Habit Persistence and Teen Sex: Could Increased Access to Contraception have Unintended Consequences for Teen Pregnancies?*

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Abstract

We develop a dynamic discrete choice model of teen sex and pregnancy that incorporates habit persistence. Habit persistence has two sources here. The first is a 'fixed cost' of having sex which relates to a moral or psychological barrier that has been crossed the first time one has sex. The second is a 'transition cost' whereby once a particular relationship has progressed to sex, it is difficult to move back. We estimate significant habit persistence in teen sex, implying the the long run effects of contraception policy may be different from their short run counterparts. Programs that increase access to contraception are found to decrease teen pregnancies in the short run but increase teen pregnancies in the long run.

Keywords: habit persistence, access to contraception, teen pregnancy, dynamic discrete choice

JEL: J13, C33, C51

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1 Introduction

Teenage pregnancy rates, although steadily declining since 1990, are still very high in the United States with 83.6 pregnancies per 1000 teenage women in 2000 (Alan Guttmacher Institute 2004). This rate is substantially higher than Canada and Western Europe (Singh and Darroch 2000). Furstenberg (1998) argues that the higher rate in the United States is in part due to the lack of availability of contraception compared to Western Europe. On the other hand, it may be argued that increased availability of contraceptives will decrease the rate of unprotected sex, *and* lead some individuals to choose sex when they otherwise would have abstained due to the lower risk of pregnancy because of lowered costs of contraception.

Previous research has shown that regulations and the availability of contraception affect sexual behavior. Using aggregate data, researchers have found that restrictions on Medicaid funding of abortions or access to clinics reduced the number of adolescent abortions but either had no effect or reduced the number of teen births (for example, Kane and Staiger (1996) and Levine, Trainor, and Zimmerman (1996)). For abortions to fall with no effect on teen births, there must be a strong behavioral response in sexual actiivity. Similarly, using data from the United Kingdom, Paton (2002) found no evidence that nearness to family planning clinics reduced either the pregnancy rate or the abortion rate, with some evidence that family clinics increased the pregnancy rate, while Girma and Paton (2006) found no effect of the availability of emergency contraceptives on teen pregnancies. Should contraception become more available, those who switch from unprotected sex to protected sex will lower the teen pregnancy rate, while those who move from abstaining to protected sex will increase the teen pregnancy rate due to contraception failure.

The effects of contraception policy may differ between the long and the short run if there is habit persistence in teen sexual behavior. While habit persistence is generally associated with addictive goods, such as alcohol or cigarettes, it can result from other sources as well. For example, if there is a moral or psychological barrier which is crossed the first time one has sex (a fixed cost), once an individual has sex they will be more likely to have sex in the future.[1] The importance of virginity is implicitly stressed by much of the sociological literature

[1]Evidence, even if anecdotal, that a fixed cost to sex may exist is to be found in the growth of social movements for 'virginity pledges' where promises are made to wait until marriage before having sex. Virginity movements have been associated with significant decreases in teen sex and pregnancy rates, particularly for

on adolescent sex through the attention paid to time of first intercourse.[2] This emphasis on virginity suggests that the costs to abstaining from sex are higher for those who have been sexually active in the past.[3]

Data from the 1997 National Longitudinal Survey of Youth (NLSY97) also speak to the possibility of the cost of abstaining from sex being higher once one has become sexually active. This panel data set follows individuals who were between the ages of 12 and 16 in 1997. Table 1 shows the sex patterns for women who answered the questions on whether they had sexual intercourse in the first four waves of the survey and who were between the ages 14 and 16 in wave 1.[4] Besides abstaining in all four waves, the most populous cells for each age are those where once one has become sexually active, one is sexually active from that point forward. Further, the least populous cells are those in which the individual transitions in and out of sexual activity. The patterns in the data suggest that there may be a fixed cost (a moral or psychological barrier that has been crossed) and a transition cost (which may be relationship-specific).

Note that person-specific effects cannot be completely driving the persistence. For example, consider an individual who had sex in 1997 but not in 1998. This individual is considerably *less* likely to have sex in 1999 than someone who had sex in 1998 but not in 1997. Having sex in one year and not the next is rare. In fact, the least likely outcome for all ages was a pattern of two stops in sexual activity; having sex, then not, then having sex, then not. To further illustrate this point, consider a sixteen year old in 1997 who in the first three periods

those under the age of 18 (Bearman and Brückner 1997). This same study finds that those who take pledges and break them are more likely to have unprotected sex. This result also parallels the results here in that programs that lower the utility of contraceptive sex lead to less sex but also less contraception conditional on sex. Our policy simulations suggest that the former effect dominates the latter in the long run.

[2]See, for example, Day (1992), Furstenberg, Brooks-Gunn, and Morgan (1987), Widmer (1997), Zabin et al. (1986), and Zelnik and Shaw (1983) among many others.

[3]Bearman and Brückner use the Add Health data (http://www.cpc.unc.edu/projects/addhealth) for their analysis. There is a burgeoning literature using this data that examines the relationship between various social and economic factors and teen sexual activity, e.g., Bearman, Moody and Stovel (2004) analyze the effects of social networks; Adamczyk and Felson (2006) study the effects of the religious propensity of friends; Ashby, Edmonson and Arcari (2006) investigate the impact of exposure to television programming. None of these studies examine the persistence of sexual behavior.

[4]Similar patterns hold for males as well, with slightly more males having breaks in their sexual behavior, suggesting women may be the ones dictating whether sex occurs.

had the pattern $\{0, 0, 1\}$. The probability that this person will have sex in the fourth period is over 86%. Now consider the probability of having sex in the fourth period given a similar sixteen year old with the pattern for the first three periods given by $\{1, 1, 0\}$. The probability of having sex in the fourth period is only 55%, despite the fact that this letter individual had been more sexually active in the past, suggesting a transition cost associated with sex.

Table 1: Persistence in Female Sexual Activity†

				Age in 1997		
Sex in 97	Sex in 98	Sex in 99	Sex in 00	14	15	16
No	No	No	No	41.3%	30.1%	19.4%
No	No	No	**Yes**	13.5%	11.5%	8.6%
No	No	**Yes**	**Yes**	13.3%	12.4%	11.9%
No	**Yes**	**Yes**	**Yes**	15.5%	18.0%	21.0%
Yes	**Yes**	**Yes**	**Yes**	8.8%	16.4%	27.1%
No	No	**Yes**	No	0.9%	1.8%	1.9%
No	**Yes**	No	No	0.4%	1.2%	0.9%
No	**Yes**	No	**Yes**	3.8%	2.3%	1.9%
No	**Yes**	**Yes**	No	0.4%	0.6%	1.4%
Yes	No	No	No	0.4%	0.6%	0.5%
Yes	No	No	**Yes**	0.2%	0.8%	0.4%
Yes	No	**Yes**	No	0.0%	0.3%	0.4%
Yes	No	**Yes**	**Yes**	0.4%	1.8%	1.2%
Yes	**Yes**	No	No	0.2%	0.5%	0.9%
Yes	**Yes**	No	**Yes**	0.7%	1.2%	1.1%
Yes	**Yes**	**Yes**	No	0.0%	0.5%	1.4%

† All females who had valid answers for the sex questions in first four waves. Sample sizes are 498, 727, and 640 for ages 14, 15, and 16 respectively.

In this paper we examine the difference between the short and long run effects of contra-

ception policy that may arise due to the presence of habit persistence in sexual activity. We estimate a dynamic model of sex and fertility for teenage women which allows for habit persistence in both the choice to have sex and the choice to contracept. In each year, individuals decide whether to be sexually active and, if so, whether to use contraception that requires advanced planning (for example, the pill) or to use contraception which can be implemented at the time of the act itself (for example, condoms). Should an individual choose to engage in sex, she becomes pregnant with a probability that depends upon the choice of contraception. As in Hotz and Miller (1993) and Carro and Mira (2006), contraception will reduce, but not eliminate, pregnancy risk. We use the model estimates to forecast the short run and long run effects of increased access to contraception on the rates of teen sex and pregnancy.

The estimates of the model reveal strong habit persistence in teen sexual behavior. These effects are so strong that policies which increase access to certain types of contraception such as condoms, while lowering teen pregnancy rates in the short run, may raise teen pregnancy rates in the long run. Consider a sixteen year old exposed to a policy that increases access to contraception, ceteris paribus. If the policy is a surprise, our simulations reveal that this individual will be less likely to become pregnant at age sixteen. However, a fourteen year old exposed to the same policy from the ages of fourteen through sixteen will actually have a higher probability of becoming pregnant at age sixteen. The differences in the long and short run effects are driven by the habit persistence. Individuals who are sixteen at the time the policy was implemented have already established certain sexual behaviors. Individuals exposed to the policy from age fourteen are more sexually active due to 'moral hazard' arising from the lower contraception costs (which lowers the risks of pregnancy). This increased sexual activity is reenforcing due to habit persistence and results in higher long run pregnancy rates. Thus our results imply that well intentioned policies regarding teen access to contraception can have unintended consequences in the presence of habit persistence.[5]

Previous dynamic models of fertility decisions have not focused on the persistence of sexual behavior (for example Hotz and Miller 1988 and 1993, Rosensweig and Shultz 1985, and Wolpin 1984). This is primarily because these studies focus on married couples and the optimal spacing

[5]Another way to capture these trends in the data would be to use time-varying heterogeneity. The data are not rich enough to distinguish between habit persistence and time-varying heterogeneity. We discuss this in more detail in the last section of the paper.

of children; the act of sex itself is taken as given. Models of teen behavior have not focused on the dynamics of sex, in part because of inadequate data. Indeed, the two studies perhaps most related to our own, Lundberg and Plotnik (1995) and Oettinger (1999), used an earlier version of our data set which only asked at what age the individual first had sex; year by year questions on sexual behavior were not asked.

Lundberg and Plotnick (1995) estimate a sequence of choices in a static context using data from the 1979 National Longitudinal Survey of Youth (NLSY79). They estimate a nested logit model where the sequence of decisions is whether to have a premarital pregnancy, conditional on pregnancy, whether to have an abortion, conditional on not having an abortion, whether to become married. Lundberg and Plotnick find that the behavior of whites responds to the incentives of state welfare, abortion, and family planning policies. While we do not model the decision to marry or abort, we do model the choice to have sex and the choice of contraception and we explicitly account for the dynamics of the decisions.

Oettinger (1999) is one of the few studies in the economics literature to actually examine the decision to have sex as opposed to fertility outcomes. He also looks at fertility outcomes as well, but does not link the model of fertility to the model of sex. He estimates a hazard model of the time to first sex and time to first pregnancy using the NLSY79. Persistence in sexual activity, however, cannot be taken into account because the survey only asked when the respondent first engaged in sexual activity.

2 Model and Estimation

What distinguishes our work from much of the previous literature is that we do not model fertility as a single choice, but as a sequence of choices integrated with uncertainty about pregnancy outcomes. Similar to Hotz and Miller (1998, 1993), individuals make decisions regarding sex knowing that there is some probability of becoming pregnant, with the probability being lower if contraceptives are used. Individuals may still engage in unprotected sex even though *ex post* they may regret the decision if they become pregnant. This can still be consistent with a rational expectations framework. The key is that, given the probability of getting pregnant without contraception, the expected utility was still higher for having unprotected sex. Hence, the flow utility of having sex without contraception compensated the individual for

the increased probability of becoming pregnant. We first discuss the model without including unobserved heterogeneity and then follow with how unobserved heterogeneity is incorporated.

2.1 Base Model

We propose a dynamic discrete choice model of sex and contraception decisions. Throughout the model, we want to distinguish 'flow utility', utility in the period, from the full consequences of having sex which include the utility of various pregnancy outcomes. Although decisions with regard to sex are joint decisions, since women have to bear the consequences of a pregnancy through carrying the child and have the exclusive right to abort the child, we model the decisions from the perspective of the woman.

In each period of T periods women choose whether to engage in sexual activity. Those who engage in sex must also decide whether to contracept and, if so, what type of contraception to use. We distinguish between two types of contraception: *scheduled contraception*, which requires advanced planning such as the pill, and *episode-specific contraception*, where the choice to use it can be postponed until the act itself. Define c_t as the sex and contraception combination chosen at time t where:

$$c_t = \begin{cases} NS & \text{if abstains} \\ NC & \text{if sex, but no contraception} \\ EC & \text{if sex with episode-specific contraception} \\ SC & \text{if sex with scheduled contraception} \end{cases} \tag{1}$$

Conditional on having sex, individuals also chooses among discrete levels of their sexual activity. In particular, we assume that the level of sexual activity, l_t, takes on one of three values: low, medium and high.[6]

Individuals receive flow utility from having sex that may vary across observable characteristics such as the family environment. The flow utility may also depend upon past sexual decisions. We allow there to be both a fixed and transition cost for sex itself, as well as fixed and transition costs for the two types of contraception. The fixed and transition costs for sex are included to capture a moral or psychological barrier associated with losing one's virginity (the fixed cost) or through having sex the first time in a particular relationship (the transition

[6]As we discuss in the data section, these levels correspond to 1-10 times since the date of last interview, 11-50 times, and 51 or more times.

cost). With regard to contraception, in addition to a per-period cost to using it, there may be a fixed cost to learning or acquiring particular contraception and it may also be easier to access particular forms of contraception if they were used recently. Let s_{ft} represent the possible fixed cost states and s_{lt} the lagged choices which are over the same set as c_t. Define s_{ft} as:

$$s_{ft} = \begin{cases} NS & \text{if never had sex in the past} \\ NC & \text{if had sex in the past, but never used contraception} \\ EC & \text{if had sex in the past, but only used episode-specific} \\ & \text{contraception or no contraception} \\ SC & \text{if had sex in the past, but only used scheduled} \\ & \text{contraception or no contraception} \\ BC & \text{if had sex in the past and have used both scheduled} \\ & \text{and episode-specific contraception} \end{cases}$$

Note that these fixed and transition costs depend upon whether the individual engaged in particular acts, not how often.

The utility of sex may also be a function of the family environment (e.g., mother works, two parent family, religion). We denote these variables as s_{xt}. Normalizing the flow utility of abstaining to zero, the base utility of engaging in sexual actiivty (regardless of level) without contraception, with episode-specific contraception, and with scheduled contraception are specified as follows:

$$\begin{aligned} u(NC, s_t) &= s_{xt}\alpha_0 \quad -[1-(s_{ft} \neq NS)]\alpha_1 - [1-(s_{lt} \neq NS)]\alpha_2 && (2) \\ u(EC, s_t) &= s_{xt}\alpha_0 \quad -[1-(s_{ft} \neq NS)]\alpha_1 - [1-(s_{lt} \neq NS)]\alpha_2 && (3) \\ &\qquad -[1-(s_{ft} \in \{EC, BC\})]\alpha_{31} - [1-(s_{lt} = EC)]\alpha_{41} - \alpha_{51} \\ u(SC, s_t) &= s_{xt}\alpha_0 \quad -[1-(s_{ft} \neq NS)]\alpha_1 - [1-(s_{lt} \neq NS)]\alpha_2 && (4) \\ &\qquad -[1-(s_{ft} \in \{SC, BC\})]\alpha_{32} - [1-(s_{lt} = SC)]\alpha_{42} - \alpha_{52} \end{aligned}$$

Note that the coefficients on s_{xt} are common across the sex choices. Similarly, the fixed and transition costs for sex itself does not vary across the contraception choices.

The total flow utility depends on the choice of the level of sexual activity, l_t, age, s_{at}, and preference shocks for particular contraception and sex level combinations, $\epsilon_t(c_t, l_t)$. We assume

that the ϵ's are distributed Type I extreme value and IID across time and choices.[7] Further, in order to insure that we are truly picking up habit persistence, we allow for the utility of each of the possible choices to depend flexibly on age.[8] In particular, we have separate age dummies for each of the sex and contraception choices, $\alpha_6(c_t, s_{at})$, as well as separate age dummies for each of the levels of sexual activity, $\alpha_7(l_t, s_{at})$. Finally, we have separate dummies for each contraception choice and level combination, $\alpha_8(c_t, l_t)$. The flow utility for a particular choice c_t and l_t is then given by:

$$U(c_t, l_t, s_t, \epsilon_t) = u(c_t, s_t) + \alpha_6(c_t, s_{at}) + \alpha_7(l_t, s_{at}) + \alpha_8(c_t, l_t) + \epsilon_t(c_t, l_t) \tag{5}$$

Those who engage in sex weigh the flow utility of sex against the probability and consequences of becoming pregnant. Conditional on having sex, the probability of becoming pregnant will depend upon age, the choice of contraception, and the level of sexual activity. We assume that the probability of becoming pregnant follows a logit form:

$$p_{clt} = \frac{\exp(s_{at}\gamma_0 + \gamma(c_t) + \gamma(l_t) + (c_t \neq NC)s_{at})\gamma_1}{1 + \exp(s_{at}\gamma_0 + \gamma(c_t) + \gamma(l_t) + (c_t \neq NC)s_{at}\gamma_1)} \tag{6}$$

The γ_c's refer to indicator variables for each of the possible contraception choices (no contraception, episode-specific, or scheduled). We assume that individuals know these probabilities when they make their sex decisions.[9]

Given that the decision as to whether to abort or give birth is often very traumatic, and given limited data on abortions,[10] we do not model the abortion decision. Rather, we model the lifetime utility from that point forward using a terminal value function. The terminal value function, V_{pt}, flexibly maps the states at t that we expect to affect the lifetime utility

[7] More general correlation structures are possible using a GEV framework (for example, Arcidiacono 2005 and Khwaja 2001). We experimented with more flexible correlation structures and were unable to reject the Type I extreme value assumption.

[8] We must therefore set the discount factor, setting $\beta = 0.9$. Arcidiacono, Sieg, and Sloan (2007) use age-behavior profiles to identify the discount factor. We have also estimated the model with the discount factor set at zero and the habit persistence parameters were large and significant under this alternative specification. This suggests that the presence of habit persistence is robust to the value of the discount factor.

[9] An alternative is to ask individuals about what they know regarding contraceptive efficacy. Delavande (2008) examines what individuals know about contraceptive effectiveness and how their knowledge affects contraceptive choice. van der Klaauw (2000) shows how to incorporate these subjective expectations into a dynamic discrete choice model.

[10] See Jones and Forest (1992) for a detailed discussion of the quality of abortion data from surveys.

of a pregnancy, s_{pt} into discounted present value utility.[11] Examples of variables which will affect this terminal utility but not the flow utility of having sex are ability measures and family income as the opportunity cost of a child will be higher for those who have better expected labor market outcomes. Note that treating pregnancy as terminal state in no way diminishes the importance of future labor market outcomes when making sexual decisions. Individuals may recognize how pregnancies affect their educational paths and future work profiles. Indeed, as the estimation reveals, the human capital measures in the terminal value function play a significant role in sexual activity choices.

In addition to uncertainty regarding future pregnancy outcomes and on unobservable preferences, individuals also face uncertainty regarding the state variables themselves.[12] We assume that individuals know the stochastic processes governing the transitions of the demographic variables and these transitions do not depend upon decisions made by the individual regarding their sexual behavior. Since the transitions on the demographic variables are not the focus of the analysis, we discuss the estimation of the transitions of these variables in the appendix. The transition of sexual histories is completely determined by the individuals' choices. Let s_t denote the full set of state variables, including the state variables that affect sex, the transitions on the demographics, and the cost of pregnancy, the probability of pregnancy, We then specify the probability of moving from state s_t to s_{t+1} as $q(s_{t+1}|s_t, c_t)$ implying that s_{t-1} only affects s_{t+1} through s_t and c_t.[13]

Since we are only interested in teenage sexual behavior, we also assign a terminal value for individuals who arrive to age nineteen without becoming pregnant. Normalizations must be made in order to identify the model. We normalize the utility of making it to age 20 (T+1) without a pregnancy to zero. The conditional value functions at T, $v(c_T, l_T, s_T, \epsilon_T)$, are then given by:

$$v_T(c_T, l_T, s_T, \epsilon_T) = U_T(c_T, l_T, s_T, \epsilon_T) + \beta p_{cT} V_{pT+1}(s_{pT+1}) \tag{7}$$

where β is the discount factor. The value function at time T is then $V_T(s_T, \epsilon_T) = \max_{c_T, l_T}\{v_T(c_T, l_T, s_T, \epsilon_T)\}$.

[11] The next section describes the variables that are used as input into the terminal value function.

[12] While uncertainty also exists due to the probability of contracting a sexually transmitted disease, our data set includes no information on STDs.

[13] Note that the conditioning on c_t only matters through the sexual histories.

The conditional valuation functions at $T-1$ then follow:

$$\begin{aligned} v_{T-1}(c_{T-1}, l_{T-1}, s_{T-1}, \epsilon_{T-1}) &= U_{T-1}(c_{T-1}, l_{T-1}, s_{T-1}, \epsilon_{T-1}) \\ &\quad +\beta E\left[p_{cT-1} V_{pT}(s_T) + (1-p_{cT-1}) V_T(s_T, \epsilon_T) | c_{T-1}, s_{T-1}\right] \end{aligned} \tag{8}$$

where the expectations are taken over pregnancies and the values of the observed and unobserved state variables. Using backwards recursion we can then write the conditional valuation functions at time t as:

$$v_t(c_t, l_t, s_t, \epsilon_t) = U_t(c_t, l_t, s_t, \epsilon_t) + \beta E\left[p_{ct} V_{pt+1}(s_{t+1}) + (1-p_{ct}) V_{t+1}(s_{t+1}, \epsilon_{t+1}) | c_t, s_t\right] \tag{9}$$

Given the assumptions on the ϵ's, closed form solutions for the conditional expectations of future utility exist (Rust 1987). Denote $v_t(c_t, l_t, s_t) = v_t(c_t, l_t, s_t, 0)$, the conditional valuation function net of the ϵ's. We can then write equation (9) as:

$$\begin{aligned} v_t(c_t, l_t, s_t, \epsilon_t) &= U_t(c_t, l_t, s_t, \epsilon_t) \\ &\quad +\beta \sum_{s_{t+1}} \left[p_{ct} V_{pt+1}(s_{t+1}) + (1-p_{ct}) \ln \left(\sum_{c_{t+1}} \exp(v_{t+1}(c_{t+1}, l_{t+1}, s_{t+1})) \right) \right] q(s_{t+1} | c_t, s_t) \end{aligned} \tag{10}$$

In order to ensure that we are truly picking up habit persistence, we also control for a full set of age-choice interactions normalized with respect to the utility of no sex. Full sets of age dummies come at a cost as it is now unclear what variation in the data identifies the discount factor and we therefore set the discount factor to 0.9.[14]

Probabilities of choosing particular sex and contraception combinations then yield multinomial logit probabilities where, instead of the term inside the exponential function being linear in the parameters, it is highly nonlinear. The log likelihood function is then the sum of three parts:

1. L_c–the log likelihood of the sex and contraception choices,
2. L_p–the log likelihood of the pregnancy outcomes
3. L_s– the log likelihood of the transitions on the demographics.

[14] Arcidiacono, Sieg, and Sloan (2007) use age-behavior profiles to identify the discount factor. We have also estimated the model with the discount factor set at zero and the habit persistence parameters were large and significant under this alternative specification. This suggests that the presence of habit persistence is robust to the value of the discount factor.

The full log likelihood function is then:

$$L(\alpha,\gamma)=\sum_{n=1}^{N}\sum_{t=1}^{T}L_c(c_{nt},l_{nt}|s_{nt},\alpha,\beta,\gamma)+L_p(p_{nt}|c_{nt},l_{nt},s_{nt},\gamma)+L_s(s_{nt}|s_{nt-1},\gamma) \tag{11}$$

where L_c, L_p, and L_s refer to the log likelihood contributions of the sexual activity and contraception decisions, the probability of becoming pregnant, and the transitions on the other state variables. Since the log likelihood is additively separable, it is possible to estimate the parameters of the model in stages. In particular, we use maximum likelihood to first estimate the pregnancy and transition parameters using only L_p and L_s. Next, taking estimates of the pregnancy and transition parameters as given, use maximum likelihood to estimate the utility function parameters using L_c.

2.2 Unobserved Heterogeneity

There may, however, still be unobservable preferences for having sex. Not controlling for unobserved heterogeneity may attribute too much sexual activity to habit persistence.[15] In order to account for unobserved preferences, we estimate the model using mixture distributions to allow for unobserved heterogeneity in the taste for sex. Mixture distributions can be used to overcome this problem and control for 'dynamic selection.'[16] Namely, let there be K types of people with π_k being the population probability of being the kth type. Preferences are common across types and types are known to the individuals. We assume that, conditional on observed characteristics and one's unobserved type, the unobserved preferences are serially uncorrelated. Treating type as a random effect, it is possible to integrate out the probability of being a particular type. The log likelihood function is then:

$$L(\alpha,\gamma,\pi)=\sum_{n=1}^{N}\log\left(\sum_{k=1}^{K}\pi_k\left[\prod_{t=1}^{T}\mathcal{L}_c(c_{nt},l_{nt}|s_{nt},\alpha,\beta,\gamma,k)\mathcal{L}_p(p_{nt}|c_{nt},l_{nt},s_{nt},\gamma)\mathcal{L}_s(s_{nt}|s_{nt-1},\gamma)\right]\right) \tag{12}$$

[15] Gilleskie and Strumpf (2005) deal with a similar issue in the context of youth smoking.

[16] In addition to Gilleskie and Strumf, mixture distributions have been used to account for dynamic selection in dynamic discrete choice models by Keane and Wolpin (1997, 2000, 2001), Eckstein and Wolpin (1999), and Cameron and Heckman (1999, 2001) among many others. In their analysis of married couples, Carro and Mira (2006) model the unobserved heterogeneity on pregnancy probabilities rather than sex.

where the π's are the population probabilities of being a particular type[17] and the $\mathcal{L}$'s are the likelihoods rather than the log likelihoods. Since the probability of a pregnancy conditional on sexual behavior as well as the other transition processes does not depend upon type, we can rewrite the log likelihood as:

$$L(\alpha,\gamma,\pi)=\sum_{n=1}^{N}\log\left(\sum_{k=1}^{K}\pi_k\left[\prod_{t=1}^{T}\mathcal{L}_c(c_{nt},l_{nt}|s_{nt},\alpha,\beta,\gamma,k)\right]\right)+\sum_{t=1}^{T}L_p(p_{nt}|c_{nt},l_{nt},s_{nt},\gamma)+L_s(s_{nt}|s_{nt-1},\gamma). \tag{13}$$

Estimation can again proceed in stages. As before, we first estimate the probability of becoming pregnant conditional on the choice of sexual activity as well as the transitions on the demographic variables. Taking these parameters as given, we estimate the parameters of the utility function.

3 Data

We use the 1997 National Longitudinal Survey of Youth (NLSY97) to estimate the model. The NLSY97 data contain surveys of youths born during the years 1980 to 1984. The first survey was conducted in 1997, when the individuals were between the ages of 12 and 16. Participants are interviewed roughly each year, with Blacks and Hispanics oversampled.

In each wave those surveyed by the NLSY97 answer questions about their sexual activity. To accommodate the model in the previous section, we discretize sexual frequencies into three categories: having sex between 1-10 times since the date of last interview, 11-50 times, and more than fifty times. Conditional on being sexually active in a particular year, 45%, 34%, and 21%, were in each of the groups, respectively.[18]

They are also asked what percentage of the time they used contraception and what their primary form of contraception was. Almost 59% of our sample reports using birth control every time they had sexual intercourse.[19] We classify those who use contraception less than 100% of the time under the unprotected (no contraception) category. Those individuals who reported using contraception every time but whose primary method of birth control was withdrawal

[17] In principle, these population probabilities can vary with state variables. See, for example, Keane and Wolpin (1997, 2000, 2001). This is done to account for initial conditions, something which is unnecessary as we have the full sex history.

[18] We examine how discretizing the data in this way affects our results in section 4.

[19] Note that this does not include those who report withdrawal or rhythm as their method of birth control.

or the rhythm method were classified as unprotected as well. Episode-specific contraception was defined as condoms, foam, jelly, sponges, and diaphragm. Scheduled contraception was defined as the pill, intrauterine devices (IUDs), Norplant, Depo-Provera, and injectables.[20] We only use continuous sex histories beginning from age 14. For example, if an individual is 14 in wave 1 and answers the sex questions in wave 1 and 2 but not wave 3, no survey answers after wave 2 would be used regardless of whether or not answers were given in waves 4 and 5. For more detailed descriptive statistics on the sex rates and the use of contraception, see Walker (2003). Finally, we only keep those individuals who had not experienced a pregnancy as a result of sex from a previous survey wave.

Means conditional on the choice of sex and contraception type are given in Table 2 using the first five waves of the survey.[21] A little over thirteen percent of the sample was classified as unprotected, with thirteen and six percent using episode-specific and scheduled contraception respectively. Those who engage in sex tend to be older, particularly those who choose scheduled contraception.

With the exception of the level of sexual activity, the variables listed either affect the flow utility directly or affect decisions through the terminal value function. All independent variables are taken from wave one of the survey with the exception of mother working, two-parent family and whether the individual was living with their biological mother. The mother work variable takes on a value of one if the mother works full-time.[22] Two-parent family refers to the family structure where the teen lives with both biological parents. While coming from

[20] In earlier waves, individuals were asked what fraction of the time they used birth control and, if they were protected what the primary method of birth control was. In later waves, the individuals were first asked what percent of the time a condom was used when they had sex. They were also asked what percent of the time birth control was used as well as the primary birth control method besides a condom. If the woman reported using a condom 100% of the time, than the birth control method was classified as episode-specific. If all the acts were protected but a condom was used less than 100% of the time, we used the primary method besides a condom to determine whether to classify the birth control as episode-specific or scheduled.

[21] Only individuals fourteen and older were asked the sex questions, while only individuals fourteen and younger in 1997 were asked about parental religious practices, limiting our sample sizes. We also eliminate all individuals who did not report a family income in wave 1.

[22] In wave 1, we do not observe whether the mother worked full-time or part-time. For wave 1, we classify a mother as working full-time if she also worked full-time in wave 2. For those who did not work full-time in wave 2 but reported working in wave 1, we set the probability of working full-time in wave 1 to match the transitions from work to not work, and work to work in the future waves. This probability was 0.38.

a two-parent family is associated with less sex, having a working mother or no longer living with one's biological mother is associated with higher sexual activity.

Characteristics of the mother and the household itself are highly correlated with sexual activity. Having a college-educated mother makes abstaining more likely, but also more likely that the individual will choose scheduled contraception. Having a mother who prays more than once a day is associated with abstaining,[23] as is coming from a two-parent family, higher test scores,[24] and higher grades.[25] Higher test scores and grades are also associated with choosing scheduled contraception over the other contraception categories.

Those who use scheduled contraception have sex more often than those in the other contraception categories. Episode-specific contraception is associated with the least frequency conditional on being sexually active. This may be in part driven by how our requirement of having individuals use protection 100% of the time in order to be counted as protected. We investigate the robustness of our results to this assumption later in the paper.

The NLSY97 contains detailed information on the timing of births, abortions, and miscarriages. For the pregnancy data, we date all births, abortions, and miscarriages back to when the sex act would have taken place. A birth reported in wave 2 may have resulted from intercourse in either wave 1 or wave 2. To determine whether pregnancy resulted from sex in wave 1 or wave 2, the date a birth takes place is dated back nine months. This latter date is then linked to the sex decisions for the relevant wave. Similarly, the NLSY97 reports the date of miscarriages and abortions as well as how far along the pregnancy was at the time of the miscarriage or abortion. Pregnancies are then the sum of births, miscarriages, and abortions.

Table 3 presents pregnancy probabilities given the choice of contraception and the level of sexual activity. Because there are so few variables used here and since by assumption the pregnancy parameters can be estimated outside of the model, we are able to use a much larger sample. The overall pregnancy rate in the sample is 15% for those who are sexually active. The level of sexual activity strongly correlates with the probability of a pregnancy. For those

[23] We also investigated the effects of denominations and found no relationship between denomination and sexual behavior.

[24] The test score used was the adjusted PIAT math score. The mean is above zero in the population because women score higher than men.

[25] The grade categories were: 1. Mostly below Ds, 2. Mostly Ds 3. About half C's and half D's, 4. Mostly C's, 5. About half B's and half C's, 6. Mostly B's, 7. About half A's and B's, and, 8. Mostly A's.

Table 2: Means Conditional on Sex and Contraception Choices[†]

			Contraception Conditional on Sex		
	Full			Episode-	
	Sample	No Sex	None	Specific	Scheduled
Black	0.230	0.221	0.236	0.317	0.116
Adjusted test score	0.110	0.140	0.046	-0.040	0.263
	(0.955)	(0.969)	(0.934)	(0.960)	(0.775)
Grades in 8th grade	6.06	6.26	5.52	5.66	5.93
	(1.65)	(1.59)	(1.72)	(1.67)	(1.67)
Age	16.3	16.0	16.9	16.7	17.2
	(1.3)	(1.3)	(1.3)	(1.3)	(1.1)
Mother has some college	0.251	0.255	0.252	0.219	0.275
Mother college graduate or more	0.183	0.200	0.123	0.145	0.225
Mother Works Full-time[‡]	0.641	0.611	0.721	0.676	0.716
Two Parent Family[§]	0.571	0.613	0.407	0.489	0.514
No Longer Living with Mother	0.157	0.112	0.291	0.212	0.232
Mother Prays Regularly (1997)	0.565	0.587	0.508	0.540	0.500
Household Income (1997)	46274	49043	38693	41196	43863
	(38895)	(41389)	(31741)	(33942)	(30785)
Sex 1-10 times	0.148		0.310	0.688	0.194
Sex 11-50 times	0.111		0.420	0.226	0.398
Sex 51+ times	0.071		0.270	0.076	0.408
Observations	4858	3258	660	656	284

[†]Standard deviations in parenthesis

[‡]Conditional on living with one's biological mother and after wave 1. In wave 1, no distinction was made between part and full-time work.

[§] Conditional on living with one's biological mother. No updated information is available on these variables when the individual leaves home.

who do not report using contraception 100% of the time, the probability of becoming pregnant increases from less than 20% to over 30% as we move from the lowest level of sexual activity to the highest.

Pregnancy rates are much lower if the individual reports using contraception 100% of the time.[26] Although both methods result in much lower pregnancy rates than those who are not protected, scheduled contraception is significantly more effective, particularly in the highest level of sexual activity.

These pregnancy rates may seem high. However, such high pregnancy rates exist conditional on reported 100% protection is consistent with the medical literature. Black et al. (2010) state that women in the U.S. report that 50% of unintended pregnancies are the result of contraceptive failure, with the corresponding number in France being 65%. Trussell's 2004 review article, where the samples studied are typically older than the ones in our data, found that typical use of male condoms resulted in pregnancy rates of 15% while if condoms had been used correctly the rate would have been 2%. Similar to the data here, methods such as the pill are more effective than condoms, both when used correctly and under typical use. Pregnancy rates under typical use for the pill are 8%.

4 Results

We now proceed to the estimates of the model, beginning with the pregnancy parameters. Estimates of the transition parameters on family status, mother working, and living with one's biological mother are reported in the appendix. Recall that the pregnancy parameters are only estimated for those who chose to engage in sexual intercourse. Table 4 presents the logit estimates of the probability of a pregnancy. As expected, higher levels of sexual activity

[26] We also considered cutoffs lower than 100% to qualify as protected. Although one would expect pregnancy rates to substantially increase for the unprotected group is a lower cutoff is used, using a cutoff of 75% protected has little effect on the average pregnancy probabilities for those classified as unprotected. Namely, the pregnancy rates were 18%, 26%, and 30% for the three levels of sexual activity. In contrast, steep increases in pregnancy probabilities were seen for those using episode-specific contraception, with the corresponding pregnancy rates rising to 10%, 16%, and 28%. This suggests that those who reported using contraception almost all the time are more similar to those who reported using little contraception than those who used contraception 100% of the time.

Table 3: Probability of Becoming Pregnant Conditional on Choice of Contraception and Level of Sexual Activity†

	Unprotected	Episode-Specific Contraception	Scheduled Contraception
Sex 1-10	0.193	0.078	0.057
	689	*1315*	*227*
Sex 11-50	0.230	0.087	0.076
	846	*503*	*408*
Sex 51+	0.309	0.219	0.077
	579	*169*	*402*

†Number of observations in italics. Sample includes all females between the ages of 14 and 19 who had sex in waves 1-5. All pregnancies are dated back to the sex decisions in these waves. The sample also include pregnancies reported in wave 6 that resulted from sex acts in wave 5.

are associated with higher probabilities of a pregnancy while contraception is associated with lower pregnancy probabilities.[27] Individuals become better at using contraception with age, though the coefficient is not statistically significant.

To get a sense for the magnitudes of these effects Table 5 shows the estimated pregnancy probabilities conditional on age, contraception choice, and level of sexual activity. Increased sexual activity increases pregnancy rates, particularly when contraception is not used. A sixteen year old moving from the lowest level of sexual activity to the highest sees their probability of becoming pregnant increase by 13 percentage points if unprotected, a little over 7 percentage points if using episode-specific contraception, and by 5 percentage points if using scheduled contraception. Unprotected sex results in pregnancy rates that are 1.5 times to 2.5 times higher than those using episode-specific contraception, and 2.5 times to over 4 times higher than those using scheduled contraception. [28] The lower pregnancy rates associated

[27] Adding the number of times an individual had sex did not improve the fit of the model. The coefficient on the number of times was small and insignificant, suggesting that we are losing little by discretizing sexual activity.

[28] These differences may seem small but recall that an individual was classified as having protected sex only

Table 4: Logit Estimates of the Probability of Becoming Pregnant[†]

	Coefficient	Standard Error
Sex 11-50	0.2479	(0.1005)
Sex 50+	0.6943	(0.1101)
Episode-specific	-0.6688	(0.2258)
Scheduled	-1.1497	(0.2679)
Age	0.0246	(0.0405)
Contraception × Age	-0.0933	(0.0652)
Intercept	-1.8873	(0.6924)
Observations	5136	

[†] Logit estimates. Sample includes all females between the ages of 14 and 19 who had sex in waves 1-5. All pregnancies are dated back to the sex decisions in these waves. The sample also include pregnancies reported in wave 6 that resulted from sex acts in wave 5.

with contraception grow with the individual's age as the individual learns how to use the contraception correctly.

The parameters characterizing the flow utility of sex are given in Table 6. The first set of rows shows the coefficients on the demographic characteristics. Having a mother who prays regularly and coming from a two parent family both lowers the utility associated with sex relative to abstinence. In contrast, having a mother who works or not living with one's biological mother positively affects the utility associated with sex. Mother's education has no effect on utility associated with sex but has a substantial effect on sex choices through the terminal value function.

The specification and coefficient estimates of the terminal value function are reported in the appendix. What can be see from those estimates is that pregnancy costs are higher when individual's mother is college educated. Due to the non-linear portions, the other effects are

if the individual reported using contraception one hundred percent of the time. The unprotected category then includes individuals who often used protection but did not report using contraception every time.

Table 5: Estimated Pregnancy Probabilities

	Number of	Age					
Protection	Times	14	15	16	17	18	19
	Sex 1-10	0.176	0.180	0.183	0.187	0.191	0.195
Unprotected	Sex 11-50	0.215	0.219	0.224	0.228	0.232	0.237
	Sex 51+	0.300	0.305	0.310	0.316	0.321	0.326
Episode-specific	Sex 1-10	0.099	0.093	0.087	0.082	0.077	0.072
Contraception	Sex 11-50	0.123	0.116	0.109	0.103	0.096	0.091
	Sex 51+	0.180	0.170	0.161	0.152	0.143	0.135
Scheduled	Sex 1-10	0.063	0.059	0.056	0.052	0.049	0.046
Contraception	Sex 11-50	0.080	0.075	0.070	0.066	0.062	0.058
	Sex 51+	0.119	0.112	0.106	0.099	0.093	0.088

less easy to see, but variables associated with higher human capital (grades, test scores, family income), and therefore greater labor market rewards, increase pregnancy costs as well.

We parameterized the unobserved preferences for sex using a two-type mixture distribution.[29] The second type, which makes up a little less than a quarter of the population, is substantially less likely to have sex than the first type.

The final set of rows show the persistence parameters. For both contraception choices, we see no transition costs. However, the fixed costs of scheduled contraception is quite large. There then may be a tradeoff between encouraging the use of the pill versus encouraging condoms. Condoms help prevent sexually transmitted diseases, but encouraging individuals to use the pill will make birth control more of a habit. Both fixed and transition costs are significant for sex itself, with the transition cost being approximately three times the fixed cost. Such large effects imply that the long run effects of policy on sexual behavior may be

[29] We experimented with more types but the results consistently yielded estimates such that additional types were indistinguishable from the first two types.

different from the short run effects.

Table 6: Parameters of the Utility Function†

	Variable	Coefficient	Std. Error
	Black	0.205	0.120
	Mother Works Full-time	0.275	0.085
	Two Parent Family	-0.357	0.092
Flow	No Longer Living with Mother	0.230	0.116
Utility	Mother Prays Regularly	-0.239	0.075
	Mother Some College	-0.048	0.122
	Mother College	0.115	0.147
	Type 2	-1.406	0.403
	Sex Transition Cost	-1.551	0.258
	Sex Fixed Cost	-0.540	0.172
Habit	Episode-Specific Contraception Transition Cost	-0.397	0.216
Persistence	Episode-Specific Contraception Fixed Cost	0.306	0.257
	Scheduled Contraception Transition Cost	-0.209	0.298
	Scheduled Contraception Fixed Cost	-2.258	0.232
	Prob. Type 2	0.234	0.041
	Observations	4858	

† Estimates from the dynamic discrete choice model on only those who have continuous sex histories. The discount factor is set at 0.9. The utility function included age interacted with each of the choices which allows for pregnancy costs and flow tastes for the various choices to vary by age.

The utility function parameters are difficult to interpret because of the nonlinearities in the choice function. To see how demographic characteristics and habit persistence affect the sex choices, we calculate the probabilities of each of the contraception choices, aggregating over the level of sexual activity, given different demographics and sex histories. In particular, we

forecast the decisions of sixteen year olds given the characteristics of those who are fourteen. We then assign the different values for particular demographic characteristics and see how these affect the probability of choosing particular sex options at age sixteen. Hence, when examining the effects of mother's education, we assign all individuals to the same level of mother's education and then repeat with a different level of mother's education. Results of these simulations are given in Table 7.

The first set of rows gives the unconditional probabilities of sex choices at age sixteen. Moving from having a mother who does not pray regularly to one who does decreases the probability of having sex by seven percentage points. Conditional on having sex, unprotected sex is more common for those with mothers who do not pray regularly. Individuals who are more likely to have sex in the future also expect to receive higher benefits from paying the fixed costs associated with contraception. The effect of an intact family is similarly strong–moving from an intact family at age fourteen to a single parent family at age fourteen results in a nine percentage point increase in the probability of having sex at age sixteen.

Recall that mother's education had little effect on the preferences for sex. However, the effect through the terminal value function is strong. Switching from a mother who has no education past high school to one with a college education results in an over five percentage point increase in the probability of abstaining. The shift away from sex is particularly strong for unprotected sex, with the move away from unprotected sex representing over half of the shift from sex. Grades, which only operate through the terminal value function have very large effects on the costs of pregnancy, likely due to their association with human capital. Moving from receiving mostly A's to mostly C's increases the probability of engaging in sexual activity by almost 19 percentage points, again with most of the drop coming from unprotected sex.

The next set of rows conditions on history. That is, instead of forecasting what the history will be given particular demographic characteristics, we will instead assume a particular sexual history. The second set of rows assumes a history of no sex while the third set assumes the person had sex in the previous period (age 15) and used episode-specific contraception. The differences across the second and third set of rows are quite large. While an individual who had an intact family at age sixteen would abstain eighty percent of the time conditional on abstaining in the past, the probability that a similar individual who had sex with episode-specific contraception in the previous period is thirty percent. Habit persistence is much more

important in determining sexual activity than having a praying mother, an intact family, a mother with a college education, or even grades.

These estimated effects and the policy simulations conducted in the next section are not informative if the model does a poor job of fitting the data. Using the sample of those aged fourteen, we forecast the sex choices and fertility outcomes and see how well this matches the trends in the data. The model predictions for ages 14 through 18 are shown in Table 8. Although we would expect to match the trends given the full set of age interactions, we are forecasting ahead with a particular subset of individuals. While in general predictions are very close to the data, the model slightly over-predicts sex rates at older ages. Conditional on having sex, the model predicts the level of sexual activity very well.

5 Policy Simulations

Given the model matches the predicted choices of sex and contraception use reasonably well, we now turn to policy simulations that examine the effects of changes in access to contraception for teens. In particular, we forecast the sex and contraception decisions and consequent pregnancy outcomes for sixteen year olds both when the policy is initially put into place (and thereby surprising the current sixteen year olds) and in the next two years after the policy. We use the characteristics of the fourteen year olds for the simulations. Hence, in year three of the policy sixteen year olds will have been exposed to the policy since they were fourteen.

We focus on two hypothetical policies. The first policy simulates the effects of decreasing access to all contraception, both episode-specific and scheduled. In this case the utility of using birth control is decreased (increasing the effective cost), though the utility of sex itself is left *unchanged*. An example of this could be curbing the distribution of contraceptives on school premises. The second policy simulates the effects of increases in access to episode-specific contraception and/or increases in the effectiveness of episode-specific contraception. Ad campaigns that encourage the use of condoms or through making condoms available in school bathrooms, both of which lower the effective costs of using condoms (raising the net utility of episode-specific contraception). Alternatively, sex education classes could lead to increased effectiveness of contraception (lowering pregnancy rates).

Table 9 shows the effect of the first policy change, decreasing access to contraception, on

Table 7: Choice Probabilities For Those Aged 16 Under Different Demographics[†]

		Mother Prays		Mother's Education		Family Intact		Grade in 8th Grade	
		Yes	No	College +	HS or less	Yes	No	Mostly A's	Mostly C's
Unconditional Probability	Abstain	0.7254	0.6528	0.7269	0.6726	0.7252	0.6330	0.7946	0.6059
	Unprotected Sex	0.1152	0.1407	0.1002	0.1385	0.1159	0.1489	0.0690	0.1760
	Episode-Specific Contraception	0.1188	0.1553	0.1301	0.1421	0.1225	0.1644	0.0989	0.1707
	Scheduled Contraception	0.0405	0.0511	0.0428	0.0468	0.0365	0.0537	0.0375	0.0474
Conditional on $c_{fc} = NS$, $c_{15} = NS$	Abstain	0.8085	0.7600	0.8150	0.7739	0.8074	0.7521	0.8600	0.7339
	Unprotected Sex	0.0859	0.1027	0.0695	0.1017	0.0855	0.1044	0.0495	0.1286
	Episode-Specific Contraception	0.0835	0.1037	0.0866	0.0977	0.0844	0.1116	0.0679	0.1066
	Scheduled Contraception	0.0222	0.0336	0.0289	0.0268	0.0228	0.0319	0.0227	0.0309
Conditional on $c_{fc} = EC$, $c_{15} = EC$	Abstain	0.2933	0.2438	0.3018	0.2628	0.2962	0.2331	0.3591	0.2266
	Unprotected Sex	0.2882	0.2868	0.2470	0.2965	0.2797	0.2851	0.2135	0.3353
	Episode-Specific Contraception	0.3393	0.3782	0.3589	0.3567	0.3443	0.3823	0.3409	0.3568
	Scheduled Contraception	0.0792	0.0912	0.0923	0.0840	0.0798	0.0995	0.0865	0.0813

[†]Forecasted from the characteristics of fourteen year-olds. Effects for intact family and mother works are the effects from having these characteristics at age 14.

Table 8: Comparing Model Predictions with the Data†

	Age=14		Age=15		Age=16		Age=17		Age=18	
Probability of:	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data
Abstaining	0.8809	0.8745	0.7779	0.8171	0.6830	0.7117	0.5703	0.5942	0.4425	0.4702
Unprotected Sex	0.0557	0.0607	0.0878	0.0718	0.1311	0.1198	0.1656	0.1582	0.2397	0.2235
Episode-Specific	0.0567	0.0586	0.1160	0.0954	0.1397	0.1286	0.1731	0.1660	0.1910	0.1872
Scheduled	0.0067	0.0063	0.0183	0.0157	0.0462	0.0399	0.0910	0.0817	0.1268	0.119
Sex 1-10	0.0845	0.0879	0.1393	0.1141	0.1838	0.1669	0.1798	0.1702	0.1784	0.1727
Sex 11-50	0.0292	0.0314	0.0581	0.0492	0.0948	0.0879	0.1536	0.1479	0.1998	0.1930
Sex 51+	0.0054	0.0063	0.0247	0.0197	0.0384	0.0335	0.0963	0.0877	0.1794	0.1640

†Model predictions are calculated using the characteristics of fourteen year olds.

sexual activity and pregnancy rates, aggregating across the levels of activity, in the first three years of the policy. Each element then gives the percentage change in the activity relative to the corresponding activity before the policy change. The first panel of Table 9 reports results for the population. In year 1 of the policy, decreasing access to contraception results in an almost eight percent increase in unprotected sex relative to the pre-policy rate. However, by year 3 increase is less than four percent. Large shifts are seen away from both contraception methods, and more so with longer exposure to the policy. The shift towards no sex is magnified over time, with a three percent increase relative to pre-policy in year 1 and an over five percent increase in year 3. Pregnancy rates drop in all three years of the policy, but are very small in the first year. For the population as a whole, even though rates of unprotected sex increase, the movement away from contraception methods that are not fully effective results in a drop in pregnancies. The drop in pregnancy rates relative to the pre-policy rate increase with the length of the policy as those who enter age 16 now have different sexual histories.

The effects of the policy may differ depending upon one's propensity to engage in sexual activity. Namely, if someone is unlikely to engage in sexual activity then the movement in the probability of protected sex to unprotected sex may be small relative to the movement from protected sex to no sex. However, the reverse may hold true for those who are likely to engage in sex. The second panel of Table 9 repeats the analysis for the 37% of the sample with the lowest grades in 8th grade, those individuals who had grades of half B's and C's or worse. Here we see an increase in pregnancy rates in the first year of the policy. The nine percent increase in unprotected relative to the pre-policy rates in the first year of the policy leads to increases in pregnancy rate that are higher than the corresponding decreases due to some individuals moving from protected sex to no sex. However, in the long run, the pregnancy rate are lower here are well. This again results from the differences in sexual histories in the long run, as the fraction of individuals who have not had sex in the past increases in the long run.

Our second policy simulation focuses on making episode-specific contraception more attractive and/or more effective at preventing pregnancy. Table 10 presents the policy simulations for the population while Table 11 conditions on having grades that were about half B's and C's or worse in the 8th grade. Increasing access to episode-specific contraception increases pregnancy rates in the long run. In the short run, those who have low grades see a small drop

Table 9: 16 year old Short and Long Run Responses to Decreasing Access to Contraception†

		No Sex	Unprotected Sex	Episode-Specific Contraception	Scheduled Contraception	Pregnancy
Population	Year 1	3.00%	7.90%	-14.57%	-18.78%	-0.83%
	Year 2	4.56%	5.18%	-17.59%	-22.99%	-3.73%
	Year 3	5.26%	3.77%	-18.76%	-24.89%	-5.14%
Low grades	Year 1	3.38%	8.97%	-13.96%	-18.55%	1.31%
	Year 2	5.16%	7.38%	-16.38%	-22.51%	-0.64%
	Year 3	6.07%	5.87%	-17.00%	-24.12%	-2.00%

†Forecasted from the sample of 14 year-olds assuming the change in policy was a surprise. Percent changes use the forecasts with no policy as the base. To simulate the policy, we lower the intercept parameters in equations (3) and (4) by 0.2. We experimented with different values for these changes and the qualitative results remained the same. Low income forecasts are done only for those individuals who had parents earnings at or below the 25th percentile of the income distribution in the data.

Table 10: 16 year old Short and Long Run Responses to Changes in the Attractiveness and Effectiveness of Condoms[†]

		No Sex	Unprotected Sex	Episode-Specific Contraception	Scheduled Contraception	Pregnancy
Increased	Year 1	-2.33%	-5.40%	17.64%	-7.08%	1.23%
Access	Year 2	-3.70%	-3.43%	21.48%	-5.83%	3.70%
	Year 3	-4.40%	-2.22%	22.92%	-4.16%	5.02%
Increased	Year 1	-0.26%	-0.59%	1.97%	-0.90%	-2.75%
Effectiveness	Year 2	-0.42%	-0.41%	2.41%	-0.61%	-2.52%
	Year 3	-0.53%	-0.23%	2.63%	-0.28%	-2.33%
Increased Both	Year 1	-2.65%	-6.51%	20.50%	-8.21%	-2.35%
Access and	Year 2	-4.32%	-4.20%	25.15%	-6.45%	0.48%
Effectiveness	Year 3	-5.16%	-2.88%	27.09%	-4.67%	1.94%

[†]Forecasted from the sample of 14 year-olds whose grades were half B's and C's or worse, assuming the change in policy was a surprise. Percent changes use the forecasts with no policy as the base. For increased access to episode-specific contraception, we increase the intercept parameter in equation (3) by 0.2, leaving the fixed and transition costs unchanged. We experimented with different values for these changes and the qualitative results remained the same. For increased effectiveness, we increased the efficacy of episode-specific contraception by 10%.

Table 11: 16 year old Short and Long Run Responses to Changes in the Attractiveness and Effectiveness of Condoms Conditional on Having Low Grades[†]

		No Sex	Unprotected Sex	Episode-Specific Contraception	Scheduled Contraception	Pregnancy
Increased	Year 1	-2.83%	-6.16%	17.06%	-7.52%	-0.10%
Access	Year 2	-4.55%	-4.64%	20.22%	-6.59%	1.80%
	Year 3	-5.35%	-3.70%	21.05%	-4.86%	2.77%
Increased	Year 1	-0.18%	-0.22%	0.90%	-0.57%	-2.62%
Effectiveness	Year 2	-0.27%	-0.15%	1.06%	-0.41%	-2.53%
	Year 3	-0.36%	-0.09%	1.19%	-0.16%	-2.46%
Increased Both	Year 1	-2.98%	-7.10%	18.95%	-7.98%	-3.56%
Access and	Year 2	-5.02%	-5.29%	22.68%	-6.90%	-1.34%
Effectiveness	Year 3	-6.04%	-4.20%	24.15%	-5.74%	-0.18%

[†]Forecasted from the sample of 14 year-olds whose grades were half B's and C's or worse, assuming the change in policy was a surprise. Percent changes use the forecasts with no policy as the base. For increased access to episode-specific contraception, we increase the intercept parameter in equation (3) by 0.2, leaving the fixed and transition costs unchanged. We experimented with different values for these changes and the qualitative results remained the same. For increased effectiveness, we increased the efficacy of episode-specific contraception by 10%.

in pregnancy rates that are undone in the long run due to changes in sexual histories. Making condoms 10% more effective at stopping pregnancy while leaving preference unchanged, however, results in drops in pregnancy rates in all years. While the long run effects are smaller than the short run effects, there is not enough of a change in behavior to compensate for the lower pregnancy rates associated with using episode-specific contraception. Mixing the two policies lowers pregnancy rates in both the short and long run for those with low grades, though by year 3 the effects are miniscule. For the population, however, a crossing is observed: first pregnancy rates fall but then, as sexual behavior adjusts, pregnancy rates rise.

Taken together, the policy simulations suggest making contraception more attractive may lead to higher pregnancy rates, particularly in the long run. However, increasing the efficacy of contraceptive use (yet somehow not affecting access) is likely to result in decreases in pregnancy rates both in the short and long run.

6 Conclusion

There is much persistence in teen sexual behavior. If this habit persistence arises from a moral or psychological barrier that has been crossed once an individual has sex for the first time (a fixed cost) or the first time in a relationship (a transition cost), programs that increase rates of teen sexual activity may lead to higher pregnancy rates in the long run than in the short run.

Our estimates show large transition and fixed costs to having sex. Persistence is also observed in using birth control methods like the pill, with smaller effects for condoms. The persistence in sexual activity is such that policies that affect access to contraception may have very different effects in the short run than the long run. Our results suggest that increasing access to contraception may actually increase long run pregnancy rates even when short run pregnancy rates fall. On the other hand, policies that decrease access to contraception, and hence sexual activity, may lower pregnancy rates in the long run. The primary purpose of our research is to illustrate the unintended consequences that may result if the dynamic aspects of teen decisions regarding sexual activity are ignored. In spite of the limitations that we discuss below, we believe that our work is important in showing that policy makers should be aware of such dynamic considerations when developing contraceptive policies.

It also needs to be emphasized that our focus is on teen sexual behavior and pregnancy outcomes. Hence our conclusions are not necessarily applicable to older individuals. For example, Goldin and Katz (2002) provide evidence on the benefits of the availability to oral contraception to women of college going and older ages. In our analysis we also do not examine the effects of access to contraception on incidence of sexually transmitted diseases. This is another factor that could be important in determining appropriate policies regarding access to contraception, particularly condoms.

There are many other factors, however, that may also point towards increased access to contraception having negative consequences. For example, Akerlof, Yellen, and Katz (1996) argue that contraception and birth control changed the bargaining terms between men and women, and led to an increase in out-of-wedlock births. We also do not examine the effects of peer networks or multiplicity of sexual partners on teen sexual decisions and pregnancy outcomes, both of which may lead to greater access to contraception having negative effects in the long run. For example, we may see fixed costs in the form of a moral or psychological barrier the first time one has sex outside of a committed relationship. To the degree that increased access to contraception encourages experimentation outside the committed relationship, habit persistence may again lead to greater access to contraception increasing teen pregnancy rates. Future research that extends our analysis to incorporate factors such as sexually transmitted diseases, bargaining in relationships, and multiplicity of partners will improve our understanding of the consequences of increased access to contraception for teens.

An alternative explanation of why there is so much persistence in sexual activity in the data is that the individual-level heterogeneity that we model as permanent is actually time-varying. In this case, the persistence observed in the data would not be endogenous to past behaviors but would reflect exogenous taste shocks that may be persistent over time. The policy implications of these two explanations are very different. Under the time-varying heterogeneity only our short run policy simulations are relevant. Our data are not rich enough to distinguish between these two hypotheses. Moreover, with rare exceptions (e.g., Pakes 1987), the convention in the dynamic discrete choice literature has been to allow for serial correlation between observed variables but not between unobserved variables. As in our work, this is commonly done using the procedure proposed by Heckman and Singer (1983) that allows for permanent unobserved heterogeneity. In our context an additional empirical argument in fa-

vor of the permanent unobserved heterogeneity approach is that most of biological maturation has already occurred by age fourteen.[30]

Finally, in the spirit of Stigler and Becker[31] (1977) we have eschewed an explanation based on time varying unobserved heterogeneity. In making standard assumptions we find strong evidence of habit persistence. A clear direction for future research would be to attempt to distinguish habit persistence from time-varying unobserved heterogeneity. If, as our results suggest, the persistence observed in the data is indeed behavior-driven, even if partially, then the long run implications of our simulations need to be considered seriously in the development of contraception policies given the potential for unintended consequences.

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[30] Chumelea et al. (2003) found that 90% of U.S. girls had attained menarche by 13.75 years of age. Further, menarche is one of the late events of puberty (Zabin et al. 1986).

[31] E.g., Becker and Stigler state (p. 76) "On our view, one searches, often long and frustratingly, for the subtle forms that prices and incomes take in explaining differences among men and periods. If the latter approach yields more useful results, it is the proper choice."

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Appendix

In this appendix we show the estimating equations and results for the transition parameters as well as the parameters of the terminal value function. In particular, we show results on whether or not one's mother works full-time, whether a divorce occurs, and whether the individual lives with his biological mother. This last measure is designed to capture whether the individual no longer lives at home without modeling every possible living arrangement. We assume that the state variables at time t depend only on the state variables at time $t-1$:

$$q(s_t|s_{t-1}) = q(s_t|s_{t-1}, s_{t-2}, ...)$$

We assume that each follows a logit process subject to the following restrictions:

1. Divorce is an absorbing state

2. No longer living with one's biological mother is an absorbing state

Since we cannot distinguish between full-time and part-time work for the mother in the first wave, we estimate the transitions using outcomes from waves 3-5 with the corresponding lagged values coming from waves 2-4.

Table 12 presents the estimates of the transition parameters. The most significant predictor of one's mother working full-time at time t is whether one's mother worked full-time at time $t-1$. Living with both biological parents reduces the probability of the mother working, though this effect is less than one-tenth the size of the lagged mother working effect. The effect of a praying mother is also negative, but smaller and only marginally significant. The coefficients on age and black are small and insignificant.

The probability of the biological family remaining intact at time t falls if the mother worked at time $t-1$. A mother who prayed regularly in 1997 increases the probability of the family remaining intact, while black families are significantly more likely to experience divorce. An intact family at time $t-1$ significantly lowers the probability an individual will leave home, as does begin black and having higher test scores. Not surprisingly, age has a strong positive effect on the probability of leaving home.

We specify the terminal value function for pregnancy flexibly in the hopes of accounting for heterogeneity in labor market returns and the costs a pregnancy imposes on those labor market returns. Note that embedded in this terminal value function is the fact that individuals can abort. Absent abortion, the human capital measures would likely take on an even greater role. We approximate a terminal value function using linear terms in race, mother's education, test scores, grades in 8th grade, and household income. We then put in squared terms and interactions for all non-dummy variables (test scores, grades, and household income). Results are reported in Table 13.

Table 12: Transition Parameters

	Mother Work		Intact Family		Leave Home	
	Coeff	Std Err	Coeff	Std Err	Coeff	Std Err
Lag Mother Work	3.334	0.069	-0.800	0.252	-0.123	0.112
Lag Intact Family	-0.233	0.073			-0.859	0.116
Black	0.053	0.984	-0.597	0.267	-0.607	0.137
Age	0.009	0.027	0.050	0.085	0.617	0.049
Mother Prays	-0.149	0.070	0.427	0.233		
Mother Some College	0.320	0.084	0.140	0.262	-0.239	0.132
Mother College +	0.450	0.096	0.756	0.315	-0.586	0.176
Math Score (00's)					-0.071	0.060
Constant	-1.262	0.165	3.785	0.510	-5.204	0.301
Observations	6918		3822		5870	

Table 13: Terminal Value Function for Pregnancy

	Coefficient	Std. Error
Black	-1.6838	0.7359
Adjusted test score	-2.374	0.9564
Household Income (000's)	-0.1273	0.288
Mother has some college	-0.1683	0.7229
Mother college graduate or more	-2.0338	0.9302
Grades in 8th grade	1.7295	0.4689
Test score squared	-0.2974	0.1746
Test score times income	0.1300	0.0845
Test score times grades	0.3722	0.1503
Income squared	-0.0053	0.0075
Income times grades	0.0006	0.0461
Grades squared	-0.2493	0.0557