The Impact of Emergency Contraception on Dating and Marriage

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Abstract

I study the effects of improvements in contraception on premarital sexual behavior, pregnancy, and marriage. I develop a model where individuals date before marrying in order to learn about relationship quality. While dating, individuals face the risk of pregnancy or contracting a sexually-transmitted infection (STI). The model predicts that contraceptive improvements increase the number of sexual partners, increase sexual acts, increase STI rates, and, under certain conditions, delay marriages and lower single motherhood rates. I use changes in states' over-the-counter (OTC) sales policies for emergency contraception as a natural experiment in varying access to contraceptive technology. Using multiple sources of data on birth rates, STIs, marriages, and sexual activity, I confirm the predictions of the model and find that OTC policies have a significant impact on sexual behavior and relationships.

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1 Introduction

One of the biggest changes in marriage and dating over the past 100 years has been the rapid advancement in contraceptive technology. In the early 1900s, sexual activity was largely unprotected and carried substantial risk of unwanted pregnancies. The number of premarital sexual partners was much lower and people married at younger ages. In the past 50 years, several forms of new and better contraceptive devices have become available. Better condoms, the birth control pill, the sponge, the diaphragm, intrauterine devices, and emergency contraception have all played a role in making sex a much less risky proposition. How these technological improvements have improved men and women's lives has been an active topic of research.

This paper makes two contributions to the literature on contraception. First, it provides a theoretical analysis of how improvements in contraception should impact women's sexual and marital decisions. This highlights how access to effective contraception influences individual's incentives when in relationships. Second, the paper empirically investigates how changes in contraceptive access stemming from the introduction of emergency contraception influence dating and sexual behavior. Most previous work has studied the introduction of the birth control pill which, unfortunately for researchers, occurred during a period of much more limited data collection. Studying a more recent change in contraceptive access allows me to study a broad range of outcomes including levels of sexual activity and the number of sexual partners, as well as more well-studied outcomes such as marriage and fertility rates.

I study the role of contraception in a dynamic model of sexual behavior, dating, and learning. The model has several testable predictions about how changes in contraceptive access affect dating and marriage. While dating, individuals learn about match quality and make decisions about sex, marriage, and ending a relationship. Sexually active relationships are faced with STI and pregnancy risks. Contraceptive availability influences the risk of pregnancy. Following a premarital pregnancy, a woman can have an abortion, become a single mother, or have a shotgun wedding. Her choice will depend on her beliefs about the quality of her current relationship.

As contraceptive technology improves, the marginal cost of additional sex declines and so sexual activity increases. Better contraception also increases the value of dating, particularly in the early stages of relationships where people are the most uncertain about match quality and the cost of a premarital pregnancy is much greater. Better contraception also makes dating more attractive relative to marriage. Relationships are less likely to become marriages and more likely to break up. The total number of sexual partners and sexual activity with one partner should increase when contraception improves. This in turn increases rates of STI infection.

Changes in contraceptive access can either raise or lower single motherhood rates or abortion rates depending on model parameters. As contraception improves, pregnancy becomes less likely from any one sexual encounter, but the total number of sexual encounters will also increase because sex is less costly. There is no *a priori* way to sign the change in the total number of unplanned pregnancies. The impact of contraceptive access on single motherhood is an empirical question.

The model predicts that changes in contraception will change average marriage ages, although the direction depends on model parameters. There are offsetting effects. People are less likely to marry one partner and less likely to have a premarital pregnancy. Both of these forces delay marriages. Simultaneously, dating relationships end more frequently and people seek out more premarital relationships. Having more potential mates decreases the time until a woman finds a man worth marrying. Like single motherhood, the impact of contraception on marital timing is an empirical question.

The model's predictions are used to motivate my empirical investigation into the importance of over-the-counter access (OTC) to emergency contraception on sexual behavior and relationships. Emergency contraception (Plan-B, or the Morning-After Pill, here abbreviated EC) is an oral contraceptive that may be taken up to 72 hours following intercourse to prevent pregnancy. The drug is, more-or-less, a quadruple dosage of one conventional birth control pill. EC has been a source of a large amount of political controversy. Conservative groups have argued that it is effectively an abortifacient drug, eliminating a fertilized egg, and thus access should be heavily regulated. Ease of access to EC has therefore differed drastically across states and over time. EC was not FDA-approved until mid-1998, and following that approval, states' legislatures took different approaches in legislating access to emergency contraception, from allowing pharmacists to refuse sales to requiring parental consent or disallowing insurance coverage. Probably the most important of these in practical importance is whether a woman needs to obtain a prescription before purchasing EC. With such a small window of drug effectiveness, prescription requirements can be quite onerous, especially if most sexual encounters occur on the weekends. Women may be unable to get to a doctor's office quickly or cheaply, thus diminishing the advantages of having EC available.

My empirical estimation uses variation in the timing of when states adopted an OTC policy. In the years following FDA approval of EC, nine states chose to legislate OTC access to EC. These states may have chosen to pass OTC policies due to underlying trends in sexual behavior specific to these states. To overcome these endogeneity concerns, I also use the fact that in mid-2006, the FDA approved OTC access to EC for women aged 18 and older in the other 41 states. By comparing outcomes before and after these policy changes, I estimate the impact of OTC access to EC and evaluate the theoretical predictions of my model.

Using this variation in OTC access and data from several different sources, I find results consistent with the theoretical predictions and that the passage of OTC access has been important in changing a wide range of sexual and dating behavior. To summarize my results, I find that OTC access to emergency contraception lowers single motherhood birth rates by approximately 3 births per 1,000 women, increases STI rates by 125 incidences per 100,000 women, increases lifetime sexual partners by 1.5 people, and decreases cohort marriage rates for young women by 5 percent.

The magnitudes of the empirical estimates on lower birth rates are slightly larger but significantly consistent with back-of-the-envelope calibrations using both reported sales data and survey data on EC usage during the time period. However, the results are significantly larger than simulated estimates generated from the model.

This work contributes to many ongoing literatures in economics and demography. There have been several studies analyzing how the introduction of the birth control pill in the 1960s affected women's career decisions and fertility. Goldin and Katz (2002) is the seminal paper in this literature, using variation in access by state and cohort in the introduction of the pill to study how women's careers and family planning changed after the pill was introduced. Bailey (2006) finds that better access to the pill reduced early fertility and increased labor force participation. Ananat and Hungerman (2008) find evidence that the pill had a larger impact on households of above average socioeconomic characteristics who had the most to gain from retiming births and investing more in human capital. Guldi (2008) looks specifically at minors, again finding a large impact of the pill in reducing fertility. Oza (2009) is the most similar paper to mine, as she also uses variation in OTC access to EC to assess its impact on abortions and STI incidence. Using insurance claims data in the years before and after 2006, she finds that abortions significantly declined and STI rates increased in the states that were forced to adopt OTC policies by the FDA in 2006.

Two other notable papers on the impact of contraception on sexual behaviors are Akerlof et al. (1996) and Fernandez-Villaverde et al. (2009). Akerlof et al. model how the introduction of new contraception changes the bargaining power between men and women, and across different types of women, and how that can affect shotgun weddings and single motherhood. One striking finding is that women who do not wish to use contraception at all may be harmed by better contraception since it lowers their value relative to women who will use contraception. This makes it harder to extract promises to marry if a premarital pregnancy happens which could explain the decline in shotgun weddings and the rise of single mothers when birth control pills proliferated. Fernandez-Villaverde et al. model the role of intergenerational norm transmission and how the contraceptive environment plays an important role in shaping the sexual decisions of young people. A contribution of these papers is understanding how the equilibrium in the dating market changes in response to changing contraception technology. To contrast, this paper studies dating in a partial equilibrium setting and focuses on how contraception influences individual incentives and decisions.

This paper also adds to our understanding of the dynamics of the dating and marriage market.[1] Brien et al. (2006) present a model of dating and learning, similarly styled after

[1] Other work on dating markets has focused on the two-sided matching problem and stability of matches in both theory. Bloch and Ryder (2000), Smith (2006), Choo and Siow (2006) and others present different models of how relationships are formed in the presence of search frictions or different match specific production functions. In recent years, researchers such as Fisman et al. (2006), Fisman et al. (2008), and Hitsch

Jovanovic (1979). Their goals are to explain the dynamics between dating, cohabitation, marriage, and divorce and to explain stylized facts such as marriages that are preceded by cohabitation are more likely to result in a divorce, even conditional on demographics such as religiosity. Becker et al. (1977), Weiss and Willis (1997), and others discuss the importance of learning in households, usually focused on explaining divorce and household dissolution and how that factors into household bargaining.

The paper is organized as follows. Section 2 presents a model of dating, pregnancy, and contraception. Section 3 discusses the history of EC and OTC policies and my identification strategy. Section 4 summarizes the various data sources. Section 5 outlines the empirical strategy. Section 6 presents the estimated results, and section 7 concludes.

2 A model of dating and contraception

One of the primary reasons for dating and courting before marriage is for partners to learn about each other before committing to marriage. In this section, I model how this uncertainty affects individuals' courtship decisions. The learning process while dating is fundamentally similar to the well-studied problem of labor market learning; this model is styled after Jovanovic's (1979) model of labor match quality and turnover. As mentioned, Brien et al. (2006) present a similar model of the importance of learning in dating, cohabitation, and marriage, although they do not include decisions about sexual activity or focus on the role of contraception in couples' decisions.

Consider an individual who, having found a dating partner, is initially uncertain of

et al. (2010) have tried to directly measure dating preferences using data from speed dating experiments or online matchmaking sites.

match quality, so she must date for a while before she decides whether to marry her partner or separate and find a new match. She must also choose how much sexual activity to have, if any. Sex is risky, however, and a woman may become pregnant or contract an STI when having sex.

Every period the agent must make two decisions. First, she must decide the level of sexual activity she will have with her current partner. Second, she makes a decision about the next stage of the relationship given her current beliefs about the quality of the match and the realization of pregnancy shocks. If she is currently pregnant, she must choose between being a single mother, obtaining an abortion, or immediately having a shotgun wedding with her current partner. If she is not pregnant, she may choose to take one of three actions: marry her current partner, continue dating for at least one more period, or dump her partner and find a new match. I assume that marriages and single parenthood last forever and that there is a fixed search cost associated with leaving a relationship and finding a new partner.

The optimal amount of sexual activity trades off the utility from more sex with the increase in STI and pregnancy risk. Since the subsequent value of becoming pregnant depends on her beliefs about match quality, the optimal amount of sex will also depend on these beliefs. She will desire more sex from higher quality partners and from longer lasting relationships.

An agent's optimization over the learning process is characterized by thresholds in match quality. One threshold is between marriage and continuing to date. If she believes the current match is of high enough quality, she will opt out of dating and into marriage. Another threshold is between leaving her current relationship and continuing to date. If she believes the current relationship is bad enough and has a low likelihood of improving, then she will separate from her current match and start over and find a new partner. Finally, there are thresholds that describe how she responds to pregnancy. Depending on her beliefs about the match, she will choose to marry high quality partners, become a single mother with middling quality partners, and get an abortion with low quality partners.

2.1 Learning about match quality

When an individual begins dating, she receives a match of quality q drawn randomly from the pool of potential matches. Each period t in a relationship she receives utility from the match plus an idiosyncratic shock. She receives $q_t = q + \varepsilon_t$ where ε is an i.i.d. noise shock. I assume that both the uncertain match quality and the noise parameter are normal and drawn from the following distributions:

$$q \sim N(\mu_0, \sigma^2)$$
$$\varepsilon \sim N(0, \sigma_\varepsilon^2)$$

Let μ_t and σ_t^2 represent the mean and variance of the posterior on match quality as functions of the observed shock history at time t, $\{q_1, q_2, \ldots, q_t\}$. By Bayes' Rule, we know that the posteriors are normal at all times t with mean and variance

$$\mu_t = \sigma_t^2 \cdot \left(\frac{\mu_0}{\sigma^2} + \frac{\sum_{i=1}^t q_i}{\sigma_\varepsilon^2} \right)$$
$$\sigma_t^2 = \frac{\sigma^2 \sigma_\varepsilon^2}{t\sigma^2 + \sigma_\varepsilon^2}$$

The precision of the posterior increases linearly with t and agents become increasingly certain about the true match quality over time. The state variables (μ, t), the mean belief and relationship duration, are sufficient to describe the state of the relationship. I make an additional assumption that there is a time period T where a couple can no longer date; they must either marry or separate.[2]

2.2 Value of dating

While dating, an individual receives utility from their current partner equal to $(q+\varepsilon_t)$ where q is the true underlying quality of their match and ε_t is an i.i.d. noise shock. An individual immediately updates her beliefs about her partner's quality. She then faces three decisions this period. First, she must choose an amount of sex, s, to have. She enjoys sex, but having more sex increases the probability of becoming pregnant or contracting an STI. Let $v(s)$ be the utility she receives from an amount of sex s. For simplicity, allow s to be continuous. A woman may choose $s = 0$ and have a chaste relationship.

Let p denote the exogenous probability of pregnancy in any one sexual act. Assume that every sexual act creates an independent chance of becoming pregnant.[3] The probability of becoming pregnant in a period can be written as $Prob\{Pregnant\} \equiv g(s,p)$ which is a function of the amount of sexual activity and the probability of becoming pregnant in one act. Under the assumption of independence, $g(s,p)$ can be written

$$g(s,p) = 1 - (1-p)^s$$

How does the probability of pregnancy change with the level of sex and the act specific

[2]This assumption ensures that the value functions are bounded which guarantees existence and uniqueness. See Brien et al. (2006) for additional discussion.

[3]The timing of a woman's menstrual cycle makes this assumption unrealistic for short periods. It is more reasonable for periods longer than month so long as women are not using the calendar method of contraception.

pregnancy probability? Taking derivatives,

$$g_s = -\ln(1-p)\cdot(1-p)^s > 0$$
$$g_p = s(1-p)^{(s-1)} > 0$$
$$g_{sp} = (1-p)^{(s-1)}\,(1+s\cdot\ln(1-p)) \gtreqless 0$$

The probability of becoming pregnant in one period increases as the amount of sexual activity increases and as the probability of pregnancy in one act increases. It can be shown that $g_{ss} < 0$ and $g_{pp} < 0$, and so the probability is concave in both s and p.

The cross-derivative, g_{sp}, is unsigned and depends on the magnitudes of both s and p. For very large values of p and a given value of s, g_{sp} is large and negative. This implies that worse contraception (a rise in p) actually *decreases* the marginal cost of sex. Intuitively, if p increases to the point where a couple gets pregnant with almost certainty, then the marginal cost of additional sex is very low which encourages further sexual activity.

While $g_{sp} < 0$ is mathematically possible, it is clear that $g_{sp} > 0$ for any reasonable combination of s and p. The actual value of p is very small, even for unprotected sex and when p is small, $g_{sp} > 0$ given any realistic level of s. For instance, the medical literature estimates monthly fecundability for couples attempting to achieve pregnancy at around 0.16 with only one coital act during the six day window of fertility (see Potter and Millman). If a couple randomly has sex during one month, the implied pregnancy probability would be slightly below 4%.[4] For a value of $p = 0.04$, a couple would have to have sex over 4899 times in a year in order for g_{sp} to be negative, an average of around 13 times per day. Thus, I assume that $g_{sp} > 0$ for the rest of this paper.

[4]This number is also a conservative guess and would be much lower for couples using typical contraceptive regimes.

If r is the probability of contracting an STI during one sexual act, then the probability of contracting an STI in one period, denoted $h(s, r)$ is similarly

$$h(s, r) = 1 - (1 - r)^s$$

The cost of contracting an STI is a one-period treatment cost, R. For ease of exposition, I do not allow for the resolution of STI risk to provide additional information about the quality of the match. It is likely the case that not contracting an STI in the early stages of a relationship provides information about match quality and the probability of contracting an STI in later stages of a relationship. An alternative way to model STIs is to let the STI risk only matter in the first period of sexual activity. To conserve on notation, I instead allow STIs to occur independently over all dating periods.

Having made the decision about how much sex to engage in, she faces another decision after she learns whether or not she is pregnant. If she gets pregnant, she must either marry, abort and end the relationship, or become a single mother. If she does not get pregnant, she chooses one of three options: marry her current partner, continue dating, or end the relationship. If she ends the relationship, she is eventually matched with another partner from the random pool of potential dates.

The individual's value function while dating, given her posterior mean and length of relationship, (μ, t), is

$$D_t(\mu) = \max_s \Big\{ \mu + v(s) - h(s, r) \cdot R + g(s, p) \cdot \beta \int_{-\infty}^{\infty} \max\{M(\mu'), -A + \bar{D} - k, SP(\mu')\} dF_t(\mu'|\mu)$$
$$+ (1 - g(s, p)) \cdot \beta \int_{-\infty}^{\infty} \max\{(\bar{D} - k), M(\mu'), D_{t+1}(\mu')\} dF_t(\mu'|\mu) \Big\}$$

This is the expected period flow of the relationship, plus the value of sex, minus the expected STI costs, plus the expected value of next period's choices conditional on new information and the resolution of pregnancy risk. $M(\mu)$ and $SP(\mu)$ are the values of marriage and single parenthood, respectively. A is an individual specific cost of obtaining abortion. $\bar{D}$ is the expected value of starting a new dating relationship and k is the cost of being single and searching. $\bar{D}$ is constant with respect to any information about the current match, although $\bar{D}$ must be solved for in equilibrium, as it equals the expected value of dating given the prior on quality distribution in the economy. $F_t(\mu'|\mu)$ is the expected distribution of mean beliefs in period $t+1$ given an agent's current mean beliefs μ.

2.3 Value of marriage

As other papers, such as Goldin and Katz (2002), have shown, contraception may play an important role in the timing of childbearing within a marriage. The purpose of this model is to illustrate the impact of contraception on dating and courtship, so I abstract away from these issues here. I simplify first by assuming that marriage lasts forever.[5] I then model marriage as providing the value of $(a_m + b_m \cdot (q + \varepsilon_t))$ every period. This value includes the expected value of having sex and children with her current partner and abstracts away from within-marriage childbearing decisions. The constants a_m and b_m are scaling parameters that define the relative period value of being married to dating. An agent with posterior beliefs summarized by (μ, t) will have the expected value function

$$M(\mu) = \frac{a_m + b_m \cdot \mu}{1 - \beta}$$

[5] For details on how learning may influence divorce timing, see Becker et al. (1977), Weiss and Willis (1997), and Brien et al. (2006).

The scaling parameters, a_m and b_m, define the relative value of dating to marriage. Marriage adds a_m in value per period, regardless of the match quality. b_m scales how the match quality provides utility during a marriage. Letting $b_m > 1$ ensures that higher quality matches provide more utility in marriage than while dating.

2.4 Value of single parenthood

I also make simplifying assumptions about single parenthood. As with marriage, single parenthood is assumed to last forever. The quality of relationship prior to single parenthood matters for the mother. This is plausible as absent parents often continue to contribute to children's upbringing. Similar to marriage, I model single parenthood as providing the value of $(a_s + b_s \cdot (q + \varepsilon_t))$ every period, where a_s and b_s are again scaling constants. The expected value function is therefore

$$SP(\mu) = \frac{a_s + b_s \cdot \mu}{1 - \beta}$$

As with marriage, the scaling parameters define the relative value of single parenthood to marriage and dating. I assume that the parameters a_m, b_m, a_s, and b_s satisfy two single crossing properties. First, single parenthood is preferred to marriage for some matches, but this preference ordering switches for higher quality matches. Second, dating is preferred to single parenthood for all values of match quality.

2.5 Value of abortion

If a pregnant never-married mother wishes to abort her pregnancy, she must pay a fixed cost of A immediately. A encompasses all the costs of abortion, including financial bills and any psychological costs. For simplicity, I assume that women who receive an abortion also terminate their relationship immediately and become single women again.

2.6 Optimal sexual activity

I now characterize how much sex a woman chooses to have and how that depends on the state of the relationship and the contraceptive regime. For notational simplicity, define the expected value of becoming pregnant and the expected value of not becoming pregnant as, respectively,

$$EV_{p,t}(\mu) = \beta \int_{-\infty}^{\infty} \max\{M(\mu'), -A + \bar{D} - k, SP(\mu')\} dF_t(\mu'|\mu)$$
$$EV_{np,t}(\mu) = \beta \int_{-\infty}^{\infty} \max\{(\bar{D} - k), M(\mu'), D_{t+1}(\mu')\} dF_t(\mu'|\mu)$$

Neither of these expected values depend on the level of sexual activity this period as they are conditional on the realization of the pregnancy shock. The value of dating can then be written as

$$D_t(\mu) = \max_s \{\mu + v(s) - h(s,r) \cdot R + g(s,p) \cdot EV_{p,t}(\mu) + (1 - g(s,p)) \cdot EV_{np,t}(\mu)\}$$

The FOC of this problem is

$$v_s \leq h_s \cdot R + g_s \left(EV_{np,t}(\mu) - EV_{p,t}(\mu)\right) \qquad \text{(with equality if s > 0)}$$

If she has any sex, then the marginal benefit of sex must equal the marginal cost of sex which includes the additional expected cost of an STI and the additional expected cost of becoming pregnant.

It is straightforward to show how the level of sexual activity changes with the state of the relationship, which is summarized in the following proposition:

Proposition 2.1

1. $\frac{\partial s}{\partial \mu} > 0$*: Sexual activity increases with the quality of a relationship.*
2. $\frac{\partial s}{\partial t} > 0$*: Sexual activity increases with the length of the relationship.*
3. $\frac{\partial s}{\partial p} < 0$*: Sexual activity increases with better contraceptive access.*

Proof See Technical Appendix for proof.

Even without complementarities between relationship quality and the utility from sex, sexual activity increases in better and longer relationships. The cost of pregnancy is declining in both the quality and length of a relationship. Getting pregnant with a high quality partner is not as bad as a pregnancy with a poor quality partner. Better contraception decreases the marginal cost of additional sex which leads to increased sexual activity.

2.7 Optimal relationship timing

Let $s_t^*(\mu; p)$ be the optimal value of sexual activity as a function of the state of the relationship. Substituting this optimal value into the dating value function gives

$$\begin{aligned} D_t(\mu) =& \mu + v(s_t^*(\mu;p)) + h(s_t^*(\mu;p), r) \cdot R \\ &+ g(s_t^*(\mu;p), p) \cdot \beta \int_{-\infty}^{\infty} \max\{M(\mu'), -A + \bar{D} - k, SP(\mu')\} dF_t(\mu'|\mu) \\ &+ (1 - g(s_t^*(\mu;p), p)) \cdot \beta \int_{-\infty}^{\infty} \max\{(\bar{D} - k), M(\mu'), D_{t+1}(\mu')\} dF_t(\mu'|\mu) \end{aligned}$$

For notational ease, define $\tilde{h}_t(\mu, p, r) \equiv h(s_t^*(\mu;p), r)$ and $\tilde{g}_t(\mu, p) \equiv g(s_t^*(\mu;p), p)$, and we can rewrite the dating value function as

$$\begin{aligned} D_t(\mu) =& \mu + \tilde{h}_t(\mu, p, r) \cdot R + \tilde{g}_t(\mu, p) \cdot \beta \int_{-\infty}^{\infty} \max\{M(\mu'), -A + \bar{D} - k, SP(\mu')\} dF_t(\mu'|\mu) \\ &+ (1 - \tilde{g}_t(\mu, p)) \cdot \beta \int_{-\infty}^{\infty} \max\{(\bar{D} - k), M(\mu'), D_{t+1}(\mu')\} dF_t(\mu'|\mu) \end{aligned}$$

The solution is characterized by several thresholds at any time t. First, there is a threshold, $\bar{\mu}_t$, where an individual is indifferent between marrying and continuing to date given her posterior mean and the length of her relationship. This threshold satisfies:

$$M(\bar{\mu}_t) = D_{t+1}(\bar{\mu}_t)$$

Another threshold, $\underline{\mu}_t$, is the value of the posterior mean where an individual is indifferent between continuing the relationship and starting over with a new partner of unknown quality.

This threshold satisfies:

$$D_{t+1}(\underline{\mu}_t) = \bar{D} - k$$

Combining these two thresholds defines the expected value of not being pregnant:

$$EV_{np,t}(\mu) = \beta(\bar{D} - k)F_t(\underline{\mu}_t|\mu) + \beta \int_{\underline{\mu}_t}^{\bar{\mu}_t} D_{t+1}(\mu)dF_t(\mu'|\mu) + \beta \int_{\bar{\mu}_t}^{\infty} M(\mu')dF_t(\mu'|\mu)$$

Graphically, the next period value function of not being pregnant is the upper envelope of dating, separating, or marriage, as shown in Figure 1.

There are also thresholds that characterize how a woman responds to a premarital pregnancy. These thresholds depend critically on the individual cost of abortion. First, consider a woman who treats abortion as so costly that she will never get an abortion. For such a woman, single parenthood and marriage are always preferred to abortion. There will be a threshold of relationship quality that makes her indifferent between marriage and single parenthood. If we denote this threshold μ_t^* then the threshold satisfies

$$SP(\mu^*) = M(\mu^*)$$

Using the value of marriage and single parenthood, we can solve for this threshold directly:

$$\mu^* = \frac{a_s - a_m}{b_m - b_s}$$

This threshold does not depend on the length of the relationship nor the probability of pregnancy p.

How would this change if we studied women who would possibly choose abortion? Let μ_A denote the threshold in relationship quality where a woman is indifferent between either marriage or single motherhood. This threshold satisfies

$$\bar{D} - k - A = \max\{M(\mu_A), SP(\mu_A)\}$$

The value functions denoting the choices between abortion, single parenthood, and marriage are graphed in Figure 2a for women who personally find abortion too costly of an option to ever consider. In Figure 2b we see the value functions for a women who would consider abortion and so $A_2 < A_1$. As the cost of abortion falls, there will be fewer and fewer women who elect to become single mothers because women in the poorest quality relationships have the greatest incentive to obtain an abortion. Of course, as A falls even further, women will elect to receive abortions instead of marriage as well. The distribution of the cost of abortion in the population will play a critical role in how women handle premarital pregnancies.

Having defined the thresholds that characterize the optimal policies as functions of the relationship quality and duration, I now derive properties of these thresholds. Lemma 2.2 summarizes key results for the policies when a woman is not pregnant.

Lemma 2.2 *The value of dating and thresholds of marriage and separation have the following properties:*

1. *The value of dating is declining in relationship length for any mean beliefs, or,* $D_t(\mu) > D_{t'}(\mu)\ \forall \mu, t, t'$ *where* $t < t'$.

2. *The threshold between marriage and dating is declining in the length of the relationship:* $\bar{\mu}_t > \bar{\mu}_{t+1}$.

3. *The threshold between separating and continuing to date is increasing in the length of the relationship:* $\underline{\mu}_t < \underline{\mu}_{t+1}$.

Proof See Technical Appendix.

As relationships age, partners become increasingly certain of the true match quality. Increased certainty lowers the value of additional learning and so the value of continuing to date decreases over time and the relative value of both marriage and separation increases. This result is shown graphically in Figure 3, which plots the marriage and separation thresholds over the space of relationship lengths and mean quality beliefs. We can see that the range of acceptable dating beliefs narrows as relationships age. Long-lasting dating relationships thus exhibit a form of survivorship truncation; the couple was neither so happy as to marry, nor so unhappy as to break up.

The policy thresholds following a premarital pregnancy are plotted in Figure 4. By the assumption that marriage and single parenthood are absorbing states and the risk neutrality with respect to match specific utility in these states, these thresholds are invariant to relationship length. Optimal policies are plotted for two types of women. In panel (a) thresholds are plotted for a woman with a high cost of abortion. For her, she will generally prefer to either marry or become a single mother. Only for very low quality matches will she choose abortion. Panel (b) shows the thresholds for a woman with a low cost of abortion. Given this low cost, abortion dominates single parenthood for her. Only for sufficiently high quality matches will she choose marriage.

Figure 5 plots both sets of thresholds for a woman with a high enough abortion cost such that she prefers single motherhood for a range of matches. The survivorship truncation has important implications for the relationship between relationship length and how a woman responds to a premarital pregnancy. Any relationship lasting longer than t^A will be of high enough quality that a premarital pregnancy will never result in an abortion, and if a relationship lasts longer than t^*, then any premarital pregnancy will always result in marriage. Lousy couples separate quickly, so longer lasting relationships tend to be of sufficiently high quality that marriage is increasingly likely following a premarital pregnancy.

2.8 Improvements in contraception

What happens when contraceptive technology improves (i.e., p falls)? Dating becomes more valuable, especially in the early stages of a relationship. A woman will be less willing to marry and more willing to separate. This increases the churn in the dating market and increases both the number of lifetime sexual partners and the sexual activity within a relationship.

To describe the impact contraception has on relationship timing, let $\bar{M}(t)$ be the cumulative probability of having married within one relationship by time t and $\bar{S}(t)$ be the cumulative probability of having separated. Since information is fully revealed at date T and no one chooses to date following that time, then $\bar{M}(T) + \bar{S}(T) = 1$. The following proposition then summarizes the impact of better contraception:

Proposition 2.3 *When birth control technology improves and p falls, the following occurs:*

1. *$\bar{S}(t)$ increases for all t: the probability of having separated at all ages of a relationship increases.*

2. *$\bar{M}(t)$ decreases for all t: the probability of a relationship resulting in marriage by time t declines.*

3. *The number of premarital partners increases.*

Proof See Appendix.

Since contraception determines the probability of pregnancy while dating, it follows that dating becomes increasingly valuable as contraceptive quality improves. Further, this increase in the value of dating is specifically concentrated at the early stages of relationships. That is, pregnancy risks have greater potential losses at the beginning of dating than in long-lasting relationships. The intuition for this result comes from the survivorship bias in long-lasting relationships. The value of a long relationship is close to that of marriage. Since the result of a pregnancy shock in long relationships is to marry, there is therefore not much lost for a long-lasting relationship that experiences an unplanned pregnancy. Newer relationships face greater uncertainty and a woman stands to lose more by getting pregnant.

This increased value in dating following contraceptive improvements leads to two important model predictions (summarized in Figure 6). First, people will be less willing to marry at every stage of a relationship. Dating increases in value relative to marriage and so the demand for marriage decreases. This implies the probability of marrying in one particular relationship is lower. Matches have to be of much higher quality before people are willing to commit to marriage.

The second important result is that people are more willing to end current relationships and start new ones. As the decline in pregnancy risk is more valuable in the early stages of relationships, new relationships become more desirable. The model therefore predicts that improvements in contraception will increase relationship turnover. In every relationship, a woman is more likely to find a new partner, so it follows that the number of lifetime sexual partners will increase.

The direction of how contraceptive access changes the single motherhood rate or the abortion rate depends on the parameters. I argue that this is a feature of any good model of contraceptive change because the improvements in contraception will have two offsetting effects. The first, which I call a 'technological' effect, is the direct effect of the lower risk of a pregnancy through improved efficacy. The second effect, that I call 'behavioral', is that women will respond to this change in incentives by increasing their sexual activity. Although the probability of pregnancy in *any one* sexual act has declined, the overall pregnancy rate may increase if the *total number* of sexual acts increases more than proportionately. In short, the impact on pregnancy during dating depends on the elasticity of sexual behavior with respect to contraceptive improvements.

We can see these effects in this model as well. A decline in p clearly lowers the probability of any relationship experiencing an unplanned pregnancy. However, this improvement in contraception is met by a change in dating and sexual behavior whereby women spend a greater portion of their life in the 'at-risk' phase for single motherhood. Better contraception increases the number of sexual partners, and, further, increases the time spent in new relationships. And newer relationships are more likely to become single parents following a premarital pregnancy. Although contraceptive technology is now better, men and women are having more, risky sex so the model does not make any predictions about how single motherhood rates should change. We will have to let the data answer that question.

I also cannot use the model to say how the age of first marriage changes as contraceptive technology improves. As women meet more potential matches, the probability that they meet one worth marrying increases. In forming the average age of first marriage, there are offsetting forces. For one relationship, the time until marriage falls because women demand higher quality relationships before they commit. However, there are many more relationships with better contraception.

I now briefly summarize the predictions of the model, which I will evaluate in the following sections.

- The probability of a premarital pregnancy resulting in abortion is declining in relationship length.
- The probability of a premarital pregnancy resulting in single motherhood is declining in relationship length.
- Improvements in contraceptive technology:
  - Increases the number of sexual acts
  - Increases STI rates
  - Increases the number of sexual partners
  - Uncertain impact on single motherhood rates and marriage rates

3 The introduction of Emergency Contraception

Emergency contraception (EC), or the Morning-After Pill, or Plan-B, is a contraceptive drug that can be taken up to 72 hours after sexual intercourse to prevent pregnancy. Although the medical technology behind EC has existed for several decades (it is, more or less, a quadruple dosage of regular birth control pills), Plan-B was only FDA-approved for sale in the U.S. in mid-1998. The delay in approval is largely attributed to a public debate about whether post-coital contraception was equivalent to abortion.

The debate was divided enough that following FDA approval states adopted differing stances in restricting access to EC. Typically following red-blue political lines, states adopted a wide range of public policies and regulations post-1998 which either improved or reduced the ease of access to EC. Such policies include: allowing EC to be purchased over-the-counter (OTC), granting pharmacists the right to refuse sale of EC, requiring emergency rooms to inform sexual assault victims about EC, requiring pharmacists to carry and sell EC, and whether EC is covered by Medicaid family planning provisions.

This variation in state-level policies surrounding the introduction of Plan-B provides a quasi-experimental setting that can be used to investigate the impact of improved contraception on sexual behavior and single motherhood. The political debate around EC and subsequent differing stances in state-level policy provide a valuable tool for investigating the change in behavior following changes in contraceptive access. In particular, nine states allowed Plan-B to be sold by pharmacists OTC to women without a doctor's prescription. These nine states adopted their OTC laws in different years, with Washington being the first in 1998, and Vermont's bill going into law in 2006. See Table 1 for details on each state's passage of OTC. The passage of these laws was typically the result of advocacy among liberal and pro-choice groups. Nationally, efforts to mandate OTC access for EC were led by Planned Parenthood and supported by a range of medical and policy professionals. Most notably the American Medical Association has been a supporter of OTC access since 2000. Opponents to OTC access were usually conservative and family political groups. Conservative politicians in both national and more local settings have been outspoken about declaring EC an abortifacient and wanting to regulate and limit access.

By mid-2006, OTC legislation had been introduced in most of the other 41 states and was either pending in state legislatures or had been voted down. But the FDA forced the hands of the other 41 states in late 2006, approving OTC access to EC nationally for women 18 and older. Subsequently, since 2006 any adult woman could purchase EC without a prescription.[6]

Emergency contraception is inexpensive, with prices as low as $5 per dose in some states, and EC could be a cost-minimizing choice of contraception for women who are both rarely sexually active and lacking health insurance. For such women, purchasing the pill may be too expensive, given that she only needs the benefits of the pill relatively rarely. EC may be a far cheaper option to prevent pregnancy. EC is also effective, reducing the chances of pregnancy by 75%.[7] For example, if a woman had unprotected sex on a random day during her cycle, her chance of becoming pregnant would decline from 4% to 1% by taking EC. For additional details, see Trussell (2004).

The medical literature has studied how access to emergency contraception may change sexual behavior and pregnancy in randomized control trials. These studies vary access by providing EC to a treatment group in advance while control groups are either unable to obtain EC or must obtain it through a pharmacist. Examples include Glasier and Baird (1998) and Raymond et al. (2006). These studies generally find that advance provision of EC does not change women's usage of other contraceptive devices but may decrease abortions and unplanned pregnancies.

[6] A judge lowered the minimum age for OTC purchase from 18 to 16 in 2009.

[7] EC's efficacy is not directly comparable to other birth control regimes such as the pill or condoms due to measurement issues. For other regimes, efficacy is measured in annual failure rates which is the percent of women who follow a regime who get pregnant over a year. The medical literature uses survey response data, typically from the National Survey of Family Growth (NSFG) to estimate these failure rates. The newness of EC has made estimates of failure rate unavailable. Instead, the efficacy of EC is reported in the change in the probability of pregnancy in one sexual act.

There are reasonable concerns about studying emergency contraception because it might not be used frequently or may be used solely as a back-up for more common contraception mistakes such as broken condoms or forgetting to take birth control pills. Data from the 2006-8 National Survey of Family Growth (NSFG) suggest that these concerns are not a problem. Usage statistics from the NSFG are reported in Table 2. We see that 10.7% of women aged 15-19 have used EC at least once, while more than 1 in 5 women aged 20-24 have used EC. Looking at usage in the past year, rates are similar for both age groups; around 4% of young women use EC in a year. The NSFG also asks women why they used EC. The possible answers are “My primary birth control method failed,” “I didn’t use birth control that time,” and “Other reasons.” Usage of EC for teens appears to be primarily driven as a primary method, with only 25% of teenage women using EC because their normal method failed. Instead, EC appears to be a viable option of birth control, which is plausible given that teenage women are less sexually active than 20-24 aged women and may have fewer resources available to obtain other birth control methods. Table 2 also compares the demographics of women who used EC at least once to women who never used EC in the entire NSFG sample of women aged 15-44. EC users are generally younger, better educated, and more sexually active than non-EC users.

4 Data

I use several different sources of data to construct the various outcomes of interest for my empirical investigation. This section briefly discusses each data source and reviews summary statistics for each sample. In general, the datasets range in years from the mid-1990s until the late 2000s, although data availability varies by dataset. Table 3 summarizes the sources of data. See the Data Appendix for information on sample selection and other details of the data construction.

4.1 Sexually-transmitted infection (STI) rates

I focus on three major STIs - chlamydia, gonorrhea, and syphilis. I obtained Center for Disease Control (CDC) data on the total number of STI cases by gender, state, and 5-year age interval from 1996 to 2008. Table 4 presents the STI incidence rates for women during the sample period by age. We see that chlamydia and gonorrhea are much more prevalent than syphilis, which has been basically eliminated as an important STI. Rates are highest for young women, which is consistent with previous research and corresponds to the ages when women are most sexually active and have a large number of sexual partners.

4.2 Sexual behavior

I use data from the National Longitudinal Survey of Youth 1997 (NLSY97) to measure sexual behavior. The NLSY97 asks respondents annual questions about their number of sexual partners and the number of times that they had sexual intercourse. I combine information from both these surveys with restricted geocode information which provides information on when survey respondents obtained OTC access to emergency contraception.

The drawback of the NLSY97 is that age range of the respondents were 12-16 on January 1st, 1997. The respondents are therefore typically in the early to mid-20s when they received access to OTC emergency contraception. The average respondent was 24 years old when their state adopted OTC access. Further, over 80% of respondents were 23 or older at the time of passage. If new contraceptive technology is primarily adopted by women who are just beginning to have sex and choosing a contraceptive regime for the first time, then the age profile of the NLSY97 may understate the true impact. Looking at the nine states that adopted OTC EC policies on their own initiative may give a more accurate estimate of the effect of OTC policies.

Summary statistics for the NLSY97 are shown in Table 5. By the 2007 wave of the NLSY97 sample, the average woman has had sexual intercourse with about 5 men and has had sex almost 800 times in her life. The early adopting states tend to have higher reported levels of sexual partners and acts, although these 2007 averages may include the impact of differential OTC access.

4.3 Single motherhood rates

Birth rates are constructed using birth certificate data from the National Center for Health Statistics (NCHS). The birth certificate data provides counts of the number of births within state/race/age/education cells from 1990 to 2006. These counts are further broken down by mothers' reported marital status at the time of the birth. I also use population estimates from the Census by state/race/age to construct birth rates within each cell. Unfortunately, data is unavailable following 2006 so my identification will rely solely on the nine states that adopted OTC on their own initiative as I do not have any data on birth rate for the other 41 states in the years following their (forced) adoption of OTC access. I can still use the other 41 states to help estimate national time trends in birth rates.

Summary statistics for birth rates in this sample are shown in Table 6, which confirms the well-established results that single motherhood rates are relatively large for teens and young adults, but married births dominate for twenty-somethings. We also see the wellknown racial gap in single motherhood birth rates.

4.4 Marriage timing

I construct life-cycle marriage probabilities for young women using American Community Survey (ACS) data from 2001 to 2008. My measure is the percent of a state/cohort that have ever married by a given age. Having data through 2008 allows me to use the judicial decision in 2006 compelling 41 states to allow women to purchase emergency contraception OTC. I can thus use all 50 states in my analysis and control for the states that adopted an OTC policy on their own initiative.

Table 7 shows the percentage of women who have ever married by age and race. We see that very few teenagers are married, but the percent of women who have ever married increases rapidly during their early twenties. We can also see the well-documented fact that black women are substantially less likely to marry than white women, and that this disparity grows larger as women age. The median age for marriage is 24.7 in this sample.

5 Empirical strategy

I analyze the impact of OTC access to EC on a variety of outcomes suggested by economic theory. The basic analysis will compare the trends in variables of interest (eg, single motherhood rates) before and after states adopt OTC policies.

My baseline estimation of the impact of OTC access is

$$y_{st} = \alpha + \sum_{k=-n}^{m} D_{st}^{k} \delta_k + \lambda_s + \lambda_t + \varepsilon_{st} \tag{1}$$

where D_{st}^{k} is a dummy variable equaling one when state s allowed access in year $t-k$.[8] The δ_k then summarize the time path of the impact of OTC on a given outcome y. By allowing δ_k to vary in the *pre* period before OTC access I am considering the possibility that a state choosing to allow OTC access is not random but may be correlated with underlying trends in sexual behavior within a state. If δ_k is approximately 0 for $k < 0$, then that should be taken as evidence against the endogeneity of OTC laws. I estimate δ_k from m years before the passage of OTC to n years following. Ideally, I would be able to use uniform choices of m and n across outcomes of interest. However, due to data limitations, the sample period will vary by outcome.[9]

One limitation of this approach is that with a relatively small number of switches, I may be unable to precisely estimate each separate δ_k. An alternative, less data-intense method will be to estimate a simple linear model comparing the pre- and post-OTC regimes. I will still be able to use the variation in the timing of OTC access across states to control for state and year fixed effects. This baseline OLS estimation specification is

$$Y_{st} = \alpha + \beta \cdot OTCpolicy_{st} + \gamma X_i + \lambda_s + \lambda_t + \varepsilon_{st} \tag{2}$$

where Y_{st} is the studied outcome of interest, and will include single motherhood rates, marriage rates, rates of STIs, relationship quality, etc. $OTCpolicy_{st}$ is a dummy variable

[8] For instance, $D_{WA,1997}^{-1} = 1$ while $D_{WA,1998}^{-1} = 0$ because Washington is one year before granting OTC access in 1997.

[9] Please see the Data Appendix for a discussion of how this estimating equation creates an unbalanced panel and the limitations this imposes on the data.

indicating that state s had an over-the-counter law in place at some point during year t. X is a vector of individual demographic characteristics. λ_s and λ_t are, respectively, state and year fixed effects.

For addressing the impact of OTC on marriage timing, I use a slightly different specification that follows cohorts over time. I will compare the timing of marriage between cohorts that have had different years of exposure to OTC access. A simple estimator of this effect is:

$$\ln(\%married_{st}) = \alpha + \beta \cdot (yearsOTC)_{st} + \lambda_s + \lambda_t + \varepsilon_{st} \tag{3}$$

where this regression is estimated for multiple ages. $yearsOTC$ is a variable counting the years that a cohort has had OTC access. I take logs of cohort marriage rates to make the effect comparable across different ages, as marriage rates for 18 year olds are much lower than marriage rates for 24 year olds. If $\beta < 0$ for a given age, then cohorts that had increased access to EC lowered their marriage rates at that age, delaying marriage.

6 Results

Estimates of Equation 1 are shown in Figures 7-11 for single mothers, STI rates, sexual behavior, and marriage quality. Figure 12 shows a similar analysis by cohort timing for marriage timing. I discuss each result in turn.

Looking first at the impact of OTC policies on STIs, Figure 7 shows STI incidence rates in the years preceding and following the passage of OTC access for EC, controlling for state and year fixed effects. Incidence of STIs climbed dramatically following the improvement in access to emergency contraception. As was the case with single motherhood birth rates, there are no significant trends in STI rates prior to women obtaining OTC access, which is further evidence against endogenous policy timing.

Table 8 reports the estimates of Equation 2 for the impact of OTC access on STI rates. We see that the improving access to emergency contraception increases incidence of STIs. The effect is positive for all three types of STIs studied and robust to inclusion of age, state, and year fixed effects. The magnitudes of these results are consistent with Oza's 2009 study of the impact of OTC access to EC on STIs and abortions.

Figure 8 shows the estimated impact of OTC policies on sexual activity measures from the NLSY97. Both the number of annual sexual partners and sexual acts slightly increased following the adoption of OTC policies. Table 9 shows the estimated impact of OTC access on a series of sexual behaviors for never married women in the NLSY97 sample from 1997 to 2007. Each cell represents a separate regression and results are presented for all 50 states and for the nine states that adopted OTC access prior to the judicial decision granting women access on the national level. Granting OTC access led to an increase in the number of partners and the levels of sexual activity for unmarried women. Consistent with the estimates using aggregate state data, women with access to OTC contraception are less likely to become single mothers and less likely to marry.

Turning now to single motherhood rates, estimates are plotted in Figure 9. In the years following the OTC policy, single motherhood birth rates fall dramatically. Further, there is little evidence of changes in single motherhood rates in the years preceding OTC access which suggests that the adoption of OTC policies is not endogenously related to changes in single motherhood rates.

This steep decline in single motherhood rates following the introduction of OTC policies can further be decomposed into changes within age groups. As discussed previously, OTC legislation did not change access for minors. We would thus expect to find no effect of OTC policies on single motherhood rates for that age range. The change in single motherhood rates is broken down by age groups in Figure 10. Consistent with the our predictions, we see that women aged 18-19 and 20-29 experience a much greater decline in single motherhood rates while women aged 15-17 see only a small decline in single motherhood.

Figure 11 presents similar results for all single mothers, but also includes birth rates for married women as well. Both married women's and single women's birth rates follow similar trends in the years preceding states' adoption of an OTC policy, but then diverge after the policy change. Both groups see a decline in birth rates, although the change is markedly steeper for single women, providing further evidence of the importance of emergency contraception in single motherhood.

Table 10 shows the estimated impact of OTC policy on single motherhood rates. Consistent with the plotted estimates, OTC access decreased single motherhood birth rates by about 3.8 births per 1,000 women. The impact is somewhat lessened for married women and for young women who were not affected by the OTC legislation.

To consider the impact of OTC access to EC on young women's marital decisions, I construct synthetic cohorts based on the timing of adopting OTC policy. For example, women aged 15 in California in 2001 and women aged 15 in Maine in 2005 are treated as in the same cohort, because both were 15 years old when they received OTC access. I can then follow each synthetic cohort over their lifecycle and observe their marriage rates.

Marriage-age profiles for these synthetic cohorts are plotted in Figure 12, controlling for state and year fixed effects. Consider Age 22 on the x-axis: there are three cohorts plotted, women who received OTC access at age 20, 21, and 22. It is clear that women who received OTC at age 22 have higher marriage rates at age 22 than women who received OTC access when 21 and 20. In other words, the downward shift of younger cohorts indicates that women who were exposed to OTC policies for longer periods of times delay marriage when compared to women who had a shorter exposure to OTC policies for emergency contraception.

OLS estimation of the impact of OTC policies on marriage timing confirms the graphical evidence. Table 11 reports the coefficients from regressions of the log of % women who have ever married at a given age on the total number of years a cohort has had OTC access to emergency contraception. Having access to OTC emergency contraception for an additional year lowers marriage rates by 8% for 16 year olds.

OTC access to emergency contraception appears to have had a sizable impact on marital outcomes, as women who are able to purchase emergency contraception for longer periods of time see a substantial increase in the length of time they remain single and in the dating market.

7 Are these results plausible?

The above findings suggest that OTC policies for EC have had a substantial impact on young women's sexual, dating, and marital behavior. A natural following question is whether these results are of a plausible magnitude given both the economic model and our information on usage statistics. Cross-checking the empirical results is particularly important given that I have focused exclusively on reduced form relationships between the passage of OTC policies and outcomes without addressing in detail the magnitude of the first stage relationship. That suggests a number of questions about my results: Does emergency contraception usage increase with the passage of OTC policies? Does it increase in sufficient quantities to generate my observed results? Are the increases in sexual activity small enough to be consistent with the decline in birth rates? I address these questions in turn.

First, I consider the issue of emergency contraception usage. Data is limited on this question, so I present a variety of circumstantial evidence and back-of-the-envelope calculations in support. The best evidence comes from the NSFG 2006-2008 survey which asked detailed questions about EC usage. Table 12 reports usage statistics broken down by calendar year. Note the substantial increase following 2006 which is coincident with the forced adoption of OTC policies in 41 states by the FDA. This increase is statistically signficant; a regression of usage on yearly fixed effects and demographic controls finds that there is a signficant difference in usage between 2006 and both 2007 and 2008, while no statistical difference is found between 2007 and 2008. This increase can be taken as a coarse measure of the impact of OTC policies on EC usage. The simple OLS regression estimates that there is a 3.1% increase in usage between 2006 and both 2007 and 2008.

Another way to estimate usage rates is through revenue data. Press releases in 2004 report a $30 million revenue to Plan B's manufacturer, on the basis of 1 million units sold. Given that there were approximately 37 million women aged 15 to 34 in the United States, this puts annual usage rates at around 2.7%, a number consistent with the NSFG data. By 2008, Plan B's manufacturer reported annual sales of $80 million. Assuming prices remained constant, that would imply an increase in usage to over 6% annually. The back-of-the-envelope calculation is again approximately 3% increased in usage being driven by the adoption of OTC policies.

Given a plausible estimate of the first stage impact of OTC policies on EC usage of 3%, a natural next question is whether this increase in usage is consistent with the impacts estimated above. However, a lot of the changes in behavior may be driven by the availability and therefore possibility of using EC, not the actual usage itself. People may increase their sexual behavior because EC is easier to access even without substantially increasing their usage of EC. One outcome that should be directly tied to usage, however, is birth rates. Any birth had the possibility of better contraception usage at an earlier time. To the extent that EC usage has actually increased, we expect that the documented decline in birth rates to be consistent with these usage patterns.

Given the back-of-the-envelope calculation of OTC policies increasing EC usage by around 3% annually, a simple calibration can give a conservative estimate on what magnitude of declining birth rates we should expect to see. Let's conservatively assume that the 3% of women who begin using EC all use it in conjuction with a typically used birth control regime. FDA estimates indicate that birth control regimes have a typical failure rate of 8% annually. Given the 75% effectiveness of EC, the 3% of women who now start using EC should instead experience a failure rate of 2% annually. Converted to birth rates, that implies that the increased usage in EC should lead to a decline in 1.8 births per 1,000 women.[10] This calibration is on the lower end of the estimates presented above but remain within the standard errors for the estimated impact of OTC policies. This calibration is also conservative in the substitution patterns across contraception. The estimate would be larger if the women who begin to use EC were previously using condoms or not using protection.

[10]To see this, we estimate that 30 out of 1000 women began using EC. Before using EC, those women experienced 2.4 births due to birth control failure (2.4 = 30 * 0.08). After beginning to use EC, those women experienced 0.6 births due to birth control failure (0.6 = 30 * 0.02). The estimated decline in birth is therefore 1.8 births (2.4 - 0.6).

Another concern with my estimates is that the increase in sexual activity and STIs is actually inconsistent with the observed decline in single motherhood rates. If the level of sexual activity increased by enough, then we would expect to see an actual increase in single motherhood instead of a decline. To evaluate whether these numbers are consistent, I simulate the model presented in Chapter 2. Simulation of the model presents similar but slightly smaller in magnitude estimates of the impact of EC access.

Table 13 presents baseline values assumed for the model simulation. Variables refer to the model developed in Chapter 2. The scaling parameters were chosen to ensure that the necessary single crossing properties were satisfied. For instance, it is assumed that no one will choose to become a single mother while dating. That restricts the values of both a_s and b_s to ensure that the value of single motherhood is lower than dating everywhere. For simulation ease, I set the maximum number of periods spent dating at 30. I omit STIs and abortions from the simulation.

I estimate by guessing an initial value of the expected value of dating. I then solve the model backwards to calculate the thresholds $\bar{\mu}_t$ and $\underline{\mu}_t$. These thresholds imply a possibly different value of $\bar{D}$, so I iterate the simulation using this revised estimate of $\bar{D}$ until the guessed value converges to the estimated value.

For an initial baseline, I set $p = 0.004$ which is consistent with the FDA's typical failure rates for a woman using birth control pills. To simulate the introduction of emergency contraception, I do two exercises. In the first, I reduce p by 75% to $p_1 = 0.001$. The simulation results of this first counterfactual provide the expected change for one woman who now chooses to use emergency contraception in conjuction with her normal birth control regime. I am assuming that she can well target the EC usage to effectively lower the typical failure rate. In the second experiment, I reduce p using the effectiveness of EC but scaling by the 3% of the population that I estimated begin to use EC as a result of OTC policies. This is a much smaller change as I set $p_2 = 0.00391$. This smaller reduction may be a more useful estimate in evaluating the percentage changes in observed behavior in the population, however, because it more correctly accounts for the actual adoption patterns of the contraceptive technology shock.

Results from these two counterfactuals are presented in Table 14. Both experiments increase the number of expected lifetime partners, but not by the magnitudes estimated in the reduced form OTC experiment. Relationship duration increases as well, which indicates that the effect of delaying marriages is outweighing the increased desire for turnover within one relationship. Sexual activity also increases, but again by less than was estimated. The probability of single motherhood declines in both cases as well. These results suggest that, at least in the baseline calibration, the model provides too weak of estimates of the impact of OTC adoption policies.

8 Conclusion

I have presented a model of how improvements in contraceptive access could change women's sexual behavior and formation of relationships. The model predicted that better contraception will increase the level of sexual activity, the rate of STI incidence, and the number of premarital partners. Sexual activity increases because of the diminished pregnancy risk which in turn raises STI rates. The number of premarital partners increases because better contraception matters most for newly formed relationships where there is the most uncertainty about relationship quality. As contraceptive access improves, people are more willing to leave relationships and try out new possible partners.

Contraception also matters for single motherhood rates, abortion rates, and marital timing, although the directions of these effects are theoretically ambiguous. The ambiguity arises because of behavioral adjustments in the search for a partner. As contraception improves, it's more desirable to try out more potential marriage partners which can make marriage happen sooner. More frequent partnering also increases the chance that premarital pregnancies transition into single motherhood as newly formed relationships are especially risky and of potentially poor quality.

I evaluated the model using changes in OTC access to emergency contraception across states during the late 1990s and early 2000s. I evaluated the nine states that chose to adopt OTC policies, and, where possible, the other 41 states who adopted OTC policies following a 2006 FDA ruling that forced OTC nationwide for women aged 18 and older. I found the predictions of the economic model were broadly confirmed.

Changing access to contraception by adopting OTC policies for emergency contraception lowered single mother birth rates, increased STI incidence rates, increased sexual activity within relationships, increased the number of sexual partners, and delayed marriages. This is broad evidence that both OTC policies matter for women and dating and that economic theory can help us understand the incentives that face men and women when making decisions about dating and marrying.

There are many interesting possibilities to extend this framework to give a more complete picture of the role of contraception in shaping marriage outcomes. One possibility is to include the option of divorce and reentry into the dating market. If contraceptive access makes dating more valuable, then people will be more willing to leave bad marriages and transition back to being single and dating. This effect may help explain the simultaneous rise in divorce rates as contraception improved during the 1960s and 70s. Changes in contraception also may matter for other decisions within marriage. As Goldin and Katz (2002) show, women's career choices and investment in human capital are influenced by contraception. In turn, this may impact the timing of children and investment in their children's human capital.

One limitation of the current model is the simplistic way it treats the man in the relationship. The woman has all the power: she chooses when to have sex, how much sex to have, when they should break up, and when they should marry. Giving the man a say could add another important layer in understanding the importance of contraception in relationships. A natural way to model this would be to nest this model, or a simplified version, in a larger model of household bargaining or two-sided search framework. Changes in contraception access can then change the relative bargaining power of men and women in relationships. Most forms of contraception, especially more recent innovations, are a woman's responsibility and women bear the bulk of the costs of single parenthood.

The model presented here can also be used to provide a novel framework in extending the literature on the impact the power of the birth control pill and suggesting other dimensions that the pill could have driven social changes since its introduction. The framework could help us answer interesting questions such as what was the role of the pill in the Sexual Revolution of the late 1960s, or to what extent birth control caused the large change in average marriage ages during since the 1960s. A reevaluation of the pill's impact using the methodology described here could shed light on the ways that the contraceptive revolution has shaped today's society.

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A Technical appendix

Proposition A.1 *Proposition 2.1 in the text.*

1. $\frac{\partial s}{\partial \mu} > 0$*: Relationships with greater mean beliefs have more sex*
2. $\frac{\partial s}{\partial t} > 0$*: Longer lasting relationships have more sex.*
3. $\frac{\partial s}{\partial p} < 0$*: Worse contraception decreases sexual activity*

Proof

1. Recall the FOC for the optimization on sexual activity:

$$v_s \leq h_s \cdot R + g_s \left(EV_{np} - EV_p\right) \qquad \text{(with equality if s > 0)}$$

Differentiating again gives the SOC that

$$v_{ss} - h_{ss}R - g_{ss}\left(EV_{np} - EV_p\right) < 0$$

Using implicit differentiation of the FOC w.r.t. μ gives

$$\frac{\partial s}{\partial \mu} = \frac{g_s}{v_{ss} - h_{ss}R - g_{ss}(EV_{np} - EV_p)} \left(\frac{\partial EV_{np}}{\partial \mu} - \frac{\partial EV_p}{\partial \mu} \right)$$

We know $g_s > 0$ and the denominator of the first term is negative by the SOC. We have also established that $\left(\frac{\partial EV_{np}}{\partial \mu} - \frac{\partial EV_p}{\partial \mu} \right) < 0$, so we conclude that $\frac{\partial s}{\partial \mu} > 0$. $\blacksquare$

2. Abusing notation, we can can differentiate the FOC with respect to the age of the relationship t:

$$\frac{\partial s}{\partial t} = \frac{g_s}{v_{ss} - h_{ss}R - g_{ss}\left(EV_{np} - EV_p\right)} \cdot \left(g_s \left(\frac{\partial EV_{np}}{\partial t} - \frac{\partial EV_p}{\partial t} \right) \right)$$

Noting that the denominator of the first term is the SOC, the first term must be negative. We showed that $g_s > 0$ and that $\frac{\partial EV_{np}}{\partial t} - \frac{\partial EV_p}{\partial t} < 0$. We conclude that $\frac{\partial s}{\partial t} > 0$.

$\blacksquare$

3. Differentiating the FOC with respect to p and omitting arguments,

$$v_{ss}\frac{\partial s}{\partial p} = \left((g_{ss} + h_{ss}R)\frac{\partial s}{\partial p} + g_{sp} \right) \left(EV_{np} - EV_p\right) - g_s \left(\frac{\partial EV_{np}}{\partial p} - \frac{\partial EV_p}{\partial p} \right)$$

Solving for $\dfrac{\partial s}{\partial p}$ yields

$$\frac{\partial s}{\partial p} = \underbrace{\left(\frac{1}{v_{ss} - h_{ss}R - g_{ss}\left(EV_{np} - EV_p\right)} \right)}_{(-)} \cdot \left(\underbrace{g_{sp}}_{(+)} \underbrace{\left(EV_{np} - EV_p\right)}_{(+)} - \underbrace{g_s \left(\frac{\partial EV_{np}}{\partial p} - \frac{\partial EV_p}{\partial p} \right)}_{(-)} \right)$$

The first term is negative by the SOC. Feasibility constraints on sexual intercourse imply that $g_{sp} > 0$ and the value of not being pregnant dominates the value of pregnancy while dating. We have shown that $g_s > 0$ and that the last term is negative. We conclude that $\dfrac{\partial s}{\partial p} < 0$. ∎

Proposition A.2 *Lemma 2.2 in the text*

1. *The value of dating is declining in relationship length for any mean beliefs, or,* $D_t(\mu) > D_{t'}(\mu)\ \forall \mu, t, t'$ *where* $t < t'$.

2. *The threshold between marriage and dating is declining in the length of the relationship:* $\bar{\mu}_t > \bar{\mu}_{t+1}$.

3. *The threshold between separating and continuing to date is increasing in the length of the relationship:* $\underline{\mu}_t < \underline{\mu}_{t+1}$.

Proof

1. To show that the value of dating is declining in relationship length, note that the distribution $F_t(\mu'|\mu)$ is a mean-preserving spread of $F_{t'}(\mu'|\mu)$, as both distributions are normal with mean μ but variances $(\sigma_t^2 + \sigma_\varepsilon^2)$ and $(\sigma_{t'}^2 + \sigma_\varepsilon^2)$, respectively. As $\sigma_t^2 > \sigma_{t'}^2$, it follows that $F_{t'}(\mu'|\mu)$ second order stochastically dominates $F_t(\mu'|\mu)$. Also note that for two random variables, X and Y, if the distribution of X is a mean-preserving spread of Y, then for all convex functions $h(\cdot)$, $E[h(X)] > E[h(Y)]$.

   Recall that no dating is possible after time T. The value of dating at time T is

$$\begin{aligned} D_T(\mu) =& \gamma\mu - \tilde{h}_t(\mu, p)R \\ & + \beta\tilde{g}_t(\mu, p)\max\{M(\mu), -A + \bar{D} - k, SP(\mu)\} \\ & + (1 - \tilde{g}_t(\mu, p))\beta\max\{\bar{D} - k, M(\mu)\} \end{aligned}$$

where dating is an inferior option to either marriage or finding a new partner. The thresholds between finding a new partner and marriage are equal, or, $\underline{\mu}_T = \bar{\mu}_T$. It is evident that both $\max\{M(\mu), -A + \bar{D} - k, SP(\mu)\}$ and $(\max\{\bar{D} - k, M(\mu)\})$ are convex and increasing in μ. As expectations of convex, increasing functions are convex, increasing functions themselves, it follows that $D_T(\mu)$ is an increasing, convex function. Therefore, the value of D_{T-1} is

$$D_{T-1}(\mu) = \gamma\mu - \tilde{h}_t(\mu, p)R + \beta\tilde{g}_t(\mu, p) \int_{-\infty}^{\infty} \max\{M(\mu'), -A + \bar{D} - k, SP(\mu')\} dF_{T-1}(\mu'|\mu)$$
$$+ \beta(1 - \tilde{g}_t(\mu, p)) \int_{-\infty}^{\infty} \max\{(\bar{D} - k), M(\mu'), D_T(\mu')\} dF_{T-1}(\mu'|\mu)$$

As D_{T-1} is the expectations of convex functions, it follows that D_{T-1} must also be convex. Inducting backwards for $(T-2), (T-3), \ldots$ establishes that $D_t(\mu)$ is convex in μ for all t.

Consider $D_t(\mu)$ and $D_{t'}(\mu)$ for any μ and $t' > t$. Both are expectations over convex functions and the distribution at time t is a mean-preserving spread of the distribution at time t'. Therefore, $D_t(\mu) > D_{t'}(\mu)$. ∎

2. The reservation value $\underline{\mu}_t$ is the solution to $D_{t+1}(\underline{\mu}_t) = (\bar{D} - k)$. The value of ending a relationship, $(\bar{D} - k)$, does not depend on either μ or t. It suffices to show that $D_{t'}(\mu) < D_t(\mu)$ for all values of μ and at all times t and t' where $t' > t$. The value of dating is declining in relationship length. It follows that $\bar{\mu}_t > \bar{\mu}_{t+1}$. ∎

3. $\bar{\mu}_t$ solves $D_{t+1}(\bar{\mu}_t) = M(\mu_t)$. $M(\mu)$ does not depend on t, so it is sufficient to show that $D_{t'}(\mu) < D_t(\mu)\ \forall \mu, t' > t$. As above, this follows because the value of dating is declining in relationship length. We conclude that $\underline{\mu}_t < \underline{\mu}_{t+1}$. ∎

In proving Proposition 2.3, I first prove three lemmas about how contraceptive change the value of dating and the optimal thresholds.

Lemma A.3 $\frac{\partial D_t(\mu)}{\partial p} < 0, \forall t, \mu$: *worse contraceptive technology lowers the value of dating at all possible states.*

Proof Recall the value of dating is, omitting arguments,

$$D_t(\mu) = \gamma\mu - \tilde{h}R + \beta\tilde{g}EV_p + (1-\tilde{g})\beta EV_{np}$$

Differentiating with respect to p gives

$$\frac{\partial D_t(\mu)}{\partial p} = -\frac{\partial \tilde{h}}{\partial p}R + \beta\frac{\partial \tilde{g}}{\partial p}(EV_p - EV_{np}) + \beta\tilde{g}\frac{\partial EV_p}{\partial p} + \beta(1-\tilde{g})\frac{\partial EV_{np}}{\partial p}$$

We know that $\dfrac{\partial h}{\partial p} > 0$ and $\dfrac{\partial g}{\partial p} > 0$. The value of not being pregnant weakly dominates the value of being pregnant while dating, so $(EV_p - EV_{np}) < 0$. We know $\dfrac{\partial EV_p}{\partial p} = 0$ and that $\dfrac{\partial EV_{np}}{\partial p} < 0$ as contraception does not affect the value after having gotten pregnant. We conclude that $\dfrac{\partial D_t(\mu)}{\partial p} < 0$. ∎

Lemma A.4 $\dfrac{\partial \bar{\mu}_T}{\partial p} < 0$, *or worse contraceptive technology lowers the limiting threshold between marriage and finding a new unknown partner.*

Proof $M(\bar{\mu}_T) = \bar{D} - k$, or

$$\bar{\mu}_T = (1-\beta)(\bar{D} - k)$$

Differentiating with respect to the parameter p, we see that

$$\frac{\partial \bar{\mu}_T}{\partial p} = (1-\beta)\frac{\partial \bar{D}}{\partial p}$$

Since A.3 showed that $\bar{D}$ is decreasing in p, it follows that $\bar{\mu}_T$ also falls as p increases. $\blacksquare$

Lemma A.5

1. $\dfrac{\partial \bar{\mu}_t}{\partial p} < 0$*: Worse contraception lowers the upper threshold when not pregnant.*
2. $\dfrac{\partial \underline{\mu}_t}{\partial p} \leq 0$*: Worse contraception lowers the lower threshold when not pregnant.*

Proof

1. The upper threshold when not pregnant satisfies

$$M(\bar{\mu}_t) = D_{t+1}(\bar{\mu}_t)$$

   Lemma A.3 proved that $\dfrac{\partial D_t(\mu)}{\partial p} < 0$ and the value of marriage is unchanged by p. The result is immediate. $\blacksquare$

2. The lower threshold when not pregnant satisfies

$$\bar{D} - k = D_{t+1}(\underline{\mu}_t)$$

   An equivalent formulation of the proposition is therefore

$$\frac{\partial \bar{D}}{\partial p} \geq \frac{\partial D_t(\mu)}{\partial p} \qquad \forall \mu \text{ and } \forall t > 0$$

Since $\bar{D} = D_0(\mu_0)$, abusing differentiability w.r.t. t rewrites the proposition as

$$\frac{\partial^2 D_t(\mu)}{\partial p \partial t} < 0 \qquad \forall \mu \text{ and } \forall t$$

In other words, the change in the value of dating as contraceptive access worsens is highest at the earliest stages of a relationship.

To calculate this cross-derivative, recall that as in Lemma A.3,

$$\frac{\partial D_t(\mu)}{\partial p} = -\frac{\partial \tilde{h}}{\partial p} + \beta \frac{\partial \tilde{g}}{\partial p}(EV_p - EV_{np}) + \beta(1-\tilde{g})\frac{\partial EV_{np}}{\partial p}$$

Differentiating again yields

$$\frac{\partial^2 D_t(\mu)}{\partial p \partial t} = \beta \frac{\partial \tilde{g}}{\partial p}\left(\frac{\partial EV_p}{\partial p} - \frac{\partial EV_{np}}{\partial p}\right) + \beta(1-\tilde{g})\frac{\partial^2 EV_{np}}{\partial p^2}$$

We know that $\frac{g}{p} > 0$ and as shown in Lemma A.1 the first and second terms are negative, yielding the result. ∎

Proposition A.6 *When birth control technology improves and p falls, the following occurs:*

1. $\bar{S}(t)$ *increases for all* t*: the probability of having separated at all ages of a relationship increases.*
2. $\bar{M}(t)$ *decreases for all* t*: the probability of a relationship resulting in marriage by time* t *declines.*
3. *The number of premarital partners increases.*

Proof

1. Define $q^t \equiv \{q_1, q_2 \ldots, q_t\}$ as a given shock history until time t. q^t is measurable, and the probability of marriage at time t is the measure on the set of shocks $\{q^t | \mu(q^t) > \bar{\mu}_t\}$. This is the set of all the shocks that would have ended in marriage by time t. Consider this probability under two pregnancy probabilities, $p < p'$. Since $\bar{\mu}_t(p) > \bar{\mu}_t(p')$ for all times t, it follows that any shock that resulted in marriage with p will also result in marriage with p'. Further, there are several shocks that will not result in marriage with p but would have with p'. Therefore, the set of marriage shocks under p is a subset of marriage shocks under p' and it follows that the probability of marriage is lower with p than with p'.

2. Suppose two pregnancy probabilities $p < p'$. Since $\underline{\mu}_t(p) > \underline{\mu}_t(p')$, it again follows that any q^t that results in separation under p' also results in a separation under p. There are also shocks that result in separation under p that do not with p'. Therefore, the set of shocks at time t that result in separation given p contains the set of separation shocks given p', and so the probability of separation is higher with p than with p'.

   As in the text, let $\tilde{S}(t)$ be the cumulative distribution of having separated by time t within one relationship. Let $\phi = \tilde{S}(t)$ for all marriages and single motherhood. An example of $\tilde{S}(t)$ is shown in Figure A 1. Note that $(1 - \phi)$ represents the probability that a relationship results in either marriage or single motherhood.

   As the pregnancy probability falls from p to p', the probability of separation increases and the probability of reaching an absorbing state falls at all times t so $S(t|p) < S(t|p')\forall t$. This shift in the separation time distribution is graphed in Figure A 2. The probability of eventually separating increases from ϕ to ϕ'.

3. Let ϕ denote the probability of eventually separating from a relationship at time 0 of

the relationship. It was shown above that ϕ increases as p declines.

$$E[\# \text{ of partners}] = 1 + \phi + \phi^2 + \cdots$$
$$= \frac{1}{1-\phi}$$

Since ϕ increases as p decreases, it follows that the expected number of partners also increases.

Proposition A.7 *Improvements in birth control has an ambiguous impact on:*

1. *The number of single mothers.*

2. *The average time until marriage.*

Proof

1. Define $\psi(p)$ as the probability of becoming a single mother during one relationship as a function of the contraceptive effectiveness p. $\psi(p)$ is equal to the probability of becoming pregnant multiplied by the measure of the shock histories that leave μ_t between μ^* and $\underline{\mu}_t$. Note that $\psi' > 0$, as a higher p increases the set of possible shock histories *within* one relationship that leave the mean beliefs between the lower threshold and the single parent threshold.

   The probability of eventually becoming a single mother over one's life is the probability of becoming a single mother in one relationship multiplied by the expected number of relationships. This follows from the infinite-horizon and the independence of relationships. As shown in Proposition A.6, the expected number of relationships is $\frac{1}{1-\phi(p)}$ where $\phi(p)$ is the probability of any one relationship separating.

Therefore, the probability of one person becoming a single mother can be written as

$$Pr(\text{Ending as a single mother}) = \psi(p)\frac{1}{1-\phi(p)}$$

Differentiating with respect to p, we see that the probability of becoming a single mother increases if and only if

$$\psi' > -\frac{\psi}{1-\phi}\phi'$$

which provides a set of conditions concerning the optimal policy thresholds and the shock process. Future work will show more precise conditions relating the changing of policy thresholds to the direction of single parents.

2. Let m denote the random variable of periods until marriage for a person beginning to date. The average time to marriage is then $E[m]$. Define ϕ as the probability that one relationship ends in separation. Note that $\phi = S(T)$, the cumulative probability of separation at date T where all information is fully revealed. Decompose the average time until marriage as

$$E[m] = (1-\phi)E[m|\text{marry}] + \phi E[m|\text{separate}]$$

The average time until marriage is the time until marriage within one relationship times the probability that relationship becomes a marriage plus the time until marriage following a separation times the separation probability. Define e as the random variable of the period of separation within one relationship and assume that searching for a new partner does not take any time. Then by the independence of relationships, the time until marriage conditional on separating is the sum of time until separation and the time 0 time until marriage.

$$E[m|\text{separate}] = E[e|\text{separate}] + E[m]$$

Substituting and rearranging yields

$$E[m] = E[m|\text{marry}] + \frac{\phi}{1-\phi}E[e|\text{separate}]$$

It is now clear that there are two offsetting effects on marriage timing as contraception access improves. As Proposition 3.2 proved, better contraception lowers $E[m|\text{marry}]$ as people become less willing to marry their current partner, but raises $E[e|\text{separate}]$ as people become more willing to leave their current partner. It is thus unclear whether marriage rates will increase or decline following changing contraceptive access. This formula suggests a sufficient statistic for the effect: whether the average time spent dating (not married) increases or declines.

B Data appendix

Sexually-Transmitted Infection rates

Data on chlamydia, gonorrhea, and syphilis were downloaded from the Center for Disease Control (CDC) STI morbidity database. Data is available on the total number of chlamydia, gonorrhea, and syphilis case reports submitted by state and local health departments to CDC's Division of STD/HIV Prevention. The data is available by gender, state, and 5-year age group. The data was combined by the CDC with population estimates for gender, states, and age groups from the U.S. Census Bureau. Please see http://wonder.cdc.gov/wonder/help/std-std-2008-race-age.html#Source for additional details on the population estimates.

Reported cases with missing demographic information are omitted from the data by the CDC and no attempt is made at imputing the missing information. The rates calculated here are therefore an understatement of the true rates of STIs in the population. It is possible that there is a systematic underreporting of demographic information by various groups. I do not attempt to correct for this possibility.

New York State did not report chlamydia incidences to the CDC during the years 1996-2008. I set these values to missing.

Sexual behavior: NLSY97

I use the women in the NLSY97 to form measures of sexual behavior. I merge this with restricted access geocode data on respondents' state of residence at the time of each interview. Women with missing geocode data are dropped from the sample. I use the original 1997 sampling weights.

Marital status is not asked for women younger than 15. I set their status to missing. There are 62 invalid skips in marital status questions. If the marital status before and after the invalid skip were the same, I recode the invalid skips to match the surrounding years. Other invalid skips are treated as missing. Some respondents report having never married even though they reported being married in previous interview waves. I recode these respondents by assuming that if a woman ever reports having been married then she has been married in all future interviews.

Women are asked about their number of lifetime sexual partners (acts) and the number of sexual partners (acts) in the previous 12 months. If they do not recall, they are asked to provide interval estimates. Respondents with interval estimates for any question are coded as having missing information for that particular question. Respondents who refuse to answer the question are coded as missing. Individuals who have never been sexually active are not asked about their number of partners (acts). I code these values as 0. All invalid skips are coded as missing. The number of partners and acts are both topcoded at 999. I do not adjust these topcodes.

In reporting pregnancies, a few respondents report not having been pregnant after reporting a pregnancy in previous survey years. Like marriage, I recode pregnancy status based on the first reported incidence of pregnancy. Invalid skips and refusal to answer are coded as missing values.

Single motherhood

Birth rates are constructed using birth certificate data from the National Center for Health Statistics (NCHS) VitalStats database. The data is the universe of official births in the United States from 1990 to 2007. The data was downloaded as counts of the number of births within state/race/age/education/marital status cells from 1990 to 2007. The state is the mother's reported state of residence, not the state of birth. Marital status is either single or married; the data do not distinguish between never married and divorced/widowed.

Aggregate cell data were used instead of individual birth certificates due to restrictions in geocode identifiers; mother's state of residence is not available on individual data after

2003. All variables were constructed by the NCHS from aggregating information provided on birth certificates. To construct birth rates, I combine the birth data with estimates of the number of residents within age, sex, state, and year cells from the U.S. Census Bureau. Birth data are missing from Oklahoma in 1990 and from New Hampshire in 1990-1992.

Marriage timing

I construct state and cohort marriage probabilities for young women using American Community Survey (ACS) data from 2001 to 2008. My measure is the percent of a state/cohort that have ever married by a given age. Ever married includes all married, separated, divorced, and widowed women. I exclude all institutionalized individuals and any woman with allocated values for age, race, sex, and marital status.

Unbalanced panels

Given the fixed endpoints of each data source (for example, the birth rate data is available from 1990 until 2006) and the differences in timing of state OTC policies, each dataset is unbalanced around the years before and after OTC adoption. For instance, Washington is the only state that has had 11 years of OTC access by 2006. To ensure identification of all state and year fixed effects, I restrict my samples to states and years such that there are always at least five different states in a year relative to OTC access. In practice, this means I do not include Washington data after 2002 and California data in 2006.

Table 1: States that adopted OTC access to EC prior to 2006 judicial ruling.

State	First Year of OTC
Washington	1998
California	2002
Alaska	2003
Hawaii	2003
New Mexico	2003
Maine	2004
Massachusetts	2005
New Hampshire	2006
Vermont	2006

Table 2: Emergency Contraception usage statistics

	Ages 15-19	Ages 20-24
Ever used EC	10.7%	20.6%
Used EC past 12 months	4.6%	4.0%
Times used (conditional on use)	1.7	1.9
Used b/c primary method failed	26.8%	50.3%
	EC users	Non EC users
Age	26.8	31.7
Highest Grade	14.2	13.4
Age at 1st sex	16.7	17.6
Total Partners (single women only)	1.7	1.2

Data from National Survey of Family Growth, 2006-2008. Sample is women aged 15-44 who have ever had sexual intercourse.

Table 3: Summary of data sources

Outcome	Predicted Impact	Source	Years	Level of Aggregation
STIs	↑	CDC	1996-2008	State, Age Group, Year
Sexual acts	↑	NLSY97	1997-2007	Individual, Year
Sexual partners	↑	NLSY97	1997-2007	Individual, Year
Birth rates	(?)	Vital Stats	1990-2006	State, Age Group, Year
Marriage rates	(?)	ACS	2001-2008	State, Age, Year

Table 4: Average STI rates by age

	All states			**Early adopters**			**Late adopters**		
Women, aged:	15-19	20-24	25-29	15-19	20-24	25-29	15-19	20-24	25-29
Chlamydia	1820.1	1683.9	586.5	1529.8	1563. 7	597.7	1882.2	1709.3	584.0
	(2039.2)	(1754.0)	(655.6)	(1182.2)	(1044.7)	(437.7)	(2171.7)	(1867.5)	(693.5)
Gonorrhea	522.2	473.6	198.1	207.5	198.1	87.8	588.9	531.2	221.9
	(896.4)	(799.8)	(327.6)	(360.9)	(299.3)	(123.3)	(959.7)	(857.6)	(352.2)
Syphilis	3.2	4.8	4.1	0.8	1.2	1.2	3.7	5.5	4.7
	(9.9)	(14.3)	(13.2)	(1.4)	(2.2)	(2.7)	(10.8)	(15.6)	(14.4)

Data from Center for Disease Control Sexually Transmitted Disease Morbidity reports, 1996-2008. Rates are per 100,000 women. Early adopters are the nine states that adopted OTC policies before the 2006 FDA ruling. Late adopters are the other 41 states. Standard deviations in parentheses.

Table 5: Sexual behavior in the NLSY97 female sample

	All states	**Early adopters**	**Late adopters**
% black	11.4	5.1	13.2
% hispanic	11.2	24.9	7.6
% married, 2007	31.4	24.8	32.3
age, 2007	24.8	24.7	24.8
lifetime number of sexual partners, 2007			
average	5.2	6.1	5.0
std. dev.	(16.3)	(16.9)	(16.1)
median	3	4	3
lifetime number of sexual acts, 2007			
average	779.6	832.7	771.9
std. dev.	(1020.5)	(1097.2)	(1008.1)
median	410	437	402
number of sexual partners, last 12 months			
average	2.8	2.9	2.8
std. dev.	(16.7)	(19.6)	(16.3)
median	1	1	1
number of sexual acts, last 12 months			
average	103.7	103.8	107.1
std. dev.	(137.0)	(140.6)	(136.2)
median	50	50	50

Data from females in the National Longitudinal Survey of Youth 1997, 1997-2007. Statistics use original 1997 sampling weights. Standard deviations in parentheses. See data appendix for details of constructing the total # of sexual acts and partners. Early adopters are the nine states that adopted OTC policies before the 2006 FDA ruling. Late adopters are the other 41 states.

Table 6: Average birth rates by marital status, race, and age

	All states			**Early adopters**			**Late adopters**		
Ages:	15-17	18-19	20-29	15-17	18-19	20-29	15-17	18-19	20-29
Single women	21.7	53.0	34.3	14.2	39.3	10.7	22.9	55.1	35.4
	(13.7)	(15.1)	(14.7)	(9.5)	(10.7)	(9.2)	(13.9)	(14.6)	(15.1)
Married women	3.0	18.7	67.9	2.1	14.9	61.7	3.2	19.3	69.0
	(4.4)	(13.3)	(23.1)	(2.9)	(10.7)	(21.5)	(4.6)	(13.6)	(23.2)
Single women, Whites	13.9	37.7	22.9	11.2	32.4	22.2	14.4	38.5	23.1
	(9.3)	(11.0)	(10.6)	(7.8)	(9.6)	(8.1)	(9.5)	(11.0)	(11.0)
Single women, Blacks	55.0	118.8	84.9	36.5	88.8	69.6	57.9	123.5	87.4
	(31.9)	(35.2)	(31.6)	(25.2)	(31.0)	(22.9)	(31.9)	(33.6)	(32.2)

Birth certificate data from Center for Disease Control and National Center for Health Statistics, 1990-2007. Rates are per 1,000 women. Early adopters are the nine states that adopted OTC policies before the 2006 FDA ruling. Late adopters are the other 41 states. Standard deviations in parentheses.

Table 7: Percent of young women who have ever married by age and race

	All	White	Black	All	White	Black	All	White	Black
	All states			**Early adopters**			**Late adopters**		
15	0.9%	0.7%	1.3%	0.7%	0.6%	1.2%	0.9%	0.8%	1.4%
16	1.0%	0.9%	1.1%	0.8%	0.8%	1.1%	1.0%	1.0%	1.1%
17	1.3%	1.2%	1.4%	1.0%	1.0%	1.7%	1.4%	1.3%	1.4%
18	2.9%	3.1%	2.1%	2.2%	2.3%	1.4%	3.1%	3.4%	2.1%
19	6.3%	7.1%	3.1%	5.8%	6.1%	3.0%	6.7%	7.6%	1.4%
20	10.7%	11.9%	5.7%	8.4%	8.8%	5.5%	11.3%	12.7%	5.9%
21	16.7%	18.5%	9.0%	13.9%	14.1%	11.5%	17.3%	19.4%	8.8%
22	23.4%	26.1%	11.2%	19.6%	20.4%	12.3%	24.1%	27.1%	11.1%
23	29.7%	32.9%	15.5%	24.7%	25.3%	17.4%	30.6%	34.2%	15.5%
24	37.6%	41.1%	19.3%	31.2%	32.6%	19.9%	38.7%	43.4%	19.5%

Data from American Community Survey, 2001-2008. Numbers are percent of women who are married at a given age in the 8 year sample. The non-monotonicity in age for 15 and 16 year old black women arises because of sampling error in the cross-sectional data. Early adopters are the nine states that adopted OTC policies before the 2006 FDA ruling. Late adopters are the other 41 states.

Table 8: Estimated impact of OTC policies on STI rates

Incidence rates (per 100,000 women)	(1)	(2)
	All States	Early Adopters
Overall	117.7***	70.9***
	(27.5)	(17.1)
Chlamydia	221.6***	210.5**
	(59.7)	(76.9)
Gonorrhea	115.7**	2.1
	(56.3)	(32.8)
Syphilis	7.2***	0.4
	(1.6)	(0.73)
N	1989	351

Each entry represents the coefficient on an indicator of OTC access in a regression of STI rates within an age/state/year cell, weighted by cell population. State, age, and year fixed effects are included. Column (1) includes all 50 states, while column (2) is just the nine states who adopted prior to 2006. Data from CDC, 1996-2008. Robust standard errors are clustered at the state level. $*$: significant at 10% level. $**$: significant at 5% level. $***$: significant at 1% level.

Table 9: Estimated impact of OTC policies on sexual behavior

	(1)	(2)
	All States	Early Adopters
# of sexual partners (lifetime)	1.57**	1.23*
	(0.76)	(0.64)
# of sexual partners (last 12 months)	0.25	0.26
	(0.26)	(0.60)
# of sexual acts (lifetime)	36.48**	39.81*
	(17.48)	(19.08)
# of sexual acts (last 12 months)	3.89	7.55
	(3.25)	(6.80)
Probability of marriage	-0.05**	-0.09
	(0.02)	(0.10)
Probability of pregnancy	-0.38***	-0.13**
	(0.12)	(0.05)

Each entry represents the coefficient on an indicator of OTC access in a regression on a measure of sexual behavior. State, age, race, and year fixed effects are included. Column (1) includes all 50 states, while column (2) is just the nine states who adopted prior to 2006. Data from NLSY97, never married women, 1997-2007. Robust standard errors are clustered at the state level. Sample sizes vary by regression due to missing values. See Data appendix for details.
$*$: significant at 10% level. $**$: significant at 5% level. $***$: significant at 1% level.

Table 10: Estimated impact of OTC policies on birth rates

Birth rates (per 1,000 women)	(1)	(2)	(3)	(4)
		All states		
Single women	-3.8***	0.61	-6.1**	-5.8***
	(1.33)	(0.60)	(2.53)	(1.92)
Married women	-1.3***	0.10	-.21	-3.6***
	(0.50)	(0.42)	(1.43)	(0.75)
Single women, white	-4.1**	-1.1**	-7.8***	-5.4***
	(1.23)	(0.5)	(2.12)	(1.85)
Single women, black	-3.8*	2.4	-6.0**	-5.9**
	(1.93)	(1.8)	(3.45)	(2.89)
N:	3,452	863	863	863
Ages	15-29	15-17	18-19	20-29
		Early adopters		
Single women	-2.6**	-0.73	-4.1*	-4.0**
	(1.33)	(0.69)	(2.49)	(2.06)
Married women	-0.91	-0.19	-1.4	-1.76
	(0.53)	(0.48)	(1.78)	(1.06)
Single women, white	-3.1**	-1.1*	-5.2**	-4.4*
	(1.45)	(0.57)	(2.72)	(2.45)
Single women, black	-0.5	-0.01	-3.2	0.11
	(1.62)	(1.79)	(3.37)	(2.56)
N:	612	153	153	153
Ages	15-29	15-17	18-19	20-29

Each entry represents the coefficient on an indicator of OTC access in a regression of birth rates within an age/state/year cell, weighted by cell population. State and year fixed effects are included, as well as age fixed effects in Column (1). Column (1) includes all age groups 15-17, 18-19, 20-24, and 25-29. Data from CDC National Vital Statistics, 1990-2007. Robust standard errors are clustered at the state level.

$*$: significant at 10% level. $**$: significant at 5% level. $***$: significant at 1% level.

Table 11: Estimated impact of OTC policies on marriage probability

Age	16	18	20	22	24
Log % Women Ever Married					
All states	-0.08***	-0.06***	-0.04***	-0.02***	-0.02***
	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)
N:	108	138	168	173	173
Early adopters	-0.21	-0.17**	-0.06***	-0.11**	-0.05***
	(0.12)	(0.03)	(0.01)	(0.03)	(0.003)
N:	16	26	41	44	44

Each entry represents the estimated impact of an additional year of exposure to OTC access on the marriage rate in a state/cohort cell. Regressions weighted by cell population. State and cohort fixed effects are included. Each column denotes a different age. Data from ACS, 2001-2008. Robust standard errors are clustered at the state level.
$*$: significant at 10% level. $**$: significant at 5% level. $***$: significant at 1% level.

Table 12: Emergency contraception usage by year

	2006	2007	2008
Used EC past 12 months	1.3%	5.2 %	4.0 %

Data from the NSFG, 2006-2008, women aged 15-29.

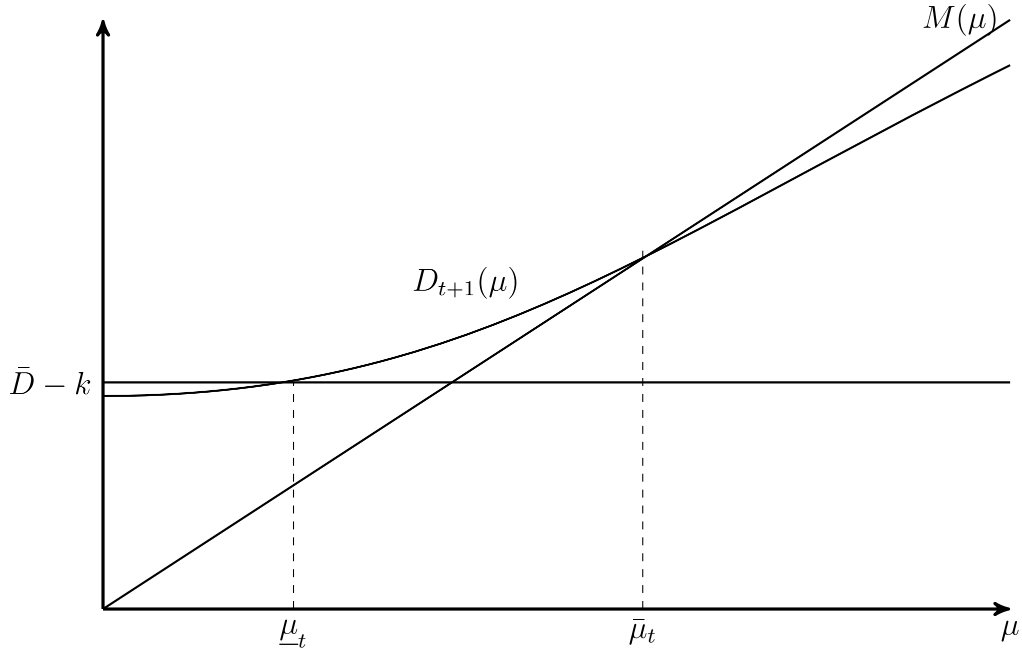
Table 13: Baseline parameter values for simulation

a_m	-25
b_m	3
a_s	-10
b_s	0.1
k	15
μ_0	10
σ^2	10
σ_ε^2	1
T	30
$v(s)$	$s^{\frac{1}{2}}$
β	0.95

Table 14: Simulated effect of improved contraception

p	0.004	0.001	0.00391
Expected # of partners	3.9	4.4	4.0
Expected relationship duration	12.1	13.4	12.2
Sexual activity per period	32.2	36.8	32.9
Probability of single motherhood	0.231	0.196	0.226

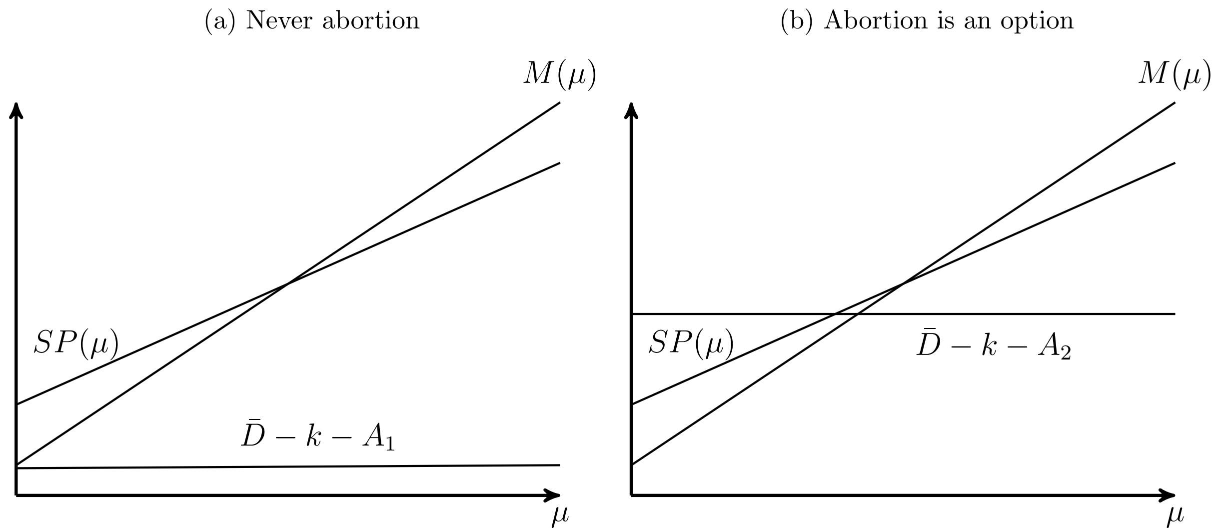
Figure 1: Next period value functions if not pregnant



Value functions are plotted in the state space, (μ, t), of mean relationship quality and duration. $M(\mu)$ is the value of marriage, $\bar{D} - k$ is the expected value of separation including search costs, and $D_{t+1}(\mu)$ is the value of continuing the relationship. The thresholds $\bar{\mu}_t$ and $\underline{\mu}_t$ represent the indifference between the possible states.

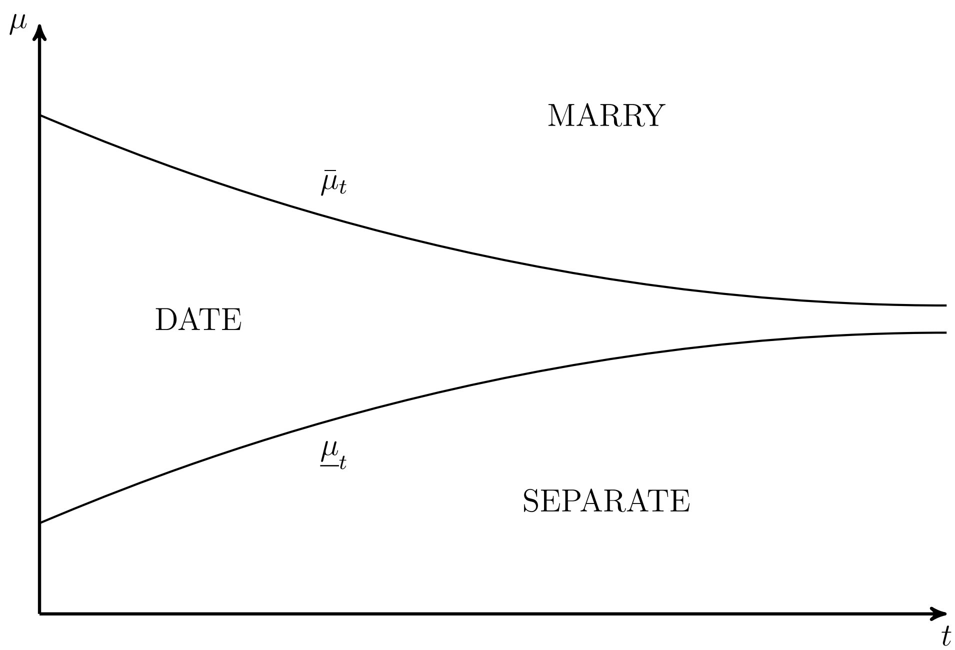
1

Figure 2: Next period value functions if pregnant



Value functions are plotted in the state space, (μ, t), of mean relationship quality and duration. $M(\mu)$ is the value of marriage, $SP(\mu)$ is the value of single parenthood, and $(\bar{D} - k - A)$ is the cost of getting an abortion and finding a new partner. Panel (a) plots the value functions for a woman whose personal cost of abortion is high enough that she will never choose abortion. Single motherhood and marriage strictly dominate abortion for all relationships. Panel (b) plots the values for a woman with a much lower cost of abortion. She will choose abortion over single motherhood for several relationships, but will still choose to marry or carry the pregnancy to term if the relationship is of sufficiently high quality.

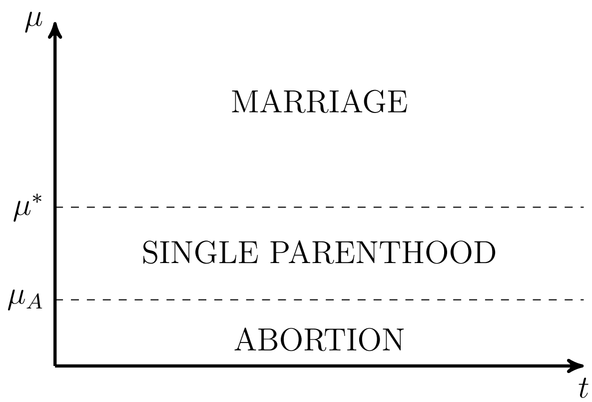
Figure 3: Optimal policies when not pregnant



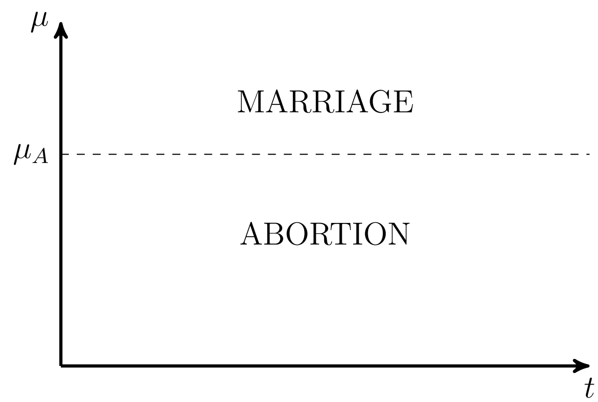
Policy thresholds for a non-pregnant woman are plotted in the relationship quality (μ) and length (t) state space. $\bar{\mu}_t$ are the points where a woman is indifferent between marriage and continuing to date. $\underline{\mu}_t$ are the points where a woman is indifferent between continuing to date and separating and finding a new partner. Sufficiently high quality matches become marriages and sufficiently low quality matches break up. Over time, these thresholds narrow to the same point.

Figure 4: Optimal policies when pregnant

(a) High cost of abortion

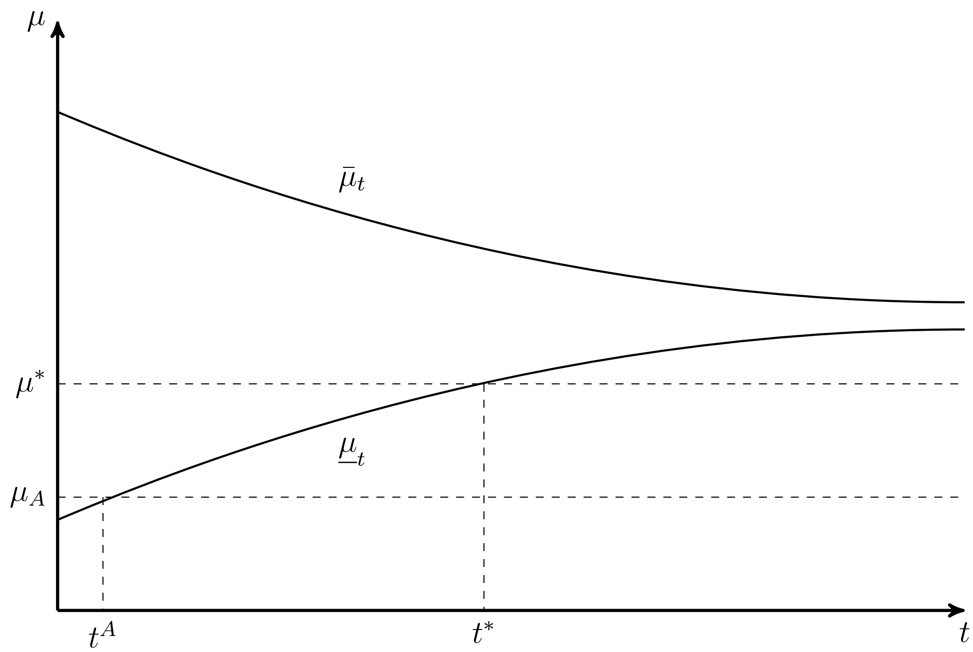


(b) Low cost of abortion



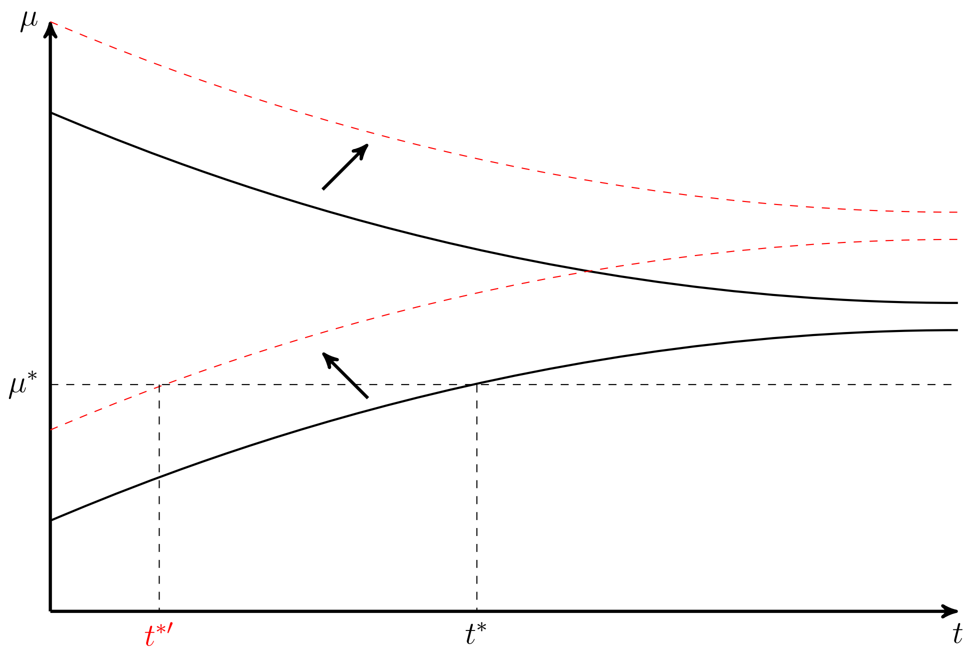
Policy thresholds following a pregnancy are plotted in the relationship quality and duration state space. Panel (a) are the thresholds for a woman with a high personal cost of abortion. Only for low quality matches will she choose abortion. She will choose single parenthood for middling quality matches and marriage for high quality matches. Panel (b) shows thresholds for a woman with a low personal cost of abortion. Abortion strictly dominates single parenthood and she will only choose marriage for sufficiently high quality matches.

Figure 5: Optimal policy thresholds



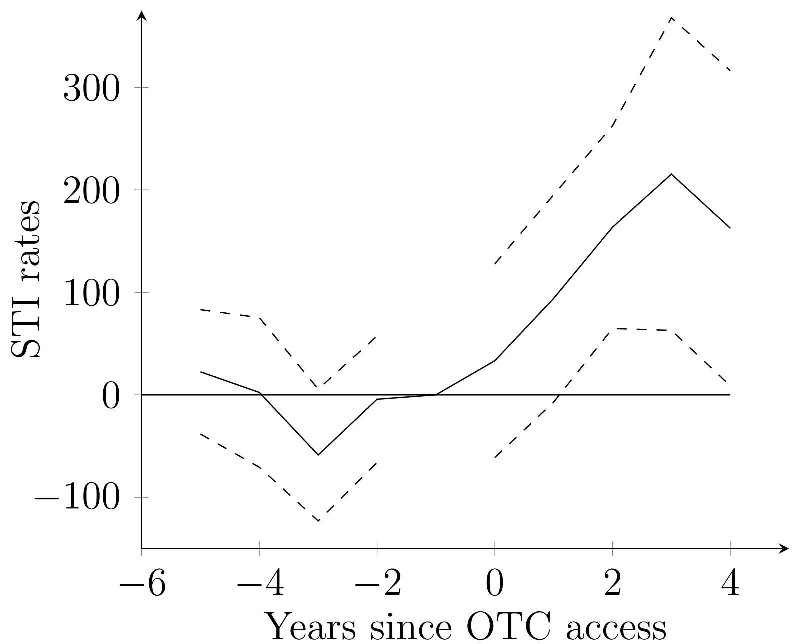
All four policy thresholds are plotted in the relationship quality and duration state space. Solid lines represent the decision thresholds if a woman is not pregnant. $\bar{\mu}_t$ is where she is indifferent between marriage and continuing to date. $\underline{\mu}_t$ is where she is indifferent between continuing to date and separating. The dashed lines represent the decision thresholds if a woman has a premarital pregnancy. Below μ_A she will obtain an abortion. Between μ_A and μ^* she will choose to become a single mother. Above μ^* she will marry her current partner. The graph assumes that abortion costs are high enough that single motherhood is a possibility. Relationships lasting longer than t^A periods will never result in abortions. Relationships lasting longer than t^* will never result in single parenthood.

Figure 6: The impact of improvements in contraception on continuation thresholds



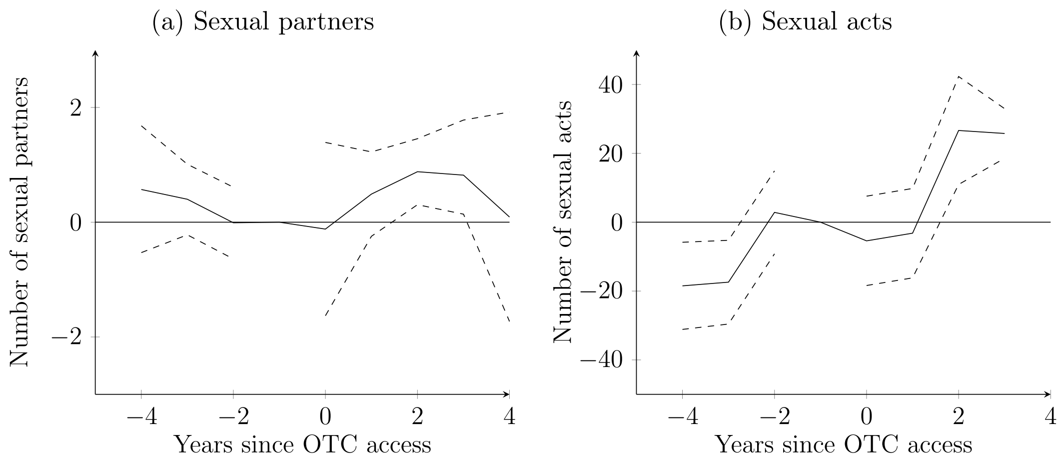
The solid lines represent the policy thresholds in a poor contraceptive regime and the dashed lines represent policy thresholds in a good contraceptive regime. The upper threshold between marriage and continuing to date shifts up as contraceptive access improves. The value of dating has increased and a woman is more reluctant to marry. The lower threshold between continuing to date and separating also shifts up as the earliest stages of relationships gain the most from the improvement in contraception, increasing the turnover. μ^*, the threshold of indifference between marriage and single parenthood following a premarital pregnancy, is unchanged. The abortion decision is omitted for clarity.

Figure 7: The impact of OTC access on STI rates (per 100,000 women)



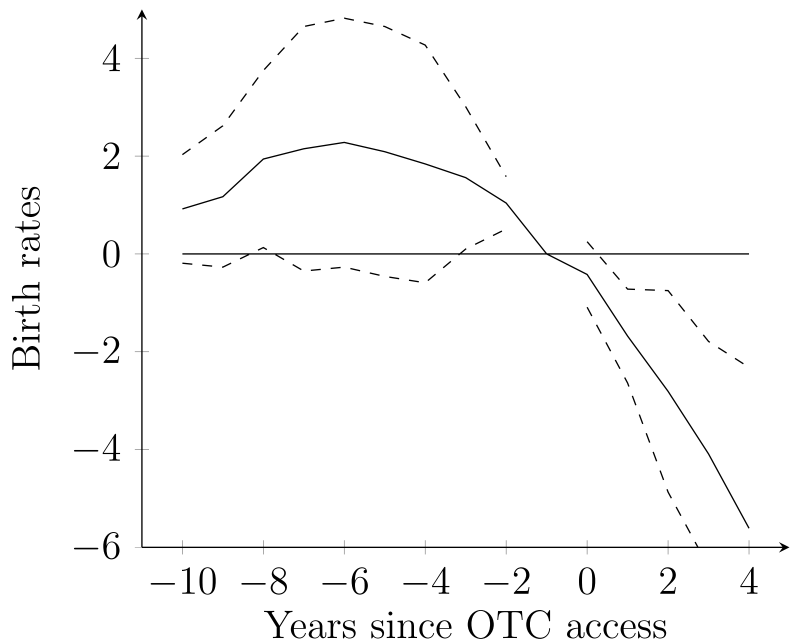
Solid line is the regression estimate of changes in STI rates (per 100,000 women) in the years before and after OTC access was adopted in a state, controlling for state and year fixed effects (Equation 1 in the text). Changes are relative to the level the year before OTC access was adopted. STIs defined as total incidence of chlamydia, gonorrhea, and syphilis. Data from CDC, 1998-2006. Dashed lines are 95% confidence intervals. Year -1 is the omitted variable in the regression so there is no confidence interval for that year.

Figure 8: The impact of OTC access on sexual activity



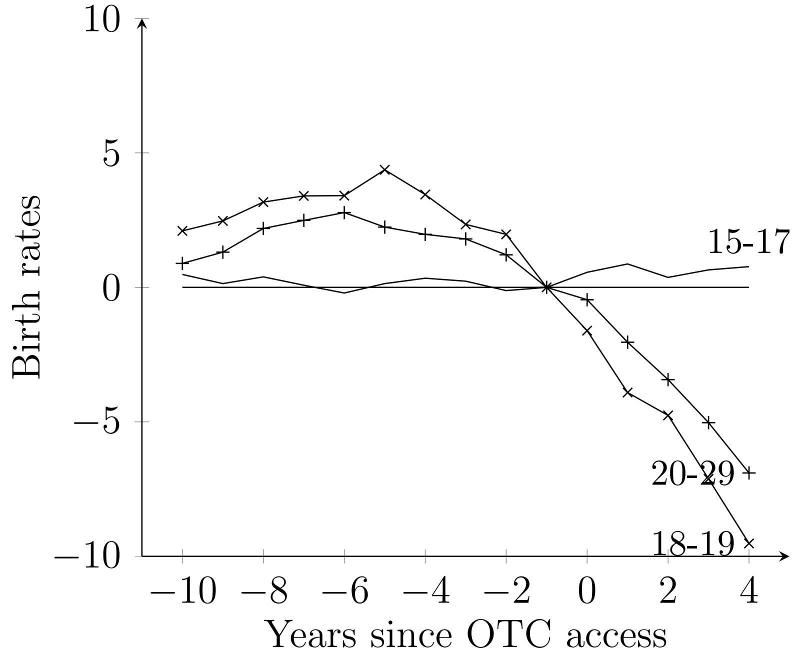
Solid lines are the regression estimate of changes in sexual activity in the years before and after OTC access was adopted in a state, controlling for state, age, race, and year fixed effects (Equation 1 in the text). Changes are relative to the level the year before OTC access was adopted. Panels (a) and (b) show the impact on the number of sexual partners and sexual acts since the last interview, respectively. Data from NLSY97, 1997-2007, single women older than 15 with valid interviews, state identifiers and reported sexual partners in the past year. Dashed lines are 95% confidence intervals. Year -1 is the omitted variable in the regression so there is no confidence interval for that year.

Figure 9: The impact of OTC access on single motherhood rates (per 1,000 women)



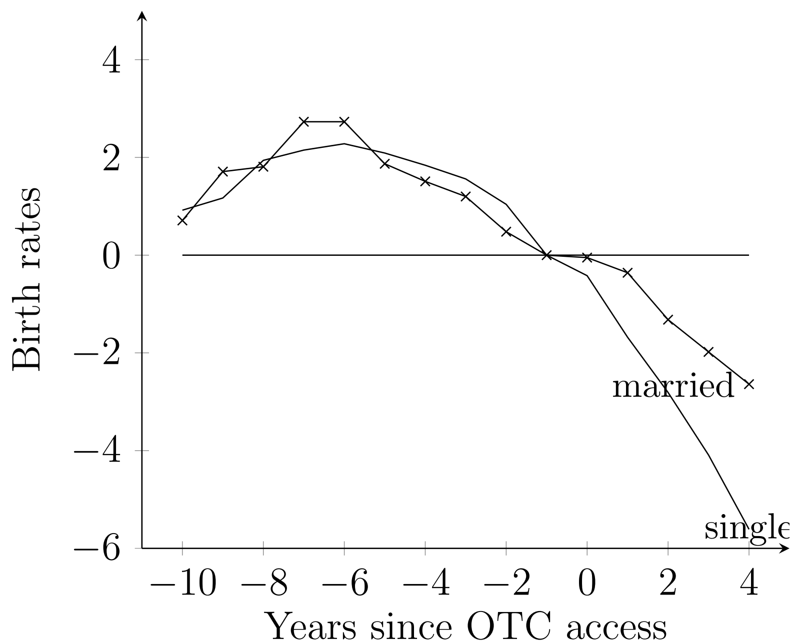
Solid line is the regression estimate of changes in single motherhood rates (per 1,000 women) in the years before and after OTC access was adopted in a state, controlling for state and year fixed effects (Equation 1 in the text). Changes are relative to the level the year before OTC access was adopted. Data from CDC Vital Statistics, 1990-2006. Dashed lines are 95% confidence intervals. Year -1 is the omitted variable in the regression so there is no confidence interval for that year.

Figure 10: The impact of OTC access on birth rates (per 1,000 women)



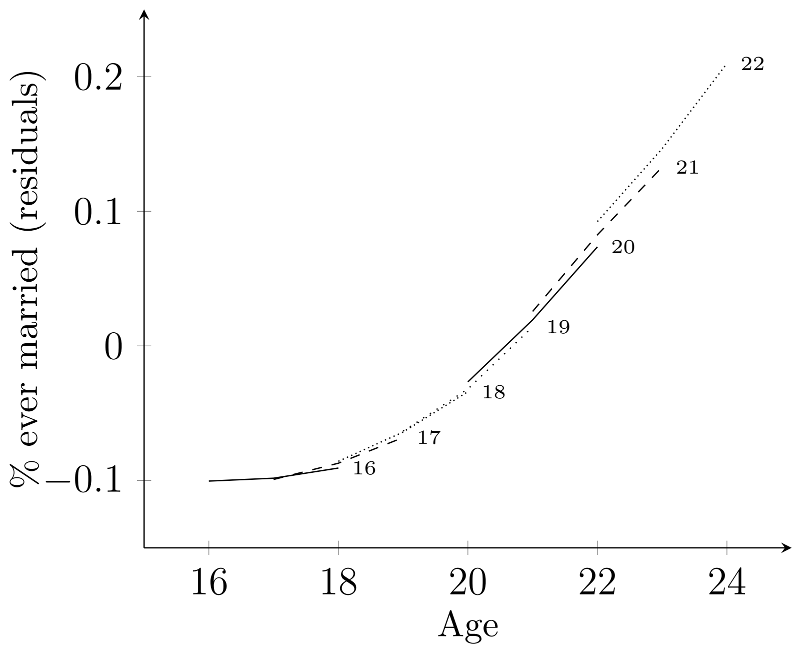
Plotted are regression estimates of changes in birth rates (per 1,000 women) for different age groups before and after OTC access was adopted in a state, controlling for state and year fixed effects (Equation 1 in the text). The solid line is women aged 15-17, the line with Xs is women aged 18-19, the line with +s is women aged 20-29. Changes are relative to the level the year before OTC access was adopted. Data from CDC Vital Statistics, 1990-2006. Confidence intervals are omitted for visual clarity. Estimated effects are significant at the 5% level for the 18-19 age group and for the 20-29 age group after Year 2. No significant effect at the 10% level is found for women aged 15-17.

Figure 11: The impact of OTC access on birth rates (per 1,000 women)



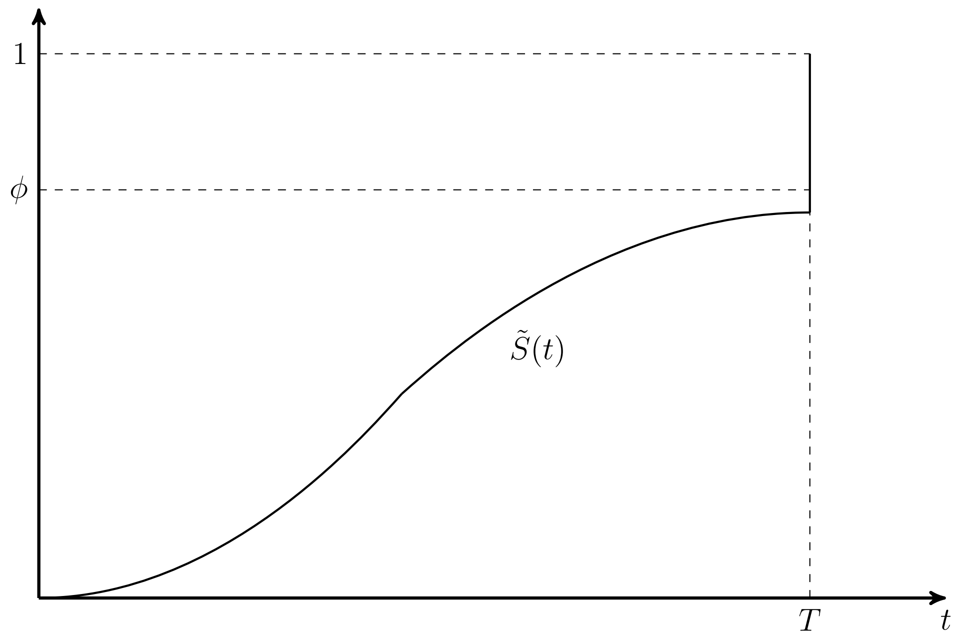
Plotted are regression estimates of changes in birth rates (per 1,000 women) for single (solid line) and married (solid with Xs) women in the years before and after OTC access was adopted in a state, controlling for state and year fixed effects (Equation 1 in the text). Changes are relative to the level the year before OTC access was adopted. Data from CDC Vital Statistics, 1990-2006. Confidence intervals are omitted for visual clarity. Both lines are significantly different at the 5% level from zero after Year 2.

Figure 12: The impact of OTC access on cohort marriage rates



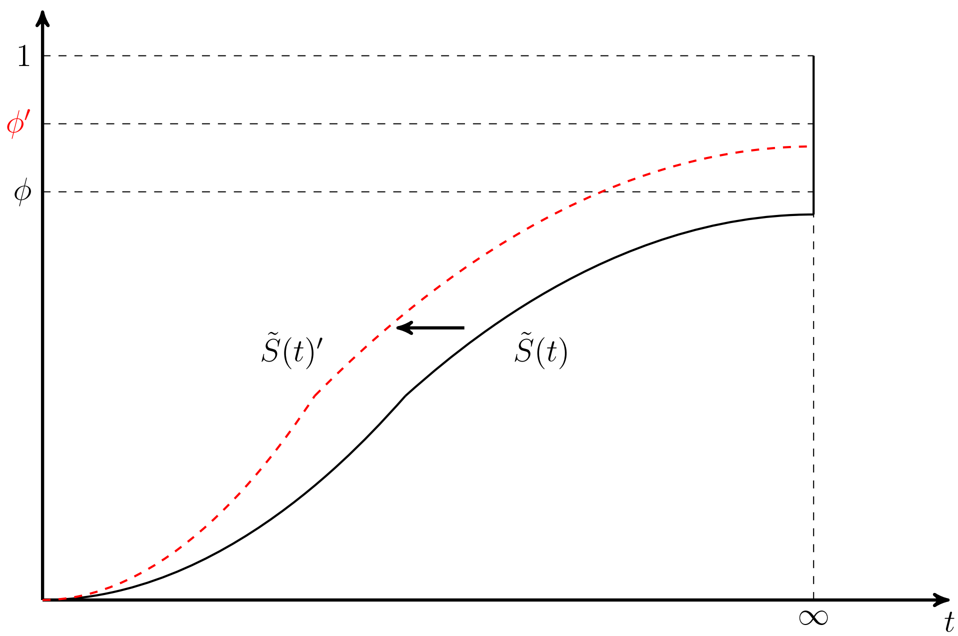
Each line represents a synthetic cohort based on age in which a woman's state adopted an OTC policy. The y-axis is the average marriage rate for a synthetic cohort across states, controlling for state and year fixed effects. For example, looking vertically at Age 22, the highest (dotted line) is the marriage rate for women who were 22 when they got OTC access. The dashed line below is the marriage rate for women who were 21 when they got OTC access and the solid line on the bottom is the marriage rate for women who were 20 when they got OTC access. Data from the American Community Survey, 2001-2008.

Figure A 1: *cdf* of separation over relationship duration



$\tilde{S}(t)$ is the probability of having separated from one relationship by time t. By assumption, dating relationships end at time T and ϕ is the cumulative probability that a relationship separates. The discrete jump at time T reflects the positive mass of people who are still dating that are forced to either separate or marry.

Figure A 2: Improvements in contraception decrease the time until separation.



$\tilde{S}(t)$ and $\tilde{S}(t)'$ are the cumulative probabilities of having separated from one relationship by time t in two contraceptive regimes $p < p'$. By assumption, dating relationships end at time T and ϕ and ϕ' are the cumulative probabilities that a relationship separates in the two contraceptive regimes. The discrete jump at time T reflects the positive mass of people who are still dating that are forced to either separate or marry.