Early Marriage and Female Schooling in Bangladesh[+]

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Abstract: This paper provides empirical evidence of the influence of adolescent marriage opportunities on female schooling attainment and gives predictions of the impact of imposing universal age-of-consent laws. Using data from rural Bangladesh, we explore the commonly cited hypotheses that women attain less schooling as a result of marrying young. We isolate the causal effect of marriage timing by exploiting variation in the timing of menarche as an instrumental variable for age of first marriage. Our results indicate that marriage age matters: Each additional year that marriage is delayed is associated with 0.30 additional years of schooling and 6.5% higher probability of literacy. Delayed marriage is also associated with a significant increase in use of preventive health care services, some of which appears to be independent of the change in schooling, indicating separate "age effects" of delaying marriage. In the context of competitive marriage markets we show that the above results can be used to obtain estimates of the change in equilibrium female education that would arise from introducing a minimum legal age of marriage. The resulting analysis implies that, under reasonable assumptions, enforcing universal age of consent laws would have a strong positive impact on female schooling.

JEL Classification: I32, I12, J12, J13, J16, O12
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1 Introduction

In much of the developing world, adolescent and child marriage continues to be a strong social norm, particularly for girls. Early female marriage is associated with a number of poor social and physical outcomes for young women and their offspring. On average, girls who marry as adolescents attain lower schooling, have lower social status in their husbands' families, report less reproductive control, and suffer higher rates of maternal mortality and domestic violence.[1] In addition, these individual outcomes suggest a number of larger social consequences of early marriage, including higher population growth, more rapid spread of disease, and a higher incidence of orphans.

As a result of these patterns, governments in developing countries face increasing pressure to eradicate the practice with legal sanctions against parents who marry daughters before a standard age of consent. Proponents of age of consent laws argue that forcing parents to delay marriage will increase female schooling attainment and reproductive control, and decrease incidence of domestic violence. On account of these arguments, social programs increasingly contain program rules designed to discourage the practice. For instance, a prominent micro-finance program in India excludes parents who marry daughters before 17, and national education vouchers in Bangladesh exclude married girls. However, while statistics indicate that women who marry young fare worse, it is difficult to assess the extent to which these outcomes are driven by the timing of marriage as opposed to common factors related to poverty and traditional gender views that also hinder female advancement. Given that child marriage is most common in impoverished and culturally traditional settings, the observation that women who married young have on average less education clearly does not imply that forcing girls to postpone wedlock would improve their outcomes.

This paper attempts to shed light on the issue by studying the schooling consequences of early marriage for girls in rural Bangladesh, an area with one of the highest rates of child marriage worldwide. Since it is also an environment of rapidly expanding schooling opportunities and returns to education for girls, adolescent marriage is frequently blamed for the persistent gender gap in schooling attainment. To estimate the influence of marriage practices on girls' schooling we employ a two-step methodology. In the first step we measure changes in schooling investment that result from a random subset of girls being forced to postpone

[1] Jensen and Thornton (2003) provide a recent overview of these patterns worldwide.

marriage. In particular, we make use of variation in the timing of menarche as an instrumental variable (IV) for age of first marriage. The idea behind this identification strategy is the following: While there are frequently incentives to marry daughters as young as possible, in Bangladesh as in many parts of the world girls are typically withheld from the marriage market until the onset of puberty. This institutional feature in the context of high rates of very early marriage presents a binding constraint on exposure to adolescent marriage opportunities. In particular, natural variation in the timing of first menstruation within the age range of 11 to 17 generates quasi-random differences in the earliest age at which girls are at risk of marrying.[2] Our estimates indicate that each additional year that menarche is delayed postpones marriage 0.69 years. This forced physical barrier to younger marriages, in so far as it is independent of schooling investment, presents a unique opportunity to assess the effects of child marriage on female education outcomes.

The validity of the IV strategy depends on potential unobservable differences in family background influencing both adolescent maturation and adult outcomes. Survey data on parents' wealth as well as adult height and health indicators reveal no significant differences in family background according to age of menarche within the age range to which we restrict our estimates. More importantly, this bias would work against our central findings. Hence, the results may underestimate parents' increase in schooling investment that arises from delayed marriage.

We also present evidence that reaching menarche indeed affects schooling through marriage decisions, rather than through a direct effect, by comparing the size of the effect of postponed puberty according to sibling birth order among women with at least one female sibling. Given traditionally strong preference for marrying daughters in birth order, we anticipate that the degree to which menarche influences marriage will be declining strongly in birth order, a prediction that is inconsistent with a scenario in which traditional families automatically remove daughters from school at puberty. Indeed, the estimated program effect is highly sensitive to birth order and nearly twice as large for eldest siblings.

In the second stage of the analysis we show how the previous empirical results can be used for macro-level policy analysis. The IV estimates correspond to how a change in a woman's individual constraint affects her schooling attainment. In contrast, an age of consent law imposes a universal constraint on marriage choices, which gives rise to potentially complicated

[2] See Palmert and Boepple (2001) for a discussion of distributions of age of menarche across populations.

equilibrium adjustment effects with ambiguous direction of influence. However, we show that in a competitive marriage market an intuitive condition on preferences implies that the equilibrium adjustment is very simple: those women who would marry younger than the minimum legal age in the absence of regulation marry exactly at the minimum legal age if the restriction is imposed, while the marriage age decisions of all other women are unaffected. The condition requires that women can be ordered with respect to their incremental utilities from marrying a year later and men can be ordered with respect to incremental (dis)utilities from marrying a bride who is a year older, a plausible assumption in the setting under study. We investigate possible motives underlying marriage timing preferences and interpret the above sorting condition in terms of these motives. The resulting equilibrium adjustment procedure implies that our empirical estimates can be used to predict the impact of age of consent laws since the effect of a universal constraint on a woman's marriage age is identical to her facing the same individual constraint.

The results we obtain indicate that female schooling is substantially constrained by marriage opportunities at young ages. One year postponement of marriage between the ages of 11 and 16 increases schooling by an estimated 0.30 years and adult literacy by 6.5%. Correspondingly, at the aggregate level we estimate that legally restricting marriages below age 17 would increase aggregate female schooling by 0.58 years, or 9%. The individual effect of postponement is substantially higher below age 16 than above, but at the aggregate level this is partially offset by the fact that for each additional year there are more individuals who are not biologically constrained: A universal constraint on marriages below 16 would increase average schooling by only 0.19 years. In addition to increasing education, later marriage is associated with significant improvements in utilization of prenatal care services. Since these gains are independent of schooling attainment, they indicate an important age effect of marrying late in addition to the potential impact of education on health behavior.

Our approach fills an important gap in the existing literature on marriage institutions in developing countries by generating possibly the first estimates of the causal effect of child marriage on female schooling and predicted impact of age of consent laws. While there is a small literature that investigates the correlates of marriage age, little research has examined the direct influence of early marriage, presumably due to the difficulty of finding exogenous variation in institutional rules. The methodology we introduce to predict equilibrium responses from reduced form estimates can potentially be used in other settings to assess the impact of imposing constraints on transactions in a competitive market.

2 Motivation

The gender gap in schooling attainment remains high in many parts of the developing world, even in settings in which the economic returns to schooling appear to be as large or larger for women than for men or the direct costs are lower (Schultz, 1987). For instance, in Bangladesh, only 56% of women between the ages of 25 and 30 in 1996 completed primary school (grade 5) relative to 77% of men in their cohort, and more than twice as many boys as girls enrolled in grade 10 (Bruce et al., 2001; Khandker and Samad, 1995). Particularly striking is the fact that even in recent years when the government of Bangladesh has provided a universal stipend for female secondary school that covers the bulk of the direct costs of education for girls but not boys, the attainment gap has persisted. Although girls and boys are now equally likely to *enroll* in secondary school, girls drop out by grade 11 (age 16) at five times the rate of boys![3]

In settings such as Bangladesh, traditional customs that sanction adolescent marriage are frequently blamed for low female schooling attainment because they raise the opportunity cost of educating girls. As summarized in the abovementioned report, "the pressure for early marriage remains a powerful force that shapes the alternatives girls have and constrains their access to secondary education" (Mahmud, 2003). However, while it is true that child marriage and low female schooling attainment go hand in hand since girls rarely continue school once they are married, this by itself reveals little about the degree to which parents' choices are constrained by marriage opportunities and hence the added schooling that girls would receive if the practice were abolished.

For a number of reasons, laws that encourage girls to postpone marriage may not improve their schooling outcomes or overall well-being. First, parents' motives for marrying daughters at young ages are often strongly related to economic circumstances of the family. In addition to removing the economic burden on their parents' household, younger brides typically attain higher status husbands with lower dowries. Hence, families who choose this path may be those that are unable to provide for their daughters or care least about their welfare. Higher education

[3] In particular, according to a recent project evaluation, female students constituted 48 percent in grades 6-10 but only 13 percent in grades 11-12 (Mahmud, 2003).

may further increase the price a girl has to pay for a spouse if social norms require that husbands have higher education levels than wives, giving further disincentive for parents to invest in daughters' schooling before marriage. In contrast, a girl's education is rarely valued in traditional marriage markets so would not directly improve her choice set. Second, delaying marriage might not increase girls' education because of lack of schooling opportunities, in which case forcing girls to marry later might cause them to be sent into the labor force to provide for their families and cover the increased cost of marriage.

In what follows we focus on the question how age of consent laws would affect female education, and restrain from interpreting the results in a formal welfare analysis. This is mainly because the data available to us do not provide sufficient information for such an analysis. First of all, in most cases of adolescent marriage, the relevant decision makers are parents or caretakers and we cannot assess the extent to which they internalize the interests of their children. For example, if parents are not fully altruistic and marriage is costlier for girls who marry later, then girls end up marrying inefficiently early. Even if parents try to incorporate their daughters' interests into marriage decisions, they might make systematic errors, for example underestimating the value of education.[4] Second, it is difficult to quantify the positive externalities of an increase in female education in Bangladesh. Third, if an age of consent law affects the level of dowries in the marriage market, then a welfare analysis would need to take into account the induced changes in household consumption.

3 Data and Methods

3.1 Setting

We examine the causal effect of adolescent marriage among a representative sample of women in Matlab, a relatively impoverished region of rural Bangladesh. The setting is appropriate given low levels of average schooling and marriage age. Nation-wide only about 70% of children in Bangladesh enroll in primary school, of which almost two-thirds drop out before completing the 5-6-year cycle. Bangladesh also has one of the lowest adult literacy rates in the world, averaging around 30% for adults over 40, and only 22% for women. In addition, early marriages are customary for female adolescents throughout rural Bangladesh, almost all of

[4] Older generations in Bangladesh are very poorly educated, which arguably increases their likelihood of this kind of error.

which are arranged by parents.[5] The International Centre for Research on Women's Demographic Health Survey 1996–2001 lists Bangladesh as the country with the second-highest rate of child marriage, with an estimated 75 per cent of girls married before they reach age 18 (ICRW 2003). In response to the problem, the government has attempted on several occasions to institute age of consent laws, none of which have had a discernable effect on marriage practices in rural areas.[6] While the country has witnessed a gradual increase in the average age of female marriage of approximately three years over the past quarter century, a significant fraction of girls continue to marry below the age of 16.[7]

An important feature of local marriage markets is the dowry system. Although dowries are currently illegal in Bangladesh, they are prevalent among Muslims and Hindu families alike. In the MHSS data, roughly two-thirds of recent brides (under age 30) report some amount of dowry given to their husbands' families at marriage. Dowry is typically under control of the woman's husband and in-laws, and it can be difficult for a woman to secure for her own use should the marriage terminate (Bates et al., 2004).

3.2 Data

Data for the analysis come from the 1996 Matlab Health and Socioeconomic Survey (MHSS). The primary survey consists of household- and individual-level information on 4,364 households clustered in 2,687 baris, or residential compounds, an approximate one-third random sample of the total number of baris in the surveillance area (Rahman et al., 1999). The primary sampling unit of the MHSS was the bari, a cluster of extended families that functions as the basic unit of economic activity, landholding, and social identity. In each bari a maximum of two households were selected for interview. Within households, all individuals over 55, the head, spouse and parents of the head, and a random sample of other members between 15 and 49 were interviewed.

The MHSS data are ideal for implementing our identification strategy. First, detailed economic and demographic data were collected at the individual, household and village levels. In particular, each ever married woman was asked to provide complete schooling, marital and

[5] In Matlab, only 1.6% of women under 44 report independently selecting their spouse (1996 MHSS data).
[6] Arends-Kuening and Amin (2000) report that the series of child marriage acts in Bangladesh, which gradually increased the legal age of marriage from 12 to 18, had almost no effect on the timing of marriage for rural households other than to encourage misreporting on marriage documents.
[7] An estimated 75 percent of rural girls in Bangladesh marry before the age of 16 (Barkat and Majid, 2003).

reproductive histories, including the timing of menarche, age at first marriage and outcome of all pregnancies. An important advantage of the data is the fact that survey reports of births and marriages could be cross-checked with vital statistics information including marriage and birth records from the regional Demographic Surveillance System (DSS), minimizing concern over recall bias and misreporting.[8] All sample members were also asked about current health status and survey-takers collected anthropometric measures including height and weight on site. Information on family background was collected in a survey module pertaining to sample members' parents, and currently married women were asked about details of their married life and health behaviors.

3.3 Sample construction

We limit our sample to the 4,028 ever married women between the ages of 25 and 75 who were selected for interview, excluding women in the Determinants of Natural Fertility Survey (DNFS) sub-sample. The left-hand cut-off point was chosen to minimize censoring of women who marry for the first time late in life while retaining the largest possible share of the sample. Of all MHSS women over the age of 24, 82% are currently married, 16% are widows, 1% is separated or divorced, and only 0.7% is unmarried. Among women aged 40-60, 99.5% of those who ever married did so for the first time before age 20. Since age of marriage has risen over the past few decades, 25 is arguably an appropriate maximum observed first age of marriage to maximize these objectives.

Summary statistics for the sample are presented in Table 1. Column 2 reports summary statistics for the sub-sample of women aged 25-43, who will be the focus of the empirical analysis. The data reflect the national patterns of low female marriage age, schooling and literacy, and high fertility. The median age of first marriage is 15, and the sample has extremely low levels of education and literacy. Among women aged 25-43, 41% cite marriage as the primary reason for quitting school. Roughly one third of the sample reports some form of subservience to their spouse or in-laws, as indicated by having money or possessions taken from them, exclusion from family decisions, and being prevented from leaving the house for work or family visits.

[8] Note that approximately 25% of sample members born outside of the region are absent from birth records and marriage records are missing for at least 5% who married prior to 1973.

As reported in columns 3 and 4, differences in schooling outcomes between women who marry early and late are consistent with the global trends: The literacy rate among women who married before age 16 is almost half that of women who marry later and schooling attainment is 1.6 years lower. The fact that father and mother's schooling and own school enrollment at age 9 are also significantly higher for women who marry later indicates important unobservable differences between these subsamples confounding OLS estimates of the relationship between marriage age and adult outcomes.

3.4 Estimation strategy

To assess the causal effect of early marriage on female schooling, we use age of menarche as an instrumental variable (IV) for marriage age. As demonstrated in numerous medical studies, the transition from childhood to reproductive age in normal, healthy adolescents occurs across a wide range of ages in any population (Scott et al., 1985; CEDG, 1998). In Bangladesh, where age at first marriage is traditionally bounded below by menarche, these differences generate exogenous variation in girls' risk of marrying young (Begum, 2003). Although informal pre-arrangements may be made when children are young, it is relatively rare to enter a girl into an official union before she has reached puberty.[9] Meanwhile, menarche generates a strong shift in parents' demand to marry daughters. As explained by Begum (2003), "In Bangladeshi society a teenage daughter reaching menstruation becomes a burden for many parents because preservation of her virginity is the greatest concern for a bride. As a result … parents like to get their daughters married as early as possible."

For the most part, the MHSS data reflect these patterns. Table 2 reports the mean ages at first marriage corresponding to each year of menarche in the sample, also illustrated in Figure 1. Over 70% of first marriages take place within 2 years of menarche. Less than 18% of women report pre-pubescent marriages, and the majority (68%) of these cases are those in which marriage precedes menarche by 1 year. As evident in Figure 1, after age 12 the timing of first marriage climbs steadily with the onset of puberty. Figures 2a and 2b show the distributions of age of marriage and menarche, revealing a significant symmetric shift in the timing of marriage with each tercile of menarcheal age.

[9] Bullough (1981) reports that "In Islamic countries it was criminal to have sexual relations with a woman before she had menstruated. Before a marriage … women were to examine the girl to see that she was physically prepared."

The IV approach involves estimating a two-stage model of the following form, where Y_i is the outcome of interest, A_i is individual i's age at marriage, and Z_i is i's age at menarche, the instrument used to identify the first-stage equation:

$$Y_i = \alpha_0 + \alpha_1 A_i + \alpha_2' X_i + \upsilon_i \quad [1]$$

$$A_i = \beta_0 + \beta_1 Z_i + \beta_2' X_i + \nu_i \quad [2]$$

In all of the estimates, X_i includes the following set of controls: adult height, family background and family composition characteristics, religion, and a dummy variable indicating whether the woman currently resides in a district of Matlab that is part of the treatment region for the national fertility intervention. Family background characteristics include: father and mother's education, whether father owned farmland or a family business, value of father's property, number of siblings, number of female siblings, whether mother and father survived to age 50, and whether the individual was enrolled in school at age nine. As detailed in Joshi (2003), economic circumstances of the family, including whether a girl's father was alive at marriage, are strong predictors of marriage market outcomes in the MHSS sample.[10] We also include five-year age intervals, and a linear time trend for age.[11] Robust standard errors are used in the analysis to correct for clustering at the bari level. The above set of equations in which Y_i is continuous implies a standard two-stage estimation procedure with continuous dependent and endogenous variables. For all binary outcomes, including literacy and school enrollment, the effect of marriage timing is estimated with the Amemiya Generalized Least Squares (AGLS) estimator for probits with endogenous regressors.[12]

Identification of the IV model requires a strong correlation between age of menarche and age of first marriage. As the pattern in Figure 1 illustrates, this requirement is well satisfied in the MHSS data. Results from the first stage regression with and without the full set of controls and village fixed effects are presented in Table 3. For the specification with full set of controls (columns 3 and7), every additional year that puberty is delayed, marriage is postponed an

[10] Dummy indicators of whether parents were alive at marriage produce similar results to mortality by age 50, but are arguably less exogenous to marriage timing.

[11] All estimates are also run with single year of birth fixed effects and dummy indicators of village of residence. The point estimates throughout are robust to this specification, although the Table 8 results lose statistical significance when both sets of fixed effects are included.

[12] Newey (1987, eq. 5.6) provides the formula used. The endogenous regressors are treated as linear functions of the instruments and the other exogenous variables (Keshk, 2003; Maddalla, 1983). In Stata, this is implemented using the *divprob* command.

estimated 0.64 years, with a standard error of 0.04 and an F-statistic of 47. Among the younger sub-sample, marriage is delayed by an estimated 0.69 years. Columns 2 and 6 allow for non-linearity in the effect of menarche on marriage by including dummy indicators of menarcheal age. Throughout the analysis, results are presented with the specification of column 7, but are universally robust to a non-linear first-stage and additional controls.

4 Estimation Issues

4.1 Endogenous instruments

In order to identify an IV model using age of menarche as an instrument for marriage timing, the exclusion restriction requires that the relationship between puberty and adult outcomes is fully mediated by changes in age at first marriage, such that delayed marriage is the only pathway through which physical maturation influences schooling. Biological research into the determinants of age of menarche reveals that genetic factors are by far the strongest predictors of adolescent development and that random genetic variation is a significant component of timing (Campbell et al., 1995). For instance, in one landmark study, Kaprio et al. (1995) compared the correlation in age of onset across 1,283 pairs of monozygotic and dizygotic twins and found that the correlation in age of onset among dizygotic twins was merely 0.21, while the correlation among monozygotic twins was nearly three times as large. These differences indicate a high degree of genetic determinism and hence a minimal role of environmental influences on maturation.[13]

While these patterns indicate a high degree of variation in timing of menarche that is unrelated to family background, there is nevertheless room for external influences on age of onset that may be particularly relevant in less developed countries. The following factors are known from laboratory experiments to have the potential to influence menarche: geography and climate (altitude and cold weather are thought to delay puberty; Nazian et al., 1976; Lehrer, 1986); strenuous physical activity or stress (ambiguous direction of influence, but in most cases causes delay; Pellerin-Massicotte et al., 1997; Bronson, 1997); exposure to endocrine-disrupting chemicals, including hormone-mimicking agents other

[13] The same study estimated that genetic factors explained 74% of variance in age at menarche, a finding that is consistent with many other estimates of heritability from human (Meyer et al., 1991; Gedda and Brenci, 1975; Fishbein; 1977; Sklad, 1977) and animal studies (Nelson et al., 1990).

toxic substances such as lead (direction of influence varies by compound; estrogen-mimicking compounds hasten onset while testosterone-mimicking compounds delay onset)[14]; sex composition of peer group (ambiguous direction; Vandenbergh, 1969; Vandenbergh et al., 1975; Mucignat-Caretta et al., 1995); and abrupt changes in diet resulting in acute malnutrition in utero or in childhood (delays onset).[15]

The first five factors are unlikely to confound our analysis. In the relatively small and uniformly rural district of Matlab, there is little variation in climate or altitude. Sex composition of peer group is arguably distributed across individuals independently of adult outcomes. While exposure to environmental pollutants such as lead and pesticides are strongly correlated with income in some settings, within Matlab chemical exposure is unlikely to confound the analysis, controlling for age. Similarly, while in many parts of the world hard labor is strongly associated with poverty, it is unlikely to vary within this population since very few adolescent girls engage in work outside of the residence.

In contrast, the potential correlation between menarche and nutrition is a concern in this sample: the rate of acute malnutrition in rural Bangladesh was 10.7% in 1999.[16] The extent to which this poses a problem for our analysis depends on whether differences in nutrition are large enough to exert an influence on endocrine systems. Though a vast number of non-experimental studies suggest that age of menarche is potentially sensitive to moderate changes in nutritional intake, results from human studies are inconclusive due to the difficultly of isolating influences on puberty in non-experimental settings. A review of this literature and its shortcomings is detailed in Appendix A. As a result, laboratory experiments arguably provide the most reliable evidence on sources of interference.

While experiments show that food restriction has the potential to trigger delays in onset of puberty, this body of research reveals two important caveats. First, there is ample evidence that the influence of nutrition on hormone-releasing agents that trigger menses is only experienced at extremely high levels of food restriction. Among the laboratory studies investigating the correlation between food restriction and pubertal development reviewed

[14] Whitten, 1993; Walters, 1993; Gellert, 1995; Kimmel et al, 1980; Komura et al, 1998; Der et al, 1974; Howdeshell et al, 1997; Stoker et al,2000; Laws et al, 2000; Clark et al, 2000; Gray et al, 1995; Golub et al, 2004; Whitney et al, 2001; Yamada et al,1989; Kramer et al, 1982; Cooper et al, 1997; Withuhn et al, 2003; Toppari et al, 1996; Andersson et al, 1999; Monosson et al , 1999; Gellert, 1978; McLachlan et al., 1977.

[15] All laboratory evidence involves abrupt changes in food intake as opposed to chronic deprivation, so it is ambiguous whether such a shock is necessary to throw the hormone system off balance.

[16] WHO Global Database (1999). See also Shahabudin et al. (2000).

as part of the Environmental Protection Agency's Endocrine Disrupter Screening Program (EDSP), only differences in food intake that reduced weight gain by more than 50% during developmental stages preceded and followed by abrupt return to normal levels of food intake resulted in delayed onset of puberty.[17] More importantly, there is also significant evidence that any change in nutrition that has consequences for the timing of menarche would reveal itself in growth stunting. While no studies contained in the EDSP review in which food intake was manipulated to reduce body weight gain by 10 to 34% had any effect on menarche, stunting occurred at considerably lower levels of food restriction. Extensive animal studies from the 1910s and 1920s (see Krogman 135-137) also show consistently that malnutrition has a far bigger effect on growth in size than on maturational progress. Hence, while it is difficult to extrapolate observed dose responses to human populations, even a conservative interpretation of laboratory results indicate that only malnutrition severe enough to cause stunting during childhood could cause a delay in menarche, consistent with a recent assessment of human populations (Stathopolu et al., 2003). This fact allows us to assess the degree of endogeneity with data on the height of women in our sample. Adult height is commonly linked to early health status and nutrition. Since height is largely driven by prepubescent growth, it is widely considered to capture the degree of stunting due to inadequate nutrition and health in childhood.[18]

Table 4 presents summary statistics broken down by menarche age terciles for a number of adult outcomes available in the MHSS including height. If the claim is correct that under-nutrition severe enough to delay menarche will necessarily reveal itself in extreme stunting, the data indicate no significant association between nutrition and age of menarche in the population of girls who reach puberty in the restricted age range. In a regression of adult height on age of menarche the coefficient estimate is very close to zero and insignificant, evident in the height data in column 3 of Table 2. Figure 3a shows the kernel density estimate of adult height by terciles of menarcheal age, revealing that the population distributions and not just averages are

[17] Engelbregt et al., 2002; Wilen et al., 1981; Dougherty et al., 1998; Friedman et al., 1990; I'Anson et al., 1991; Messer et al., 2000; Schneider et al., 1997; Vasallo et al., 1998; Wade et al., 1992; Aguilar et al., 1984; Merry et al., 1979; Ronnekleiv et al., 1978; Kennedy, 1963, 1957; Widdowson et al., 1960; Howenstein et al., 2000; Barash et al., 1996; Ahima et al., 1996, 1997; Plant et al., 1997; Cheung et al., 2001, 1997; Chehab et al., 1997; Mann et al., 2002.

[18] A number of studies suggest the height of a child by age four is a discriminating indicator of previous nutrition and childhood disease, and a reasonably accurate predictor of adult height (Fogel, 1990, 1991; Herrinton and Husson, 2001; Martorell and Habicht, 1986; Martorell, 1993).

remarkably similar across all subsamples.[19] This evidence is also consistent with the results of a recent detailed health study conducted in four rural villages of Bangladesh which found no statistically significant differences in the prevalence of major health conditions among menstruating and non-menstruating girls below age 16 (Chowdury et al., 2000).

Other family background characteristics reinforce the anthropometric evidence. None of the following measures appear to differ significantly by age of menarche: father's and mother's education, family wealth, and number of siblings (Tables 2 and 4). Nor is there an apparent difference in menarcheal age, controlling for height, by time trends in economic conditions. Figure 3b splits the sample into three age cohorts which reflect distinct periods of national economic growth and recession. Children born between 1921 and 1955 reached age 12 during a period of steady but slow economic growth, those born between 1956 and 1965 reached adolescence during a period of sharp economic decline leading to severe depression until 1976, and those born between 1966 and 1971 reached adolescence during a period of rapid growth. While there is a slight but steady shift over time in reported age of menarche, there is no relationship between per capita growth rates and menarche timing.

The comparison is further illustrated in Figure 4a, where cohort average marriage and menarcheal ages are plotted against a time trend in per capita GDP corresponding to the year in which girls in that cohort reached age 12. While economic trends fluctuate considerably over time, menarcheal age is extremely flat throughout the period and marriage age is steadily rising. Figure 4b includes a trend for annual average rainfall in the Matlab region during the year when a woman reaches age 12. While precipitation levels vary substantially from year to year and indicate at least one severe drought, none of the fluctuations appear to coincide with changes in menarcheal age.[20] Statistical tests confirm the absence of a significant correlation between puberty and economic conditions during childhood.

This set of evidence suggests that much of the variation in timing of first menstruation is uncorrelated with determinants of adult well-being other than marriage age, and that differences in family background according to age of menarche are unlikely to confound the analysis. Height

[19] If anything, adult height appears to be slightly skewed to the left for girls who mature early, consistent with studies from development biology that show that reaching puberty early is associated with shorter stature in adulthood with no corresponding effects on health.

[20] University of Delaware Air and Temperature Precipitation Data are available for the years 1950-1996. These data are provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, CO, and can be downloaded from following web site: http://www.cdc.noaa.gov/.

can also be included as a right-hand-side variable in the regression analysis in order to control for early nutritional status. Because adult height may not be a sufficient statistic for childhood nutrition, we also control for other available indicators of childhood SES, listed in Section 3.3.

Perhaps most importantly, the potential association between age at menarche and early childhood nutritional status is substantially less of a concern due to the fact that low socio-economic status (SES) is universally associated with lower educational attainment. Hence, omitted variables related to childhood SES would presumably bias downward our estimates of the casual effect of delayed marriage on education and literacy. In addition, because endogeneity is an issue of central concern to the analytical methods, we limit the age range of menarche to 11 to 17 years in order to reduce the likelihood that maturation is correlated with family background. This range covers 95% of women in the sample. Both very early and very late first menstruation is linked to chronic medical conditions, as well as extreme physical and emotional stress (Palmert and Boeppel, 2001).

4.2 Selective mortality

Another estimation issue in using retrospective information is selective mortality. If either early marriage or early menarche is associated with higher mortality in adulthood, the estimates could be biased. For the bulk of the analysis we restrict the sample to women under the age of 44, which substantially reduces the degree of selection. Data from the region indicates that selective mortality is unlikely to present a problem. According to MHSS data on respondents' mothers, 82% of mothers born between 1935 and 1945 are alive in 1996. Although the statistic is not perfectly analogous to probability of dying between 15 and 43 since mothers are on average older than 15, life expectancy should be significantly higher for women in younger cohorts and at younger ages.

4.3 Recall bias

Another concern with the data is potential measurement error due to recall bias or systematic misreporting in the variables collected retrospectively. As mentioned earlier, the ability to double check birth and marriage data with DSS records eliminates much of the concern over measurement error in these data.[21] In contrast, age of menarche is not possible to cross-check with outside sources as no records are kept of this event by government or health practitioners. Given this, one fear is that imperfect recall may lead respondents to approximate menarche with marriage such that the correlation is spuriously strengthened.

We do not expect measurement error to present a significant problem in these data for two reasons. First, recalled age of menarche has been shown to be highly reliable in numerous studies. According to a survey by Ellis (2003), "both adolescent girls and adult women are generally willing and able to report accurately on their ages at menarche … and retrospective reports may be more reliable than those obtained during puberty (reviewed in Graber, Petersen, & Brooks-Gunn, 1996; see also Dorn, Nottelmann, et al., 1999)."[22] Although women in Matlab are in many ways uncharacteristic of average respondents, special care was taken by MHSS survey-takers to collect accurate reproductive histories, including probing respondents with memory triggers and monitoring responses with a range of consistency checks (Rahman et al., 2000). Furthermore, since the DSS has operated for over 30 years in Matlab, residents are relatively accustomed to calculating and reporting ages associated with lifecycle events. Hence, it is reasonable to expect respondents to report menarche with equal accuracy.

Second, due to the social importance of this event in rural society, marked by many important and dramatic lifestyle changes, it is reasonable to expect that women remember the timing with even greater precision than women in developed countries. For example, as soon as a Muslim girl in Bangladesh reaches menstruation she is instructed to pray five times a day, to keep fast, to wear special clothes such as long shirts and trousers, and to cover her head and breast with a veil (Begum, 2003). According to a recent qualitative study of adolescents in Matlab, 100% of girls associate menarche with changes in dress, and 67% associate menarche with increased housework (Bosch, 2001). Additional research reports that the majority of girls are unaware of menstruation before it begins and as a result frequently terrified and traumatized by the event (Nahar et al., 1999). The religious beliefs associated with these practices in addition to observable physical changes that occur with puberty also decrease the possibility that families

[21] Because a considerable fraction of women were either born outside of Matlab or are too old to have complete demographic records, we conduct separate analyses of older cohorts and in-migrants.
[22] As the article elaborates, "Test–retest reliability has been established in several long-term prospective studies in which self-reported age at menarche was first obtained in adolescence and then again 17 to 37 years later. Correlations across these two measurement periods have been consistently high, ranging from .67 to .79 (Casey et al., 1991; Damon et al., 1969; Livson & McNeill, 1962; Must et al., 2002)."

are willing and able to disguise menarche in an effort to reduce potential stigma associated with postponing wedlock. Furthermore, there is no anecdotal evidence that stigma of marrying late falls as puberty rises. If anything, families have strong economic incentive to reveal a daughter's eligibility for marriage as soon as it is socially acceptable to do so.

Finally, there is no empirical evidence of significant recall bias. For instance, many types of imperfect recall would show up in changes in the distribution of menarcheal age over time, yet the data reveal no significant heteroskedasticity with respect to menarche reports and respondents' age.[23] A more comprehensive diagnostic check involves comparing the distributions of menarche age between women with educated and uneducated mothers, reported in Figures 5a and 5b.[24] In particular, we separate mothers according to whether they were sent to school before age 10, which is presumably unrelated to maturation. Here, the idea is to isolate a group of families who have a pre-existing preference for later marriage unrelated to their daughter's maturation. Since menarche is exogenous to this preference, a significant difference in reported age-of-onset across these types would suggest either recall bias or strategic misreporting. Instead, as revealed in Figure 5a, while the first group has a significantly higher first marriage age and the distribution of marriage age is strongly shifted to the right, Figure 5b reveals no significant difference between the distributions of age-of-onset across the sub-samples.

4.4 Intergenerational effects

The genetic component of age of menarche may imply that women with later onset of puberty have the additional advantage of having mothers that also experienced later marriage. In this sense, the benefits of late marriage may be transmitted through intergenerational linkages other than biology. If later marriage leads to higher schooling attainment, families in which this biological trait is prevalent across generations may be those with persistently higher investment in girls.

[23] However, it is important to note that potential population changes over time in the timing of menarche limit the ability to perform standard diagnostic checks of additive measurement error with age. For instance, it is ambiguous whether the fact that average age of menarche rises slightly over time reflects a real biological phenomenon or a relationship between recall bias and age.

[24] In particular, we separate mothers according to whether they were sent to school before the age of 10, which is presumably unrelated to maturation.

While the data will not allow us to directly measure intergenerational correlations between age of menarche and marriage timing, we predict the influence of this indirect channel to be relatively minor for a number of reasons.[25] First, marriage timing has little potential influence on the schooling outcomes of older cohorts of women, for whom schooling opportunities were extremely scarce. Second, Tables 2 and 4 reveal that observable measures of family background are balanced by menarche age group. Finally, regression controls for available characteristics such as family size minimize the potential influence of second-order effects on the empirical estimates.

5 Results

5.1 Schooling and literacy

To gauge the impact of marriage timing on schooling attainment, we measure the impact of delayed marriage on the age at which women who have enrolled in school quit school and their corresponding literacy rates. Literacy is defined broadly from respondents' reports of reading and writing ability on a scale of one to three. Respondents that reported either one or two on both measures were considered literate for the purpose of the analysis. For obvious reasons, we focus the analysis on girls for whom the marriage constraint is potentially binding by restricting the sample to those who were enrolled in school at age 9. Although earliest menarche is 11, we choose 9 as the cut-off point for school attendance since signs of menarche may appear as early as two years before onset. In addition, we restrict the sample to women between the ages of 26 and 44 since women over 43 in 1996 were unlikely to have any opportunity to attend secondary school. Due to extremely limited educational opportunities for girls in rural Bengal prior to 1962, less than a third of MHSS women over 43 were enrolled in school at age 9 and only 3.64% attended secondary school, implying that very few women remained in school long enough for matriculation to be effected by physical maturation.[26]

[25] An unfortunate disadvantage of these data is that the sample of ever-married women contains very few sibling or mother-daughter pairs due to the fact that, in rural areas of the country, married couples generally live in the husband's parents' household during the husband's fathers' lifetime.

[26] According to MHSS school survey data, 75% of the schools in the region were established after 1960. In 1960, there were only 4 secondary schools in Matlab, only one of which accepted girls. We choose the cut-off age for schooling opportunities to be consistent with the cut-off age in the regression analysis: when the first schools built during expansion opened in 1962, women born in 1953 would have been 9 years old, so we identify this cohort as the first group of women for whom secondary school was a real possibility.

Results from the IV estimates for schooling and literacy are reported in Table 5 alongside corresponding OLS estimates. Columns 1 through 4 report years of schooling and literacy for women who entered school as children. The results indicate that postponing marriage by one year between ages 11 and 16 increases educational attainment by an average of 0.30 years. Correspondingly, an additional year of delay increases adult literacy by 6.5%. These estimates suggest that universal marriage postponement would generate substantial increases in educational attainment and literacy, certeris peribus. For instance, expanding this estimate by the number of postponed marriage years necessary to increase the average marriage age from 15 to the legal minimum of 18 implies a 17.3% increase in average female schooling and an almost identical change in female literacy.

Columns 5 and 6 of Table 5 show results from a control experiment in which marriage age instrumented with menarcheal age is regressed on school enrollment at 9. Assuming parents cannot predict timing of puberty from girls' observable characteristics at 9, the positive and significant coefficient on marriage age in column 5 indicates the presence of unobservable determinants of both schooling and marriage age that bias OLS estimates upwards. Meanwhile, the IV estimate is close to zero and insignificant, suggesting that the instrument is not contaminated by the same unobservable correlates. Despite the upward bias, OLS estimates that control for observable characteristics are smaller than IV estimates. The difference likely reflects the difference between population average effects and local average treatment effects (LATE) obtained from IV. That is, the effects of delayed marriage are stronger than average among girls for whom menarche presents a binding constraint.[27]

5.2 Direct effect of menarche on schooling

Menarche itself may be the barrier to schooling, in which case increasing legal age at marriage would not have the estimated effect on education. This violation of the IV exclusion restriction could arise if traditional rules governing female mobility prevented girls from attending school after first menstruation. As opposed to the case of marriage, the MHSS data reveal that puberty is not a universal constraint on school attendance: 75% of girls that are enrolled in school a year before menarche remain in school for at least two years and their average length of time in school post-menarche is 2.5 years. Still, it could be the case that all of

[27] See Angrist and Imbens (1994) and Card (2001) for a discussion of LATE estimation.

the estimated schooling effect is attributable to a relaxation of the puberty constraint facing up to 25% of girls from traditional families.

To test whether menarche has a direct effect on schooling we examine variation in the magnitude of estimates across women facing different observable constraints on marriage timing based on sex-specific birth order, a characteristic that is exogenous to age of puberty. On account of the traditional preference for marrying daughters according to birth order, women with older female siblings should have less opportunity to respond to early maturation since they face additional constraints imposed by sibling marital status. Hence, if education is influenced by marriage opportunities rather than puberty itself, schooling responses to puberty should be larger on average among first-born girls and decline steadily with sex-specific birth order. In contrast, if the effect of puberty delay is driven solely by traditional attitudes towards school attendance, the effects should be independent of birth order. To test this, we restrict the sample to women with at least one female sibling (90% of the sample) and regress schooling attainment on age of menarche and age of menarche interacted with number of older female siblings and sex-specific birth order.[28] Because number of female siblings may be correlated with other family characteristics, all regressions control for total female and male siblings.

Results from both specifications are presented in Table 6. The estimates indicate that the schooling attainment of younger daughters is significantly less sensitive to age of menarche than that of older daughters. Since elder and younger daughters are evenly distributed across traditional and non-traditional families conditional on sibship size, this indicates *within*-family differences in the effect of menarche on schooling which must therefore be independent of parents' preference to keep girls out of school when they hit puberty. A courser way of studying these relationships is to divide the sample according to sex-specific birth order and run the baseline regressions separately for eldest and younger daughters. Doing so reveals that, conditional on enrollment at age 10, age of quitting school is sensitive to menarche *only* for eldest daughters. Unless traditional attitudes systematically apply only to eldest girls, this finding provides strong evidence that puberty does not *directly* cause girls to quit school. It is hard to imagine that any social norm grounded in religious beliefs would vary systematically according to birth order.

[28] Sex-specific birth order is defined as the number of older female siblings divided by total number of female siblings.

This finding is consistent with two additional pieces of evidence. First, in a recent qualitative study of adolescents' views about menarche in Matlab, 86 post-menarcheal adolescent girls were asked to list any lifestyle changes associated with menarche (Bosch, 2001). Although a wide range and number of changes were reported, school attendance was not mentioned. In contrast, 67% report that they started helping with daily housework. Second, MHSS respondents were asked the primary reason they quit school, and none cite puberty or menarche.

5.3 Secondary outcomes

5.3.1 Health care behavior

Both an increase in education and an increase in marriage age may have secondary effects on female outcomes. To explore this, we analyze MHSS data on health care practices during pregnancy, including the rate at which a woman seeks pre-natal care when she is pregnant, the average number of pre-natal visits, and whether she has ever received an anti-tetanus shot (ATS) while pregnant.[29] Although there is evidence from past research that many health behaviors are positively influenced by schooling, the effect of early marriage on preventive care may operate through channels other than education. In particular, girls who begin their reproductive cycle at younger ages may be more isolated or less empowered and as a result less likely to seek appropriate health care during pregnancy and childbirth. To make this conceptual distinction clear, we refer to behavioral changes related to marriage age but not education as "age effects."

To empirically disentangle the effects of education from determinants of health care practices related to marriage age, we make use of the fact that the education effects of marriage timing are only experienced by the subpopulation of girls who were enrolled in primary school. In this manner, marriage age and schooling attainment can be separately identified by comparing sub-samples of women that were and were not enrolled in school at age 9. Only if the influence of marriage age is restricted to the former group could education gains be entirely responsible for behavior change. If the unschooled are also better off, age effects must play a role. Table 7

[29] Variables constructed from averaging responses across all pregnancies from following survey questions asked about each of a woman's pregnancies: (1) "During pregnancy […] did you ever have a pregnancy check-up?" (2) "How many antenatal visits did you have during [ ] pregnancy?" (3) "When you were pregnant with [ ] were you given an injection in the arm to prevent the baby from getting tetanus, that is, convulsions after birth?"

presents results from the IV analysis on both sub-samples. In all estimates, age of marriage is instrumented by age of menarche and age of menarche interacted with the binary indicator for residing in a treatment area for contraceptive services. Since reproductive health care services were a central focus of this intervention, health behaviors - and the influence of marriage age on health behaviors - should depend heavily on treatment assignment.

These estimates suggest that health care practices improve substantially with later marriage. Interestingly, the estimates reveal significant improvements in prenatal care not only among the educated but also among the subpopulation for whom schooling is unaffected by marriage age, indicating that the increases in health care utilization do not operate exclusively through changes in schooling. A year of marriage delay is associated with an 11.4% increase in the likelihood of prenatal care during pregnancy for women who attended school and a 6.7% increase for woman who did not attend school. There is also an associated increase on the intensive margin: A year of marriage delay is associated with a 6.8% increase in the average number of anti-natal visits for women who attended school and an 11% increase for woman who did not attend school, and the effect is only significant for the latter. With respect to receiving ATS during pregnancy, there is no detectable influence of marriage age among girls who did not attend primary school. Not surprisingly, this suggests that the increase is experienced by those women on the extensive margin who are encouraged to get prenatal care, consistent with a scenario in which most women who go for prenatal care also receive ATS.

The results indicate that, whereas educated women are encouraged to take up prenatal services as a result of marrying late, uneducated women are influenced by later marriage only in terms of switching from one to several clinic visits. One interpretation of this pattern is that secondary school improves women's awareness of available health services, thereby increasing the likelihood that they will seek out any care. Meanwhile, marriage age alone increases the likelihood that a woman will have the freedom to take advantage of services known to her, for instance, by responding to health workers' suggestions for more frequent check-ups. For instance, uneducated women who marry later may have greater freedom to leave the home for or spend money on health care services. Consistent with this story, results from a regression of an indicator of personal freedom on marriage age indicates that unschooled women who marry later face fewer restrictions by husbands and in-laws with respect to consumption and mobility (columns 7 and 8). The dependent variable in these regressions is constructed from the following

MHSS survey questions: whether respondent reports that husband or in-laws have ever prevented her from leaving the bari for work or family visits, or have taken away her money or possessions. Separate analysis on each of the four components reveals that the largest change comes from reducing the likelihood that women are prevented from leaving the bari for work. Since marriage age is not associated with a reduction in household restrictions among educated girls, there is no evidence that it operates through schooling. More likely, the effect is related to convergence in age between spouses that accompanies later marriage.

5.3.2 Spousal quality

The last stage of analysis examines trade-offs parents face in making decisions about marriage timing by looking at data on dowry payments at marriage and observable characteristics of spouses. The finding that marriage opportunities curtail schooling investment suggests that the benefits to girls of delaying marriage come at a cost to their families, presumably in terms of higher dowry payments or less desirable spousal characteristics. Anecdotally, in rural Bangladesh dowries increase with each additional year that marriage is postponed because of the demand for youthful brides.[30] Meanwhile, past findings from India confirm a strong positive association between dowry payments and suitability of the husband, measured in terms of his relative superiority in education and family socio-economic status (Halli, 2003).

To explore how parents respond to these trade-offs, we estimate the dowry cost of later marriages using the same IV strategy from the previous section. In these regressions, we instrument marriage age separately for Hindu and Muslim brides with age of menarche and age of menarche interacted with religion, due to the fact that dowry has different historic traditions across religions. We similarly explore how characteristics of spouses in terms of education level, age, and family wealth are related to marriage timing. If parents indeed spend more on daughters who marry later, we can assess based on the distribution of husbands' observable characteristics whether the additional expenditure on later marriages is sufficient to buy their daughters

[30] Cited reasons for this preference include the beliefs that younger brides are (a) more fertile, (b) more likely to lack sexual experience, and (c) easier for husbands and in-laws to control. Foster and Kahn (2000) argue that the increase in female age at marriage and corresponding reduction in average age differences between spouses as an equilibrating mechanism for demographic changes in the supply of spouses reflects a decrease in the demand for youth in the marriage market.

positions in families of comparable quality to those of younger brides.

These estimates are presented in Table 8. Indeed, examination of the MHSS data reveals that the increased schooling accompanying late marriage comes at a substantial cost to the family. An IV estimate of the dowry cost of later marriages, presented in column 1, indicates that the wealth a girl brings into marriage increases by an average of 10% with each additional year. Meanwhile, columns 2-4 reveal no corresponding improvements in the characteristics of spouses in terms of education level, age, or family wealth. This combination of marriage market outcomes indicates that the average additional dowry cost of late marriage is a good approximation of the decrease in female marriage market value that accompanies age in rural Bangladesh. The fact that late-bloomers are no worse off in terms of observable spousal quality potentially suggests a preference among parents for allocating marriage payments across daughters to equate their marital outcomes.

6. Equilibrium analysis

The previous empirical estimates address how a woman's educational choice changes if her individual constraint, age of menarche, changes. This corresponds to asking how chosen level of education changes when varying an individual's constraint *within the same equilibrium*. Hence, it is not immediately obvious what this estimate can tell us about the overall impact of imposing a universal constraint, which leads to a new equilibrium. In general, the resulting effects on marriage age choices and therefore education choices are ambiguous. Women who marry younger than the legal age in the absence of regulation might marry strictly above the legal age if an age law is imposed, and women who marry later than the minimum age in the absence of regulation might end up marrying younger. The reason that a complicated equilibrium adjustment like that can arise is that the order of women with respect to incremental utilities from marrying a year older, and the order of men with respect to incremental disutilities from marrying a bride who is a year older can be different at different ages. This would happen for example if there were men who relative to other men cared a lot about marrying a 13-year-old as opposed to a 14-year-old bride, but if they are only allowed to marry brides who are at least 15 years old they do not care much whether the bride is 15 or older. In this case, if a minimum age of 15 is imposed, men who in the absence of regulation married younger than average brides would now marry older than average brides. Since this changes the marriage market balance, relative dowry levels will change and as a consequence the marriage age choice of any other man and woman can change in any direction.

To investigate the equilibrium effects of introducing an age of consent law, we analyze a formal model of marriage markets in Bangladesh. We consider a competitive market in which dowries serve as market-clearing prices and they depend on bride's age. We show that if both women and men are well ordered with respect to incremental utilities from delaying marriage by a year then the equilibrium adjustment is very simple: women who marry younger than the minimum marriage age marry exactly at the new minimum age, while all other women's marriage time is unchanged (and the relative level of dowries above the new minimum age is unchanged as well). We interpret this condition for various possible motives (fertility, spousal control, educational attainment) that could drive marriage timing preferences.

The simple equilibrium adjustment procedure makes it possible to use age of menarche as an instrument to assess the effect of age of consent laws. This is because in this case the effect of a universal constraint has the same effect on every individual as imposing an individual constraint such as puberty. We use this result to predict the impact of introducing different minimum legal marriage ages.

6.1 The model

We consider a marriage market with a set of women $W = \{w_1, ..., w_{n_w}\}$ and men $M = \{m_1, ..., m_{n_m}\}$. The model is static in that all individuals enter the marriage market at the same time, however Appendix B shows that the same model can be derived from a dynamic model in which different cohorts enter the market each year.[31] Therefore the static model can be viewed as a simplification that provides a shortcut for the analysis. In the model, women choose levels of schooling and age of marriage, and men choose the age of their brides. Both men and women have the option not to marry. For simplicity, men's schooling decisions are assumed to be independent of marriage market outcomes and therefore excluded from the analysis. Similarly, we assume that women do not care about the age of their spouses and do not explicitly

[31] More precisely in the appendix it is shown that the stationary equilibria of the dynamic model exactly correspond to the competitive equilibria of the static model analyzed in this section.

model men's decisions concerning what age to marry.[32] Note that although we talk about decisions of women and men in the marriage market, what we have in mind are the preferences and choices of the relevant decision makers such as parents.

Women can marry at ages $t_{\min}, t_{\min}+1, ..., t_{\max}$. Let x_i denote the marriage age decision of $w_i \in W$ and let y_i denote the decision of $m_i \in M$ on the age of his bride. For notational simplicity define x_i (similarly y_i) to be $t_{\max}+1$ in the case that the individual decides not to marry. Women are constrained in their marriage age decision by age of puberty: $x_i \geq p_i$ where p_i is the age when $w_i \in W$ reaches puberty. With respect to schooling choices, let e_i denote the years of education above $t_{\min}$ woman w_i chooses. An important assumption in the model is that women's education levels are constrained by marriage. In particular if woman w_i decides to marry at age t then $e_i \leq t - t_{\min}$. This assumption corresponds to both empirical observation and anecdotal evidence that married women are almost never sent to attend school by in-laws or spouses.[33]

We assume that the market is competitive, and that the market-clearing prices are dowries women pay to grooms at marriage that depend only on bride's age. Let $d(t)$ denote the amount of dowry a woman has to pay if decides to marry at age t. A woman who does not get married does not have to pay any dowry: $d(t_{\max}+1)=0$. Individuals' preferences are assumed to be quasilinear in the amount of dowry paid or received.

The utility of woman w_i from marriage net of transfers is $u_i(x_i, e_i)$. Given that we assume that dowry depends on x_i but not e_i, we can simplify the utility function of women by substituting in the optimal level of education compatible with any given possible marriage time. Let $U_i(x) = \max_{0 \leq e \leq x - t_{\min}} u_i(x, e)$ for $x \in (t_{\min}, ..., t_{\max})$ and $U_i(t_{\max}+1) = \max_{0 \leq e} u_i(t_{\max}+1, e)$ (women who do not marry do not face any constraint on education). We assume that U_i is concave but put no restriction on whether it is increasing or decreasing. The utility of man m_i from marriage

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[32] The dynamic model in Appendix B, from which the static model presented here can be derived, does incorporate these decisions of men.

[33] One practical reason for this is that, in rural Bangladesh, marriage usually entails migration to the husband's village which places increased restrictions on girls' mobility and ability to continue in the same secondary school.

net of transfers is $V_i(y_i)$.[34] We assume that V_i is decreasing and concave, which implies that dowries have to be increasing in bride's age in order to clear the market.[35]

6.2 Competitive equilibria with and without minimum legal age of marriage

We define competitive equilibrium in the marriage market the standard way.

Definition: A competitive equilibrium of the marriage market consists of a vector of dowries $\hat{d}(t_{\min}),...,\hat{d}(t_{\max})$ and marriage age decisions $\hat{x}_1,...,\hat{x}_{n_m},\hat{y}_1,...,\hat{y}_{n_w}$ such that $\hat{x}_i \geq p_i \;\; \forall \;\; w_i \in W$ and the following conditions hold:

(i) Given the vector of dowries all men make an optimal choice and all women make a constrained optimal choice given that they can only marry after reaching puberty:

$$U_i(\hat{x}_i) - \hat{d}(\hat{x}_i) \geq U_i(x_i) - \hat{d}(x) \quad \forall \quad p_i \leq x \leq t_{\max} + 1 \text{ and } w_i \in W$$

$$V_i(\hat{y}_i) + \hat{d}(\hat{y}_i) \geq V_i(x) + \hat{d}(x) \quad \forall \quad t_{\min} \leq x \leq t_{\max} + 1 \text{ and } m_i \in M$$

(ii) The market clears for every possible marriage age:

$$\#\{w_i \in W : \hat{x}_i = x\} = \#\{m_i \in M : \hat{y}_i = x\} \quad \forall \quad t_{\min} \leq x \leq t_{\max}$$

We also consider markets in which there is a minimum legal marriage age $\bar{t}$ such that $t_{\min} < \bar{t} \leq t_{\max}$. In this case dowries are only specified for marriage ages $\bar{t},\ldots,t_{\max}$. A competitive equilibrium of the constrained market is defined analogously to the unconstrained market case.

As stated previously, it is in general difficult to relate equilibrium marriage age choices in the unconstrained market to a market with an age minimum. Appendix C features a simple example in which some women marry earlier when a minimum marriage age is introduced. In what follows we impose a restriction on preferences in order to generate sharper predictions about how marriage decisions respond to the imposition of a minimum age constraint. In

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[34] In particular the utility of a man who decides not to get married is $V_i(t_{\max} + 1)$.

[35] Note that the model assumes that all women and men are of equal quality, in particular any man is indifferent between marrying two brides of the same age. This assumption is made to keep the model simple. Our conclusions would remain the same if parallel marriage markets existed for different quality women and men. The latter is suggested by the finding in 5.3.2 that spousal quality of a woman does not change with marriage age, only the dowry she has to pay increases.

particular, we assume that both women and men can be unambiguously ordered with respect to their incremental utilities from delaying marriage by one year. We also make an assumption that rules out nongeneric cases in which there exist a woman and man for whom increasing the bride's age at marriage by one year gives them exactly the opposite incremental utilities. The latter assumption is needed to guarantee uniqueness of equilibrium, which facilitates the comparison of unrestricted and restricted markets.

A1: For any $w_i, w_{i'} \in W \quad (i \neq i')$ it holds that if $U_i(x) - U_i(x+1) \geq U_{i'}(x) - U_{i'}(x+1)$ for some $t_{\min} \leq x \leq t_{\max}$ then $U_i(x') - U_i(x'+1) > U_{i'}(x') - U_{i'}(x'+1) \;\; \forall \;\; t_{\min} \leq x' \leq t_{\max} - 1$.

A2: For any $m_i, m_{i'} \in M \quad (i \neq i')$ it holds that if $V_i(x) - V_i(x+1) \geq V_{i'}(x) - V_{i'}(x+1)$ for some $t_{\min} \leq x \leq t_{\max}$ then $V_i(x') - V_i(x'+1) > V_{i'}(x') - V_{i'}(x'+1) \;\; \forall \;\; t_{\min} \leq x' \leq t_{\max}$.

A3: For every $x \in \{t_{\min}, ..., t_{\max}\}$ it holds that there are no $w_i \in W$ and $m_j \in M$ such that $U_i(x) - U_i(x+1) = -(V_i(x) - V_i(x+1))$

The meaning and validity of the above assumptions depend on the reasons behind preferences over female marriage age. Consider first that the main motivation for preferring younger brides is to increase fertility by expanding the reproductive interval.[36] Then A2 is equivalent to assuming that, if for a man the incremental utility of the *k*th child is higher than for another man, then the same relationship holds between incremental utilities of the *l*th child as well, for any *k*,*l* >0. A1 can be similarly interpreted in terms of women's incremental utilities/disutilities from having an additional child. It is important to note that the relevant range for *k* and *l* is the ages between the theoretically maximal attainable fertility levels at the minimum and maximum marriage age, so the stability of the ordering need only pertain to fertility preferences after a relatively large number of existing children.[37]

Consider next that degree of spousal control rather than fertility drives preferences over bride's age. Then A2 is equivalent to assuming that if an increase in spousal control gives higher utility to a man than to another one at some level of control, then the same relationship holds at

[36] There is mixed evidence that this is true scientifically, but anecdotal evidence that it is widely believed.
[37] For instance, the theoretical maximum fertility for a birth interval starting at age 12 is around 32, while the theoretical maximum at age 17 is 28.

every level (A1 again has a symmetric interpretation concerning women's marginal disutility from being controlled).

Finally, consider that women are mainly concerned abut age of marriage because of schooling. Then A1 is equivalent to assuming that the order of women concerning incremental utilities from additional years of schooling (conditional on the fact that all previous years of schooling were obtained) does not depend on which school year is considered. One characteristic of the setting that makes this assumption more appealing is that degree completion is uncommon within the age period under study. Since secondary school starts around age 12 and ends around age 18, the additional years of schooling we examine are additional years of high school for the majority of our sample.[38]

Note that A1 implies that the utility functions U_i and $U_{i'}$ can cross at most once, with U_i crossing $U_{i'}$ from below. Since A2 imposes a similar condition on utility functions of men, the assumptions we make imply single-crossing.

Theorem 1: Assume A1-A3 hold. Then there exists a unique vector of marriage time choices $\hat{x}_1,...,\hat{x}_{n_m},\hat{y}_1,...,\hat{y}_{n_w}$ that can be part of a competitive equilibrium. Similarly, for every minimal legal marriage age $\bar{t} \in \{t_{\min}+1,...,t_{\max}\}$ there exists a unique vector of marriage choices $\hat{x}^{\bar{t}}{}_1,...,\hat{x}^{\bar{t}}{}_{n_m},\hat{y}^{\bar{t}}{}_1,...,\hat{y}^{\bar{t}}{}_{n_w}$ that can be part of a competitive equilibrium of the corresponding constrained market.

Proof: See Appendix D.

The sketch of the proof is the following: A1 is shown to imply that if in some equilibrium a woman's marginal disutility for marrying a year earlier is smaller (larger) than the marginal reduction of the dowry at some age, then the same applies to all higher (lower) ages. A similar claim holds for men. This is used to prove that equilibrium matching is assortative in a weak sense.[39] The man who has rank *k* in the order of men with respect to incremental utilities of increasing bride age marries at the same time as the woman who has rank *k* in the order of

[38] We do not have the relevant information on private schools.

[39] Although the models are very different from ours, there are similar results to the above finding in the literature on search and matching. For example Shimer and Smith (2000) and Legros and Newman (2002) impose supermodularity assumptions, which resemble our assumptions A1 and A2, to obtain positive assortative matching.

women with respect to incremental utility of marriage age among women who reach puberty no later than the marriage age decision of the above man.[40] From this it is shown that a woman and a man who marry at the same time in one equilibrium also marry at the same time in every equilibrium. Then A3 can be used to establish uniqueness of marriage time choices.

Now we establish the main theorem of the section, namely that the introduction of a minimum age changes equilibrium decisions of women and men in a simple manner if the above assumptions hold. In particular, those individuals who would have married earlier than the minimum legal age in the unconstrained market get married exactly at the minimum legal age in the constrained market, while the rest of the women and men get married at the same time as they would have in the unconstrained market.

Theorem 2: Assume A1-A3 hold. Let the unique vector of marriage choices in competitive equilibrium be $\hat{x}_1,...,\hat{x}_{n_m},\hat{y}_1,...,\hat{y}_{n_w}$. Then for any minimal binding age $\bar{t} \in \{t_{\min}+1,...,t_{\max}\}$ the unique vector of marriage choices $\hat{x}^{\bar{t}}{}_1,...,\hat{x}^{\bar{t}}{}_{n_m},\hat{y}^{\bar{t}}{}_1,...,\hat{y}^{\bar{t}}{}_{n_w}$ in competitive equilibrium of the constrained market with minimum legal age $\bar{t}$ satisfies $\hat{x}_i^{\bar{t}} = \bar{t}$ if $\hat{x}_i < \bar{t}$ and $\hat{x}_i^{\bar{t}} = \hat{x}_i$ if $\hat{x}_i \geq \bar{t} \quad \forall \quad w_i \in W$. Similarly, $\hat{y}_i^{\bar{t}} = \bar{t}$ if $\hat{y}_i < \bar{t}$ and $\hat{y}_i^{\bar{t}} = \hat{y}_i$ if $\hat{y}_i \geq \bar{t} \quad \forall \quad m_i \in W$.

Proof: See Appendix D.

The proof shows that there is an equilibrium dowry vector of the unconstrained market such that its restriction to the new legal possible marriage ages constitutes an equilibrium of the market with minimum marriage age $\bar{t}$ with the marriage age choices specified in Theorem 2. This implies the claim in Theorem 2 since marriage age decisions are unique in equilibrium by Theorem 1.

One implication of our model is that equilibrium dowry levels remain essentially unchanged above the new minimum legal age. This is related to the assumption implied by A1 that the same order applies to incremental utilities between getting married at age $t_{\max}$ versus not getting married (recall that a marriage age $t_{\max}+1$ stands for not getting married) than the order

[40] They do not have to marry each other. The marriage markets we consider are impersonal, men are perfect substitutes and so are two women who marry at the same time.

of incremental utilities concerning getting married a year earlier or later. Simply put, our assumptions imply that women who are more willing to marry early are also more desperate to marry. There are potential reasons why this might not be true. However, with additional technical assumptions, A1 can be relaxed such that it only applies to ages $\{t_{\min}+1,...,t_{\max}\}$, without invalidating the main results of this section. In particular the conclusions on how marriage time decisions are affected by an age of consent law remain the same. The main difference is that the age of consent law, instead of leaving dowry levels unchanged, generally decreases them. In particular, incremental dowries above $\bar{t}$ remain essentially the same as before imposing the legal minimum age, but the dowry at age $\bar{t}$ typically decreases.[41] This would presumably further increase the level of education of daughters chosen by their families. Therefore maintaining the stronger form of A1, which implies that age of marriage laws leave dowry levels unchanged, biases downward our estimate of the effect of age of consent laws.

6.3 The effect of a minimum legal age of marriage on women's education

In our model, the level of female education is influenced by marriage markets through the constraint that women have to leave school when they marry. Theorem 2 then implies the following: First, introducing a minimum legal marriage age of $\bar{t}$ does not have any effect on women (with respect to their schooling choice) who reach puberty at age $\bar{t}$ or later. Second, if $p_i < \bar{t}$ then the introduction a minimum legal marriage age of $\bar{t}$ has the same effect on the education of woman w_i as postponing her menarche from p_i to $\bar{t}$. The introduction of a minimum marriage age imposes exactly the same lower bound on a woman's marriage age as if menarche was delayed, and since dowries above the minimum age essentially do not change after imposing a legal minimum age, optimal choices adjust the same way in the above two scenarios. Then if age of menarche is distributed among women independently of their preferences, a reduced form estimate of the influence of delay in age of menarche on educational attainment can be used to provide an estimate of the average change in female education that arises from introducing distinct minimal legal ages of marriage. In particular, the effect on average female education of introducing minimal marriage age $\bar{t} > t_{\min}$ is:

[41] Contact the authors for the formal details.

$$\Delta \overline{E}_{\bar{t}} = \sum_{t=t_{\min}}^{\bar{t}-1} g(t) D_{t,\bar{t}}, \qquad [6.1]$$

where g is the distribution function of menarche and $D_{t,\bar{t}}$ is the average effect of postponing the age of menarche from t to $\bar{t}$ on years of schooling. This result enables us to provide a structural estimate of the impact of age of consent laws. In particular, the $D_{i,j}$ terms can be recovered from an OLS regression of schooling attainment on age of menarche, in which each menarcheal age is entered separately as a binary variable in the regression. Then [6.1] can be calculated for each possible $t_{\min} < \bar{t}$ using information from the MHSS sample on the distribution of age of onset.

For the policy predictions we restrict the sample to women between the ages of 25 and 35 in order to best match future cohorts in terms of supply of secondary schools and attitudes towards girls' education. We also restrict the estimates to women who were enrolled in school at age 8, under the presumption that future cohorts will have near universal enrollment at early ages. According to these estimates, presented in Table 9, imposing a minimum marriage age of 14 would increase the average education of girls in Matlab by an average of only 0.07 years, while a legal minimum of 16 would increase average schooling by 0.376 years, holding the local supply of schools constant. The marginal effect of an age minimum is increasing through age 16, then falls thereafter.

To understand the determinants of this marginal effect, it is useful to rewrite [6.1] the following way:

$$\Delta \overline{E}_{\bar{t}} = \sum_{t=t_{\min}}^{\bar{t}-1} \left(\sum_{k=t_{\min}}^{t-1} g(k) \right) D_{t,t+1}, \qquad [6.2]$$

This formula reveals that the aggregate effect of increasing the minimum age depends on two factors: the number of women for whom it introduces a new constraint, and the extent to which it affects the schooling choices of these women. As we saw in Section 5, $D_{t,t+1}$, the incremental effect of an additional unmarried year for those who are affected by this change (the "treated" in the IV estimate) is substantial until age 16 and then significantly lower. However, this is partially offset by the fact that the number of women affected by the change, $\sum_{k=t_{\min}}^{t-1} g(k)$, is monotonically increasing. The higher the minimum legal age, the larger is the number of women who reach puberty by that age. In particular a substantial proportion of women reach puberty at age 16, increasing the marginal effect of setting the minimum legal age to17 as opposed to 16.

Nevertheless, the marginal effect of increasing the legal age is decreasing after age 16. According to our estimates, minimum age laws of 16 would generate two-thirds of the schooling effects of minimum age laws of 17. This result has potentially important policy implications given the current predominance of high minimum marriage ages that appear to be too costly to enforce. A minimum marriage age of 16 would likely be far easier to enforce than the current targets and still achieve most of the benefits in terms of female education.

6.4 Robustness of the model predictions

The model presented above can be extended in several directions without invalidating our main results. It is straightforward to establish that all of our qualitative conclusions remain unchanged if, in addition to bride's age of marriage, marriage preferences of both women and men depend on various exogeneous characteristics of potential spouses (i.e. if there are different types of women and men in the market). It is also possible to extend the analysis to the case in which marriage market value depends on the bride's education, either because men directly care about spouse's education or because social convention dictates that men cannot marry women who are more educated than themselves. If utility functions are additively separable with respect to bride's age and education, and assumptions A1-A3 are extended such that women and men are ordered the same way with respect to incremental utilities from bride's age as with respect to bride education (i.e. the men who are more eager to marry younger women are also more eager to marry less educated women, and the women who are more willing to marry younger are also less eager to obtain more education), results similar to Theorems 1 and 2 hold. In particular, the equilibrium adjustment with respect to marriage time is the same as in the model presented. The adjustment of female education is more complicated because the type of man a given woman marries might change from the unconstrained to a constrained equilibrium. However, it can be shown that the latter adjustment still positively affects overall female education since matching becomes more assortative (an age of consent law makes women more symmetric with respect to age of marriage constraints). This means that, in this context, our IV estimates serve as lower bounds for assessing the impact of age of consent laws on female education. If men cannot marry women who are less educated, then imposing an age law also increases male education through the increase in female schooling.[42]

7 Conclusions

This paper provides empirical evidence that the institution of adolescent marriage in developing countries reduces female education. When individual girls in rural Bangladesh are forced by biology to delay marriage, they attain significantly more schooling and are more likely to be literate. Under plausible assumptions about the local marriage market these results indicate a 5-8% improvement in average female schooling from enforcing age of consent laws from ages 15-17.

The approach we introduce to estimate equilibrium adjustment effects from partial equilibrium results can potentially be used in other competitive market settings to assess the impact of imposing lower bounds on transactions. One can for example examine the effect of imposing minimum quality standards for a particular product of heterogeneous quality. Our methodology would identify the conditions under which exogeneous individual-level variation in the marginal cost of product quality can be used to assess the impact of a universal quality regulation.

[42] Please contact the authors for the details of these extensions.

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Appendix A: Review of Human Evidence on the Relationship between Nutrition and Menarche

The relationship between nutritional intake and onset of menarche is the source of significant debate in the fields of biology, anthropology and demography, and has generated an enormous body of literature. Observed correlations between poverty and maturation are frequently presumed to reflect differences in nutrition, leading several researchers to argue strongly that body weight triggers menarche (Frisch et al., 1974, 1978, 1980). This association is observed (though not consistently) both within and across populations, including evidence of cross-country correlation in mean age of menarche and GDP (Weil, 2004) and time trends in mean age of onset related to GDP growth (Bongaarts, 1980).

However, evidence from human studies is far from conclusive, and statistical flaws have been noted in much of this work (Trussell, 1980; Scout, 1985; Bullough, 1981; Johnston, 1975; Coleman, 2002; Parent, 2003). With respect to time trends, there is large debate over the quality and consistency of historical data. Much of the perception that age of menarche is falling appears to originate in a landmark study that reported changes in mean age over the last century as large as four years (Tanner, 1976), and was later revealed to be highly inaccurate. Reassessment of this work indicates only moderate changes over time, if any (Bullough, 1981). Given that observed trends are small, it is important to acknowledge potential selection issues with respect to the source of much historical data that could generate observed reductions in age of menarche over time. It is also important to consider carefully the role of other potential factors that may be correlated with SES, particularly given the absence of evidence showing distributional changes that are consistent with scientific theories of endocrine interference via food restriction. In particular, laboratory evidence indicates a sharply discontinuous relationship between energy intake and maturation, such that the endocrine system does not respond to moderate fluctuations in energy levels, but shuts down temporarily at near-starvation. Hence, population changes that shift the mean but not the variance of menarcheal age are unlikely to reflect changes in nutrition.

To evaluate the evidence, we conducted a survey of biomedical studies available from the archives of the National Library of Medicine, which produced 59 studies of the relationship between SES and menarche in developing countries. A frequent problem in this literature is that adolescents are sampled in school, which is likely to bias the analysis towards finding a result since low-income girls with early puberty are more likely to exit school, particularly in settings with high rates of adolescent marriage. In traditional settings, girls may be discouraged from attending school during menses, and attitudes could vary with SES. Montero et al. (1999) report menstruation as the most common reason for school absence in Morocco. Among the 59 studies that we found, 30 were sampled from junior high or high schools.[43] This methodology also calls into question observed time trends in age of onset,

[43] Qamra et al., 1990; Montero et al.,1999;Sharma,1990;Hesketh et al.,2002; Rao et al.,1989;Artaria et al.,2002;Chompootaweep et al.,1997;Shakir,1971;Linhares et al.,1986;Pasquet et al.,1999;Attalah et al.,1983; Badrinath et al.,2004; Abioye-Kuteyi,1997;Ayatollahi et al.,2002;Padez et al.,2003;Tavares et al.,2002;Dare et al.,1992;Roberts et al.,1977; Chavarro et al.,2004;Loukid et al.,1996;Alleyne et al.,1980;Wright,1990;Piya-Anant et al.,1997; Samsudin,1990; Musaiger,1991; Mancebo et al.,1990; Huen.,1997; Fakeye,1985;Mahachoklertwattana,2002;Jauratanasirikul, 1995.

which could reflect increasing marriage age and schooling in certain settings. A second problem with the literature is that a large fraction of studies base conclusions about the causal role of nutrition on correlations between adolescent anthropometric measures and onset of puberty. Among the 29 studies not sampled in schools (and five that were), 11 found evidence *only* of associations between onset of menarche and BMI or height.[44] However, since the process of puberty is itself associated with significant physical changes related to developmental processes, it is inevitable that anthropometric measures will have strong predictive power. Large growth spurts occur during adolescence in both males and females, frequently accompanied by an increase in appetite. Yet an alarming number of studies take as evidence of the causal role of nutrition the fact that girls who have reached menarche are taller and heavier than pre-pubescent girls. Equally problematic are longitudinal analyses that relate *changes* in body weight to maturation. Changes in BMI cannot be linked causally to onset of menarche since this too is associated with puberty. Similarly, some studies link energy intake causally to the timing of menarche, but it is ambiguous whether this reflects physiological changes in appetite associated with puberty. Even associations between adult height and maturation would provide only questionable evidence of a causal relationship since age of onset can lead to differences in physical trajectories (Hulanika, 2001; Ibanez et al., 2000).

Among the remaining 18 papers reviewed, ten found no differences in maturation according to SES even in the presence of large variation in nutritional intake and income.[45] This included the only randomized trial, in which nutritional supplements were distributed to a sample of children in Guatemala and menarche and skeletal maturation tracked over ten years (Pickett et al., 1995), the results of which "suggest that the effect of improved nutrition in childhood on maturation in adolescence is weak to absent." These inconsistencies indicate that environmental influences on puberty may be responsible for or required to mediate the relationship between income and puberty. Seven of the remaining eight papers reviewed faced strong sample selection problems related to rural-urban migration and sampling methods (acknowledged by the authors), such that comparison groups are invalid. In particular, Garnier et al. (2003, 2001) study a population in which adolescent girls have a high rate of rural migration (and even report that "A number of girls were absent since they work in the capital city"). Faird-Coupal et al. (1981) sampled unmarried girls ages 9-20 still living at home. Kurdzielewicz et al. (2001) sampled rural and urban patients from a pediatric gynecology clinic in the city, and Galler et al. (1985), Satyanarayana and Naidu (1979), and Khan et al. (1995, 1996) all had non-random sample attrition rates above 30%. All of these methods are likely to disproportionately exclude low-income girls with lower age of onset due to the relationship between migration and maturation, marriage age and maturation, and the cost of seeking medical attention.

In the only study associating income with timing of puberty that did not face these problems, results also revealed strong differences according to SES in exposure to environmental contaminants and hard labor, such that the positive coefficient on income may simply reflect unmeasured differences in environment or labor rather than nutrition (Graham et al., 1999). Laboratory evidence on both physical exertion and hormone

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[44] Bharati et al., 1998; WHO, 19986; Fakeye, 1985; Chowdury et al., 1977, 2000; Beunen et al., 1994; Groos et al., 1992; Du et al., 2003; Chie et al., 1997; Osteria, 1983; Piya-Anant et al., 1997; Fakeye, 1985; Samsudin, 1990; Musaiger, 1991; Ayatollahi et al., 2002; Simondon et al., 1997.

[45] Sengupta et al., 1996; Benefice et al., 2001; Ersoy et al., 2004; Lindgren, 1976; Koziel and Jankowska, 2002; Adair, 2001; Haq, 1984; Nilses et al., 1997; Pickett et al., 1995; Radojevic, 1983.

exposure is far more robust than the evidence on nutrition (see Ellis, 2004, for a review of the evidence).

If spatial patterns are not driven primarily by variance in caloric intake, what are possible explanations? One hypothesis for both cross-sectional variation and time trends in age of menarche is exposure to endocrine disrupters, including phytoestrogen, PCBs, methoxychlor, lead and hydrocarbons in pollutants, which have a strong influence on maturation in laboratory studies. These could also explain the relatively consistent urban-rural difference that appears to be independent of income (CEGD, article 10.5; Gonzales et al., 1996; Kurdzielewicz, 2001). Another factor that is thought to play a role is the level of strenuous labor, for which there is also considerable laboratory evidence. Finally, it is also possible that immigration is responsible for some of the observed time trends due to geographic patterns of genetic variance.[46] The frequently cited hypothesis that the decline in age of menarche is driven by the rise in adolescent BMI is not well supported by empirical analyses (Mann et al., 2002).

[46] However, one recent longitudinal analysis found no relationship between the two patterns in the US (Demerath et al., 2004).

Appendix B: A Dynamic Extension of the Model in Section 6

In this appendix we construct a dynamic model with overlapping generations of women and men in the marriage market and show how stationary equilibria of this model correspond to the equilibria of the model presented in Section 6. The point of this excercise is to show that the static model is a valid shortcut for the analysis despite the fact that in the model different people get married at different ages.

Consider a marriage market over time which is such that in each period $t \in \{\ldots,-2,-1,0,1,2,\ldots\}$ a new generation of women $W^t = \{w_1^t,\ldots,w_{n_w}^t\}$ and men $M^t = \{w_1^t,\ldots,w_{n_m}^t\}$ reach minimum potential age of marriage $t_{\min}$.

All women and men in every generation can get married at ages $t_{\min},\ldots,t_{\max}$ or decide not to get married (denote this choice by $t_{\max}+1$). Assume that women cannot get married before reaching puberty. Let p_i^t denote the age $w_i^t \in W_i^t$ reaches puberty. Assume that women do not care about the age of their spouses at the time of marriage, only about their own age at marriage. The utility of $w_i^t \in W_i^t$ from marriage is $U_i^t(x)$ where x is her age at marriage. The utility of $m_i^t \in M_i^t$ from marriage is $V_i^t(o,y)$ where o is his age at marriage and y is his bride's age at marriage. Let x_i^t denote the marriage age choice of $w_i^t \in W_i^t$ and let (o_i^t,y_i^t) denote the marriage age choice and bride age choice of $m_i^t \in M_i^t$.

Women have to pay dowries to men at marriage and the dowry depends on calendar time and the woman's age at marriage. Let $d^t(x)$ denote the dowry a woman who gets married at time t has to pay if her age is x at that time.

Assume that all generations are identical. In particular $U_i^t(\cdot) = U_i(\cdot)$, $m_i^t = m^t \;\; \forall \; i = 1,\ldots,n_w$ and $V_i^t(\cdot,\cdot) = V_i(\cdot,\cdot) \;\; \forall \; i = 1,\ldots,n_m$.

Definition: a stationary competitive equilibrium of the dynamic model is a sequence of marriage age choices x_i^t, (o_i^t,y_i^t) and dowry vectors $d^t(\cdot)$ for $t \in \{\ldots,-2,-1,0,1,2,\ldots\}$ such that $x_i^t \geq p_i \;\; \forall \; i,t$ and the following conditions hold:

(i') All women and men make optimal decisions given the sequence of dowry vectors:

$$U_i^t(\hat{x}_i^t) - \hat{d}^{t+\hat{x}_i^t-t_{\min}}(\hat{x}_i^t) \geq U_i^t(x) - \hat{d}^{t+x-t_{\min}}(x) \quad \forall \quad p_i \leq x \leq t_{\max}+1 \quad \text{and} \quad w_i^t \in W^t$$

$$V_i^t(\hat{o}_i^t,\hat{y}_i^t) + \hat{d}^{t+\hat{y}_i^t-t_{\min}}(\hat{y}_i^t) \geq V_i^t(o,x) + \hat{d}^{t+x-t_{\min}}(x) \;\; \forall \;\; t_{\min} \leq x \leq t_{\max}+1, \quad o \in (t_{\min},\ldots,t_{\max}\}$$

and $m_i^t \in M^t$

(ii') The market clears for every possible calendar time and marriage age:

$$\#\{w_i^{t-x} \in W^{t-x} : \hat{x}_i^{t-x} = x\} = \sum_{t' \in \{\ldots,-2,-1,0,1,2,\ldots\}} \#\{m_i^{t'} \in M^{t'} : t' + \hat{o}_i^{t'} - t_{\min} = t \text{ and } \hat{y}_i^{t'} = x\} \;\; \forall$$

$t_{\min} \leq x \leq t_{\max}$ and $t \in \{\ldots,-2,-1,0,1,2,\ldots\}$

(iii') Stationarity:

$x_i^t = x_i$, $o_i^t = o_i$, $y_i^t = y_i$ $\forall$ $t \in \{\ldots,-2,-1,0,1,2,\ldots\}$, and $d^t(x) = d(x)$ $\forall$ $x \in \{t_{\min},\ldots,t_{\max}\}$ and $t \in \{\ldots,-2,-1,0,1,2,\ldots\}$.

Stationarity implies that for every calendar year t and every $i \in \{1,\ldots,n_w\}$ there exists exactly one t' such that $w_i^{t'}$ gets married at t. Similarly, for every calendar year t and every $i \in \{1,\ldots,n_m\}$ there exists exactly one t'' such that $m_i^{t''}$ gets married at t. The set of women and men who get married at any given year is analogous to the set of women and men who reach the minimum possible age of marriage.

The following claims establish connections between stationary equilibria of the dynamic model introduced here and equilibria of the static model introduced in Section 6. If men's utility functions are additively separable in own age and bride's age at marriage, then there is an exact correspondence between stationary equilibria of the dynamic model and equilibria of a naturally defined static model. The proofs of these claims are straightforward and available by request from the authors.

Claim 1: Consider a dynamic model with utility functions $(U_i)_{i=1,..,n_w},(V_i)_{i=1,..,n_m}$ and let $\widehat{x}_1,\ldots,\widehat{x}_{n_w},\widehat{o}_1,\ldots,\widehat{o}_{n_m},\widehat{y}_1,\ldots,\widehat{y},\ \widehat{d}()$ constitute a stationary competitive equilibrium in this model. Then $\widehat{x}_1,\ldots,\widehat{x}_{n_w},\widehat{y}_1,\ldots,\widehat{y},\ \widehat{d}()$ constitute a competitive equilibrium in the static model with utility functions $(U_i')_{i=1,..,n_w}$, $(V_i')_{i=1,..,n_m}$ such that:

$U_i'(x) = U_i(x)\ \forall\ i = 1,\ldots,n_w$ and $x \in \{t_{\min},\ldots,t_{\max+1}\}$

$V_i'(x) = V_i(\widehat{o}_i,x)\ \forall\ x \in \{t_{\min},\ldots,t_{\max+1}\}$.

Claim 2: Consider a dynamic model with utility functions $(U_i)_{i=1,..,n_w},(V_i)_{i=1,..,n_m}$ where $V_i(o,y) = V_i^1(o) + V_i^2(y)$. Consider the static model with utility functions $(U_i')_{i=1,..,n_w},(V_i')_{i=1,..,n_m}$ such that:

$U_i'(x) = U_i(x)\ \forall\ i = 1,\ldots,n_w$ and $x \in \{t_{\min},\ldots,t_{\max+1}\}$

$V_i'(x) = V_i^2(x)\ \forall\ x \in \{t_{\min},\ldots,t_{\max+1}\}$.

If $\widehat{x}_1,\ldots,\widehat{x}_{n_w},\widehat{y}_1,\ldots,\widehat{y}_{n_m},\ \widehat{d}()$ constitute a competitive equilibrium in the static model then there exist $\widehat{o}_1,\ldots,\widehat{o}_{n_m}$ such that $\widehat{x}_1,\ldots,\widehat{x}_{n_w},\widehat{o}_1,\ldots,\widehat{o}_{n_m},\widehat{y}_1,\ldots,\widehat{y},\ \widehat{d}()$ constitute a stationary competitive equilibrium of the dynamic model.

Appendix C: An example showing that an age of consent law can induce nonmonotonic changes in marriage time decisions

The following stylized example demonstrates that without restrictions on preferences it is not true that introducing a minimum legal marriage age unambiguously induces all people to get married (weakly) later than they would in the absence of regulation.

Suppose there are only two women and two men, three possible marriage ages and that both women reach puberty at $t_{\min}$. Assume that each additional year in the bride's age decreases man 1's utility by 50, and decreases man 2's utility by only 10. Furthermore, assume that woman 1 is indifferent between marrying at $t_{\min}$ or $t_{\min}+1$, but marrying at $t_{\min}+1$ as opposed to $t_{\min}+2=t_{\max}$ gives her a disutility of 30. For woman 2, each additional year of marriage age gives a utility of 20. Formally, let $U_1(t_{\min})=U_1(t_{\min}+1)=20$, $U_1(t_{\min}+2)=50$, $U_2(t_{\min})=20$, $U_2(t_{\min}+1)=40$, $U_2(t_{\min}+2)=60$ and $U_1(t_{\min}+3)=U_2(t_{\min}+3)=0$. And let $V_1(t_{\min})=150$, $V_1(t_{\min}+1)=100$, $V_1(t_{\min}+2)=50$, $V_2(t_{\min})=30$, $V_1(t_{\min}+1)=20$, $V_1(t_{\min}+2)=10$ and $V_1(t_{\min}+3)=V_2(t_{\min}+3)=0$. It is straightforward to verify that in any competitive equilibrium in the absence of minimum legal marriage age, woman 1 marries man 1 at age $t_{\min}$, while woman 2 marries man 2 at age $t_{\max}$. Consider now the introduction of a minimum marriage age of $t_{\min}+1$. In any competitive equilibrium of this constrained market it is woman 2 who marries man 1 at age $t_{\min}+1$, and woman 1 marries man 2 at age $t_{\max}$. Therefore the introduction of minimum marriage age induces woman 1 to marry two years later, but induces woman 2 to marry a year earlier.

Appendix D: Proofs

Lemma 1: Assume A1 and A2 hold. If $\widehat{d}(t_{\min})$,..., $\widehat{d}(t_{\max})$, $\widehat{x}_1,\ldots,\widehat{x}_{n_w}$, $\widehat{y}_1,\ldots,\widehat{y}_{n_m}$ is a competitive equilibrium then for every $x,x' \in \{t_{\min}$,..., $t_{\max}+1\}$ such that $x' > x$ the following properties hold:

$\#\{w_i \in W : \widehat{x}_i = x'\} \neq 0$ implies $U_i(x') - U_i(x) \leq \widehat{d}(x') - \widehat{d}(x) \quad \forall \quad w_i \in W$ st $\widehat{x}_i \leq x$,

$\#\{m_i \in M : \widehat{y}_i = x'\} \neq 0$ implies $V_i(x) - V_i(x') \geq \widehat{d}(x') - \widehat{d}(x) \quad \forall \quad m_i \in M$ st $\widehat{y}_i \leq x$,

$\#\{w_i \in W : \widehat{x}_i = x\} \neq 0$ implies $U_i(x') - U_i(x) \geq \widehat{d}(x') - \widehat{d}(x) \quad \forall \quad w_i \in W$ st $\widehat{x}_i \geq x'$ and $p_i \leq x'$,

$\#\{m_i \in M : \widehat{y}_i = x\} \neq 0$ implies $V_i(x) - V_i(x') \leq \widehat{d}(x') - \widehat{d}(x) \quad \forall \quad m_i \in M$ st $\widehat{y}_i \geq x'$.

Proof : Suppose the claim does not hold. Consider first the case that $\exists$ $m_i \in M$ and $x,x' \in \{t_{\min}$,..., $t_{\max}+1\}$ such that $\widehat{y}_i \leq x$, $x < x'$, $\#\{m_j \in M : \widehat{y}_j = x\} \neq 0$ and $V_i(x) - V_i(x') < \widehat{d}(x') - \widehat{d}(x)$. If $\widehat{y}_i = x$, then the previous inequality directly implies that $\widehat{y}_i$ cannot be an optimal choice for m_i , a contradiction. Suppose now that $\widehat{y}_i < x$. Since $\#\{m_j \in M : \widehat{y}_j = x\} \neq 0$, $\exists$ $m_{i'} \in M$ such that $\widehat{y}_{i'} = x$. Since $\widehat{y}_{i'} = x$ and $\widehat{y}_i < x$, it has to be that $V_{i'}(\widehat{y}_i) - V_{i'}(x) \leq V_i(\widehat{y}_i) - V_i(x)$. Then A1 implies that $V_{i'}(x) - V_{i'}(x') \leq V_i(x) - V_i(x')$, which further implies that $V_{i'}(x) - V_{i'}(x') < \widehat{d}(x') - \widehat{d}(x)$, contradicting that $\widehat{y}_{i'} = x$ is an optimal choice for $m_{i'}$. Consider next the case that $\exists$ $m_i \in M$ and $x,x' \in \{t_{\min}$,..., $t_{\max}+1\}$ such that $\widehat{y}_i \geq x'$, $x < x'$, $\#\{m_j \in M : \widehat{y}_j = x'\} \neq 0$ and $V_i(x) - V_i(x') > \widehat{d}(x') - \widehat{d}(x)$. If $\widehat{y}_i = x'$, then the previous inequality directly implies that $\widehat{y}_i$ cannot be an optimal choice for m_i , a contradiction. Suppose now that $\widehat{y}_i > x'$. Since $\#\{m_j \in M : \widehat{y}_j = x'\} \neq 0$, $\exists$ $m_{i'} \in M$ such that $\widehat{y}_{i'} = x'$. Since $\widehat{y}_{i'} = x'$ and $\widehat{y}_i > x'$, it has to be that $V_{i'}(x') - V_{i'}(\widehat{y}_i) \geq V_i(x') - V_i(\widehat{y}_i)$. Then A1 implies that $V_{i'}(x) - V_{i'}(x') \geq V_i(x) - V_i(x')$, which further implies that $V_{i'}(x) - V_{i'}(x') > \widehat{d}(x') - \widehat{d}(x)$, contradicting that $\widehat{y}_{i'} = x'$ is an optimal choice for i'. Proving that the corresponding claims for women is analogous to the above, using assumption A1. QED

Lemma 2: Assume A1 and A2 hold and there is a minimum legal age of marriage $\bar{t} \in \{t_{\min}+1,\ldots,t_{\max}-1\}$. If $\widehat{d}(\bar{t})$,..., $\widehat{d}(t_{\max})$, $\widehat{x}_1,\ldots,\widehat{x}_{n_w}$, $\widehat{y}_1,\ldots,\widehat{y}_{n_m}$ is a competitive equilibrium then for every $x,x' \in \{\bar{t}$,..., $t_{\max}\}$ such that $x' > x$ and $\#\{w_i \in W : \widehat{x}_i = x'\} \neq 0$ the following hold:

$U_i(x) - U_i(x') \leq \widehat{d}(x') - \widehat{d}(x) \quad \forall \quad w_i \in W$ st $\widehat{x}_i \leq x$

$V_i(x') - V_i(x) \geq \widehat{d}(x') - \widehat{d}(x) \quad \forall \quad m_i \in M$ st $\widehat{y}_i \leq x$

Furthermore, for every $x, x' \in \{\bar{x}$,..., $t_{\max}\}$ such that $x' > x$ and $\#\{j \in W : \hat{x}_j = x\} \neq 0$ the following hold:

$U_i(x) - U_i(x') \geq \hat{d}(x') - \hat{d}(x) \quad \forall \quad w_i \in W$ st $\hat{x}_i \geq x'$ and $m_i \leq x'$

$V_i(x') - V_i(x) \leq \hat{d}(x') - \hat{d}(x) \quad \forall \quad m_i \in M$ st $\hat{y}_i \geq x'$ and $m_i \leq x'$

Proof : Analogous to the proof of Lemma 1.

Proof of Theorem 1: Standard arguments establish the existence of competitive equilibrium. Suppose that the assumptions of the theorem hold and let $\hat{d}(\bar{t})$,..., $\hat{d}(t_{\max}), \hat{x}_1, \ldots, \hat{x}_{n_w}, \hat{y}_1, \ldots, \hat{y}_{n_m}$ and $\hat{\hat{d}}(\bar{t})$,..., $\hat{\hat{d}}(t_{\max}), \hat{\hat{x}}_1, \ldots, \hat{\hat{x}}_{n_w}, \hat{\hat{y}}_1, \ldots, \hat{\hat{y}}_{n_m}$ be two competitive equilibria of the marriage market with minimum marriage age $\bar{t} \in \{t_{\min}, \ldots, t_{\max}\}$, where $\bar{t} = t_{\min}$ refers to the unrestricted market.

Reindex women and men such that $U_i(x) - U_i(x') > U_{i'}(x) - U_{i'}(x')$ and $V_i(x) - V_i(x') < V_{i'}(x) - V_{i'}(x')$ whenever $i' < i$ and $x < x'$. Assumptions A1 and A2 imply that there is a reindexing like that. Then we claim that if $x_1, \ldots, x_{n_w}, y_1, \ldots, y_{n_m}$ constitutes a competitive equilibrium with some dowry vector then $i' < i$ implies $y_{i'} \leq y_i$, and $i' < i$ and $p_{i'} \leq x_i$ imply $x_{i'} \leq x_i$. To see this, note that $y_{i'} > y_i$ for $i' < i$ contradicts that both $x_{i'}$ and x_i are optimal choices under the same dowry vector. Similarly, $x_{i'} > x_i$ and $x_i \geq p_{i'}$ for $i' < i$ contradict that both $x_{i'}$ and x_i are optimal choices under the same dowry vector.

Suppose now that $\hat{x}_i = \hat{y}_j$ and $\hat{\hat{x}}_i > \hat{\hat{y}}_j$. The above results then imply that $\hat{\hat{y}}_j < p_i$ and that $\exists \quad i' > i$ such that $\hat{x}_{i'} > \hat{y}_j$ and $\hat{\hat{x}}_{i'} = \hat{\hat{y}}_j$. Then $\hat{d}(\hat{x}_{i'}) - \hat{d}(\hat{y}_j) \leq U_{i'}(\hat{y}_j) - U_{i'}(\hat{x}_{i'})$. By Lemma 1 this implies $\hat{d}(\hat{y}_j) - \hat{d}(\hat{\hat{y}}_j) \leq U_{i'}(\hat{y}_j) - U_{i'}(\hat{\hat{y}}_j)$. Furthermore, since $\hat{y}_j$ is an optimal choice for m_j given $\hat{d}(\bar{x})$,..., $\hat{d}(t_{\max})$, $\hat{d}(\hat{y}_j) - \hat{d}(\hat{\hat{y}}_j) \geq V_j(\hat{\hat{y}}_j) - V_j(\hat{y}_j)$. Combining the previous inequalities implies $V_j(\hat{\hat{y}}_j) - V_j(\hat{y}_j) \leq U_{i'}(\hat{y}_j) - U_{i'}(\hat{\hat{y}}_j)$. This can only be compatible with $\hat{\hat{x}}_{i'} = \hat{\hat{y}}_j$ if $V_j(\hat{\hat{y}}_j) - V_j(\hat{y}_j) = U_{i'}(\hat{y}_j) - U_{i'}(\hat{\hat{y}}_j)$. But this, together with concavity of V_j and $U_{i'}$ would imply $V_j(\hat{\hat{y}}_j) - V_j(\hat{\hat{y}}_j + 1) = U_{i'}(\hat{\hat{y}}_j + 1) - U_{i'}(\hat{\hat{y}}_j)$, contradicting A3. Therefore $\hat{x}_i = \hat{y}_j$ implies $\hat{\hat{x}}_i \leq \hat{\hat{y}}_j$. The same arguments establish that $\hat{\hat{x}}_i = \hat{\hat{y}}_j$ implies $\hat{x}_i \leq \hat{y}_j$. Combining these establishes that $\hat{x}_i = \hat{y}_j \quad \Leftrightarrow \quad \hat{\hat{x}}_i = \hat{\hat{y}}_j$.

Suppose now that $\hat{y}_i \neq \hat{\hat{y}}_i$ for some $m_i \in M$. Wlog let $\hat{y}_i < \hat{\hat{y}}_i$. Let $w_j \in W$ be such that $\hat{x}_j = \hat{x}_i$ (the existence of such a woman is guaranteed by the market clearing condition). The result in the previous paragraph implies that $\hat{\hat{x}}_j = \hat{\hat{y}}_i$. Since $\hat{y}_i$ is optimal given $\hat{d}(\bar{t})$,...,

$\widehat{d}(t_{\max})$, $V_i(\widehat{y}_i) - V_i(\widehat{\widehat{y}}_i) \geq \widehat{d}(\widehat{\widehat{y}}_i) - \widehat{d}(\widehat{y}_i)$. Since $\widehat{\widehat{y}}_i$ is optimal given $\widehat{\widehat{d}}(\bar{t})$,..., $\widehat{\widehat{d}}(t_{\max})$, $V_i(\widehat{y}_i) - V_i(\widehat{\widehat{y}}_i) \leq \widehat{\widehat{d}}(\widehat{\widehat{y}}_i) - \widehat{\widehat{d}}(\widehat{y}_i)$. Since $\widehat{x}_j$ is optimal given $\widehat{d}(\bar{t})$,..., $\widehat{d}(t_{\max})$, $U_j(\widehat{\widehat{y}}_i) - U_j(\widehat{y}_i) \leq \widehat{d}(\widehat{\widehat{y}}_i) - \widehat{d}(\widehat{y}_i)$. Since $\widehat{\widehat{x}}_j$ is optimal given $\widehat{\widehat{d}}(\bar{t})$,..., $\widehat{\widehat{d}}(t_{\max})$, $U_j(\widehat{\widehat{y}}_i) - U_j(\widehat{y}_i) \geq \widehat{\widehat{d}}(\widehat{\widehat{y}}_i) - \widehat{\widehat{d}}(\widehat{y}_i)$. These four inequalities can only hold simultaneously if $V_i(\widehat{y}_i) - V_i(\widehat{\widehat{y}}_i) = \widehat{d}(\widehat{\widehat{y}}_i) - \widehat{d}(\widehat{y}_i) = \widehat{\widehat{d}}(\widehat{\widehat{y}}_i) - \widehat{\widehat{d}}(\widehat{y}_i) = U_j(\widehat{\widehat{y}}_i) - U_j(\widehat{y}_i)$. Concavity of V_i and U_j then implies $V_i(\widehat{y}_i) - V_i(\widehat{y}_i + 1) = U_j(\widehat{y}_i + 1) - U_j(\widehat{y}_i)$. Therefore $\widehat{y}_i = \widehat{\widehat{y}}_i \quad \forall \quad m_i \in M$. Then the result obtained in the previous paragraph establishes the claim. QED

Proof of Theorem 2: For $\bar{t} = t_{\max}$ the claim is trivial. Let $\bar{t} \in \{t_{\min} + 1, \ldots, t_{\max} - 1\}$. Let $\widehat{d}(t_{\min}), \ldots, \widehat{d}(t_{\max})$ be a vector of endowments that together with $\widehat{x}_1, \ldots, \widehat{x}_{n_w}$, $\widehat{y}_1, \ldots, \widehat{y}_{n_m}$ constitute a competitive equilibrium of the unrestricted market (as noted in the proof of theorem 1, a competitive equilibrium always exists).

Let $W^* = \{w_i \in W : \widehat{x}_i < \bar{t}\}$ and let $M^* = \{m_i \in M : \widehat{y}_i < \bar{t}\}$. Define x^* to be the minimal x such that $x \geq \bar{t}$ and $\#\{m_i \in W : \widehat{y}_i = x\} \neq 0$. Let $\Delta(x) = \min_{m_i \in M^*}(U_i(x) - U_i(x^*))$ $\forall$ $x \in \{\bar{t},...,x^* - 1\}$. Construct a new dowry vector $\widehat{d}'$ such that $\widehat{d}'(x) = \hat{d}(x)$ $\forall$ $x \geq x^*$ and $\widehat{d}'(x) = \hat{d}(x^*) - \Delta(x)$ $\forall$ $x^* > x > \bar{t}$. We claim that $\widehat{d}'$, together with $\widehat{x}_1^{\bar{t}}, \ldots, \widehat{x}_{n_w}^{\bar{t}}, \widehat{y}_1^{\bar{t}}, \ldots, \widehat{y}_{n_m}^{\bar{t}}$ as constructed in the theorem constitute a competitive equilibrium of the marriage market with minimum legal age of marriage $\bar{t}$. By construction $\widehat{d}(\bar{t}) = 0$, $\#\{m_i \in W : \widehat{y}_i = x\} = \#\{w_i \in W : \widehat{x}_i = x\}$ $\forall$ $\bar{t} \leq x \leq t_{\max}$ and $\widehat{x}_i \geq p_i$ $\forall$ $w_i \in W$. Furthermore, note that $\widehat{d}'(x) - \widehat{d}'(x') = \widehat{d}(x) - \widehat{d}(x')$ $\forall$ $x,x' \in \{x^*, \ldots, t_{\max}\}$. But then the starting assumption that $\widehat{x}_1, \ldots, \widehat{x}_{n_w}, \widehat{y}_1, \ldots, \widehat{y}_{n_m}$, $\widehat{d}(t_{\min}), \ldots, \widehat{d}(t_{\max})$ constitutes a competitive equilibrium of the unconstrained marriage market implies that if for some $w_i \in W$ $\widehat{x}_i \geq \bar{x}$ then $\widehat{x}_i^{\bar{t}} = \widehat{x}_i$ is a better decision than any other choice from $\{x^*, \ldots, t_{\max}\}$ if the dowry vector is $\widehat{d}'$. By A1 and the definition of $\widehat{d}'(x)$ for $x^* > x \geq \bar{t}$, $\widehat{x}_i^{\bar{t}}$ is a better decision than any x for which $x^* > x \geq \bar{t}$ given dowry vector $\widehat{d}'$. This concludes that $\widehat{x}_i^{\bar{t}}$ is an optimal decision for $w_i \in W/W^*$ in the constrained market with minimum legal marriage age $\bar{t}$ under dowry vector $\widehat{d}'$. It is completely analogous to show, using A2 that $\widehat{y}_i^{\bar{t}}$ is an optimal decision for $m_i \in M/M^*$ in the constrained market with minimum legal marriage age $\bar{t}$ given dowry vector $\widehat{d}'$. Furthermore, Lemma 2 implies that $U_i(x) - U_i(x^*) < \widehat{d}(x) - \widehat{d}(x^*) = \widehat{d}'(x) - \widehat{d}'(x^*)$ $\forall$ $x \in \{x^* + 1, \ldots, t_{\max} + 1\}$ and $w_i \in W^*$ and that $V_i(x^*) - V_i(x) \geq \widehat{d}(x) - \widehat{d}(x^*) = \widehat{d}'(x) - \widehat{d}'(x^*)$ $\forall$ $x \in \{x^* + 1, \ldots, t_{\max} + 1\}$ and $m_i \in M^*$.

By A2 and the definition of $\widehat{d}^{'}(x)$ for $x^* > x \geq \bar{t}$, it is also true that $V_i(\bar{t}) - V_i(x^*) \geq \widehat{d}^{'}(x^*) - \widehat{d}^{'}(\bar{t}) = \widehat{d}^{'}(x^*)$. This concludes that $\widehat{x}_i^{\bar{t}}$ is an optimal decision for $m_i \in M^*$ in the constrained market with minimum legal marriage age $\bar{t}$ under dowry vector $\widehat{d}^{'}$. Consider now any $m_j \in W^*$. Define x^{**} to be the maximal x such that $x < \bar{t}$ and $\#\{w_i \in W : \widehat{x}_i = x\} \neq 0$. By Lemma 2 $U_j(x^*) - U_j(x^{**}) \leq \widehat{d}(x^{**}) - \widehat{d}(x^*)$. Also by Lemma 2 $V_i(x^{**}) - V_i(x^*) \geq \widehat{d}(x^{**}) - \widehat{d}(x^*)$ $\forall$ $m_i \in M^*$. This implies $V_i(x^{**}) - V_i(x^*) \geq U_j(x^*) - U_j(x^{**})$ $\forall$ $m_i \in M^*$. The concavity of the utility functions and $x^{**} < \bar{t} \leq x^*$ then imply $V_i(\bar{t}) - V_i(x^*) \geq U_j(x^*) - U_j(\bar{t})$ $\forall$ $m_i \in M^*$. Then by the construction of $\widehat{d}^{'}$ it holds that $U_j(x^*) - U_j(\bar{t}) \leq \widehat{d}^{'}(\bar{t}) - \widehat{d}^{'}(x^*)$. Combining the above findings concludes that $\widehat{x}_j^{\bar{t}}$ is an optimal decision for $w_j \in W^*$ in the constrained market with minimum legal marriage age $\bar{t}$ given dowry vector $\widehat{d}^{'}$. This establishes that $\widehat{x}_1^{\bar{t}}, \ldots, \widehat{x}_{n_w}^{\bar{t}}$, $\widehat{y}_1^{\bar{t}}, \ldots, \widehat{y}_{n_m}^{\bar{t}}$ and $\widehat{d}^{'}$ constitute a competitive equilibrium of the marriage market with minimum legal age of marriage $\bar{t}$. Then by Theorem 1 marriage time choices in every competitive equilibrium of the constrained market with minimum legal marriage age $\bar{t}$ are $\widehat{x}_1^{\bar{t}}, \ldots, \widehat{x}_{n_w}^{\bar{t}}, \widehat{y}_1^{\bar{t}}, \ldots, \widehat{y}_{n_m}^{\bar{t}}$. QED

Table 1. Summary Statistics

	Full sample	Ages 25-43			
	(1)	All (2)	First married at 15 or younger (3)	First married older than 15 (4)	p-value $\Delta 3,4$
Age	41.25	33.61	33.88	33.69	0.143
Height (cm)	149.09	150.05	150.11	149.97	0.750
Hindu	0.113	0.116	0.115	0.121	0.541
Family Background					
Father farmer	0.780	0.762	0.765	0.753	0.449
Value father's property	62353	67784	64458	64812	0.298
Father business	0.066	0.070	0.073	0.063	0.362
Father's schooling	2.39	2.69	2.89	2.70	0.313
Mother's schooling	0.644	0.817	0.785	0.837	0.866
Number of siblings	4.10	4.69	4.73	4.70	0.744
Female siblings	1.92	2.17	2.09	2.16	0.299
Mom survived to 50	0.929	0.961	0.963	0.962	0.781
Dad survived to 50	0.965	0.977	0.975	0.979	0.821
School Outcomes					
Literate	0.262	0.339	0.327	0.354	0.378
Enrolled in school at 9	0.38	0.47	0.48	0.48	0.367
Age quit school (for enrolled)	4.456	5.714	5.905	5.587	0.753
Quit school for marriage (among enrolled)	0.160	0.193	0.197	0.188	0.601
Marriage Outcomes					
Age of marriage	15.10	15.84	14.70	15.70	0.000
Value of dowry	2110	3271	3073	3141	0.187
Marriage not arranged	0.012	0.016	0.015	0.016	0.758
Spouse education level	6.58	6.85	6.89	6.91	0.430
Reproductive Outcomes					
Total pregnancies	5.65	4.39	4.60	4.39	0.072
Fraction pregnancies failed	0.065	0.067	0.074	0.067	0.612
Age first birth	18.32	18.68	17.97	18.63	0.000
Likelihood prenatal care	0.250	0.393	0.329	0.427	0.355
Average visits to anti-natal clinic	0.918	1.374	1.202	1.456	0.707
Likelihood antitetanus shot	0.365	0.552	0.474	0.590	0.569
Participate in decisions	0.889	0.882	0.858	0.903	0.116
Husband/in-laws have prevented her from leaving bari	0.264	0.264	0.265	0.262	0.780
Husband/in-laws have taken money or possessions against her will	0.604	0.633	0.543	0.660	0.439
Obs	4035	2442	689	867	

Table 2. Family Background Characteristics by Year of Menarche, Ages 24-43

Age of menarche	Mean age of marriage	Woman's BMI	Woman's height (cm)	Father's education	Father is farmer	Value father's land	N
11	13.36	19.70	150.8	3.00	0.727	30,636	11
12	14.94	19.44	150.0	3.23	0.784	86,008	134
13	14.64	19.15	150.1	2.67	0.762	59,832	544
14	15.70	19.38	150.0	2.67	0.753	64,812	867
15	16.51	19.13	150.0	2.15	0.777	73,126	528
16	17.19	19.41	150.0	3.03	0.755	85,910	233
17	17.77	18.90	150.4	2.77	0.760	51,376	125

Table 3. First-stage regression: Age of first marriage

	Full sample				Ages 25-43			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Age of menarche	0.72		0.644	0.663	0.728		0.690	0.748
	(0.039)**		(0.038)**	(0.040)**	(0.049)**		(0.049)**	(0.053)**
Menarche 12		0.677				1.674		
		(0.888)				(0.953)		
Menarche 13		0.334				1.274		
		(0.864)				(0.912)		
Menarche 14		1.347				2.341		
		(0.865)				(0.910)*		
Menarche 15		2.176				3.148		
		(0.867)*				(0.911)**		
Menarche 16		2.882				3.829		
		(0.876)**				(0.926)**		
Menarche 17		3.464				4.404		
		(0.890)**				(0.935)**		
Height (cm)			0.009	0.009			0.007	0.004
			(0.008)	(0.008)			(0.011)	(0.012)
Age			-0.075	-0.033			-0.102	-0.118
			(0.032)*	(0.012)**			(0.042)*	(0.043)**
Value father's property			0.000	0.000			-0.000	-0.000
			(0.000)	(0.000)			(0.000)	(0.000)
Contraceptive intervention			0.248	-4.381			0.215	-3.137
			(0.092)**	(2.269)			(0.121)	(1.662)
Father business			-0.213	-0.234			-0.152	-0.129
			(0.166)	(0.172)			(0.222)	(0.230)
Father farmer			-0.154	-0.181			-0.158	-0.192
			(0.124)	(0.131)			(0.159)	(0.164)
Number siblings			-0.075	-0.068			-0.109	-0.091
			(0.030)*	(0.031)*			(0.039)**	(0.040)*
Female siblings			0.102	0.106			0.122	0.127
			(0.045)*	(0.046)*			(0.056)*	(0.057)*
Father's schooling			0.003	-0.003			0.013	0.003
			(0.016)	(0.016)			(0.020)	(0.021)
Mother's schooling			0.101	0.097			0.113	0.095
			(0.032)**	(0.032)**			(0.039)**	(0.039)*
Hindu			0.722	0.647			0.941	0.82
			(0.159)**	(0.203)**			(0.203)**	(0.256)**
Mom alive age 50			0.17	0.131			0.264	0.224
			(0.137)	(0.142)			(0.211)	(0.215)
Dad alive age 50			-0.229	-0.259			-0.194	-0.253
			(0.161)	(0.164)			(0.235)	(0.244)
In school at age 9			0.534	0.5			0.517	0.502
			(0.107)**	(0.109)**			(0.131)**	(0.137)**
Village fixed effects	No	No	No	Yes	No	No	No	Yes
F-stat	336.83	67.37	46.57	-	220.16	43.29	23.54	-
Observations	4035	4035	3620	3620	2442	2442	2213	2213

Note: Ordinary least squares regression, dependent varilable is age at marriage. Standard errors in parentheses. Robust standard errors account for sample clustering (baris). Regressions also include number older brothers and 5-year age dummies. Results robust to single year age fixed effects. Difference in number of observations reflects missing data on control variables.

Table 4. Summary Statistics by Age of Menarche, Ages 25-43

	All (1)	Menarche 11-13 (2)	Menarche 14 (3)	Menarche 15-17 (4)	p-value Δ2,3	p-value Δ2,4
Age	33.61	33.88	33.69	33.33	0.465	0.035
Height (cm)	150.05	150.11	149.97	150.07	0.668	0.894
Hindu	0.116	0.115	0.121	0.112	0.696	0.856
Family Background						
Father farmer	0.762	0.765	0.753	0.769	0.592	0.862
Value father's property	67784	64458	64812	73278	0.966	0.294
Father business	0.070	0.073	0.063	0.074	0.476	0.885
Father's schooling	2.63	2.78	2.67	2.52	0.556	0.191
Mother's schooling	0.817	0.785	0.837	0.822	0.593	0.706
Number of siblings	4.69	4.73	4.70	4.67	0.804	0.584
Mom survived to 50	0.778	0.771	0.797	0.764	0.209	0.760
Dad survived to 50	0.888	0.877	0.897	0.889	0.198	0.433
School Outcomes						
Literate	0.339	0.327	0.354	0.334	0.256	0.753
Enrolled in school at 9	0.47	0.48	0.48	0.46	0.820	0.281
Age quit school for enrolled	5.714	12.603	13.009	13.143	0.029	0.018
Quit school to marry	0.408	0.447	0.411	0.371	0.312	0.036
Marriage Outcomes						
Age of marriage	15.84	14.70	15.70	16.87	0.000	0.000
Value of dowry	3271	3073	3141	3551	0.835	0.155
Marriage not arranged	0.016	0.015	0.016	0.018	0.795	0.584
Spouse education level	6.85	6.89	6.91	6.75	0.939	0.516
Adult Health Outcomes						
Anemia	0.274	0.293	0.257	0.274	0.114	0.419
Diabetes	0.073	0.070	0.065	0.084	0.690	0.130
Arthritis	0.411	0.386	0.418	0.424	0.209	0.772
Urinary infection	0.174	0.184	0.156	0.183	0.134	0.130
Respitory disease	0.053	0.058	0.057	0.046	0.897	0.331
Gastritis	0.484	0.472	0.494	0.485	0.389	0.349
Other health condition	0.092	0.094	0.087	0.095	0.592	0.545
Overall health (self-rated 1-4)	1.811	1.842	1.775	1.823	0.258	0.389
Obs	2442	689	867	886		

Table 5. Effect of Marriage Age on Schooling and Literacy

Dependent Variable:	Age Quit School		Literacy		Enrolled in school age 9	
Universe:	*Enrolled in school at age 9*				*Full sample*	
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
Age of marriage	0.225	0.298	0.021	0.044	0.012	-0.006
	(0.031)**	(0.102)**	(0.004)**	(0.019)*	(0.003)**	(0.012)
Height (cm)	0.055	0.055	0.004	0.004	0.004	0.004
	(0.017)**	(0.017)**	(0.002)	(0.003)	(0.002)*	(0.002)**
Age	-0.163	-0.153	-0.001	-0.006	-0.011	-0.013
	(0.059)**	(0.062)*	(0.010)	(0.011)	(0.007)	(0.007)
Father business	0.659	0.669	0.062	0.067	0.115	0.114
	(0.370)	(0.368)	(0.043)	(0.046)	(0.037)**	(0.037)**
Father farmer	-0.196	-0.189	0.045	0.061	0.045	0.042
	(0.228)	(0.229)	(0.039)	(0.041)	(0.024)	(0.024)
Number siblings	0.057	0.064	-0.009	-0.011	0.011	0.008
	(0.060)	(0.062)	(0.010)	(0.010)	(0.007)	(0.007)
Female siblings	-0.165	-0.168	0.023	0.023	-0.003	-0.000
	(0.076)*	(0.076)*	(0.013)	(0.014)	(0.010)	(0.010)
Father's schooling	0.103	0.103	0.022	0.021	0.039	0.040
	(0.023)**	(0.024)**	(0.004)**	(0.004)**	(0.003)**	(0.003)**
Mother's schooling	0.184	0.174	0.014	0.011	0.035	0.038
	(0.040)**	(0.041)**	(0.006)*	(0.007)	(0.005)**	(0.006)**
Hindu	-0.261	-0.331	0.058	0.024	-0.092	-0.075
	(0.287)	(0.303)	(0.047)	(0.056)	(0.032)**	(0.034)*
Mom survived to age 50	0.143	0.114	0.024	0.008	0.038	0.042
	(0.266)	(0.268)	(0.044)	(0.047)	(0.028)	(0.029)
Dad survived to age 50	0.497	0.523	0.004	0.012	0.027	0.024
	(0.308)	(0.312)	(0.051)	(0.051)	(0.035)	(0.035)
R^2	936	936	1065	1065	2213	2213
Observations	0.22	0.21	0.10	0.08	0.21	0.20

Notes: Columns 1, 3 and 5 are ordinary east squares regression estimates; columns 2, 4 and 6 are intrumental variables estimates, instrument is age of menarche. All regressions also control for reported value of father's property, indicator of residing in contraceptive intervention region, number of older brothers, indicators of whether each parent is currently under age 50, and five-year cohort dummies. Robust standard errors account for clustering at bari level. Dependent variable in columns 3 and 4 constructed from is binary indicator of whether respondent can read a Bangla newspaper and write a letter in Bangla: (a) easily, (b) with difficulty, or (c) not at all. Respondents defined as literate if they report (a) or (b) to both questions. Results robust to more stringent criteria for literacy.

Table 6. Older female siblings, age of menarche and schooling attainment

	Age quit school		Age of marraige	
	(1)	(2)	(3)	(4)
Age of menarche	0.397	0.390	0.959	0.916
	(0.11)	(0.11)	(0.14)	(0.13)
Number older female siblings	1.950		2.701	
	(0.99)		(1.42)	
(Number older female siblings)*	-0.140		-0.176	
(Age of menarche)	(0.07)		(0.09)	
Sex-specific birth order		4.754		5.453
		(2.19)		(2.96)
(Sex-specific birth order)*		-0.336		-0.339
(Age of menarche)		(0.15)		(0.20)
Number female siblings	-0.099	-0.107	-0.039	0.022
	(0.09)	(0.08)	(0.09)	(0.08)
Number siblings	0.022	0.021	-0.055	-0.054
	(0.05)	(0.05)	(0.03)	(0.03)
N	836	836	823	823

Note: To standardize for family size, sex-specific birth order is measured as number of older female siblings divided by total number of female siblings.

Table 7. Effect of Marriage Age on Utilization of Reproductive Health Care Services

	Prenatal care		Number anti-natal visits		Whether received anti-tetanus shot		Freedom of mobility and consumption	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Age of marriage	0.051	0.023	0.105	0.132	0.070	0.032	-0.009	-0.036
	(0.014)**	(0.012)*	(0.057)	(0.060)*	(0.018)**	(0.018)	(0.018)	(0.017)*
Height (cm)	-0.002	0.001	-0.004	-0.005	-0.001	-0.001	-0.006	-0.001
	(0.002)	(0.002)	(0.008)	(0.007)	(0.003)	(0.002)	(0.003)*	(0.003)
Age	-0.028	-0.024	-0.068	-0.022	-0.012	-0.017	0.013	0.004
	(0.009)**	(0.007)**	(0.038)	(0.030)	(0.012)	(0.010)	(0.011)	(0.011)
Contraceptive	0.278	0.291	0.762	0.827	0.252	0.316	-0.002	0.096
intervention	(0.023)**	(0.021)**	(0.091)**	(0.090)**	(0.031)**	(0.029)**	(0.030)	(0.029)**
Value father's land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Father business	0.026	-0.093	0.19	-0.478	0.075	-0.188	0.013	0.048
	(0.039)	(0.051)	(0.148)	(0.187)*	(0.048)	(0.069)**	(0.051)	(0.065)
Father farmer	-0.026	0.011	-0.15	0.003	0.037	-0.006	0.059	0.061
	(0.032)	(0.023)	(0.150)	(0.097)	(0.043)	(0.032)	(0.044)	(0.035)
Number siblings	0.007	0.008	0.034	0.053	0.018	0.015	0.014	0.021
	(0.008)	(0.007)	(0.033)	(0.030)	(0.011)	(0.010)	(0.011)	(0.010)*
Female siblings	-0.007	0.006	-0.11	-0.034	-0.03	-0.006	-0.008	-0.027
	(0.011)	(0.010)	(0.044)*	(0.047)	(0.015)	(0.015)	(0.014)	(0.014)
Father schooling	0.003	0.008	0.016	0.021	0.003	0.007	0.004	-0.006
	(0.003)	(0.004)	(0.015)	(0.016)	(0.004)	(0.005)	(0.004)	(0.006)
Mother schooling	-0.001	-0.007	0.017	0.048	-0.011	-0.002	-0.002	-0.005
	(0.006)	(0.010)	(0.027)	(0.050)	(0.008)	(0.013)	(0.008)	(0.015)
Hindu	-0.036	-0.004	-0.079	-0.066	-0.101	-0.024	-0.045	-0.076
	(0.044)	(0.032)	(0.247)	(0.138)	(0.055)	(0.042)	(0.056)	(0.045)
Mom alive age 50	-0.016	-0.052	-0.15	-0.267	-0.012	-0.103	-0.033	-0.062
	(0.036)	(0.029)	(0.157)	(0.133)*	(0.050)	(0.040)**	(0.038)	(0.037)
Dad alive age 50	0.051	-0.059	0.151	-0.01	-0.001	0.001	-0.011	0.019
	(0.039)	(0.038)	(0.153)	(0.139)	(0.058)	(0.048)	(0.051)	(0.044)
Enrolled in school at 9	Yes	No	Yes	No	Yes	No	Yes	No
R^2	0.24	0.31	0.11	0.11	0.00	0.19	-	-
Observations	1048	1136	1064	1142	1064	1142	1064	1142

Notes: Instrumental variables estimates, instruments are age of menarche and age of menarche interacted with contraceptive intervention dummy. Dependent variable in columns 1 and 2 is indicator of prenatal care averaged over all pregnancies; dependent variable in columns 3 and 4 is number of visits to anti-natal clinic averaged over all pregnancies; dependent variable in columns 5 and 6 is indicator of prenatal anti-tetanus shot averaged over all pregnancies; dependent variable in columns 7 and 8 is binary indicator of whether respondent reports that husband or inlaws have ever prevented her from leaving bari for work or family visits, or have taken away her money or possessions. Outcomes for certain respondents, including all or fraction of pregnancies and experience with in-laws, do not necessarily pertain to first marriage. 7.5% of respondents have been married more than once.

Table 8. Marriage Market Outcomes, Ages 25-43

	Value dowry	Spouse highest grade passed*	Spouse's father's education**	Spouse wealthier at marriage	Spouse age
	(1)	(2)	(3)	(5)	(4)
Age of marriage	303.17	0.093	-0.072	0.002	-0.144
	(149.01)*	(0.100)	(0.077)	(0.012)	(0.278)
Enrolled age 9	533.24	1.637	0.899	-0.041	-0.067
	(288.36)	(0.218)**	(0.163)**	(0.026)	(0.542)
(Enrolled age 9)*Hindu	3394.60	0.666	0.707	0.169	-1.340
	(1,455.24)*	(0.584)	(0.489)	(0.067)*	(1.887)
Father business	408.21	0.215	0.260	0.103	1.031
	(519.87)	(0.336)	(0.282)	(0.047)*	(0.897)
(Father business)*Hindu	5168.59	-0.245	-0.400	-0.056	-1.211
	(3326.63)	(0.814)	(0.724)	(0.109)	(1.943)
Father farmer	510.36	0.189	-0.243	0.162	0.708
	(261.20)	(0.252)	(0.165)	(0.027)**	(0.654)
(Father farmer)*Hindu	-2.10	-0.099	0.111	0.045	-1.217
	(1515.72)	(0.561)	(0.413)	(0.063)	(1.840)
Height (cm)	14.92	0.017	-0.013	-0.004	-0.078
	(19.46)	(0.015)	(0.012)	(0.002)*	(0.044)
Height*Hindu	26.85	0.026	0.044	0.006	0.119
	(87.49)	(0.036)	(0.025)	(0.005)	(0.126)
Father schooling	12.29	0.141	0.176	-0.003	0.047
	(40.44)	(0.027)**	(0.027)**	(0.004)	(0.083)
(Father schooling)*Hindu	265.98	0.052	-0.089	0.000	0.020
	(192.81)	(0.076)	(0.080)	(0.009)	(0.268)
Mother schooling	-111.92	0.196	0.063	-0.002	-0.134
	(83.71)	(0.047)**	(0.054)	(0.007)	(0.138)
(Mother schooling)*Hindu	882.51	0.108	0.141	-0.008	-0.037
	(608.26)	(0.142)	(0.131)	(0.021)	(0.463)
Hindu	6313.93	-5.013	-7.599	-0.648	-7.497
	(13394.24)	(5.632)	(3.736)*	(0.688)	(19.653)
R^2	0.22	0.25	0.13	0.04	0.14
Observations	2207	1323	1790	2215	2215

Notes: Instrumental variables estimates, instrument is of age of menarche. All regressions also include 36 age of birth fixed effects by religion. Robust standard errors account for clustering at bari. Value of dowry collected from following survey question: "What was the total value of dowry from your [ ] marriage?" asked of each of respondent's marriages. Whether value given reflects 1996 value or value at time of marriage is ambiguous, particularly since two-thirds of dowries include in-kind transfers such as jewelrey, land and animals. *Number of observations reflects igh rate of non-response for dependent variable. ** Asked of current spouses only, so column 3 includes only women married to first spouse in 1996.

Table 9. Predicted effect of age of consent laws on average female education in Matlab

	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17
Beta $_{(Menarche\ at\ t)}$		0.548	0.664	0.833	1.053	1.268
Standard error		(0.43)	(0.41)	(0.39)	(0.45)	(0.57)
g(t)	0.067	0.244	0.353	0.202	0.086	0.043
Implied policy effect of t_{min} $(\Delta\mu_E)$		0.037	0.073	0.185	0.376	0.581

Notes: In first row of table, Beta refers to coefficient on age-specific dummy for menarcheal age from regression of schooling attainment on menarche. In row 3, g(t) is the distribution function of menarche at each age, t. The implied policy effect is calculated according to formula 6.1 in the paper.

Figure 1. Age of Menarche and Age of First Marriage

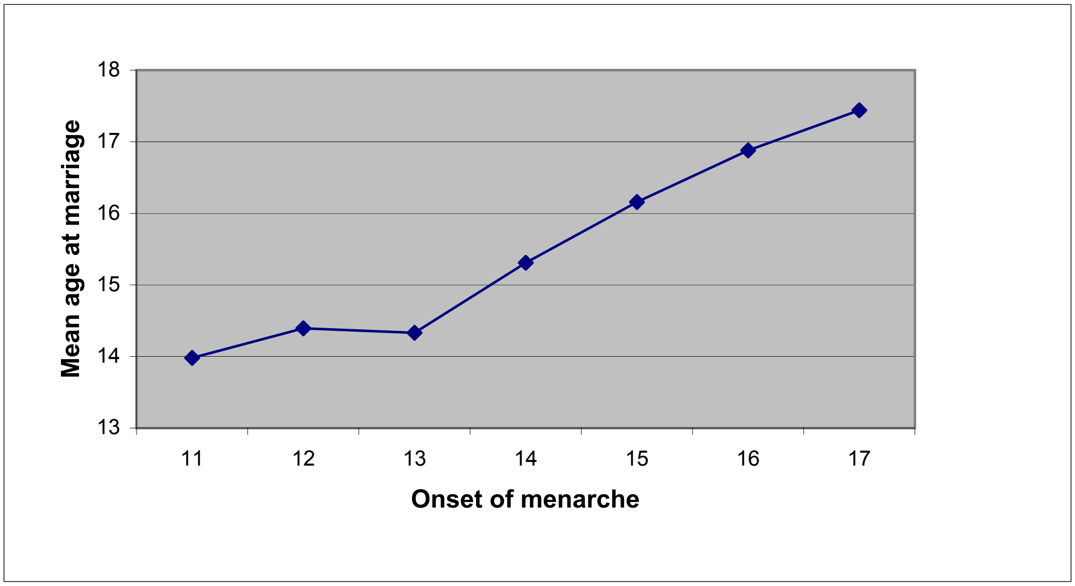


Figure 2a: Kernel density, Age of Menarche and Marriage

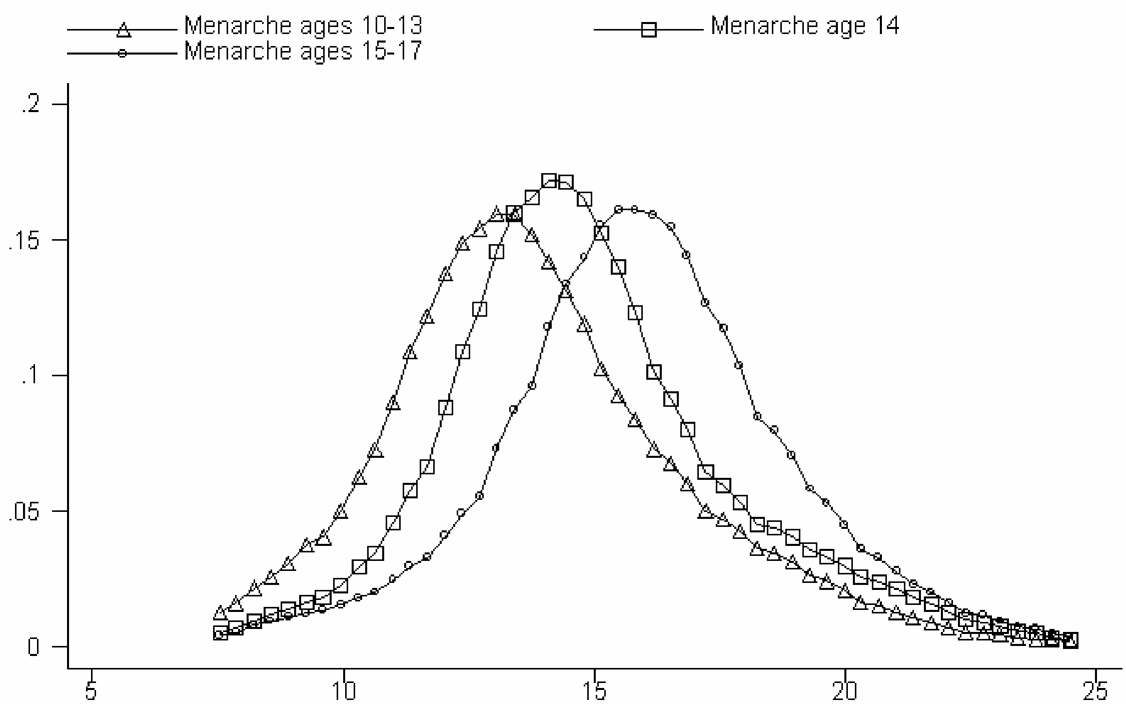


Figure 2b: Kernel density, Age of Marriage

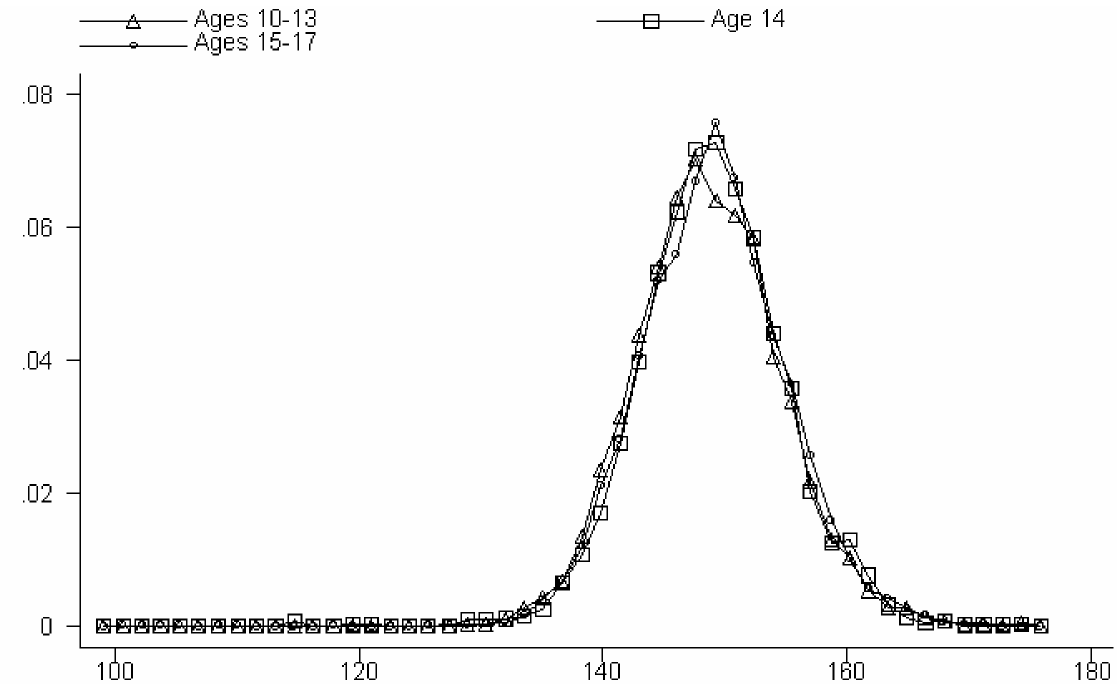


Figure 3a: Kernel density, Adult Height

Figure 3b: Kernel density, Menarcheal Age by Cohort

Figure 4a: Time trends in Menarche, Marriage and GDP

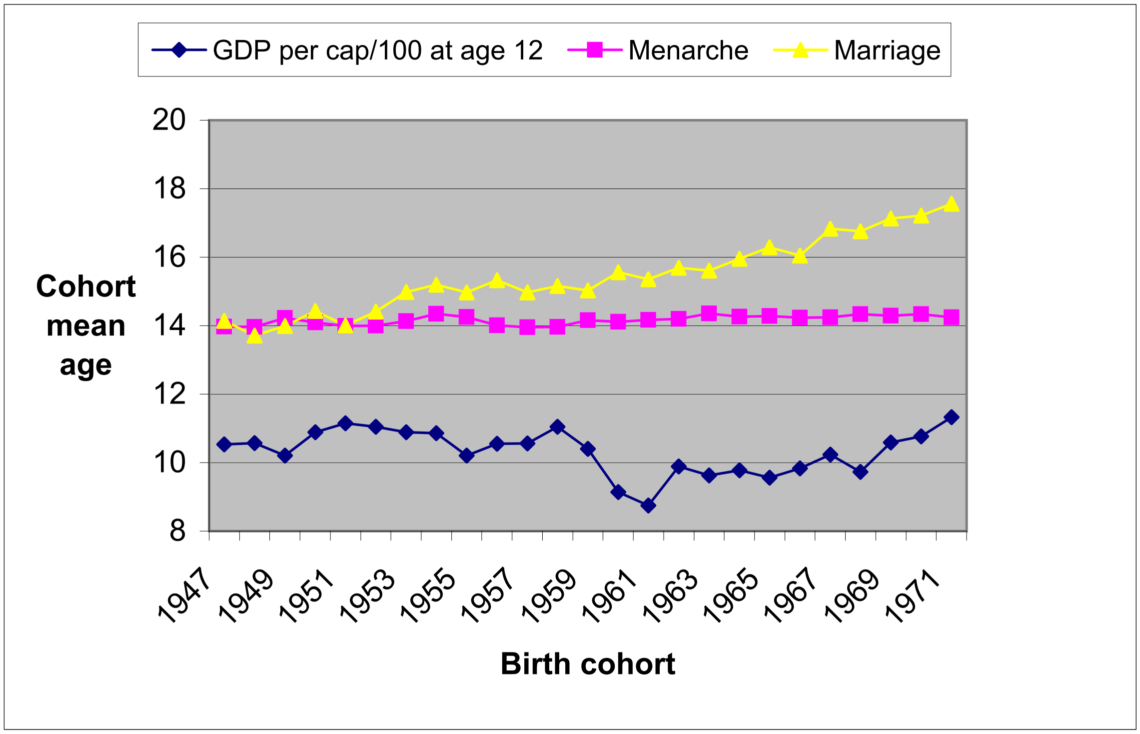
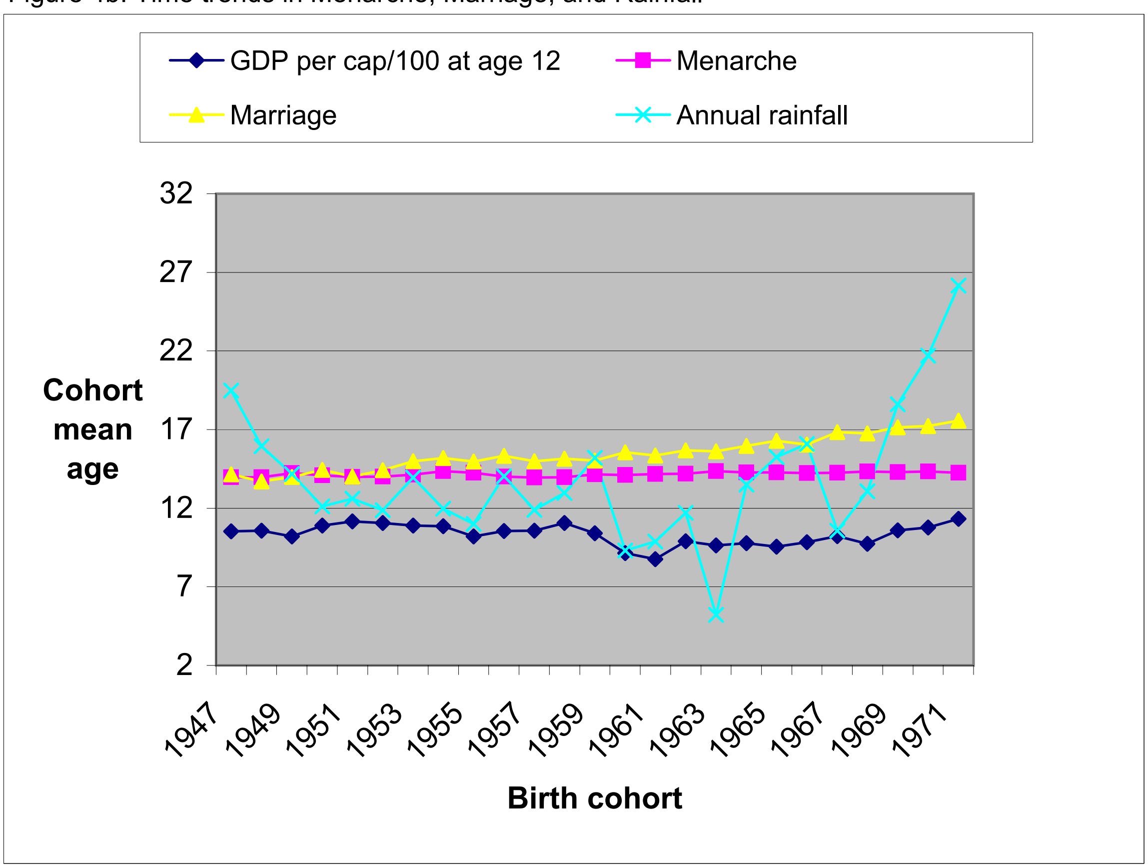


Figure 4b: Time trends in Menarche, Marriage, and Rainfall



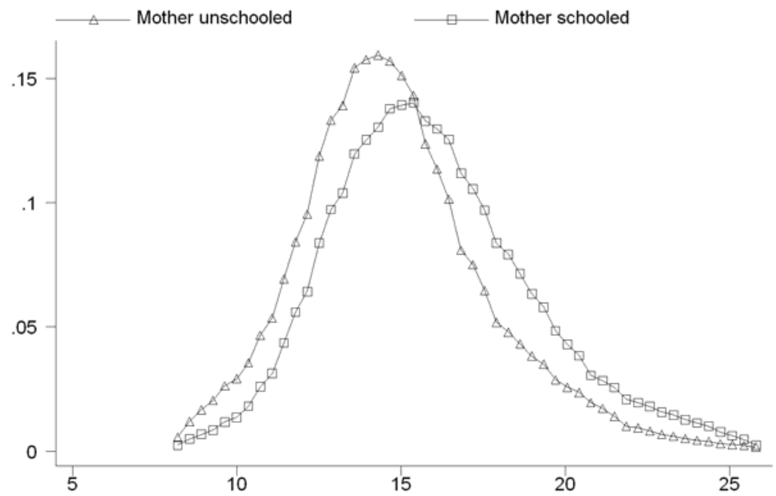


Figure 5a: Age of marriage, schooled and unschooled mothers

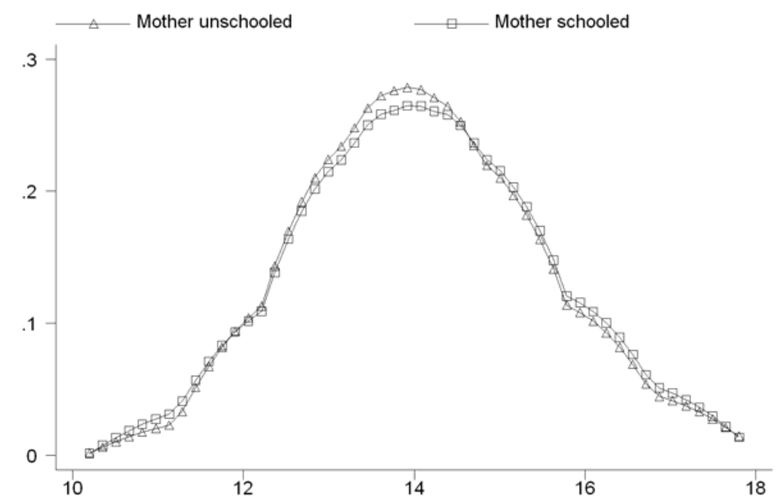


Figure 5b: Age of menarche, schooled and unschooled mothers