January 2010.

Judd B Kessler, Corinne Low, and Colin Sullivan. Incentivized resume rating: Eliciting employer preferences without deception. *American Economic Review*, Forthcoming.

Henrik J Kleven, Camille Landais, and Jacob E Sogaard. Children and gender inequality: Evidence from denmark. *American Economic Journal: Applied Economics*, Forthcoming.

Robert Kominski and Paul M Siegel. Measuring education in the current population survey. *Monthly Labor Review*, 116:34, 1993.

Jeanne Lafortune. Making yourself attractive: Pre-marital investments and the returns to education in the marriage market. *American Economic Journal: Applied Economics*, 5(2):151–178, 2013.

David Lam. Marriage markets and assortative mating with household public goods: Theoretical results and empirical implications. *The Journal of Human Resources*, 23(4):pp. 462–487, 1988.

Ilse Lindenlaub and Fabien Postel-Vinay. Multidimensional sorting under random search. In *2017 Meeting Papers*, number 501. Society for Economic Dynamics, 2017.

Gretchen Livingston, D'Vera Cohn, and Paul Taylor. *The new demography of American motherhood.* Pew Research Center, 2010.

Corinne Low. *Essays in Gender Economics.* PhD thesis, Columbia University, 2014.

George J. Mailath, Andrew Postlewaite, and Larry Samuelson. Pricing and investments in matching markets. *Theoretical Economics*, 8(2):535–590, 2013.

George J Mailath, Andrew Postlewaite, and Larry Samuelson. Premuneration values and investments in matching markets. *The Economic Journal*, 127(604):2041–2065, 2017.

Jane Menken, James Trussell, and Ulla Larsen. Age and infertility. *Science*, 233(4771):1389–1394, 1986.

Robert T Michael and Robert J Willis. Contraception and fertility: Household production under uncertainty. In *Household production and consumption*, pages 25–98. NBER, 1976.

Georg Nöldeke and Larry Samuelson. Investment and competitive matching. *Econometrica*, 83(3): 835–896, 2015.

Samuel H Preston and Caroline Sten Hartnett. The future of american fertility. In *Demography and the Economy*, pages 11–36. University of Chicago Press, 2010.

Elaina Rose. Education, hypergamy and the "success gap". *Center for Statistics and the Social Sciences working paper*, (53), 2005.

Kenneth J Rothman, Lauren A Wise, Henrik T Sørensen, Anders H Riis, Ellen M Mikkelsen, and Elizabeth E Hatch. Volitional determinants and age-related decline in fecundability: a general population prospective cohort study in denmark. *Fertility and sterility*, 99(7):1958–1964, 2013.

Steven Ruggles, J. Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. Integrated public use microdata series: Version 5.0 [machine-readable database]. Minneapolis, MN: Minnesota Population Center, 2010.

Christine R. Schwartz and Robert D. Mare. Trends in educational assortative marriage from 1940 to 2003. *Demography*, 42(4):621–646, Nov 2005. Annual Meeting of the Population-Association-of-America, Boston, MA, APR 01-03, 2004.

Lloyd S Shapley and Martin Shubik. The assignment game i: The core. *International Journal of game theory*, 1(1):111–130, 1971.

Andrew Shephard. Marriage market dynamics, gender, and the age gap. 2019.

Aloysius Siow. Differential fecundity, markets, and gender roles. *Journal of Political Economy*, 106 (2):334–354, 1998.

Betsey Stevenson and Justin Wolfers. Marriage and divorce: Changes and their driving forces. *The Journal of Economic Perspectives*, 21(2):27–52, 2007.

James P Toner. Age = egg quality, fsh level = egg quantity. *Fertility and sterility*, 79(3):491, March 2003.

Robert Trivers. Parental investment and sexual selection. In Bernard Grant Campbell, editor, *Sexual selection and the descent of man, 1871-1971*, pages 136–179. Aldine de Gruyter, New York, 1972.

Hanzhe Zhang. Courtship as an investing game: Labor-market and marriage-market outcomes by age at marriage. Technical report, Mimeo, Michigan State University, 2017a.

Hanzhe Zhang. A marriage-market perspective of the college gendergap. Technical report, Mimeo, Michigan State University, 2017b.

A Appendix: Experiment

A.1 Methodology

To generate the hypothetical dating profiles, I purchased stock photos that were similar in appearance to photos on dating websites, then randomly assigned characteristics. I started with 50 photos of men and 50 photos of women, depicting caucasian individuals of "ambiguous age," meaning no balding or gray hair, no obvious facial wrinkles, and no overly youthful hairstyles or clothing. I then had 120 undergraduate students rate each photo's physical attractiveness and guess the age of the individual in the photo. Average attractiveness and average "visual age" was then balanced between the men and women, and photos with an average guessed age outside the ages being used for the study were removed.

Using the selected photos, 40 male and 40 female dating profiles were created. The following characteristics were randomly assigned to each dating profile: a username, a height, and three interests. The usernames were assigned by using the top 40 names for men and women from the decade of birth for 30-40-year-olds, then assigning a random three-digit number. The heights were assigned randomly from a normal distribution using the mean and standard deviation of heights for caucasian men and women. Gender-neutral interests were assigned from a list of top hobbies, with more popular interests being assigned more frequently. All profiles listed the person as "looking for: serious relationship," in order to signal that the rater should consider this person as a potential long-term partner. Each of these characteristics were assigned to the profile and remain fixed throughout the experiment. Then, as each profile was shown, age and income were randomly assigned: age between 30 and 40 (inclusive), and an income range from roughly the 25th to 95th percentile for single individuals with at least an associate's degree in the 2010 Census. Each respondent who completed the survey viewed all 40 profiles.[32]

Summary statistics from the data are presented in Table A1, for my target sample of white individuals between 30 and 40.[33] Without these restrictions, in the initial sample 77% of male

[32]After agreeing to the consent form, respondents were asked to rate profiles on a scale from 1 to 10. After 10 profiles, the respondents ordered the profiles from most preferred to least preferred, both to break up the monotony of the rating, and to provide a check for participants randomly entering answers without thinking about them (in which case there would be a low correlation between their ratings and rankings). Following this, they completed a brief post-survey including demographic information, dating preferences, and, finally, their knowledge of age-fertility limits for men and women.

[33]The consent form required respondents to certify that "I am between 30 and 40 years old, currently single, and seeking a partner of the opposite gender." However, in the post survey, some initial-sample respondents listed birth years outside the 30-40-year-old range. In my main specification, I exclude these responses. Also, although the profiles feature only white men and women, I did not restrict the race of respondents, so I also exclude non-white respondents

and 78% of female participants are white, and 74% fall within the targeted age range. In the Qualtrics sample all individuals are white and within the specified age range, due to pre-screening by Qualtrics.

Table A1: Summary Statistics

	Initial Sample				**Qualtrics Sample**			
	Men N=35		**Women N=44**		**Men N=207**		**Women N=104**	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age	35.216	3.637	35.933	3.512	34.647	3.049	34.375	3.206
High Income	0.486	0.507	0.356	0.484	0.386	0.488	0.154	0.363
College Grad	0.676	0.475	0.689	0.468	0.493	0.501	0.462	0.501
Has kids	0.351	0.484	0.432	0.501	0.203	0.403	0.423	0.496
Wants (more) kids now	0.243	0.435	0.159	0.370	0.184	0.388	0.183	0.388
Wants marriage	0.459	0.505	0.432	0.501	0.469	0.500	0.442	0.499
Date lowest age	25.838	3.571	32.955	3.929	24.865	4.330	29.971	4.130
Date highest age	40.838	5.419	46.864	6.920	41.575	6.094	44.212	7.384
Preferred low	28.486	3.731	35.295	4.322	27.029	4.702	32.519	4.384
Preferred high	37.216	4.547	44.205	6.341	37.432	5.550	41.337	6.662
Fem Fert cutoff?	1.000	0.000	1.000	0.000	0.975	0.157	0.990	0.099
Fem cutoffage	41.189	6.368	39.674	4.719	43.108	7.113	41.098	6.231
Male fert cutoff?	0.892	0.315	0.767	0.427	0.835	0.372	0.796	0.405
Male cutoff age	53.667	8.912	55.455	8.460	51.946	9.091	56.549	9.077

Notes: Summary statistics for in-sample men and women from online dating experiment. High income is classified as earning over $60,000 annually. The fertility variables ask if there is an age at which it becomes biologically difficult for women or men to conceive, and then what that age is.

Because the recruitment of additional respondents was motivated by testing for heterogeneity in male responses, male respondents in the Qualtrics sample were enrolled at a 2:1 ratio to female respondents. The oversampled males were also drawn from the higher end of the income distribution, in order to have an income distribution that better mirrors the general population (Qualtrics respondents, in absence of this sampling concentration, tended to be lower-income, which would not allow for a test of income heterogeneity).

Table A1 shows that men and women taking the survey display similar characteristics, although the men are more likely to be high-income, defined as income over $65,000 per year, in the initial sample. Where men and women differ substantially is their stated preferences for the age of their partner. In the initial sample, men state on average that the youngest they would date is a 26-year-old and the oldest is a 41-year-old, whereas women state averages of 33 and 47. When it comes

during the analysis phase, since cross-racial rankings may be driven by different factors. For the Qualtrics sample, respondents were pre-screened based on race, relationship status, and age.

to their preferred dating range, men look for women aged 29 to 37, whereas women seek partners between the ages of 35 and 44. This pattern provides some preliminary evidence that men have differential preferences over their partner's age, compared to women.

The final questions on the survey ask men and women at what age they believe it becomes biologically difficult for members of each gender to conceive a child. 100% of initial-sample respondents believe there is a cutoff for women (97% of men and 99% of women in the Qualtrics sample), indicating that there is some knowledge of differential fertility decline, whereas 89.2% of men and 76.7% of women believe that such a cutoff exists for men. Female respondents put the start of the fertility decline for women somewhat earlier than male respondents, at 39.7 years, as compred to 41.2 for men. Both male and female respondents, conditional on thinking there *is* a cutoff, believe the cutoff to be higher for men.

A.2 Alternative hypotheses: heterogeneous male or female tastes for income

I now examine evidence of possible alternative hypotheses that explain negative assortative matching at the top of the income distribution, using the experimental data. The first alternative hypothesis that I test for is that *women* who are very high-earning may exhibit a less strong preference for income than lower-earning women, and thus the observed non-assortative matching could really be driven by women's tastes. The question, essentially, is whether women who are very high-earning have a lower marginal utility of additional income. Table A2 interacts the rater's income with the profile's income for both men rating women (column 1) and women rating men (column 2)—the resulting coefficients are positive, although only significant for male raters. As mentioned, this indicates that tastes over income appear to take the supermodular form assumed by the model: those with more income value additional partner income more. Columns 4 and 5 show that "high-income" raters, both male and female, have a greater taste for additional income, by interacting a dummy for having annual income over $65,000 with the income in the profile. Thus, I find no evidence of a decreasing marginal utility of income for women.

It is also possible that men dislike income itself in potential mates, perhaps due to gender norms, which could lead to the non-assortative matching at the top without reproductive capital. Men may not dislike all income equally, but may dislike it when women earn more than they do (e.g., Bertrand et al. [2015]), or may dislike *very* high-earning women. Table A3, column 1, regresses men's ratings on a dummy for whether the profile's listed income is higher than the rater's own income. The

Table A2: Preferences over partner income, men and women: Qualtrics sample

	Dependent variable: Profile rating			
	Men	Women	Men	Women
	(1)	(2)	(3)	(4)
Age	-0.043***	0.028*	-0.043***	0.028*
	(0.010)	(0.015)	(0.010)	(0.015)
Income ($0,000s)	-0.008	0.001	0.016	0.024*
	(0.018)	(0.025)	(0.012)	(0.014)
Inc × rater inc	0.007***	0.008		
	(0.002)	(0.005)		
Inc × rater high inc			0.040**	0.083*
			(0.018)	(0.046)
Observations	8080	4040	8080	4040
R-Squared	0.491	0.464	0.491	0.464

Notes: Regression of profile rating on randomly assigned age and income for men-rating-women and women-rating-men, from the second sample collected via Qualtrics. Columns 1 and 2 interact profile income with rater income. Columns 3 and 4 interact profile income with whether the rater is "high income," earning above $60,000 annually. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses, clustered at the rater level.
*** p<0.01, ** p<0.05, * p<0.1

coefficient on "profile earns more" is positive, indicating men in this sample do not exhibit distaste for women earning more than them. The second column interacts "profile earns more" with profile income, to see if the slope of additional income turns negative, or is much smaller, for marginal dollars after the rater's own income. The coefficient is negative, but non-significant, and it is much smaller than the main effect. Thus, marginal dollars of income still contribute positively to rating. The last column examines whether very high-income women are viewed less positively. Using a dummy for each income level, with the lowest income level, $20-34,999, as a baseline, we see that the coefficients on income level rise monotonically: the highest income level has a higher coefficient than all income levels before it.

This demonstrates that there does not appear to be a penalty to being high earning, or earning more than one's partner, in contemporary data. It is possible the dissipation of these gender norms have driven the changes over time, as suggested by Bertrand et al. [2016] but my model demonstrates that a portion of what appears as a "norm shift" may be driven by economic fundamentals.

A.3 Non-linearity in preferences over age

Table A4 checks for non-linearity in men's preferences over their partners' ages. If the preference for younger women displayed in the experiment is really a preference for fertility, then all years should not have equal weight in this calculation. Aging that takes place closer to the time when a

Table A3: Male preferences over partner income: Qualtrics sample

	Dependent variable: Profile rating (Male subjects)		
	Binary	Interaction	By income level
	(1)	(2)	(3)
Age	-0.043***	-0.043***	-0.043***
	(0.009)	(0.009)	(0.010)
Income ($0,000s)	0.027***	0.039***	
	(0.010)	(0.014)	
Profile earns more	0.053		
	(0.082)		
Earns more × inc		-0.006	
		(0.010)	
$35-49,999			0.134
			(0.083)
$50-64,999			0.151*
			(0.087)
$65-79,999			0.205**
			(0.085)
$80-94,999			0.213**
			(0.093)
$95-109,999			0.264***
			(0.095)
$110-124,999			0.343***
			(0.099)
Observations	8080	8080	8080
R-Squared	0.490	0.490	0.490

Notes: Regression of profile rating on randomly assigned age and income for men-rating-women, from the second sample collected via Qualtrics. Columns 1 controls for whether the profile has a higher income than the respondent. Column 2 interact profile income with the profile having a higher income than the respondent. Column 3 shows the shape of the rating - profile income relationship by including dummies for different profile income levels (lowest income level omitted). Rater and profile fixed effects included in all columns. Robust standard errors in parentheses, clustered at the rater level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

woman may begin to have difficulty conceiving should be viewed more negatively than aging that is far before or far after this "infertility threshold." The age range that was presented to participants, from 30 to 40 years old, was too narrow to detect any non-linearity in the response to age. However, this non-linearity should most naturally occur in relation to the *perceived* infertility threshold of each respondent. Thus, by creating a new variable of profile age minus each respondent's individual belief regarding the infertility age, I effectively recover an expanded range of ages: from 20 years before infertility to 4 years after, restricting to cells with more than 100 data points. For example, if someone says that it becomes biologically difficult for a woman to conceive at age 36, and the profile age shown is 40, that data point becomes four years past infertility. If the respondent believes the age is 50, and the profile age shown is 40, that would be ten years prior to infertility, or -10.

For the analysis in table A4, errors are clustered at the profile level, because the "treatment" will be correlated with the raters' underlying characteristics, since only individuals who list very high infertility ages can have very negative values for "years past infertility," and only those who list very low infertility ages can have the upper range of "years past infertility" values. This also means that these results should be taken as suggestive only, as individual factors that may bias the response to age may be connected to those factors that cause one to list a higher or lower age at infertility. As in the other analysis that relies on heterogeneity across male respondents, these results are most reliably interpreted in Panel B, with the larger Qualtrics sample.

Table A4: Non-linearity in aging using rater-specific fertility cutoffs: Qualtrics sample

	Dependent variable: Profile rating (Male subjects)		
	Ind cutoff	Cutoff^2	By phase
	(1)	(2)	(3)
Years past	-0.038***	-0.083***	-0.031***
	(0.010)	(0.019)	(0.010)
Years past^2		-0.003***	
		(0.001)	
Yrs past × 10-6 yrs pre			-0.031***
			(0.009)
Yrs past × 5-1 yrs pre			-0.046**
			(0.019)
Yrs past × 0-4 yrs post			-0.001
			(0.048)
Income ($0,000s)	0.032***	0.032***	0.032***
	(0.011)	(0.011)	(0.011)
Observations	6833	6833	6833
R-Squared	0.465	0.467	0.467

Notes: Regression of profile rating on randomly assigned age and income for men-rating-women, from the second sample collected via Qualtrics. The respondent's estimate as to when women become less fertile is subtracted from the profile age to form a measure of how many "years past" this fertility cutoff the profile is. Column 1 shows that this measure can be used as an alternate measure of age, based on the subjective view of fertility by the respondent, and yield similar effect sizes. Column 2 shows the non-linear relationship between rating and this variable. Column 3 shows the value of the coefficient on "years past" at different stages: far from the fertility cutoff, close to the fertility cutoff, and after the fertility cutoff. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses, clustered at the rater level.
*** p<0.01, ** p<0.05, * p<0.1

Column 1 substitutes the constructed years past the individual rater's "infertility cutoff" variable for profile age, showing a coefficient with similar magnitude and significance to the age analysis. Column 2 shows that when a squared term is added, this term is also negative and significant, indicating that distaste for additional years intensifies as age approaches and crosses the perceived infertility cutoff. Finally, column 3 demonstrates that the negative relationship between age and rating follows a backwards "s-curve": shallow, then steep, then shallow. The coefficient grows stronger as age approaches the respondent's perceived cutoff, with a negative and significant slope interaction for being between 6 and 10 years from the cutoff, and a stronger negative and significant effect for additional years within 5 years of the cutoff. Then, once the cutoff has been passed, the coefficient on additional years reverts back to its baseline level (with the interaction being statistically zero), the same as additional years more than 10 years from the cutoff. In the initial sample, these effects are not significant, but follow the same pattern.

A.4 Test for plausibility of surplus function properties

The theoretical model derives predictions from two crucial assumptions. First, the surplus function is supermodular in the two spouses' incomes. Second, the surplus function exhibits a marginal rate of substitution between income and fertility that declines with income. This section uses the experimental data to test the plausibility of these assumptions. Although I cannot test the effect on the surplus function as a whole, which involves the men's and women's utilities added together, I can derive an understanding of the shape of the surplus function from individual preferences.

For the first property, supermodularity in incomes, I look at the effect of the interaction between own income and profile income on overall rating, as discussed in the context of women's preferences for income. Table A2 shows that taste for partner income is indeed an increasing function of own income. In columns 1 and 2, the rater's own income interacted with the profile's income has a positive and significant coefficient for regressions of each male and female ratings on profile characteristics, providing evidence for the supermodularity assumption. This table is discussed in more detail in the next section.

Table A5 tests for the second assumption, decreasing marginal valuation of income relative to fertility as income increases. The relationship between men's ratings of profiles and women's ages shown in the profile is indeed heterogeneous across income groups. This justifies the non-index approach to solving the matching model, since not all men value partner characteristics alike. However, rather than merely increasing in income, the age penalty appears to be U-shaped, with the poorest men having the greatest preference for young partners, middle income men having the lowest preferences, and the highest income men having higher preferences than the middle-income. This may be due to cultural norms acting on the lowest income men, while the model's mechanism of decreasing marginal valuation of income relative to fertility (due, in part, to the growing importance of investments in children in the overall surplus produced by marriage) may be causing the heightened valuation of age among the higher-income men. The increasing side of the "U," though, is the one most likely to impact individuals considering post-bachelor's educational investments, and thus the relevant section for the model presented here. Additionally, because in both the three-segment and the positive assortative equilibrium the very poorest men *do* match with fertile women in the model, these equilibria would be robust to the very poorest men, in addition to the richest men, having heightened sensitivity to age. The negative assortative matching equilibrium may be ruled out by these preferences, however (in addition to being unlikely to appear due to typically assortative matching on social class).

Table A5: Income heterogeneity: Qualtrics Sample

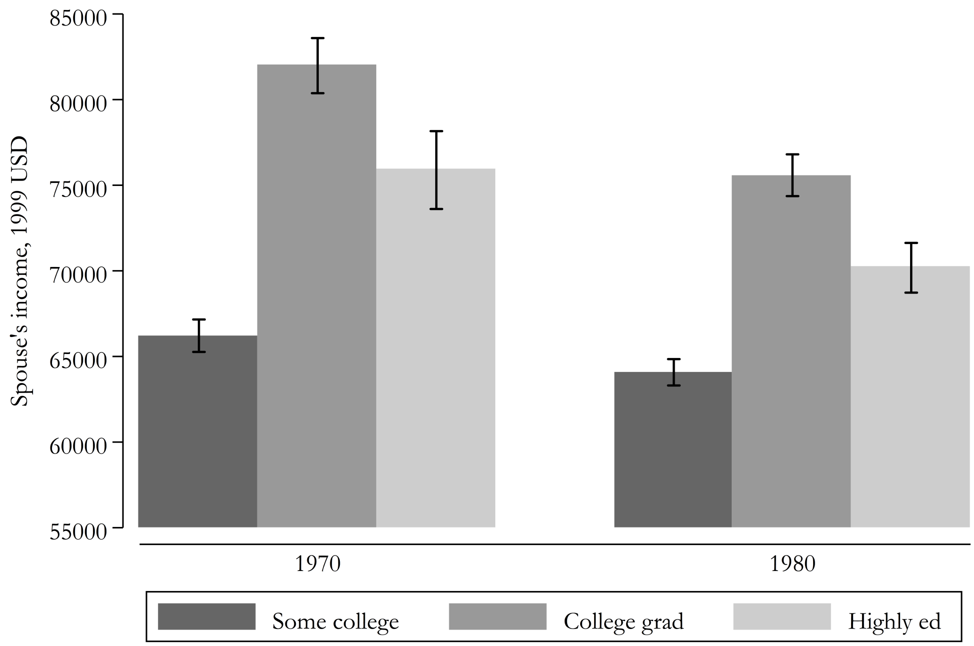
	Dependent variable: Profile rating		
	Age interaction	Income and age	Control for knowledge
	(1)	(2)	(3)
Age	-0.001	-0.001	-0.026
	(0.015)	(0.015)	(0.018)
Income ($0,000s)	0.032***	0.034**	0.032*
	(0.009)	(0.016)	(0.017)
High income × age	-0.038*	-0.038*	-0.037*
	(0.022)	(0.022)	(0.022)
Low income × age	-0.070***	-0.070***	-0.063***
	(0.022)	(0.022)	(0.021)
High income × inc		0.022	0.025
		(0.021)	(0.022)
Low income × inc		-0.029	-0.025
		(0.024)	(0.024)
No knowledge × age			0.057***
			(0.017)
Observations	8080	8080	7800
R-Squared	0.491	0.492	0.490

Notes: Regression of profile rating on randomly assigned age and income for men-rating-women and women-rating-men, from the second sample collected via Qualtrics. Column 1 interacts profile age with the rater being high income or low income. Column 2 adds interactions with profile income. Column 3 controls for rater fertility knowledge interacted with profile age. Rater and profile fixed effects included in all columns. Robust standard errors in parentheses, clustered at the rater level.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

B Appendix: Census Data

Figures A1 and A2 repeat analysis in Figures 6 and A2, but restricting to first marriages. In order to do this, I must exclude data from 1990 and 2000, when number of marriages was not available.

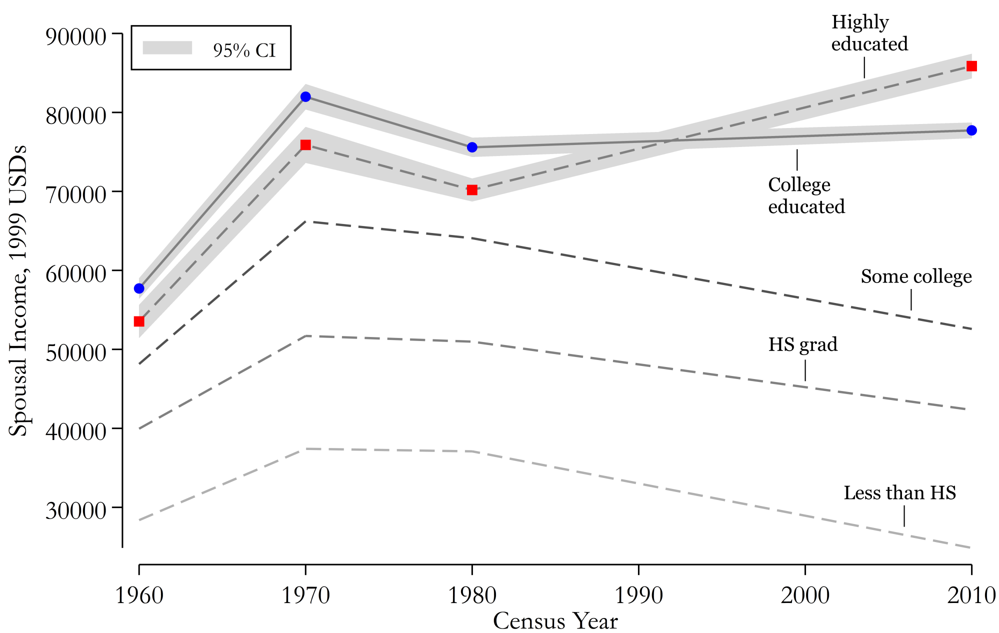
Figure A1: Non-monotonicity in spousal income by wife's education level, first marriages only



Notes: Income of spouse based on wife's education level, with "highly educated" constituting all formal education beyond a college degree. Restricted to first marriages. Difference between college and highly educated women's spousal earnings is significant in all three samples. 95% confidence interval shown by black lines. Source: 1 percent Census data from 1970 and 1980 Sample consists of white women, ages 41-50 years old.

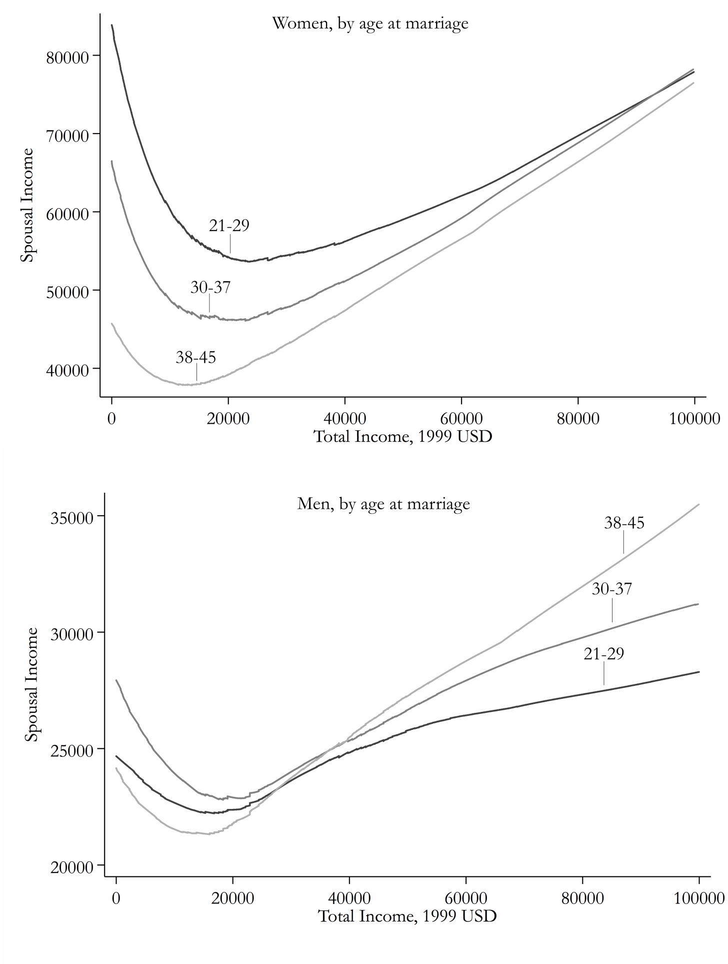
Figure A3 shows that conditional on income, marrying older is always worse for women, but not for men. For women, no matter their own income, women who marry at an older age have a lower-earning spouse. For men, on the other hand, marrying at an older age is linked to a higher-earning spouse when they themselves are high-earning.

Figure A2: Spousal income by wife's education level, first marriages only



Notes: Income of spouse based on wife's education level, with "highly educated" constituting all formal education beyond a college degree. Restricted to first marriages. Source: 1 percent Census data from 1960 and 1970, and American Community Survey from 2000 and 2010. Sample consists of white women, ages 41-50 years old.

Figure A3: Lowess-smoothed spousal income by age at marriage



Notes: Figure graphs own income versus spousal income for three different age groups. Women who marry older marry poorer men no matter their own income, whereas for wealthy men, those marrying older are matched with higher-earning spouses.

Table A6 examines whether there has been an increasing skill premium among women who attain post-bachelor's education, using data from aptitude scores and educational attainment of three National Longitudinal Surveys NLS cohorts—the 1968 Young Women panel, the 1979 Youth panel, and the 1997 Youth panel. (Unfortunately, the earliest cohort with the necessary test score information only captures the tail end of the non-assortative matching group, but nonetheless, the trend should be informative about whether there are large shifts occurring in underlying selection factors.) If women were previously selecting into post-bachelor's education due to negative selection in other areas, they may be expected to be less positively selected on intelligence and academic potential. The data shows, to the contrary, that highly educated women indeed had substantially higher aptitude scores on average than college educated women even in the earliest cohort, and that the two numbers are not systematically diverging (which would indicate greater skill-driven selection).

Table A6: Relative college and post-bachelor's average test score percentiles of three NLS cohorts

	NLS Young Women 1944-1954 birth cohort	NLS Youth '79 1957-1964 birth cohort	NLS Youth '97 1980-1984 birth cohort
College graduate	66.5	70.3	63.6
Highly educated	72.0	74.9	69.3

Notes: Numbers represent percentiles for test scores by education group, compared to other women of all education levels with test score information available, in three different National Longitudinal Study cohorts. Young Women test score data is from the SAT converted into an IQ measurement. 1979 and 1997 data is from the Armed Forces Qualification Test. Gap in scores between college and graduate-educated women is large and relatively stable. The difference in percentile at both educational levels between the different years may be attributable to score data being available for a different selection of individuals in different survey rounds (e.g., for the Young Women sample, it was only available for individuals who reached the later years of high school).

Table A7 demonstrates the change in spousal income based on educational status over time in a regression format.

Figure A4 shows that women who were highly educated always made higher wages than women who were only college educated, and thus that own income does not show a similar "crossing" as does husband's income.

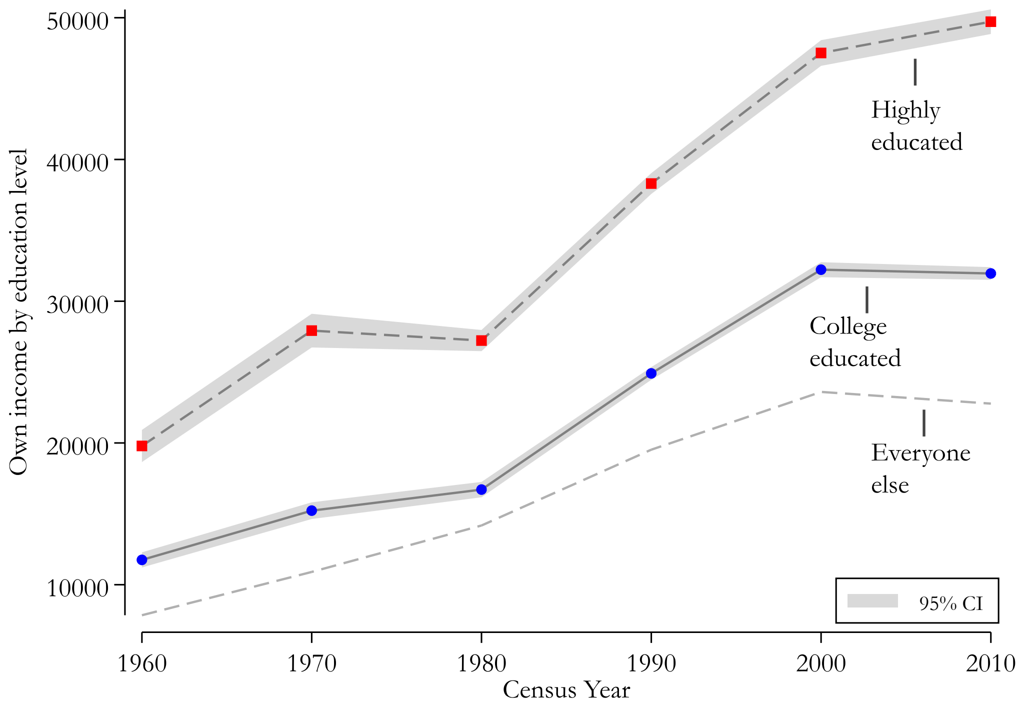
Table A7: Spousal income by wife's education level

	Dependent variable: Spousal income, 1999 USD		
	(1)	(2)	(3)
1960 × highly ed	-3,809	-3,809	-3,833
	(2,355)	(2,355)	(2,355)
1970 × highly ed	-5,368***	-5,368***	-5,386***
	(1,926)	(1,926)	(1,926)
1980 × highly ed	-5,584***	-5,584***	-5,580***
	(1,554)	(1,554)	(1,554)
1990 × highly ed	-2,300**	-2,300**	-2,300**
	(1,055)	(1,055)	(1,055)
2000 × highly ed	4,290***	4,290***	4,268***
	(828.7)	(828.7)	(829.1)
2010 × highly ed	6,625***	6,625***	6,623***
	(758.9)	(758.9)	(758.9)
Year FEs	Y	Y	Y
YOB FEs		Y	Y
Spouse age			Y
Observations	115,223	115,223	115,223
R-squared	0.540	0.540	0.540

Notes: Regressions of spousal income on wife's education level interacted with year for women with at least a college degree, with "highly educated" constituting all formal education beyond a college degree. No constant or "highly" dummy is included, so coefficients can be interpreted as the additional spousal income for those in the highly educated category in each sample. Source: 1 percent samples of US Census data from 1960, 1970, 1980, 1990 Census, and 2000 and 2010 American Community Survey. Sample consists of white women, ages 41-50. Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Figure A4: Own income by education level



Notes: Figure shows own income for women by education level, with "highly educated" constituting all formal education beyond a college degree. 1 percent samples of US Census data from 1960, 1970, 1980, 1990 Census, and 2000 and 2010 American Community Survey. Sample consists of white women, ages 41-50. Income in 1999 USDs.