Essays in Gender Economics

Corinne Low

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This dissertation examines women's choices regarding reproduction, sexual activity, and marriage in an economic framework. The first two chapters address the impact of the "biological clock" on women's marriage market outcomes, and thus its implications for career decisions.

Women's ability to have children declines sharply with age. This fecundity loss may negatively affect marital prospects for women who delay marriage to make career investments. In chapter 1, I incorporate depreciating "reproductive capital" into a frictionless matching model of the marriage market, where high-skilled women are likely to make pre-marital career investments. When the fertility costs of these investments are large relative to the income gains, the model predicts non-assortative matching at the top of the income distribution, with the highest-earning men forgoing the highest-earning women in favor of poorer, but younger, partners. However, if women's incomes rise or desired family size falls, high-skilled women may be able to compensate their partners for lower fertility, leading to assortative matching. Historical patterns in US Census data are consistent with these predictions. In the 1920-1950 birth cohorts, women with post-bachelors education match with lower-income spouses than women with only college degrees, while in recent years this pattern has reversed.

The model relies on men internalizing their partners' expected fertility when choosing a mate. In chapter 2, I test this premise using an online experiment where age is randomly assigned to dating profiles, to control for other factors (such as beauty) that change with age in observational data. I find that men, in contrast to women, have a strong preference for younger partners, but only when they have no children of their own and are aware of the age-fertility tradeoff.

Chapter 3 addresses another decision, protecting against unintended pregnancy, in the context of the introduction of a new technology that can prevent pregnancy after intercourse. Emergency contraception (EC) can prevent pregnancy after sex, but only if taken within 72 hours of intercourse. Over the past 15 years, access to EC has been expanded at both the state and federal level. We find that expanded access to EC has had no statistically significant effect on birth or abortion rates. Expansions of access, however, have changed the venue in which the drug is obtained, shifting its provision from hospital emergency departments to pharmacies. We find evidence that this shift may have led to a decrease in reports of sexual assault.

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For the women who chose

Chapter 1

A Model of Reproductive Capital on the US Marriage Market

Corinne Low

1.1 Introduction

Women's ability to conceive children falls off rapidly around age 40. This decline in fecundity has rarely been treated as an economic factor, despite large potential implications for women's welfare. If marriages are formed partly to have children, and marriages tend to improve the economic circumstances of women, then a woman is economically worse off after age-induced infertility than before. If she is unmarried, her value as a partner has diminished and thus her marital prospects are worse; if she is married, her outside option has decreased. Thus, fecundity can be thought of as a depreciating economic asset, which I call "reproductive capital."

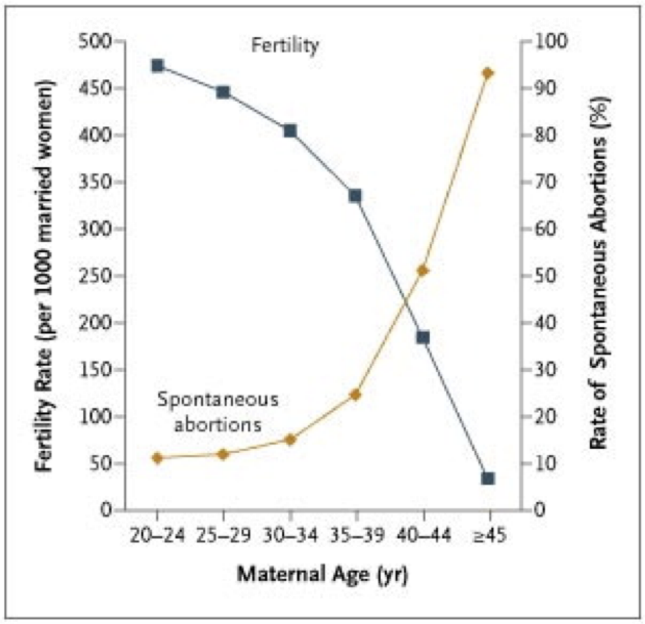
This paper explores how this asset is valued on the marriage market and, consequently, the tradeoff women face when making career investments that delay marriage. First, I use a bi-dimensional matching model to study marriage patterns when the most skilled women are likely to marry later. I then document for the first time patterns in US Census data consistent with the model's predicted patterns.

Figure 1.1 shows the stark consequences of aging for female reproduction. Although menopause does not occur until around age 50, women face increasing difficulty becoming pregnant, and having healthy children, as they approach and pass 40 (Frank, Bianchi, and Campana 1994). 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), while remaining egg quality declines (Toner, 2003). Figure 1.1 shows the non-linear decline in fertility with age in traditional societies where women do not use birth control, and thus fertility may more closely mirror fecundity.[1] Figure 1.1 also shows that miscar-

[1]Extrapolations of later-life fecundity levels from fertility in traditional societies 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. However, even more recent prospective studies that show that many women in their late thirties can successfully conceive nonetheless show an accelerating decline in

riages increase sharply with maternal age (measured using hospital records on pregnancies in Denmark between 1978 and 1992), as do fetal abnormalities (Hook, et al., 1983), meaning that even when later-life pregnancy is possible, healthy births are increasingly difficult.

Figure 1.1: Rates of Infertility and Miscarriage (Spontaneous Abortion) Increasing Sharply with Age



Source: Heffner 2004, "Advanced Maternal Age: How old is too old?"

Notes: Fertility adapted 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. Spontaneous abortions adapted from Andersen, et al. (2000), comprising data on over 600,000 women in Denmark between 1978 and 1992.

On the marriage market, the differential impact of aging on women appears to be reflected in a societal preference for younger female, but not male, partners. 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 2010 American Community Survey in Figure 1.2. In contrast,

fecundity by age 40 for women, whereas men's fertility is relatively stable. For example, Rothman, et al. (2012), 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%.

men's age is not systematically related to the income of their spouse. 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.

Figure 1.2: Spousal Income by Age at Marriage

Notes: From 2010 American Community Survey (1% sample) marital histories for white women, 46-55 years old.

The model incorporates reproductive capital into a transferable utility matching framework: men are characterized by their income, while women have both income and fecundity. This second dimension creates a tradeoff for women between increasing their income and maximizing reproductive capital. When skilled women make time-consuming career investments, the resulting marriage market patterns can be non-assortative on income—the highest-earning men may forego matching with the highest-earning women in favor of lower-earning, more fertile partners. This in turn increases the cost to women of making such investments, adding a marriage-market cost to the personal utility cost of lower fertility. If this marriage-market penalty shifts, the appeal of career investments, and thus the number of women seeking higher education, may also shift.

The non-assortative equilibrium match predicted by the model is of particular interest because it may also be non-*monotonic* in income, a unique feature mirrored by historical marriage data. In the non-monotonic equilibrium, some portion of richer men match with richer women, but the *richest* men, who have enough of their own income, prefer poorer women. I demonstrate that under two conditions on the surplus produced by marriage—super-modularity in incomes and a decreasing marginal rate of substitution between income and fecundity—it is possible to find parameter values that support such a non-monotonic stable match. This violation of *both* positive assortative matching and negative assortative matching appears in US Census data for women from the 1920–1950 birth cohorts. Among these women, those with college degrees marry wealthier spouses than those with high school degrees or some college only, as expected in an assortative matching framework. However, women with post-bachelors education match with *poorer* spouses than those with college degrees.

In more recent cohorts, the fate of educated women on the marriage market has improved. The model's comparative statics provide insight into potential drivers of this shift. In the model, the impact of career investments on marriage market outcomes depends on the income gained from investment compared to the resulting loss of fertility. When career investments yield small income gains or large fertility losses, equilibrium matches are non-assortative for highly skilled women. By contrast, if the labor market return on investment rises or the fertility cost falls sufficiently, the highest-earning women may be able to compensate their partners for foregone fertility, and thus match assortatively. Using US Population Census data, I show that matching patterns in the US are consistent with these predictions. As returns to career investment for women have risen and desired family sizes—and thus the cost of delaying fertility—have fallen, women with post-bachelors education have matched with richer husbands, surpassing women with college degrees. The rate of marriage for these women has also risen, while the divorce rate has fallen. I demonstrate that these changes in educated women's marriage outcomes have been driven entirely by women with *post-bachelors* education, who are most likely to experience a tradeoff between income and reproductive capital from their investment.

These results may also help to explain the dramatic rise in the rates of women seeking higher education in recent years. If the marriage market has transitioned from a non-assortative matching equilibrium to an assortative one, the marriage market cost of making time-consuming career investments has fallen. This partial elimination of the marriage-market penalty associated with post-college education may have amplified the effects of the increase in labor market returns to education. Thus, this model provides an underlying mechanism for an increasing marriage market return to education for women, which Chiappori, Iyigun, and Weiss (2009) find is necessary to explain why schooling rates have increased differentially for women despite increasing returns to education benefiting both women and men.

This research contributes to an understanding of the broader consequences of differential reproductive decline between men and women, and how this biological fact may contribute to social trends. The model purposely abstracts away from gender-specific preferences for mates, instead examining whether reproductive capital alone can produce patterns similar to those seen in observational data. The model shows that the fertility loss from investment can affect marriage market outcomes for educated women, and thus the total return to educational investment. This predicted equilibrium responds to underlying factors, such as the labor market return to education, the ability to have children later in life, and flexibility in combining family and career. Thus, individuals, policymakers, and firms may be able to use a better understanding of this tradeoff to blunt the impact of reproductive capital's decline.

Section 2 of this paper reviews related research, Section 3 develops the model, Section 4 compares the model's predicted patterns to US Census data, and Section 5 concludes.

1.2 Related Literature

The findings of the model and Census data analysis contribute to the literatures on fertility and marriage, work and family tradeoffs, and spousal matching patterns over time.

The idea that fertility may have market value has been introduced in economics literature previously (e.g., Edlund, 2006, and Grossbard 1976), but not linked to a model of marriage market matching. Edlund argues that the institution of marriage is designed to transfer parental rights from wife to husband, and that wives receive economic transfers in return. Grossbard connects the demand for additional wives in polygamous societies to fertility, noting that older women will be less effective at providing this type of wife-service, and thus may be more likely to have co-wives.[2] There is also work showing that payments for marriage (Arunchalam and Naidu, 2010) and forgoing marriage (i.e., sex work, Edlund and Korn, 2002, Edlund et al., 2009) may be connected to fertility. The market value of fertility is taken as a given in other disciplines, such as evolutionary biology (Trivers, 1972),

[2] This idea is further expanded in Grossbard-Shechtman, 1980, Grossbard-Shechtman, 1986, and Grossbard-Shechtman, 1993. Grossbard (1982) further notes that demand for wives is likely to follow their productivity in wife services, and that this productivity may peak earlier than husband's labor market productivity due to biological limits on fecundity.

anthropology (Bell and Song, 1994), and sociology (Hakim, 2010). This paper contributes to this literature by providing one potential model in which marital transfers are tied to fertility as an equilibrium result.

In the theoretical literature, some marriage market models have started from the premise that older women are less desirable on the marriage market, while this paper develops a model that provides foundations for this assumption. Siow (1998) considers the impact of fecundity limits on marriage and relative wages, through a model where women do not have the option to remarry later in life due to infertility. Women thus have less motivation to make career investments early in life, since they cannot hope to attract a secondary spouse post divorce, unlike men. Dessy and Djebbari (2010) incorporate this restriction on older women's marriage success into a coordination game regarding optimal marriage timing among women. Mazzocco and Bronson (2013) develop a search model of the marriage market under the restriction that women can only marry when young. This results in variation of the marriage market gender ratio when cohort size changes, and predicting fluctuations in marriage rates that match historical data. In contrast to this earlier work, this paper provides a formal model of the mechanism through which age can affect women's marriage market outcomes, thus offering micro-foundations for the assumption that older women face difficulty marrying.

This paper also introduces another element: the connection between human capital decisions and the "ticking clock" of fecundity. 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.[3] The literature on the link between

[3]Perhaps because of this connection, the relationship between age-at-marriage and spousal income is especially apparent for college-educated women, as shown in Appendix Figure A.4. These women realize the greatest gain in spousal income by waiting until their late twenties or early thirties to marry, due to either

fertility and career has generally considered the problem of too much fertility, rather than too little. If children are an unavoidable byproduct of being sexually active (due to lack of contraception access), women may be hampered in pursuing greater education and career opportunities (Michael and Willis, 1976). Goldin and Katz (2002) as well as Bailey (2006) and Bailey et al. (2012) examine how the introduction of oral contraceptives enabled women to control their fertility and thus make larger career investments, increasing female education and labor supply and reducing the gender wage gap. Adda, Dustmann, and Stevens (2011) quantify the cost of children in terms of lost wages to women, which they find explains a large portion of the gender wage gap. Buckles (2012), by contrast, examines the impact of fertility limitations, arguing that later-life biological limits on fecundity may restrict women's career participation. 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. This paper incorporates this tradeoff between career investments and delayed fertility into a model that provides predictions for matching patterns and investment.

On the other hand, career investments, and the higher human capital and income that follow from them, may themselves be potential assets on the marriage market, for women as well as men. This idea is explored by Lafortune (2013), Grossbard-Shechtman (1982 and 1993), Iyigun and Walsh (2007), and Chiappori, Iyigun, and Weiss (2009). This work also fits with literature linking the increase in women seeking higher education over time to a concurrent improvement in marriage market outcomes for these women (Chiappori, Iyigun and Weiss, 2009; Ge, 2011; Chiappori, Salanié, and Weiss, 2012). My work helps explain the underlying reason for an increase in the marriage market premium for education, in the partial elimination of the penalty associated with lower reproductive capital (due to increased

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.

income for highly educated women and a fall in desired family size). Changing marriage patterns for educated women have been noted in recent work, which has in particular documented a rise in marriage rates, and fall in divorce rates, for women with post-college education (Stevenson and Isen, 2010). I distinguish between women with bachelor degrees and women with post-bachelors education, and show that these trends have been driven by only the highly educated women, indicating that the time-cost of education is a key factor.

This paper additionally fits with other literature looking at how men and women value different characteristics on the dating and marriage markets (Fisman et al., 2006; Hitsch, Hortaçsu, and Ariely, 2010; Bertrand, Pan, and Kamenica, 2013) and how social forces may drive the degree of assortativeness in mating (Hurder, 2013; Guner et al., 2012; Fernandez, Guner, and Knowles, 2005; Mare and Schwartz, 2005).

Finally, the model I develop provides an interesting application of an anomalous bi-dimensional matching pattern, in which matching is non-monotonic along a single dimension (here, income). Because the matching model I present is truly bi-dimensional, it allows for matches that are not simply either assortative or negative-assortative along a "quality index." Matching models that look at two or more characteristics often 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. Galichon and Salanié (2012) offer a multi-factor example. This type of model is an emerging strand of the literature, and equilibrium characteristics in this setting have only recently been explored. The model I develop also allows the woman's two characteristics to be endogenously chosen, with one affecting the other: she can choose to improve her income only at the expense of reproductive capital. I provide general conditions under which this setting—one side of the market being heterogeneous in two negatively correlated characteristics–can result in non-monotonic matching.

1.3 A Model of the Marriage Market

This section develops a transferable utility matching model to study how the tradeoff between human capital investment and reproductive capital depreciation can impact marriage outcomes. I first describe the setup of the model and then characterize the stable equilibrium using a simple example. I then provide general conditions under which a non-monotonic matching equilibrium can appear. Finally, I use an extension to discuss how this marriage market equilibrium will affect women's human capital investments, and provide empirical predictions to be compared with Census data.

The model is based on the simple assumption that some kinds of income-increasing career investments require women to delay marriage and childbearing. Thus, in addition to being heterogeneous in income, women are also heterogeneous in fecundity: those that make career investments have higher earnings, but lower reproductive capital. With standard utility functions that include both private consumption and children, this model can predict non-assortative matching at the top of the income distribution. If the loss of fertility is large enough relative to the return to women's career investments, there exists a stable equilibrium where the very highest-income women match with lower-income men than a segment of poorer, but more fertile women. This matching outcome is generalizable to surplus functions where the value of marrying a high-earning women is greater for a high-earning man (super-modularity), but the value of a gain in fertility *relative* to a gain in income is also greater for a high-earning man (a marginal rate of substitution between fertility and income that decreases in income).

The fact that men take reproductive capital into account when choosing a partner adds a marriage-market cost to the personal cost of lowered fertility resulting from time-costly career investments. This can thus reduce women's willingness to invest in human capital. But, the model also predicts that as women's incomes grow, and the fertility penalty from investment falls, high-earning women can compensate their spouses for their lower fertility, and matching will be purely assortative on income. Lower fertility is still costly, as women must make transfers to their husbands to "make up" for foregone fertility, but the lower marriage-market penalty may increase women's willingness to seek higher education and other human capital investments.

Instead of making the assumption that fertility impacts matching and intra-household transfers, the model I present yields this as an equilibrium result, stemming from a driving mechanism, that I will later test, of fertility entering the utility of men evaluating different matches. Transferable utility matching models (Shapley and Shubik, 1971, and Becker, 1973) derive matching patterns from the efficient division and creation of surplus. 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. These payoff shares essentially act 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, a model with simple assumptions only about the form of the utility function can generate rich predictions about matching patterns and transfer flows related to women's level of reproductive capital. Here, the complementarity between fertility and income creates the potential for a non-monotonic match along income. I provide general conditions under which this type of match can occur, which has applications outside the specific question of fertility's role on the marriage market.

1.3.1 Cobb-Douglas, uniform example

In this model, career investments yield earnings gains, but delay marriage and childbearing. Women who invest arrive on the marriage market with high income and low fertility (richer and older) while those who do not invest have low income and high fertility (poorer and younger). This feature of the model is intended to capture the impact of large, lumpy career investments such as completing medical school and a residency, pursuing partnership at a law firm, or completing a PhD. To first determine this stratification's impact on marriage market outcomes, I treat the woman's decision as exogenously given. I later extend the model to allow women to choose whether or not to invest, taking into account the marriage market equilibrium.

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

I begin with a simple example where utilities are Cobb-Douglas and the distribution of men and women is uniform, to allow for clean exposition of theoretical results and graphical representations. The following section discusses the generalizability of these findings.

Men and women are each endowed with skill, s. In the man's case, human capital investment is costless, and he therefore arrives on the marriage market with a single characteristic, income y^h, distributed uniformly on $[1, Y]$.[4]

Women, starting with skill s distributed uniformly on $[0, S]$, can improve their level of income, but doing so takes time, and this time is costly in terms of reproductive capital depreciation. As a result, if they make investments, they will have a lower probability of becoming pregnant when they get married. Women are therefore characterized by a pair of

[4]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.

characteristics, (y^w, π). This pair is equal to (s, P) if the woman marries without investing or $(\lambda s, p)$ if the woman marries after investing, where $\lambda > 1$ and $P > p$. Note that the "fertility penalty" of investment is the same for all women, whereas the wage difference from investment increases with skill. Thus, higher skilled women have more to gain from investing.

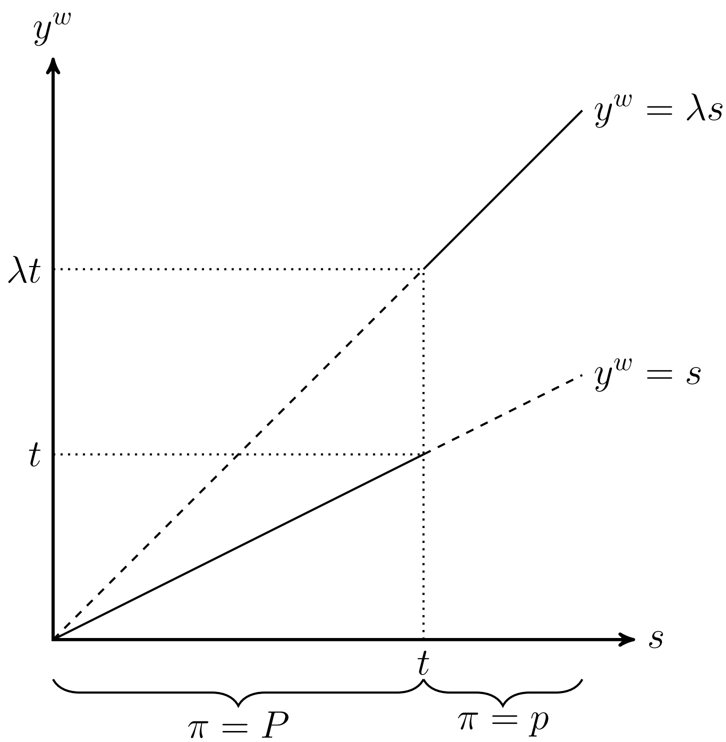
Because of this, one intuitive form of initial investment is for only high skilled women, above some skill threshold t, to invest. This section solves for the marriage market equilibrium assuming an exogenously given t, while the next section shows under what conditions this marriage market equilibrium is general. I then use an extension of the model to discuss how the marriage market equilibrium will impact women's investment decisions if they internalize the marriage market consequences of their investment choice, providing conditions under which some women will be willing to invest despite poor marriage market outcomes, and under which the investment decision will indeed have the "threshold" form.

For now, assume women with $s > t$ invest and earn income of λs and have fertility p, whereas women with $s < t$ earn income s and have fertility P, as shown in Figure 1.3.

To solve for the matching equilibrium, we can 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 spend income on 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. Let the utility of each be given by the Cobb-Douglas functions:

$$u^h(q^h, Q) = q^h(Q + 1)$$
$$u^w(q^w, Q) = q^w(Q + 1)$$

Figure 1.3: Women's income versus potential income



With budget constraint $q^h + q^w + Q = y^h + y^w$

These utilities satisfy the Bergstrom-Cornes property for transferable utility (Chiappori et al., 2007, Bergstrom and Cornes, 1983), and thus consumption decisions can be found by maximizing the sum of utilities, subject to the budget constraint. Assuming $y^h + y^w > 1$:

$$q^* = \frac{y^h + y^w + 1}{2}$$
$$Q^* = \frac{y^h + y^w - 1}{2}$$

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:

$$T = \pi \frac{(y^h + y^w + 1)^2}{4} + (1 - \pi)(y^h + y^w)$$

Finding the stable match

Under some conditions, there exists a stable match where the wealthiest men do not match with the wealthiest women, pairing instead with poorer, younger wives. The existence of this equilibrium depends on the fertility cost of career investments relative to the income gained from such investments.

A matching is defined as a set of probabilities that a given man is matched with a given woman, and value functions for each agent indicating their equilibrium surplus share from the resulting match.

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

Thus, we require:

$$\begin{aligned} \forall y^h: &\quad u(y^h) \geq y^h \\ \forall s: &\quad v(y^w(s), \pi(s)) \geq y^w(s) \\ \forall y^h, \forall s: &\quad u(y^h) + v(y^w(s), \pi(s)) \geq T(y^h, y^w(s), \pi(s)) \end{aligned}$$

where $u(y^h) + v(y^w(s), \pi(s)) = T(y^h, y^w(s), \pi(s))$ for individuals matched together.

As shown in Becker (1973), super-modularity of the surplus function yields positive assortativeness in a unidimensional setting. 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.

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 couples with men of different incomes.

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 on income or not. It could be that the value of extra fertility, although increasing in income, never outweighs the value of extra income, which is *also* increasing in income due to super-modularity. 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.

For the Cobb-Douglas example, the joint product is super-modular in incomes (here, just convexity in income, since the two incomes enter additively):

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

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.

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

$$MRS = -\frac{d\pi}{dy^w} = \frac{\frac{\partial T}{\partial y^w}}{\frac{\partial T}{\partial \pi}} = \frac{\pi \frac{y^h + y^w + 1}{2} + (1 - \pi)}{\frac{(y^h + y^w + 1)^2}{4} - (y^h + y^w)}$$

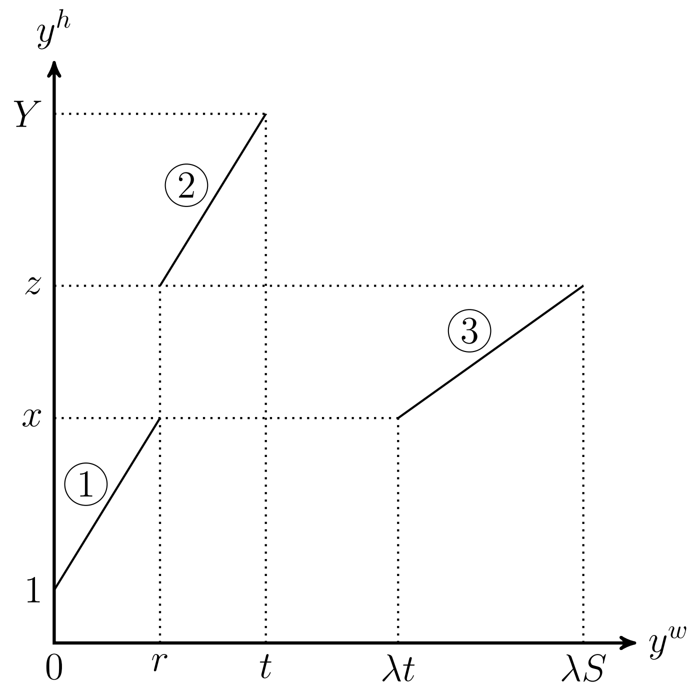
This is the relative change in surplus from an increase in y^w versus an increase in π This ratio is decreasing in y^h:

$$\frac{\partial(MRS)}{\partial y^h} = -\frac{2(\pi(y^h + y^w - 1) + 4)}{(y^h + y^w - 1)^3}$$

Therefore, the richer the husband is, the less improvement in fertility is required to compensate for income loss. In this sense, couples with richer husbands care more about fertility relative to income, and thus in equilibrium 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.

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 1.4.

Figure 1.4: Non-monotonic equilibrium match



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 group of women matches 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 more high-skilled women among those who have not invested and are thus still fertile.[5]

This general form allows for the match to be non-monotonic, as depicted, or collapse to positive assortative matching, when $r^* = t$ (and thus segment 2 in Figure 1.4 has zero mass),

[5]The matching functions in this uniform case are linear, but in the general case, their form will be determined by the distribution so that the number of women above any point on each "segment" exactly matches the number of men above that point.

or block-negative assortative matching when $r^* = 0$ (and thus segment 1 has zero mass).

By the Becker-Shapley-Shubik result, a match is stable if and only if it solves the total surplus maximization problem for the entire marriage market. Thus, we can easily determine if there is a non-empty set of parameters that yields non-monotonic matching by checking if there is ever an r strictly between 0 and t that solves the surplus maximization problem. The cutoffs x and z can be rewritten in terms of r and t, and as t is fixed before the matching stage, we simply need to find the r^* that maximizes total surplus. If there is an interior solution for r^*, we will have the three-segment, non-monotonic equilibrium. If no such equilibrium exists, then the maximizing r^* will be either t (and the stable match will be positive assortative) or zero (and the stable match will be locally assortative, but negative across the investment threshold).

The stable equilibrium depends on the value of λ, the labor market returns to investment for women, relative to $\frac{P}{p}$, the fertility return to *not* investing, and the size of male incomes. Intuitively, the maximization process is about finding the optimal threshold, if one exists, for men to "break" from assortative matching—the income that is high enough for the fertility-income complementarity to overwhelm the income-income complementarity. If men are very rich relative to even those women who have invested (and the fertility penalty to investment is large), many men may wish to "break" from their assortative mates, and match with the lower-income, more fertile women. If women earn large salaries post-investment, and the fertility penalty is not too large, it would take a higher male income to justify "breaking" from the assortative match.

Proposition 1. *The maximizing r^*, and thus the form of the stable equilibrium is determined by the value of λ relative to other parameters.*

- *If $\lambda \leq \frac{S-t}{S+t}(\frac{P}{p} - 1)\frac{Y-1}{S}$, then $r^* = 0$*

- *If* $\frac{S-t}{S+t}(\frac{P}{p}-1)\frac{Y-1}{S} < \lambda < 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p}-1)\frac{Y-1}{S}$*, then there is an interior solution for* r^**.*

- *If* $\lambda \geq 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p}-1)\frac{Y-1}{S}$*, then* $r^* = t$*.*

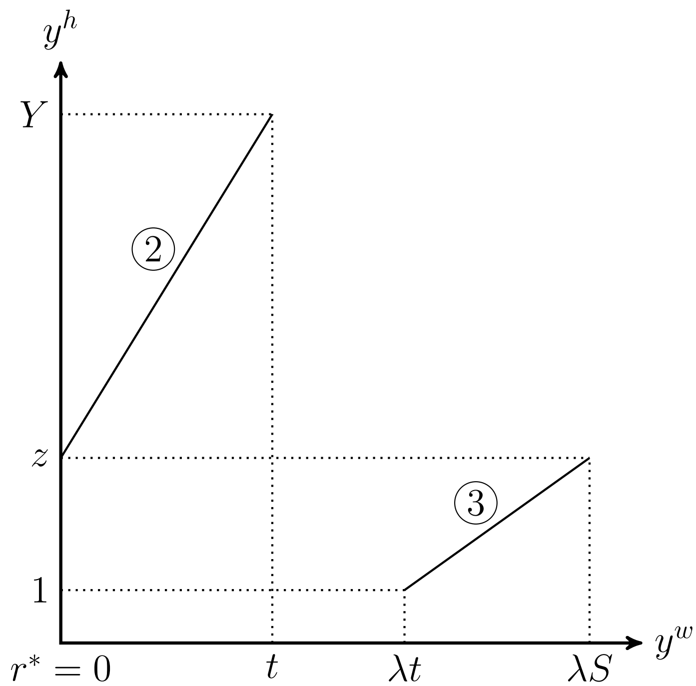
The full proof of this proposition is presented in Appendix A.1, but I present a sketch of the proof here.

Proof intuition: The joint product of marriage can be written in terms of y and s. To find the total surplus, we need to integrate the joint marital product for each segment across the three segments depicted in Figure 1.4. To do this, we need to know which y is matched with which s in any equilibrium. Since matching must be assortative on either side of t, the matching function must pair up the lowest-earning women with the lowest-earning man, the next-higher-earning man with the next-higher-earning woman, and so forth. Finding this function allows the writing of s as a function of y. Thus, the total market surplus can be found by integrating the individual pair's surplus as a function of y over all three segments. This is a function of r because the end points for integration and the matching function depend on r.

The total surplus is then maximized with respect to r, over the interval from 0 to t. The total surplus function, 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. If both first derivatives are negative, the maximand is 0, and if both are positive, the maximand is t. This yields the thresholds outlined in the proposition.

When $r^* = 0$, then the match will be "block" negative assortative, with two segments only, as shown in Figure 1.5. When $r^* = t$, then the match will be positive assortative, as shown in Figure 1.6. When there is an interior solution for r^*, the match will have 3 segments as depicted in Figure 1.4.

Figure 1.5: Low λ equilibrium match



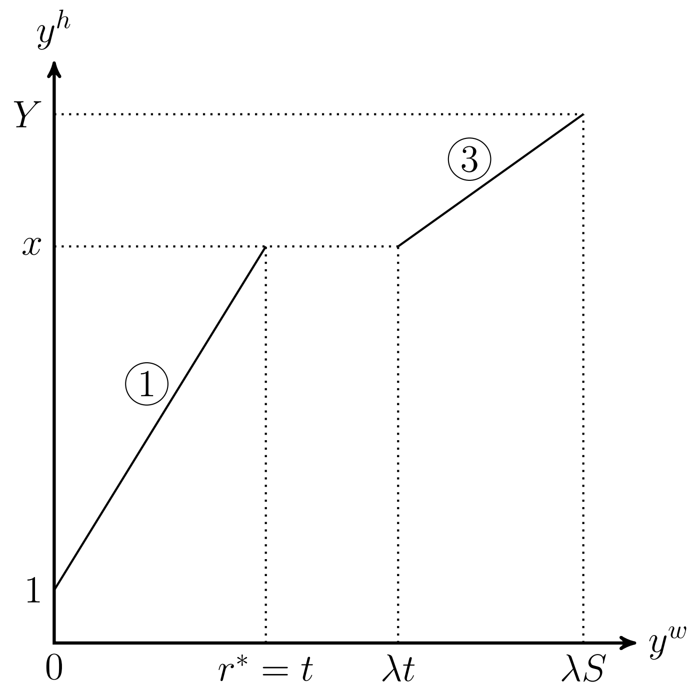
The parameter space for the exact interior solution is non-empty, as $\frac{S-t}{S+t}$ is always less than one and $2\frac{P}{p}\frac{t}{t+S}$ is strictly positive. Thus, the non-monotonic equilibrium can arise whenever the return to investment, λ, is large relative to male income, and the loss of fertility from investment. Said another way, for any value of S, t, P, p, and Y, it is possible to find a λ that will yield non-monotonic matching.

A visual depiction of these thresholds over the p, λ space is shown in Figure 1.7, for $t = 0.7$, $Y = 2$, $S = 1$, and $P = 1$.

Finding the equilibrium payoffs

Now we can find the 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 partner's payoffs must equal the total marital product, and that each person chooses his

Figure 1.6: High λ equilibrium match



or her spouse to maximize his or her own payoff, under the constraint that the spouse will accept that match.

Let $v_i(s), i \in \{1, 2, 3\}$ represent the value function of a woman of skill s matching in segment i, and $u_i(y), i \in \{1, 2, 3\}$ the value function of a man of income y matching in segment i.

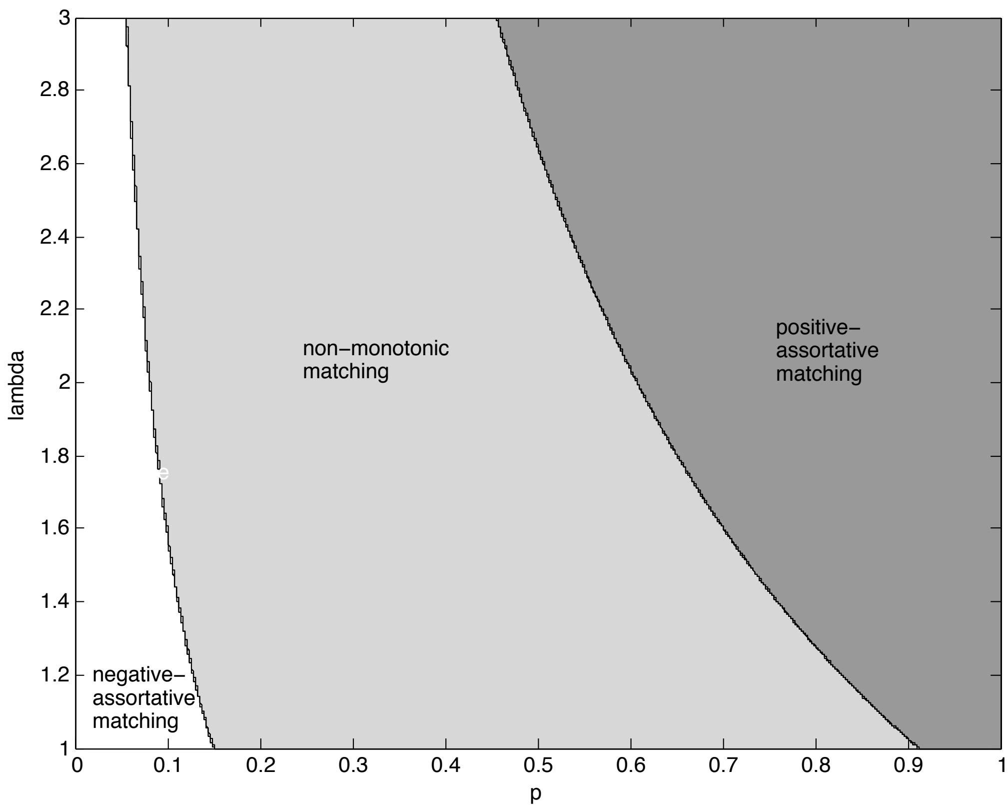
Note that for any individuals of skill s and income y, $u_i(y)+v_i(s) \geq T_i(y, s)$. For married individuals, this holds with equality, and we can solve for the slope of the value function:

$$u_i(y) = Max_s\{T_i(y, s) - v_i(s)\} \Rightarrow v_i'(s) = \frac{\partial T_i(y, s)}{\partial s}$$

and

$$v_i(s) = Max_y\{T_i(y, s) - u_i(y)\} \Rightarrow u_i'(y) = \frac{\partial T_i(y, s)}{\partial y}$$

Figure 1.7: Matching equilibrium for varying λ *and* p
$Y = 2,\ S = 1,\ P = 1$



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.

Appendix A.1.3 shows this process in detail, as well as simulations of the value functions under different parameters.

In a transferable utility matching model, the surplus shares represent "prices" that are assigned based on the value and scarcity of each person's characteristics. The value is determined in terms of contribution to total surplus: Individuals with "good" characteristics generate so much surplus that they can make their partners better off even if they themselves receive high surplus shares. Thus, these individuals' equilibrium "prices," or surplus shares, will be higher.

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.

1.3.2 General Characterization of Match

The existence of a potentially non-monotonic equilibrium is generalizable to surplus functions exhibiting supermodularity in spouses' incomes and a marginal rate of substitution between income and fertility that decreases in income.

The supermodularity assumption, which is fairly standard in marriage models with children acting as a public good (for example, Lam, 1998), reflects the returns to income being multiplied by the ability to spend additional dollars on both private consumption and investments in children, where enjoyment from children is shared by both husband and wife. In a single dimensional model, this assumption is a good fit for aggregate data, where in general married partners are very similar to one another (although I will document violations of assortativeness in matching in the next section).[6]

The marginal rate of substitution assumption has two intuitive explanations: first, it reflects diminishing marginal returns to income relative to other inputs in the surplus function. Although the surplus is super-modular in incomes, it is natural that if income is abundant, the value of additional income relative to fertility diminishes. Secondly, it is tied to the growing importance of additional surplus from the public good as the amount spent on the public good rises. If a large amount of the value of additional income is coming from the ability to spend that income on a joint child, the couple's surplus will be very sensitive to the probability of being able to conceive in the first place.

Proposition 2. *Assume a population of men, characterized by income $y^h \in (0, Y)$, and a population of women endowed with skill $s \in (0, S)$, characterized by income and fecundity (y^w, π). Due to time-consuming career investments by high-skill women,*

$$(y^w, \pi) = \begin{cases} (s, P), & \textit{if } s < t \\ (\lambda s, p), & \textit{if } s \geq t \end{cases}$$

For simplicity, assume the populations of men and women are equal, atomless and continuous in y and s, and have outside options such that all prefer to marry. When the surplus function $T(y, \pi)$, where $y = y^w + y^h$, increasing in both arguments, exhibits the following properties:

[6] Appendix B.1 puts these assumptions to a very basic test using data from the online experiment presented in Chapter 2, and I find suggestive evidence of both.

A1 $\frac{\partial^2 T}{\partial y^w \partial y^h} = \frac{\partial^2 T}{\partial y^2} > 0$ *(supermodularity in both spouses' income, equivalent here to convexity in income)*

A2 $\frac{\partial MRS}{\partial y} < 0$ *where* $MRS \equiv \frac{\frac{\partial T}{\partial y}}{\frac{\partial T}{\partial \pi}}$ *(The marginal rate of substitution between fertility and income in the surplus function is decreasing in income, meaning higher-income couples value fertility more relative to income),*

then the stable match has three characteristics:

- *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*
- *There exist parameter configurations for which 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*.*
- *If some man who marries a woman with* $s < t$ *is richer than another who marries a woman with* $s > t$*, then every man richer than the first also marries a woman with* $s < t$*.*

To prove this requires four lemmas.

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 $(t, S) \times (0, Y)$: Suppose that for two women, each having fertility level π, $s' > s$, and $y \in \phi(s)$ and $y' \in \phi(s')$, with $y > y'$. Because T is convex in total income, $T(\lambda s' + y, \pi) +$

$T(\lambda s + y', \pi) > T(\lambda s' + y', \pi) + T(\lambda s + y, \pi) = u(y) + u(y') + v(s) + v(s')$, given the current matching.

This violates the constraints that $u(y) + v(s') \geq T(\lambda s' + y, \pi)$ and $u(y') + v(s) \geq T(\lambda s + y', p)$. Therefore, $y' \geq y$, and μ exhibits positive assortative matching for all women with the same fertility level, and thus on $(t, S) \times (0, Y)$ and $(0, t) \times (0, Y)$ $\square$

I will now demonstrate that Assumption 2, the marginal rate of substitution condition, is sufficient for non-assortative matching under some parameter values. To do this, I first establish that A2 implies increasing differences in the husband's income of the surplus gain from swapping a high-fertility, low-income wife for a low-fertility, high-income wife.

Lemma 2. $\frac{\frac{\partial T}{\partial y}}{\frac{\partial T}{\partial \pi}} \equiv MRS$ *decreasing in income implies that* $T(y + \delta, P) - T(y' + \delta, p)$ *is an increasing function of* δ*.*

This proof is presented in appendix A.1.4. I now turn to the implications for matching across the threshold.

Lemma 3. *If* t*,* Y*,* $\frac{P}{p}$*,* S *and* λ *are such that* $T(t + Y, P) > T(\lambda S + Y, p)$*, there exists* y *and* y'*,* $y < y'$*, such that* $\psi(y') < \psi(y)$ *(non-assortative matching possible for* Y *big enough).*

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 $\frac{\frac{\partial T}{\partial y}}{\frac{\partial T}{\partial \pi}}$ 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 $y < Y$. $\square$

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 $T(t+Y, P) > T(\lambda S + Y, p)$. But, note that this region will still not always exist, because Y may not be large enough relative to λS and the fertility loss, $\frac{P}{p} - 1$.

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 $y' > \bar{y}$, $\psi(y') < t$ (single threshold for non-assortative matching).*

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, $T(\bar{s} + \bar{y}, P) + T(\lambda s' + y', p) > T(\lambda s' + \bar{y}, p) + T(\bar{s} + y', P)$.

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

Taken together, these four lemmas demonstrate that the match is of the form stated in Proposition 2. 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 and the other side is characterized by two negatively correlated characteristics that cannot be summarized by an index.

Note that for the sake of simplicity I present this characterization of the equilibrium using a threshold for investment, t. However, the same principles for matching apply for any distribution of investment: there is positive-assortative matching within an investment category, there can be negative assortative matching across investment categories, and that if any man matches negative-assortatively than every richer man must as well.

1.3.3 Extension: Exploring optimal human capital investments

I have now characterized the equilibrium 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 whether to invest? Then, in addition to the commonly mentioned personal cost of lowered fertility, women would face a second cost: that of matching with a lower quality partner or compensating a higher quality partner to make up for foregone fertility.

To find how these concerns will impact investment decisions, this section extends the model to endogenize t, allowing women to choose whether they want to invest or not, given the marriage they will eventually encounter. This section also provides parameter ranges under which the "single threshold" approach to investment decisions is valid.

To simplify this section, I use the Cobb Douglas, uniform example, and set $Y = 2$, $S = 1$, and $P = 1$, and add a small fixed cost of educational investment, c, making λ, p, c and, t the only unknowns.

The equilibrium payoffs from the matching stage reflect an individual's *total* payoff within the prescribed marriage, rather than just the payoff from the marriage itself. Thus, we can use these payoffs to find the optimal investment decisions. Note that the process for finding the payoff function internalizes not just the individual change in utility from a different fertility level, but also any change in the share of surplus received. This reflects the impact of traits on the overall surplus: someone with traits that yield a large surplus will in exchange receive a favorable match with a high surplus share. Someone with less desirable traits will face a less desirable match and a lower surplus share. Thus, when equalizing the payoff between investing and not investing to find the optimal threshold, both the personal cost of lower fertility and the cost to the marital surplus are taken into account. Taking these marriage market consequences into account yields a lower t for a given λ and p than if women needed to consider their own preferences for fertility only, or if matching were somehow irrespective of reproductive capital. Thus, the marriage market adds a "second cost" of investment to women's own valuation of foregone fertility.

Assuming for now a single threshold for investment, I set $v_3(t) = v_2(t)$ to solve for the skill threshold above which women should invest, $t^*(\lambda, c, p)$. Although its functional form is complex, t^* varies with the parameters in expected ways: it is increasing in c, decreasing in λ, 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. 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). Appendix A.1.5 shows a graphical representation of this calculation, under different parameter values.

For the remainder of the discussion, and illustrations, I fix $c = 0.2$.

Under some parameter values, there is no solution for t^* within the range of $[0, 1]$, the range of s. In this case, the payoff from not investing ($v_2(s)$) is always greater than the payoff from investing ($v_3(s)$) over the range of s, and thus no women should invest. That is, if the returns to investment or the fertility probability post-investment are very low, no woman will optimally choose to invest.[7] One could also imagine that if these parameters are very high, all women will want to invest, but here, the fixed cost of investment and the

[7] Note, though, that there may be other reasons for investing in education that are not reflected in the utility function used in this model. In this case, some women may invest regardless, and the matching stage of the model can be informative about the marriage market consequences of this decision.

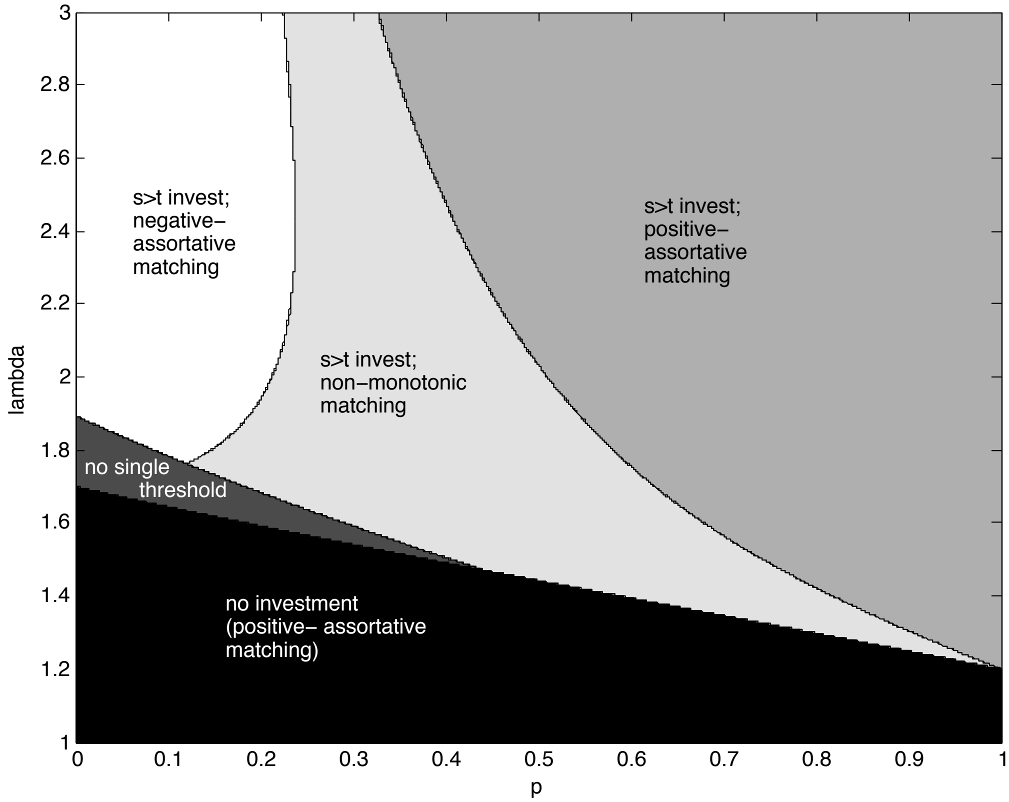
very low returns to investing for low-skilled women make it such that there are always some women who optimally do not invest.

In addition to no investment and a single investment threshold, there is an additional possibility for the investment decision equilibrium: some woman with $s > t$ may wish to invest, but another woman with $s' > t$ may not wish to invest. The shape of the surplus function suggests that if any woman with $s > t$ wishes to not invest, it should be the woman with $s = S$, because the relative value of income compared to fertility in the surplus is increasing in income, and women with the highest s will be in the highest surplus matches. So, to check for this possibility, we can see if the top woman could ever profitably deviate to non-investment. If she did, she would necessarily be paired with the highest income man, since matching must be assortative amongst women of the same investment status. Thus, we need to check whether $v_3(S) < T_2(Y, S) - u_2(Y)$ for any value of λ or p. Figure 1.8 depicts there three possibilities for education decisions over a wide range of λ—from no return on investment, $\lambda = 1$, to a three-fold return—and p. The lower black triangle represents the region for which there is no investment (note that below a λ of 1.2 there is no investment no matter the p, due to the fixed cost of 0.2). The grey sliver represents the region for which there is no single threshold in investment—some woman wants to invest, but the top woman does not want to invest. And, the top three segments represent the region for which there is a single threshold for investment—all women with s greater than some t invest.

Figure 1.8 also shows the regions for the three marriage market equilibria given an endogenous t. Recall that these regions depend on λ relative to P, p, Y, S, t, and here c.

Because the cutoffs for λ depend on t, the cutoffs have a more complex form than with an exogenously given threshold. However, the general form remains: for low λs and ps, there is negative-assortative matching, for intermediate λs and ps there is a non-monotonic equilibrium, and for high λs and ps there is positive-assortative matching.

Figure 1.8: Matching and education equilibrium for varying λ and p
$Y = 2,\ S = 1,\ P = 1,\ c = 0.2$



Determining the matching equilibrium in the absence of a single t threshold is left to future work, although it must still follow the principles described in Proposition 2.

1.3.4 Model predictions

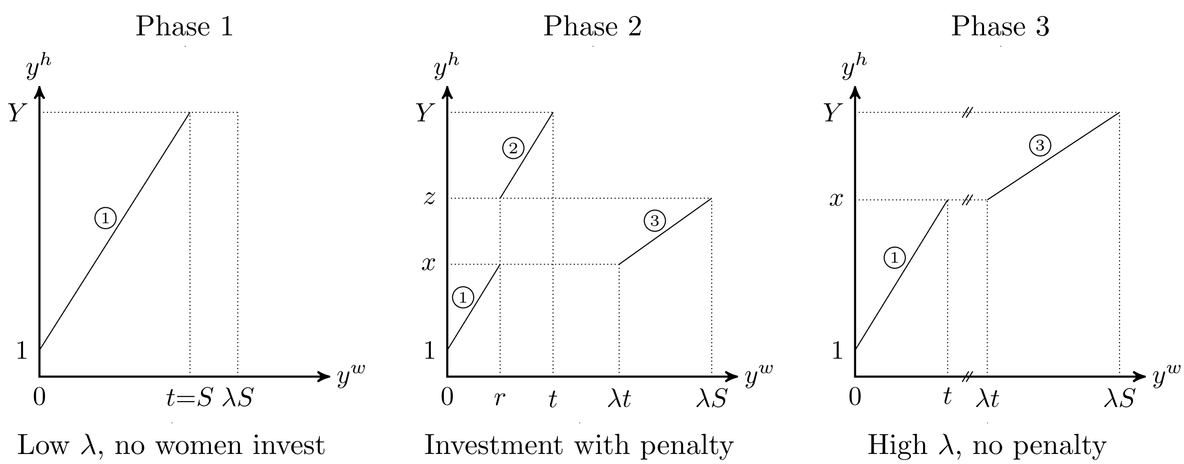
This section describes the model's predictions for marriage patterns that can be compared to historical data. First, the model predicts that non-monotonic matches should occur when the gain from investment for women is small relative to the fertility loss. Second, it predicts that in an environment with increasing returns to education, falling family sizes, and extended fertility frontiers, matching should move towards assortativeness. Third, the model provides the informal predictions of rising marriage and falling divorce rates for highly educated women.

Matching patterns

The first prediction of the model is that non-monotonic matching is possible, and expected to appear when the return to investment for women is insufficient to compensate comparably skilled men for their foregone fertility. Thus, we expect non-assortative matching at the top of the distribution when men's incomes are large relative to women's, when women gain little from investment (e.g., due to discrimination), when family sizes are large, and when access to fertility treatments and adoption are limited. For low enough λs relative to $\frac{P}{p}$, matching may be completely non-assortative, but in this case, the parameter values are likely to deter investment in the first place. Thus, we expect the middle, non-monotonic equilibrium to be observed, but potentially not the fully block-negative assortative equilibrium. In the non-monotonic equilibrium, the highest skilled women are expected to marry lower-earning men than lower-skilled, and lower-earning, women who have not made career investments.

The model's comparative statics can provide useful predictions for historical shifts. An

Figure 1.9: Potential historical transitions



increase in λ, the returns to education to women, could cause a move between equilibria. 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 toward assortative matching with the best men. Interestingly, though, because of the fixed component of the cutoff $\lambda \geq 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p} - 1)\frac{Y-1}{S}$, if *both* λ and Y increased simultaneously, the marriage market could shift from the three-segment equilibrium to positive assortative matching. Thus 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 since the 1960s: women have gone from being penalized on the marriage market for making human capital investments to being rewarded 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 λ is more likely to exceed both the first and second cutoff. Thus, in-vitro fertilization technology (which increases older women's chances of becoming pregnant), 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.

Falling desired fertility may also lead to a shift toward the assortative matching equilibrium over time: If the total children demanded by a couple is lower, then the fertility cost of a time-consuming investment will be lower, because the chance of being able to successfully achieve a smaller number of children is higher at any given age. The "effective" p is higher when a smaller family is desired.

Combining this with the implications for human capital investments, the model predicts a movement from not very many women making time-costly human capital investments (because the double costs of fertility and the marriage-market response to lower fertility outweigh the gain), to women making these investments but matching non-assortatively, to, finally, assortative matching.

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. The model has no formal predictions for who marries (which would require introducing search frictions, or additional heterogenous characteristics, as in Choo and Siow, 2006), but can provide informal intuition for the relative marriage rates between women who invest and those who do not.

Imagine random shocks that cause marriage to be less appealing for some individuals. If these shocks are distributed independently of the endowments of s and y, marriages will be least likely to form (or most likely to break up) where the total surplus is low. In unions with higher surplus, a small shock will be insufficient to derail the match, and thus marriages will only break up (or fail to form) in the case of rarer, larger shocks.

In this model, surplus for individuals who marry (anyone with joint income greater than one) is increasing in the sum of the partner's incomes, for the same fertility level. Thus, when women who have invested match positive-assortatively, the surplus generated by these matches is higher than the surplus generated by matches with high-income women and mid-income men in the three-segment equilibrium. Thus, in a transition from the three-segment equilibrium to the positive-assortative equilibrium, the surplus generated by marriages including the top segment of women grows. This in turn makes these marriages more resilient to shocks, making them more likely to form.

Therefore, over time, marriage rates should increase for women who have made time-costly career investments, relative to other women. Those in higher surplus matches should also divorce less frequently, if the marriage is hit by a shock post-union, and thus divorce rates for highly educated women should also fall.

The next section looks for evidence of these predicted patterns in US Census data.

1.4 US Census data patterns

This section examines patterns in US Census data relative to the patterns predicted by the model, using women who receive post-bachelors education as a proxy for women who have made potentially fertility-disrupting career investments. I show that, in the cross-section, marriage matches for the 1920–1950 birth cohorts violate *both* positive assortative matching *and* negative assortative matching, with college educated women marrying richer spouses than both women with some college only and women with post-bachelors education. This non-monotonic matching pattern has dissolved in recent cohorts: post-bachelors women now match assortatively with richer men than college women. At the same time, marriage rates have drastically increased and divorce rates fallen for this group.

This reversal in marriage market fortune for educated women has been noted by the literature (e.g., Chiappori, Salanié, and Weiss, 2012, Stevensen and Isen, 2010), but my results show it has been driven by *highly* educated (post-bachelors) women, indicating time-costly investments, and their accompanying fertility cost, may play a role in these societal changes. While there are many potential drivers of these patterns, this section demonstrates that reproductive capital may be a useful complement to existing explanations of marriage outcomes for educated women. In addition to making predictions specifically for highly educated women, the reproductive capital model also has the appealing feature of matching these patterns without requiring gender-specific preferences over partner characteristics.

1.4.1 Data

This section describes the data and demonstrates that women who receive post-bachelors education (masters, MDs, JDs, PhDs, MBAs, etc.) earn more, marry later, and have fewer children than women with college degrees only, making them a reasonable proxy group for women who make time-consuming career investments. I use 1% samples of US Census data from 1960, 1970, 1980, 1990, 2000, and 2010. In later years, the data comes from the American Community Survey, which continued to contain some demographic questions that were dropped from the decennial population Census.

I restrict my analysis to 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. 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. In all regressions and figures, I use 41-50 year-old women when age at marriage is not an included variable, and 46-55 year-old women when age at marriage is included, in order to allow for a full range of marriage ages. 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 does not contain a variable for marriage number.

Table 1.1 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 holds true in both 1980 and 2010. I regress total income (in constant 1999 dollars), age at marriage, and children ever born (available for 1980 only) on a dummy variable for post-bachelors versus college-only education.[8] 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 comparison group of college educated women may contain some women who will make a large career investment, which would attenuate any difference between the groups, but certainly women with graduate degrees are more likely to delay marriage and childbearing, as shown by Table 1.1.

1.4.2 Non-monotonicity in matching

Census data for women born between 1920 and 1950 shows that marriage matches for this group exhibit the predicted non-monotonicity in matching between male income levels and female education levels (education is preferable to income to describe female "types" because income is chosen endogenously post marriage). In figure 1.10, women from the 1930–1940 birth cohort (measured when they are 41-50 years old in 1980) who gained a college degree, versus only some college, matched with richer spouses. However, women who went beyond

[8]Children at home, which is available for both years, but is impacted by other factors such as the age of mothers, shows a similar pattern, with highly educated women having fewer children at home in both years, despite likely having children later.

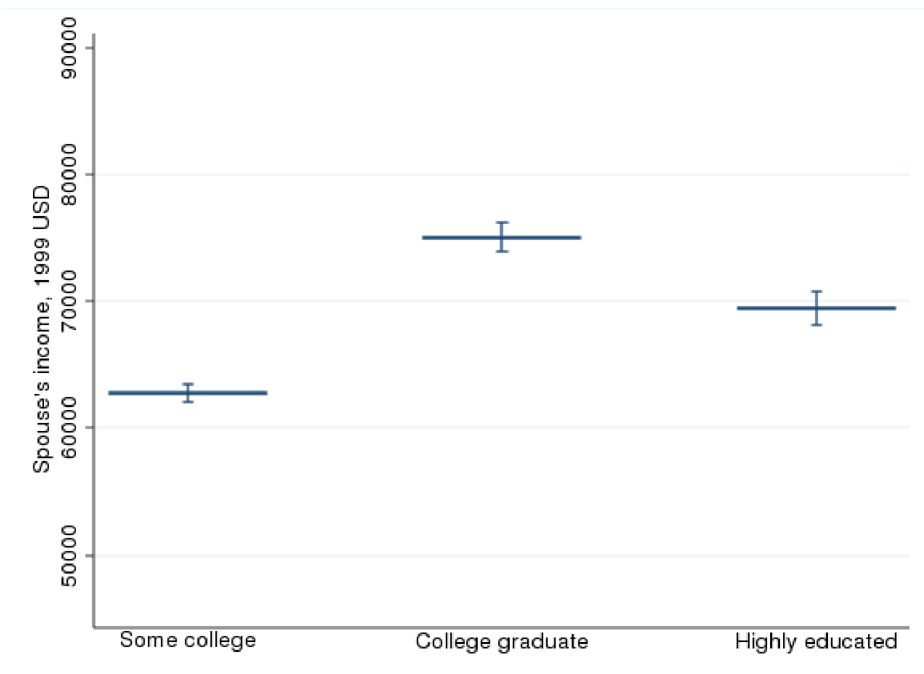
Table 1.1: Income, age at marriage, and children versus education (women aged 46-55)

	(1)	(2)	(3)
Dep. variable:	**Total income**	**Age at marr.**	**Children born**
	2010 American Community Survey		
Highly educated	18,027***	0.928***	–
	(387.9)	(0.0717)	
Constant	36,373***	28.31***	–
	(233.6)	(0.0428)	
Observations	56,563	50,815	–
	1980 Population Census		
Highly educated	11,140***	0.468***	-0.467***
	(465.2)	(0.101)	(0.0336)
Constant	21,134***	23.38***	2.623***
	(302.3)	(0.0638)	(0.0218)
Observations	10,907	9,920	10,907

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

a college degree to receive graduate education matched with poorer spouses than those that stopped at a college degree. This pattern is present as well for the 1920–1930 cohort. For the 1940–1950 cohort, the difference between highly educated and college educated women's spousal incomes is not significant, but the relationship is still non-monotonic, in that spousal income statistically significantly increases for women with a college degree versus some college, but then levels off for women with even higher education. These graphs are shown in Appendix A.2.

Figure 1.10: Non-monotonicity in spousal income by wife's education level, 41-50 year old women in 1980 Census (1930–1940 birth cohort)



What is the source of this non-monotonicity? The data show that conditional on income, marrying older is always linked to marrying a poorer spouse, as shown in appendix Figure A.5. But educational investments change *both* age and income. Because most women do not start childbearing before age 22, and there are still many fertile years left after age 22, even for someone who wants a large family, the reduction in reproductive capital from earning a college degree is expected to be small. Thus, because the women who gain such degrees are more skilled and earn more, they match with higher-income spouses. Women who gain graduate degrees, however, may substantially delay marriage or childbearing, especially since these women may go on to make other career investments.[9]

This distinction is important, as it means that even when there is no apparent marriage-market penalty, in the form of lower matches for educated women, there is still a cost to the loss of reproductive capital—it is simply balanced out by the greater income gained, and thus the woman's ability to sufficiently compensate her spouse.

For the 1920–50 cohort, the loss of reproductive capital outweighed the gain in income on the marriage market. The next section will examine whether later cohorts exhibit the transition to assortative matching predicted by the model.

1.4.3 Changes over time

Market opportunities for women have risen dramatically in the past 50 years (e.g. Hsieh et al. 2013). Meanwhile, average family size has fallen, with a rapid transition from "four or more" as the modal answer for ideal family size to "two" between 1965 and 1975.[10]

These societal trends correspond in the model to an increase in λ relative to $\frac{P}{p}$, since returns to education at the top of the skill distribution have risen while desired family size has fallen, causing a lower differential between "early start" and "late start" (post-investment) fertility. Thus, we expect a movement from an equilibrium where first no women invest due

[9]For example, the natural course of action following law school is to become an associate at a law firm, 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.

[10]Pew Center, The new demography of American motherhood, August 2010. See Appendix A.2 for graph.

to the high costs, 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.

Repeated cross-sections from the US Census align with the comparative statics of the model, as shown in Figure 1.11. In the 1960s, only about 2% of women received education higher than a bachelor degree. By 1980, around 8% of women had achieved post-bachelors education, but these women were matching with men who were poorer than the spouses of women who stopped at a bachelor degree. Finally, by the 2000s, the highly educated women are matching assortatively with higher-income mates than college-educated women. This is also apparent in a regression with dummies for each cohort, as shown in Table 1.2.

As noted earlier, the difference between the college and highly educated groups may be attenuated somewhat by some women in the college-only groups going on to make career investments. Moreover, it 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. These two facts make 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 indicate 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.

It is also important to note that this shift is *not* caused by an underlying shift in how either age at marriage or women's income are treated on the marriage market. A regression comparing the 1980 and 2010 census years (meaning the 1925-35 birth cohort versus the 1955-65 cohort), shown in Table 1.3, demonstrates that in both years women's own income is correlated with higher spousal income and age is correlated with lower spousal income,

Figure 1.11: Spousal income by wife's education level, white women 41-50

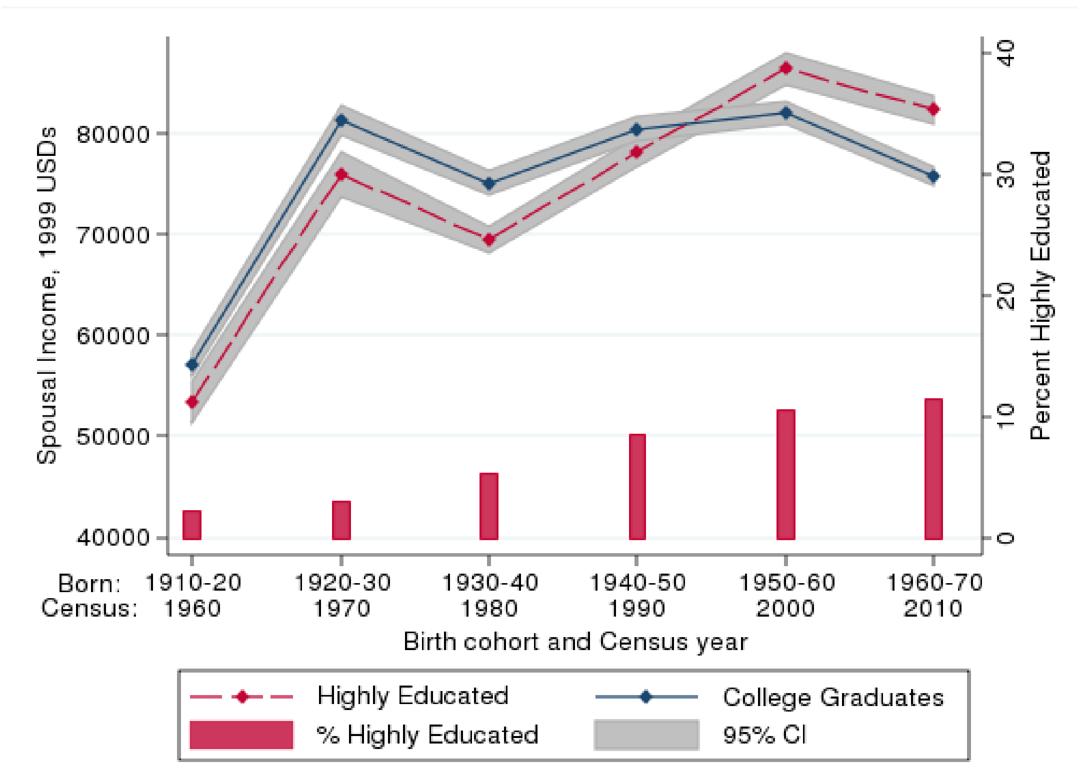


Table 1.2: Spousal income by wife's education level, white women 41-50

Dependent variable: Spousal income, 1999 USD			
	(1)	(2)	(3)
Highly educated	-3,809	-4,141*	-4,138*
	(2,355)	(2,354)	(2,354)
1970 × highly	-1,559	-729.4	-722.5
	(3,042)	(3,025)	(3,025)
1980 × highly	-1,775	-1,398	-1,396
	(2,821)	(2,817)	(2,817)
1990 × highly	1,509	1,813	1,810
	(2,580)	(2,579)	(2,579)
2000 × highly	8,099***	8,460***	8,465***
	(2,496)	(2,496)	(2,496)
2010 × highly	10,434***	10,792***	10,793***
	(2,474)	(2,473)	(2,473)
Constant	57,183***	54,232***	56,056***
	(1,224)	(3,948)	(4,627)
Year FEs	Y	Y	Y
YOB FEs		Y	Y
Spouse age			Y
Observations	115,223	115,223	115,223
R-squared	0.007	0.008	0.008

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1.3: Regression of husband income on wife's income and age at marriage

Dep. variable: Spousal income	(1) **1980 census**	(2) **2010 census**
Own income	0.120**	0.153***
	(0.0531)	(0.0130)
Age at marriage	-658.9***	-1,206***
	(202.1)	(122.9)
Constant	79,457***	100,642***
	(6,328)	(3,929)
Observations	1,055	10,936
R-squared	0.013	0.020

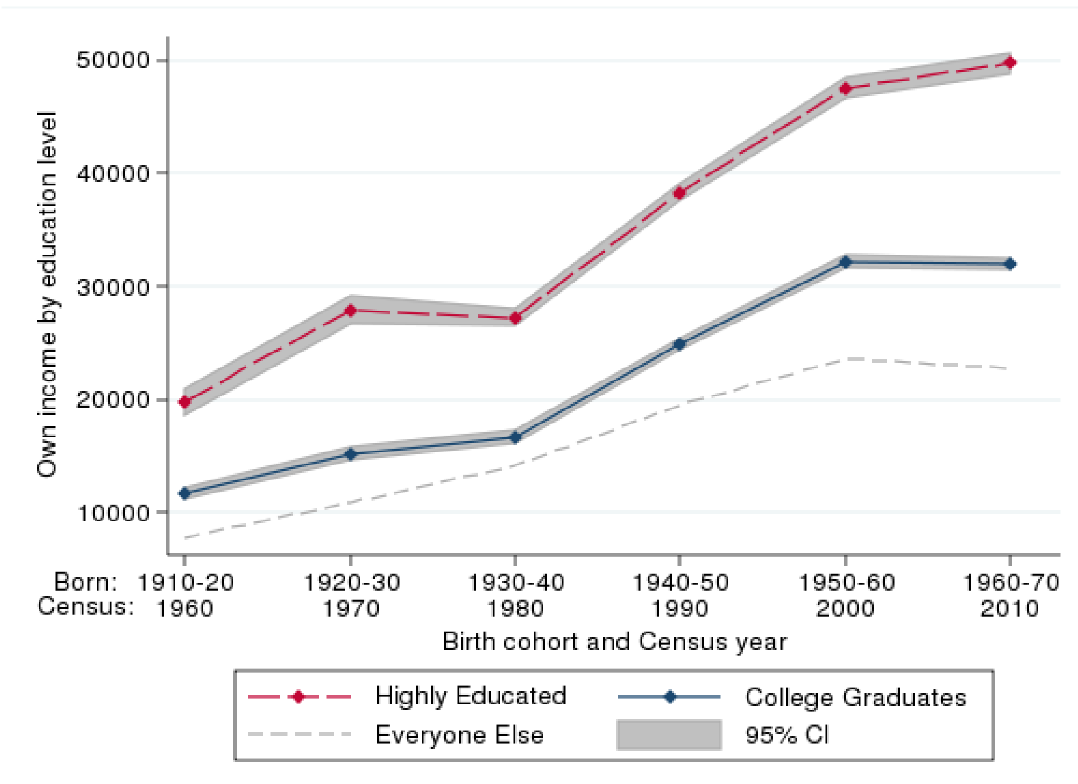
For women who are in the workforce, 45-55 years old
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

when each factor is controlled for. Note, only women with non-zero wage income are used, as otherwise labor supply response to husband's income creates a negative correlation.

These time-invariant relationships between women's characteristics and husbands' incomes support the idea that it is shifts in how these two factors trade off against one another, in terms of how much reproductive capital is lost from career investments and how much income is gained, that has caused the transition to assortative matching for highly educated women, as predicted by the model. Note that the results are also not driven by a crossing in women's own income resulting from the two educational categories—Figure 1.12 shows that highly educated women's incomes were always higher than college-educated women's incomes.

These patterns are also unlikely to be driven by high-earning women having different tastes for partners. If, potentially, high-earning women prefer lower-earning partners because of either income effects (they are higher earning and thus the marginal benefit of

Figure 1.12: Own income by education level, white women 41-50



additional income is lower) or a preference for partners who are more likely to be able to spend time at home, it may be possible to recover the initial non-monotonic pattern in matching. (Although, such preferences in traditional models would tend to predict negative assortative matching, since partner income is complementary, 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.[11]

One might be concerned that the selection of women into post-bachelors education has changed in a way that could align with the observed matching patterns. For example, if women previously selected into post-bachelors 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.[12] While the current analysis cannot rule out this possibility, I do perform two checks to test the potential magnitude of selection effects. First, I repeat all analyses excluding Hispanic and non-US born women, who make up a larger portion of educated women in later years, and thus may be partially driving differential selection. The results are nearly identical to the graphs presented earlier. I then use data from the National Longitudinal Surveys (NLS) to examine whether there has been an increasing skill premium among women who attain post-bachelors education. If women were previously selecting into post-bachelors education due to negative selection in other areas, they may be expected to be less positively selected on intelligence and academic potential. Table 1.4 examines this, using data from aptitude scores and edu-

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[11]Moreover, in Appendix B.2, I use the experiment presented in Chapter 2 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, in line with the supermodular form of the surplus function used in the model.

[12]It should be noted that in earlier cohorts, the same selection forces may have applied to college-educated women as well, since college education was still somewhat rare.

cational 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 negative-assortative matching group, but nonetheless, the trend should be informative about whether there are large shifts occurring in underlying selection factors. These numbers show that there was indeed a large gap in the aptitude between college and highly educated women in the earliest cohort, and that the two numbers are not systematically diverging, which would indicate greater skill-driven selection.

Table 1.4: Relative college and post-bachelors average test score percentiles of three NLS cohorts

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

Notes: Numbers represent percentiles compared to other women with the test score information available. 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. 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).

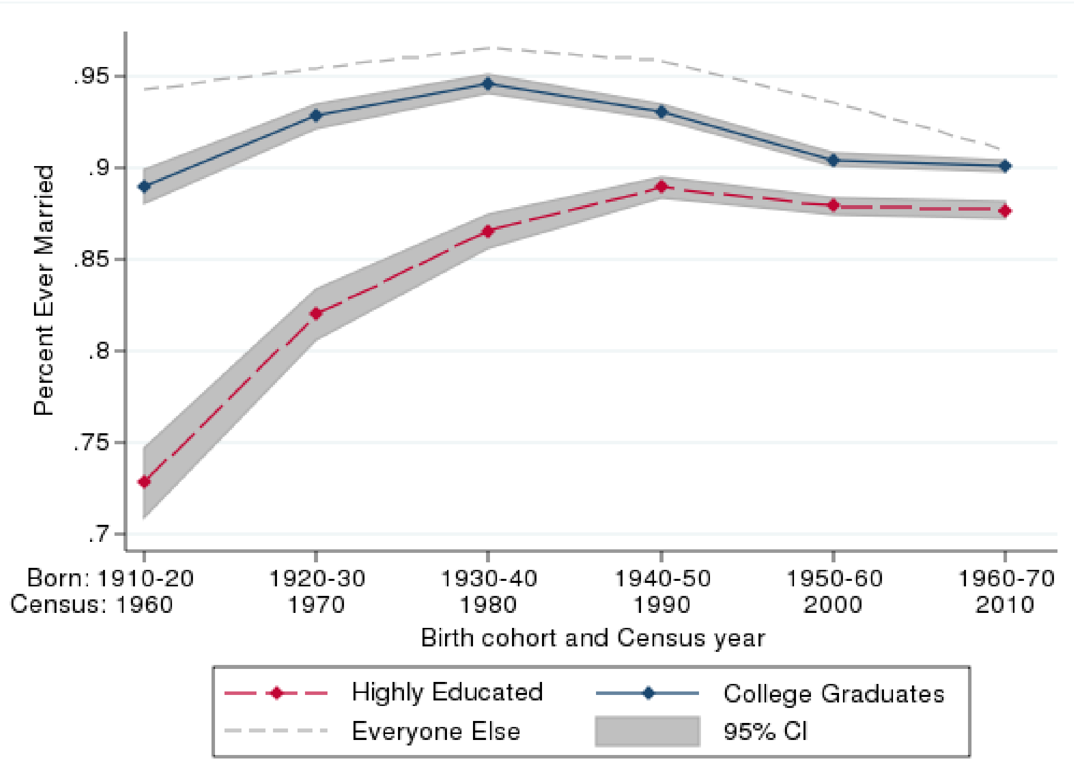
While these analyses provide some information about the potential impact of selection, future research instrumenting for education level would be useful in testing whether the observed changes in marriage-market outcomes are robust to fully controlling for changing selection.

1.4.4 Marriage and divorce rates

The model's predictions regarding marriage rates also match trends in the data. The model predicts marriage rates for women who make career investments to rise as returns to career investments increase, and matching becomes more assortative in income. This results from the surplus in matches involving the highest-earning women together with the highest-earning men being greater than the surplus with the highest women and mid-level men.

Figure 1.13 demonstrates this shift in marriage rates for highly educated women. Marriage rates for college educated women closely track marriage rates for less educated women.

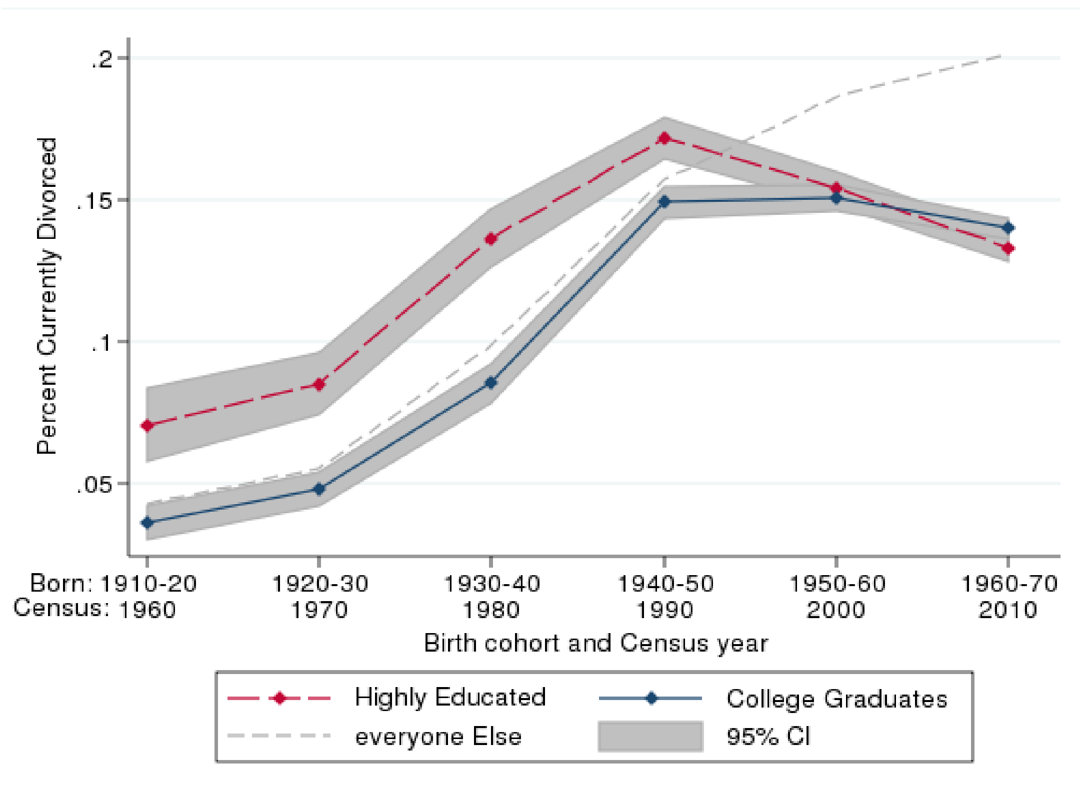
Figure 1.13: Ever married rates by education level, white women 41-50



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 and Isen 2010), whereas previously educated women struggled to find quality mates. However, the graph demonstrates that *highly* educated women are the ones who have made the greatest gains, whereas marriage rates for college educated women (who are usually lumped together with highly educated in the "educated" bucket) have remained relatively flat. Post-bachelors education uniquely requires significant time, and signals future investments requiring even more time, that will delay marriage and child-bearing. Thus, 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.

Highly educated women also previously experienced higher divorce rates, consistent with being in a match of lower surplus, and now have comparable divorce rates to college educated women, as shown in figure 1.14.

Figure 1.14: Currently divorced rates by education level, white women 41-50



The results presented in this section are consistent with Goldin's (2006) documentation of the "revolution" of women switching from marrying before solidifying their identities to now making pre-marriage investments: once seeking higher education is not penalized in the marriage market, women are more likely to invest before marriage. It is also consistent with the findings of Chiappori, Salanié, and Weiss (2012) that the marriage market return to education has increased steeply for women. In the reproductive capital model, this increase in marital surplus accruing to women with high education results from a decrease in the penalty associated with the age-income tradeoff. Furthermore, the findings documented here match those presented by Rose (2005), who found that the "success gap," the disadvantage faced by successful women on the marriage market, declined from 1980 to 2000.

These analyses show that including reproductive capital into a model of the marriage market allows us to explain both the previously low marriage outcomes for highly educated women and the recent improvements in outcomes for these women on the marriage market. Although the results from the Census show that the matching penalty from seeking higher education has abated, it is important to note that this does not mean that aging is therefore costless to women from more recent cohorts. The results related to education are due to the dual effects of increased income and lower fertility counter-balancing one another. The model predicts that lower fertility *in isolation*, and thus older age, will be penalized on the marriage market no matter the matching regime. In related work presented in Chapter 2, I use an online experiment to test for this penalty explicitly, controlling for other factors.

1.5 Conclusion

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. The consequences of this tradeoff are examined through a bi-dimensional matching model and observational data on matching patterns.

The model demonstrates that a small, reasonable set of assumptions can yield non-monotonic matching on income on the marriage market, where the highest-earning women are paired with lower-earning men than poorer, but younger, 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 also must match with lower caliber mates or compensate their partners for this loss as well. 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. The model can also predict assortative matching when the returns to career investment are sufficiently high compared to the fertility loss from investing.

The model's comparative statics are consistent with patterns in US Census data that I document for the first time: women who received education beyond a bachelor degree previously matched with lower-income men (and married less frequently) than women who only received a college degree. As average family size has fallen and the returns to education have risen, this pattern has reversed, with highly educated women matching assortatively.

"Reproductive capital" is relevant to many issues in business, development economics, and social policy. Firms interested in attracting and retaining top female talent might be able to use a better understanding of reproductive capital to adjust compensation packages to reflect the ever-increasing opportunity cost of career investment as reproductive capital depreciates. This could be realized as greater 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, or provisions to allow women to rejoin the workforce and make time-costly investments once they have already had children. Due to depreciating reproductive capital, 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 efforts to promote women's human capital accumulation, such as parental leave policies and workforce re-entry programs. Moreover, government policies that ease access to infertility treatments may have spillover impacts on human capital decisions. When viewed through this framework, insurance coverage of infertility treatments becomes a question of not just health policy, but also labor and economic 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 work also has implications for social policy addressing older women who are divorced or never married. When reproductive capital is included, these women have less 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. It also implies that policy-makers should consider the impact of declining marriage rates on women's economic well-being (e.g., Edlund and Pande, 2002) 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 childbirth 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 (e.g., Peru, India, and the US). 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, the 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.[13] 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 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 women's labor market opportunities and the reproductive costs of capitalizing on such opportunities provides a more accurate measure of women's economic empowerment.

[13] Focus group discussions conducted by author in October 2011.

By framing fertility as an economic asset, and evaluating the tradeoffs its depreciation creates for women, this paper aims to explain historical and contemporary patterns in women's marriage outcomes and human capital investments without resorting to differing preferences as a catch-all.[14] The theoretical and empirical work presented here indicates that reproductive capital's decline may be a useful complement to other explanations of the changing outcomes for educated women on the marriage market, and the growth in rates of women seeking education.

[14] Thus heeding Becker-Stigler's (1977) caution to exhaust economic mechanisms before quibbling over tastes.

Chapter 2

Pricing the Biological Clock: Experimental Evidence of a Dating Market Cost of Aging for Women

Corinne Low

2.1 Introduction

There is a large amount of anecdotal evidence that men prefer younger women on the dating market (e.g., dating website OK Cupid has published data showing that men list their target age ranges as women much younger than themselves, and target their messaging at the younger end of that range).[1] The 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.

Yet, there is little existing evidence that this preference over age on the marriage market stems from a *conscious* preference for fertility, rather than an evolutionary-induced preference for age-related beauty. Valuing younger looks will also drive a penalty against older women, and hence time-costly career investments, on the marriage market, but the policy implications of a *conscious* preference for fertility versus a beauty-driven preference for youth are different. For example, if a conscious preference for fertility is partly at play, then policies promoting access to assisted reproduction technology could alleviate the marriage-market penalty to delayed marriage, whereas if the preference for youth is exclusively a preference for younger looks, such policies would be ineffective.

Moreover, the frequent co-occurrence of late marriage with high human capital and income means that observational evidence may also make it difficult to disentangle whether age is really being penalized on the marriage market for women, versus high earning itself, or otherwise not conforming to traditional gender norms. Low (2014), presented in chapter 1, suggests a mechanism through which declining fecundity, referred to as depreciating "repro-

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

ductive capital" can impact marriage market outcomes for older women, while high human capital and high income are still valued by partners. Children enter into men and women's utility functions along with private consumption, and thus men take their partner's expected fertility into account when choosing a mate. Higher income women more frequently delay marriage, and thus have lower reproductive capital. But, higher earning men may value fertility more *relative* to income, and thus may prefer matching with the poorer, but younger, women who have not invested in their careers. Because of this, higher-income women are not always preferred over lower-income women, even when income is valued in isolation. The evidence presented from US Census shows that the model is consistent with several historical phenomena, including patterns of non-monotonicity in matching and an upswing in marriage "quality" and marriage rates for highly educated women.

To determine whether there is a penalty for women being older in isolation of other factors, I utilize an online experiment in which singles rate profiles of hypothetical partners, with the age randomly assigned while other characteristics, such as beauty, remained fixed. Income is also randomly assigned to the profiles, providing a measure of the preference for each the marginal rate of substitution between these two characteristics in partners' preferences.

Participants rating the hypothetical profiles were incentivized to provide honest responses through the experiment's compensation. In exchange for participating in the study, they received professional dating advice on how to optimize their own online profiles, which was customized based on their ratings in the study. I find that not only do men uniquely have a preference for younger partners, but that this preference is driven by men who have reason to care about fertility and the required knowledge to connect age variation to changes in fertility. Men who already have children, or who believe that female fertility only starts to decline after age 45 (whereas ages in the experiment only vary from 30 to 40), show no preference for partner age. By comparing the impact of an additional year of (randomly assigned) age to the impact of an additional dollar of income, I derive the dating market "price" of the biological clock: a woman who is one year older must make an additional $7000 for her potential partner to be indifferent.

The results of this online experiment show that men, but not women, rate profiles lower when the randomly assigned age is higher. Moreover, this preference is driven by individuals who currently have no children and have accurate knowledge of the age-fertility tradeoff. This provides evidence that at least some portion of the preference for young women on the dating market is driven by a conscious preference for fertility.

2.2 Methodology

The methodology I use isolates age from other factors, while incentivizing participants to give honest responses. The study design is as follows: 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. However, unlike in most traditional economics experiments, there is no clear way to incentivize self-serving behavior 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). 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 were offered free customized advice on their own online dating profiles to attract the type of people they had indicated interest in *based on their answers to the experimental questions.* The customized advice was provided by a dating coach hired for this purpose. For the initial sample, 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.

For the initial sample, subjects were recruited using online ads, placed on dating sites or targeted through Google on 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

After this initial sample was collected and analyzed, I enlisted a survey firm, Qualtrics, to recruit additional respondents in order to test for heterogeneity in effect size among male 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). The disadvantage of this study population is that they were motivated by and provided with other incentives in addition to the date coaching (which was still provided). The advantage is that I was able to recruit many more participants more quickly, and strictly require that they fell within demographic parameters and completed the entire survey. The results from this second study support the initial results, and also allow me to test for heterogeneity of the effects based on male characteristics. They additionally serve as an external validity check on the initial results, in case those men enticed to participate by the offer of free dating advice have non-representative preferences for younger partners.

To generate the hypothetical dating profiles, I purchased stock photos that were similar in appearance to photos on dating websites and randomly assigned characteristics. I started with 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. 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, 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 long-term partner, not a short-term date. Each of these characteristics was 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.

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 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 that completed the survey was shown all 40 profiles. 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.

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 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. For the Qualtrics sample, respondents were pre-screened based on race, relationship status, and age.

2.3 Results

The results of the experiment show that men have a preference for younger women, even when physical characteristics are controlled for. Moreover, women exhibit no such preference, indicating that this preference is tied to unique characteristics of aging females. My results further show that fertility is a likely explanation for this preference: men who are not interested in marriage, already have children, or have no knowledge of the age limits of fertility do not exhibit such a preference.

2.3.1 Summary statistics

Summary statistics are presented in Table 2.1, for my target sample of white individuals between 30 and 40.[2] Without these restrictions, in the initial sample 77% of male 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.

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 (as Qualtrics respondents, in absence of this sampling concentration, tended to be lower-income, which would not allow for a test of income heterogeneity).

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, in the initial sample—in the Qualtrics sample high-income men were deliberately over-sampled. Where men and women 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 in the initial sample. 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 initial-sample

[2] I only have birth year, so all birth years where the individual could have been between 30 and 40 when participating were included.

Table 2.1: Summary Statistics

	Initial Sample			
	Men		**Women**	
	N=35		**N=44**	
Variable	**Mean**	**SD**	**Mean**	**SD**
Age	35.22	3.64	35.84	3.50
High income	.487	.507	.341	.479
College grad	.676	.475	.682	.471
Has kids	.351	.484	.432	.501
Wants (more) kids now	.257	.443	.159	.370
Wants marriage	.460	.505	.432	.501
Date lowest age	25.84	3.57	32.95	3.93
Date highest age	40.84	5.42	46.86	6.92
Preferred low	28.49	3.73	35.30	4.32
Preferred high	37.22	4.55	44.20	6.34
Fem fert cutoff?	1	0	1	0
Fem cutoff age	41.19	6.37	39.67	4.72
Male fert cutoff?	.892	.315	.767	.427
Male cutoff age	53.67	8.91	55.45	8.46

	Qualtrics Sample			
	Men		**Women**	
	N=207		**N=104**	
Variable	**Mean**	**SD**	**Mean**	**SD**
Age	34.65	3.05	34.38	3.21
High income	.387	.488	.159	.363
College grad	.493	.501	.462	.501
Has kids	.203	.403	.423	.496
Wants (more) kids now	.184	.388	.183	.388
Wants marriage	.469	.500	.442	.499
Date lowest age	24.86	4.33	29.97	4.13
Date highest age	41.57	6.09	44.21	7.38
Preferred low	27.03	4.702	32.52	4.38
Preferred high	37.43	5.55	41.34	6.66
Fem fertility cutoff?	.975	.157	.990	.099
Fem cutoff age	43.11	7.11	41.10	6.23
Male fertility cutoff?	.835	.372	.796	.405
Male cutoff age	51.95	9.09	56.55	9.08

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, versus 41.2. Both male and female respondents, conditional on thinking there *is* a cutoff, believe the cutoff to be higher for men.

2.3.2 Age preference

I first compare the relationship between individuals' ratings and the randomly assigned ages and incomes for men rating women and women rating men, using the specification:

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

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. 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 right-hand-side variable of interest, age, since it is orthogonally assigned within subject, and thus the criterion for requiring a cluster correction is not met.[3] The exception to this is table 9, when an interaction between rater characteristics and the randomly assigned profile characteristics is the variable of interest, in which case standard errors clustered at the rater level are presented.

Table 2.2 shows this analysis for both the initial sample (panel A) and the Qualtrics sample (panel B). Panel A shows the analysis for all data collected (including incomplete responses) and for those who meet my sample requirements of being between 30 and 40 and

[3]See: Angrist and Pischke 2009, page 311

white (the 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). Panel B shows the initial sample of 101 men and 101 women, who were recruited using identical methods, as well as the full sample of 202 men, which includes the over-sampling for high income.

Table 2.2: Age-Rating Relationship for Men vs. Women

Panel A: Initial sample				
Dep. variable:	(1)	(2)	(3)	(4)
Profile rating	**Men All**	**Men in Sample**	**Women All**	**Women in Sample**
Age	-0.024**	-0.044***	0.079***	0.131***
	(0.010)	(0.015)	(0.010)	(0.015)
Income ($0,000s)	0.023**	0.061***	0.147***	0.134***
	(0.011)	(0.016)	(0.011)	(0.016)
Constant	5.811***	6.252***	1.074***	-0.080
	(0.467)	(0.662)	(0.409)	(0.658)
Observations	3,752	1,440	4,220	1,800
R-squared	0.487	0.471	0.452	0.394

Panel B: Qualtrics sample			
Dep. variable:	(1)	(2)	(3)
Profile rating	**Men**	**Men + oversample**	**Women**
Age	-0.062***	-0.043***	0.028***
	(0.009)	(0.006)	(0.010)
Income ($0,000s)	0.0070	0.032***	0.036***
	(0.009)	(0.007)	(0.010)
Constant	7.475***	9.768***	3.340***
	(0.426)	(0.271)	(0.552)
Observations	4,040	8,080	4,040
R-squared	0.479	0.490	0.463

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 stronger 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. These results also hold in the Qualtrics sample.

The reduction in rating for an additional year of age is .044 points, on a scale from 1 to 10. Thus, if a woman is 10 years older than another, she will be on average rated 0.4 points lower. A woman who is \$10,000 poorer would be rated .06 points lower. To make up for an additional year of age, a woman must therefore earn \$7,000 more.

The contrasting results for men versus women demonstrate that the negative relationship between a female profile's listed age and the rating cannot only be some kind of 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 2.3 shows the results for men for several robustness checks. In Panel A, 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 restrict to those who did not opt out of the compensation, which happened in a small number of cases.[4] 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

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

to include 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. In the Qualtrics sample, only the "high correlation" and "no opt out" robustness checks are necessary, and these also do not substantially alter the results.

Table 2.3: Robustness Checks

Panel A: Initial sample				
Dep. variable:	(1)	(2)	(3)	(4)
Profile rating	**Finished**	**No Opt Out**	**High Corr**	**Load Delay**
Age	-0.040**	-0.049***	-0.045***	-0.039**
	(0.018)	(0.016)	(0.016)	(0.017)
Income ($0,000s)	0.067***	0.069***	0.062***	0.061***
	(0.018)	(0.018)	(0.017)	(0.018)
Observations	1,120	1,280	1,360	1,160
R-squared	0.435	0.460	0.465	0.451

Panel B: Qualtrics sample		
Dep. variable:	(1)	(2)
Profile rating	**No Opt Out**	**High Corr**
Age	-0.046***	-0.050***
	(0.010)	(0.007)
Income ($0,000s)	0.025**	0.027***
	(0.011)	(0.008)
Observations	3,160	5,600
R-squared	0.489	0.485

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

Table 2.4 shows two additional specifications that try to control for potential confounders. 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 “bad 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 120 undergraduate students 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, and the taste for similarly-aged partners, may affect the relationship between age and ratings. The effect of rater age is not non-parametrically identified, as the age difference and female age together would be collinear with both male age and female age affecting ratings. For this reason, I use a specification that limits the form to a taste for similarity, column 3, or the taste for similarity with the husband being slightly (two years) older, column 4. There is some evidence of tastes for partner age taking this form (e.g., Hitsch, Hortascu, Ariely, 2010; Choo and Siow, 2006; and Buss, Shackelford, and LeBlanc, 2000). Neither of these additions absorbs men’s preference for younger partners, although accounting for two years of the age preference in the age difference control in column 5 reduces the main effect size accordingly. As a note, when the same age-difference-minus-two control is added to the regression for women rating men, the coefficient on age becomes close to zero and non-significant, indicating that wanting a two-year age difference is a primary driver for women’s preferences over age, while it is not for men. Together, these results suggest that men have a preference for younger partners, even when beauty is controlled for by exogenously assigning age to profiles of potential partners.

2.3.3 Fertility preference heterogeneity analysis

Table 2.5 now tries to test whether this taste for younger age is really a preference for fertility, and whether some of this preference operates on a conscious level. Because these regressions look for heterogeneity in the treatment effect based on male characteristics, the initial sample

Table 2.4: Additional Age Controls

Panel A: Initial sample				
Dep. variable:	(1)	(2)	(3)	(4)
Profile rating	**Base Spec.**	**Visual Age**	**Age Difference**	**"Ideal" Age D.**
Age	-0.043***	-0.171***	-0.044***	-0.038**
	(0.016)	(0.052)	(0.016)	(0.017)
Income ($0,000s)	0.065***	0.065***	0.065***	0.065***
	(0.016)	(0.016)	(0.016)	(0.016)
Visual age - age		-0.129**		
		(0.050)		
$(\text{Age diff})^2$			-0.001	
			(0.002)	
$(\text{Age diff -2})^2$				-0.001
				(0.002)
Observations	1,360	1,360	1,360	1,360
R-squared	0.477	0.477	0.478	0.478

Panel B: Qualtrics sample				
Dep. variable:	(1)	(2)	(3)	(4)
Profile rating	**Base Spec.**	**Visual Age**	**Age Difference**	**"Ideal" Age D.**
Age	-0.0427***	-0.093***	-0.040***	-0.024***
	(0.006)	(0.022)	(0.006)	(0.007)
Income ($0,000s)	0.032***	0.032***	0.032***	0.032***
	(0.007)	(0.007)	(0.007)	(0.007)
Visual age - age		-0.050**		
		(0.0214)		
$(\text{Age diff})^2$			-0.004***	
			(0.001)	
$(\text{Age diff -2})^2$				-0.004***
				(0.001)
Observations	8,080	8,080	8,080	8,080
R-squared	0.490	0.490	0.491	0.491

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

has insufficient size. Thus, these results can be most reliably interpreted in Panel B. Panel B shows that when the profile age is interacted with key rater characteristics—wanting children soon ("Want kids"), not having any children currently ("No kids"), wanting to get married soon ("Want marr"), and knowing that women become less fertile before age 45 ("Knowledge")—the main effect on age becomes smaller, and the interaction term is negative and significant. This shows that men who have more reason to care about fertility—either because they want children soon, do not already have children, are looking for a marriage partner—have a stronger preference for younger women. In fact, men who already have children (column 4) exhibit no preference over age, with all of the preference being driven by men who currently have no children.

Perhaps the strongest evidence comes from the final column, which interacts age with a knowledge about fertility, defined as a man saying the age that it becomes biologically difficult for women to have children is before 45. For men who lack such knowledge, *there is no preference* over age—the main effect is statistically zero—whereas for the knowledgeable men the negative perception of age is much stronger. The interaction in this final column is also significant in the smaller initial sample.

Appendix B.4 shows that these same mediators do not impact how much men value attractiveness (as rated from the pictures), again showing that age and attractiveness move in divergent ways in this experiment. In fact, the only significant interaction between these mediators and attractiveness is that men who have no kids value attractiveness *less*, whereas they value randomly assigned youth more. This provides further evidence that randomly assigned age is not providing a proxy for some unmeasured component of attractiveness, but rather appears to proxy for fertility.

These results suggest that at least some of the observed preference for younger partners stems from preferences for fertility. If some kind of latent preferences for partner attractive-

Table 2.5: Fertility Mediators

Panel A: Initial sample					
Dep variable:	(1)	(2)	(3)	(4)	(5)
Profile rating	**Base**	**Marriage**	**Want kids**	**Current kids**	**Knowledge**
Age	-0.043***	-0.051***	-0.028	-0.029	0.014
	(0.016)	(0.020)	(0.018)	(0.028)	(0.025)
Income ($0,000s)	0.065***	0.065***	0.065***	0.065***	0.065***
	(0.016)	(0.022)	(0.022)	(0.022)	(0.022)
Want marr × age		0.017			
		(0.038)			
Want kids × age			-0.051		
			(0.048)		
No kids × age				-0.022	
				(0.042)	
Knowledge × age					-0.078**
					(0.038)
Observations	1,360	1,360	1,360	1,360	1,360
R-squared	0.477	0.477	0.478	0.478	0.479
Panel B: Qualtrics sample					
Dep variable:	(1)	(2)	(3)	(4)	(5)
Profile rating	**Base**	**Marriage**	**Want kids**	**Current kids**	**Knowledge**
Age	-0.043***	-0.028**	-0.037***	0.002	-0.007
	(0.006)	(0.010)	(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	8,080	8,080	8,080	8,080	7,800
R-squared	0.490	0.490	0.491	0.491	0.488

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

ness as communicated through age were responsible, then whether or not the man wants to have children, or knows about the age-fertility relationship, should have no bearing on the strength of the preference over age. Moreover, this preference appears to be driven by the factors that should be taken into account by a rational, utility-maximizing agent with preferences over fertility. The relative importance of fertility for an individual, and their knowledge of its connection to age, impacts how they respond to age in a potential partner. Thus, instinctive forces connecting age to beauty are not entirely responsible for the dating market youth preference, and policies that impact older-age fertility may very well change the marriage market costs to aging to women.

Appendix B.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. Appendix table B.4 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.

Overall, the experiment provides evidence that men do value age independently from beauty, and that this preference appears to be tied to underlying fertility. The experiment also provides an estimate of the monetary valuation of this decline, by comparing the impact of an additional year of age to additional income, finding that a woman must make $7,000 more for her partner to be indifferent to a one-year increase in age.

2.4 Conclusion

Low (2014), Chapter 1, shows that if men value fertility on the marriage market, educated women may match with lower-income spouses than those with less education, but more fertility. Because of this, women may be less willing to undertake human capital investments in the first place. However, little empirical evidence exists that men indeed take fertility into account when choosing a mate, despite the widespread belief that age differentially affects women's attractiveness on the dating market. To separately identify the age-fertility relationship from other factors, such as beauty, in dating preferences, I implemented an online dating experiment where age was randomly assigned to hypothetical dating profiles. The experiment introduces a unique way of incentivizing participants to provide honest responses: participants were compensated with professional dating advice that was customized based on their ratings in the study, making truthful revelation of preferences incentive compatible. The experiment shows that men's preferences respond to randomly assigned age. There is a preference for younger partners equivalent to $7000 in annual income per each additional year of age. Moreover, this preference is driven by men who have no children currently and are aware of the age-fertility tradeoff. This experiment provides the first well-identified evidence that fertility matters for women's dating market appeal: the biological clock has a price.

Chapter 3

What Happens the Morning After? The Costs and Benefits of Expanding Access to Emergency Contraception

Tal Gross, Jeanne Lafortune and Corinne Low

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3.1 Introduction

In the 1960s, the introduction of oral contraception had a profound impact on women's fertility, education, and labor market outcomes (Goldin and Katz, 2002a; Bailey, 2006a; Guldi, 2008; Bailey et al., 2012a). Oral contraception, however, requires that women obtain a prescription and consume pills on a daily basis in order to prevent pregnancy. This paper studies the impact of increasing access to a different form of contraception, emergency contraception (EC), more commonly known as the "morning-after pill." EC, unlike oral contraception, is effective when taken within 72 hours following intercourse. While EC cannot be used on a daily basis, it offers women a chance to avert pregnancy after intercourse, when previously their only options would have been either abortion or carrying the pregnancy to term.

Access to EC has changed dramatically in the last 15 years. Early forms of EC were pioneered in the 1970s, but their existence was not widely known.[1] It was not until 1997 that the Food and Drug Administration (FDA) first approved a commercial EC product in the United States, Preven, available by prescription only. In 1999, "Plan B," the most widely known form of EC, was introduced, available only with a prescription. At the time of EC's introduction, researchers and policy-makers alike were optimistic about its potential to prevent unintended pregnancies and abortion (Trussell et al., 2004). A 2002 Guttmacher Institute report estimated that EC had been responsible for a"substantial proportion" of the decline in abortion rates over the last decade, estimating that EC had averted 51,000 abortions in 2000 alone (Jones et al., 2002). This technology was expected to be especially instrumental in preventing pregnancy from sexual assault; Trussell and Stewart (2000) estimate that provision of EC following assault could have prevented 22,000 of the 25,000 pregnancies resulting from reported assaults in 1998.

[1] Ellertson (1996) summarizes the early history of EC. Initially, EC was simply an off-label use of traditional oral contraceptives and intra-uterine devices.

To be effective, EC must be taken soon after intercourse. Because of this, various policies have been put in place since 1997 to increase access to EC. Between 1997 and 2007, nine states allowed pharmacists to directly dispense EC without a prescription and regardless of the patient's age.[2] We call such laws "pharmacy-access laws." Furthermore, 16 states, plus the District of Columbia, mandated that hospitals inform victims of sexual assault about EC.[3] We call such laws "ED-access laws." Finally, in 2006, the FDA allowed EC to be sold in pharmacies without a prescription to all women over the age of 18.[4]

This paper studies these expansions of access to EC. We study how such policies affected fertility and abortion rates. We also explore how the expansion of access to EC changed the venue in which women procure the medication, and the potential consequences of such a change.

Despite the convictions of many policy makers, the theoretical impact of EC on fertility and abortions is not obvious. We first present a simple model that explains the conditions under which easier access to EC will lower natality and abortions. The effect of EC is ambiguous, because easier access to EC, which mitigates a risk of sexual activity, may change women's behavior.

This paper then explores the impact that each of these policies has had on fertility-related outcomes. We first estimate the impact of state policies before the 2006 FDA policy change. We then estimate the impact of the FDA policy change by comparing outcomes

[2]Most of these states required that the pharmacist enter a collaborative practice agreement with a physician, the others simply established a protocol. In Appendix Table 4, we distinguish between the two types of laws as a robustness check and find similar effects for each type of laws.

[3]The majority of these laws mandate that the hospital itself provide the medication. Two states, South Carolina and Ohio, passed EC-related legislation for assault victims, but failed to enforce it. We ignore this legislation in our empirical specifications, following the classification of the Guttmacher Insitute.

[4]In 2009, this availability was extended to all women older than age 17. Our data do not allow us to study this, more recent, policy change.

in states that previously had EC-related legislation to those that did not. We find that pharmacy-access laws and ED-access laws had little effect on birth or abortion rates. The estimates, for instance, rule out decreases in overall fertility larger than 2 percent.[5] We find similar results even amongst sub-populations that are less likely to use regular contraceptives. Nonetheless, we demonstrate that sales of EC rose dramatically during this time period. This suggests that women who purchased EC following the policy change may have faced a small risk of pregnancy beforehand or that a behavioral response counteracted the increase in contraceptive power.

Our results stand in stark contrast to research on other forms of contraception. Bailey (2010) finds that greater availability of the contraceptive pill decreased marital fertility, while Kearney and Levine (2009) demonstrate that the price of oral contraceptives affects the teenage birth rate.[6] Similarly, policies that have expanded access to abortion have had a significant impact on fertility and the composition of births (Ananat et al., 2009, 2007; Donohue and Levitt, 2001; Angrist and Evans, 1996; Levine et al., 1999; Gruber et al., 1999; Levine et al., 1996), while policies that mandate waiting periods for abortion may have decreased the abortion rate (Joyce and Kaestner, 2000).

Our results confirm those presented by Durrance (2013). While her work focuses on a single state, Washington, our results indicate that the absence of a significant impact on births is not particular to the first state to adopt these laws. These results contrast with those of two other studies (Oza, 2009; Zuppann, 2010) that focus on increased access to EC in the general US population. Oza (2009) studies the change in outcomes after the FDA policy change. She relies on a database of private insurance claims and finds that the FDA

[5]The 95-percent confidence intervals on our main estimates rule out decreases larger than 2 percent for *overall* fertility. The confidence intervals are wider for different age groups.

[6]In addition, there exists some evidence that oral contraceptives changed the *composition* of births (Ananat and Hungerman, 2011).

policy change decreased the number of abortions. Zuppann (2010) studies how pharmacy-access laws affected birth rates before the FDA policy change. He finds that the state laws led to large decreases in birth rates.[7]

Our results suggest that the findings from small-scale, randomized-controlled medical trials of no effect of EC on fertility extend to the overall female population (Raymond et al., 2006; Raine et al., 2005). Raymond et al. (2007) review 23 studies of EC and conclude that randomized access to EC has not been shown to decrease unintended pregnancies. One study that does find effects of fewer unintended pregnancies among the group given a supply of EC to keep at home included only a small sample of subjects, selected because they had all previously used EC or had an abortion (Glasier and Baird, 1998). Glasier et al. (2004) find that the provision of emergency contraception also does not change abortion rates.[8]

Having found little evidence that easier access to EC has changed fertility-related outcomes, we then measure whether EC-related laws affect the venue in which women acquire the pill. To do so, we use a near census of ED visits for selected states. We find that the FDA ruling led to a large decrease in ED visits related to EC. This suggests that expansions of access to EC have affected the venue in which women acquire the medication and thereby lowered the total cost of distributing EC. We also find that, in the absence of pharmacy access laws, ED-access laws increase EC-related visits, indicating that guaranteed access to EC may play a role in determining whether women seek emergency medical care.

While cost-saving, the shift to over-the-counter provision of EC may have led to unin-

[7]To our knowledge, no other study has estimated the impact of ED-access laws so far.

[8]A related question is whether access to EC may encourage risky behavior. Previous research has found little evidence for this. Raine et al. (2000) find that women given an at-home supply of emergency contraception shifted to less effective methods of contraception. This result, however, has not been found by other, similarly conducted studies (Jackson et al., 2003). Gold et al. (2004) find no effect of EC on the use of other contraceptives. Meanwhile, Belzer et al. (2005) suggest that teenagers who are given advanced provision of EC are more likely to have unprotected sex, but the methodology involved has been criticized (Trussell et al., 2006).

tended consequences. Sexual assaults may be one reason women seek EC at the ED. Hospital staff, unlike pharmacists, provide other services beyond EC provision, and such services may not be utilized if EC is accessed over the counter. In particular, we find suggestive evidence that expansions of access to EC led to a decrease in the number of sexual assaults reported to law enforcement. Such results must be interpreted cautiously; we rely on only one source of data on sexual assaults and find an impact only of pharmacy-access laws before the FDA ruling. Still, this finding is consistent with the fact that assault victims are likely to encounter less encouragement and opportunity to report the crime at a pharmacy than at an ED.

The paper proceeds as follows. The next section presents a theoretical framework that clarifies how access to EC ought to affect outcomes. The following section describes the data at our disposal and our empirical strategy. The penultimate section presents our empirical results: how access to EC affects births, abortions, ED visits, and reports of sexual assault. The final section concludes.

3.2 Theoretical Framework

This section explains how EC can affect fertility-related outcomes. EC is unlike traditional contraception in that it is intended for use after intercourse. Unlike abortion, however, EC must be taken before one knows whether intercourse has resulted in pregnancy. In this sense, EC lies between traditional contraception and abortion in a woman's decision tree. This section studies that decision tree with a simple model, inspired by the work of Levine and Staiger (2002) and Kane and Staiger (1996).

The model predicts how EC will affect the number of sexual encounters, pregnancies, abortions, and births. In general, the model suggests that the effect of EC on these outcomes is surprisingly ambiguous. The ambiguity stems from how EC can change exposure to pregnancy risk. Suppose, for instance, that women react to the introduction of EC by having more sexual encounters. That reaction alone increases the number of births, while the use of EC decreases the number of births. The net effect of EC on births and other outcomes is thus ambiguous. Below, we present this intuition more formally. Note that this is a similar result to that obtained by Myers (2012).

3.2.1 Structure of the Model

Suppose that women face a utility gain from intercourse, $S \in \left(0, \bar{S}\right)$, and a utility gain from having a child, $B \in \left[\underline{B}, \bar{B}\right]$. If $B > 0$, then a pregnancy is wanted, and if $B < 0$, then a pregnancy is unwanted. These variables are randomly distributed in the population based on a density function $g\left(s, b\right)$. Abortion is available once a woman is pregnant at a utility cost, A.[9]

Once pregnant, women compare the benefits of carrying the pregnancy to term to the cost of obtaining an abortion.[10] They will choose abortion if $B < -A$. Thus, if a pregnancy occurs, a woman will receive a utility of $P \equiv \max\left\{B, -A\right\}$.

Suppose that, initially, the probability that a sexual encounter leads to pregnancy is q. Therefore, a woman will consent to sex if $S + q \cdot P > 0$. The share of women who have sex

[9]These costs and benefits reflect not only the financial cost of abortion or pregnancy, but also stigma, opportunity cost, and psychic costs.

[10]This paper studies the effect of EC during a time period in which abortion was legal. The effect of EC might be very different were abortion to be illegal (Bailey et al., 2013; Joyce, 2013).

is:

$$\gamma\left(q\right) \equiv \int_{0}^{\bar{B}} \int_{0}^{\bar{S}} g(S,B) dSdB + \int_{\underline{B}}^{-A} \int_{q\cdot A}^{\bar{S}} g(S,B) dSdB + \int_{-A}^{0} \int_{-q\cdot B}^{\bar{S}} g(S,B) dSdB. \tag{3.1}$$

That is, the share of women who have sex is composed of those who want a baby (the first term in equation 3.1) and those who do not. The latter are composed of two groups: those who will pursue an abortion if pregnant (the second term in equation 3.1) and those who will not (the third term in equation 3.1). A woman can only become pregnant if she consents to sex, and thus the share of women who become pregnant is $\gamma(q) \cdot q$.

This framework can be re-interpreted to focus not on the decision to have sex, but on the decision regarding the *frequency* of sexual activity. One can consider the key parameters (S, B, and A) as reflecting not the overall population, but rather the distribution faced by one woman each time she must decide whether or not to have sexual intercourse. The model would then lead to the number of sexual encounters a given woman has instead of the number of sexually active or inactive females in the population.

3.2.2 The Effect of Emergency Contraception

Suppose that EC is introduced, and that it lowers the probability of pregnancy from q to q' at a cost of c. The parameter q' reflects not just the effectiveness of the technology, but also the probability that a woman obtains EC and uses it correctly.

After sexual intercourse, a woman must compare the benefits of taking EC with its cost. She will prefer taking EC if $S + q \cdot P < S + q' \cdot P - c$.[11] Under these assumptions, EC will

[11]We assume that EC is less costly than abortion, and thus $-A < \frac{c}{q'-q}$.

unambiguously raise the share of women who have sex, since some women with a previously negative total payoff to sex now face a positive payoff.[12]

The share of women who become pregnant, however, may rise or fall after the introduction of EC. Wanted pregnancies are unaffected by EC, because women for whom a baby is welfare-enhancing will not consume EC. Unwanted pregnancies, however, may increase or decrease. That ambiguity stems from two forces. On the one hand, the availability of EC leads more women to have sexual intercourse. On the other hand, pregnancy is now less likely to occur. The appendix demonstrates that unwanted pregnancies will decrease if the ability of EC to reduce pregnancies is large relative to the induced behavioral change.

The share of women who have an abortion may also rise or fall. There are two sources of uncertainty that cause individuals to use abortion (Levine and Staiger, 2002). First, some women decide to have sex based on a sufficiently high expected value of B, but are uncertain of the true value of B until a pregnancy occurs. Such women are unlikely to use EC to replace abortion, because they do not gain additional information about B from waiting until after intercourse. The second source of uncertainty is the stochastic nature of pregnancy itself. Abortion is a cost that is only realized if pregnancy occurs, whereas traditional contraception and EC must be used before knowing whether pregnancy will occur. No additional information is gained by waiting until intercourse occurs, but EC may act as insurance against pregnancy. The net effect of EC on abortion is ambiguous, and for the same reason that the effect of EC on pregnancies is ambiguous. On the one hand, EC induces more women to choose sexual intercourse. On the other hand, the probability that these women need an abortion falls, because they consume EC. Finally, combining the ambiguous effect of EC on pregnancies and abortions yields the prediction that EC may raise or lower the number of births.

[12]The appendix presents a formal proof of both this prediction and the following predictions.

The ambiguity of EC on these outcomes depends on the magnitude of q' relative to q. If, for instance, EC were to reduce the probability of pregnancy from q to *zero*, then EC would unambiguously reduce the number of pregnancies, abortions, and births. EC, however, only reduces the probability of pregnancy by 75–95 percent (Trussell and Raymond, 2012). Over one year, a sexually active woman who uses EC as her only form of birth control faces a 20–40 percent risk of pregnancy. Consequently, we cannot rule out that the effect of EC on these outcomes is theoretically ambiguous.[13]

In this way, the model describes the introduction of EC and not expansions of access to EC. The model, however, leads to nearly identical predictions in either case. We clarify the difference between the introduction of EC and expansions of access in the theoretical Appendix.

3.2.3 Emergency Contraception versus Traditional Contraception

This model does not explicitly capture the choice between traditional contraception and EC. Formally incorporating traditional contraception into the model would complicate the derivations, but would not provide additional insights.[14] Instead, we discuss traditional contraception informally as follows.

Traditional contraception must be purchased before sexual intercourse. Women who are certain of the benefits of sex, S, will purchase traditional contraception rather than EC.[15] For such women, EC provides no additional benefit. There also exist, however, women for

[13]Note that the introduction of EC unambiguously increases the welfare of women in this framework.

[14]Women would have to choose between traditional contraception and EC based on which one provided the highest protection at the lowest cost. If EC were relatively more expensive, no woman would use it and an expansion of access to EC would have no effect on outcomes. If, on the other hand, EC were relatively inexpensive, then some women would consume EC. Only in this case would EC affect outcomes.

[15]EC is comparable in cost to one month of oral contraceptives.

whom the benefits of sex, S, are uncertain. For such women, EC offers an advantage over traditional contraception. When the benefits of sex, S, are uncertain but expected to be low, women may not wish to purchase traditional contraception. If S is revealed to be very large, then such women can purchase EC after intercourse. Uncertainty in S, or rather, uncertainty over future sexual encounters, thus drives demand for EC.

A second reason women may choose EC involves stochastic shocks to q. For example, if a condom breaks during intercourse, then the probability of pregnancy is suddenly higher than it had been before. The woman may then consume EC, as a result. In this way, EC can be used once additional information about S and q is revealed.[16]

Without such uncertainty, very few economic agents would consume EC. First, EC is relatively expensive. Second, EC cannot be used frequently, and provides little additional benefit if a primary method of contraception is already used properly. In this sense, the availability of EC will only affect women who face greater uncertainty over future sexual encounters. Women who face such uncertainty are more likely to be young, poorer and unmarried.[17] For that reason, we stratify some of the empirical results below on age, race, and marital status.

A final instance of high encounter-specific uncertainty is the case of sexual assault, where EC plays a materially different role than traditional oral contraceptives.

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[16] Abortion is available once q has been realized and potentially, once additional information regarding B has been revealed.

[17] The National Campaign to Prevent Teen and Unplanned Pregnancy reports that 66 percent of pregnancies are unplanned for women less than 25 years old, versus 34 percent for women 25 and older; 60 percent of pregnancies are unplanned for women with income less than 200 percent of the poverty line, versus 38 percent for women at 200 percent or over; and 72 percent of pregnancies are unplanned for unmarried women, versus 26 percent for married women.

3.2.4 Victims of Sexual Assault

In the context of the model, victims of sexual assault are women for whom $S + q \cdot P$ is negative, and yet they are forced to have sex.[18] For such women, EC does not induce a behavioral response; the rate of sexual assaults is likely unaffected by the availability of EC. Furthermore, given the low probability of assault, women are unlikely to use traditional contraceptives specifically to insure against pregnancy resulting from assault. Assault victims may therefore face a high q, and correspondingly a greater gain to the introduction of EC. Thus, in contrast to the ambiguous results above, EC has an unambiguous effect on victims of sexual assault. For victims of sexual assault, the model predicts that the availability of EC reduces the number of births and abortions. Victims of assault, however, compose a small share of the total population. It is thus difficult to estimate the effect of EC on outcomes for that population alone. We are aware of no studies that assess the effect of contraception access on victims of sexual assault, and believe that this represents a fruitful avenue for future research.

We focus on testing empirically how the availability of EC affects the *reporting* of sexual assaults. When a sexual assault is reported to law enforcement, the victim provides a public good while bearing a private cost. She provides authorities with the identity of the perpetrator and thus lowers the probability that the perpetrator commits another assault.[19] As in the case of other public goods, reporting of assaults may be under-provided.[20] We

[18]The model could be changed to incorporate the possibility of sexual assault algebraically. In that case, a share of women would become the victims of sexual assault. Those women would then all find it optimal to consume EC. Their existence would then strengthen the direct effect of EC on births and abortions, and weakens the average behavioral response.

[19]Although victims of sexual assault may be male or female, in this context we are concerned with female victims, since they have the potential to become pregnant and therefore be affected by access to contraception.

[20]After an assault, the victim may also be tested for sexually-transmitted infections. This may involve an additional positive externality.

present below suggestive evidence that access to EC in pharmacies reduces the share of assaults that are reported to law enforcement. This suggests that when the private benefit to reporting is diminished, fewer assaults are reported. In that sense, wider access to EC decreases the private costs borne by victims, but may also decrease the provision of a public good. We discuss this implication further in the penultimate section.

3.3 Data and Empirical Strategy

We measure the effect of EC with a simple, difference-in-differences framework. Specifically, we first evaluate the state laws that expanded access, and then test how states that passed such laws were differentially affected by the FDA policy change.

Table 1 presents the dates when EC-related laws were passed.[21] Between 1997 and 2006, 9 states passed pharmacy-access laws and 10 states passed ED-access laws. An additional 6 states, and the District of Columbia, passed ED-access laws after the FDA policy change made EC available at pharmacies.[22] The states that passed EC-related legislation may be systematically different from states that did not. Still, all of our empirical results control for fixed differences between the states. Moreover, we test for time-varying differences between states by including linear time trends in our regressions and by exploring event-study specifications.[23]

The FDA policy change was announced on August 24, 2006. However, unlike the state laws, the FDA policy required suppliers to produce a new, over-the-counter version of EC.

[21] For the results below, we adjust the relevant date that each law was passed based on the outcome. For visits to the ED, we use the actual date. For abortions, we add 60 days to the law's passage, to account for the average gestation at abortion. For births, we add 266 days.

[22] Note that both types of state laws did not restrict the age at which women could obtain EC, whereas the FDA ruling made EC available only to women older than 18.

[23] A table without state-specific time trends is included in the appendix.

Table 3.1: State Laws

State or region	Pharmacy Access Date	Type	ED Access Date	Type
Alaska	25-Apr-2002	collab. practice		
Arkansas			9-Apr-2007	inform
California	1-Jan-2002	state protocol*	1-Jan-2003	provide
Colorado			15-Mar-2007	inform
Connecticut			1-Oct-2007	provide
Hawaii	24-Jun-2003	collab. practice		
Illinois			1-Jan-2002	inform
Maine	3-Mar-2004	state protocol**		
Massachusetts	15-Sep-2005	collab. practice	14-Dec-2005	provide
Minnesota			1-Aug-2007	provide
New Hampshire	15-Aug-2005	collab. practice		
New Jersey			20-Apr-2005	provide
New Mexico	15-May-2003	state protocol	1-Oct-2003	provide
New York			31-Jan-2004	provide
Ohio			31-Mar-2003	recommendation†
Oregon			1-Jan-2008	provide
Pennsylvania			26-Jan-2008	provide‡
South Carolina			19-Jun-2005	pay (but not inform)†
Texas			1-Sep-2005	inform
Utah			25-Mar-2009	provide
Vermont	29-Mar-2006	collab. practice		
Washington	1-Jul-1997	collab. practice***	13-Jun-2002	provide
Washington, DC			25-Mar-2009	provide
Wisconsin			28-Mar-2008	provide
National	24-Aug-2006	18 and over****		

* Legislation initially allowed collab. practice only; expanded to state protocol 10/1/03.
** Hybrid model: collab. required but not regulated. Listed as state protocol by Guttmacher.
*** Initially, a two-year pilot program building on existing collab. practice law for some drugs.
**** Expanded to 17-year-olds on April 22, 2009.
† These states are not considered access states by Guttmacher, thus we exclude.
‡ Includes conscience exemption.
Note: Dates denote effective date if available, legislation signing date if effective date unknown, and adoption by legislature date if signing date unknown.
Sources: National Conference of State Legislatures; state legislative records; Guttmacher Institute; Lexis Nexis and Google news search.

Suppliers shipped that version in November of 2006, roughly three months after the FDA policy change. We thus consider the effective date of the FDA policy change to be November of 2006.

For the state laws, we estimate a regression of the form:

$$y_{st} = \beta \cdot I\left\{\text{EC State Law}_{st}\right\} + \gamma \cdot X_{st} + \alpha_s + \alpha_t + \alpha_s \cdot t + \varepsilon_{st},$$

where y_{st} is an outcome in state s at time t and $I\left\{\text{EC State Law}_{st}\right\}$ is equal to 1 when the state has such a law in place.[24] The regression allows each outcome to evolve along a separate linear time-trend and to differ permanently by state. We also include a variety of time-varying controls in each regression: the state unemployment rate, its poverty rate, welfare benefits for a family of four, the AFDC/TANF benefit level, and the availability of subsidized contraception through Medicare as compiled by Kearney and Levine (2009).[25] We adjust the standard errors to allow for auto-correlation between observations from the same state.[26] This framework requires one key assumption: that, in the absence of the policy changes, the path of the outcomes in each state would have differed only by a linear trend. We test the validity of that assumption below using more flexible event-study specifications.

To evaluate the 2006 FDA policy change, we estimate a similar regression in which states that had already passed a pharmacy-access law are the control group. We only use the latest

[24]For annual data, we code a law as having been implemented if the law (or its expected consequence) was in place for more than 183 days of the year. For monthly data, we require that the law or its consequences be in place for more than 14 days of the month.

[25]The information on welfare comes from the University of Kentucky Poverty Research Center database (2011) and from Bitler et al. (2006).

[26]For these regressions, we restrict our sample to the years before the FDA policy change, since we expect that states with such laws in place would be affected very differently by the FDA ruling. Specifically, for outcomes in which we expect an immediate change in behavior, we only look at years before (and including) 2005, while for births, where we expect the outcome to be delayed by a year, we only restrict our sample to years before (and including) 2006.

period of the data (2004–2008) for that estimation since many of the control states changed their laws during the previous period.[27] Although the FDA policy was not a substitute for ED-access laws, it may have obviated such laws; thus, we also compare the impact of the FDA policy on states that previously had ED-access laws in place.

We have compiled outcomes from a variety of sources. We observe the number of births per month in each state from a census of births collected by the National Vital Statistics System.[28] For abortion rates, we rely on state-by-year estimates of the number of abortions calculated by the Centers for Disease Control and Prevention.[29]. We have also compiled data on sexual assaults reported to authorities via the Federal Bureau of Investigation (FBI) Uniform Crime Report.[30]

Finally, we have compiled a large database of ED visits by month and year based on data from the Healthcare Cost and Utilization Project (HCUP). Our sample includes a near census of ED visits from Arizona (2005–2008), California (2005–2008), Iowa (2004–2007), New Jersey (2005-2008), and Wisconsin (2004–2008).[31] Of these five states, New Jersey, Wisconsin, and California passed ED-access laws.[32] We construct aggregate counts of all

[27]In such regressions, we exclude any state that changed its policies such that it would have affected the outcomes of interest in 2006.

[28]We stratify births by the age of the mother and set the number of births equal to 0.5 when the cell does not record any births. We have also stratified births based on the marital status and race of the mother. The results are extremely similar to the ones presented below.

[29]These abortion data rely on states themselves reporting the relevant statistics, unlike the survey data compiled by the Alan Guttmacher Institute. The latter, however, are not available on an annual basis by state. We have data on 48 states in our sample.

[30]The crime data exist at the state-year level. Some states make available monthly crime data, but too little such data exist to precisely estimate the regression above at the monthly level.

[31]The administrative data cover all hospitals regulated by the state. Thus, for instance, we do not observe ED visits at Veteran Administration hospitals. Such visits are likely a very small share of all visits related to EC.

[32]California also passed a pharmacy-access law. Both California laws were implemented before the HCUP sample period, which prevents us from measuring their impact.

ED visits by month for these states, and isolate ED visits in which the patient received EC or in which the patient was listed as a sexual assault victim.[33]

3.4 Results

This section presents our empirical results. We first discuss the effect of access to EC on births and abortions, outcomes on which most of the public debate and previous literature has focused. As our model indicates, however, the effect of EC on such outcomes is theoretically ambiguous. We then describe how access to EC affects visits to hospitals and reports of sexual assault, outcomes for which the model suggests we are more likely to observe an impact.

3.4.1 Births and Abortions

Table 2 presents a series of difference-in-difference estimates that test for the effect of access to EC on monthly natality using state-by-month log number of births as our dependent variable. The regressions include state-specific linear time trends and time-varying control variables.[34] We focus on four different measures of natality: total births, total births for women under the age of 18, total births for women aged 18–30, and total births for women older than 30. The first panel restricts the sample to 1995–2006, before the FDA policy change. The second panel presents estimates based on 2004–2008, in which states with pharmacy-access laws compose the control group for the FDA policy change. The table

[33]EC-related visits have International Classification of Diseases 9$^{\text{th}}$ Revision (ICD-9) code "V2503," and assault-related visits have ICD-9 code "V715."

[34]As described above, these time-varying control variables include the state unemployment rate, its poverty rate, welfare benefits for a family of four, the AFDC/TANF benefit level, and the availability of subsidized contraception through Medicare as compiled by Kearney and Levine (2009).

presents regressions that include controls for both types of state laws simultaneously. We obtained similar results when evaluating each law separately.[35]

Panel A of Table 2 suggests little relationship between natality and ED-access laws; all point estimates are extremely small, although the confidence intervals only rule out decreases in overall natality of roughly 2 percent.[36] In addition, Panel A presents no evidence that pharmacy-access laws lowered births in each state. In contrast, the results suggest a 2.2 percent *increase* in births after states pass a pharmacy-access law (for women aged 18–30). That increase in births is surprisingly statistically significant. To test whether this increase is a true effect of the legislation, we run event-study regressions, which estimate the effect of pharmacy-access laws in each year before and after their passage. Figure 1 presents the results of that regression. The figure suggests that pharmacy-access laws did not have a discontinuous effect on natality. Natality in states that passed pharmacy-access laws was on an increasing (non-linear) trend before passage of the laws. This suggests that the results in panel A of Table 2 are misleading.

Furthermore, if the results of panel A were taken at face value, they would imply an unusual response to pharmacy-access laws. As described by our model, access to EC will increase the birth rate when the behavioral response to the drug is substantially larger than the birth-prevention effect of the drug. The point estimates seem unusually large given that less than 5 percent of women say that they have used EC in the last year. Those women who have used EC used it less than twice on average (Zuppann, 2010). Any increase in births would need to be driven by women changing their behavior based on availability of the drug, but becoming pregnant nonetheless.

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[35]In results available from the authors upon request, we examine the effect of each law separately.

[36]The regressions in Table 2 are demanding of the data; they include many controls. We find, however, qualitatively similar estimates when we exclude state-specific linear time trends and state-specific time-varying control variables.

Table 3.2: Effect of EC-Related Laws on Natality

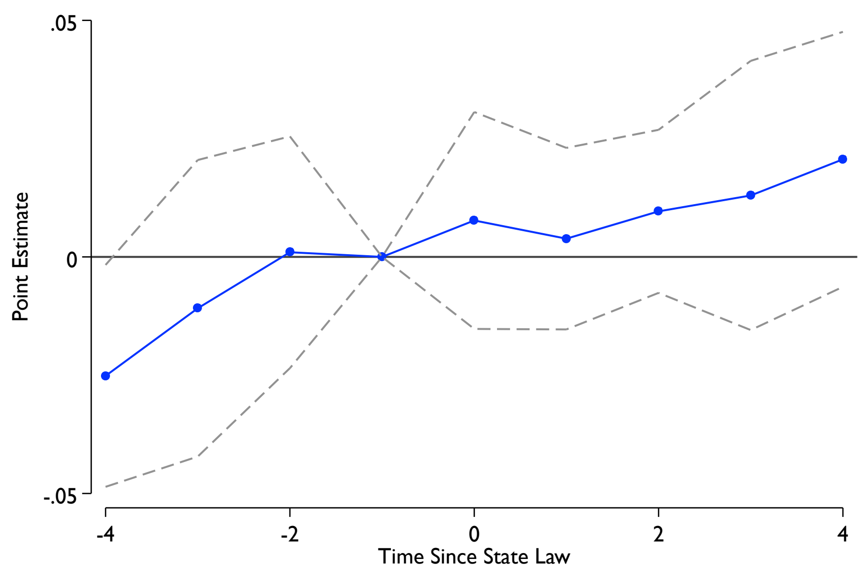
Dependent Variable: The logarithm of births for the given sample

Sample:	(1) All Women	(2) Under age 18	(3) Aged 18-30	(4) Aged 30 plus
		A: State Law Changes, 1995-2006		
Passed ED-Access Law	- 0.004	- 0.020	0.003	- 0.004
	(0.010)	(0.020)	(0.008)	(0.016)
Passed Pharmacy-Access Law	0.014	0.014	0.022**	0.009
	(0.008)	(0.020)	(0.007)	(0.013)
Average Births	6,574.8	269.5	4,257.9	2,047.0
R^2	0.999	0.989	0.999	0.998
		B: FDA Policy Change, 2004-2008		
No ED-Access Law $\times$ Post FDA	- 0.001	- 0.001	- 0.002	- 0.016
	(0.011)	(0.023)	(0.012)	(0.020)
No Pharmacy-Access Law $\times$ Post FDA	- 0.006	0.036	- 0.018	0.008
	(0.017)	(0.022)	(0.012)	(0.029)
Average Births	7,012.6	289.6	4,579.3	2,143.3
R^2	0.999	0.990	0.999	0.998

Note: For panel A, N = 7,344 and for panel B N=6,888. Standard errors in parentheses are robust to auto-correlation between observations from the same state. State fixed effects, month fixed effects, and state linear time-trends not shown. The sample consists of month effects, by state totals of all births. The second panel excludes states which changed their legislation such that births in 2006-2008 would have been affected.

* statistically significant at 10% level ** statistically significant at 5% level.

Figure 3.1: The Effect of Pharmacy-Access Laws on Natality



Finally, the bottom panel of Table 2 suggests little effect of the FDA policy change on natality. For 18–30 year-olds, states with no pharmacy-access law experienced a statistically insignificant 1.8 percent decrease in natality after EC was available over-the-counter. Such estimates can reject a negative impact of the FDA policy change on births larger than 4 percent.

In all regressions, the outcome of interest is the logarithm of the number of births by month. We do not rely on annual birth rates as the outcome of interest, because precise estimates of population are only available with each decennial census, and less precise population estimates may introduce substantial measurement error. Appendix Table 1, however, provides estimates using annual log births (in the first four columns) and using weighted annual birth rates (in the last four). Our results are not materially different when using this alternative specification. We are unable to find a significant negative effect of EC-related legislation in either approach. The standard errors and magnitudes are fairly similar and allow us to rule out effects larger than 2–4 percent or about 2 births per 1,000 (from an average of 52). Appendix Table 3, however, shows that using the annual birth rate specification and dropping linear time trends, we replicate Zuppan's (2010) results and find a significant and negative impact of Pharmacy-Access Laws on fertility. However, in Panel B, we find that the introduction of FDA legislation led to a significant increase in fertility, something that may highlight the spurious nature of these results.

Potentially, we may not estimate a statistically significant effect here because the utilization and impact of EC is too low in the general population. We have conducted the analysis for many sub-populations (race, marital status, number of previous pregnancies, and so on) and have still found no negative impact. For instance, Table 3 presents estimates of our preferred specification solely for a number of sub-groups.[37] We focus progressively on a population that is least likely to be using traditional contraceptives, and thus at highest risk of unintended pregnancy without access to EC. Table 3 presents no evidence that natality fell for that population after the policies of interest.

Table 4 presents a similar set of estimates to Table 2, but with abortions by state and year as the outcome of interest. As a whole, the table suggests no negative effect of EC-related laws on abortion. No negative point estimates are statistically significant at conventional levels, but the confidence intervals are wide. For instance, the results only rule out a reduction in abortions among women aged 20–29 of more than 12 percent after ED-access laws. The estimated impact of pharmacy-access laws is positive for most age groups, but statistically insignificant. The results do not reject reductions of less than 7 percent.

In summary, neither Table 2 nor Table 4 present significant evidence that EC-related

[37]Information on educational attainment exists only for certain states and certain years, thus the number of observations in the last column of Table 3.

Table 3.3: Effect of EC-Related Laws on Sub-Samples

Dependent Variable: The logarithm of births for the given sample

Sample:	(1) All married women	(2) All unmarried	(3) White, unmarried	(4) Black, unmarried	(5) Black, unmarried, 18-30	(6) Black, unmarred, 18-30, ≤HS
			A: State Law Changes, 1995-2006			
Passed ED-Access	- 0.012	0.014	- 0.011	0.026	0.026	- 0.066
Law	(0.014)	(0.009)	(0.023)	(0.024)	(0.026)	(0.148)
Passed Pharmacy-	0.020*	0.006	0.088*	- 0.017	- 0.014	- 0.136
Access Law	(0.012)	(0.007)	(0.048)	(0.051)	(0.054)	(0.104)
Average Births	4,329.3	2,245.5	1,462.7	691.2	504.2	369.3
R^2	0.999	0.998	0.996	0.987	0.985	0.984
N	7,344	7,344	7,344	7,344	7,344	5,376
			B: FDA Policy Change, 2004-2008			
No ED-Access	- 0.010	- 0.015	- 0.001	- 0.014	- 0.034	- 0.338
Law × Post FDA	(0.013)	(0.012)	(0.028)	(0.043)	(0.045)	(0.207)
No Pharmacy-Access	- 0.013	0.013	0.009	0.076	0.086	0.348*
Law × Post FDA	(0.020)	(0.011)	(0.033)	(0.059)	(0.061)	(0.184)
Average Births	4,508.2	2,478.7	1,626.3	790.1	580.2	412.4
R^2	0.999	0.998	0.994	0.987	0.985	0.984
N	6,888	6,888	6,888	6,888	6,888	4,860

Note: Standard errors in parentheses are robust to auto-correlation between observations from the same state. State fixed effects, month fixed effects, and state linear time-trends not shown. The sample consists of month-by-state counts of all births. The second panel excludes states which changed their legislation such that births in 2006-2008 would have been affected.

* statistically significant at 10% level, ** statistically significant at 5% level.

Table 3.4: Effect of EC-Related Laws on Abortions

Dependent Variable: The logarithm of abortions for the given sample

Sample:	(1) All Women	(2) Under age 20	(3) Aged 20-29	(4) Aged 30 plus
	A: State Law Changes, 1995-2005			
Passed ED-Access	- 0.052	-0.047	-0.017	- 0.071
Law	(0.059)	(0.057)	(0.066)	(0.049)
Passed Pharmacy-	0.038	-0.016	-0.002	- 0.005
Access Law	(0.075)	(0.074)	(0.060)	(0.049)
Avg. Abortions	16,666.8	3,171.8	9,312.7	4,279.3
R^2	0.987	0.986	0.988	0.990
N	505	498	503	503
	B: FDA Policy Change, 2004-2008			
No ED-Access	-0.117	-0.045	-0.008	-0.005
Law × Post FDA	(0.130)	(0.115)	(0.104)	(0.085)
No Pharmacy-Access	0.236*	0.231*	0.117	0.070
Law × Post FDA	(0.117)	(0.118)	(0.079)	(0.066)
Avg. Abortions	11,849.1	2,281.5	6,728.4	2,938.7
R^2	0.986	0.983	0.986	0.988
N	448	441	445	445

Note: Standard errors in parentheses are robust to auto-correlation between observations from the same state. State fixed effects, year fixed effects, and state linear time-trends not shown. The sample consists of year-by-state totals of all abortions, estimated by the CDC. The second panel excludes states that changed their legislation between 2006 and 2008.

* statistically significant at 10% level, ** statistically significant at 5% level.

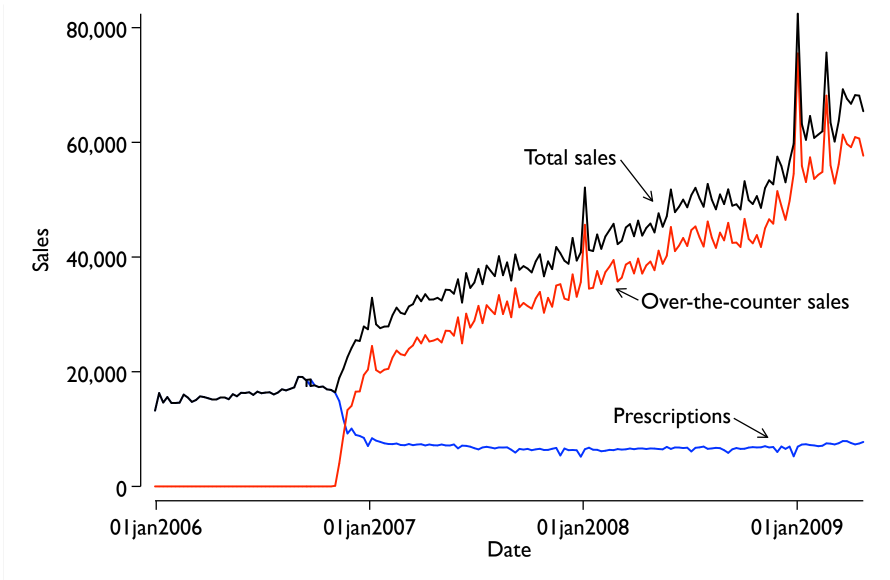
legislation affected births or abortions.[38] This confirms the results of medical studies, but care should be taken in interpreting these results.

First, one may wonder whether the legislation had little effect because it did not actually increase the consumption of EC. (This would be akin to a weak first stage in an instrumental variable setting.) We investigate this possibility with sales records from Barr Pharmaceuticals, the primary producer of EC. Unfortunately, the sales data are not available at the state-year level. Nevertheless, we directly observe the impact of the FDA policy change on national sales of EC. Figure 2 plots the total sales of Plan B from 2006 through 2009. The figure demonstrates the rapid decline of prescription sales for EC following the August, 2006 FDA policy change. The policy change also led to a rapid increase in over-the-counter sales, as Barr Pharmaceuticals released the newly packaged product for over-the-counter sale. From 2006 to 2007, Plan B sales more than doubled, increasing by $47 million, with unit sales going from approximately 16,000 sales per week to over 34,000 in 2007. Sales continued a steady climb, doubling again between 2007 and 2009. This large increase in Plan B sales is evidence of the direct effect of the FDA policy change. We are thus skeptical that the lack of a pattern in Table 2 and Table 4 is driven by lack of variation in sales of the pill. Furthermore Kavanaugh et al. (2011) argue that pharmacy access of EC is responsible for doubling the number of women who have ever used EC from 4 percent in 2002 to nearly 10 percent in 2008.

A second possibility is that we may simply be unable to detect significant effects of the EC-related legislation because of the way EC operates. EC only prevents pregnancy from a single sexual encounter, so it eliminates a risk of pregnancy of only 3–5 percent, the risk of

[38] We also explored whether birth and abortion rates of 18- versus 17-year-olds changed differently around the FDA ruling, given the differential treatment of ages under the policy. To do so, we used natality and abortion records from the state of Texas. We found no evidence of such a pattern. Moreover, we used the natality records to explore whether there was any change in women's attributes around the FDA ruling and were unable to obtain any significant results as well.

Figure 3.2: Sales of EC by Week



pregnancy from a single, unprotected sexual encounter. If, however, women use EC because they believe themselves to be at a greater risk of pregnancy, then women taking EC may face a 10 percent pregnancy risk, the approximate peak risk of pregnancy during the menstrual cycle (Wilcox et al., 2001).[39] In that case, if EC lowers this pregnancy risk by 75 percent, then women taking EC would experience a 7.5 percentage-point reduction in pregnancy risk.[40] If all new EC pills consumed in pharmacy access states after the policy change were used by women between 18 and 30, and if these women were previously at a 10 percent risk of pregnancy, and if EC caused no behavioral response, a change of as much as 3-4 percent in the level of births would be possible. Such a change is ruled out by our findings. However,

[39]The risk of pregnancy from a single, unprotected sexual encounter reaches 29 percent on the day before ovulation, but due to ovulation occurring irregularly within the menstrual cycle, a woman is unlikely to pinpoint this peak risk.

[40]Clinical trials show EC to be up to 89 percent effective, but this effectiveness decreases with the time between intercourse and consumption of the pill.

more likely than these extreme assumptions is that not all women who consumed EC were at an extremely high risk, or there was some behavioral response.

If women who take EC are actually at a decreased risk of pregnancy, then we would expect very small effects from expansion of access. For instance, women who take EC may do so principally because another method of contraception has failed. Some studies indicate that this is indeed the case (Trussell et al., 2004). If women who consume EC face a lower risk of pregnancy from a single sexual encounter than average, say 2 percent, then the pregnancies averted by additional EC access would be negligible relative to total births.

Similarly, if some women change their sexual behavior in response to the availability of EC, small and undetectable impacts are expected. The US population is much larger than the number of EC pills consumed, thus it takes only a small fraction of all US women changing their behavior to offset the decrease in births driven directly by EC. For example, if 100,000 EC pills are consumed by women who increase their sexual activity as a result of the availability of EC, such a change would be sufficient to largely offset the effect of those who were already at risk and use the pill to reduce this risk.

Under either scenario, very large changes to births or abortions are unlikely, given that each additional pill prevents pregnancy from only a single sexual encounter. More broadly, unexpected sexual encounters may account for a small percentage of overall pregnancies. Roughly half of women seeking abortions had been using some form of contraception, and few report unexpected sex as a factor in their abortion (Jones et al., 2002). If individuals who use EC actually face a low risk of unintended pregnancy, and individuals most likely to experience unintended pregnancy are unlikely to seek EC, then the impact of expanded access will be greatly diminished. We conclude that policies offering over-the-counter access to EC avert a private cost in acquiring the pill through a physician, but do not avert the social cost of unintended pregnancy.

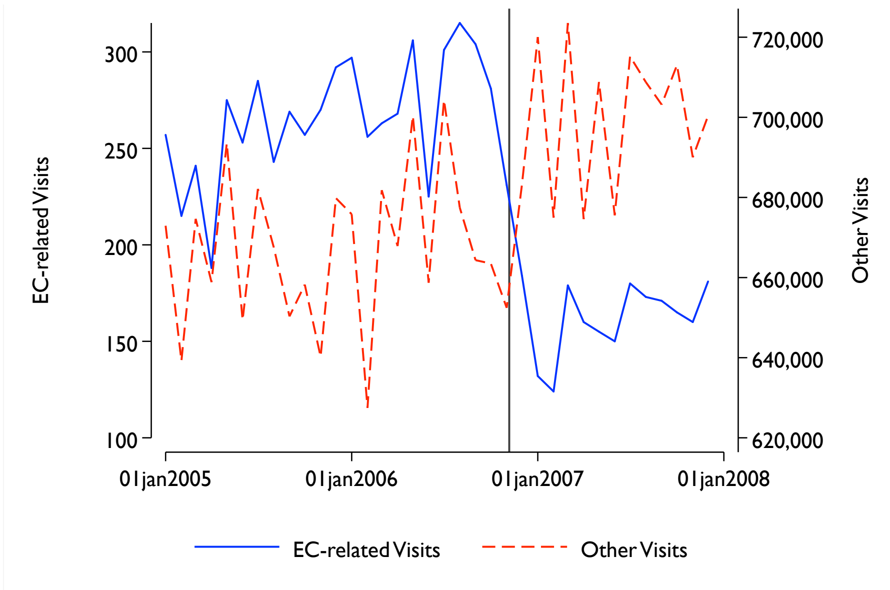
3.4.2 ED Visits

Despite the estimated null effect on birth and abortion rates above, state and federal legislation may have changed the way women acquire EC. To test for that possibility, Figure 3 presents monthly counts of EC-related visits to emergency departments. The vertical line indicates the date when the FDA allowed all women to obtain EC in pharmacies without a prescription.[41] The figure shows a clear decrease in EC-related visits after the FDA ruling. EC-related visits decrease from roughly 250 each month to roughly 150 each month. In contrast, the number of other visits seems to rise. Though a relatively small share of ED visits are related to EC, Figure 3 suggests that such visits became less common after women could obtain EC in pharmacies. Given that our five states capture about 20 percent of the population in the United States, this would suggest that the FDA policy change led to a decrease of about 500 visits per month to EDs.

In contrast to the pharmacy-access policies, we would expect ED-access laws to increase visits to the ED to obtain the pill, as its provision would be guaranteed. ED data do not exist that would allow us to estimate how each ED-access law affected the number of ED visits. Nevertheless, we have obtained records of ED visits for New Jersey, which passed such a law in April of 2005. Figure 4 presents ED visits in New Jersey before and after the state passed its ED-access law. The figure suggests that EC-related ED visits were decreasing before the law was passed and then increased dramatically immediately after the law was passed. In contrast, other ED visits experienced a secular increase before and after the law. The magnitude of the change suggests an increase of about 25 visits per month. Given that the population of New Jersey is about 3 percent of that of the United States, that increase is slightly larger than the decrease that was experienced after the FDA ruling. By contrast, no

[41] We restrict the sample to visits by women older than age 18. Only such women would have been affected by the legislative change. No drop is observed for EC-related visits by women younger than 18.

Figure 3.3: ED Visits in Entire HCUP Sample

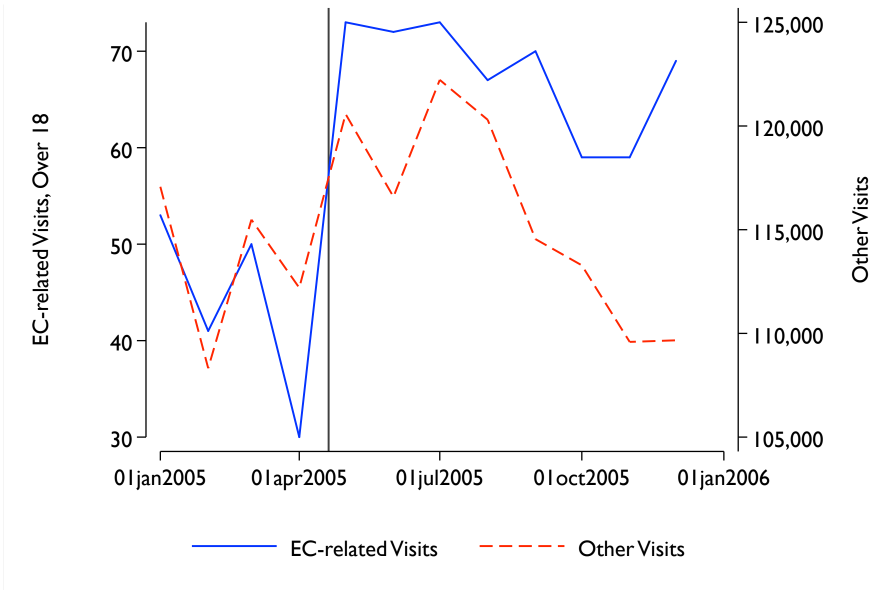


such pattern is observed in Wisconsin, which passed its ED-access law after the FDA policy change. This implies women did not increase their visits to the ED for EC in response to guaranteed access when a lower cost route, pharmacy access, is already available.

As a whole, these figures suggest that expansions of access to EC substantially changed the venue in which women procured the medication. Given the expense of ED visits (Bamezai et al., 2005), the figures suggest that such laws affect the total cost of distributing EC. These costs are both monetary as well as related to the time and stress associated with visiting the ED.[42]

[42] One can only speculate as to how pharmacy access has lowered the cost of distributing EC. We find that the FDA policy change eliminated 500 EC-related ED visits each month. The average cost of a non-trauma ED visit is roughly $300 (Bamezai et al., 2005), thus this change alone translates into annual savings of about $1.8 million. In addition, after the FDA policy change, women no longer had to visit a physician to procure a prescription for EC. These foregone visits to the doctor would then add to the total change in distribution costs. But any estimates of the social cost of doctor's visits, along with the associated time costs, are inherently speculative. The sum of $1.8 million each year is then a lower bound for the true change in distribution costs.

Figure 3.4: ED Visits in New Jersey



However, patients in an ED are given access to a wider array of staff and services than customers in a pharmacy. Potentially, that difference may lead to changes in outcomes. We test for such changes next.

3.4.3 Reports of Sexual Assault and EC

We next test whether expansions in access to EC affect reports of sexual assault. A priori, one might expect such an effect. In our model, victims of sexual assault are those for whom the impact of EC would be the largest. We thus expect EC-related legislation to affect reports of sexual assault through the following mechanisms: First, both ED-access laws and pharmacy-access laws may affect the venue in which women procure EC. The previous section explored this possibility. Second, the venue in which a woman procures EC may influence whether she chooses to report the crime. In either a pharmacy or an emergency department, it is the victim's decision as to whether a sexual assault is reported to the police. Hospital staff, however, may be more effective at encouraging women to report such crimes relative to the staff of pharmacies. In that case, when sexual assault victims procure EC in pharmacies they may be less likely to report the crime to the police.

This reasoning suggests that pharmacy-access laws will decrease reports of sexual assault, since more women will procure EC in pharmacies. It also suggests that ED-access laws will increase reporting of assaults. That said, the effect of ED-access laws on the reporting of assaults may be less pronounced. Many assault victims likely received EC in the ED before ED-access laws. Thus we would expect pharmacy-access laws to have the largest effect on reports of assault.

Table 5 presents the results of difference-in-difference regressions with reported sexual assaults as the outcome of interest. The second row of Panel A suggests that pharmacy-access laws did indeed reduce reported sexual assaults. In particular, states experienced a significant 9 percent decrease in reported assaults after they passed pharmacy-access laws. This implies a decrease of 0.31 reported assaults per 10,000 people (compared to an average of 3.5 assaults per 10,000 people). While this effect is not large, it is consistent with the decreased number of visits to the ED (6,000 annually).

To check that this result is not spurious, Figure 5 presents the point estimates from an event-study specification that evaluates the effect of state ED-access laws on reports of sexual assault. None of the 95-percent-level confidence intervals in Figure 5 exclude zero. We find this unsurprising; an event-study specification is demanding, given that these data only exist at the state-year level. Still, we find the figure suggestive. The point estimates suggest that reported assaults dropped for all post-law periods and did so exactly the year that the pharmacy-access laws were passed. While that drop is not statistically significant at conventional levels, the point estimates do not form a linear trend, but rather a step

Table 3.5: Effect of EC-Related Laws on Reports of Assault

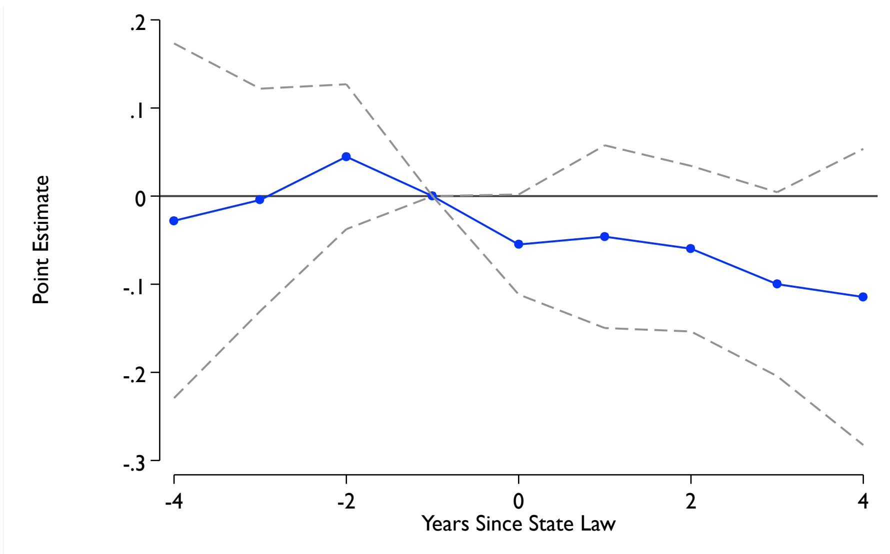
	(1)	(2)	(3)	(4)
Dep. Variable:	Logarithm of Sexual Asslts	Sexual Asslts per 10,000	Logarithm of Agrvtd Asslts	Agrvtd Asslts per 10,000
		A: State Law Changes, 1995-2005		
Passed ED-Access Law	0.042	0.215*	- 0.061	- 1.638
	(0.027)	(0.118)	(0.038)	(1.120)
Passed Pharmacy-Access Law	-0.093**	-0.308**	0.021	- 0.530
	(0.036)	(0.119)	(0.026)	(1.219)
Mean of Outcome	1,839.6	3.5	18,411.0	30.0
R^2	0.995	0.951	0.997	0.984
		B: FDA Policy Change, 2004-2008		
No ED-Access Law × Post FDA	0.036	- 0.102	0.038	- 0.121
	(0.054)	(0.222)	(0.032)	(1.108)
No Pharmacy-Access Law × Post FDA	0.011	0.279	- 0.006	0.190
	(0.055)	(0.308)	(0.046)	(1.477)
Mean of Outcome	1,797.9	3.5	18,771.6	31.5
R^2	0.994	0.941	0.995	0.977

Note: For panel A, N = 561, for panel B, N = 585. Standard errors in parentheses are robust to auto-correlation between observations from the same state. State fixed effects, year fixed effects, and state linear time trends not shown. The sample consists of year-by-state counts of all assaults reported to the FBI. The second panel excludes states that changed their legislation between 2006 and 2007.

* statistically significant at 10% level, ** statistically significant at 5% level.

function.

Figure 3.5: Effect of Pharmacy-Access Laws on Reports of Sexual Assaults



In addition, Table 5 suggests that ED-access laws increased the reporting of sexual assaults. Perhaps such laws increased the number of women choosing to go to the ED following a sexual assault. Those point estimates are only statistically significant at the 10–15 percent level. Nevertheless, the finding is consistent with the role that ED access has in guaranteeing care for prevention of pregnancy to assault victims. This further suggests that women who seek EC in hospitals are likely to report sexual assault.

Columns 3 and 4 of Table 5 report the results of a falsification check. We estimate similar regressions in which the number of aggravated assaults reported to the FBI is the dependent variable. Aggravated assaults are non-sexual in nature, and the reporting of such crimes should not be related to the availability of EC. Reassuringly, columns 3 and 4 suggest that EC-related legislation had no effect on aggravated assault.[43]

[43]Reports of robbery are similarly unaffected.

Panel B of Table 5 presents similar estimates for the FDA policy change. We find no evidence of a statistically change in the report of sexual assaults after the national policy change. However, the results in Panel B are much noisier and none of the coefficients are statistically significant but they do not rule out effects of the size found in Panel A.

Finally, we examine the impact of the FDA policy change on the nature of ED visits. Specifically, we test whether the FDA policy change affected ED visits for sexual assaults in our HCUP sample. Figure 6 presents the number of such visits over time.[44] The number of sexual-assault-related visits fell dramatically around the time of the FDA ruling. In contrast, ED visits for other conditions remained on the same trend. Although visits for sexual assault became more common in the summer of 2007, the relative number of such visits remained below trend.[45] The effect of the FDA policy change is also clear, however, if we control for month-of-year fixed effects. The magnitude of this change is substantial; assault-related visits decreased by about 100 visits per month in our five-state sample.

Overall, this evidence is suggestive. It implies that pharmacy access to EC may have led to a decrease in reported sexual assaults. The welfare implications of this finding are unclear. Easier access to EC means lower transaction costs for victims of sexual assault. However, it may also limit the other services provided to sexual assault victims, and hinder the apprehension of perpetrators. More research is needed in this area, to confirm how access affects assault reporting, and what policy steps could be taken to mitigate the unintended consequences of increased access.

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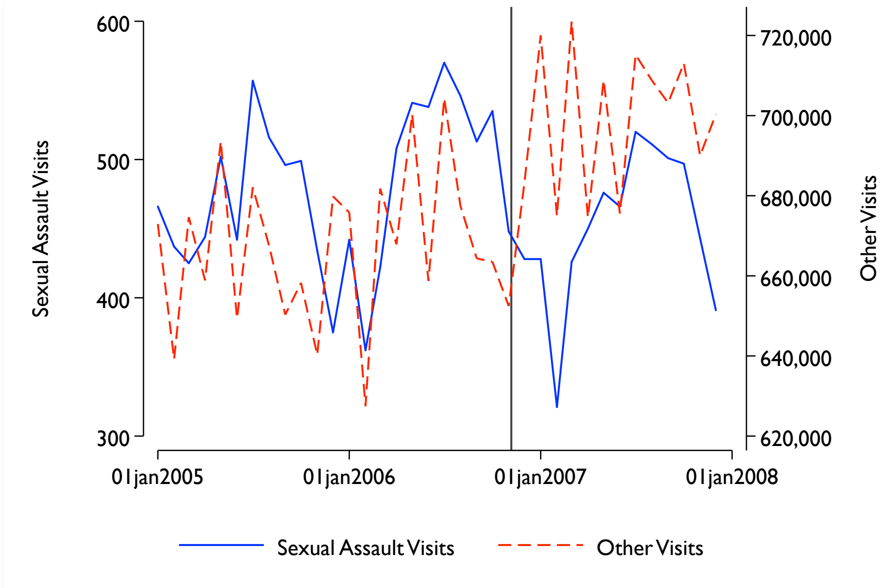
[44] Only visits by women older than 18 are in the sample.

[45] Visits related to sexual assault are subject to a seasonal pattern, occurring more frequently in the summer than in the winter.

Figure 3.6: Sexual Assault Visits in HCUP Sample



3.5 Conclusions

In summary, this paper studies the effects of access to EC. We first present a theoretical framework that suggests that the net effect of EC is ambiguous. On the one hand, there exists a direct effect—the consumption of EC prevents pregnancies. On the other hand, there exists an indirect effect; EC may induce a behavioral response which leads to more sexual encounters, and hence, more pregnancies. Finally, the likely impact of EC depends on when additional information on uncertain variables is revealed to the woman: information revealed near the time of intercourse (such as a broken condom) is related to EC use, while information that is gained long before or long after intercourse will make EC less useful relative to traditional contraception or abortion. Our model also suggests that the use of EC relative to traditional contraceptives and abortion will depend on the timing of information updates on the costs and benefits of unprotected sex and pregnancy.

Consistent with this model, we find no empirical evidence that expanded access to EC has decreased birth rates or abortions, even for at-risk populations. We caution that the associated confidence intervals are relatively wide, and that more research is needed to recover precise estimates. Still, we do not observe large changes in natality or abortion, as some opponents of EC have feared, nor do we find large decreases in unintended pregnancy, as some proponents had hoped. We find that wider access to EC increases utilization of EC, thus we do not believe that a lack of variation in the actual consumption of EC is driving our results. EC may mostly affect women for whom the chance of pregnancy is low, and thus it would be impossible to observe very large decreases in response to such policies.

These results clarify the dynamics of unintended pregnancies. The likely impact of EC depends on when additional information on uncertain variables is revealed to the woman: information revealed near the time of intercourse encourages EC use, while information that is gained long before or long after intercourse will make EC less useful relative to traditional contraception or abortion. If EC were to have a large effect on births, then one might conclude that, immediately after intercourse, women were anticipating unintended pregnancies, and turning to EC as a result. Our results, however, imply little effect of EC. This suggests that few unintended pregnancies are anticipated immediately after intercourse. Long term decisions may play a larger role in determining risk for unintended pregnancy, and the women facing the greatest risk of such pregnancies may not be the users of EC. Sexual assault victims represent an exception, given that they face a large unanticipated shock that EC can be used to mitigate.

Our results do suggest that expanded access to EC has changed the venue in which women obtain EC, encouraging women to visit EDs when access there is guaranteed, and then switch from EDs to pharmacies when the drug is available over-the-counter. Visits to pharmacies are less expensive than visits to emergency departments. Thus, if nothing else, expansions in access to EC have lowered the total cost of distributing the drug.

This lower cost, however, appears to have brought a potential unintended consequence: access to EC in pharmacies may reduce the reporting of sexual assault. To mitigate this impact, new policies may be necessary to encourage crime reporting by sexual assault victims that visit pharmacies. Further evidence is needed on this, but such a possibility was not, to our knowledge, discussed in the debate over EC, and deserves greater attention.

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Appendices

Appendix A

Appendix for Chapter 1

A.1 Model

A.1.1 Stable match for Cobb-Douglas uniform example

Proposition 1. *The maximizing r^*, and thus the form of the stable equilibrium is determined by the value of λ relative to other parameters, which falls into one of three regions:*

- *If $\lambda \leq \frac{S-t}{S+t}(\frac{P}{p}-1)\frac{Y-1}{S}$, then $r^* = 0$*
- *If $\frac{S-t}{S+t}(\frac{P}{p}-1)\frac{Y-1}{S} < \lambda < 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p}-1)\frac{Y-1}{S}$, then there is an interior solution for r^*.*
- *If $\lambda \geq 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p}-1)\frac{Y-1}{S}$, then $r^* = t$.*

Proof. Note that the joint product of marriage can be written in terms of y and s:

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

To find the total surplus, we need to integrate the joint marital product for each segment across the three segments depicted in Figure 1.4. To do this, we need to know what y is matched with what s in any equilibrium. Because matching must be assortative on either side of t, the matching function is defined as the function that ensures an exactly equal number of women with income less than some level are matched to the number of men with income less than some level. Along the first segment, the man who has income 1 will be matched with the woman who has income 0, and similarly, the man with income x will be matched with the woman of skill r, and we can use the fact that the density of $r - 0$ must equal $x - 1$ to solve for s. In the uniform case, this yields a linear matching function between s and y. For example, for segment 1:

$$\begin{aligned} \frac{s}{S} &= \frac{y-1}{Y-1} \\ s &= \frac{y-1}{Y-1}S \\ s &= \frac{S}{Y-1}(y-1) \end{aligned}$$

This can be repeated for all segments, and the resulting functions for s in terms of y plugged in to the surplus function, which is then integrated with respect to y.

$$\begin{aligned} H_1(r) &= \int_1^x \left(P\frac{\left(y + \frac{S}{Y-1}(y-1)+1\right)^2}{4} + (1-P)\left(y + \frac{S}{Y-1}(y-1)\right)\right) dy \\ H_2(r) &= \int_z^Y \left(P\frac{\left(y + r + \frac{S}{Y-1}(y-z)+1\right)^2}{4} + (1-P)\left(y + r + \frac{S}{Y-1}(y-z)\right)\right) dy \\ H_3(r) &= \int_x^z \left(p\frac{\left(y + \lambda\left(t + \frac{S}{Y-1}(y-x)\right)+1\right)^2}{4} + (1-p)\left(y + \lambda\left(t + \frac{S}{Y-1}(y-x)\right)\right)\right) dy \end{aligned}$$

The sum of these functions, $H = H_1 + H_2 + H_3$, is then maximized with respect to r, over the interval from 0 to t. r appears in the matching functions and also in the limits of integration, since x and z are functions of r. The total surplus function, H, 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.

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

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

Which gives us:

$$\frac{S-t}{S+t}(\frac{P}{p}-1)\frac{Y-1}{S} < \lambda < 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p}-1)\frac{Y-1}{S}$$

If $\lambda \leq \frac{S-t}{S+t}(\frac{P}{p}-1)\frac{Y-1}{S}$, 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 $\frac{S-t}{S+t}(\frac{P}{p}-1)\frac{Y-1}{S} < \lambda < 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p}-1)\frac{Y-1}{S}$, 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. This exact interior solution is given by:

$$r = \frac{(\frac{P}{p}-1)(t-S) + \frac{S}{Y-1}\lambda\,(t+S)}{2(\frac{P}{p}-1)) + 2\frac{P}{p}\frac{S}{Y-1}}$$

If $\lambda \geq 2\frac{P}{p}\frac{t}{t+S} + (\frac{P}{p}-1)\frac{Y-1}{S}$, then $h(t) > 0$, and thus the function is increasing on the entire interval $[0, t]$, and the maximum is reached for $r = t$. $\square$

A.1.2 Finding the payoff functions

For notational simplicity, let's define $\theta \equiv \frac{S}{Y-1}$.

Recall the matching function for the first segment, with

$$y = \frac{1}{\theta}s + 1$$
$$s = \theta(y-1)$$

And the surplus function:

$$T_1(y,s) = \left(\frac{y+s+1}{2}\right)^2 P + (y+s)(1-P)$$

Through the above maximization procedure, we can then determine the value function, plugging in for y as a function of s, and s as a function of y.

$$\begin{aligned}
u_1\prime(y) &= (y+s+1)\frac{P}{2} + (1-P) \\
&= (y+\theta(y-1)+1)\frac{P}{2} + (1-P) \\
u_1(y) &= \int (y+\theta(y-1)+1)\frac{P}{2} + (1-P)\,dy \\
u_1(y) &= \left(\frac{y^2}{2}(1+\theta) + y(1-\theta)\right)\frac{P}{2} + y(1-P) + C_1
\end{aligned}$$

$$\begin{aligned}
v_1\prime(s) &= (y+s+1)\frac{P}{2} + (1-P) \\
&= \left(\frac{1}{\theta}s + 1 + s + 1\right)\frac{P}{2} + (1-P) \\
v_1(s) &= \int \left(\frac{1}{\theta}s + 1 + s + 1\right)\frac{P}{2} + (1-P)\,ds \\
v_1(s) &= \left(\frac{s^2}{2}\left(\frac{1}{\theta}+1\right) + 2s\right)\frac{P}{2} + s(1-P) + K_1
\end{aligned}$$

Note that for two matched individuals, $u(y) + v(s) = T(y,s)$. Thus:

$$\left(\frac{y^2}{2}(1+\theta)+y(1-\theta)\right)\frac{P}{2}+y(1-P)+C_1$$
$$+\left(\frac{s^2}{2}\left(\frac{1}{\theta}+1\right)+2s\right)\frac{P}{2}+s(1-P)+K_1$$
$$=\left(\frac{y+s+1}{2}\right)^2 P+(y+s)(1-P)$$

Plugging in for y:

$$u_1(\frac{1}{\theta}s+1)+v_1(s)=T_1(\frac{1}{\theta}s+1,s)$$
$$\Rightarrow C_1+K_1=\frac{1}{4}P(\theta+1)$$

For segment two, the matching function is:

$$y=z+\frac{1}{\theta}(s-r)$$
$$s=r+\theta(y-z)$$

Following the same maximization and integration procedure, plugging in for y as a function of s, and s as a function of y, and noting that $T_2(y,s)=T_1(y,s)$, we find:

$$\begin{aligned}
u_2\prime(y) &= (y+s+1)\frac{P}{2} + (1-P) \\
&= (y+r+\theta(y-z)+1)\frac{P}{2} + (1-P) \\
u_2(y) &= \int (y+r+\theta(y-z)+1)\frac{P}{2} + (1-P)\,dy \\
u_2(y) &= \left(\frac{y^2}{2}(1+\theta) + y(1+r-\theta z)\right)\frac{P}{2} + y(1-P) + C_2
\end{aligned}$$

$$\begin{aligned}
v_2\prime(s) &= (y+s+1)\frac{P}{2} + (1-P) \\
&= \left(z+\frac{1}{\theta}(s-r)+s+1\right)\frac{P}{2} + (1-P) \\
v_2(s) &= \int \left(z+\frac{1}{\theta}(s-r)+s+1\right)\frac{P}{2} + (1-P)\,ds \\
v_2(s) &= \left(\frac{s^2}{2}\left(\frac{1}{\theta}+1\right) + s(1+z-\frac{1}{\theta}r)\right)\frac{P}{2} + s(1-P) + K_2
\end{aligned}$$

Again we have the restriction that $u(y)+v(s)=T(y,s)$, yielding:

$$\begin{aligned}
&\left(\frac{y^2}{2}(1+\theta) + y(1+r-\theta z)\right)\frac{P}{2} + y(1-P) + C_2 \\
+&\left(\frac{s^2}{2}\left(\frac{1}{\theta}+1\right) + s(1+z-\frac{1}{\theta}r)\right)\frac{P}{2} + s(1-P) + K_2 \\
=&\left(\frac{y+s+1}{2}\right)^2 P + (y+s)(1-P)
\end{aligned}$$

Plugging in for y:

$$
\begin{aligned}
&u_2(z+\frac{1}{\theta}(s-r))+v_2(s)=T_2(z+\frac{1}{\theta}(s-r),s)\\
\Rightarrow &C_2+K_2=\frac{1}{4\theta}\left(Pr^2-2Prz\theta+Pz^2\theta^2+P\theta\right)
\end{aligned}
$$

Plug in for z:

$$
C_2+K_2=\frac{1}{4\theta}\left(PY^2\theta^2-2PYt\theta+Pt^2+P\theta\right)
$$

In the final segment, the matching function is:

$$
y=x+\frac{1}{\theta}(s-t)
$$

$$
s=t+\theta(y-x)
$$

In this case, the joint product, T_3, has a different form:

$$
T_3(y,s)=\left(\frac{y+\lambda s+1}{2}\right)^2 p+(y+\lambda s)\,(1-p)
$$

Again maximizing and integrating gives:

$$
\begin{aligned}
u_3\prime(y) &= (y + \lambda s + 1)\,\frac{p}{2} + (1-p) \\
&= (y + \lambda(t + \theta(y-x)) + 1)\,\frac{p}{2} + (1-p) \\
u_3(y) &= \int (y + \lambda(t + \theta(y-x)) + 1)\,\frac{p}{2} + (1-p)\,dy \\
u_3(y) &= \left(\frac{y^2}{2}(1+\lambda\theta) + y\,(1+\lambda(t-\theta x))\right)\frac{p}{2} + y\,(1-p) + C_3
\end{aligned}
$$

$$
\begin{aligned}
v_3\prime(s) &= (y + \lambda s + 1)\,\frac{\lambda p}{2} + \lambda\,(1-p) \\
&= \left(x + \frac{1}{\theta}(s-t) + \lambda s + 1\right)\frac{\lambda p}{2} + \lambda\,(1-p) \\
v_3(s) &= \int \left(x + \frac{1}{\theta}(s-t) + \lambda s + 1\right)\frac{\lambda p}{2} + \lambda\,(1-p)\,ds \\
v_3(s) &= \left(\frac{s^2}{2}\left(\frac{1}{\theta} + \lambda\right) + s(1 + (x - \frac{1}{\theta}t))\right)\frac{\lambda p}{2} + s\lambda\,(1-p) + K_3
\end{aligned}
$$

The restriction that $u(y) + v(s) = T(y,s)$ gives:

$$
\begin{aligned}
&\left(\frac{y^2}{2}(1+\lambda\theta) + y\,(1+\lambda(t-\theta x))\right)\frac{p}{2} + y\,(1-p) + C_3 \\
&+ \left(\frac{s^2}{2}\left(\frac{1}{\theta} + \lambda\right) + s(1 + (x - \frac{1}{\theta}t))\right)\frac{\lambda p}{2} + s\lambda\,(1-p) + K_3 \\
&= \left(\frac{y + \lambda s + 1}{2}\right)^2 p + (y + \lambda s)\,(1-p)
\end{aligned}
$$

Plugging in for y:

$$u_3(x + \frac{1}{\theta}(s-t)) + v_3(s) = T_3(x + \frac{1}{\theta}(s-t), s)$$
$$\Rightarrow C_3 + K_3 = \frac{1}{4\theta}\left(p\lambda t^2 - 2p\lambda tx\theta + p\lambda x^2\theta^2 + p\theta\right)$$

Plugging in for x:

$$C_3 + K_3 = \frac{p}{4\theta}\left(\lambda r^2 - 2\lambda rt + 2\lambda r\theta + \lambda t^2 - 2\lambda t\theta + \lambda\theta^2 + \theta\right)$$

The constants can then be solved for using the constraints that, in order for the match to be stable, two men with the same income cannot receive different utilities. Thus, the men at all "break points," between two segments, must be indifferent. Additionally, a woman of the same income level must always receive a unique payoff. (For now, we do not restrict that all women of the same skill level must receive the same payoff, since the educational decision was undertaken before entering the marriage market, and cannot be changed).

In particular, $v_1(r) = v_2(r)$ yields a relationship between K_1 and K_2. But, given $K_1 = 0$, this allows us to solve for $K_2 = \frac{1}{2\theta}(Pr\theta + Prt - PYr\theta)$.

From segment 2, we have $C_2 + K_2 = \frac{1}{4\theta}(PY^2\theta^2 - 2PYt\theta + Pt^2 + P\theta)$, which allows us to solve for $C_2 = \frac{1}{4}\frac{P}{\theta}(\theta + Y^2\theta^2 - 2r\theta - 2rt + t^2 + 2Yr\theta - 2Yt\theta)$.

Then $u_2(z) = u_3(z)$ gives us a relationship between C_2 and C_3, which allows us to solve for $C_3 + \frac{1}{2}p\left(\left(\lambda\left(t - \theta\left(\frac{r}{\theta}+1\right)\right)+1\right)\left(Y + \frac{1}{\theta}(r-t)\right) + \frac{1}{2}(\theta\lambda+1)\left(Y + \frac{1}{\theta}(r-t)\right)^2\right) - \left(Y + \frac{1}{\theta}(r-t)\right)(p-1)$.

Then, using the relationship from segment 3 between the two constants, we can solve for $K_3 = \frac{p}{4\theta}(\lambda r^2 - 2\lambda rt + 2\lambda r\theta + \lambda t^2 - 2\lambda t\theta + \lambda\theta^2 + \theta) - C_3$.

We then can use $u_1(x) = u_3(x)$ to solve for C_1, which gives us two equations for C_1, which can be used to find r, giving us:

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

which is the same as the equation found through the surplus maximization method. Together with the equations $x = \frac{1}{\theta}r + 1$ and $z = Y - \frac{1}{\theta}(t-r)$, we now have eliminated the unknowns from the model.

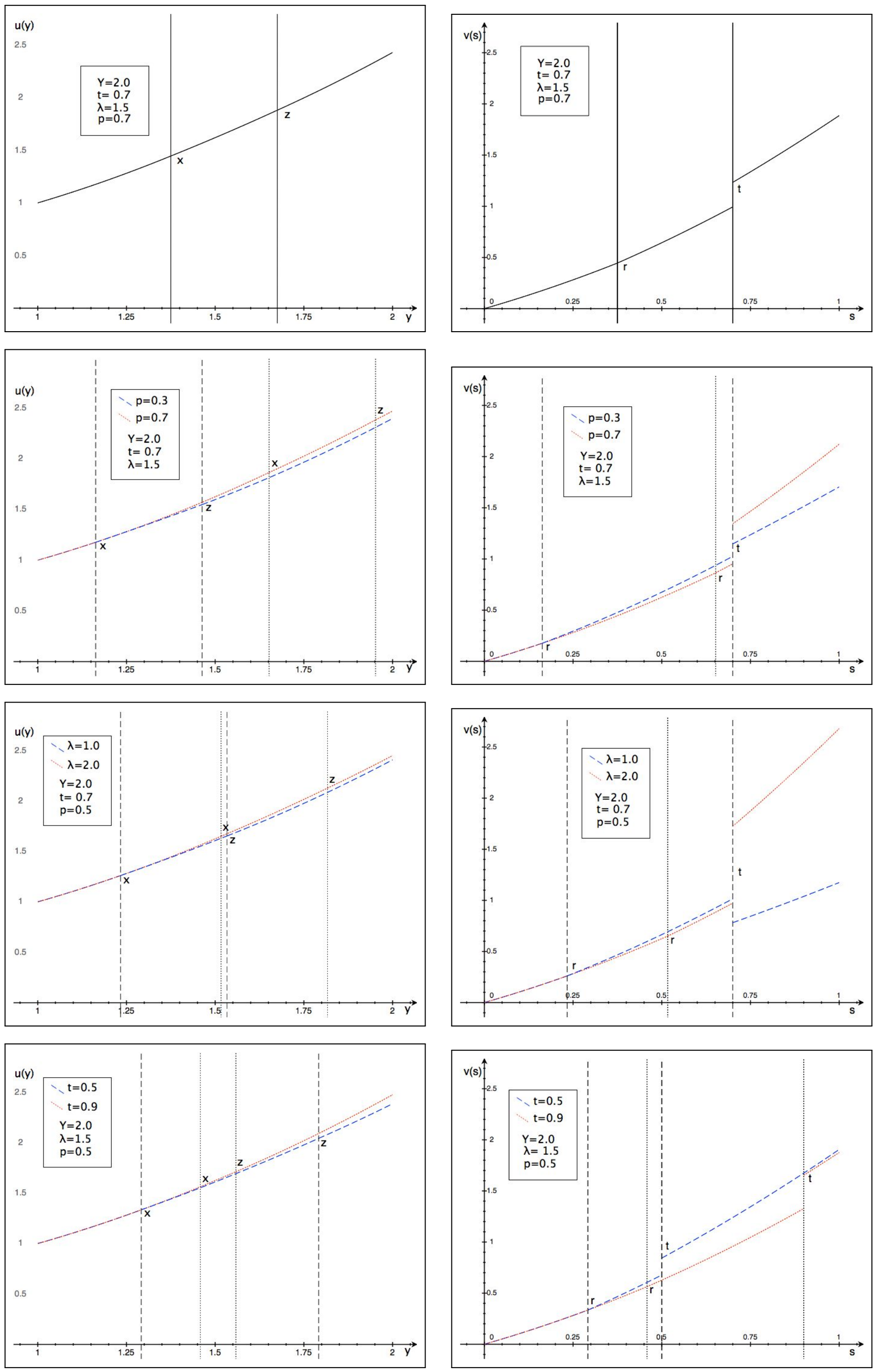
A.1.3 The form of the payoff functions

These payoffs are strictly increasing in y and s, for men and women respectively, but are not necessarily strictly increasing across segments 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 A.1 shows what these payoffs look like for the parameter values $S=1$, $Y=2$, $P=1$, $p=.5$, $\lambda=1.5$, 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 λ 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 λ for the three-segment

Figure A.1: Payoff simulations

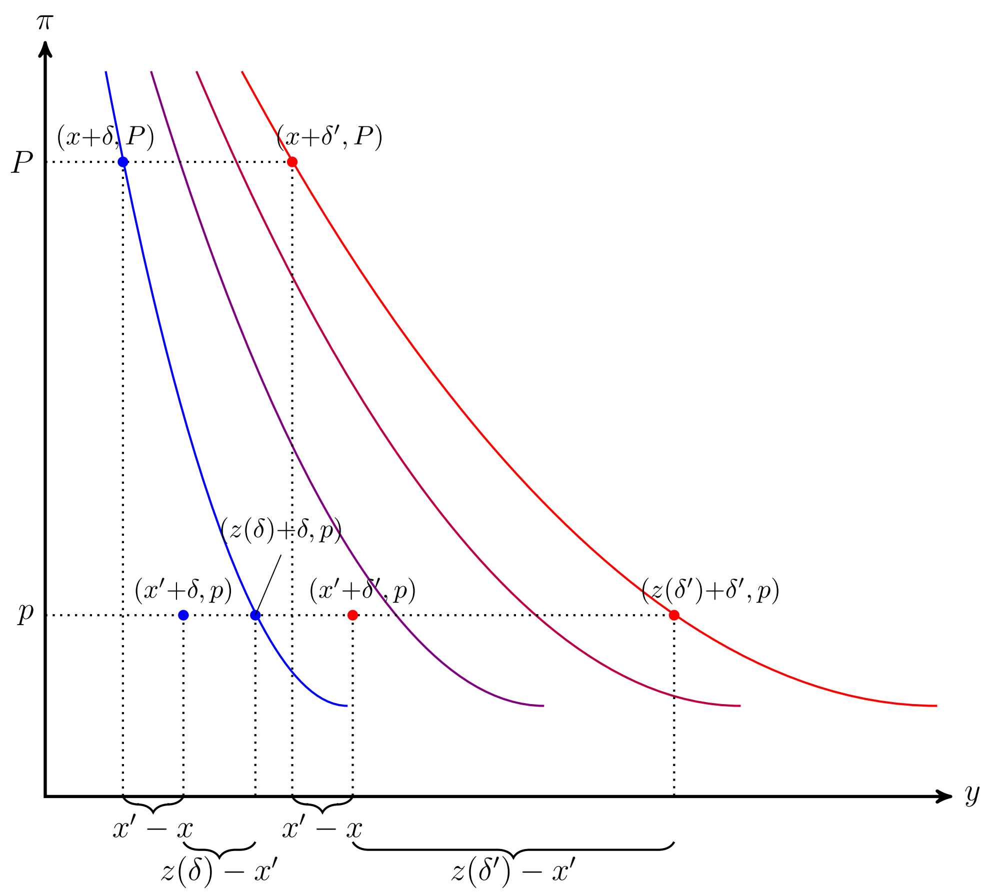


equilibrium to be stable are not satisfied. For example, if p is too high, then $r = t$ is surplus maximizing (with a high chance of pregnancy after investment, there's no reason for men to break from assortative mating), and if p is too low, $r = 0$ is optimal.

A.1.4 General from of the match

Lemma 2. *For $T(y, \pi)$ increasing in both arguments, if $\frac{\frac{\partial T}{\partial y}}{\frac{\partial T}{\partial \pi}} \equiv MRS$ is decreasing in y and $T(x + d, P) > T(x' + d, p)$ for some d and $P > p$, $x' > x$, then for each $\delta > d$, $T(x + \delta, P) - T(x' + \delta, p)$ is an increasing function of δ.*

Figure A.2: Illustration showing $z(\delta) - x'$ increasing in δ for MRS decreasing in y



Proof. Define $z(\delta)$ as the level of income that makes $T(z(\delta)+\delta, p) = T(x+\delta, P) \equiv T_\delta$.

Since $T(z(\delta)+\delta, p) = T(x+\delta, P)$, to prove $T(x+\delta, P) - T(x'+\delta, p)$, we only need show that $T(z(\delta)+\delta, p) - T(x'+\delta, p)$ increasing in δ

To show that $T(z(\delta)+\delta, p) - T(x'+\delta, p)$ is increasing in δ, it is sufficient to show $z(\delta)$ is weakly increasing in δ, since convexity of the surplus in income means that a given loss of y decreases the surplus more for higher y couples:

$$
\begin{aligned}
T(z(\delta)+\delta, p) - T(x'+\delta, p) &= \int_{x'}^{z(\delta)} \frac{\partial T}{\partial y}(y+\delta, p)dy \\
&> (z(\delta)-x')\frac{\partial T}{\partial y}(y+\delta, p)
\end{aligned}
$$

because $\frac{\partial^2 T}{\partial y^2} > 0$. (Note, this is where the assumption that $T(x+d, P) > T(x'+d, p)$, and hence $T(z(\delta)+\delta, P) > T(x'+\delta, p)$, is required.)

Thus, we need to show that $z(\delta)$ is weakly increasing in δ.

Let $g \in [0,1]$ define the distance traveled from P to p along an iso-surplus curve at level T_δ starting from $(x+\delta, P)$, such that $\pi(g) = P - g(P-p)$, and finishing at $(z(\delta)+\delta, p)$. Note that $\pi(g)$ is independent of δ. At each g, we define $y_\delta(g)$ as the value of y such that $T(y_\delta(g), \pi(g)) = T_\delta$. Then:

$$
\frac{\partial T}{\partial y}\frac{\partial y_\delta}{\partial g} + \frac{\partial T}{\partial \pi}\frac{\partial \pi}{\partial g} = 0
$$

as we "walk" along the iso-surplus curve.

This implies

$$\frac{\partial y_\delta}{\partial g} = -\frac{\frac{\partial T}{\partial \pi}}{\frac{\partial T}{\partial y}} \frac{\partial \pi}{\partial g}$$
$$\int_0^1 \frac{\partial y_\delta}{\partial g} dg = -\int_0^1 \frac{1}{MRS(y_\delta(g), \pi(g))} \frac{\partial \pi}{\partial g} dg$$

$y_\delta(0) = x + \delta$ at the starting point of the T_δ iso-surplus curve. $\frac{\partial \pi}{\partial g}$ can be replaced with the linear function $-(P - p)$. This yields:

$$z(\delta) + \delta - (x + \delta) = \int_0^1 \frac{1}{MRS(y_\delta(g), \pi(g))}(P - p)dg$$
$$\Rightarrow z(\delta) = \int_0^1 \frac{1}{MRS(y_\delta(g), \pi(g))}(P - p)dg + x$$

I will now show that the righthand side expression is increasing in δ. For this to be the case, the MRS must be decreasing in δ. Its second argument, $\pi(g)$ is constant in δ, by definition. We know the MRS is decreasing in y, by assumption, for a constant π. To determine how $y_\delta(g)$ changes in δ, note that T_δ is strictly increasing in δ, because $T(x+\delta, P)$ is strictly increasing in δ, and $T_\delta \equiv T(x+\delta, P)$. Thus, since $\pi(g)$ is constant in δ, $y_\delta(g)$ must be increasing in δ.

Thus, since the MRS is decreasing in y, $\frac{1}{MRS}$ is increasing in y. Because the expression inside the integral is increasing in δ for each g, the integral must also be increasing in δ, and thus the righthand side expression is increasing in δ.

Then, the lefthand side must also be increasing, meaning $z(\delta)$ is increasing in δ. $z(\delta)$

increasing in δ implies:

$$T(z(\delta)+\delta,p)-T(x'+\delta,p) \text{ increasing in } \delta$$
$$\Rightarrow T(x+\delta,P)-T(x'+\delta,p) \text{ increasing in } \delta$$

□

An illustration of the proof methodology is shown in figure A.2.

A.1.5 Optimal human capital investments

Figure A.3 demonstrates that it is possible to sustain an equilibrium in the first stage, with some women choosing to invest in their careers, even if the second stage features non-monotonic matching. Figure A.3 graphs a woman of skill t's payoff if she invests, $v(\lambda t, p)$ minus her payoff if she does not invest, $v(t, P)$, with P, the non-investment fecundity, set equal to 1, S, the max female skill, set equal to one, and Y, the max male income, set equal to two. In all these graphs, I add a small fixed cost of female education, as this generally insures there is a non-zero solution when λ is at its maximum value.

When the graph of $v(\lambda t, p) - v(t, P)$ is above zero, it means that the first stage will not be in equilibrium, because women just below t will want to also invest, to gain the greater utility. If the graph is below zero, women will regret investing. Therefore, the point at which the graph crosses zero, and thus $v(\lambda t, p) = v(t, P)$ represents the t^* that sustains an equilibrium in the first stage. If this crossing is between 0 and 1, the range of s (since $S = 1$ in this section), there exists an interior equilibrium. If $t^* < 0$, all women should invest, and if $t^* > 1$, no women should.

The top left panel shows a λ—return on investment—of 1.5, with a fixed cost of education of 0.2. Under this relatively low return to education, the first stage equilibrium can be sustained with a probability of conceiving post-investment of 0.9 or 0.5, but not with 0.1. If the probability of conceiving post investment is 0.1, no women should invest. With a return to investment of 2, however, whom in the top right panel, the first stage equilibrium has an interior solution at all three levels of p. Note that for a fixed c and λ, t^* is decreasing in p, meaning that the higher the probability of conceiving post investment, the more women invest. Note also that for the same p and c, t^* will be lower for higher returns on investment, λ.

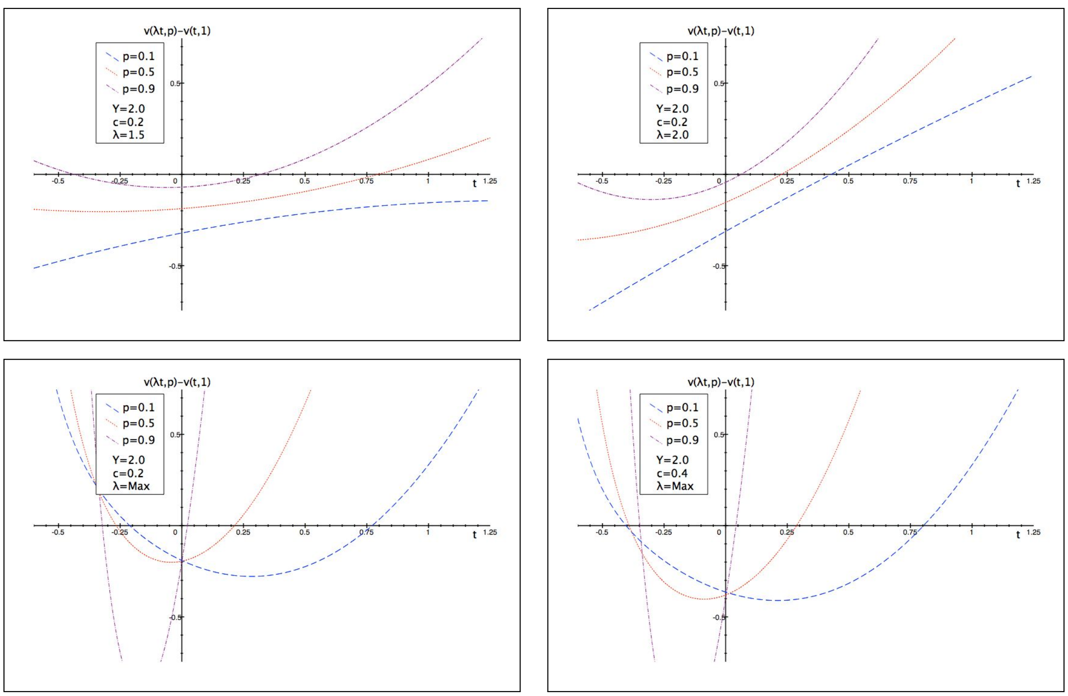
The bottom two panels confirm that these first-stage equilibria are possible with a λ that sustains the second-stage non-monotonic matching, by replacing λ with the maximum λ for which the equilibrium takes on the three-segment form, $\lambda = \frac{1}{p-1} + \frac{2t}{t+1}\frac{1}{p} + \frac{2c}{1+t}$ (where the last term results from the addition of the fixed cost, c, and the equation is simplified somewhat by the assumptions that $Y = 2$, $S = 1$, and $P = 1$).

This changes the shape of the curve, since the maximum λ depends on t and p, but shows that for all three levels of p, it is possible to have a first-stage equilibrium while within the boundaries of the λ required for a non-monotonic second-stage equilibrium. The left shows this image with the same fixed cost of education, $c = 0.2$, while the right side doubles this fixed cost, demonstrating that it simply shifts the equilibrium t^* outward for each λ and p.

A.2 Census Data

Figure A.4 shows that the tradeoff between age at marriage and spousal income is especially high for highly educated women. These 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

Figure A.3: Equilibrium t under different parameter values



salient for those with the most to gain from making large career investments.

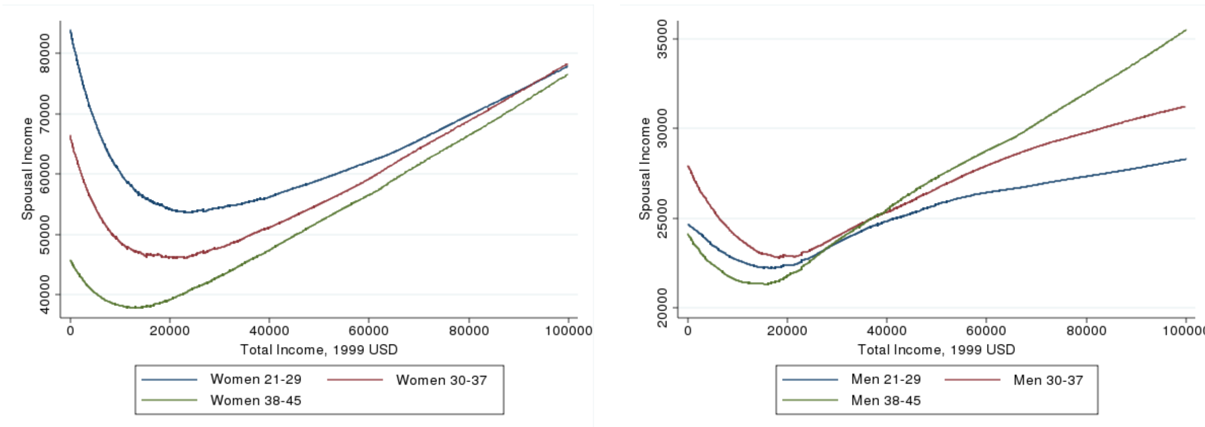
Figure A.4: Spousal Income by Age at Marriage, by Education Level

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.

Figure A.5 shows that conditional on income, marrying older is always worse for women, but not for men.

Figures A.6 and A.7 show that marriage outcomes for the 1920–1930 and 1940–1950 birth cohorts also exhibit the non-monotonicity shown in the 1930–1940 birth cohort. In the

Figure A.5: Lowess-Smoothed Spousal Income for Women and Men who Marry at a Given Age, by Income



later cohort, the penalty has abated somewhat, with highly educated women only pairing with men who are no richer than college-educated women's mates, rather than statistically significantly poorer men.

Figure A.8 shows that the wage premium for highly educated women has indeed risen since the 1940 birth cohort. This demonstrates that the rising wage premium could be responsible for a change of equilibrium. (Note, the falling premium for the earlier cohorts is likely due to more women making investments, thus changing the pool of each education group).

Figure A.9 shows the rapid transition in desired family size during the 1960s and 1970s, which, if treated as exogenous to the model, could spur a shift between matching equilibria. This change was most likely brought on from the substitution from child quantity to child quality as overall wealth increases, and the rise of women in the workforce, increasing the opportunity cost of childbearing.

Figure A.10 repeats Figure 1.13, using currently married rather than ever married as an outcome, and thus combining marriage and divorce rates.

Figure A.6: Non-monotonicity in spousal income by wife's education level, 41-50 year old women in 1970 Census

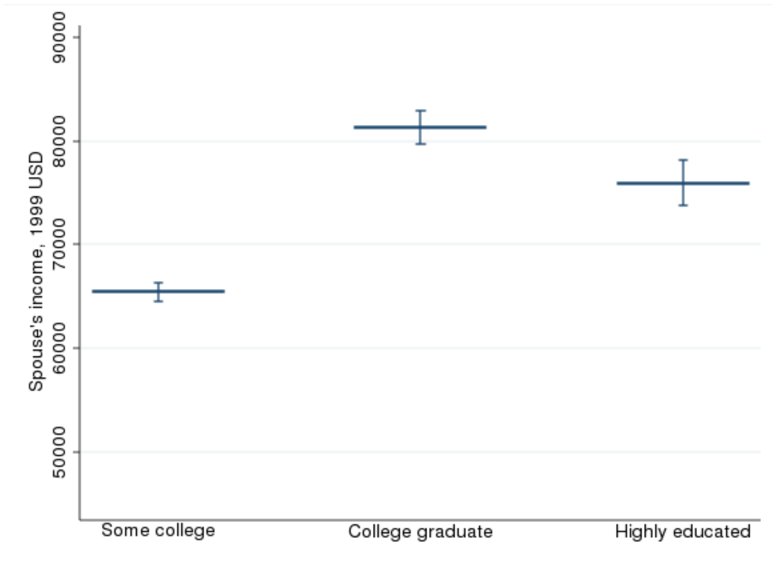


Figure A.7: Non-monotonicity in spousal income by wife's education level, 41-50 year old women in 1980 Census

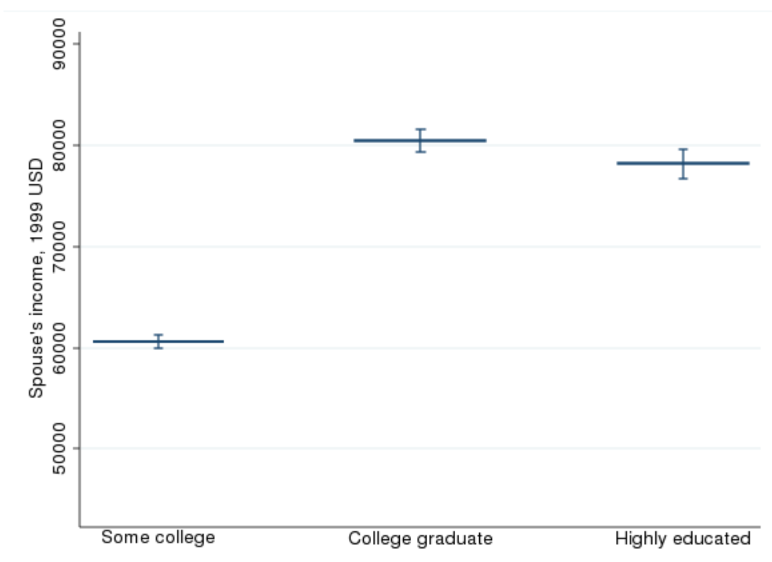


Figure A.8: Wage premium over "some college"

Figure A.11 repeats Figure 1.14, using ever divorced rather than currently divorced as an outcome, but necessarily omitting 1990 and 2000, where this data is not available.

Both Figures A.10 and A.11 demonstrate the same trend of increasing marriage rates and decreasing divorce rates for highly educated women, compared to college educated women.

Figure A.9: Desired family size transition

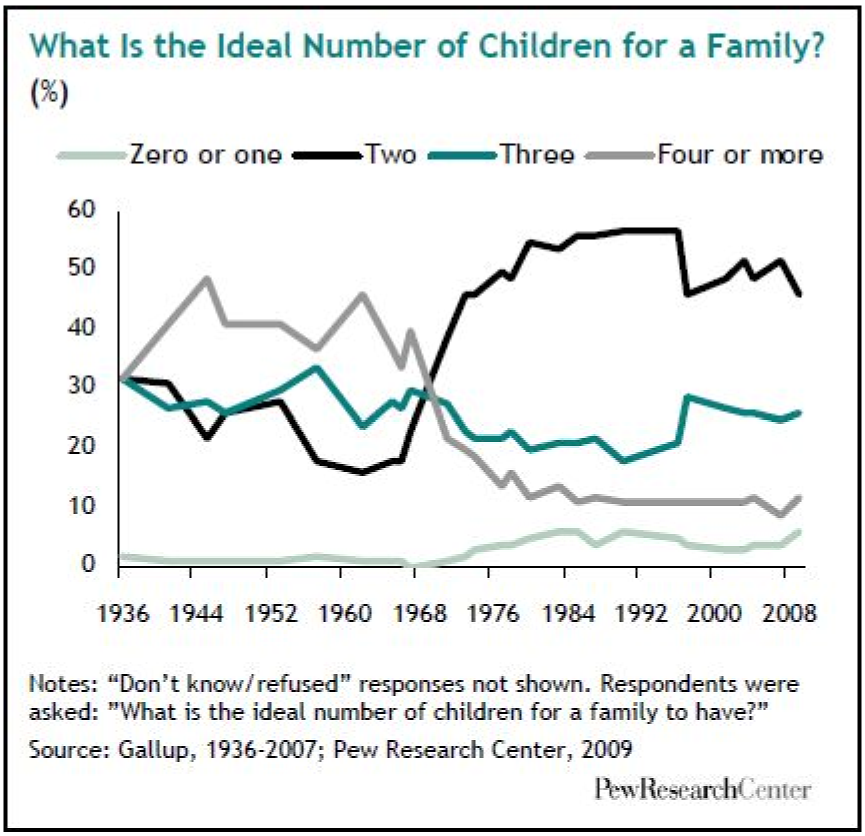


Figure A.10: Currently married rates by education level, white women 41-50

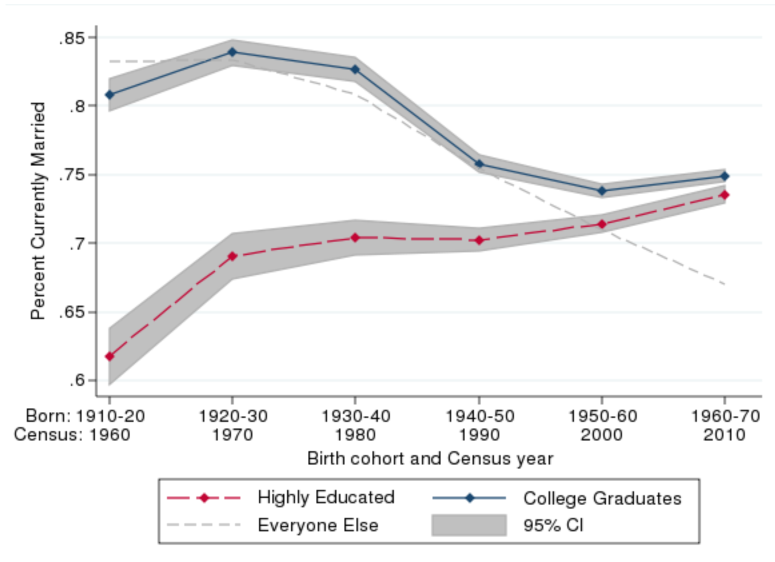
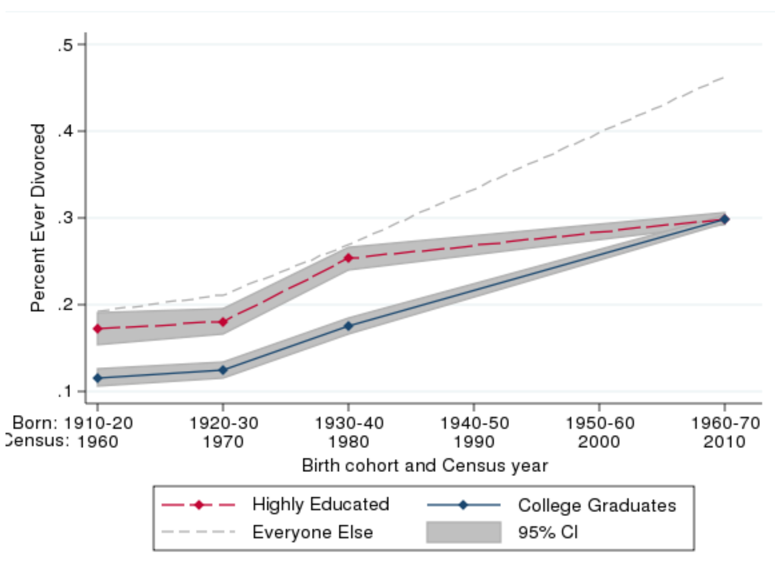


Figure A.11: Ever divorced rates by education level, white women 41-50



Appendix B

Appendix for Chapter 2

B.1 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.

Table B.1 tests for the second assumption, decreasing marginal valuation of income relative to fertility as income increases. This and all appendix tables are shown only for the larger Qualtrics sample—results from the original sample are similar, although in some cases lower powered.

Table B.1 shows that 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-bachelors 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).

For the first property, super-modularity in incomes, I look at the effect of the interaction between own income and profile income on overall rating. Table B.2 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 B.1: Income heterogeneity, Qualtrics sample

Dep. variable: **Profile rating**	(1) **Age interaction**	(2) **Income and age**	(3) **Control for knowledge**
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)	(0.022)
High income × inc		0.022	0.025
		(0.021)	(0.022)
Low income × inc		-0.029	-0.025
		(0.024)	(0.024)
No knowledge × inc			0.567***
			(0.166)
Observations	8,080	8,080	7,800
R-squared	0.491	0.492	0.490

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

Table B.2: Preferences over partner income, men and women, Qualtrics sample

Dep. variable **Profile Rating**	(1) Men	(2) Women	(3) Men	(4) Women
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	8,080	4,040	8,080	4,040
R-squared	0.491	0.464	0.491	0.464

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

B.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. 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 B.2 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 and significant, for both male and female 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, Pan, and Kamenica, 2013), or may dislike *very* high-earning women. Table B.3, 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 coefficient on "Profile earns more" is positive. The second column interacts the profile earning more with 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.

Table B.3: Male preferences over partner income, Qualtrics sample

Dep. variable: **Profile rating**	(1) Binary	(2) Interaction	(3) By income level
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
$50-64,999			0.151*
$65-79,999			0.205**
$80-94,999			0.213**
$95-109,999			0.264***
$110-124,999			0.343***
Observations	8,080	8,080	8,080
R-squared	0.490	0.490	0.490

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

B.3 Non-linearity in preferences over age

Table B.4 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 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 B.4, 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.

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. As a note, raters were also asked at what age they thought women's physical attractiveness starts to decline. This "cutoff" variable is not significant, and has 10% of the

Table B.4: Non-linearity in aging using rater-specific fertility cutoffs, Qualtrics sample

Dep. variable: **Profile rating**	(1) Ind cutoff	(2) Cutoff^2	(3) By phase
Years past "infertile"	-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)	0.0320***	0.032***	0.032***
	(0.011)	(0.011)	(0.011)
Observations	6,833	6,833	6,833
R-squared	0.465	0.467	0.467

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

magnitude as the infertility cutoff.

Column 2 shows that when a squared infertility cutoff 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.

B.4 Interactions with attractiveness

Table B.5 shows that the mediators used in 2.5 do not have the same interaction signs nor significance when interacted with attractiveness, providing further evidence that the randomly assigned age variable is proxying for fertility, rather than an unmeasured component of attractiveness. Attractiveness here was rated by 120 undergraduate students. Although this may not be a perfect measure of the male raters' views of attractiveness, this measure has a positive and strongly significant impact on rating, so it does correspond to something viewed favorably by male raters. The coefficient size on attractiveness is much larger than the effect size of income or age. Wanting marriage, wanting kids, and fertility knowledge have no impact on the overall relationship between ratings and attractiveness. Not having kids interacts negatively with attractiveness: those without children currently are less picky about the attractiveness of their partners. This moves in the opposite direction of the interaction with age, as those with no kids had stronger preferences for younger partners.

Table B.5: Interactions of fertility mediators with attractiveness, Qualtrics sample

Dep variable: **Profile rating**	(1) **Base**	(2) **Marriage**	(3) **Want kids**	(4) **Current kids**	(5) **Knowledge**
age	-0.043***	-0.043***	-0.043***	-0.043***	-0.042***
	(0.006)	(0.010)	(0.010)	(0.010)	(0.009)
inc_num	0.032***	0.032***	0.032***	0.032***	0.033***
	(0.007)	(0.009)	(0.009)	(0.009)	(0.010)
attractiveness		0.297***	0.321***	0.495***	0.295***
		(0.074)	(0.067)	(0.097)	(0.083)
Want marr × attr.		0.0798			
		(0.085)			
Want kids × attr.			0.069		
			(0.126)		
No kids × attr.				-0.199**	
				(0.098)	
Knowledge × attr.					0.073
					(0.085)
Observations	8,080	8,080	8,080	8,080	7,800
R-squared	0.490	0.490	0.490	0.491	0.487

Robust standard errors in parentheses, clustered by rater

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

Appendix C

Appendix for Chapter 3

C.1 Theory Appendix

Before EC, the share of women who have an unwanted pregnancy is:

$$q \cdot \left(\int_{\underline{B}}^{-A} \int_{q \cdot A}^{\bar{S}} g(S, B) dS dB + \int_{-A}^{0} \int_{-q \cdot B}^{\bar{S}} g(S, B) dS dB \right).$$

The fraction of women who have an abortion before EC is introduced is:

$$q \cdot \int_{\underline{B}}^{-A} \int_{q \cdot A}^{\bar{S}} g(S, B) dS dB.$$

After EC is available, the model described in section 3.2 makes four predictions. First, it predicts that the share of women who have sex will unambiguously rise. The share of women who have sex after the introduction of EC is:

$$\int_{\underline{B}}^{-A} \int_{c-q'\cdot A}^{\bar{S}} g(S,B)dSdB + \int_{-A}^{\frac{c}{q'-q}} \int_{c-q'\cdot B}^{\bar{S}} g(S,B)dSdB$$
$$+ \int_{\frac{c}{q'-q}}^{0} \int_{-q\cdot B}^{\bar{S}} g(S,B)dSdB + \int_{0}^{\bar{B}} \int_{0}^{\bar{S}} g(S,B)dSdB.$$

This share is unambiguously larger than the share before EC, $\gamma\left(q\right)$.

Note also that as c increases, the share of women having sex decreases, because the derivative is given by:

$$\begin{aligned} &- \int_{\underline{B}}^{-A} g(c-q'\cdot A,B)dB - \int_{-A}^{\frac{c}{q'-q}} g(c-q'\cdot B,B)dB \\ &+ \frac{1}{q'-q}\left(\int_{-\frac{cq}{q'-q}}^{\bar{S}} g(S,\frac{c}{q'-q})dS - \int_{-\frac{cq}{q'-q}}^{\bar{S}} g(S,\frac{c}{q'-q})dS\right) = \\ &- \int_{\underline{B}}^{-A} g(c-q'\cdot A,B)dB - \int_{-A}^{\frac{c}{q'-q}} g(c-q'\cdot B,B)dB < 0. \end{aligned}$$

Second, the model predicts that the share of women who become pregnant after EC may rise or fall. The share of women who become pregnant once EC is available is:

$$q\cdot\left(\int_{\frac{c}{q'-q}}^{0} \int_{-q\cdot B}^{\bar{S}} g(S,B)dSdB + \int_{0}^{\bar{B}} \int_{0}^{\bar{S}} g(S,B)dSdB\right) +$$
$$q'\cdot\left(\int_{\underline{B}}^{-A} \int_{c+q'\cdot A}^{\bar{S}} g(S,B)dSdB + \int_{-A}^{\frac{c}{q'-q}} \int_{c-q'\cdot B}^{\bar{S}} g(S,B)dSdB\right).$$

For this number to be lower than the number of pregnancies before EC, EC must lower the number of unwanted pregnancies. (EC has no effect on the number of wanted pregnancies.)

The number of unwanted pregnancies will fall only if:

$$\frac{q'}{q} < \frac{\int_{\underline{B}}^{-A} \int_{qA}^{\bar{S}} g(S,B)dSdB + \int_{-A}^{\frac{c}{q'-q}} \int_{-qB}^{\bar{S}} g(S,B)dSdB}{\int_{\underline{B}}^{-A} \int_{c+q'A}^{\bar{S}} g(S,B)dSdB + \int_{-A}^{\frac{c}{q'-q}} \int_{c-q'B}^{\bar{S}} g(S,B)dSdB} < 1,$$

that is, only if the effectiveness of EC surpasses the number of added sexual encounters it generates.

When the price of EC rises, the impact on pregnancies is given by the following expression:

$$-q' \cdot \left(\int_{\underline{B}}^{-A} g(c+q' \cdot A, B)dB + \int_{-A}^{\frac{c}{q'-q}} g(c-q' \cdot B, B)dB \right)$$
$$\frac{1}{q'-q} \cdot \left(-q \int_{-\frac{cq}{q'-q}}^{\bar{S}} g(S, \frac{c}{q'-q})dS + q' \int_{-\frac{cq}{q'-q}}^{\bar{S}} g(S, \frac{c}{q'-q})dS \right) =$$
$$-q' \cdot \left(\int_{\underline{B}}^{-A} g(c+q' \cdot A, B)dB + \int_{-A}^{\frac{c}{q'-q}} g(c-q' \cdot B, B)dB \right) + \int_{-\frac{cq}{q'-q}}^{\bar{S}} g(S, \frac{c}{q'-q})dS.$$

Third, the model predicts that the share of women who have an abortion may rise or fall. The share of women who have an abortion after EC is introduced is:

$$q' \cdot \int_{\underline{B}}^{-A} \int_{c+q' \cdot A}^{\bar{S}} g(S,B)dSdB.$$

This number may be larger or smaller than the number of abortions without EC. Abortion will only decrease if:

$$\frac{q'}{q} < \frac{\int_{\underline{B}}^{-A} \int_{qA}^{\bar{S}} g(S,B)dSdB}{\int_{\underline{B}}^{-A} \int_{c+q'A}^{\bar{S}} g(S,B)dSdB} < 1.$$

For an increase in the price, the comparative statics are much simpler and indicate that a lower price of EC will increase abortions since the derivative is given by:

$$-q' \cdot \int_{\underline{B}}^{-A} g(S, c + q' \cdot A) dS < 0.$$

Expansions of access to EC will unambiguously increase the number of abortions as long as abortions are more expensive than EC. On the one hand, the availability of EC induces more women to have sex. Some of these women are those who would want an abortion if EEC fails, and thus the availability of EC reduces the abortion rate. When the cost of EC (c) decreases, this second effect is not present. Based on the assumptions of the model, all women who were previously pursuing abortion were already consuming EC. Thus the only effect of a decrease in c is to increase the number of women who use EC. And, because EC is not foolproof, for some women, EC will fail and lead to more abortions. This result would not hold if, for some women, abortion is actually cheaper than EC, in which case, the effect of lowering c would be ambiguous again.

Finally, the model predicts that the number of births may rise or fall. Births will fall if:

$$\frac{q'}{q} < \frac{\int_{-A}^{\frac{c}{q'-q}} \int_{-qB}^{\bar{S}} g(S, B) dS dB}{\int_{-A}^{\frac{c}{q'-q}} \int_{c-q'B}^{\bar{S}} g(S, B) dS dB} < 1$$

An expansion of access will also have an uncertain impact since the derivative is given by:

$$-q' \cdot \int_{-A}^{\frac{c}{q'-q}} g(c - q' \cdot B, B) dB + \int_{-\frac{cq}{q'-q}}^{\bar{S}} g(S, \frac{c}{q'-q}) dS$$

C.2 Appendix Tables

Table C.1: Effect of EC-Related Laws on Natality Using Annual Data

Dep. Variable:	Logarithm of births				Birth per 1,000 women			
Sample:	(1) All women	(2) Under age 18	(3) Aged 18-30	(4) Aged 30 plus	(5) All women	(6) Under age 18	(7) Aged 18-30	(8) Aged 30 plus
	A: State Law Changes, 1995-2006							
Passed ED-Access Law	- 0.003	- 0.017	- 0.001	0.003	0.378	0.148	1.276	0.144
	(0.010)	(0.021)	(0.010)	(0.018)	(0.520)	(0.484)	(1.006)	(0.311)
Passed Pharmacy-Access Law	0.012	0.003	0.024**	0.005	1.104*	0.760*	2.480**	0.350
	(0.011)	(0.022)	(0.009)	(0.017)	(0.577)	(0.425)	(1.216)	(0.332)
Mean of Outcome	78,898	3,234	51,095	24,564	52.04	20.01	104.36	27.23
R^2	0.999	0.999	0.999	0.999	0.988	0.995	0.991	0.996
	B: FDA Policy Change, 2004-2008							
No ED-Access Law × Post FDA	0.003	0.011	0.003	- 0.008	- 0.418	- 0.161	- 1.138	- 0.364
	(0.013)	(0.022)	(0.014)	(0.020)	(0.434)	(0.411)	(0.808)	(0.292)
No Pharmacy-Access Law × Post FDA	- 0.010	0.010	- 0.022	0.006	- 0.884	- 0.701	- 1.941	- 0.261
	(0.019)	(0.023)	(0.015)	(0.030)	(0.614)	(0.419)	(1.464)	(0.354)
Mean of Outcome	84,151	3,475	54,951	25,720	52.74	20.56	106.39	26.96
R^2	0.999	0.999	0.999	0.999	0.981	0.993	0.986	0.995

Note: For panel A, N = 612 and for panel B N=574. Standard errors in parentheses are robust to auto-correlation between observations from the same state. State fixed effects, year fixed effects, and state linear time-trends not shown. The sample consists of year-by-state counts of all births in the first four columns and of births per 1,000 women in the last four columns. The second panel excludes states which changed their legislation such that births in 2006-2008 would have been affected.

* statistically significant at 10% level, ** statistically significant at 5% level.

Table C.2: Effect of EC-Related Laws on Abortions Using Rates

Dependent Variable: Abortions per 1000 women in given age group

Sample:	(1) All Women	(2) Under age 20	(3) Aged 20-29	(4) Aged 30 plus
	A: State Law Changes, 1995-2005			
Passed ED-Access Law	-0.096	-0.220	-0.386	-0.188
	(0.433)	(0.597)	(1.093)	(0.145)
Passed Pharmacy-Access Law	0.190	-0.043	0.152	0.046
	(0.252)	(0.429)	(0.890)	(0.082)
Mean of Outcome	12.591	15.278	27.821	5.434
R^2	0.982	0.975	0.980	0.983
N	505	498	503	503
	B: FDA Policy Change, 2004-2008			
No ED-Access Law × Post FDA	0.506	0.732	2.319	0.519
	(1.293)	(1.652)	(1.644)	(0.313)
No Pharmacy-Access Law × Post FDA	0.165	0.280	-1.038	-0.316
	(1.227)	(1.443)	(1.408)	(0.302)
Mean of Outcome	10.753	13.057	23.717	4.515
R^2	0.960	0.951	0.960	0.957
N	448	441	445	445

Note: Standard errors in parentheses are robust to auto-correlation between observations from the same state. State fixed effects, year fixed effects, and state linear time-trends not shown. The sample consists of year-by-state totals of all abortions, estimated by the CDC. The second panel excludes states that changed their legislation between 2006 and 2008.

* statistically significant at 10% level, ** statistically significant at 5% level.

Table C.3: Effect of EC-Related Laws without Linear Time Trends

Dependent Variable: Births or abortions per 1,000 for the given sample				
	(1)	(2)	(3)	(4)
Outcome:	Natality	Natality	Abortion	Abortion
Sample:	All women	Ages 18-30	All women	Ages 20-29
	A: State Law Changes, 1995-2006			
Passed ED-Access	- 0.339	- 1.054	-0.322	-0.573
Law	(0.545)	(1.006)	(0.403)	(0.985)
Passed Pharmacy-	-0.732*	-3.552**	0.947	0.457
Access Law	(0.383)	(0.663)	(0.608)	(1.161)
Mean of Outcome	52.035	104.355	11.074	24.351
R^2	0.957	0.961	0.965	0.963
N	612	612	505	503
	B: FDA Policy Change, 2004-2008			
No ED-Access	0.399	0.067	-0.544	-2.644**
Law × Post FDA	(0.995)	(1.916)	(0.714)	(1.012)
No Pharmacy-Access	0.632	4.636*	0.190	2.678**
Law × Post FDA	(1.338)	(2.557)	(0.775)	(1.259)
Mean of Outcome	52.737	106.393	10.473	22.748
R^2	0.939	0.940	0.910	0.911
N	574	574	448	445

Note: Standard errors in parentheses are robust to auto-correlation between observations from the same state. State and year-month fixed effects not shown. The sample consists of month-by-state counts of all births. The second panel excludes states which changed their legislation such that births in 2006-2008 would have been affected.
* statistically significant at 10% level, ** statistically significant at 5% level.

Table C.4: Effect of EC-Related Laws by Type of Law

Dependent Variable: The logarithm of births, abortions or sexual assault for the given sample

	(1)	(2)	(3)
Outcome:	Natality	Abortion	Sexual Assaults
Sample:	Ages 18-30	Ages 20-29	All Women
	A: State Law Changes, 1995-2006		
Passed ED-Access Law	0.002	-0.034	0.050*
	(0.008)	(0.071)	(0.029)
Passed Pharmacy-Access Law, Collaborative	0.02**	-0.038	-0.071*
	(0.009)	(0.082)	(0.037)
Passed Pharmacy-Access Law, Protocol	0.025**	0.038	-0.117*
	(0.010)	(0.109)	(0.060)
R^2	0.999	0.988	0.995
N	7,344	503	561
	B: FDA Policy Change, 2004-2008		
No ED-Access Law X Post FDA	- 0.007	-0.066	0.044
	(0.011)	(0.105)	(0.051)
No Pharmacy-Access Law–Collaborative × Post FDA	-0.031**	0.117	0.035
	(0.012)	(0.079)	(0.075)
No Pharmacy-Access Law–Protocol × Post FDA	0.003	0.232**	- 0.021
	(0.010)	(0.108)	(0.041)
R^2	0.999	0.986	0.994
N	6,888	445	585

Note: Standard errors in parentheses are robust to auto-correlation between observations from the same state. State fixed effects and month fixed effects not shown. The sample consists of month-by-state counts of all births. The second panel excludes states which changed their legislation such that births in 2006-2008 would have been affected.

* statistically significant at 10% level,
** statistically significant at 5% level.