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From Shame to Game in One Hundred Years: A Macroeconomic Model of the Rise in Premarital Sex and its De-Stigmatization

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A Macroeconomic Model of the Rise in Premarital Sex

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Abstract

Societies socialize children about sex. This is done in the presence of peer-group effects, which may encourage undesirable behavior. Parents want the best for their children. Still, they weigh the marginal gains from socializing their children against its costs. Churches and states may stigmatize sex, both because of a concern about the welfare of their flocks and the need to control the cost of charity associated with out-of-wedlock births. Modern contraceptives have profoundly affected the calculus for instilling sexual mores. As contraception has improved there is less need for parents, churches and states to inculcate sexual mores. Technology affects culture.

Keywords: Add Health, children, church and state, contraception, culture, parents, peer-group effects, premarital sex, out-of-wedlock births, shame, socialization, stigmatization, technological progress

1. Introduction

Shame is a disease of the last age; this seemeth to be cured of it. Marquis of Halifax (1633-1695)

The last one hundred years have witnessed a revolution in sexual behavior. In 1900, only 6% of U.S. women would have engaged in premarital sex by age 19–see Figure 1 (all data sources are discussed in Appendix 12.1). Now, 75% have experienced this. Public acceptance of this practice reacted with delay. Only 15% of women in 1968 had a permissive attitude toward premarital sex. At the time, though, about 40% of 19 year-old females had experienced it. The number with a permissive attitude had jumped to 45% by 1983, a time when 73% of 19 year olds were sexually experienced. Thus, societal attitudes lagged practice.[1] Beyond the evolution and acceptance of sexual behavior over time, there are relevant cross-sectional differences across females. In the U.S., the odds of a girl having premarital sex decline with family income. So, for instance, in the bottom decile 70% of girls between the ages of 15 and 19 have experienced it, versus 47% in the top one. Similarly, 68% of adolescent girls whose family income lies in the upper quartile would feel "very upset" if they got pregnant, versus 46% of those whose family income is in the lower quartile. The goal here is to present a model that can account for the rise in premarital sex, the decline in shame and stigma associated with it and the cross-sectional observations about sex and the attitudes towards it.

The idea is that young adults will act in their own best interest when deciding to engage in premarital sex. They will weigh the benefits from the joy of sex against its cost; i.e., the possibility of having an out-of-wedlock birth. An out-of-wedlock birth has many potential costs for a young woman: it may reduce her educational and job opportunities; it may hurt her mating prospects on the marriage market; she may feel shame or stigma. Over time the odds of becoming pregnant (the failure rate) from premarital sex have declined, due to the facts that contraception has improved and more teens are using some method–Figure 2. The cost of engaging in premarital sex fell, as a result. This leads to the paradoxical situation where, despite the fact that the efficacy of contraception has increased, so has the number of out-of-wedlock births.

The shame or stigma that a young woman incurs from premarital sex may drop over time too. Suppose that parents inculcate a proscription on premarital sex into their daughters'

[1] Observe that toward the end of the sample period the level of premarital sex declines and attitudes become more conservative. It is possible that the emergence of AIDS/HIV played a role in the decline of premarital sex, because this activity became more risky–see Greenwood and Guner (2010). This might also have affected attitudes.

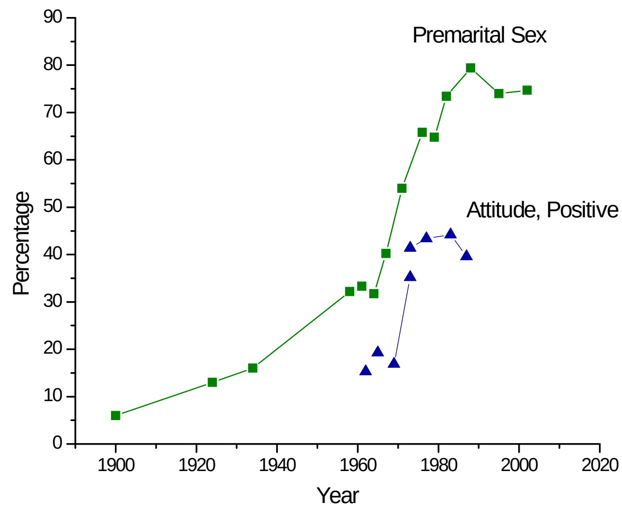

Figure 1: Premarital Sex, attitudes and practice

moral fibers. If a daughter engages in this activity she may feel a sense of guilt or impropriety due to this inculcation. Call this *shame*. As Coleman (1990, p. 295) nicely puts it: "the strategy is to change the self and let the new self decide what is right and what is wrong (for example, by imagining what one's mother would say about a particular action)." Parents do this because they want the best for their daughter. They know that an out-of-wedlock birth will hurt their daughter's welfare. As contraception improves, the need for the proscription diminishes and with it the amount of parental indoctrination. Additionally, a girl may feel less guilt about engaging in premarital sex when more of her friends are practicing the same thing. Call this a *peer-group* effect.

The same shift in incentives may also change the moral proscriptions of institutions such as the church and state. Churches and states care about the well-being of their members. They also must care about the cost of providing alms to unwed mothers and out-of-wedlock children. A girl or parent who violates these proscriptions may bear a mark of disgrace or discredit, with the church, state or community. Label this *stigma*, whose archaic meaning is "a scar left by a hot iron." If shame or stigma have a capital good aspect that is transmitted over time, however, their reduction may lag the increase in sexual activities.

Differences in the costs of an out-of-wedlock birth also explain the cross-sectional observations. The desire to socialize by a parent will be smaller the less socialization's impact is on a child's future well being. Therefore, there may be little incentive to socialize children at the bottom of the socioeconomic scale because they have no where to go in life anyway.

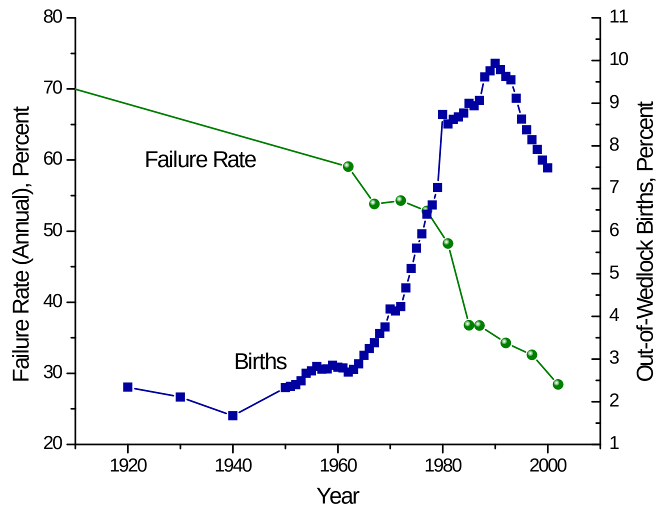

Figure 2: Effectiveness in contraception and out-of-wedlock births to teenage girls

Similarly, the payoff for a parent to changing his offspring's self is higher the closer and longer the parent's connections to the child are. Hence, in societies where parents lose contact with their offspring when they grow up, the incentives to socialize the latter may be attenuated.

These mechanisms will be examined here by developing an overlapping generations model where parents invest effort into the socialization of their children. The concept of socializing children is operationalized by letting a parent influence his offspring's tastes about an out-of-wedlock birth. Doing so incurs a cost in terms of effort to the parent, say spent educating his children about sexual mores. After socialization, some offspring will engage in sex, resulting in a percentage of out-of-wedlock births, and others will not. In the following period, there is a matching process in the marriage market. The presence of an out-of-wedlock child will diminish the attractiveness of a woman as a partner. After marriages occur, the new households will produce, consume, and raise and socialize their own kids (including any previous out-of-wedlock children).

The developed model also includes a role for peer-group effects. In particular, a young female feels less shame from having an out-of-wedlock birth when her friends and acquaintances are engaging in premarital sex. Peer group effects are likely to increase the equilibrium amount of premarital sex. Therefore, they strengthen the need for shaming by parents. Just how much is a quantitative question. This is investigated here.

A steady state for the model is calibrated to match some stylized facts for today's U.S. economy. This is done to show that the framework can replicate some features of modern times and to discipline the analysis before computing the model's transitional dynamics. The stylized facts are: (i) the observed cross-sectional relationship between a girl's education and the likelihood that she will engage in premarital sex; (ii) the amount of time that a mother spends socializing her daughter as a function of the former's educational background; (iii) the degree of assortative mating in the U.S. conditioned upon the presence or not of an out-of-wedlock birth; (iv) the observed relationship between peer-group effects and the likelihood that a girl will enter into a sexual relationship. After this, some transitional dynamics are computed for the situation where society faces a known time path of technological progress in its contraceptive technology. It is demonstrated that the model can replicate the observed rise in premarital sex and out-of-wedlock births.

Illegitimacy is also costly for institutions such as the church and state, which have typically provided unwed mothers with some form of charity. A Ramsey-style problem is considered where the church-cum-state tries to influence attitudes in order to minimize the number of out-of-wedlock births net of the cost of socialization. That is, the church-cum-state works to stigmatize premarital sex. Specifically, a parent whose child has an out-of-wedlock birth will feel a mark of discredit or opprobrium. This encourages parents to provide a moral education to their children, say by taking them to church. When doing this, church-cum-state takes into account the influence that it has on peer-group behavior. This is something, society's mores so to speak, that parents must take as exogenous when deciding how to socialize their daughters. Group behavior is something, though, that social institutions may sway.

Before proceeding onto a more detailed exploration of the historical evidence, the investigation should be framed within the literature on modelling the purposeful transmission of preferences, beliefs, and norms using economic models.[2] The modern analysis of how to affect a child's preferences through parental investments starts with Becker (1993), who was undoubtedly influenced by the work of Coleman (1990). He explored how parents may predispose childrens' preferences toward providing them with old age support. Becker and Mulligan (1997) focus on the manipulation of the child's rate of time preference. This idea is extended in Doepke and Zilibotti's (2008) work on the decline of the aristocracy that accompanied the British Industrial Revolution. They argue that parents, who thought that their children might enter the class of skilled workers, instilled in their offspring a patience that allowed their children to sacrifice today in order to acquire the human capital necessary so that they

[2] There is also a growing literature on evolutionary models of preferences transmission. [See Barkow *et al.* (1992) for an Evolutionary Psychology perspective, and Robson and Samuelson (2010) for a survey in Economics.] Similarly, Durham (1992) explores the coevolution of genetic traits with endogenous socialization. While those mechanisms are clearly relevant in the long run, the time frame of the sexual changes focused on here, around a century, excludes a large role for evolution in the observed variations of behavior.

would earn more tomorrow.[3]

The current work builds on the preference transmission literature by emphasizing how technological innovation induces changes in the socialization decisions of parents through shifts in incentives. Parents' decisions become an amplification mechanism of the original technological shocks. The paper can be read, in part, as an example of this type of amplification mechanism. Other examples are the shifts in investments that parents make in promoting the patience, self-discipline, religiosity, ethnic or national identification, or cultural appreciation when the economic environment changes. Furthermore, the analysis focuses on how endogenous socialization generates a lag between behavior and societal attitudes. In such a way, a mechanism is built that formalizes the insights of Ogburn (1964) regarding the existence of a lag between technology and cultural change. Greenwood and Guner (2010) also study the impact that technological advance in contraception has had on social behavior and interaction. They build an equilibrium matching model where youths make decisions about which social groups (either abstinent or promiscuous ones) to circulate within. The group they mix with will depend both on the state of contraceptive technology and on what others are doing. They define social change simply as shifts in the relative sizes of these social groups, which reflect the aggregation of decentralized decision making at the individual level. The emphasis here is very different: the spotlight is on the role that parents, and institutions, play in shaping their children's sexual mores, and therefore their behavior, and on the lags between this behavior and societal acceptance.

Finally, there is a large empirical literature relating culture and economic behavior that is too wide to survey here. Guiso *et al.* (2006) provide a nice summary of many of the issues studied by economists over the last few years. Of particular interest is the evidence regarding the effect of "ethnic capital" as documented by Borjas (1992), Fernández and Fogli (2009), and Guiliano (2007). The current analysis can be used to interpret this evidence as the result of the persistence in parents' decisions induced by the role that socialization plays as a state variable; i.e., the action of a youth today is influenced by the socialization she or he received from her or his parents, which in turn is affected by the socialization they experienced from their parents.

The discussion now turns to a review of some historical evidence establishing that premarital sex was not widespread in Western societies until the 20th century. This begets two questions: How did society control premarital sex in yesteryear? And, why did sexual

[3] Bisin and Verdier (2001), and a number of following papers, approach the problem of preferences transmission from a different perspective: parents want children to behave like them [see Bisin and Verdier (2008) for a short summary of the existing knowledge]. Under this assumption, they analyze the evolution of the distribution of traits in the population and how the incentives of parents regarding the level of socialization invested in their children evolve depending on the aggregate distribution of traits.

behavior change in such a dramatic fashion during the 20th century?

2. Historical Discussion

> Every lewd woman which have any bastard which may be chargeable to the parish, the justices of the peace shall commit such women to the house of correction, to be punished and set on work during the term of one whole year. Statute of 7 James, cap 4 (1610).[4]

Widespread participation in premarital sex is a recent phenomenon in Western societies. In yesteryear only a small fraction of women must have entertained it.[5] This can be inferred from Figure 3, which plots the number of out-of-wedlock births for England and Wales from 1580 to 2004. The experience for other Western European countries is similar. Therborn (2004, p. 149) reports that the percentage of children born out of wedlock among live births around 1896-1900 was 6% in Australia, 8% in Belgium, 9% in Germany, 6% in Italy, 4% in New Zealand, 3% in the Netherlands, 2% in Ontario (Canada), 5% in Spain, and 5% in Switzerland. Furthermore, prenuptial conception (i.e., births happening less than 9 months after the wedding) was relatively low.[6]

Given the primitive state of contraception, the small number of out-of-wedlock births is only consistent with a small fraction of the population engaging in premarital sex, especially because some women might have had more than one such birth and because a substantial fraction of those births came from long-lasting cohabitating couples that for some reason or another had not formalized their marriage.[7] It is interesting to note that the recent rise in out-of-wedlock births occurred at a time when the gross reproductive rate (GRR) was

[4] As quoted by MacFarlane (1980, p. 73).

[5] The case for men might be different since prostitution was a rather common practice in Western societies–Therborn (2004).

[6] In some pockets of Western Europe prenuptial conception was higher during the 16th to 18th centuries. This observation must be handled with care, however. In the traditional European marriage pattern, there was a betrothal and a formal wedding, often with a non-trivial amount of time between the two. Betrothal was a serious affair. It was a legally binding contract. It established the really important things back then: who would get what. The courts enforced these contracts by imposing serious penalties on those who broke them. Although the Church was adamantly opposed to it, the practice in rural Europe was often to look the other way from the sex of the soon-to-be married couples. [Many peasants thought that they were married after the betrothal. See for example, the description in Godbeer (2002, p. 3)]. Therefore, prenuptial conceptions might have been post-betrothal conceptions (and there are reasons to believe this was the vast share). For the model developed below it does not matter whether the line defining premarital sex is drawn at the betrothal or the marriage.

[7] For instance, a typical reason for the large number of cohabitating couples in Paris of the 19th century was the legal costs of civil marriage (including a notarized parental consent), which could amount to more than one month's wage for a poor working couple–Fuchs (1992).

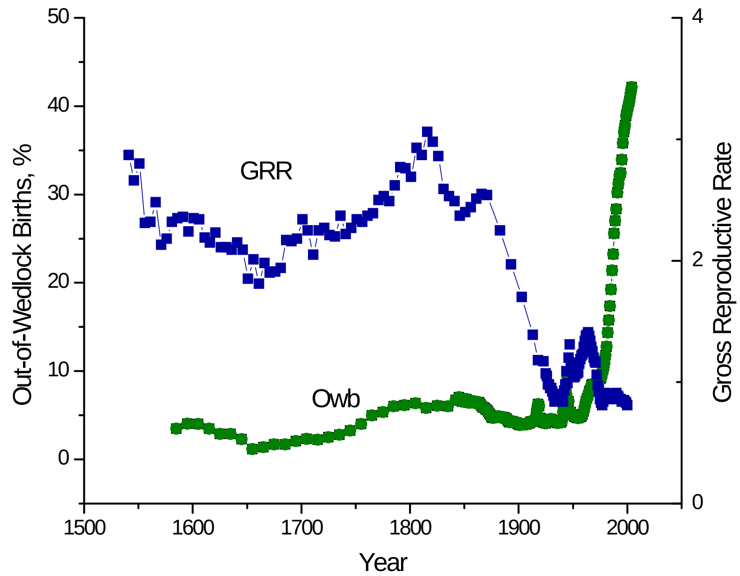

Figure 3: The percentage of all births that are out-of-wedlock from 1580-2004 and the gross reproductive rate 1540-2000, both for England and Wales

declining. The small number of out-of-wedlock births is also surprising in light of the fact that for much of the period women tended to marry late (around 26 years of age in the seventeenth century), with a significant fraction never marrying–see Voightlander and Voth (2009) for a discussion of the European marriage pattern. The trend in U.S. teenage out-of-wedlock births follows a very similar pattern–recall Figure 2. Why was this practice so limited in the past?

Engaging in premarital sex was, until recently, a risky venture. First, it was illegal and viewed as being morally reprehensible. Second, an out-of-wedlock birth placed a female in a perilous economic state. Some historical examples of how premarital sex was stigmatized will now be presented. In 1601, the Lancashire Quarter sessions condemned an unmarried father and mother of a child to be publicly whipped.[8] They then had to sit in the stocks still naked from the waist upwards. A placard on their heads read 'These persons are punished for fornication.' In early America, a New Haven court in 1648 fined a couple for having sex out of marriage.[9] The magistrate ordered that the couple "be brought forth to the place of correction that they may be shamed." He said that premarital sex was "a sin which lays them

[8]This case is taken from the classic book by Stone (1977, p. 637).

[9]The discussion on premarital sex in early America derives from Godbeer (2002).

open to shame and punishment in this court. It is that which the Holy Ghost brands with the name of folly, it is wherein men show their brutishness, therefore as a whip is for the horse and asse, so a rod is for the fool's back." These were not isolated cases. The prosecution of single men or women either for "fornication", or of married couples who had a child before wedlock, accounted for 53% of all criminal cases in Essex country, Massachusetts, between 1700 and 1785. Likewise, 69% of all criminal cases in New Haven between 1710 and 1750 were for premarital sex. In the Chesapeake Bay, when an unmarried woman gave birth to a child, she was levied a large fine or, in case she could not pay, publicly whipped–see Fisher(1989). The otherwise moderate and pacific Quakers found that the English Crown decided in 1700 to suspend their Pennsylvania Law Code of 1683 against fornication because it was unreasonably harsh, a revealing judgement since the English crown was not particularly progressive in its views about crime and punishment.

It is also telling that in colonial America, abortion was punished when it was intended to cover adultery or fornication; however, it was overlooked when it was used as a device to control fertility within a marriage. In Pennsylvania, the law was taken even one step further. If a bastard child was found dead, the mother was presumed to be guilty unless she could prove otherwise, overriding the general English law principle of presumption of innocence. This change in the principle of the law was particularly harsh, as the punishment for the crime was hanging.[10]

The shame and stigma attached to premarital sex, and other forms of illicit sex, is reflected by the language used to describe such acts. Words such as debauched, lascivious, lewd, loose, incontinent, vain and wanton were used to reflect a lack of self control; others such as base, defiling, polluting, unclean, and vile described the desecration of the body associated with illicit sex; yet others such as adultery, disorderly, indolation, misdirection, rebellion, uncivil, unlawful, conjured up the notion of civil or religious disobedience and affected even those in situations of social prestige and power. So, for example, the son and namesake of the renowned minister John Cotton was excommunicated in 1664 by the First Church of Boston "for lascivious unclean practices with three women."

There are also plenty of historical examples of the relationship between the environment and promiscuity. The economic consequences for an unwed mother and her child could be dire. Churches, courts and parents tried to make the father and mother of an out-of-wedlock child marry. The next best option was to ensure that the father paid child support. Sometimes neither of these two options worked. The outlook for the mother and child could then be bleak. Note that the statute cited at the beginning of this section only seemed to apply to women that

[10]See Klepp (1994, p. 74).

needed support. Now, nineteenth century France, an anomaly compared with other Western European countries, provides an interesting illustration of how the environment can affect social behavior.[11] The French Civil Code of 1804 prohibited questioning by the authorities about the paternity of a child. As a consequence, males could evade the responsibility for bringing up their illegitimate offspring. Roughly at the same time, all French hospitals were instructed to receive abandoned children. These laws may have drastically changed the cost and benefit calculations of engaging in premarital sex, and encouraged illegitimacy and abandonment on a grand scale. In 1816 about 40% of births in Paris were out of wedlock, and 55% of these children were abandoned. In 1820 a staggering 78% of these kids would have died. (Many of these out-of-wedlock births were undoubtedly from young women who lived outside of Paris and who moved to the anonymity of the capital after getting pregnant.) Why would an unwed mother abandon her child?

The decision to abandon a child was most likely dictated by the economic circumstance. A woman was paid about half that of a man in a similar job. Her earnings barely covered her subsistence. In the 1860s, a working woman could earn somewhere between Fr250-600 a year taking into account seasonal unemployment. It cost approximately Fr300 a year for rent, clothing, laundry, heat, and light. Even at the maximum salary this did not leave much for food–less than a franc a day–let alone the costs of clothing and wet nursing a baby (the later is estimated at Fr300 a year). A working woman could certainly not afford to raise a child alone. Furthermore, there is evidence, especially for the early part of the century, that abandonments were correlated with the price of bread.[12]

Illegitimacy disproportionately affected the ranks of the working class. In 1883 the Registry General for Scotland tabulated that only 0.5% of illegitimate births were to the daughters of professional men.[13] The middle and upper classes had to worry about how illegitimacy would disrupt the transfer of property through the lineage. English author Samuel Johnson expressed this concern well: "Consider of what importance to society the chastity of women is. Upon that all the property in the world depends. We hang a thief for stealing a sheep, but the unchastity of a woman transfers sheep, and farm, and all from the right owner." Illegitimacy was connected to the structure of the environment that the working class lived in. In nineteenth century Scotland, the Lowlands had a much higher rate of illegitimacy than the

[11] The material on France is drawn exclusively from Fuchs (1984).

[12] The excellent monograph by Boswell (1988) provides a survey of child abandonment in Western Europe from late antiquity to the Renaissance. Two important conclusions of this study are the following. First, many abandoned children were born from married couples. Therefore, the statistics on abandonment cannot be read as statistics on pre-marital sex. Second, abandonment was relatively common even among the elites, because it precluded succession issues and inheritance disputes (another economic motive).

[13] The source for Scotland is Smout (1980).

Highlands. This has been tied to the economy of the two places, and how it impacted on the relationship between parents and their children. In the Lowlands labor was mobile. Young and old laborers independently travelled from farm to farm, district to district, taking work where available. As a consequence, young males and females freely mixed in the residences of farms (the chaumer system). A young man could easily evade his responsibility to a pregnant woman. His parents would suffer little stigma, neither would they be forced to lend financial support. In the more stable Highlands disappearing was more difficult. Additionally, in the Lowlands it was easy for unwed mothers to find jobs milking cows or tending to turnips. Furthermore, in some places a ploughman had to provide an able-bodied female to work along side (the bondager system). Since the work unit was often then the family some feel that this meant that partners had to prove their fecundity before marriage.

Other areas of Western Europe with high illegitimacy ratios, like Alpine Austria or northern Portugal, had land property structures that prevented a large number of men and women from participating in a marriage market (thus eliminating a powerful incentive for avoiding out-of-wedlock children) and experienced large outmigration.

It will be shown next that, even today, shame influences the sexual behavior of teenagers. This force may be mitigated by the presence of peer group effects. Specifically, teens may feel less shame about engaging in premarital sexual activity when a significant number of their peers are sexually active. This will be investigated too. Beyond providing more supportive evidence for the developed model, the next section will play a disciplining role for the calibration undertaken in Section 8.

3. Evidence on Shame and Peer Group Effects in the U.S., 1994-1996

Does shame have an impact on teenage sexual behavior in modern times, where contraception is readily available? Data from the National Longitudinal Study of Adolescent Health (Add Health) will be used to address this question.

Add Health is a representative sample of U.S. adolescents who were in grades 7 to 12 at 134 junior and senior high schools during the 1994-1995 school year. The respondents have been followed in four waves, although for the current purpose only the first two (1994 and 1996, a panel of about 15,000 students) are needed. Add Health is particularly well suited for the study of social interactions because it contains detailed information about sexual behavior, sexual knowledge, shame from premarital sex or pregnancy, religiosity, parental background, school characteristics, etc. Furthermore, there are observations for many students from the same school and respondents are asked to identify their friends from the sample. Thus, peer groups can be constructed from either students who attend the same school or from groups of friends.

Peer group effects may play an important role in explaining premarital sex. Teenagers may be more likely to engage in this activity if their friends or classmates do so. Thus, the transition from the limited amount of teenage sexual activity in the past to the wide-spread participation today may have been influenced by such effects.

So, what factors in the data affect the chances that a teenage girl will engage in premarital sex? To investigate this, consider a logistic regression of the form shown below

$$\Pr(y = 1|\mathbf{x}, \overline{y}_{-i,-1}) = L(\alpha + \beta\mathbf{x} + \gamma\overline{y}_{-i,-1}), \tag{1}$$

where the independent variable y takes the value of 1 if a teenage girl starts having sex between Waves I and II and is 0 otherwise, $\mathbf{x}$ is a vector of explanatory variables (including a measure of shame discussed below), $\overline{y}_{-i,-1}$ is the fraction of teenage girls among the respondent's peers who have already had premarital sex in Wave I, and L is the (cumulative) logistic distribution function. The vector $\mathbf{x}$ includes variables related to stigma, religion, family background, etc., that are reported in Add Health.

The above logistic regression and the panel structure of the data set overcome the "reflection problem" prevalent in cross-sectional samples: group behavior affects individual behavior but the group by definition is the sum of the individuals.[14] In particular, the analysis focuses on those girls who made the transition from never having premarital sex in Wave I to having had it in Wave II. Therefore, this subset of girls could not have influenced those who had sex in Wave I, which is the peer group. Thus, $\overline{y}_{-i,-1}$ can be taken as exogenous in the regression.[15]

Another potential problem in identifying peer-group effects is the presence of correlated effects. Peer groups may not be formed randomly. Perhaps a teenager associates with her peers because they have similar unobserved characteristics. If you are interested in having sexual relationships then you may choose to associate with others who share this predisposition–see Greenwood and Guner (2010) for a model of this. In the analysis below peer groups are based on a teenager's school, assuming that the school is exogenous to the individual and parental

[14] Manski (1993) and, in more detail, Brock and Durlauf (2001a,b) demonstrate that the reflection problem is less severe in a discrete choice model with social interactions because identification is derived from the nonlinear structure of the problem. Nevertheless, it is still useful to exploit the panel structure of the data to minimize this (and other) problems in small samples.

[15] A similar approach is used by Clark and Loheac (2007) to study teenage consumption of alcohol, marijuana and tobacco and by Patacchini and Zenou (2011) to investigate the transmission of religiosity between parents and children. An alternative strategy would be to use the characteristics of nonoverlapping peers of peers for a respondent to instrument for her own peers–see Calvo-Armengol, Patacchini and Zenou (2009), Bramoulle, Djebbari and Fortin (2009), and De Giorgio, Pellizzari and Redaelli (2010).

characteristics of the respondent. Since school choice by parents might be partly endogenous, some further controls are considered. First, in Wave I, Add Heath asks parents if they chose a particular neighborhood for school quality. This can be controlled for in the analysis. Second, it is possible to differentiate between those teenagers who have moved to a neighborhood recently (within a year) and those who have been living there longer. Since correlated effects are likely to be different for these two groups, one can also control for whether the respondent is a recent resident. Teenagers within a particular school might also behave in a similar way since they face the same institutional constraints. To control for this, further regressors can be added to capture school characteristics.

3.1. The Shame Variable

Add Health contains several different variables both on the shame from sex and how religious a teenager is. Since these variables are correlated, it is not desirable to use them all. Instead, factor analysis is employed to consolidate the variables into a single one, called "shame". The basic idea is that there is a common factor, shame, which affects a respondent's answers. In the factor analysis, 11 variables are used relating to: the perceived shame a teenage girl would feel from her mother or family regarding premarital sex; the personal shame/concern the teenager would have about sex; her shame/concern about a pregnancy; and the girl's religiosity. These eleven variables are then statistically aggregated into a common single shame variable via factor analysis. This single factor explains about 50% of variation in these 11 variables–see the Appendix 12.2 for a brief discussion of factor analysis and a complete list of the variables used.

3.2. Results

Table I shows the coefficients from different logistic regressions.[16] In all regressions the dependent variable reports whether the respondent started having sex between Wave I and Wave II. The table starts with a simple specification where the only explanatory variables are shame and the fraction of teenagers who have already had sex in the respondent's school in Wave I (to capture the peer-group effects). Both the peer-group and shame variables have significant effects on teenage initiation of premarital sex (the normalization of the shame factor implies that higher values of the variable are associated with weaker feeling of shame). Next, controls are added for race and age. Controls are then included for observations such as parental income in Wave I, whether or not the respondent has a romantic relation in Wave II, her grades (an average of her math, English, science and social sciences scores, with a

[16] The basic results in Table I also hold with probit or linear probability regressions.

lower number indicating a higher average), and whether the teenager believes that she looks older than her peers.

The main lesson from Table I is that the effect of peer groups and shame is very robust across these different specifications (where *, **, and *** represent statistical significance at the 10, 5 and 1% levels, respectively). Teenagers are more likely to start having sex if they have a large group of peers who have already had sex and they are less likely to have sex if they are ashamed of it. Several other individual characteristics are considered, such as maternal education, maternal religiosity, whether the respondent lives with two biological parents, whether she has an older sibling, whether she received sex or AIDS education at school, whether her parents are satisfied with their relationship with the girl, how much parents talk about sex with her and whether the teenager works and has an independent source of income.[17] None of these additional factors enter the regression significantly, or affect the magnitude and significance of the variables of interest.

Table I: Peer Group Effects and Shame

	I	II	III	IV	V	VI
School Average	1.741**	1.592**	1.288*	1.662**	1.779*	1.772*
Shame	0.641***	0.645***	0.663***	0.617***	0.581***	0.606***
Parental Income			-0.007***	-0.008***	-0.007**	-0.007**
Romantic Relation				1.787***	1.677***	1.650***
Grades					0.379**	0.351**
Physical Development						0.582***
Control For Race	No	Yes	Yes	Yes	Yes	Yes
Control for Age	No	Yes	Yes	Yes	Yes	Yes
Number of Obs.	1,986	1,985	1,505	1,505	1,142	1,142

In Table II, additional controls are added to correct for correlated effects. Whether parents chose a particular neighborhood for school quality or whether the respondent moved into the current residence less than one year ago enter these regressions significantly.[18] The magnitudes of peer-group effects and shame are not affected in a material way, although the peer-group effect is now only significant at the 10% level. Some additional controls are also considered; viz., school type (public, private and religious), school location (urban, suburban and rural), school size, class size, the fraction of teachers with a masters or Ph.D.

[17] These additional variables are the usual controls in the literature–see, among others, Udry and Billy (1987), Fletcher (2007), and Richards (2010).

[18] The idea to differentiate between recent and not-so-recent movers was initially suggested by Gaviria and Raphael (2001).

degree, the proportion of teacher who has been working more than 5 years at the school, the proportion of parents involved in parents' organization at the school, and the proportion of white students in the school. None of these variables turn out to be significant and they do not affect the basic findings.[19]

Table II: Controlling for Correlated Effects

	I	II
School Average	1.699*	1.715*
Shame	0.616***	0.606***
Parental Income	-0.008***	-0.008**
Romantic Relation	1.648***	1.650***
Grades	0.356**	0.353**
Physical Development	0.600***	0.581***
Parental Choice	0.046	
Recent Movers		-0.034
Control For Race	Yes	Yes
Control for Age	Yes	Yes
Number of Obs.	1,119	1,142

The existing empirical literature on teenage sexual (or other) behavior usually relies on cross sectional data and tries to overcome the reflection problem by using instrumental variables (IV). A common strategy is to define peers as students who are in the same grade as the individual under study and use the peers' characteristics as instrumental variables for their sexual behavior.[20] Since the peer group is defined at the grade level, school fixed effects are added to these regressions to control for correlated effects.[21] Some IV estimates of peer-group effects are reported in the Appendix 12.2 using Wave I of Add Health. Consistent with the previous literature a significant peer-group effect is found when shame is ignored as a right hand side variable. When shame is added as an explanatory variable, peer-group effects become insignificant.

[19] Average values of the controls variables among the respondent's peers were also added to the regressions in Table I in order to control for what the literature calls exogenous (or contextual) effects. These exogenous variable were not significant and did not change the basic findings.

[20] See, for example, Fletcher (2011) or Richards (2010) for recent applications.

[21] Equation (1) could be estimated with peers defined at the grade, instead of school, level. Since the analysis focuses on the initiation of premarital sex between Wave I and Wave II, the sample size is too small here to conduct the analysis at the grade level.

3.3. The Import of the Results

How do peer-group effects and shame affect premarital sex? Given the above regressions (Table I, column VI) one can calculate the following marginal effects, expressed in terms of semi-elasticities, displayed in Table III. A shift in the shame variable by 1% leads to a change in the odds of having premarital sex of 0.023 percentage points. Similarly, a movement in the school average by 1% adjusts the probability of engaging in premarital sex by 0.068 percentage points. This implies that a change of one standard deviation in the school average would cause a shift of 2.5 percentage points in the odds of engaging in premarital sex, while a shift of one standard deviation in the shame factor is associated with a movement of 5.3 percentage points in this probability. The size of the estimated elasticity for the peer-group effect will be used to discipline the subsequent quantitative analysis. There does not appear to be a natural way to do the same thing with the shame variable, given its ordinal nature.

Table III: Marginal Effects

	Semi Elasticity
School Average (Peer Group Effect)	0.068
Shame	0.023

A model will now be developed where both peer-group effects and shame play a role in a teenager's decision to engage in premarital sex. Parents and social institutions, such as the church and state, will perform important parts in socializing teenagers about the perils of premarital sex. They do this by shaming and stigmatizing the act. The behavior of other teenagers will determine peer-group effects. Specifically, the more teenagers there are engaging in the act the less shame there will be associated with it.

4. The Economic Environment

Imagine a world comprised of overlapping generations of females and males. Assume each female will always give birth at the beginning of adult life to just one set of twins, a male and a female. Thus, there is no aggregate population growth. The birth of the twins may occur in or out of wedlock. Since males play a passive role in analysis, they are relegated into the background for the most part. Girls are socialized by their parents. This socialization is important when teenage daughters decide whether or not to engage in premarital sex. A high level of socialization by one's parents will induce a high level of shame if an out-of-wedlock birth occurs. But, why should parents socialize their daughters? Altruism is the mechanism here. In particular, later in life, old parents realize utility from the socioeconomic status of the household that their adult daughter lives in.[22] Daughters who experience out-of-wedlock births are more likely to be in households of low socioeconomic status than those who do not. Since the likelihood of this situation depends on the level of socialization given to young daughters, young parents will invest resources in it. In the analysis socialization is a costly activity, so parents undertake it judiciously.

Individuals live for three periods: youth, adulthood, and old age. Females are born with two characteristics: their productivity $y \in \mathfrak{Y} \equiv \{y_1, \cdots, y_n\}$ and their libido $l \in \mathfrak{L} = [0, 1]$, which represents the utility they realize from sex. The distributions over $\mathfrak{Y}$ and $\mathfrak{L}$ are given by Y and L. The distribution function L is independent across generations. The distribution over $\mathfrak{Y}$ is conditional on the mother's type; i.e., there is some transfer of ability across generations. In particular, $Y(y'|y)$ is increasing in y, in the sense of stochastic dominance. Because the birth rate for each type of female is fixed, there is no need to keep track of potential shifts in Y over time due to cross-sectional differences in births rates. Denote the stationary distribution associated with $Y(y'|y)$ by $\overline{Y}$. Assume that a suitable law of large numbers holds in this economy and that, consequently, individual probabilities equal aggregate shares of realizations of random variables.

5. Young Females

Youths live with their parents. Girls are socialized by their parents at the beginning of their youth. Represent the level of socialization by s. This denotes some level of investment that parents make in influencing a daughter's views on premarital sex. The word investment is used deliberately. Noncognitive skills, such as the sense to avoid risky activities like drinking, doing drugs, or engaging in premarital sex, are important for building a child's human capital. They complement the formal schooling stressed by economists–e.g. Restuccia and Urritia (2004). After this socialization occurs, female youths decide whether or not to engage in premarital sex. This is the only decision a young female makes. If they do so, they receive a utility $l \geq 0$, but risk a pregnancy with probability $1 - \pi$. Think about π as representing the quality of the contraception technology, including more drastic measures, specifically abortion and infanticide. For example, it may be reasonable to view the 1973 decision by the U.S. Supreme Court that legalized abortion as a drop in $1 - \pi$.

An out-of-wedlock birth will generate a present-value of guilt in the amount $S(s)$. The *shame* function $S(\cdot)$ is increasing and strictly concave in s. If girls do not engage in premarital

[22] The altruism is of an imperfect form. Parents don't take into account the joy their teenage daughters experience from premarital sex. This is probably a better description of the world than assuming that they do. Additiionally, altruism is only in one directions; i.e., kids do not care about their parents.

sex, they get utility normalized to zero. The shame that a girl may suffer from an out-of-wedlock birth may be mitigated by peer-group effects. Let $\mathbf{e}$ represent the aggregate number of females in the girl's generation that are engaged in premarital sexual relationships. The peer-group effect will be represented by $P(\mathbf{e})$, so that the net shame a girl will suffer from an out-of-wedlock birth is $S(s) - P(\mathbf{e})$.

A female will enter adulthood next period with a known level of productivity, y', and perhaps an out-of-wedlock child. Represent the value function for a female adult next period by $A'(y', I')$, where I' indicates whether or not she had an out-of-wedlock birth. In particular, $I' \in \{0, 1\}$ will return a value of one when an out-of-wedlock birth has occurred. Here a prime is attached to a variable to denote its value in the next period. Likewise, a prime is attached to a function to signify that the implied relation changes as time progresses. A precise definition for A will be provided in Section 6. The function will have the properties that A' is increasing in y' so that higher productivity girls can expect higher levels of utility vis à vis lower productivity ones. It will also transpire that $A'(y', 0) > A'(y', 1)$, so that an out–of-wedlock birth is costly.

5.1. Premarital Sex

Direct attention now to a female youth's decision about whether or not to engage in premarital sex. On the one hand, if a female youth is abstinent then she will realize an expected lifetime utility level of $A'(y', 0)$. On the other hand, if she engages in premarital sex, she will realize the enjoyment l, but will become pregnant with probability $1 - \pi$. Her expected lifetime utility level will be $l + \pi A'(y', 0) + (1 - \pi)[A'(y', 1) - S(s) + P(\mathbf{e})]$. She will pick the option that generates the highest level of expected lifetime utility. Her decision can be summarized as follows:

$$\begin{array}{lll} \textsc{Abstinence} & \textit{if} & A'(y', 0) \geq l + \pi A'(y', 0) + (1 - \pi)[A'(y', 1) - S(s) + P(\mathbf{e})], \\ \textsc{Premarital sex} & \textit{if} & A'(y', 0) < l + \pi A'(y', 0) + (1 - \pi)[A'(y', 1) - S(s) + P(\mathbf{e})]. \end{array} \tag{2}$$

Pick a row in (2) and fix y' and s. Observe that the right-hand side is increasing in l while the left-hand side is constant. Thus, there is a threshold for utility from sex for females, l^*, such that

$$A'(y', 0) = l^* + \pi A'(y', 0) + (1 - \pi)[A'(y', 1) - S(s) + P(\mathbf{e})],$$

or

$$l^* = \mathcal{L}(s, \mathbf{e}, y') \equiv (1 - \pi)\{S(s) - P(\mathbf{e}) + A'(y', 0) - A'(y', 1)\}. \tag{3}$$

This expression equates the utility of sex, given by l^*, with its expected cost, the difference in future expected utilities induced by an out-of-wedlock birth plus the shame, net of peer-group effects, associated with this event, multiplied by the probability of pregnancy. Hence, a threshold rule of the form $l^* = \mathcal{L}(s, \mathbf{e}, y')$ obtains such that for $l > \mathcal{L}(s, \mathbf{e}, y')$ the female agent will seek sex, and will not otherwise. This threshold will be is a function of the state of contraceptive technology, π, as can be seen from (3). As the failure rate of contraception, $1 - \pi$, declines the threshold value for libido, l^*, will drop, assuming $P(\mathbf{e})$, and $A'(y', I')$ remain constant.

The odds of a type-y' female youth, with a socialization level of s, engaging in premarital sex are given by

$$\Sigma(s, \mathbf{e}, y') \equiv 1 - L(\mathcal{L}(s, \mathbf{e}, y')), \tag{4}$$

while the probability of becoming pregnant is[23]

$$(1 - \pi)\Sigma(s, \mathbf{e}, y').$$

6. Adulthood

At the start of adulthood, females and males match for the rest of their lives. A female will enter a marriage with productivity level, y, and possibly some out-of-wedlock children, represented by I. Now, a type-(y, I) female will be matched with a male of productivity, $\widetilde{y}$, according to some marriage rule, discussed later. A young married couple realize utility from their match denoted by $U(y, \widetilde{y}, I)$. Presume that felicity of a match is increasing in the productivity of female, y, and male, $\widetilde{y}$. Higher types will earn more. It also seems reasonable to assume that $U(y, \widetilde{y}, 0) > U(y, \widetilde{y}, 1)$. An out-of-wedlock birth may prevent a female from realizing the full potential of her productivity. Perhaps she could not fulfill her educational aspirations or received less job experience due to a teenage pregnancy. The male may be less

[23] In modern times there are differences in the choice of contraception by education and income. One could add a pregnancy prevention effort choice into the analysis to proxy for this. (Note that the set of contraceptives has changed over time so that it would be difficult to model this in a systematic way.) Then, poorer types will be less diligent at preventing pregnancies because doing so has a smaller benefit for them. For example, suppose that the odds of safe sex are given by $d\pi$, where d is the diligence expended in contraception and π is the efficacy of contraception. Let the disutility of effort be given by $d^{1+\varepsilon}/(1+\varepsilon)$. Then, the teenage girl will pick d in line with

$$\max_{d}\{d\pi A(y', 0) + (1 - d\pi)[A'(y', 1) - S(s) + P(\mathbf{e})] - d^{1+\varepsilon}/(1+\varepsilon)\}.$$

It is easy to deduce that the solution for diligence, d, is given by

$$d = \{\pi[A'(y', 0) - A'(y', 1) + S(s) - P(\mathbf{e})]\}^{1/\varepsilon}.$$

Observe that d will rise with a girl's type, provided that $A'(y', 0) - A'(y', 1)$ does. Perhaps evidence of the efficacy of contraception use by socioeconomic class could be used to pin down ε.

engaged with a daughter that is not his own. Parents also derive expected utility from their daughter, $D(y', I')$, which is increasing in y' with $D(y', 0) > D(y', 1)$. A daughter with an out-of-wedlock birth may earn less and marry a less-desirable husband than a daughter who does not have one. This reduction in her socioeconomic status affects the parents' utility. Socializing their daughter involves a cost, the disutility of which is denoted by $V(s)$. The function $V(s)$ is presumed to be increasing and convex in s. All of these felicity streams are *public* goods enjoyed jointly by husband and wife.

Remember that for a female youth the probability of having out-of-wedlock children is $(1-\pi)\Sigma(s, \mathbf{e}, y')$. The odds of not having an out-of-wedlock birth are $1-(1-\pi)\Sigma(s, \mathbf{e}, y')$ $= 1-\Sigma(s, \mathbf{e}, y') + \pi\Sigma(s, \mathbf{e}, y')$. A teenage girl may not have an out-of-wedlock birth for two reasons: she may stay abstinent, which happens with probability $1-\Sigma(s, \mathbf{e}, y')$, or she may engage in premarital sex but does not become pregnant, the odds of which are $\pi\Sigma(s, \mathbf{e}, y')$. Therefore, the expected level of utility for a young adult couple in a marriage of type $(y, \widetilde{y}, I, y')$, who arbitrarily socialize their daughter to level s, will read

$$
\begin{aligned}
M(y, \widetilde{y}, I, y', s) = U(y, \widetilde{y}, I) - V(s) + [1-(1-\pi)\Sigma(s, \mathbf{e}, y')]D(y', 0) \\
+ (1-\pi)\Sigma(s, \mathbf{e}, y')\, D(y', 1).
\end{aligned}
$$

The young adult couple will choose s to maximize their lifetime utility. Hence, s solves

$$
M^*(y, \widetilde{y}, I, y') \equiv \max_s [M(y, \widetilde{y}, I, y', s)]. \tag{P(1)}
$$

The function $M^*(y, \widetilde{y}, I, y')$ gives the expected value for a type-(y, I) young adult female marrying a type-$\widetilde{y}$ young adult male, who together have a type y' daughter, and vice versa. Then, the value function for a young adult female just prior to marriage will read

$$
A(y, I) \equiv \int\int M^*(y, \widetilde{y}, I, y')\, dY^m(\widetilde{y}|y, I)\, dY(y'|y), \tag{5}
$$

where $Y^m(\widetilde{y}|y, I)$ denotes the conditional odds of a type-(y, I) female drawing a type-$\widetilde{y}$ male on the marriage market. These odds are discussed next.

6.1. Matching Process

Suppose that the conditional odds of a type-(y, I) female drawing a type-$\widetilde{y}$ male on the marriage market are described by the distribution function $Y^m(\widetilde{y}|y, I)$. Presume that the distribution $Y^m(\widetilde{y}|y, 0)$ stochastically dominates $Y^m(\widetilde{y}|y, 1)$. Thus, a girl with an out-of-wedlock birth is less likely to match with a high-type male than a girl without one. The precise form of this conditional distribution will depend upon the assumed matching process. It will be assumed that a fraction μ of couples is matched in accordance with the Gale-Shapley algorithm while the remaining fraction $1-\mu$ is matched randomly. This algorithm computes the utilities from various types of marriages and orders them from the highest down to the lowest. (Remember that all utility flows within a marriage are public goods.) The presence of an out-of-wedlock birth reduces the desirability of a match. The matching process then allocates people into marriages starting with the highest-valued matches and going down in the list until everybody is matched. The algorithm tends to match similar types with similar types. Strong assortative mating is not observed in the U.S., which explains the inclusion of randomness in the matching process. The details are in Appendix 13.1.

An out-of-wedlock birth makes it more likely that a woman will never marry. In the modern era, a teenager with an out-of-wedlock birth had a 16% chance of never marrying by ages 40-44, versus 9% for a teenager without an out-of-wedlock birth (based on data from the 2002 National Survey of Family Growth). The Gale-Shapley algorithm could be modified to allow for this. Imagine making a deduction from household utility for an out-of-wedlock birth, say κ. Then, some males and females may find it better to remain single than to accept the best match that they can attain on the marriage market. Undertaking such an extension would involve computing the value of single life for men and women.[24] Additionally, women who have an out-of-wedlock birth, while teenagers, tend to have more children. In particular, they have 2.8 children on average versus 2.1 for those women who did not (for married women, ages 40-44). Extending the framework to allow for endogenous fertility brings some interesting questions to the foreground. Would some girls choose to have an out-of-wedlock birth? Should they take the survival odds of the child into account when considering this, an important factor historically? The calibration strategy adopted in Section 8 penalizes an out-of-wedlock birth in a fairly flexible way. Hopefully, it picks up some aspects of these unmodelled cost.

6.2. Solution for Socialization

The solution to problem P(1) can now be characterized. Maximizing with respect to s yields the first-order condition

$$-(1-\pi)\,\Sigma_1(s,\mathbf{e},y')\,[D(y',0)-D(y',1)] = V_1(s). \tag{6}$$

[24] An example of such an analysis is contained in Aiyagari, Greenwood and Guner (2000).

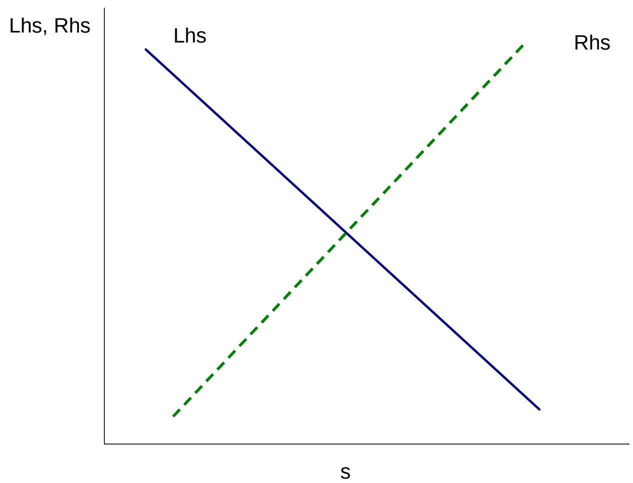

Figure 4: The determination of s

From the above efficiency condition, it is apparent that the level of socialization for a daughter, s, will be a function of her type, y', so that $s = \mathcal{S}(\mathbf{e}, y')$.

The right-hand side of equation (6) is increasing in s, because V is convex. The slope of the left-hand side of the equation will now be examined. Using (3) and (4) it is easy to see that

$$-\Sigma_1(s, \mathbf{e}, y') = L_1(l^*)(1-\pi) S_1(s). \tag{7}$$

This will be decreasing if both S and L are concave functions. Note that $L_1(\mathcal{L}(s, \mathbf{e}, y'))$ is decreasing in s, a fact evident from (3). Therefore, the left-hand side of (6) declines with s. To summarize, the situation is portrayed by Figure 4.

Intuitively, a drop in the failure rate for contraception, $1-\pi$, will cause the Lhs curve to shift leftward, resulting in a fall for the level of socialization, s. A reduction in the failure rate reduces the marginal benefit from socialization. This follows from (6) and (7) and assumes that $A(y', I')$ and $P(\mathbf{e})$ remain fixed, which influence the functions L_1 and Σ_1 through (3). A rise in the number of girls experiencing premarital sex, $\mathbf{e}$, will move the Lhs curve rightward, as can be deduced from (3), (6) and (7). A stronger peer-group effect, $P(\mathbf{e})$, increases the marginal benefit from socialization, a fact which follows from (3), (6) and (7). Socialization, s, will increase on this account. Again, this presumes that $A(y', I')$ remains fixed. Next, assume that $D(y', 0) - D(y', 1)$ is increasing in a girl's productivity, y'. This term enters the lefthand side of (6), and measures how a parent views the cost of an out-of-wedlock birth for their type-y' daughter. This assumption implies that parents of high-type girls will be hurt the most by out-of-wedlock births. A higher value for y' shifts the Lhs curve to the right because the marginal benefit from socialization will rise. High-type girls will be socialized more. If $D(y', 0) = D(y', 1)$, parents would not socialize their daughters. Last, consider the term $L_1(l^*)$, which enters (6) via (7). This term tells how a change in the threshold, l^*, will shift the odds of a daughter having premarital sex, as represented by $L_1(l^*)\,(1-\pi)\,S_1\,(s)$. When it is high, shifting the threshold through shaming will have a large effect. Hence, socialization pays off.

7. Steady-State Equilibrium

Suppose that the economy is in a steady state. The aggregate number of girls who are engaging in premarital sex, $\mathbf{e}$, will be implicitly determined by

$$\mathbf{e} = \int \Sigma\left(\mathcal{S}(\mathbf{e}, y), y\right) d\overline{Y}(y). \tag{8}$$

Note that the term $\Sigma\left(\mathcal{S}(\mathbf{e}, y), y\right)$ gives the odds that a girl of type y, who has been socialized to the level $s = \mathcal{S}(\mathbf{e}, y)$ by her parents, will engage in premarital sex. To compute $\mathbf{e}$ just integrate over all types of girls, as is done. Let F represent the joint distribution for females over (y, I). In a steady state this distribution will be given by

$$F(y, 1) = (1-\pi) \int^{y} \Sigma\left(\mathcal{S}(\mathbf{e}, y^*), y^*\right) d\overline{Y}(y^*), \tag{9}$$

with

$$F(y, 0) = \overline{Y}(y) - F(y, 1),$$

where $\mathbf{e}$ is defined by (8). The equation for (9) gives the number of young girls with a productivity level less than y that will experience an out-of-wedlock birth.

Definition. *A steady-state equilibrium consists of a threshold libido rule for female youths, $l^* = \mathcal{L}\left(s, \mathbf{e}, y'\right)$, a rule for how young parents socialize their daughters, $s = \mathcal{S}(\mathbf{e}, y')$, the matching probability for an unmarried female, $Y^m\left(\widetilde{y}'|y', I'\right)$, an aggregate level of teenage girls experiencing premarital sex, $\mathbf{e}$, and a stationary distribution for unmarried females, $F(y', I')$, such that:*

1. *The threshold rule for a female youth maximizes her utility, as specified by (3).*

2. *The parents' socialization rule maximizes their utility in line with P(1).*

3. *The matching probability is determined in line with a modified Gale-Shapley matching process described in Appendix 13.1.*

4. *The number of sexually experienced teenage girls is represented by (8).*

5. *The stationary distribution for unmarried females is given by (9).*

Recall from the historical discussion in Section 2 that pervasive premarital sex is a recent phenomenon in Western societies. It took off only with the contraception revolution that occurred during the 20th century. Living standards rose considerably between 1600 and 1900, however; this did not have an impact on premarital sex. So the functions U and D need to be structured so that increases in income do not affect the likelihood that a teenage girl will engage in premarital sex.

Lemma 1. *(Balanced growth) Suppose that U is a homogenous of degree zero function in y' and $\widetilde{y}'$ and that D is a homogenous of degree zero function in y'. An increase in all y's and $\widetilde{y}$'s by a factor χ has no effect on s.*

Proof. See Appendix 13.2. ■

8. Setting up the Simulation

The model will now be simulated to see if it can explain the rise in premarital sex and the increase in out-of-wedlock births over the last century. Simulating the model requires choosing functional forms and picking parameter values. The functional forms will be selected so that the model maps into an overlapping generations model with three phases of life; viz., youth, adulthood, and old age. They are also picked to satisfy Lemma 1. Thus, long-run trends in income will have no impact on sexual practice.

Some parameter values for the model can be taken directly from the literature or the U.S. data. For others, this cannot be done. The strategy adopted here will be to pick these parameters so that the model matches some stylized facts for the modern era, or the U.S. around the year 2000. In particular, the analysis will be disciplined by calibrating the model to a set of three cross-sectional observations for the modern time, as well as the observed strength of peer-group effects. The fact that the model can do this is not a forgone conclusion. Then, the model will be simulated to see if it can account for the observed rise in premarital sex over the last one hundred years, given the calibrated parameter values and the observed technological progress in contraception.

8.1. The Parameterization of Functional Forms

To begin with, the functions $S(s)$, $U(y,\widetilde{y},I)$, $P(\mathbf{e})$, $D(y',I')$, and $V(s)$ need to be parameterized. Before proceeding, let $\widehat{y}(y,I)$ represent the income that a type-(y,I) woman can earn on the labor market. The idea is that a woman's actual productivity, $\widehat{y}(y,I)$, may differ from her potential productivity, y, due to an out-of-wedlock birth, denoted by $I=1$. This will be made more precise shortly. Assume that there are N productivity levels for y.

1. Let
$$U\left(y,\widetilde{y},I\right)=(\beta+\beta^2)\ln(\widehat{y}(y,I)+\widetilde{y}).$$
This can be thought of as the utility that a married couple will enjoy over two periods of adult life (young and old) when they have a household income of $\widehat{y}(y,I)+\widetilde{y}$. Here, β represents the discount factor. The utility flow is discounted starting from the first period, or teenage life. There is no need to allow for lifetime growth in income–the proof is similar to the one for Lemma 1 on balanced growth.

2. The functions for shame, and peer-group effects are given standard isoelastic representations. The libido distribution is Weibull. This distribution has a flexible density function, which may rise and then fall in l, or just fall in l, depending on parameter values. The functions are:
$$S(s)=\gamma\frac{s^{1-\delta}}{1-\delta},\ P(\mathbf{e})=\zeta\frac{\mathbf{e}^{1-\iota}}{1-\iota},\ L(l)=1-\exp[-(l/\sigma)^{\eta}]\ (\text{with } \eta,\sigma>0).$$

3. Set
$$D(y',I')=\beta^2\phi\int\ln(\widehat{y}(y',I')+\widetilde{y}')dY^{m\prime}\left(\widetilde{y}'|y',I'\right).$$
The expression gives the expected discounted utility that young parents will realize from an adult daughter of type (y',I'). This utility is a function of the latter's expected standard of living when married. Young parents do not know the type of male, $\widetilde{y}'$, that their daughter will marry, which explains the expectation.

4. Assume
$$V(s)=-\beta\theta\ln(\omega-s).$$
Here ω denotes the family's endowment of non-working time. The couple's leisure is given by $\omega-s$.

5. Give the conditional distribution for productivity, $Y\left(y'|y\right)$, the following simple repre-

sentation:

$$y_i' = y_i, \qquad \text{with probability } \rho + (1-\rho)\Pr(y_i),$$
$$y_i' = y_j \text{ (for } i \neq j), \qquad \text{with probability } (1-\rho)\Pr(y_j),$$

where $\Pr(y_j)$ represents the odds of drawing y_j from the stationary distribution. With this structure, ρ determines the autocorrelation across types over time within a family.

6. Last, how does an out-of-wedlock birth affect a woman's actual productivity? The function mapping a female's potential productivity, y, into her actual level, $\widehat{y}(y, I)$, is given by

$$\widehat{y}(y, I) = \begin{cases} y, \text{ if } I = 0, \\ y - T(y)y, \text{ if } I = 1, \end{cases}$$

where

$$T(y_i)y_i = \sum_{j=1}^{i} \lambda(\frac{y_j}{y_N})^{\alpha}(y_j - y_{j-1}) + \tau, \text{ for } i = 1, 2, \cdots, N,$$

with $y_0 \equiv 0$. The function $T(y_i)$ operates as an implicit tax on an out-of-wedlock birth. It does so in a progressive fashion, so that an out-of-wedlock birth has a disproportionately damaging effect on high-type females. With this formulation, the tax function is determined by the three parameters τ, λ, and α. Taxes start at $\lambda(\frac{y_1}{y_N})^{\alpha} + \tau$ and then rise in a progressive fashion (when $\lambda > 0$ and $\alpha > 1$) with income, y_i (for $i > 1$). This is vital for explaining the cross-sectional relationship between a girl's education and the likelihood that she will have premarital sex. In fact, note that without this function there would be no cost of having an an out-of-wedlock birth; hence, there would be no need for parents to socialize their daughters. This function is also important for determining the degree of assortative mating that is observed in society (conditional on having an out-of-wedlock birth). The model abstracts from any direct costs of raising children. As a result, the role of public policy, e.g. the welfare system, on the incentive to engage in premarital sex is left outside of the analysis. One could think of the progressivity in the above tax schedule as capturing some of these considerations, albeit in an ad hoc way.

8.2. Calibration

8.2.1. Productivity

The productivity process is calibrated from the U.S. data. The analysis will focus on several stylized facts categorized with respect to a female's educational background. Hence, a mapping needs to be constructed between educational attainment and productivity. There will be three groups for educational attainment: viz., less than high school, <HS; high school and some college, HS; college and post-college, C. The productivity distributions for females and males is specified for each category of education. An educational group is divided into six productivity levels corresponding to the average wage rate for those individuals lying within the following ranges for percentiles: 0 to 10, 10 to 25, 25 to 50, 50 to 75, 75 to 90, and 90 to 100. Thus, there are in all 18 productivity levels for each sex; hence, $N = 18$. The ranking of income levels does not map monotonically into education groups. For example, women in the upper end of the high school pay scale earn more than those at the lower end of the college one. This procedure is a variation on the one employed in Guner, Kaygusuz, and Ventura (forth). The parameterization adopted for the stationary distribution, $\overline{Y}$, is summarized in Table IV, which shows the mean level of productivity for each education group. The figures have been normalized by the mean wage rate for the entire sample. With this structure, ρ determines the autocorrelation across types over time within a family. Following Knowles (1999), set the intergenerational persistence across generations at 0.70, so that $\rho = 0.7$.

TABLE IV: PROD. DIST.

	y	$\widetilde{y}$	Density for $\overline{Y}$
<HS	0.49	0.72	0.129
HS	0.72	0.98	0.596
C	1.14	1.43	0.275

(Means, tabulated from 2000 CPS)

8.2.2. Contraception

The annual failure rate for contraception in 2000 was 28%, so that the odds of safe sex are 72%. A detailed discussion about this failure rate series is contained in Greenwood and Guner (2010), but in a nutshell the idea is to combine information on the usage of different contraceptives at first premarital intercourse together with statistics on the effectiveness of each type of contraception. For example in 2000, 51.2% of girls use condoms in their first premarital intercourse and condoms are about 85% effective (which represents the odds of not becoming pregnant over a year with typical use). An aggregate effectiveness measure is constructed by taking a weighted sum of effectiveness over all different contraception methods (e.g., condoms, the pill, withdrawal, etc.). Not using any contraception at all is included an as option as well. An average teenager does not engage in premarital sex all the time. On average, females have about 3 partners by age 19.[25] Furthermore, teenage relationships tend

[25] The source is Abma et al. (2004, Table 13, p. 26).

to be short, about 13 months.[26] Taking ages 14 to 19, inclusive, as the window for teenagers to have premarital sex, on average teenage females are exposed about half of this time to risk. So, for the modern era $\pi = 1 - 0.28/2 = 0.86$; i.e., the odds of a sexually active teenager not becoming pregnant are taken to be 86%.

8.2.3. The Choice of Parameter Values and the Calibration Targets

There are 14 parameter values to determine, $\{\beta, \phi, \zeta, \gamma, \delta, \theta, \iota, \omega, \mu, \alpha, \tau, \lambda, \eta, \sigma\}$. Around 2000, the median age at first premarital sex was about 17.6, while the median age at first marriage was about 25 for females.[27] Taking 0.96 as a standard value for yearly discount factor, let $\beta = 0.96^7$, reflecting the fact that there is about a 7 year gap between the time of first premarital sex and the time of first marriage. A person is assumed to spend 40% of her/his time endowment working so set $\omega = 1 - 1/3$. The remaining parameters are picked to match four sets of targets discussed below. Given the complex nature of the system under study, there is not a simple one-to-one mapping between a parameter and data target. Still, some intuition can be provided about how the parameters operate.

1. *The cross-sectional relationship between a girl's education and the likelihood that she will have premarital sex.* The odds of premarital sex decrease with education, as can be seen from Figure 5. The calibrated model matches this cross-sectional feature of the data reasonably well, as can also be seen from Figure 5. About 73% of girls with less than a high school education engage in premarital sex in the U.S. The corresponding figure for the model is 79%. By contrast, roughly 50% of college educated girls had such an experience, both in the data and model. Overall about 66% of girls have premarital sex in the U.S. The number for the model is 64%. The tax parameters τ, λ, and α are vital here because they determine how the girls of various types are affected by an out-of-wedlock birth, both directly through their own future productivity and via the marriage market. The parameters of the libido distribution, η and σ, are obviously important because they will govern the flow of girls into premarital sexual activity as the cost of this activity falls.

2. *The amount of time that a mother spends with her child, as a function of the mother's educational background.* Time spent increases with education, as Figure 6 illustrates. The model is good at mimicking this cross-sectional feature of the data too, as can

[26] Sources: Ryan, Manlove, and Franzetta (2003) and Udry and Bearman (1998).

[27] The median age at first premarital sex is taken from Finer (2007), and is for the period 1994-2003. The median age at first marriage for 2000 is taken from the Census Bureau web page, http://www.census.gov/population/socdemo/hh-fam/ms2.pdf.

be seen from the figure. The parameters ϕ and θ are key here. They determine how parents cares about their daughters (ϕ) and how costly is socialization (θ).

3. *The correlation between a husband's and wife's education.* This correlation is examined separately for women with and without out-of-wedlock births. The match between the data and model is shown in Table V. The model has little trouble reproducing the facts. Recall that the parameter μ controls the degree of assortative mating. It is important for matching the correlation between a husband's and wife's education, especially in the absence of an out-of-wedlock birth. The presence of an out-of-wedlock birth reduces the degree of assortative mating. The tax parameters τ, λ, and α impinge directly on this target, by determining the worth of a woman, with and without an out-of-wedlock birth, on the marriage market.

Table V: Correlations–Matching by Educ.

	Data	*Model*
Female's history		
Without out-of-wedlock birth	0.49	0.51
With out-of-wedlock birth	0.29	0.28

4. *The impact of peer-group effects on the likelihood of engaging in premarital sex.* The last target is the semi-elasticity for the peer-group effect estimated in Section 3. This elasticity measures the strength of peer-group effect in data and is used to discipline the magnitude of the effect in the model. The model hits this target almost exactly–see Table VI. Not surprisingly, this fact helps to tie down the peer group parameters ζ and ι.

Table VI: Peer-Group Effect

	Data	*Model*
Semi-Elasticity	0.068	0.068

The parameter values for the model are listed in Table VII. The implicit tax schedule on an out-of-wedlock birth is shown in Figure 7. It weighs high on a young woman at the upper end of the (potential) education scale. It is interesting to note that the likelihood a teenage girl will feel "very upset" if she gets pregnant increases with her mother's education background, as the left panel of Figure 8 makes clear. The right panel plots for the model a measure of the expected shame associated with premarital sex. The required expected level

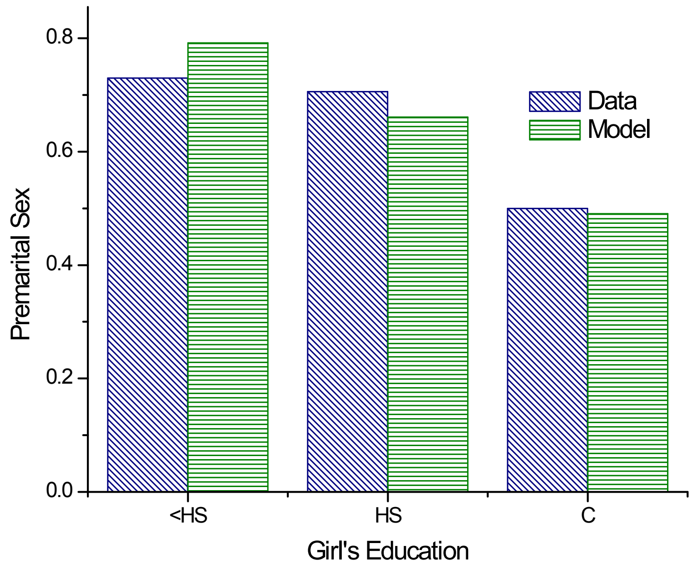

Figure 5: Cross-sectional relationship between the odds of a girl engaging in premarital sex and her educational background, data and model

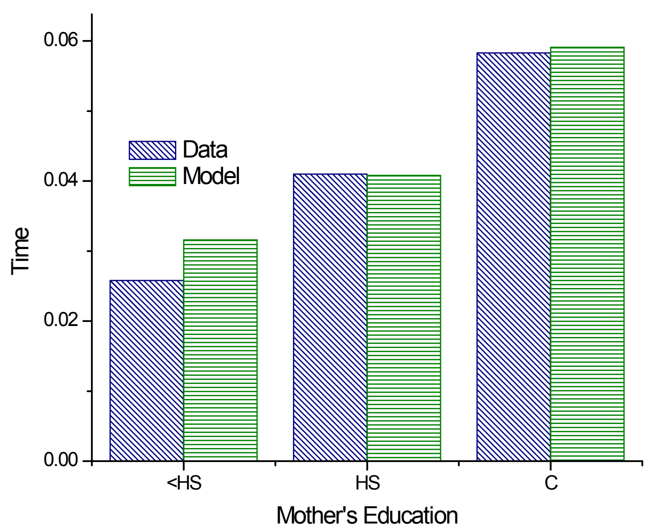

Figure 6: Cross-sectional relationship between the time spent with a daughter (as fraction of total hours) and the mother's educational background, data and model

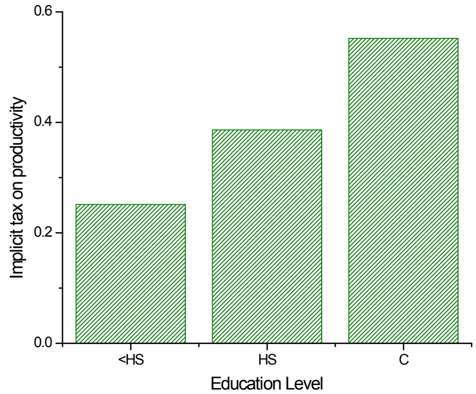

Figure 7: Implicit tax on an out-of-wedlock birth by education level, model

of shame is about 70% of the median joy from sex.[28] This seems reasonable.

[28]The average expected level of shame in the model is given by $(1-\pi)\int S(\mathcal{S}(\mathbf{e},y))d\overline{Y}(y)$. Normalize this by the median level of libido for a Weibull distribution, which is given by $\sigma \ln(2)^{1/\eta}$.

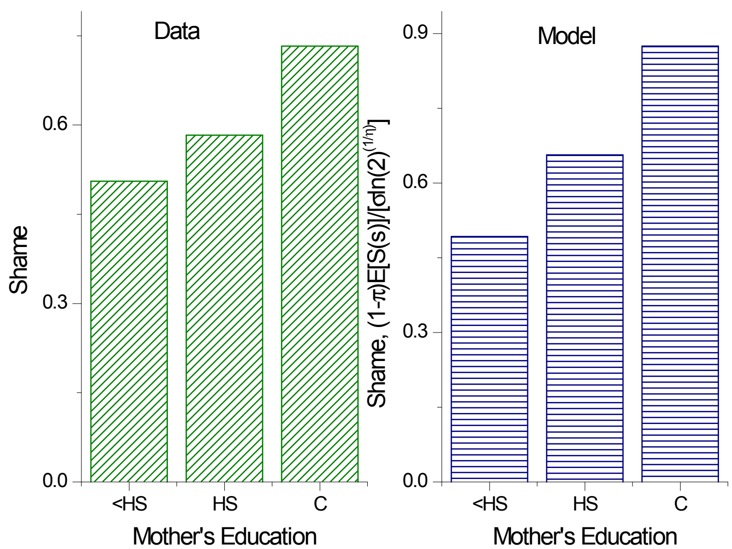

Figure 8: Left panel, Cross-sectional relationship between the daughter's shame from an out-of-wedlock birth and her mother's educational background, data; Right panel, Cross-sectional relationship between the daughter's expected shame from engaging in premarital sex (normalized by the median level of libido) and her mother's educational background, model

Table VII: Parameter Values

Parameter Value	*Comment*
Tastes	
$\beta = (0.96)^7$	Standard
$\phi = 2.41$, $\theta = 0.21$ (consumption and leisure)	Calibrated
$\gamma = 6.2$, $\delta = 0.40$ (shame)	Calibrated
$\zeta = 0.23$, $\iota = 0.42$ (peer group)	Calibrated
Productivity	
y_i's–see Table I for average values.	U.S. data
$\rho = 0.70$	Knowles (1999)
$\omega = 0.6$	Standard
Matching	
$\mu = 0.80$	Calibrated
Tax Schedule	
$\alpha = 4,500$, $\lambda = 4.9$, $\tau = 0.04$	Calibrated
Libido	
$\eta = 2.2$, $\sigma = 0.5$	Calibrated
Contraception	
$\pi_{2000} = 0.86$	Greenwood and Guner (2010)

9. The Computational Experiment

Imagine starting the world off in a situation where premarital sex is risky. Specifically, assume in the initial situation that the annual failure rate for contraception is 72%; this is Greenwood and Guner's (2010) estimate for 1900. This implies that the odds of safe sex are 1-0.72/2=64%. Let the failure rate decline smoothly over time from 36 to 14%–the number picked earlier for 2000. The odds of safe sex rose for three reasons. First, over time, there was a rise in the number of teenagers that use some form of contraception. The number of teenagers using any method increased from 40% to 80% between 1900 and 2000, perhaps due to better information offered by birth control clinics, doctors, schools, etc. Second, the effectiveness of any given method tended to rise. Third, new methods, such as the pill, became available; although, the pill had a very marginal impact on teenagers given its limited use–

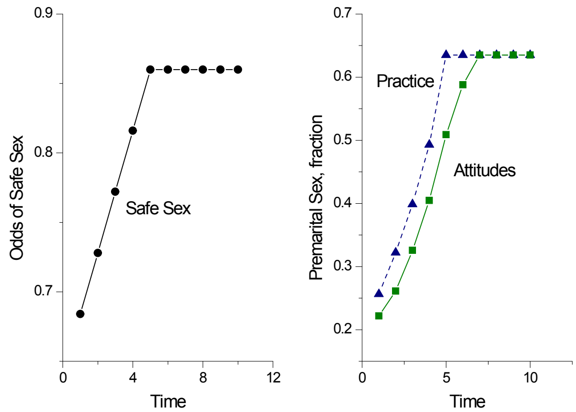

Figure 9: Sexual revolution

again, see Greenwood and Guner (2010) for more information.[29] The inputted time profile for the odds of safe sex is displayed in the left panel of Figure 9. The estimated effectiveness of contraceptives increases pretty steadily between 1960 and 2000–Figure 2. So, what will happen in the economy under study?

The increase in the efficacy of contraception induces a sexual revolution in the model, which is displayed in the right panel of Figure 9. The number of women practicing premarital sex rises from 16% to 64%. It is reasonable to postulate that the number of women engaging in premarital sex translates directly into a measure of that generation that has a favorable attitude toward it. At any point of time, the real world society is made up of many generations of women, each of which had a different sexual experience. Averaging across all generations gives a measure of society's attitude toward premarital sex. Do this for the three generations in the model. As can be seen, attitudes lag current sexual practice.[30] Additionally, as contraception becomes more effective, parents socialize their daughters less–Figure 10.

Interestingly, socialization has a humped-shaped pattern. The decline in the odds of pregnancy, $1 - \pi$, reduces the incentive to socialize, as was discussed in Section 6.2. But, it also lowers the threshold value for premarital sex, l^*, which entices more girls to engage in this activity. This can increase the density function, $L_1(l^*)$, which measures the impact of

[29]The technology of contraception is taken as exogenous here. Some innovations are no doubt driven by demand, and hence may be affected by culture as well. Condoms were known by the Egyptians and Romans but their mass production had to wait until the early 20th century. Modelling innovations in contraception within the current framework, however, would not be an easy task.

[30]See footnote 35 for an illustration of how stigma may be transmitted over time. This leads to persistence in parents' socialization decisions.

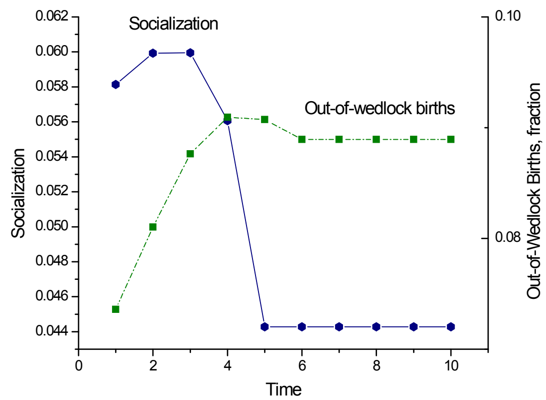

Figure 10: The decline in socialization and the rise in out-of-wedlock births

a shift in the threshold on the odds of a girl engaging in premarital sex. If this latter effect is large enough, it pays for parents to socialize their daughters more in order to raise this threshold and dissuade premarital sex.

The number of out-of-wedlock births rises. In particular, in the model they rise from 7.4% to 9.1%. This compares with an increase from 2.3%, that was observed in 1929, to 9.9%, seen in 1990. Thus, the model has a little difficulty mimicking the low observed rate in 1929. The extension developed in Section 10 helps a lot with this shortcoming. There is a $\cap$-shaped pattern in out-of-wedlock births. Figure 2, which plots out-of-wedlock births in the U.S., shares this feature. Out-of-wedlock births initially rise as more people engage in premarital sex, due to improvements in contraception. For the model, the downturn in births occurs because, after some date, the negative impact that technological progress in contraception has on out-of-wedlock births will begin to exceed the positive effect resulting from the fact that more people are engaging in premarital sex. To understand this, think about what would happen if contraception became perfect: there would be no out-of-wedlock births.

9.1. The Importance of Socialization and Peer Group Effects: Some Counterfactual Experiments

One can ask how important in the model is socialization for curtailing premarital sex. To gauge the significance of this, three counterfactual experiments are run. First, one could ask what would happen if parents did not socialize their children at all ($s = 0$). The results of this experiment are shown in top line in Figure 11. As can be seen, promiscuity would run rampant in the model. Even in the old steady state 93% of girls would engage in premarital sex. A

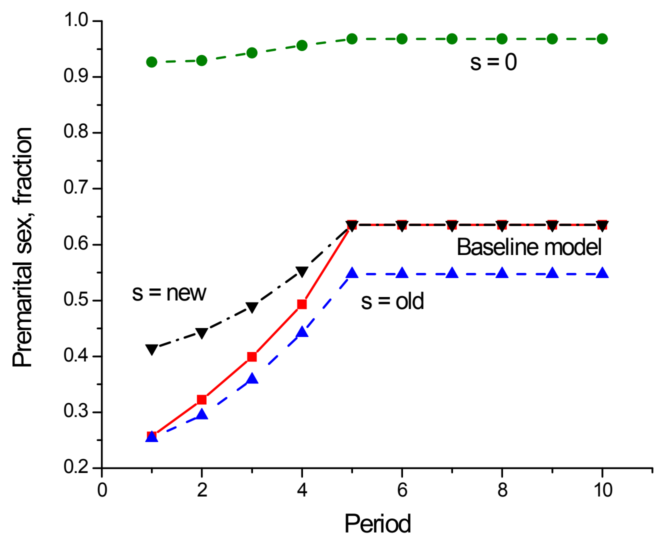

Figure 11: The impact of socialization on premarital sex, some counterfactual experiments

large fraction of these girls would become pregnant, given the poor state of contraception. This compares with roughly 20% in the baseline model.[31] Second, one could ask what would happen if parents maintained their old steady-state levels of socialization ($s = old$) even in face of technological improvement in contraception. As can be seen from the bottom line, a substantial minority of girls (45%) would remain abstinent in the new steady state. These two experiments suggest that socialization plays an important role in the model. Third, the dot-dashed line (labeled $s = new$) plots the transitional dynamics for model in the situation where parents always follow the new steady-state pattern of socialization. Here 41% of girls would engage in premarital sex in the initial period (again compared with 20% in the baseline model). Thus, the transitional dynamics to the new steady state are slower than in the baseline model.

To cast further light on the importance of socialization, imagine that a teenage girl grows up in a nation (the old country) with a primitive state of contraception ($\pi = 0.64$). Her parents socialize her according to the environment there. Now, suppose that around 15 years

[31] In a similar vein, one could ask how important is assortative matching in the model. This can be gauged by setting $\mu = 0$, so that all matches are random. In the old steady state the number of girls experiencing premarital sex would rise from 20 to 26%, while in the new steady state they would increase from 64 to 71%. Last, consider reducing the implicit tax for everyone on an out-of-wedlock birth by 50%. The number of teenage girls engaged in premarital sex would jump up to 36% in the old steady state. The level in the new steady state would be 88%.

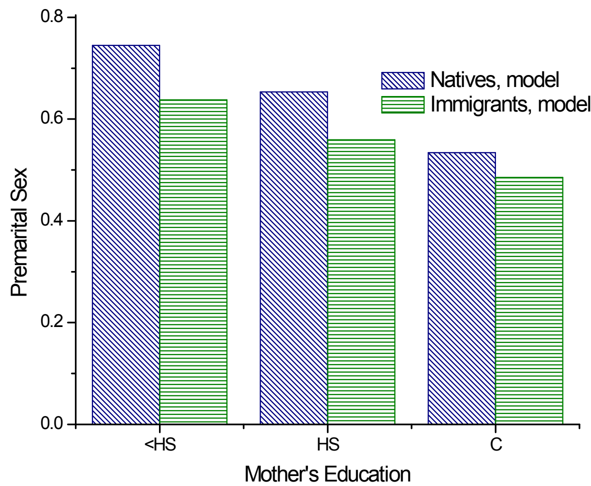

Figure 12: The cross-sectional odds of premarital sex in the immigration thought experiment

of age the girl and her family immigrate to another nation (the new country) with a more advanced state of contraception ($\pi = 0.86$). In the new country the teenager will decide whether or not to engage in premarital sex. She will do this so as to maximize her lifetime utility, taking into account: (i) the odds of becoming pregnant; (ii) how a pregnancy will affect her new-country socioeconomic status; (iii) how becoming pregnant will relate to her old-country set of values; (iv) what her new peers are doing. Figure 12 illustrates the upshot of this thought experiment. The young teenager's odds of engaging in premarital sex decrease as a function of her mother's education. In general a girl whose mother is educated has more to lose from engaging in this risky activity than one whose is not. Note that an immigrant is less likely to engage in premarital sex than a native is, at all education levels. Native girls received less socialization about the perils of premarital sex than the immigrant did. Their parents are more liberal about this, because the risk of becoming pregnant is much less in the new country versus the old country. Overall, 55% of immigrant girls will engage in premarital sex as opposed to 64% of native ones. Culture affects decisions, but the economic environment also affects culture.

Even though socialization plays an important role in the current model it may be possible to match the rise in premarital sex without including it, say by appealing to technological progress in contraception alone. The observed shift in culture would then reflect a passive adaptation to the new technological environment. Here, by contrast, a framework is developed where parents play an important role in inculcating social norms into their children. The cost/benefit calculus governing this process is affected by the state of society's technology. Cross-sectional differences in this cost/benefit calculus help identify the parameters of the model. Observations are used on: (i) the likelihood that a girl will engage in premarital sex by her own educational background; (ii) the time spent socializing children by a mother according to her educational attainment; (iii) the degree of assortative mating by the amount of schooling with and without an out-of-wedlock birth; (iv) the strength of peer-group effects on the odds that a girl will participate in premarital sex. In the next section, the analysis will be extended to modeling socialization by institutions such as the church or state. Deciphering precisely how important a role socialization plays in affecting a teenager's sexual behavior, in contrast to other factors, would require a more exacting quantitative analysis where the parameters of the model could be identified with precision. Perhaps there are other cross-sectional observations that might help toward this end. In any event, the qualitative evidence provided by historians specializing in demographic issues *strongly* suggests that socialization played an important role tampering down premarital sex.

Last, the importance of peer-group effects will be assessed. This is done by shutting them down in the model (by setting $\zeta = 0$). Additionally, the implied semi-elasticity for the peer-group in the model is increased by 100% (which requires $\zeta = 0.475$). The size of this semi-elasticity is roughly two standard deviations above the magnitude estimated in the U.S. data. As can be seen from Figure 13, while the prevalence of peer-group definitely increases the equilibrium level of premarital sex, the impact is quite moderate. In the benchmark analysis, the level of premarital sex in the final steady state is 64% with peer-group effects. This compares with 61% without them and 66% when their strength is doubled. In the analysis the size of peer-group effects is disciplined by estimating the semi-elasticity from the U.S. data. While statistically quite significant, the estimated elasticity is small. So, this limits the importance of peer-group effects in the model. Still, they are present. In a similar vein, while the presence of peer-group increases the amount of socialization done by parents, the effect is quite small.

10. The Church and State: An Extension

10.1. Historical Discussion

Illegitimacy imposes a financial burden on state and church. Different European states organized and funded orphanages and conservatories that took care of abandoned children, mostly illegitimate ones–see McCants (1997), Safley (1997), Sherwood (1989) and Terpstra (2005) for historical background. Churches, as long as they underwrote charity work, faced a similar

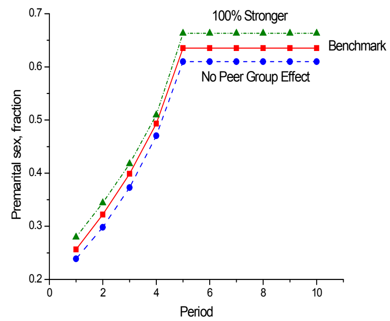

Figure 13: The impact of peer-group effects on premarital sex

burden.

To avoid these financial costs, both churches and states have used over history extensive instruments to reduce premarital sex and illegitimacy. Section 2 discussed how states employed criminal procedures to punish premarital sex. But other tools were available. One particularly powerful one was the legal concept of illegitimacy. Both in Civil law and Common law countries, a child was illegitimate if it was born to parents who were not legally married to one another at the time of birth, even if they later married. Illegitimate children were subject to a large number of discriminatory measures, from merely symbolic (as stating in the child's birth certificate his or her condition as illegitimate) to reduced inheritance rights–see Beckert (2007) and Witte (2009).[32] The most harsh of those was the English Common law idea of *filius nullius* (child of nobody): having no right to inherit from either father or mother, no right to the surname of either parent, and no claim on them for support or education. Interestingly enough, these legal mandates were explicitly justified as a way to prevent premarital sex. As the Earl of Selborne states in *Clarke v. Carfin Co. (1891), A.C. 412, 427*, this policy was designed for "the encouragement of marriage and the discouragement of illicit intercourse." Policies directed at generating stigma rather than explicit punishment were also widespread. For instance, in colonial Virginia, women engaged in premarital sex were required to offer a public apology in front of the congregated parish dressed in a white sheet and carrying a white wand–Brown (1996). Finally, there were more informal instruments in the form of some socially sanctioned activities such as supervised courtship rituals or the spread of the charivari as a ritual prosecution–Muir (2005). A particularly interesting

[32]A simple way to keep the stigma of illegitimacy public existed in Spain. By tradition, children use in daily life both the family name of the father and the mother. Women do not take the family name of their husband when they marry. Consequently, any person that used exclusively his mother's family name was immediately identified as illegitimate.

strategy was the New England's practice of "bundling." A courting couple were allowed to lie together but separated by a bundling board with, often, the woman's legs bound together by a bundling stocking–Fisher (1989). This institution allowed intimacy for the young couple without sexual contact.

Illegitimacy taxed the resources of church and state. A fine, called leyrwite, was levied on the bondwomen of medieval English manors. The name describes its purpose and is based on two Anglo-Saxon elements: 'leger' to lie down and 'wite' a fine. This tax on fornication (6d versus a daily wage of 3/4d) levied by the Lord and Lady of the manor was aimed at discouraging bastardy, which placed great financial strain on the manorial community–see Bennett (2003). (The Church punished fornicators more ruthlessly.) A related fine was childwite, which was levied on out-of-wedlock births. Stone (1977) relates how parish authorities in England frequently worked to ensure that bastards were born outside of their local jurisdictions, so that they would not have to absorb a financial liability. Hayden (1942-43) discusses a similar situation in eighteenth century Ireland. Churchwardens often employed a 'parish nurse.' This person was commonly known as a 'lifter'. Her task was to round up secretly abandoned foundlings and deposit them in a nearby parish. Sometimes she sedated the baby with a narcotic, diacodium, to muffle any crying. One woman, Elizabeth Hayland in the Parish of St. John's, lifted 27 babies in a year. Seven died in her care. A baby that she dropped off in the Parish of St. Paul's was promptly returned by their lifter–the churchwarden then told her not to deposit babies at same place too often. Her salary for lifting was £3 a year. Another nurse, Joan Newenham, started out getting paid 4s 9d for every baby she lifted. This was subsequently switched to an annual salary of £4 10s. Illegitimacy placed a great strain on the church's or state's finances. They may be called upon to provide poor relief to an unwed mother who kept her illegitimate children. They had to support the foundling hospitals and workhouses that received the abandoned babies, and provide the children with the necessary food, clothing, wetnursing, etc. And, then there was the cost of foster parents, orphanages and workhouses for the lucky children who survived.

10.2. Evidence on Religiosity and Premarital Sex in the U.S., 1994

Even during modern times there is a connection between religiosity and premarital sex. Table VIII presents the percentage of teenagers who have experienced premarital sex broken down by their religiosity. As can be seen, only 36% of girls who reported that religion was very important in their lives had engaged in premarital sex versus 50% who said that it was fairly unimportant.[33] Likewise, of those girls whose parents stated that religion was important only

[33]The numbers of girls sampled in the two not-important-at-all cells are too small to be reliable.

40% had experienced premarital sex, versus 48% for those who said it was fairly unimportant. A similar picture emerges when religiosity is measured by either the frequency of church attendance or praying. The correlation between parents' religiosity and their income is very weak in the U.S. data (Add Health), 0.08 to be specific. Similar correlations are found for the other measures of religiosity. This fact will be referred to later to motivate the setup used in the extension.

TABLE VIII: RELIGIOSITY AND THE INCIDENCE OF PREMARITAL SEX

Religiosity	*Girl's*	*Parent's*
Very important	36.1%	39.9%
Fairly important	48.6	46.6
Fairly unimportant	50.1	48.3
Not important at all	47.0	72.6

10.3. The Extension

Suppose that today's church or state officials desire to minimize the current number of out-of-wedlock births. To do this, assume that they embark on a program to encourage parents to socialize their children about the perils of premarital sex. Specifically, let an old couple feel opprobrium in the amount $O(\mathbf{r}) = \kappa \mathbf{r}^{1-\xi}/(1-\xi)$, with $0 < \xi < 1$, should their daughter experience an out-of-wedlock birth, where $\mathbf{r}$ is the level of activity undertaken by the state or church to generate this *stigma*. Given the weak correlation between religiosity and income, it will be assumed that the church and state direct their activities toward the population at large; i.e., they do not target particular subgroups. Suppose that the church or state faces the cost function $\nu \mathbf{r}^{\upsilon+1}/(\upsilon+1)$, with ν, $\upsilon \geq 1$. Clearly, the church and state may pursue other ideals, such as the well-being of society. The virtue of the specific objective adopted here is its simplicity.

The mathematical transliteration of the church's goal is

$$\min_{\mathbf{r}}\{\int (1-\pi)\Sigma(s,\mathbf{e},y')d\overline{Y}(y') + \nu \mathbf{r}^{\upsilon+1}/(\upsilon+1)\}, \qquad \text{P(2)}$$

subject to

$$-(1-\pi)\,\Sigma_1(s,\mathbf{e},y')\,[D(y',0) - D(y',1) + O(\mathbf{r})] = V_1(s), \text{ for all } y', \qquad (10)$$

taking as given $Y^{m\prime}(\widetilde{y}'|y',I')$ and $\mathbf{r}'$. The constraint is the first-order condition that parents solve this period to determine s. Note the presence of the opprobrium that they will feel if their daughter has an out-of-wedlock birth. The variables s and $\mathbf{e}$ are implicit functions of $\mathbf{r}$, as is made clear below. For simplicity, in this formulation the church neglects the secondary impact that its actions may have on the marriage market through the matching function $Y^{m\prime}(\widetilde{y}'|y', I')$. This channel is complicated to analyze.[34] So, view the extension here as an illustrative example of how the church or state might be incorporated into the analysis.

Minimizing gives the first-order condition

$$-(1-\pi)\{\int\{\Sigma_1(s,\mathbf{e},y')\frac{ds}{d\mathbf{r}}d\overline{Y}(y') + \int \Sigma_2(s,\mathbf{e},y')\frac{d\mathbf{e}}{d\mathbf{r}}d\overline{Y}(y')\} = \nu\mathbf{r}^{\upsilon}, \tag{11}$$

where

$$\begin{aligned}\frac{ds}{d\mathbf{r}} &= \frac{(1-\pi)\,\Sigma_1(s,\mathbf{e},y')\,O_1(\mathbf{r})}{\Delta} \\ &\quad + (1-\pi)\,\Sigma_{12}(s,\mathbf{e},y')\,\frac{d\mathbf{e}}{d\mathbf{r}} \times \frac{[D(y',0) - D(y',1) + O(\mathbf{r})]}{\Delta},\end{aligned} \tag{12}$$

with

$$\Delta(\mathbf{e},y',\mathbf{r}) \equiv -(1-\pi)\,\Sigma_{11}(s,\mathbf{e},y')[D(y',0) - D(y',1) + O(\mathbf{r})] - V_{11}(s) < 0,$$

and

$$\frac{d\mathbf{e}}{d\mathbf{r}} = -\frac{\nu\mathbf{r}^{\upsilon}}{(1-\pi)} \text{ [using (8) and P(2)].}$$

In its calculus the church takes into account how its action, $\mathbf{r}$, will impact on parental socialization decisions, s, and the peer-group effect, $\mathbf{e}$. These are the first and second terms on the left-hand side of the first-order condition (11), respectively. Furthermore, it also takes into consideration how a change in peer-group effects, $\mathbf{e}$, will influence parental actions, s, as the second line in (12) makes clear. By pressuring parents the church can increase the amount of socialization that they will undertake. The peer-group effect enters as an externality in daughters' and parents' decision making. The church or state has some power to influence this external effect, though, and factors this into its own choice. The church or state is solving a static Ramsey-style problem, taking as given what the future church/state will do.

The experiment conducted for the baseline model is now rerun while incorporating the Ramsey problem solved by the church. To do this, the selection for the parameters values governing the opprobrium function is $\kappa = 5.0$ and $\xi = 0$. Next, for the cost function simply set $\nu = 1.0$ and $\upsilon = 1.0$, to conserve on parameters. Last, the odds of safe sex are presumed

[34] To understand the problem note that church's actions today will affect tomorrow's type distributions $F'(y', I')$. This will have an impact on the matching function $Y^{m\prime}(\widetilde{y}'|y', I')$ described in Appendix 13.1. Characterizing the impact of F' on $Y^{m\prime}$ involves perturbing a function with respect to a *function*. Note that $Y^{m\prime}(\widetilde{y}'|y', I')$ enters into both $\Sigma(s, \mathbf{e}, y')$ and $D(y', I')$.

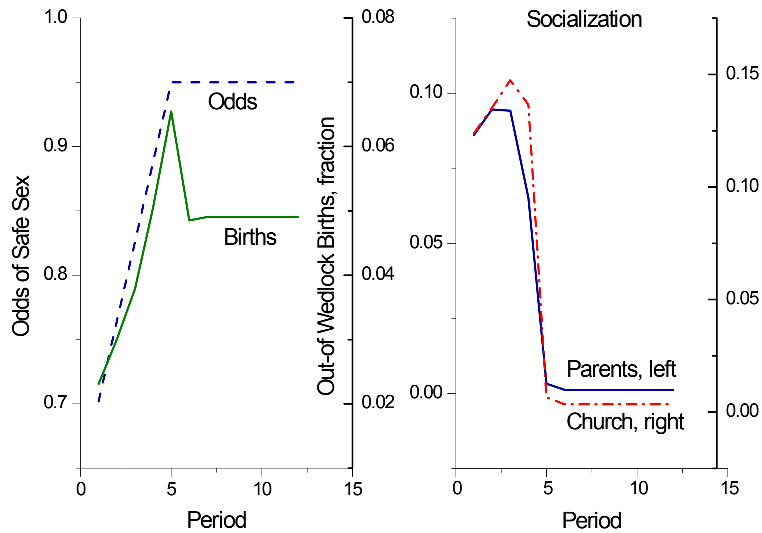

Figure 14: Socialization by church and parents

to increase to 95% (for illustrative purposes), which is higher than current U.S. levels. Figure 14 shows the upshot. Overtime socialization by both the church and parents declines as premarital sex becomes safer.[35] Out-of-wedlock births start off at 2.3% of total births, the same rate as is observed for the U.S. in 1920. Thus, the presence of the church and state has significantly battened down premarital sex in the initial steady state compared with the benchmark model. They rise to a peak of 6.5%, compared with the 9.9% observed in the U.S. in 1990. The decline in birth is sharper now because the failure rate for contraception is allowed to drop below current U.S. levels. Thus, out-of-wedlock births fall to 3.5%, which is below the rate that occurred in 2000 of 7.5%.

[35] Consider the following alternative extension that injects cultural dynamics into the analysis. Let $\mathbf{r}$ evolve according to

$$\mathbf{r} = (1-\nu)\mathbf{s} + \nu\mathbf{r}_{-1},$$

where the average level of socialization, $\mathbf{s}$, is given by

$$\mathbf{s} = \int \mathcal{S}(\mathbf{e}, y')d\overline{Y}(y').$$

Here the opprobrium, $O(\mathbf{r})$, that parents feel when their child has an out-of-wedlock birth will adjust slowly over time to any new economic circumstances. Social attitudes will have a capital aspect to them. In this spirit, Fernández, Fogli and Olivetti (2004) develop a model where men's preferences toward female labor-force participation change slowly over time in response to an increase in the fraction of working mothers in the population (promoting further participation). In their work there are no interested parties, such as churches, states or parents, trying to influence this evolution.

10.4. The Shift in Church Doctrine and the Decline in Proscription

The historical record supports the idea of lower activity in modern times by the state and churches to reduce premarital sex. Most of the legal restrictions on illegitimate children started to be erased in the 1960s. The U.S. Supreme Court, in *Levy v. Louisiana, 391 U.S. 68* (1968), stated that the rights of a child to sue on a deceased parent's behalf may not be denied merely because a person is the illegitimate child of the deceased. The Supreme Court understood that such limitation would violate the Equal Protection Clause of the Fourteenth Amendment. Moreover, the decision established that states were not permitted to classify in a way that constitutes "invidious discrimination against a particular class." This idea of "invidious discrimination" was developed in a number of subsequent decisions that eliminated nearly all legal consequences of illegitimacy in the U.S. (although a few survive, mostly related to immigration status). Similar legal changes equalizing the legal rights of legitimate and illegitimate children spread quickly in Western European countries, including England (1969 and 1989), France (1972 and 2001), Germany (1969 and 1997), Italy (1975), and Spain (1981). In 2005, France went as far as removing the very same concept of illegitimacy from its civil code.

Churches, particularly mainline protestant ones, also de-emphasized the existing strict provisions against premarital sex. In a famous example, the Episcopal Bishop of Newark, John Shelby Strong (a best-seller author of Christian books), called in 1987 for the recognition and blessing of non-marital relations. In Europe, the movement was even stronger. For instance, the German Protestant Church published in 1971 a *Memorandum on Questions of Sexual Ethics* that implied that couples who intended to marry could decide for themselves whether premarital sex was acceptable–Herzog (2007).

11. Conclusions

Engaging in a premarital conjugal relationship in yesteryear was a perilous activity for a young woman. The odds of becoming pregnant were high, given the primitive state of contraception. The economic consequences of an out-of-wedlock birth were dire for a young woman. Being born in or out of wedlock could be the difference between life or death for a child. Just like today young adults would have weighed the cost and benefit of engaging in premarital sex. The cost would have been lower for women stuck at the bottom of the socioeconomic scale, so they would have been more inclined to participate. To tip the scale against premarital sex, parents socialized children to possess a set of sexual mores aimed at shaming sex. They did this in the face of external peer-group effects that may have encouraged young women to participate in premarital sexual activity. Parents at the lower end of the social economic scale would have less incentive to engage in such practice.

The church and state also inveighed against premarital activity. Historically they were the main providers of charity for unwed mothers and out-of-wedlock children, a considerable expense. So, they had an economic incentive to stigmatize premarital sexual activity, in addition to caring about the well-being of their flock. Unlike parents, such institutions did have the ability to influence peer-group effects.

With the passage of time contraception became more efficient and the costs of premarital sex consequently declined. This changed the cost and benefit calculation for young adults so that they would be more likely to participate in sexual activity. It also reduced the need for socialization by parents, or the church and state, which would also spur promiscuity. This is an example of culture following technological progress. An interesting question is why the cultural prohibitions on premarital sex were abandoned so quickly, while others such as the dietary proscriptions associated with various religions were not. Perhaps sexual attraction is such a primal urge that there lies a huge individual incentive to abandon social norms, especially when they can be easily circumvented in private with improved contraception.

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12. Data Appendix

12.1. Data Sources

- *Figure 1.* The data on attitudes by women toward premarital sex are displayed in Figure 2 in Harding and Jencks (2003) and was kindly supplied by the authors. The numbers on the fraction of teenage girls who have experienced premarital sex by age 19 are taken from Greenwood and Guner (2010), which contains information about the source.

- *Figure 2.* See Greenwood and Guner (2010) for detailed information on how the failure rates are constructed. The data on out-of-wedlock births for teenage girls are derived as follows. For 1960-2000 the data are taken from Greenwood and Guner (2010). For the 1972-2000 period it sums births to unmarried teenagers, all abortions to teenagers, and miscarriages (calculated as 20% of births plus 10% of abortions). For the 1960-1971 period it estimates the total number pregnancies by simply assuming that the (abortions + miscarriages)/(out-of-wedlock births) ratio took the same value as it did in 1972. For 1920, 1930, 1940 and 1950-1960 the series from Greenwood and Guner (2010) is extended using the same procedure. The data on out-of-wedlock births for 1940 and 1950-1960 are from Ventura, Mathews and Hamilton (2001). For 1920 and

1930, using Bachu's (1999) estimates for 1930-1934, out-of-wedlock births are calculated as 14.5% of total births to teenagers. Total births to teenagers are from Heuser (1976).

- *Figure 3.* For the period 1580-1837 the data on out-of-wedlock births for all women are taken from Wrigley et al (1997, p. 224). For the period 1842-2005 the source is Ermisch (2006, Figure 1). Wrigley and Schofield (1981, p 230) provide data on the gross reproduction rate for 1541-1871. The data for 1876-2000 came from UK National Statistics.

- *Add Health.* This research uses data from Add Health, a program project designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris. Special acknowledgment is due to Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Persons interested in obtaining data files from Add Health should contact Add Health, Carolina Population Center, 123 W. Franklin Street, Chapel Hill, NC 27516-2524, USA (addhealth@unc.edu). Add Health is discussed further in Section 12.2.

- *Figure 5.* The data on premarital sex are calculated from the 2002 National Survey of Family Growth (Division of Vital Statistics, National Center for Health Statistics) as the fraction of women between ages 20 and 44 who had premarital sex before age 19.

- *Figure 6.* The underlying time-use data are taken from Aguiar and Hurst (2007). The figure plots the sum of educational and recreational childcare, normalized by 100 (total non-sleeping time per week). The sample includes all women between ages 20 and 44, who are not (early) retirees or students, had time diaries summing up to a complete day and had at least one child under the age of 18 at home.

- *Figure 8 (and the facts on attitudes cited in the Introduction).* Source: National Survey of Family Growth. The sample contains all teenagers in the survey (15-19 years old).

- *Table VIII.* National Longitudinal Study of Adolescent Health (Add Health) Restricted-Use Contractual data, Wave 1, 1994-1995. The sample contains all teenagers (15-19) who are not married and who did not experience forced sex.

12.2. National Longitudinal Study of Adolescent Health (Add Health)

12.2.1. Sample

The statistical analysis includes all girls between the ages of 15 and 19 in Wave I who have: (i) responded in both Wave I and Wave II, so that their transitions can be calculated; (ii) responded consistently. There are two types of inconsistencies: (a) those who say they have had sex in Wave I, but report they have never had sex in Wave II; (b) those who say they have never had sex in Wave I, report they have had sex in Wave II, but the date given for their sexual intercourse is before Wave I. All these observations are dropped. Additionally, all girls are dropped who: (i) have been married (a small number); (ii) have had involuntary sex; (iii) were in schools with less than 5 respondents. For the "peers" of a respondent all girls between the ages 15 and 19 who are in the same school are considered. The sample is restricted to girls in schools where at least 5 girls responded. The sample consists of 2,354 teenage girls who have never had sex in Wave I. Among them about 20% initiated sex between Wave I and Wave II. Table IX shows sample statistics for the variables used in the basic regression.

Table IX: Peer Group Effects and Shame–Sample Statistics

	Mean	Stan. Dev.
Initiate Sex between Wave I and Wave II	0.187	0.390
Peer Group (students from respondent's school who initiated sex by Wave I)	0.369	0.138
Shame	0	0.903
Parental Income ($)	46,850	55,736
Grades (average of grades in math, English, science and social sciences, with 1 being grade A and 4 being grade D)	2.105	0.729
Romantic Relations (fraction of respondents who have a romantic relation in Wave II)	0.670	0.470
Physical Development (fraction of respondents who feel they look older than average)	0.385	0.487
Age	16.12	0.985
Percentage White	0.599	0.490
Percentage Black	0.229	0.420

12.2.2. Factor Analysis

In the data set there are many variables on shame, religion, etc. Using all of these variables simultaneously induces a problem of multicollinearity. In the analysis a single variable, "shame", is constructed using factor analysis from the answers to a set of 11 questions. Factor analysis is used to identify or confirm the latent factor structure for a group of measured variables–see Harman (1967). Latent factors are unobserved variables that can not be directly measured, but are assumed to affect observed outcomes. In the current application, the latent factor is the "shame" that affects the answers that adolescent girls give to certain questions in Add Health.

Consider n variables with N observations (respondents) each, and suppose each of these variables are affected by m different latent factors. Then, a factor analysis model is given by

$$\begin{aligned}
x_1 - \mu_1 &= l_{11}f_1 + l_{12}f_2 + ... + l_{1m}f_m + \varepsilon_1 \\
x_2 - \mu_2 &= l_{21}f_1 + l_{22}f_2 + ... + l_{2m}f_m + \varepsilon_2 \\
&\vdots \\
x_n - \mu_n &= l_{n1}f_1 + l_{n2}f_2 + ... + l_{nm}f_m + \varepsilon_n,
\end{aligned}$$

or in matrix notation by

$$\mathbf{X} = \mathbf{LF} + \boldsymbol{\varepsilon}, \tag{13}$$

where $\mathbf{X}$ is $n \times N$, $\mathbf{L}$ is $n \times m$, $\mathbf{F}$ is $m \times N$, and $\boldsymbol{\varepsilon}$ is a $n \times N$ matrix. Here x_{ik} is the i-th observed variable for respondent k, μ_i is its mean across the N observations, f_{jk} is the j-th common random latent factor for respondent k and ε_{ik} is the unobserved error term for the i-th variable for respondent k. The basic assumptions are that the unobservable random vectors $\mathbf{F}$ and $\boldsymbol{\varepsilon}$ are independent with $E(\mathbf{F}) = 0, Cov(\mathbf{F}) = \mathbf{I}$, $E(\boldsymbol{\varepsilon}) = \mathbf{0}$, $Cov(\boldsymbol{\varepsilon}) = \boldsymbol{\Psi}$, where $\boldsymbol{\Psi}$ is a diagonal matrix. The l_{ij}'s are called factor loadings.

Note that since

$$\mathbf{XX}' = \mathbf{LFF}'\mathbf{L}' + \mathbf{LF}\boldsymbol{\varepsilon}' + \boldsymbol{\varepsilon}\mathbf{F}'\mathbf{L}' + \boldsymbol{\varepsilon}\boldsymbol{\varepsilon}',$$

the correlation matrix for the data can be written as

$$\mathbf{R_{XX}} = \mathbf{LR_{FF}L}' + \mathbf{LR}_{F\varepsilon} + \mathbf{R}_{\varepsilon F}\mathbf{L}' + \mathbf{R}_{\varepsilon\varepsilon},$$

where the operator $\mathbf{R}$ indicates a correlation matrix. Under the assumptions on $\mathbf{F}$ and $\boldsymbol{\varepsilon}$ (i.e., $\mathbf{R}_{F\varepsilon} = \mathbf{R}_{\varepsilon F} = 0$ and $\mathbf{R_{FF}} = \mathbf{I}$), this expression becomes

$$\mathbf{R_{XX}} = \mathbf{LL}' + \mathbf{R}_{\varepsilon\varepsilon}.$$

The basic idea of factor analysis is to find the $\mathbf{L}$ that minimizes $\mathbf{R}_{\varepsilon\varepsilon}$. Note that $\mathbf{R_{XX}}$ does not depend on $\mathbf{F}$. Once $\mathbf{L}$ is found, the factor matrix $\mathbf{F}$ can be recovered. In particular, consider the following linear regression of any factor j on the n observed variables:

$$f_j = \beta_{j1}x_1 + \beta_{j2}x_2 + ... + \beta_{jn}x_n, \; j = 1, .., m.$$

If the β values are known, then a factor for each respondent can be calculated as

$$f_{j,i} = \beta_{j1}x_{1,i} + \beta_{j2}x_{2,i} + ... + \beta_{jn}x_{n,i}, \ k = 1, .., m, \text{ and } i = 1, ..., N.$$

It can be shown that, Harman (1967, Chapter 16),

$$\boldsymbol{\beta}_j = \mathbf{R}_{\mathbf{XX}}^{-1}\mathbf{L}'_j,$$

where $\mathbf{L}'_j = [l_{1j}, l_{2j}, \cdots, l_{nj}]'$ is a $n \times 1$ vector of factor loadings.

In the current analysis the x_i's represent the answers to the 11 survey questions shown in Table X. There are 3,309 observations. A single "shame" factor is constructed so that $\mathbf{L}$ is a 11×1 vector and $\mathbf{F}$ is a $1 \times 3,309$ vector. This single shame factor explains about 50% of variation in these 11 variables. Table X shows the factor loadings (the l_i values for $i = 1, \cdots, 11$) for the analysis. As the relative sizes of the factor loadings show, the shame factor has a large influence on a respondent's guilt from premarital sex and on how she thinks her mother will feel about her engaging in the act.

Table X: Factor Loadings

How would your mother feel about...	
H1PA1. your having sex at this time in your life?	0.665
H1PA2. your having sexual intercourse with someone who was special	0.663
If you had sexual intercourse...	
H1MO2. your partner would lose respect for you	0.408
H1MO3. afterward, you would feel guilty	0.618
H1MO4. it would upset your mother	0.649
If you got pregnant....	
H1MO9. it would be embarrassing for your family.	0.468
H1MO10. it would be embarrassing for you	0.483
H1RE3. In the past 12 months, how often did you attend religious services?	0.478
H1RE4. How important is religion to you?	0.381
H1RE6. How often do you pray?	0.366
H1RE7. In the past 12 months, how often did you attend youth activities in churches/synagogues/etc.?	0.400

12.2.3. Instrumental Variable Analysis

Table XI shows the results from OLS and IV estimation of a linear probability model

$$\Pr(y = 1|\mathbf{x}, \overline{y}_{-i}) = \alpha + \beta\mathbf{x} + \gamma\overline{y}_{-i},$$

where the average characteristics of peers, $\mathbf{x}_{-i}$, are used as instruments for $\overline{y}_{-i}$. Here the dependent variable is whether or not the girl had sexual intercourse during Wave I. The peers are defined as students who are in the same grade in the same school. Regressions include school fixed effects. The table also reports the first stage F-test for the joint significance of the instruments and Sargan's overidentification test. The null hypothesis of weak instruments (the first stage F-test) is rejected. The instruments jointly pass the exogeneity requirement (the Sargan test). The size of peer-group effects in column II implies that a 1 percentage point increase in the share of girls who had premarital sex in the same grade as the respondent increases the probability of having premarital sex by 0.38 percentage points.

Table XI: Peer Group Effects and Shame, IV Estimates

	I (OLS)	II (IV)	III (OLS)	IV (IV)
Grade Average	-0.077	0.381**	-0.133	0.237
Shame			0.188***	0.186***
Parental Income	-0.0002	-0.0002	-0.0001	-0.0001
Romantic Relation	0.355***	0.354***	0.288***	0.287***
Grades	0.109***	0.115**	0.066***	0.072**
Physical Development	0.075***	0.079***	0.066***	0.071***
Control For Race	Yes	Yes	Yes	Yes
Control for Age	Yes	Yes	Yes	Yes
School Fixed Effects	Yes	Yes	Yes	Yes
First Stage F-test		303.60		279.76
		(p=0.000)		(p=0.000)
Sargan Overidentification Test		6.733		6.995
		(p=0.241)		(p=0.345)
Number of Obs.	2,718	2,718	2,345	2,345

13. Theory Appendix

13.1. Positive Assortative Matching

Recall that the expected lifetime utility in marriage accruing from consumption and other factors is a public good, enjoyed in equal fashion by husband and wife. Suppose that there is perfect assortative mating based on what each party will contribute to this expected lifetime utility, as measured by $\mathbf{L}(y,\widetilde{y},I)$. The lifetime utility realized for a type-(y_f,y_m,I) household will be

$$\mathbf{L}(y,\widetilde{y},I) \equiv \int M^*\left(y,\widetilde{y},I,y'\right) dY(y'|y), \tag{14}$$

where $M^*\left(y,\widetilde{y},I,y'\right)$ is defined by P(1). There will be $2n^2$ possible pairings for $\mathbf{L}$. Let F represent the joint distribution for females over (y_j,I). Then, the number of females of type (y_j,I) will be given by $\#(y_j,I)=F(y_j,I)-F(y_{j-1},I)$. Similarly, $\#(\widetilde{y}_k)$ denotes the number of type-$\widetilde{y}_k$ males.

To characterize the implied matching process simply make a list of lifetime utilities from pairings, starting from the top and going down to the bottom. The best females will be matched with best males. Now, suppose that there are more of these males than females. Then, some of the males will have to match with the next best females on the list. The matching process continues down this list in this fashion. At each stage the remaining best males are matched with the remaining best females. If there is an excess supply of one of the sexes, the overflow of this sex must find a match on the next line(s) of the list.

Now, suppose that the l-th position on the list is represented by a match of type $(y_j,\widetilde{y}_k,I)$. Some type-$\widetilde{y}_k$ males may have already been allocated to females that are higher on the list; i.e., to women that have a better combination of y and I. Let $R_m^l(\widetilde{y}_k)$ be the amount of remaining type-$\widetilde{y}_k$ males that can be allocated at the l-th position on the list. Similarly, let $R_f^l(y_j,I)$ be the number of available type-(y_j,I) females. The number of matches is given by $\min\{R_m^l(\widetilde{y}_k),R_f^l(y_j,I)\}$. Thus, the odds of a match are

$$\Pr(\widetilde{y}_k|y_j,I)=\min\{R_m^l(\widetilde{y}_k),R_f^l(y_j,I)\}/\#(y_j,I).$$

The matching process is then summarized by

$$
\begin{array}{llll}
\text{Ranking} & \text{Lifetime Utility} & \text{Odds} \\
1 & \mathbf{L}(y_n, \widetilde{y}_n, 0) & \Pr(\widetilde{y}_n | y_n, I=0) = 1 \\
\vdots & \vdots & \vdots \\
l & \mathbf{L}(y_j, \widetilde{y}_k, I) & \Pr(\widetilde{y}_k | y_j, I) = \frac{\min\{R^l_m(\widetilde{y}_k), R^l_f(y_j, I)\}}{\#(y_j, I)} \\
\vdots & \vdots & \vdots \\
2n^2 & \mathbf{L}(y_1, \widetilde{y}_1, 1) & \Pr(\widetilde{y}_1 | y_1, I=1) = 1,
\end{array}
\tag{15}
$$

where $R^{l+1}_m(\widetilde{y}_k) = R^l_m(\widetilde{y}_k) - \min\{R^l_m(\widetilde{y}_k), R^l_f(y_j, I)\}$, with $R^1_m(\widetilde{y}_k) = \#(\widetilde{y}_k)$, and $R^{l+1}_f(y_j, I) = R^l_f(y_j) - \min\{R^l_m(\widetilde{y}_k), R^l_f(y_j, I)\}$, with $R^1_f(y_j, I) = \#(y_j, I)$.

It is easy to see $Y^m(\widetilde{y}_m | y, I) = \Pr(\widetilde{y} \leq \widetilde{y}_m | y, I) = \sum_{j=1}^m \Pr(\widetilde{y} = \widetilde{y}_j | y, I)$. Now, the distribution function $Y^m(\widetilde{y}|y, 0)$ will stochastically dominate the one represented by $Y^m(\widetilde{y}|y, 1)$, because having an out-of-wedlock birth will not increase the chances of a female drawing a male with an income greater than some specified level.

Any degree of assortative matching in the economy can be obtained by assuming that some fraction μ of each type mates in the above fashion while the remaining fraction, $1-\mu$, matches randomly. With random matching $\Pr(\widetilde{y}|y, I) = \#(\widetilde{y})$, so that $Y^m(\widetilde{y}_m | y, I) = \sum_{j=1}^m \#(\widetilde{y}_j)$.

The matching process follows the Gale and Shapley (1962) algorithm–see Del Boca and Flinn (2006) for a recent marriage application. The cue for randomness in matching comes from Fernández and Rogerson (2001). Since all consumption for the couple is a public good, there are no opportunities for transfers between the husband and wife here. Also, there are no complementarities between the husband and wife's types in the production of household income. If these assumptions were relaxed, then a matching process along the lines of Becker (1981) could be used–see Chiappori, Iyigun and Weiss (2009) or Choo and Siow (2009) for recent work using this approach.

13.2. Proof (Balanced Growth)

Proof. It is easy to see that both $U(y', \widetilde{y}', 0) - U(y', \widetilde{y}', 1)$ and $D(y', 0) - D(y', 1)$ are not functions of χ'. Given this, the first result follows almost immediately from the first-order condition (6), as can be deduced from a guess-and-verify procedure. Suppose that $s, s', s'', \cdots$ are unaffected by χ'. Then, there is no impact on the matching probabilities, $Y^m(\widetilde{y}'|y', I')$'s, because a shift in χ' does not change the ranking or mass of each type of female. The difference in expected lifetime utilities, $A'(y', 0) - A'(y', 1)$, is not affected by χ'. This implies that $-\Sigma_1(s, \mathbf{e}, y')$ will remain constant from (3) and (7). Condition (6) will still hold. ■