Pricing the Biological Clock: Reproductive Capital on the US Marriage Market

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Abstract

There is an overwhelming tendency toward assortative matching on income and education on the marriage market. However, for women, greater income and education are often correlated with older age at first marriage, and therefore lower fertility. Using a bi-dimensional matching model with two factors, income and “reproductive capital,” I study the impact of career investments that delay marriage on women’s marriage market outcomes. I find there may be an equilibrium where the highest earning women do not match with the highest earning men: these men may instead match with lower-earning, but still fertile women. The extent of this negative assortative matching on income depends on the returns to career investments for women, and the reduction in fertility linked to such investments. Women’s human capital investments is in turn affected (and potentially reduced) by these anticipated marriage market outcomes. The model explains matching patterns and recent changes in marriage market outcomes for highly educated women in US Census micro data. To show that age indeed matters on the marriage market, separately from beauty, and thus that fertility acts as a form of capital, I implement an online experiment where age is randomly assigned to dating profiles. I find that men, but not women, have strong preferences for younger age, and that this preference is driven by individuals who are childless and have accurate knowledge of the age-fertility constraint.

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Women’s ability to conceive children falls off rapidly beginning in their mid thirties. This decline in fertility has rarely been treated as an economic change, despite large potential implications for women’s welfare. If marriages are formed primarily to have children, and marriages tend to improve the economic circumstances of women, then a woman is economically worse off after this fertility decline than she is before. If she is unmarried, her value as a partner has diminished and thus her marital prospects may be worse, and if she is married, her outside option has decreased.

Therefore, it seems fertility should be treated as an economic asset. Such “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. Thus, reproductive capital may be important to the understanding of economic decisions made by women, and their resulting outcomes.

Using a bi-dimensional matching model that incorporates both income and fecundity, I study the impact of the tradeoff between career investments and marriage market outcomes for women of differing skill levels. If the most skilled women are the ones most likely to make time-intensive career investments, then the most skilled and highest earning men may not match with the highest earning women—rather, they may choose to match with lower-earning but more fecund women who have chosen not to make time-costly investments. As a result, the match may be non-assortative in income of the two partners, and in particular may displays a potential non-monotonicity in income: as a woman’s income grows, she at first becomes more attractive to higher-earning men, then less attractive as the complementarity between fertility and income outweighs the income–income complementarity. This non-monotonicity can appear as long as the surplus function features both convexity in income (or super-modularity, in the case of non-transferable utility) and a decreasing marginal rate of substitution between income and the second factor, in this case
The structure of the matching equilibrium depends on the relative value of time-intensive career investments for women compared to the resulting loss of fertility. Using US census data, I show that matching patterns in the US since the 1960s have followed patterns predicted by a model that incorporates reproductive capital as a marriage market asset.

My main assumption is that men have preferences over fertility, which will translate into preferences for partner age on the marriage market, and thus a tradeoff for women when considering career investments. To test this, I use an online experiment to measure the preferences of men for a female partner’s age, when other factors, such as beauty, are controlled for. I find that men, but not women, have strong preferences for younger age, and that this preference is driven by individuals who are childless and have accurate knowledge of the age-fertility constraint.

Section 1 of this paper describes related research and lays out some empirical puzzles that motivate the development of the model, Section 2 develops the model and considers its generalizability, Section 3 tests its implications using US Census data, Section 4 presents the results of the online experiment, and Section 5 concludes.

1 Background

1.1 Motivation: Reproductive Capital?

In what is essentially an aberration in the animal kingdom, human females experience a cessation of ovulation—menopause—around age 50, beyond which time they can no longer conceive children. Prior to this cessation, women face increasing difficulty becoming pregnant, and having healthy children, as they approach and pass 40. Frank, Bianchi, and
Campana (1994) write, “The end of menopause tends to occur during the mid-50s, but natural population data indicate that fecundity usually ends at around 39-41 years.” This decline is not linear from the onset of fecundity, but rather happens sharply beginning in the mid-thirties. Women lose 97% of eggs by 40 (Kelsey and Wallace 2010), and moreover egg quality declines, as Toner (2003) notes “In women past age 40, current success rates [of pregnancy] are low overall, even in those with good ovarian reserve who make many eggs; at this age, quantity does not make up for quality.” The decrease in fertility (in several traditional societies, where women did not use birth control, and thus fertility closely mirrors fecundity\(^1\)) and increase in miscarriages as age increases is shown in Figure 1.

This cost to marrying older women appears to be reflected in a social preference for younger women on the marriage market. Women who are older at the time of first marriage (beyond age 30) tend to marry lower income spouses, as evidenced by data from the American Community Survey in Figure 2.

Note that this phenomena of matching with worse spouses for older marriage ages is unique to women—men’s partner quality appears to rise fairly constantly with age at first marriage.

We can see the preference for younger women in a different way—by looking at the age gap between spouses as age at marriage rises. As documented by England and McClintock (2009), for men, the age gap grows larger as age at marriage rises—they continue to marry young women, despite their own age increasing. For women, there is no change in age gap—they marry partners whose ages are similar to their own, even as their own age rises. But, given the pattern for men, these women will be drawing spouses from a smaller pool of

\(^1\)Figure adapted by Heffner from Menken, Trussell, and Larsen (1986), including Hutterites in the early 1900s, Geneva bourgeoisie from the 15-1600s, Canada in the 1700s, Tunis in the 1800s, Normandy in the 16-1700s, Norway in the 1800s, and Iran in the 1940s, all of which demonstrate the same pattern when studied separately.
Figure 1: Rates of Infertility and Miscarriage Increasing Sharply with Age

Source: Heffner 2004, “Advanced Maternal Age: How old is too old?”
Figure 2: Spousal Income by Age at Marriage
men, since the men their age are marrying younger women. This mis-match in the market size could naturally result in lower quality matches for women marrying older.

Figure 3: Spousal age difference (husband’s age minus wife’s age) by age at marriage (England McClintock 2009)

This pattern linking age and marriage-market outcomes for women motivates a matching model in which career investments influence both income and age at the time of marriage, which in turn affects fertility.

1.2 The marriage market value of fertility

In the economics literature, some work points to how the ability to bear children has given women their claim to economic security before female employment rates increased. Edlund (2006) postulates that the institution of marriage is designed to transfer parental rights to husband from wife. While motherhood is easy to establish, before DNA testing fatherhood had to be established by looking to the husband of the mother. In exchange for this transfer, men compensate women (or, in patriarchal regimes, their fathers) through either
explicit financial transfers or economic support during marriage. Chiappori and Oreffice (2008) present a model in which men make monetary transfers to women in marriage in part to compensate them for childbearing.

This concept has been applied to markets for sex workers as well as wives. Edlund and Korn (2002) argue that if reproductive sex has value on the marriage market, it can help explain the high premium paid for non-reproductive sex on the commercial sex market: Prostitution must pay better than other jobs to compensate for the opportunity cost of forgone marriage market earnings. Solidifying the connection between fertility and the prostitution wage premium, Edlund et al (2009) find that wages for commercial sex are hump shaped in age, peaking in the 26-30 range, and conclude that this represents compensation for foregone marriage market opportunities—to compensate sex workers for the heightened opportunity cost of reproductive sex during these fertile years.

Arunachalam and Naidu (2010) point to lower expected fertility as a driver of increasing dowries in Bangladesh following the Matlab family planning experiment. If husbands desire larger family sizes than wives, then a technology that reduces expected fertility will decrease the value of marriage to husbands, resulting in increased dowries. Their model does not address how the wife’s share of consumption may be affected by choosing lower fertility, however.

This connection between fertility and marriage market outcomes, somewhat novel in economics, is taken as a given in other disciplines. For example, anthropologists Bell and Song (1994) set forth a framework in which women can be valued in cattle according to the number of daughters they will produce, writing, “The logic of everyday economic reality offers no alternative to the consideration of bridewealth as an advance payment for services or as a lease of the service provider whereby wife takers experience benefits that exceed costs.”
This view of marriage has its origins in the evolutionary biology writings of Trivers (1972). Trivers explains that because sperm are metabolically cheap and plentiful while eggs are costly and scarce, “a male’s reproductive success is not limited by his ability to produce sex cells but by his ability to fertilize eggs with these cells. A female’s reproductive success is not limited by her ability to have her eggs fertilized but by her ability to produce eggs.” As a result, females have an incentive to ensure each egg will produce a quality offspring, and thus be choosy in mate selection, while males face no opportunity cost to fertilizing many eggs. Therefore, men compete over women, making transfers to females to secure rights to fertilize their eggs.

1.3 The work-family tradeoff

If one’s reproductive capacity has economic value, but only for a limited time, then using this time for other purposes is costly. Therefore, career investments that might produce their own economic benefits could carry with them a sufficiently steep cost that women would avoid them.

Modeling reproductive capital together with the human capital investment decision could shed light on women’s underachievement at the very top of the distribution. Indeed, while women now outpace men in gaining a college education, women still lag behind in PhDs, with 43% more men than women between the ages of 40 and 50 having doctoral degrees in the 2009 American Community Survey. 13% of men in this 40-50 year-old age group earn more than $100,000 per year, while only 4% of women do. The 95th percentile in wages for this age group is $160,000 for men; $92,000 for women. And women make up just 4% of Fortune 500 CEOs (Fortune Magazine 2013).

Perhaps because of this connection, the relationship between age-at-marriage and spousal income is especially apparent for college-educated women, as shown in Figure 4.
women realize the greatest gain in spousal income by waiting until their late twenties or early thirties to marry, due to either selection or marriage market returns to human capital accumulation, but also show the biggest drop-offs in spousal income for marriages after 30. This indicates that reproductive capital may be especially salient for those with the most to gain from making large career investments.  

Figure 4: Older, Educated Women Marry Poorer Spouses

The lack of steepness in the drop-off for marriage market outcomes for women with less education could be simply because they never marry as wealthy of husbands to begin with, or could also be because of a stronger selection effect acting upon them. For college educated women, who have something to gain in terms of their own income by delaying marriage, delaying marriage is not indicative of not wishing to have children—these women report wanting children just as much in National Survey of Family Growth data. However, for women with only a high school education, whose income path is unlikely to be greatly changed by delaying marriage, waiting to marry is much more related to not wanting children, and choosing a partner who does not want children.
The tradeoff between family and work choices for women has been explored in a voluminous economics literature, which primarily addresses the way the ability to control fertility has enabled women’s career investments, beginning with Goldin and Katz’s seminal 2002 paper on oral contraceptives. Bailey (2006) and Bailey et al (2012) continue this approach, looking at how access to the pill increased women’s lifetime labor supply and may have reduced the gender wage gap, respectively. This literature validates that there is a tradeoff between family/child-rearing and career. Buckles (2012) examines fertility limitations from the other direction—not too much fertility, but too little. She argues that biological limits on fertility may restrict women’s career participation, due to them needing to bear children, and thus take time off of work, before menopause sets in. She shows that increased access to fertility treatments is related to increased fertility and, marginally, increased labor force participation and higher wages for women over 35.

### 1.4 Age and marriage

Siow (1998) considers the impact of fecundity limits on both marriage and career. He proposes a model where women do not have the option to remarry later in life due to their lack of fertility, and thus have less motivation to make career investments early in life (since unlike their husbands they cannot hope to attract a secondary spouse post divorce). However, his work does not provide a model of the marriage market that would result in such restrictions on women’s remarriage potential.

Mazzocco and Bronson (2012) also take as given that women cannot marry later, developing a search model of the marriage market where can only marry when young. This results in variation of the gender ratio on the marriage market when cohort size changes, resulting in fluctuations in marriage rates.

This paper contributes to this literature by providing a formal model of the mechanism
through which age can affect women’s marriage market outcomes, and thus offering microfoundations for the assumption that older women cannot marry.

1.5 Transferable utility matching models

Transferable utility matching models (Shapley and Shubik (1971) and Becker (1973)), are a workhorse of family economics because they allow the study of utility division rather than just household consumption choices. And, unlike other models of the household such as Nash bargaining models, transferable utility matching models do not require assumptions about husbands’ and wives’ “bargaining power” or “consumption share” within the household. Rather, the distribution of surplus is set by the market as equilibrium “offers” where both spouses are able to attract one another. Thus, this type of model requires assumptions only about the form of the utility function. Rather than making the assumption that fertility impacts matching and intra-household transfers, the model I present yields this as an equilibrium result, stemming from the simple assumption that children matter in husband’s and wives’ utility functions.

Marriage market matching models that are truly bi-dimensional have only recently been explored by the literature. Many matching models that look at two characteristics reduce these characteristics to an index of overall desirability (e.g., Chiappori et al (2012)). However, if the value of either characteristic varies with the quantity of the other characteristic, the dimensions of the model cannot be collapsed. An example of this is Chiappori et al (2010), where smokers do not mind if their partners smoke, whereas non-smokers do, and thus no universal index of desirability can be found. Such truly bi-dimensional models allow for matches that are not simply either assortative (like with like) or negative-assortative along a “quality index.” The complementarity between fertility and income in the model I present creates the potential for a non-monotonic match. I provide conditions under which
this type of match can occur, which are applicable outside the specific question of fertility’s role on the marriage market.

2 A Model of the Marriage Market with Reproductive Capital and Income

Suppose that investing heavily in one’s career (e.g., tenure, surgical residency, becoming partner at a law firm...) yields large earnings gains but delays marriage and childbearing. This would create a choice for women between going on the marriage market as high income, low fertility (richer and older) or low income, high fertility (poorer and younger). In which case, women on the marriage market would have two relevant characteristics, fertility and income. I develop a matching model that incorporates both characteristics, and demonstrate that it allows for non-assortative matching on income at the top of the distribution. As long as the loss of fertility is large relative to the return to women’s career investments, there exists a stable equilibrium where the women at the top of the skill distribution to match with lower-earning men than do less skilled women. I first examine the marriage market implications of the model, and then use an extension to explore the implications for women’s human capital investments.

This model has four stages: 1) Women invest in careers; 2) Couples match; 3) The couple has a child with probability $\pi$; 4) The couple allocates income between private consumption and their child.

Men and women are each characterized by skill, $s$. In the man’s case, this translates directly into income, because every man will maximize his income-earning potential. Therefore, he arrives on the marriage market with a single characteristic, $y^h$.

For women, they can choose to improve their level of income, but doing so takes time.
The result is that they will have a lower probability of becoming pregnant when they get married. Therefore, women choose to either go on the marriage market immediately or after investment, and therefore are characterized by a pair of characteristics, \((y^w, \pi)\). This pair is equal to \((s, P)\) if the woman marries in the first period or \((\lambda s, p)\) if the woman marries in the second, where \(\lambda > 1\) and \(P > p\). \(P - p\) is the same for all women, whereas \(s(\lambda - 1)\) grows with skill.

To begin, I assume there is an arbitrary threshold, \(t\), above which women invest, that is exogenously given by forces outside the model (as smokers and non-smokers are exogenous to the model in Chiappori et al 2012). After determining the equilibrium in the marriage market with some portion of women who have invested, we can use this equilibrium to solve backwards for which women would optimally invest in the first stage.

Figure 5: Women’s income versus potential income

Thus, women with \(s > t\) will invest and earn income of \(\lambda s\) and have fertility \(p\), whereas women with \(s < t\) will earn income \(s\) and have fertility \(P\), as shown in Figure 5.
To solve the remainder of the model, we work backwards from consumption decisions if a child occurs, to the surplus function from marriage, to then determine the shape of the match.

Married couples can consume private consumption given by \( q^h \) and \( q^w \) and a public good, investment in children, denoted by \( Q \). If individuals do not marry, only private consumption is available.

To clarify the set-up, I use a specific example that I will return to later.

Let the utility of each be given by:

\[
\begin{align*}
    u^h(q^h, Q) &= q^h(Q + 1) \\
    u^w(q^w, Q) &= q^w(Q + 1)
\end{align*}
\]

And the budget constraint is \( q^h + q^w + Q = y^h + y^w \).

These utilities satisfy the Bergstrom-Cornes property for transferable utility (Chiappori et al, 2007), and thus consumption decisions can be found by maximizing the sum of utilities, subject to the budget constraint. Assuming \( y^h + y^w > 1 \):

\[
\begin{align*}
    q^* &= \frac{y^h + y^w + 1}{2} \\
    Q^* &= \frac{y^h + y^w - 1}{2}
\end{align*}
\]

The joint expected utility from marriage will be a weighted average between the optimal joint utility if a child is born and the fallback position of allocating all income to private consumption. Let \( T \) be the joint product of the marriage.

\[
T = \pi \left( \frac{(y^h + y^w + 1)^2}{4} + (1 - \pi)(y^h + y^w) \right)
\]
2.1 Finding the stable match

A matching is defined as the probability that a given man is matched with a given woman, and value functions for each agent giving their equilibrium surplus share from the resulting match, such that no agent would prefer to remain single, and no two agents who are not matched with one another could profitable deviate by forming a match.

For notational simplicity, because the choice impacting $y^w$ and $\pi$ are assumed to be deterministically based on $s$, I define functions based on the woman’s underlying characteristic, her skill level $s$, and use piece-wise functions to define the differences between those that invest and those that do not. Therefore, the value functions are $u_i(y)$ and $v_i(s)$, where $i$ represents the “segment” of the match, in terms of which group (those who have invested versus those who have not) is being matched.

A matching is stable if no matched agent would be better off unmatched, and no two matched individuals would prefer being matched together to their current pairing. Thus, we require:

$$\forall y : \quad u_i(y) \geq y$$
$$\forall s : \quad v_i(s) \geq s$$
$$\forall y, \forall s : \quad u_i(y) + v_i(s) \geq T_i(y, s)$$

Where $u_i(y) + v_i(s) = T_i(y, s)$ for individuals matched together.

As shown in Becker (1973), super-modularity of the surplus function is sufficient to prove positive assortativeness in a unidimensional setting. Intuitively, this relies on the equivalence between total surplus maximization and finding the stable match.\footnote{In multi-dimensional settings this generalizes to the “twisted buyer” condition described by Chiappori, McCann, and Nesheim (2010).} Thus, if
the surplus function is super-modular in incomes, then for two women of the same fertility level, the woman with the higher income must be matched with a higher income man.

In the simple example given, the joint product is super-modular in incomes (here, just convexity in income, since the two incomes enter additively):

$$\frac{\partial T}{\partial y^h} = \pi y^h + y^w + \frac{1}{2} + (1 - \pi)$$

$$\frac{\partial^2 T}{\partial y^h \partial y^w} = \frac{\pi}{2} > 0$$

Thus, we should expect assortative matching for women with identical fertility, since the increase of the joint product in one partner’s income is increasing in the other partner’s income.

But what about women with different fertility levels? To make predictions here, we need to understand how the relative trade-off between fertility and income differs for men of different incomes. Note that the value of both income and fertility in the surplus function is increasing in income. The question is, as income rises, how does the relative value of the two change?

If couples with richer men value fertility less relative to income, then the richest women should be matched with the richest men, and thus matching must always be assortative. But if couples with richer men value fertility more, we cannot say whether there should be assortative matching or not. It could be that the value of extra fertility, while increasing in income, never outweighs the value of extra income. Or, it could always outweigh the value of extra income. Or, there could be a switching point, where a man is rich enough that he changes from income being valued more in total surplus to fertility being valued more. Thus non-assortative matching on income is possible for women with different fertility
levels, depending on whether the fertility tradeoff is large enough to outweigh the gain from income super-modularity.

To examine how that tradeoff between fertility and income varies with men’s income, we can look at how the marginal rate of substitution in the woman’s two characteristics is changing in the husband’s income.

Note that \( \frac{d\pi}{dy^w} = -\frac{\partial T}{\partial y^w} \)

For this example surplus function:

\[
\frac{\partial T}{\partial y^w} = \frac{\pi (y^h + y^w + 1)}{2} + \frac{1 - \pi}{(y^h + y^w + 1)^2} - (y^h + y^w) \equiv R
\]

This is the amount of \( \pi \) required to compensate for a loss of \( y^w \). This ratio is decreasing in \( y^h \):

\[
\frac{\partial R}{\partial y^h} = \frac{2(\pi (y^h + y^w - 1) + 4)}{(y^h + y^w - 1)^3}
\]

Therefore, the richer a man is, the less improvement in fertility is required to compensate for income loss. This suggests that couples with richer men care more about fertility, and so there may be some segment of richer men who actually marry poorer, more fertile women than a segment of poorer men. This condition on the marginal rate of substitution is the crucial ingredient allowing a non-monotonic match in equilibrium, which I prove below for a more general setting.

### 2.1.1 General Characterization of Match

Assume a population of men, characterized by income \( y^h \in (0, Y) \), and a population of women endowed with skill \( s \in (0, S) \) and characterized by income \( y^w \) and fertility \( \pi \) (with the population of both men and women being atomless, continuous distributions). Women
with skill below some threshold, $t$, receive income equal to $s$ and have a probability of conceiving $P$, while women with skill above $t$ make time consuming career investments, such that they receive income $\lambda s$, $\lambda > 1$, but are less fertile, conceiving with probability $p$, where $p < P$. Assume further a surplus function from the marriage $T(y^w + y^h, \pi)$, increasing in both arguments, which exhibits the following properties:

1. $\frac{\partial^2 T}{\partial y^w \partial y^h} = \frac{\partial^2 T}{\partial y^2} > 0$ (supermodularity in both spouses’ income, equivalent here to convexity in income)

2. $\frac{\partial R}{\partial y} < 0$ and $\frac{\partial R}{\partial \pi} \geq 0$, where $R \equiv \frac{\partial T}{\partial y^w} \frac{\partial T}{\partial \pi}$ (The marginal rate of substitution between fertility and income in the surplus function is decreasing in income, meaning higher-income couples value fertility more, and non-decreasing in fertility)

Then, if we assume an equal population of men and women, and outside options such that all prefer to match:

**Proposition 1.** The general form of the match will be:

- Women with $s < t$ will match positive-assortatively with men with regard to income: if $s < s' < t$, and $s$ is matched with $y$ and $s'$ with $y'$, then $y < y'$. Similarly, women with $s > t$ will match positive-assortatively with men with regard to income

- Depending on the parameter values, some high earning men can marry a woman with $s < t$, while some lower earning men marry women with $s > t$, thus matching negative-assortatively with regard to income across $t$. This portion may be all, some, or none of the highest income men.

- If some man who marries a woman with $s < t$ is richer than a man marrying a woman with $s > t$, then every richer man also marries a woman with $s < t$. 

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Lemma 1. There is positive assortative matching between men and women on the sets $(t, S) \times (0, Y)$ and $(0, t) \times (0, Y)$.

Proof. Define $\phi(s) = \{y\}$ such that the probability that $y$ is matched with $s$ is greater than 0.

For $(t, S) \times (0, Y)$: For $s' > s$, and $y \in \phi(s)$ and $y' \in \phi(s')$, suppose $y > y'$. Because $T$ is convex in total income, $T(\lambda s' + y, p) + T(\lambda s + y', p) > T(\lambda s' + y', p) + T(\lambda s + y, p) = u(y) + u(y') + v(s) + v(s')$, given the current matching.

This violates the constraints that $u(y) + v(s') \geq T(\lambda s' + y, p)$ and $u(y') + v(s) \geq T(\lambda s + y', p)$. Therefore, $y' \geq y$, and $\mu$ exhibits positive assortative matching on $(t, S) \times Y$.

The proof for positive assortative matching on $(0, t) \times (0, Y)$ is analogous.

Because there is positive assortative matching, and the distributions of $y$ and $s$ are atomless and continuous, the sets $\phi(s)$ and $\psi(y)$ (defined symmetrically as $\psi(y) = \{s\}$ such that the probability that $s$ is matched with $y$ is greater than 0) are singletons, and the positive assortative matching is strict.

I will now demonstrate that the marginal rate of substitution condition is sufficient for non-assortative matching under some parameter values. First, we need to take a small detour to show the implications of the MRS for the surplus resulting from different pairings.

Lemma 2. $\frac{\partial T}{\partial y} \equiv \text{MRS}$ decreasing in income and non-decreasing in fertility implies that $T(x + \epsilon, P) - T(x' + \epsilon, p) > T(x, P) - T(x', p)$.

Proof. Choose a surplus level $T_0$, with $x < x'$ such that $T(x', p) = T(x, P) = T_0$.

Let $(g, c)$ define a set of paths from $x$ to $x'$ such that $T(g, c) = T(x, P) = T_c$, a constant for a given $c$, and we can write $T_c = T(y(g, c), \pi(g, c))$ with $y(g, c) = x + c + g(x' - x)$ for $g \in [0, 1]$, and $\pi(0, c) = P$.

For $T(g, c) = T_c$ for all $g$.
\[
\frac{\partial T}{\partial y} \frac{\partial y}{\partial g} + \frac{\partial T}{\partial \pi} \frac{\partial \pi}{\partial g} = 0
\]

\[\Rightarrow \frac{\partial \pi}{\partial g} = -\frac{\partial T}{\partial y} \frac{\partial y}{\partial \pi} \]

\[\Rightarrow \int_0^1 \frac{\partial \pi}{\partial g} dg = \int_0^1 -MRS(g, c) \frac{\partial y}{\partial \pi} \frac{\partial y}{\partial g} dg \]

\[\Rightarrow \pi(1, c) - \pi(0, c) = \int_0^1 -MRS(g, c)(x' - x) dg \]

For \(MRS(g, 0)\), since we know \(T(x', p) = T(x, P) = T_0\):

\[\pi(1, 0) - \pi(0, 0) = \int_0^1 -MRS(g, 0)(x' - x) dg \]

\[\Rightarrow p - P = \int_0^1 -MRS(g, 0)(x' - x) dg \]

Now consider \(c = \epsilon > 0\), with \(MRS(g, \epsilon) < MRS(g, 0)\) at every \(g\), since MRS is decreasing in income and non-decreasing in fertility, and \(y(g, \epsilon) > y(g, 0)\). For surplus level \(T(g, \epsilon) = T_\epsilon\):

\[\pi(1, \epsilon) - \pi(0, \epsilon) = \int_0^1 -MRS(g, \epsilon)(x' - x) dg \]

\[\Rightarrow \pi(1, \epsilon) - P = \int_0^1 -MRS(g, \epsilon)(x' - x) dg \]

\[\Rightarrow \pi(1, \epsilon) > p \]

This means that at the point \((x' + \epsilon, p)\), since \(\frac{\partial T}{\partial \pi} > 0\), we must be below the surplus level \(T_\epsilon\).

Thus, the MRS decreasing in \(y\) implies that if \(T(x', p) = T(x, P)\) then \(T(x' + \epsilon, p) < \)
Adding together those equations, we have:

\[ T(x + \epsilon, P) + T(x' + \epsilon, p) < T(x', p) + T(x + \epsilon, P) \]

\[ \Rightarrow T(x + \epsilon, P) - T(x' + \epsilon, p) > T(x, P) - T(x', p) \]

To show that this increasing difference does not rely on starting from two equal points, consider \( 0 < \delta < \epsilon \).

\[ MRS(g, \epsilon) < MRS(g, \delta) < MRS(g, 0) \Rightarrow \pi(1, \epsilon) - p > \pi(1, \delta) - p > 0 \Rightarrow T(x + \epsilon, P) - T(x' + \epsilon, p) > T(x + \delta, P) - T(x' + \delta, p) > 0. \]

Now, we turn to the implications for matching across the threshold.

**Lemma 3.** Assume that \( T(t + Y, P) > T(\lambda S + Y, p) \). Then, there exists some \( y' \) and some \( y < y' \) for which \( \psi(y') < t < \psi(y) \).

A slightly stronger form of assumption 2, that the marginal rate of substitution goes to zero as \( y \) goes to infinity, is sufficient to guarantee that for \( Y \) large enough \( T(t + Y, P) > T(\lambda S + Y, p) \).

**Proof.** Because \( T(t + Y, P) > T(\lambda S + Y, p) \), by continuity there exists \( s < t \) and \( s' > t \) such that \( T(s + Y, P) > T(\lambda s' + Y, p) \). Because \( \frac{\partial T}{\partial y} \) is monotonically decreasing in income, if \( T(s + y', P) > T(\lambda s' + y', p) \), then \( T(s + y', P) - T(\lambda s' + y', p) > T(s + y, P) - T(\lambda s' + y, p) \) for \( y < y' \).

Now suppose that \( \psi(Y) > t > \psi(y) \) for all \( y < Y \).

\( T(t + Y, P) > T(\lambda S + Y, p) \) and \( y < Y \) \( \Rightarrow \) \( T(s + Y, P) > T(\lambda s' + Y, p) > T(s + y, P) - T(\lambda s' + y, p) \Rightarrow T(s + Y, P) + T(\lambda s' + y, p) > T(s + y, P) + T(\lambda s' + y, p) \), and thus the total surplus can be increased by exchanging the partners of \( Y \) and \( y \), which is a contradiction. Thus \( \psi(Y) < \psi(y) \) for some \( y < Y \).
Note that this region will not always exist, because $Y$ may not be large enough relative to $\lambda S$ and the fertility loss, $P - p$.

Finally, I show that if there is non-assortative matching, there is a single “break” from the assortative match.

**Lemma 4.** If there exists some $\bar{y}$ with $\psi(\bar{y}) < t < \psi(y)$ for $y < \bar{y}$, then for all $y' > \bar{y}$, $\psi(y') < t$.

**Proof.** Suppose, to the contrary, that for $y' > \bar{y} > y$, $\psi(\bar{y}) < t < \psi(y)$ but $\psi(y') > t$. Denote $s' = \psi(y')$, $\bar{s} = \psi(\bar{y})$, and $s = \psi(y)$. In order for this match to be surplus maximizing, $T(\bar{s} + \bar{y}, P) + T(\lambda s' + y', p) > T(\lambda s' + \bar{y}, p) + T(s + y', P)$.

However, because $\frac{\partial T}{\partial y}$ is decreasing in income, for $y' > \bar{y}$, $T(\bar{s} + \bar{y}, P) - T(\lambda s' + \bar{y}, p) < T(s + y', P) - T(\lambda s' + y', p)$ (proof in appendix). But then $T(s + \bar{y}, P) + T(\lambda s' + y', p) < T(\lambda s' + \bar{y}, p) + T(s + y', P)$, which is a contradiction. Therefore, if any $\bar{y}$ has $\psi(\bar{y}) < t < \psi(y)$ where $\bar{y} > y$, so must every $y' > \bar{y}$.

Taken together, these three lemmas demonstrate that the match is of the form stated in Proposition 1. This result provides insight into how the marginal rate of substitution between two characteristics can impact matching in bi-dimensional settings, and is thus applicable to any matching problem where one side of the market is characterized by a single characteristic, whereas the other side is characterized by two negatively correlated characteristics that cannot be summarized by an index.

### 2.1.2 Match with Given Utility Function and Uniform Distribution

Returning to the specific functional form laid out earlier, I will now put more structure on the problem, in order to visualize what such an equilibrium might look like. Let male income be distributed uniformly on $[1, Y]$ (starting at 1 creates a simple illustration where
all men want to marry, because marriage is only “profitable” if total income is greater than 1), and female skill distributed uniformly on $[0, S]$, with an equal number of men and women.

The general form of an equilibrium matching that demonstrates assortative matching for women with the same fertility, but potentially non-assortative matching for women with different fertility, is shown in Figure 6. Let $x$ and $z$ represent the lower and upper ends of the second segment of men, and $r$ and $t$ represent the lower and upper cutoffs for women. Poor men, from 1 to $x$, marry low-skill, fertile women (matching assortatively). On the other side of the threshold, the richest women match assortatively with the middle group of men, from $x$ to $z$. But, the richest men, from $z$ to $Y$, marry the “best of the rest”—the most high-skilled women among those who have not invested and are thus still fertile.

The matching functions are depicted as linear here, but their form will be determined by the distribution such that the number of women above any point on each “segment” exactly matches the number of men above that point.

**Corollary 1.** In the case of a uniform distribution of agents, this match can be represented by the piecewise functions:

$$s(y) = \begin{cases} 
\frac{S}{y-1} (y-1) & : s \in [0, r] \\
r + \frac{S}{y-1} (y-z) & : s \in [r, t] \\
t + \frac{S}{y-1} (y-x) & : s \in [t, S] 
\end{cases}$$

with $x = 1 + \frac{r(Y-1)}{S}$ and $z = Y - \frac{t-1}{S}(t-r)$

**Proof.** For the first segment, the man who has income of 1 will be matched with the woman of skill 0, and the man with income of $x$ will be matched with the woman of skill $r$. Note that the number of men in this segment must be equal to the number of women, and thus
interval of men relative to $Y - 1$ will be the same as the interval of women relative to $S$.

From this, we can find an equation for the matching function:

\[
\frac{y - 1}{Y - 1} = \frac{s}{S}
\]

\[
s = \frac{y - 1}{Y - 1} S
\]

\[
s = \frac{S}{Y - 1} (y - 1)
\]

In particular:

\[
r = \frac{x - 1}{Y - 1} S
\]

\[
x = 1 + r \frac{(Y - 1)}{S}
\]
In the second segment, the man with income $z$ will be matched with the woman of skill $r$, and the man of income $Y$ will be matched with the woman of skill $t$. Following the same logic as the first segment:

\[
\frac{y - z}{Y - 1} = \frac{s - r}{S}
\]

\[
s = r + \frac{S}{Y - 1}(y - z)
\]

In particular:

\[
t = r + \frac{S}{Y - 1}(Y - z)
\]
\[
\begin{align*}
    z &= Y - \frac{Y - 1}{S} (t - r)
\end{align*}
\]

In the final segment, men of income $x$ will be matched with women of skill $t$, and men of income $z$ with women of skill $S$. Following the same logic:

\[
\frac{y - x}{Y - 1} = \frac{s - t}{S}
\]

\[
s = t + \frac{S}{Y - 1}(y - x)
\]

In particular:

\[
S = t + \frac{S}{Y - 1}(w - x)
\]
\[
S = t + \frac{S}{Y - 1}(Y - \frac{Y - 1}{S}(t - r) - (1 + r \frac{Y - 1}{S}))
\]

which is satisfied.

\[\square\]
The equilibrium can be characterized by completely assortative mating, non-monotonic mating, or negative-assortative mating, depending on the parameter values.

Recall that the stable match must solve the surplus maximization problem for the entire marriage market. Meaning, in order to find the stable match, we should find which formulation maximizes the total surplus in the economy resulting from the marriages formed. Since everything in the match is fixed except for \( r \), this amounts to finding the \( r^* \) that maximizes total surplus (which is essentially finding how many upper-income men should “break” from positive assortative matching). There can only be one \( r \), due to Lemma 2: if any man breaks from assortative matching, all wealthier men break from assortative matching as well.

If there is an interior solution for \( r^* \), we will have the three-segment equilibrium. If the total surplus is always increasing in \( r \), the optimal \( r^* \) will be \( t \), and the market will be characterized by positive assortative matching, independent of educational status. If the total surplus is always decreasing in \( r \), the optimal \( r^* \) will be zero, yielding “block” negative assortative matching–positive assortative matching on either side of the threshold, but completely negative matching across the threshold. Which equilibria is optimal will depend on relative size of \( \lambda \), or the returns to education for women.

**Proposition 2.** There will be three cases:

- if
  \[
  \lambda \leq \frac{S - t P - p Y - 1}{S + t p Y - 1} \]
  then \( r^* = 0 \)

- if
  \[
  \frac{S - t P - p Y - 1}{S + t p Y - 1} < \lambda < \frac{S + t P - 1}{S + t p Y - 1} \]
  then there is an interior solution for \( r^* \).
• if 

\[ \lambda \geq 2 \frac{P}{p} \frac{t + S}{t + S} + \frac{P - p Y - 1}{S} \]

then \( r^* = t \).

Note that the joint product of marriage takes on the form:

\[
T(y, s) = \begin{cases} 
\left( \frac{y + s + 1}{2} \right)^2 P + (y + s)(1 - P) & : s \in [0, t] \\
\left( \frac{y + \lambda s + 1}{2} \right)^2 p + (y + \lambda s)(1 - p) & : s \in [t, S] 
\end{cases}
\]

We can now find the total surplus by integrating the joint marital product for each segment across the three segments. We use the matching functions to represent this as a function of a single variable, \( y \).

\[
H_1(r) = \int_1^y \left( P \left( \frac{y + \frac{S}{Y - 1}(y - 1) + 1}{2} \right)^2 + (1 - P) \left( y + \frac{S}{Y - 1}(y - 1) \right) \right) dy
\]

\[
H_2(r) = \int_z^y \left( P \left( \frac{y + r + \frac{S}{Y - 1}(y - z) + 1}{2} \right)^2 + (1 - P) \left( y + r + \frac{S}{Y - 1}(y - z) \right) \right) dy
\]

\[
H_3(r) = \int_x^z \left( p \left( \frac{y + \lambda \left( t + \frac{S}{Y - 1}(y - x) \right) + 1}{2} \right)^2 + (1 - p) \left( y + \lambda \left( t + \frac{S}{Y - 1}(y - x) \right) \right) \right) dy
\]

We then eliminate the parameters \( x \) and \( z \) by putting them in terms of \( r \) and \( t \) according to the matching function. \( t \) is treated as fixed, so the only thing that can be manipulated to increase or decrease the surplus is \( r \).

We want to find the maximum of this function with respect to \( r \), over the interval from 0 to \( t \). The total surplus function, \( H = H_1 + H_2 + H_3 \), is a polynomial of degree 2 in \( r \), with a negative second derivative. This means that if the signs of the first derivative at
0 and \( t \) differ, there is a unique interior solution to the maximization problem. Otherwise the maximand is either 0 or \( t \).

Proof. Define \( h(r) = \frac{dH(r)}{dr} \)

For the interior case, we require \( h(0) > 0 > h(t) \)

Which gives us:

\[
\frac{S - t}{S + t} \frac{p}{p} \frac{P - pY - 1}{S} < \lambda < \frac{2}{p} \frac{t}{t + S} + \frac{P - pY - 1}{p} \frac{S}{S}
\]

If

\[
\lambda \leq \frac{S - t}{S + t} \frac{p}{p} \frac{P - pY - 1}{S}
\]

then \( h(0) < 0 \), and thus the function is decreasing on the entire interval \([0, t]\), and the maximum is reached for \( r = 0 \)

If

\[
\frac{S - t}{S + t} \frac{p}{p} \frac{P - pY - 1}{S} < \lambda < \frac{2}{p} \frac{t}{t + S} + \frac{P - pY - 1}{p} \frac{S}{S}
\]

then \( h(0) > 0 \) and \( h(t) < 0 \), and thus the max is interior: there exists an \( r^* \in [0, t] \) that maximizes the surplus

If

\[
\lambda \geq \frac{2}{p} \frac{t}{t + S} + \frac{P - pY - 1}{p} \frac{S}{S}
\]

then \( h(t) > 0 \), and thus the function is increasing on the entire interval \([0, t]\), and the maximum is reached for \( r = t \).

When \( r^* = 0 \), then the match will be “block” negative assortative, with two segments only, as shown in Figure 7. When \( r^* = \frac{(P-p)(t-\theta(Y-1))+\theta\lambda(t+\theta(Y-1)p}{2(P-p)+2P\theta} \) then 3 segments as depicted in Figure 6. When \( r^* = t \), then the match will be positive assortative, as shown.
Figure 7: Low lambda equilibrium match

Figure 8: High lambda equilibrium match
in Figure 8.

Note that for case 2, the exact interior solution is given by:

\[ r = \frac{(P - p)(t - \theta(Y - 1)) + \theta \lambda (t + \theta(Y - 1))p}{2(P - p)} + 2P\theta \]

Additionally, the parameter space for the exact interior solution is always non-empty, as \( \frac{S - t}{S + t} \) is always less than one and \( 2P \frac{t}{P + t} \) strictly positive.

### 2.1.3 Potential shifts between equilibria

What factors cause the marriage market to move between these equilibria? Obviously, an increase in \( \lambda \), the returns to education to women, could cause a move between equilibria. Meaning, if women’s earnings increase sufficiently following career investment, they will be able to compensate higher-earning men for their lower fertility, and thus move from matching with the worst men to matching with the middle group to, finally, matching assortatively with the best men. Interestingly, though, because of the fixed component of the cutoff \( \lambda \geq \frac{2P}{P + t} + \frac{P - p}{P} \frac{Y - 1}{S} \), if both \( \lambda \) and \( Y \) increased simultaneously, the marriage market could shift from the three-segment equilibrium to positive assortative matching. This means that even general (non gender-specific) increases in the labor market returns to education could result in an equilibrium shift. I will show in the empirical section that this is consistent with historical evidence that since the 1960s women have gone from being penalized on the marriage market for making human capital investments to being rewarded for them with better matches, concurrent with an increase in labor market returns to education.

In addition to changing returns to education, assisted reproduction technology could also impact the equilibrium. If \( p \) increases, then \( \lambda \) is more likely to exceed both the first cutoff and second cutoff. Thus, in-vitro fertilization technology, which increases older
women’s chances of becoming pregnant (as well as better health and nutrition, better medical insurance, and easier adoption) are all likely to push toward more assortative matching regardless of time-intensive career investments.

2.2 Finding the equilibrium payoffs

Now we can find the individual payoffs that each agent will get in equilibrium, and hence the share of the surplus captured by each spouse. This is done by using the rule that the sum of each person’s payoff must equal the total marital product, and that each person chooses his or her spouse to maximize his or her own payoff, under the constraint that the spouse will accept that match.

\[ v_i(s), i \in \{1, 2, 3\} \text{ represents the value function of a woman of skill } s \text{ matching in section } i, \text{ and } u_i(y), i \in \{1, 2, 3\} \text{ the value function of a man of income } y \text{ matching in section } i. \]

Note that for any individuals of skill \( s \) and income \( y \), \( u_i(y) + v_i(s) \geq T_i(y, s) \). For married individuals, this holds with equality, and we can solve for the slope of the value function:

\[ \text{Max } s u_i^i(y) = T_i(y, s) - v_i^i(s) \Rightarrow v_i^i(s) = \frac{\partial T_i(y, s)}{\partial s} \]

and

\[ \text{Max } y v_i(s) = T_i(y, s) - u_i(y) \Rightarrow u_i(y) = \frac{\partial T_i(y, s)}{\partial y} \]

Through integration, plugging in for \( y \) as a function of \( s \), we can identify each value function down to an additive constant. We then use the conditions that \( u_1(1) \geq 1 \) and \( v_1(0) \geq 0 \), so that each man and woman agrees to marry, as well as the conditions that a man or woman at a “threshold” between segments must be indifferent to find the constants, and thus derive the value function for each individual. This procedure is shown in the
2.2.1 The form of the payoff functions

These payoffs are strictly increasing in $y$ and $s$, for men and women respectively, but are not necessarily strictly increasing across sections for women (they are for men). For example, it is possible for the woman with skill $t + \epsilon$ to have a lower payoff than the woman with income $t - \epsilon$, because education choice is taken to be exogenous. We have, however, restricted the payoff of the woman with skill $r + \epsilon$ to be higher than the woman with skill $r - \epsilon$, by making the woman with skill exactly equal to $r$ indifferent, in order for the equilibrium to be stable.

The top two images in figure 2.2.1 shows what these payoffs look like for the parameter values $S = 1, Y = 2, P = 1, p = .5, \lambda = 1.5, \text{ and } t = .7$, while the following series of images shows the impact of perturbing these parameters. A lower $p$ causes the optimal $r$ to fall, and more men to break from assortative mating, making the portion of men the women who have invested match with less attractive. A higher $p$ moves in the opposite direction, with only the very top segment of men breaking from assortative matching. A lower $\lambda$ causes the women who have invested to have worse utilities at $t$ than those that have not, which would potentially discourage less investment, were $t$ allowed to be endogenous. A higher lambda creates excess payoff for those that have invested. A higher $t$ alters the break points for the matching and utility premiums, but does not greatly alter the payoffs.

Note that for some of these parameter values, the conditions on $\lambda$ for the three-segment equilibrium to be stable are not satisfied. For example, if $p$ is too high, then $r = t$ is surplus maximizing (with a high chance of pregnancy after investment, there’s no reason for men to break from assortative mating), and if $p$ is too low, $r = 0$ is optimal.
Figure 9: Payoff simulations
2.3 Who marries?

When the popular press laments the plight of educated women on the marriage market, they are often talking about not just whom they marry, but whether they marry. In my model, everyone marries (or, even if we added some lower income individuals who did not marry, everyone above a certain income threshold marries). In reality, some people do not marry, or some people marry later in life. There are multiple ways to insert this complexity. The first would be to insert search frictions, where non-marriage is really just the extreme of delayed marriage—a search period so long, that it may not conclude before the end of one’s life. A second way would be to insert an independently distributed taste for marriage, which would add to or subtract from the potential surplus obtained through marriage, yielding some individuals who prefer to remain single. Choo and Siow (2006) use other heterogenous characteristics, which produce the patterns theorized by unidimensional matching only on average, with some people marrying different individuals, and some not marrying at all. Rather than adding these additional layers, I informally consider who would be likely to marry, given the greater complexity of true marriage markets than that presented in my model.

Imagine random shocks that cause marriage to be less appealing for some individuals, distributed orthogonally to the endowments of $s$ and $y$. Where the largest surplus from marriage occurs, these shocks are least likely to result in marriages not forming. In unions with lower surplus, however, these shocks could easily derail the match. This means that in the case of negative-assortative-mating, because women’s incomes are lower than men’s incomes, there is more surplus available to the segment of richer men matching with poorer women than the segment of poorer men matching with richer women. Thus, marriages will be less frequent among the richer women.

A similar logic applies to the difference between the three-segment case and the positive-
2.4 Exploring optimal human capital investments

We have now answered the question of what the equilibrium looks like in the matching stage, taking the number of women who invest as given. But what if women take the matching equilibrium into account when deciding when to invest? Will women make human capital investments, given the ensuing marriage market consequences? To answer this, we need to allow $t$ to be endogenous, and women to choose whether they want to invest or not, given the marriage they will eventually encounter. To simplify this section, I set $Y = 2$, $S = 1$, and $P = 1$, making $\lambda$, $p$, and $t$ the only unknowns.

Interestingly, although the negative assortative matching equilibrium seems much “worse” for women, it is only so because the range of possible returns to investment for which this equilibrium is possible is lower. With that same return to investment available, if women were forced into positively assortative-matched relationships, it would actually be worse
for them, because there would be less surplus to distribute.

What impacts the location of the optimal $t$? We can solve for it by setting $v_3(t) = v_2(t)$ to solve for $t^*(\lambda, c, p)$. Although its functional form is complex, $t^*$ varies with the parameters in expected ways: It is increasing in $c$, decreasing in $\lambda$, and decreasing in $p$. Meaning, the higher the fixed cost of investment, the higher the skill threshold for pursuing it; the higher the return to investment, the lower the skill threshold; and, the higher the chance of conceiving following investment, the lower the threshold. A higher threshold means fewer women making career investments, and in the extreme case where it is larger than 1, nobody (except those who have other reasons) making those investments. A lower threshold means more women making career investments, and this can be spurred by a lower fixed cost of investment, greater returns, or a higher chance of conceiving (e.g., through IVF technology).

3 Validating the model with US Census data

I next do some simple checks of the model’s predictions against patterns in US Population Census data. I use a 1% sample of white individuals in their 40s and 50s, so that the vast majority of first marriage matching activity and educational investments have already taken place by the time they are observed. In later years, the data comes from the American Community Survey, which continued to contain some demographic questions that were dropped in the main Census.

Table 1 shows that the model’s basic assumption, that there is a tradeoff between career investments, and thus income, and the timing of marriage and childbearing is validated by Census data, in both 1980 and 2010. By regressing total income (in constant 1999 dollars), age at marriage, children ever born, and the number of children at home (since children ever born is not included in later Census years), we can see that women who pursue post-
Bachelor’s education earn more, marry later, and have fewer children than women who only get a college degree (the sample is restricted to all those with a Bachelor’s degree or greater). Here, becoming highly educated serves as a reasonable proxy for making time-costly career investments, since college education alone does not interfere with years of fertility, whereas PhDs, medical and law degrees, and MBAs, as well as the career path that comes with them, may.

The model’s predictions regarding the consequences of these investments, and thus marrying older, are linked to the value of investments relative to the loss of childbearing ability, and thus differ depending on the value of these parameters. But, because the only reason an older woman could still marry a high-earning man is that the additional income she has acquired could compensate for her lost fertility, if we condition on income, the model’s predictions are unambiguous: marrying later is always worse. This prediction,
too, is validated in US Census data, for 46-55 year olds in the 2010 American Community Survey. Figure 10 shows that when own income is on the x-axis and one’s spouse’s income on the y-axis, that women who marry older always marry lower-earning spouses, whereas for men, this pattern is absent.

Figure 10: Lowess-Smoothed Spousal Income for Women and Men who Marry at a Given Age, by Income

3.1 Changes over time

As the returns to investment for women, represented by $\lambda$, change over time, the equilibrium is expected to move from one where first no women invest (in the case of a normal skill distribution, this would mean only the most highly skilled women invest), to a case where some women invest but are “penalized” on the marriage market by matching with lower income men than women who have not invested, to finally an equilibrium where high-skilled women invest and yet have enough income to compensate their potential mates for their lower fertility, thus matching assortatively.

In the US, the market opportunities for educated women, and thus the returns to career
investments, have changed significantly in the last 60 years (e.g. Hsieh et al 2013). Thus, we may expect to observe the above sequence of equilibria in census data. Indeed, repeated cross-sections from the US Census, shown in Figure 14 reveal that in the 1960s, only about 2% of women received education higher than a bachelor’s degree. By 1980, around 8% of women had achieved higher education, but these women were matching with men who were poorer than were women who stopped at a bachelor’s degree. Finally, by the 2000s, the highly educated women are matching assortatively with higher income mates than college-educated women. This mirrors the three equilibria predicted by the theory.

To create this depiction, I use women with master’s degrees, MDs, JDs, and PhDs to represent the group “investing” in their careers. I then compare them to women with college education only. This is an imperfect comparison, as some of the women with college degrees may go on to make large career investments. However, college education alone is not an indicator of making a substantial career investment that will delay marriage (since college actually serves as a marriage market for some women, and women are only in their early twenties upon graduation from college, and thus fertility has not been limited by this investment alone). On the other hand, pursuing an advanced professional degree does seem to be a strong signal that a woman is making a significant career investment. For example, the natural course of action following law school is to become an associate at a law firm,
Figure 14: Spousal income by wife’s education level, white women 41-50
after med school it is to become a resident, and after an MBA it is to pursue a corporate job. Each of these “paths” represent the type of investment that could delay childbearing. However, because the comparison group of college educated women contains some women who will make a large career investment, and the “investment” group contains some women who will not, we should expect these results to be attenuated.

Moreover, the results are likely also influenced by highly educated women being 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. This makes the result of college educated women matching with “better” men at some point all the more striking. It also means, though, that the results in the 2000s may not mean that we are truly in the third equilibrium phase, but rather only that the “penalty” canceling out the highly educated women’s unobservable advantages has been reduced.

The model also has predictions, although informal, for marriage rates. In particular, marriage rates for women who make career investments are expected to be lower when there is negative assortative, or non-monotonic matching, and to rise as returns to career investments increase, and matching becomes more assortative in income. But Figure 15 shows that the change in marriage rates that has occurred in the past 40 years for educated women has been driven by highly educated women—those women whose education and career investments delay marriage. Marriage rates for college educated women closely tracks marriage rates for less educated women. It is only highly educated women whose marriage rates started out much lower, and have risen recently, while marriage rates for all others fall.

Note that these results align with a commonly observed pattern of educated women now being advantaged on the marriage market relative to less educated women (e.g., Stevenson
Figure 15: Ever married rates by education level, white women 41-50
and Isen 2010), whereas previously educated women struggled to find mates and may have matched poorly. However, the above graph demonstrates that highly educated women are the ones who have made the greatest gains, whereas college educated women (who are usually lumped together with highly educated in the “educated” bucket) have remained relatively flat. Because post-Bachelor’s education uniquely requires additional time, and signals future investments requiring more time, that will delay marriage and child-bearing, this difference between the two groups points to reproductive capital being an important factor in first the penalization to education on the marriage market and then the later reversal of this penalty as returns to investment have grown.

3.2 Opportunities for future empirical work

The model also predicts that the differential between “high-state” fertility, $P$, and “low-state” fertility, $p$, impacts both which equilibrium should predominate and at what level of skill it is rational to undertake career investments. But, the difference between $P$ and $p$ is not necessarily fixed in an age of advancing in assisted reproduction technologies. Innovations such as hormonal fertility treatments and in vitro fertilization (IVF) allow women a greater chance of conception at ever-increasing ages. Moreover, egg donation and surrogacy, while still only accessible to the wealthy, provide an alternate route for having children biologically related to the father, although not without their own complications. One complication in measuring this effect is that it is not only the availability of this technology that must shift, but also the perception of its availability by men evaluating potential partners. Nonetheless, using a state-year difference in differences design, Buckles (2007) presents some evidence of this effect, finding that insurance mandates for IVF were related to increases in labor supply for women, as well as increased wages. Future research should explore whether any sudden and widespread changes in access to assisted repro-
duction technology were related in shifts in marriage market matching for older women, or time-costly career investments.\footnote{Additionally, if companies put in place HR policies that support having children while making career investments, the length of the delay may not be as long, which would also decrease the relative change in \( \pi \). This is another possible source of identification for this effect.}

4 Online Experiment (Preliminary)

The evidence presented from US Census data demonstrates an apparent relationship between age at marriage and the “quality” (as proxied by income) of the marriage match for women. Moreover, the matching patterns in the US over time follow the anticipated pattern of equilibria based on changes to the labor market returns to education.

A remaining question is whether the preferences over age on the marriage market stem from underlying preferences for fertility or from preferences for age-related beauty (which might itself have to do with an underlying biologically ingrained preference for fertility, rather than a purely independent aesthetic standard). Although in either case career investments will be differentially costly to women, since age is only negatively correlated with matching outcomes for women, potential policies to relieve this tradeoff would differ. For example, if a conscious preference for fertility is partly at play, then relieving the fertility constraint through policies promoting access to assisted reproduction technology could alleviate the marriage market penalty to delayed marriage, whereas if the preference for fertility is entirely an evolutionary-driven, instinctual preference for younger looks, such policies would be ineffective.

A conscious preference for fertility is intuitive from a theoretical perspective, as there may naturally be a complementarity between investments in children and wealth, whereas preferences over looks may not vary systematically with income.

To determine whether there is a preference for age independent of beauty, and thus
whether tastes for fertility may underlie this preference, I implemented an online experiment in which singles rate profiles of hypothetical partners, with the age randomly assigned while other characteristics, such as the beauty displayed in the photo, remained fixed. Income was also randomly assigned to the profiles, providing a measure of the marginal rate of substitution between these two characteristics in partners’ preference functions.

4.1 Methodology

In order for the online experiment data to be valid, subjects must rate the profiles according to their own preferences. However, this is difficult given that unlike in a traditional economics experiment, there is no way to incentivize self-serving behavior. 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). In order to present the profiles as hypothetical while incentivizing honest responses, I used the compensation for participating in the experiment to provide motivation for truthful representation. Participants, recruited online, were offered free customized advice on their own online dating profiles in order to attract the type of people they had indicated interest in based on their answers to the experimental questions. This (along with a raffle for free dating site membership, of negligible actuarial value) was the only compensation for participating in the study, so anyone who completed the full experiment must have been motivated by this compensation. The customized advice was provided by a dating coach hired for this purpose.

To generate the hypothetical dating photos, I purchased stock photos that were similar in appearance to photos on dating websites. I purchased 50 photos of men and 50 photos of women, depicting 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. I then balanced the average attractiveness and average "visual age" between the men and women, as well as removing individuals whose average guessed age was far outside the ages being used for the study, ending up with 40 photos of men and 40 photos of women.

I then assigned the following characteristics to each photo, to generate a dating profile: a username, a height, some interests, and whether they were looking for a serious relationship. The usernames were assigned by using the top 40 names for men and women from the decade of birth for women and men 30-40 years of age, 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 partner, not only a short-term date. 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.

Subjects were recruited using online ads, placed on dating sites or targeted through google on dating-related keywords. Sample ad:

*A Better Dating Profile*

*Single & 30-40? Take this survey &
get expert dating profile advice!*

*www.columbiadatingstudy.com*
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 respondents listed their ages as older than 40 or younger than 30. In the analysis, 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 during the analysis phase, since cross-racial rankings may be driven by different factors.

After agreeing to the consent form, the respondents immediately begin rating profiles, on a scale from 1 to 10. After 10 profiles, the respondents are asked to order the profiles from most preferred to least preferred, both to break up the monotony of the ranking, and to provide a check for people who are just randomly entering answers without thinking about them (in which case there would be a low correlation between their ratings and rankings). Each individual rates all 40 profiles. Following this, they complete a brief post-survey including demographic information, dating preferences, and, finally, their knowledge of age-fertility limits for men and women.

This design aims to separate out the fertility impacts of age from other things that might change with age, especially attractiveness. Note, though, this will be underestimating the true impact of delaying marriage for women, because in reality women who delay marriage are both less fertile and less attractive. However, it answers the policy question of whether fertility alone factors into marriage market decisions.

4.2 Results

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 respondents listed their ages as older than 40 or younger than 30. In the analysis, 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 during the analysis phase, since cross-racial rankings may be driven by different factors.

Overall, 307 individuals participated in some portion of the experiment over a six month period. However, many of these individuals did not meet the eligibility criteria, or completed the survey partially. Summary statistics from the data are presented in Table 2, for white individuals from 29 to 41 (expanded a bit from 30-40 to account for inexact age measurement, since I only have year of birth), as this is my target sample. Without these restrictions, 77% of male participants are white, and 78% of female participants, with an age range from 24-60, although only 26% of participants fall outside the specified age range.

Table 2: Summary Statistics

<table>
<thead>
<tr>
<th>variable</th>
<th>Men N=35</th>
<th>Women N=44</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>sd</td>
</tr>
<tr>
<td>Age</td>
<td>35.22</td>
<td>3.64</td>
</tr>
<tr>
<td>High income</td>
<td>.487</td>
<td>.507</td>
</tr>
<tr>
<td>College grad</td>
<td>.676</td>
<td>.475</td>
</tr>
<tr>
<td>Has kids</td>
<td>.351</td>
<td>.484</td>
</tr>
<tr>
<td>Wants (more) kids</td>
<td>.595</td>
<td>.498</td>
</tr>
<tr>
<td>Wants marriage</td>
<td>.460</td>
<td>.505</td>
</tr>
<tr>
<td>Lowest age</td>
<td>25.84</td>
<td>3.57</td>
</tr>
<tr>
<td>Highest age</td>
<td>40.84</td>
<td>5.42</td>
</tr>
<tr>
<td>Preferred low</td>
<td>28.49</td>
<td>3.73</td>
</tr>
<tr>
<td>Preferred high</td>
<td>37.22</td>
<td>4.55</td>
</tr>
<tr>
<td>Fem fert cutoff?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fem cutoff age</td>
<td>41.19</td>
<td>6.37</td>
</tr>
<tr>
<td>Male fert cutoff?</td>
<td>.892</td>
<td>.315</td>
</tr>
<tr>
<td>Male cutoff age</td>
<td>53.67</td>
<td>8.91</td>
</tr>
</tbody>
</table>

These summary statistics show 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. Where they differ substantially is their stated preferences for the age of their partner, with men stating on average that the youngest they would date is 26, and the oldest 41, whereas for women this ranges from 33 to 47. When it comes to their preferred dating range, men look for between 29 and 37, whereas women seek a partner between the ages of 35 and 44. This 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 each men and women to conceive a child. 100% of respondents believe there is a cutoff for women, indicating that there is some knowledge of differential fertility decline, whereas 89.2% of men believe that such a cutoff exists for men, and 76.7% of women. Female respondents put the start of the fertility decline for women somewhat earlier than male respondents, at 39.7 years, versus 41.2. Both male and female respondents, conditional on thinking there is a cutoff, believe the cutoff to be higher for men.

Table 3\textsuperscript{5} compares the relationship between individuals’ ratings and the randomly assigned age and income, comparing men to women, using the specification:

\[
Rating_{ij} = \beta_0 + \beta_1 age_{ij} + \beta_2 income_{ij} + \alpha_i + \theta_j + u_{ij}
\]

Because each individual rates 40 profiles, and each profile is seen by multiple individuals, I can include both rater, \(\alpha_i\), and profile, \(\theta_j\), fixed effects.

Table 3 shows this analysis for all data collected (including incomplete responses) and for those who meet my sample requirements of begin between 30 and 40 and white (the

\textsuperscript{5}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 criteria for requiring a cluster correction is not met. See: Angrist and Pischke 2009
considerable data dropped between those specifications is because the complete dataset includes some individuals who did not complete the entire survey, and thus I do not have information on their race or ethnicity).

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

<table>
<thead>
<tr>
<th>Dep. variable: Profile rating</th>
<th>Men</th>
<th>Women</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All In Sample</td>
<td>All In Sample</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.0242***</td>
<td>-0.0436***</td>
<td>0.0788***</td>
<td>0.131***</td>
</tr>
<tr>
<td></td>
<td>(0.0103)</td>
<td>(0.0152)</td>
<td>(0.00985)</td>
<td>(0.0152)</td>
</tr>
<tr>
<td>Income</td>
<td>0.00229**</td>
<td>0.00613***</td>
<td>0.0147***</td>
<td>0.0134***</td>
</tr>
<tr>
<td></td>
<td>(0.00106)</td>
<td>(0.00161)</td>
<td>(0.00105)</td>
<td>(0.00159)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.811***</td>
<td>6.252***</td>
<td>1.074***</td>
<td>-0.0795</td>
</tr>
<tr>
<td></td>
<td>(0.467)</td>
<td>(0.662)</td>
<td>(0.409)</td>
<td>(0.658)</td>
</tr>
<tr>
<td>Observations</td>
<td>3,752</td>
<td>1,440</td>
<td>4,220</td>
<td>1,800</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.487</td>
<td>0.471</td>
<td>0.452</td>
<td>0.394</td>
</tr>
</tbody>
</table>

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 even more strong for 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, as well as excluding cross-racial ratings, as all the profiles presented were of white individuals.

The reduction in rating for an additional year of age is .0436 points, meaning that if a woman is 10 years older, she will be rated .4 points lower (on a scale from 1 to 10) than a woman 10 years younger. A woman who is $10,000 poorer would be rated .0613 points lower. This means that to make up for an additional year of age, a woman must earn $7,112 more.
Table 4 shows the results for men for several robustness checks. First, I restrict the analysis to only those who completed and submitted the survey, since those who did not may not have been incentivized to provide accurate data, since they did not claim the compensation. Then, I restrict to those who did not opt out of the compensation, which happened in a small number of cases as the compensation involved the sharing of individual data with a third party, and thus IRB required I provide the option to opt out from this sharing. I next exclude individuals who have a low correlation between their “rate” responses and their “rank” responses, since this may indicate just trying to go through the survey quickly, without regard for the answers. Finally, I exclude those who took the survey during the first two weeks, after which I made a small design change to include a one-second load delay on the photographs, so that individuals would read the profile information more quickly before responding to the photo alone. None of these changes significantly alter the results.

<table>
<thead>
<tr>
<th>Dep. variable: Profile rating</th>
<th>(1) Finished</th>
<th>(2) No Opt Out</th>
<th>(3) High Corr</th>
<th>(4) Load Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.0395**</td>
<td>-0.0490***</td>
<td>-0.0446***</td>
<td>-0.0388**</td>
</tr>
<tr>
<td></td>
<td>(0.0178)</td>
<td>(0.0164)</td>
<td>(0.0157)</td>
<td>(0.0173)</td>
</tr>
<tr>
<td>Income</td>
<td>0.00665***</td>
<td>0.00689***</td>
<td>0.00618***</td>
<td>0.00612***</td>
</tr>
<tr>
<td></td>
<td>(0.00184)</td>
<td>(0.00175)</td>
<td>(0.00166)</td>
<td>(0.00180)</td>
</tr>
<tr>
<td>Constant</td>
<td>6.050***</td>
<td>6.426***</td>
<td>6.266***</td>
<td>5.978***</td>
</tr>
<tr>
<td></td>
<td>(0.756)</td>
<td>(0.710)</td>
<td>(0.681)</td>
<td>(0.742)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,120</td>
<td>1,280</td>
<td>1,360</td>
<td>1,160</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.435</td>
<td>0.460</td>
<td>0.465</td>
<td>0.451</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

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

Table 5 shows two additional specifications that try to control for potential confounds. The first is that 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 “good for their age.” Because photos that look many different ages are paired with all ages between 30 and 40, the difference between “visual age” and the stated age is separately identified. The visual age was approximated by Columbia undergraduates taking Introduction to Econometrics. When this factor is controlled for, the penalty for higher age is stronger.

The second specification looks at how rater age may affect the relationship between age and ratings. For example, younger men may care a lot about progressively older partners, whereas older men care less. This specification, although not significant, provides suggestive evidence that this is indeed the case, and that older raters are less “picky” about the age of their partner. The final column controls for rater age in a different way, by looking at the difference in ages between the rater and the hypothetical partner, versus the average age difference at marriage of two years (with the husband being older).

Together, the above results show men appear to have a preference for age of partner, even when beauty is controlled for through exogenously assigning age to fixed profiles of potential partners. Table 6 now tries to test whether this preference for age is really a preference for fertility, and that at least some of this preference is driven by conscious utility maximization, taking fertility into account.

Compared to the base specification, when an interaction of age with not wanting any children is controlled for, the preference for age is stronger, and the interaction with not wanting children is positive, although not significant (suggesting that those that do not want children are less concerned with age than those that do). The same is true for an interaction with not wanting any, or any more, children—when this is controlled for, the main effect is stronger, and the interaction is non-significantly positive. Perhaps the strongest evidence comes from the final column. For men listing the age it becomes biologically
Table 5: Additional Controls

<table>
<thead>
<tr>
<th>Dep. variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile rating</td>
<td><strong>Base Spec.</strong></td>
<td><strong>Visual Age</strong></td>
<td><strong>Rater Age</strong></td>
<td><strong>Ideal Age Diff</strong></td>
</tr>
<tr>
<td>Age</td>
<td>-0.0436***</td>
<td>-0.139***</td>
<td>-0.219</td>
<td>-0.0375**</td>
</tr>
<tr>
<td></td>
<td>(0.0152)</td>
<td>(0.0524)</td>
<td>(0.146)</td>
<td>(0.0166)</td>
</tr>
<tr>
<td>Income</td>
<td>0.00613***</td>
<td>0.00613***</td>
<td>0.00614***</td>
<td>0.00611***</td>
</tr>
<tr>
<td></td>
<td>(0.00161)</td>
<td>(0.00161)</td>
<td>(0.00161)</td>
<td>(0.00161)</td>
</tr>
<tr>
<td>Visual age - age</td>
<td>-0.0950*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0511)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rater age X age</td>
<td></td>
<td></td>
<td>0.00499</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.00411)</td>
<td></td>
</tr>
<tr>
<td>(Age diff -2)^2</td>
<td></td>
<td></td>
<td></td>
<td>-0.00168</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.00196)</td>
</tr>
<tr>
<td>Constant</td>
<td>6.252***</td>
<td>9.796***</td>
<td>5.588***</td>
<td>6.060***</td>
</tr>
<tr>
<td></td>
<td>(0.662)</td>
<td>(1.798)</td>
<td>(0.848)</td>
<td>(0.689)</td>
</tr>
<tr>
<td>Observations</td>
<td>1.440</td>
<td>1.440</td>
<td>1.440</td>
<td>1.440</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.471</td>
<td>0.471</td>
<td>0.472</td>
<td>0.471</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
difficult for women to have children as greater than 45 (meaning they do not have good knowledge of this limitation), there is no preference over age—the interaction combined with the main effect is essentially zero.

Table 6: Interactions with Fertility Mediators

<table>
<thead>
<tr>
<th>Dep. variable:</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile rating</td>
<td>Base Spec.</td>
<td>Wanting Kids</td>
<td>Current Kids</td>
<td>Knowledge</td>
</tr>
<tr>
<td>Age</td>
<td>-0.0436***</td>
<td>-0.0604***</td>
<td>-0.0512***</td>
<td>-0.0642***</td>
</tr>
<tr>
<td></td>
<td>(0.0152)</td>
<td>(0.0217)</td>
<td>(0.0181)</td>
<td>(0.0187)</td>
</tr>
<tr>
<td>Income</td>
<td>0.00613***</td>
<td>0.00613***</td>
<td>0.00617***</td>
<td>0.00615***</td>
</tr>
<tr>
<td></td>
<td>(0.00161)</td>
<td>(0.00161)</td>
<td>(0.00161)</td>
<td>(0.00160)</td>
</tr>
<tr>
<td>No want kids X age</td>
<td>0.0410</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0300)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has kids X age</td>
<td></td>
<td>0.0221</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0337)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No infert. knwldg. X age</td>
<td></td>
<td></td>
<td></td>
<td>0.0788**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0316)</td>
</tr>
<tr>
<td>Constant</td>
<td>6.252***</td>
<td>5.403***</td>
<td>5.740***</td>
<td>4.197***</td>
</tr>
<tr>
<td></td>
<td>(0.662)</td>
<td>(0.817)</td>
<td>(1.063)</td>
<td>(0.969)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,440</td>
<td>1,440</td>
<td>1,440</td>
<td>1,440</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.471</td>
<td>0.472</td>
<td>0.471</td>
<td>0.473</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 Conclusion

This paper tries to further our understanding of the unique framework within which women make choices, going beyond the assumption of divergent preferences or black box gender-specific fixed effects. I use a multi-dimensional matching model to study the potential impacts of reproductive capital with a small, highly general set of assumptions, contributing to the understanding of the observed shifts in marriage market outcomes for educated
women by relating changes in women’s wages to the reproductive capital/human capital tradeoff. Because the ability to produce children for women declines with age, and fertility may be related to securing favorable marriage matches, through the theoretical mechanism of bi-dimensional matching, women essentially hold a depreciating economic asset. The value of this asset declines over time, and maximizing the monetary value of their human capital requires time investments. Thus, women face an added “tax” on human capital investments, in the form of reproductive capital declines. This fact is essential to understand why women may make time-consuming career investments, such as seeking education beyond college, at lower rates, and also which policies are likely to support greater investments by women.

The importance of “reproductive capital” extends beyond academia, addressing concerns in business, development economics, and social policy.

If firms are truly interested in attracting and retaining top female talent, their compensation packages might need to reflect the ever-increasing opportunity cost of work as reproductive capital depreciates. This could be realized as greater flexibility or financial rewards to retain women facing a steep drop-off in marriage market opportunities as they age, or greater flexibility to allow these women to marry and start families while still contributing to the workforce. The key implication is that with reproductive capital factored in, optimal contracts for women may be dissimilar to those that have evolved in a historically male-dominated workforce. Policy-makers could utilize a better understanding of reproductive capital to inform policy approaches to promoting women’s human capital accumulation, such as parental leave policies and workforce re-entry programs. Moreover, government policies that promote access to infertility treatments will likely affect human capital decisions. When viewed through this framework, whether or not insurance covers infertility treatments becomes a question of not just health policy, but also labor and eco-
nomic policy. Government policy welfare calculations should consider the impact of policies on both human capital and reproductive capital, and especially the tradeoff between the two.

This also has implications for social policy addressing older women who are divorced or never married. When reproductive capital is included, these women have lower capital at their disposal than younger women with similar human capital attainment. This may explain why older women are more likely to be in poverty than older men (according to the US Census). It also implies that policy-makers should consider the impact of declining marriage rates on women’s economic well-being (see the work of Edlund) as well as the effect of access to paternity rights outside marriage (Rossin-Slater 2012 shows this decreases marriage rates). This economic model may also help to explain the general social disenfranchisement and marginalization of older women.

A final area where my work can be applied is to the study of international development. Reproductive capital is likely to have an even more profound importance in developing countries where labor market opportunities for women are severely limited. Thus, risks to reproductive capital, such as through labor trauma or involuntary sterilization, should be evaluated as economic losses, similar to crop destruction resulting from severe weather. As one example, the study of reproductive capital could provide a way to quantify restitution due to women who have been forcibly sterilized in the US and other countries (e.g., Peru, India). Moreover, the reproductive capital framework can also be applied to examine observed reticence by women in developing countries who report wanting no more children to adopt family planning, particularly long-term forms. Such methods of controlling fertility, while they may better align family size outcomes with a woman’s own wishes, threaten one of the few sources of capital not controlled by men.

More broadly, model demonstrates that the lower are the returns to female skill, due to
labor market discrimination or other reasons, the more losses of reproductive capital will limit a woman’s overall well-being. This is an important way to assess women’s equality in society. If women’s access to economic security is entirely dependent on their ability to produce children, reproductive capital is in a sense their only capital. In Zambia, for example, infertile older women have spoken of being outcast from their communities and treated as social pariahs. This research implies we must not only assess women’s equality and well-being by how much they have, but also by what they could have in the absence of fertility. Reproductive capital could potentially provide a new framework for evaluating gender equality on a global level.

Even in more developed countries, the size of the gender wage gap and the time-cost associated with career investments are shown in my model to determine the marriage-market equilibrium, and thus the costs and benefits of human capital investment for women. This section of my research has direct applications to the measurement of global development. Whereas the gender wage gap is often used as a metric of women’s empowerment, the time-cost of career investment is rarely considered at the same time. Even if women can achieve equal salaries to men, if doing so requires forfeiture of reproductive capital, these women experience a steep penalty. Evaluating concurrently a women’s labor market opportunities and the reproductive costs of capitalizing on such opportunities provides a more accurate measure of women’s economic empowerment.

Framing fertility as an economic asset, and therefore evaluating the tradeoffs it creates for women, is essential for understanding the economic decisions of women without resorting to differing preferences as a catch all. This research provides a theoretical framework for this study, while providing empirical evidence that this economic asset view of fertility has merit.

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6Focus group discussions conducted by author in October 2011
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