Do Highly Educated Women Choose Smaller Families?*

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Abstract

We present evidence that the cross-sectional relationship between fertility and women's education in the U.S. has recently become U-shaped. Concurrently, the number of hours worked has increased with women's education. In our model, raising children and home-making require parents' time, which could be substituted by services such as childcare and housekeeping. Highly educated women substitute their own time for market services to raise children and run their households, which enables them to have more children and work longer hours. We find that the change in the relative cost of childcare accounts for the emergence of this new pattern.

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1 Introduction

Ever since the demographic transition, conventional wisdom suggests that income and fertility are negatively correlated. This has been documented at the aggregate level in a cross-section of countries (Weil 2005); over time within countries and regions (Galor 2005, Galor 2011) and in cross-sections of households in virtually all developing and developed countries (Kremer and Chen 2002). Jones and Tertilt (2008) used data from the U.S. census to document the history of the relationship between fertility choice and key economic indicators at the individual level for women born between 1826 and 1960. They found a strong negative cross-sectional relationship between fertility on the one hand, and income and education of both husbands and wives on the other hand, for all cohorts. Finally, Preston and Sten Hartnett (2008) and Isen and Stevenson (2010) found similar patterns for cohorts born through the late 1950s.[1]

Using data from the American Community Survey, we present below evidence that the cross-sectional relationship between fertility and women's education in the U.S. between 2001 and 2011 is U-shaped. Specifically, we classify women into five educational groups: no high school degree, high-school degree, some college, college degree and advanced degree. We start by estimating the total fertility rate (henceforth: TFR) and show that this measure exhibits a U-shaped pattern. However, estimating the TFR by educational group has a shortcoming in that women are assigned into an educational group according to their educational attainment at the time of the survey, which may differ a great deal from their completed schooling, especially for young women who are, by and large, still in their schooling period. We circumvent this problem by estimating a "hybrid" measure of fertility (Shang and Weinberg 2013). This measure combines the realized stock of children at a specified age and the current age-specific-fertility-rate from this specified age till the end of the fecundity period. We show that this

[1]This inability to find a positive correlation between income or education and fertility has led some scholars to cast doubts on the assumption that children are a normal good (see Jones and Tertilt 2008, Guinnane 2011). Black, Kolesnikova, Sanders and Taylor (2013) show that children are indeed a normal good. Using the exogenous increase in the price of coal during the energy crisis in the mid 1970s, they document that a males income in the Appalachian coal-mining region increased and that led to an increase in fertility.

measure also exhibits a U-shaped pattern with respect to education.[2]

We extend our examination of the association between fertility and women's education by estimating linear probability models. This approach enables us to control for various characteristics such as marital status, age, state of residence, and family income, which may be responsible for the relationship between fertility rates and women's education. We find that the partial correlation between fertility and women's education is indeed U-shaped.

The importance of this pattern crucially depends on the likelihood that the observed U-shaped pattern will be translated into completed fertility rates for cohorts that have not yet completed their fertility. To address this issue, we begin by showing that the U-shaped pattern is a new phenomenon. If it is not, then there is no obvious reason to expect that this pattern will be translated into completed fertility. Indeed, we find that fertility monotonically decreases in education in 1980 and that this is also true in 1990, although the differential fertility among women with exactly a college degree and women with advanced degree declines. In 2000, in contrast, we find that fertility among women with advanced degrees is slightly higher than for women with exactly a college degree.

Since the U-shaped pattern is indeed a new phenomenon, it is not surprising that it is not yet reflected in completed fertility, even for the youngest cohort for which this measure is available. Nevertheless, it is instructive to look at the fertility of cohorts that have recently approached the end of their fertile period. We show that while completed fertility monotonically declines across the educational groups for all cohorts, the changes in the cross-sectional relationship across cohorts closely follows changes in the hybrid measure of fertility. In particular, the completed fertility of women with advanced degree increases monotonically across recent cohorts, closing the gap between this group and any other group. This suggests that what we see in hybrid fertility today is likely to be translated into completed fertility in the future.

Turning to labor supply, standard models predict that to the extent that the sub-

[2] Shang and Weinberg (2013) studied in detail the fertility of college graduate women. They show that since the late 1990s, the fertility of college graduates has increased over time. They do not, however, discuss the cross-sectional relationship between fertility and female education, which is the focus here.

stitution effect dominates the income effect, more educated women – who face higher wages – supply more hours to the labor market. Indeed, this prediction is well documented and is verified in our data as well. Meanwhile, standard models of household economics suggest that there is a negative relationship between female labor supply and fertility: women who work more have less time to raise children (Gronau 1977, Galor and Weil 1996). Thus, our findings regarding the pattern of fertility, along with the pattern of labor supply, raise two questions: (i) what can account for the U-shaped fertility pattern and (ii) what can account for the positive correlation between fertility and labor supply for highly educated women.

We advance an explanation that relies on the *marketization hypothesis* (Freeman and Schettkat 2005, Freeman 2007). We argue that highly educated women find it optimal to purchase services such as nannies, baby-sitters, and day-care as well as to purchase housekeeping services to help them run their homes. This enables these highly educated women to have more children and work more hours in the labor market. Indeed, Cortes and Tessada (2011) found that (i) low-skilled immigration has increased hours worked by women with advanced degrees and that the labor supply effects are significantly larger for those with young children; (ii) hours spent on household chores declines quite dramatically along the educational gradient; and (iii) the fraction of women who use housekeeping services increases sharply with education. Similarly, Furtado and Hock (2010) found that college educated women living in metropolitan areas with larger inflows of low skilled immigrants experience a much smaller tradeoff between work and fertility. Further support for the marketization hypothesis is provided in Mazzolari and Ragusa (2013) and Manning (2004). Manning (2004) showed that the employment opportunities of unskilled labor depend on physical proximity to skilled workers. Finally, Mazzolari and Ragusa (2013) found that growth in a city top wage bill share is associated with significant low-skilled employment growth in the sector of services that substitute for home production activities.

To illustrate our argument, we use a standard model in which a mother derives utility from consumption and the full income of children.[3] On the children side,

[3]We consider here that a household comprises one female parent. Thus, throughout the paper,

parents decide upon the quantity of children (fertility) and their quality (education). We follow the standard models along two assumptions. First, we assume that education is bought in the market, as in de la Croix and Doepke (2003) and Moav (2005) and show that for highly educated women, education is relatively cheaper, which allows them to purchase more education for their children, even if they allocate the same share of income for quality. Second, as in Hazan and Berdugo (2002) and de la Croix and Doepke (2003), we assume that nature equips children with a basic skill. This basic skill implies that as parents' human capital increases, the share of income that is allocated to the quality of each child increases at the expense of the share of income allocated to quantity. This happens because the value of the basic skill in terms of income is relatively high for low income parents. As a result, parents find it optimal to spend a relatively large share of income in quantity and a relatively low share in quality. In contrast, for high income parents, the value of the basic skill is relatively small, which induces parents to allocate a higher share of income for quality at the expense of quantity.

To emphasize the reliance on market substitutes for parental time, we deviate from the existing models (e.g. Galor and Weil 2000) by allowing parents to substitute other people's time for their own time by purchasing child-care or babysitting services in the market.[4] This marketization process is an essential element in our mechanism that yields U-shaped fertility pattern. To see this, ignore for the moment this marketization channel, and assume that quantity requires parental time only. In this case, with an increase in the parent's human capital, both parent's income and the price for quantity increase by the same proportion. However, since high income parents allocate a lower share of their income to quantity, the optimal number of children monotonically declines.

Marketization, however, affects the price for quantity that parents face. For parents with low levels of human capital, (i.e., low income), marketization is low and thus the parents themselves engage in most of the child raising. Thus, the intuition explained above holds. In contrast, parents with high levels of human

we refer to female parents only, except in Section 3.3.2, in which we explicitly model a two parent household.

[4] Aiyagari, Greenwood and Seshadri (2002) allow parents to substitute child-care for their own time. However, in their model, fertility is exogenous and, therefore, they do not study the effect of such services on fertility choice.

capital optimally outsource a major part of their child-raising, which, in turn, reduces the price of children from the parents' point of view. We show that this reduction can be sufficiently large enough to induce an increase in fertility above a certain level of human capital.

In terms of parents' time, our theory suggests that time spent on raising children may decrease or increase with parents' human capital. In our basic model, where education is only bought in the market, parents' time spent on raising children decreases with parents' human capital. This occurs for two reasons. First, as discussed above, the fraction of income allocated to raising children decreases with parents' human capital. Second, parents' reliance on market substitutes increases with human capital. However, Guryan, Hurst and Kearney (2008) found that a mother's time allocated to childcare increases with a mother's education.[5] In their empirical analysis, however, childcare is defined as the sum of four primary time use components: "basic", "educational", "recreational" and "travel". Clearly, the educational and recreational components and part of the travel component are an investment in the children's quality.

Ramey and Ramey (2010) reconcile the seemingly paradoxical allocation of time, according to which mothers with a higher opportunity cost of time spend more, rather than less time with their children despite the availability of market substitutes. They argue that as slots in elite postsecondary institutions have become scarcer, parents responded by investing more in their children's quality so that they appear more desirable to college admissions officers. Since more educated parents spend more of their own time on market goods and services related to the child's quality, it implies that parental time and market goods and services are strong complements in the production of children's quality. To capture this idea, we extend our model in Section 3.3.1 by assuming that children's quality requires not only education bought in schools but also parental time and show that, consistent with the evidence, the model can predict that parental time allocated to children increases with parents' human capital.

On the consumption side, we assume that individuals combine time and a market

[5]Table 2 in Guryan et al. (2008) reports that hours per week spent in total childcare are 12.1, 12.6, 13.3, 16.5 and 17 for mothers with <12, 12, 13-15, 16 and 16+ years of schooling, respectively.

good to produce the consumption good that enters their utility function. Furthermore, we assume that parents can substitute a housekeeper's time for their own time by purchasing these services in the market. This substitutability implies that the share of income devoted to home production by parents decreases as parents' education increases.

One may suggest an alternative hypothesis to explain the positive association between fertility and female labor supply for highly educated women: spouses of highly educated women may work less to compensate for their wives' extra hours in the labor market. To examine this channel we first extend the model in Section 3.3.2 to include husbands and allow them to work and raise children. Consistent with Cherchye, De Rock and Vermeulen (2012), who studied the allocation of time between labor supply, leisure, home production, and child-care in a collective model, we find that the time of wife (husband) that is allocated to child-care decreases with her (his) human capital. When comparing households, however, one should consider how the human capital of both spouses varies across households. One stylized fact of the marriage market is assortative matching on socioeconomic backgrounds, such as parental wealth (Charles, Hurst and Killewald 2013) and spousal education (Pencavel 1998). In Section 3.3.2 we show that under this assumption, all the results of our basic model are preserved when comparing households with different levels of human capital. Secondly, we document that spouses of these highly educated women actually supply more hours compared to spouses of less educated women. Most importantly, in Section 4.2 we show that purchase of child-care services monotonically increases in women's education.

Our theory suggests that the relative price of unskilled labor intensive services, such as child-care and housekeeping, is a key explanatory variable in shaping up the relationship between fertility and women's education. Specifically, our theory suggests that the marketization mechanism is more effective when the relative price of these services is lower. To test this empirically, we used data from the March CPS for the period 1983-2012 and estimated the relative cost of child-care services for each woman, measured as the average hourly wage paid in the day child-care industry relative to each woman's wage. We find that child-care has become relatively more expensive to women with less than a college degree, while it has become relatively cheaper for women with a college or advanced degree. We then study the association between the probability of giving birth and our measure of the relative cost of child-care services, and find it negative, highly significant, and robust to the inclusions of various controls and different specifications that correct for endogeneity of women's wages and selection bias into the labor market. Moreover, we show that this structural relationship is highly stable over the last three years.

While these results are important in their own right, we are mostly interested in using them to explain the change over time of the cross sectional relationship between fertility and women's education. To this end, we estimate a counterfactual cross sectional relationship between fertility and women's education for the last decade by holding the relative cost of child-care at its early 1980s level. Interestingly, this counterfactual relationship is almost monotonically declining.[6]

The rest of the paper is organized as follows. Section 2 presents the evidence on the U-shaped fertility pattern. In Section 3, we lay out the model and present the main results of the theory. In Section 4 we study the relationship between fertility and the relative cost of childcare, and explore the implication of the change in the relative cost of child care for the change in the cross-sectional relationship between fertility and education. In Section 5, we provide evidence on labor supply and marriage rates and rule out alternative hypotheses. Finally, Section 6 provides concluding remarks.

[6]Our findings are related to Attanasio, Low and Sanchez-Marcos (2008) and Apps and Rees (2004). Attanasio et al. (2008) studied the life-cycle labor supply of three cohorts of American women, born in the 1930s, 1940s, and 1950s. Their main finding is that the increase in participation early in life for the youngest cohort is the result of a decrease in the child-care cost. Apps and Rees (2004) documented that the cross-country relationship between female labor supply and fertility, which was negative in 1970, turned positive in 1990 and argue that tax and child support policies contributed to the reversal of this relationship.

2 Patterns of American Fertility by Education

We used the American Community Survey (henceforth: ACS) to document basic facts on the fertility behavior of American women and the correlation between fertility behavior and the education of these women (Ruggles, Alexander, Genadek, Goeken, Schroeder and Sobek 2010). The ACS is a suitable survey to study current trends in the fertility of American women, as it explicitly asks each respondent whether she gave birth to any children in the past 12 months.

We pooled data from the ACS for the years 2001–2011 and restricted our sample to white, non-Hispanic women who live in households under the 1970 definition.[7] Using this data, we estimated age-specific-fertility-rates by five educational groups; no high school diploma, high school diploma, some college, college, and advanced degrees.[8] Figure 1 shows these estimates.

The pattern of these estimates is not surprising: while fertility rates of women who did not complete high school or have a high school diploma peak at ages 20–24, they peak at ages 25-29 for women with some college education and at ages 30–34 for women with college or advanced degrees.[9]

Next, we sum up these age-specific-fertility-rates, to obtain estimates of the TFR. Figure 2 shows our findings. As can be seen from the figure, TFR declines for women up to those with some college, but then increases for women with college and advanced degrees. Specifically, TFR among women with no high school diploma is 2.24, among women with high-school diploma it is 2.09, and among women with some college it is 1.78. However, the TFR among women with college degrees is 1.88 and among women with advanced degrees it is 1.96.

This U-shaped fertility pattern raises a few issues. First, how one deals with the assignment of women to educational groups, which is based on current, rather

[7]This fertility pattern is unchanged if we include women of all races, but we want to avoid compositional effects coming from changes in the fraction of each race and ethnic group over the period.

[8]We assign women into educational groups according to their current highest year of school or degree completed. In Section 2.1 we discuss the potential bias this creates and correct for it.

[9]We do not report standard errors on these estimates. Given the sample size, the standard errors on these estimates are essentially zero.

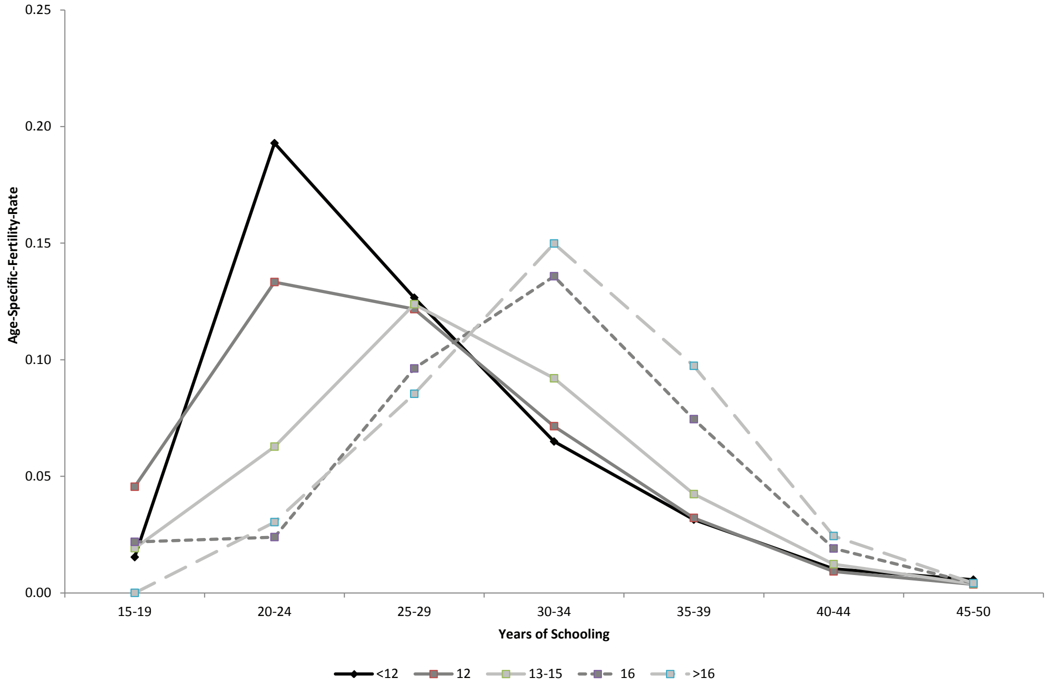

Figure 1: Age-Specific-Fertility-Rates by educational groups, 2001-2011. Authors' calculations using data from the American Community Survey.

than complete schooling? Second, is this pattern robust to differences in the age structure, marital status, and family income across women in different educational groups? Third, is the U-shaped pattern really a new phenomenon? Finally, and most importantly, what can be learned from this new pattern, namely, will these measures of fertility be translated into completed fertility? In what follows we address each of these questions. We show that our overall analysis paints a picture of an emerging new pattern of fertility by education.

2.1 The Assignment of Women into Educational Groups

One concern in our analysis so far is the assignment of women into educational groups. Given the structure of our data, we observe each woman only once and assign women into educational groups according to their educational attainment at the time of the survey, as measured by the highest year of school or degree

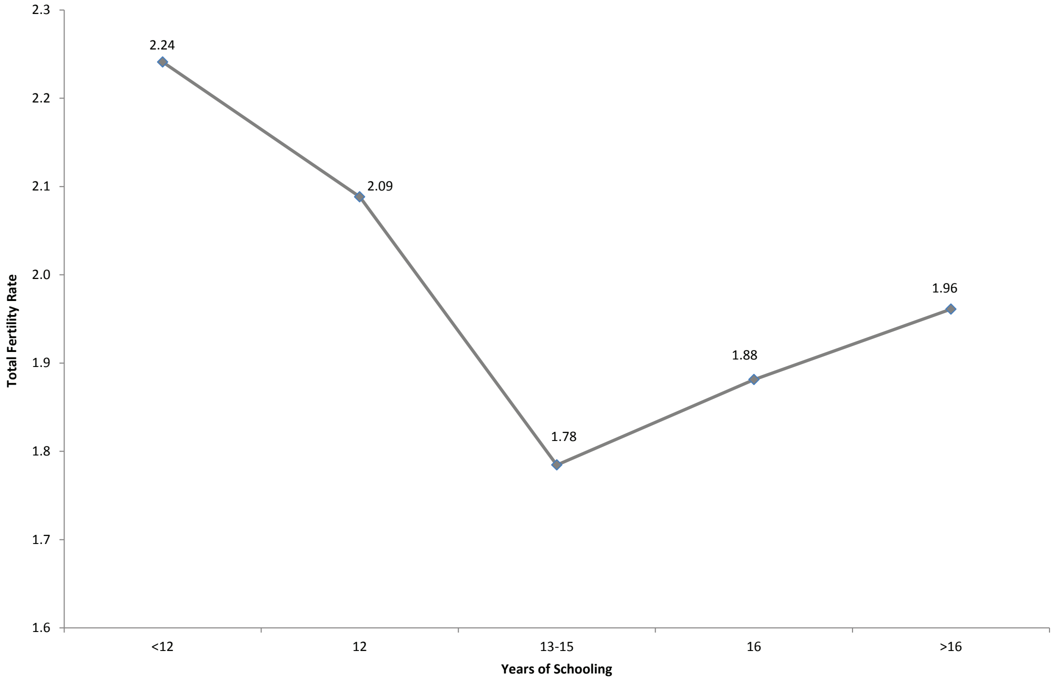

Figure 2: Total fertility rate, 2001-2011. Authors' calculations using data from the American Community Survey.

completed. While this might not be an issue for relatively older women, it creates large biases among young women. For example, almost all women age 15 are currently in high-school. This implies that we assign all of these women into the group of high-school dropouts, even though some of them will end up with advanced degrees. If the true relationship between TFR and education is decreasing, then this assignment problem may bias the estimated TFR towards a U-shaped pattern.

To address this concern, we estimate a "hybrid" measure of fertility (Shang and Weinberg 2013). As we pointed out, the bias may be severe for young women, but is less of a concern for older women. Our hybrid measure uses actual fertility experienced by young women, combined with a period measure of fertility for older women. Specifically, we sum up the number of children ever born to women at age a and the age-specific-fertility rates from age $a+1$ to age 49. To the extent that women complete their education by age a, all women are assigned to

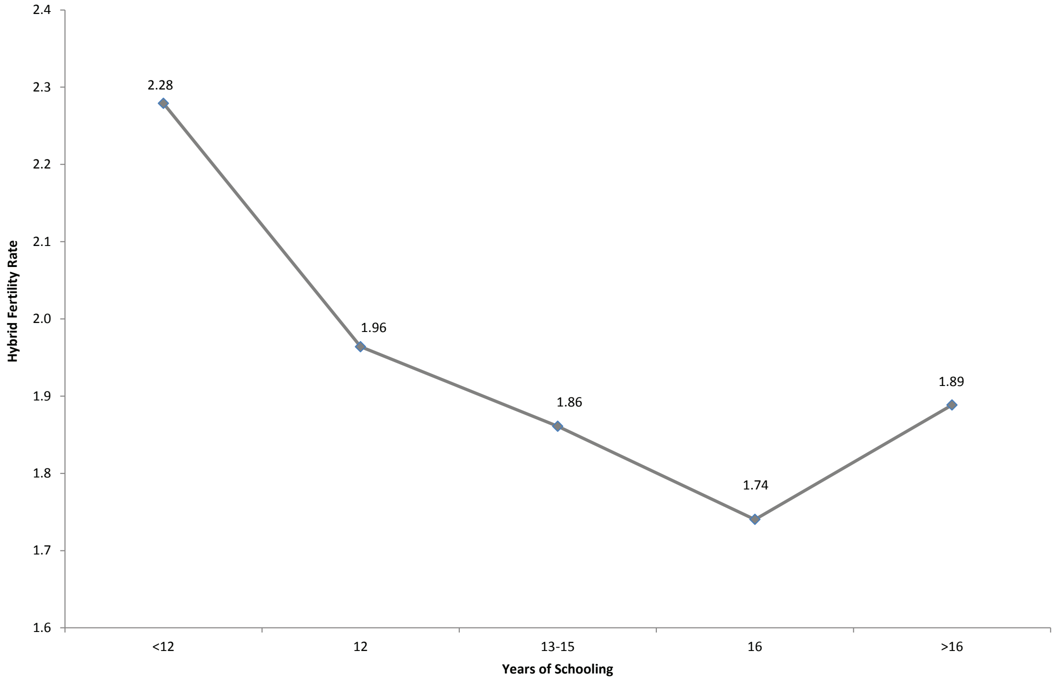

Figure 3: Hybrid Fertility Rate, 2001-2011. The hybrid fertility rate sums up the number of children ever born to women at age a and the age-specific-fertility rates from age $a+1$ to age 49. We assume $a = 24$. Authors' calculations using data from the American Community Survey.

their true educational group. This consideration suggests that we should choose a relatively large a. Such a choice, however, comes with a cost. The higher a, the larger the weight we put on past fertility rates compared to current fertility rates. Thus, if fertility rates have changed differentially across the educational groups in the 2000s, choosing a relatively large a might prevent us from finding the new pattern, even if it exists.[10] As a compromise, we set $a = 24$.[11]

Figure 3 present this hybrid measure of fertility. As can be seen from the figure, the U-shaped pattern is still present, albeit the lowest fertility is now attained by women with exactly a college degree. As a robustness check, we gradually in-

[10]Clearly, choosing a in the 40s, coincides with completed fertility, a measure we discuss in detail in Section 2.4.

[11]The average number of own children in the household at age 24 equals 1.079, 0.77, 0.486, 0.088 and 0.079 for women with less than a high-school degree, exactly a high-school diploma, some college, exactly a college degree and an advanced degree, respectively.

crease a from 24 to 30. We find that the lowest fertility is attained by women with a college degree up to $a = 29$, although the difference in fertility between this group and the group of women with advanced degree declines monotonically. At $a = 30$ the fertility of women with exactly a college degree is larger than that of women with an advanced degree.

One noticeable difference between our estimated TFR (Figure 2) and our estimated hybrid fertility (Figure 3) is that the minimum level is attained by the some college group and exactly college degree group, respectively. Given the limitations of the data, however, we do not take a stand as to whether the cross-sectional relationship between completed fertility and women's education will resemble Figure 2 or Figure 3.

2.2 The Partial Association between Fertility and Women's Education

Regression models provide a different means of presenting the association between fertility and women's education. The advantage of this approach is that we can control for various characteristics such as age, marital status, family income, year and state effects that may be responsible for the relationship between fertility and women's education. Table 1 shows the results from linear probability models that take the following structure:

$$b_{ist} = \alpha + e'_{ist}\pi + \kappa N_{ist} + X'_{ist} \cdot \gamma + \delta_a + \delta_m + \delta_t + \delta_s + \epsilon_{ist},$$

where b_{ist} is a dummy variable equals to 1 if woman i living in state s gave birth in year t and 0 otherwise. e'_{ist} is a set of dummy variables that correspond to the five educational levels described above and the coefficients of interest are π. N_{ist} is the number of children woman i has, not including the current birth.[12] X'_{ist} includes five dummies which split women according to their earnings, spouse's wage, and other family income.[13] δ_a are age dummies, δ_m are marital status dum-

[12] N_{ist} equals the number of own children in the household minus b_{ist}.

[13] We use female earnings and not wage rate because, Baum-Snow and Neal (2009) argue that in the Census and ACS surveys, reports concerning usual hours worked during the past year

mies, δ_t are year dummies and δ_s are state dummies. The educational group of high-school dropouts is the omitted category, so the coefficients on the other educational groups can be interpreted as the difference in the probability of giving birth relative to that group.

In column (1) we regress b_{ist} only on the educational dummies. Thus, the coefficients in this column are the unconditional differences in the probability of giving birth, namely "fertility rates", relative to fertility rates among women who do not have a high school diploma. As can be seen, fertility rates monotonically increase with education.[14] Column (2) adds dummies for marital status. Since the fraction of currently married women is the lowest for women lacking a high school diploma (see Figure 13 below) and one expects to find higher fertility rates among married women, controlling for marital status should lower the coefficients on education in column (2). Indeed, the coefficients are substantially lower in column (2) than in (1) and in particular, those in the groups of high-school diploma and some college change sign and are now negative. The positive coefficients on college and advanced degrees imply a U-shaped pattern in fertility rates.

In column (3), we add age dummies. Since age is not monotonically related to fertility rates, the effect on the educational dummies is not predictable. As can be seen in column (3), though, adding age dummies substantially reduces the coefficients on the educational dummies. Now the coefficients on high-school diploma, some college, and college graduates are negative and significant, while on the advanced degrees it is essentially zero. Nevertheless, this still implies a U-shaped relationship between fertility rates and women's education. In Column (4) we add year dummies and in Column (5) we also add state dummies. Neither the year dummies nor the state dummies change the results of Column (3).

Finally, in Column (6) we study the association between female earnings and fer-

contain errors that create incredible implied wages for part-time workers. The distribution of earnings has a large mass at zero and then spread over positive values. To account for this, we assign women into five groups. The omitted groups contain women without earnings. Women with positive earnings are assigned into four quartiles.

[14]This may seem at odds with the reported TFR in Figure 2, where TFR is the *highest* for women without high-school diplomas. Notice, however, that TFR sums up age-specific-fertility-rates, which are mean births rates within educational-*age* groups; it could well be that the fertility rate is lower even if the sum of the age-specific-fertility-rates are larger.

tility. As explained above, the omitted group is women without labor income and the coefficients reported in the table give the difference in the birth-rates between women whose labor income is in each of the four quartiles and the omitted group. In this specification, we also control for spouses' earnings as well as to all other sources of family income. As can be seen from the table, while the fertility rate is the highest among non-working women, there is a clear U-shaped pattern in fertility, where the minimum level of fertility rate prevails at the third quartile earnings group. Notice also that as predicted by economic theory, spouses earnings and other sources of income are positively associated with fertility rates.[15]

2.3 Is the U-shaped Fertility Pattern New?

As mentioned in the Introduction, many studies have shown that in cross-sections of households, fertility decreases with education in virtually all developing and developed countries. However, the educational classifications used in these studies are different from ours, which prevents a direct comparison between our work and the literature. For example, had we classified women into three groups of education; high-school dropouts, high-school graduates and more than high-school, we would have found a monotonically decreasing relationship between women's education and fertility as well. Hence, in this section we use earlier data to provide evidence that the U-shaped fertility pattern is indeed only a recent phenomenon.

For this purpose, we used data from the 1980, 1990 and 2000 U.S. censuses (Ruggles et al. 2010). Unlike the ACS, the census questionnaire does not contain a direct question about the occurrence of a birth during the past 12 months. The census as well as the ACS contains a related question about the age of the youngest own child in the household. One might expect, therefore, that any woman who reported giving a birth during the previous 12 months would answer that the age of youngest own child in her household is 0.[16] Given this, we construct a variable

[15] The results of these six models are essentially the same if we use a probit instead of a linear probability models. These results are shown in Table 2.

[16] Clearly, multiple births, infant mortality, and giving a child over to adoption or to relatives to raise the child could create some differences between these two measures, although we conjecture

for the occurrence of a birth during the past 12 months if a woman reports having a child aged 0 years old.

Before using this indirect measure of births to estimate the cross-sectional relationship between fertility and education in the past, it is instructive to check the reliability of this measure in the ACS data, which contain the response to both questions. The correlation between the resulting two sets of estimates for the age-specific-fertility-rates is larger than 0.99 for all five educational groups. However, the age-specific-fertility-rates based on the age of the youngest own child in the household are systematically lower than those presented in Figure 1. More importantly, the gap between the series is larger at younger ages. Although we do not have a good explanation for that, this problem is less severe when we estimate the hybrid measure of fertility. Figure 4 presents two estimates of hybrid fertility rates for the period 2001-2011. The estimate labeled "hybrid based on fertyr" is the one reported in Figure 3, while the estimate labeled "hybrid based on yngch" is the estimate based on the age of the youngest own child in the household. As can be seen from the figure, there exists a gap between the two series but it is almost constant across the educational groups.

Next we use the census data for 1980, 1990 and 2000 to estimate the hybrid fertility rate for these three years.[17] Figure 5 presents the estimates for hybrid fertility rate for the years 1980, 1990 and 2000.[18] As can be seen from the figure, fertility monotonically decreases in education in 1980. This is also true in 1990, although the slope of the curve decreases substantially (in absolute terms) when moving from women with exactly a college degree to women with an advanced degree. Finally, in 2000, this is no longer true. While fertility decreases up to women with exactly a college degree, it slightly increases for women with an advanced degree. In sum, the evolution of the cross-sectional relationship between fertility rates and women's education over time shows a clear and monotonic increase in

that in practice these are quantitatively unimportant. We therefore conjecture that discrepancies between the two measures are related to measurement errors.

[17]The educational attainment variable "EDUC" has been coded differently since 1990. Thus in 1980, we classified women with up to grade 11 as "less than high-school", women with exactly grade 12 as "high-school diploma", women with some college, but less than 1 year up to 3 years of college as "some college", women with exactly 4 years of college as "college graduates" and women with more than 4 years of college as "advanced degree".

[18]Like in Figure 3, we set $a = 24$.

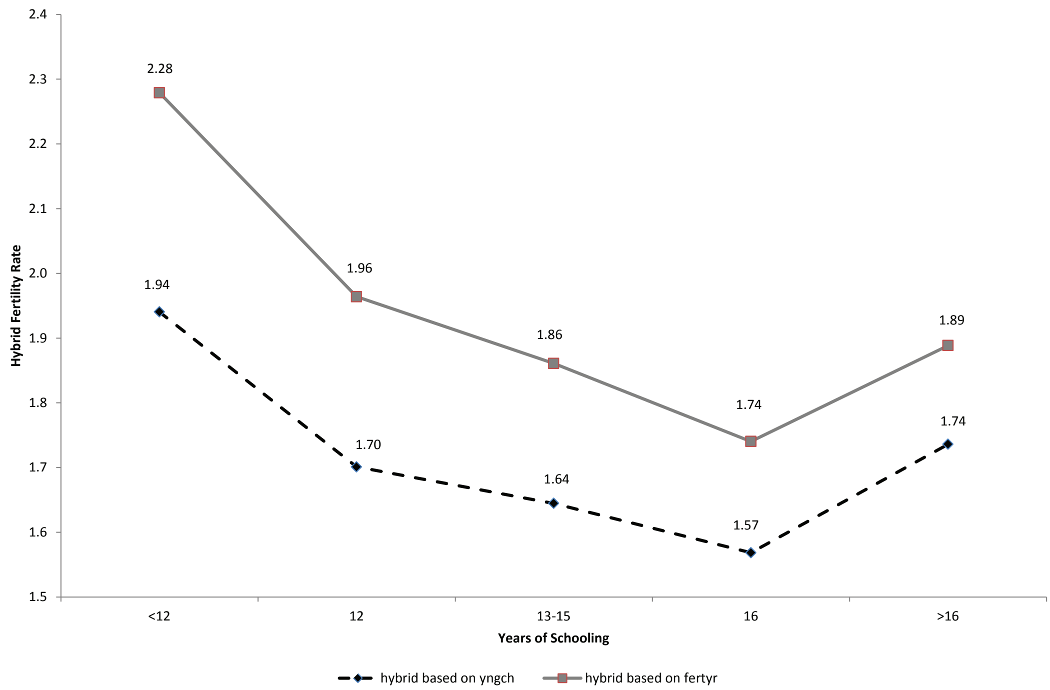

Figure 4: Two estimates for Hybrid Fertility Rate, 2001-2011. The hybrid fertility rate sums up the number of children ever born to women at age a and the age-specific-fertility rates from age $a + 1$ to 49. We assume $a = 24$. Authors' calculations using the American Community Survey.

the fertility of women with an advanced degree, relative to women with lower levels of education.

2.4 Hybrid and Completed Fertility Rates

Although our analysis is mostly concerned with hybrid fertility rates, our objective is to argue that what is observed in hybrid fertility rates today is likely to be translated into completed fertility rates for cohorts that have not yet completed their fertility.[19] Since completed fertility is estimated for women approaching the end of their fertile period, usually taken to be 40-44 years of age, the new patterns

[19]Preston and Sten Hartnett (2008) showed that, with the exception of the baby-boom period, TFR and completed fertility rate in the U.S. almost coincide during the twentieth century.

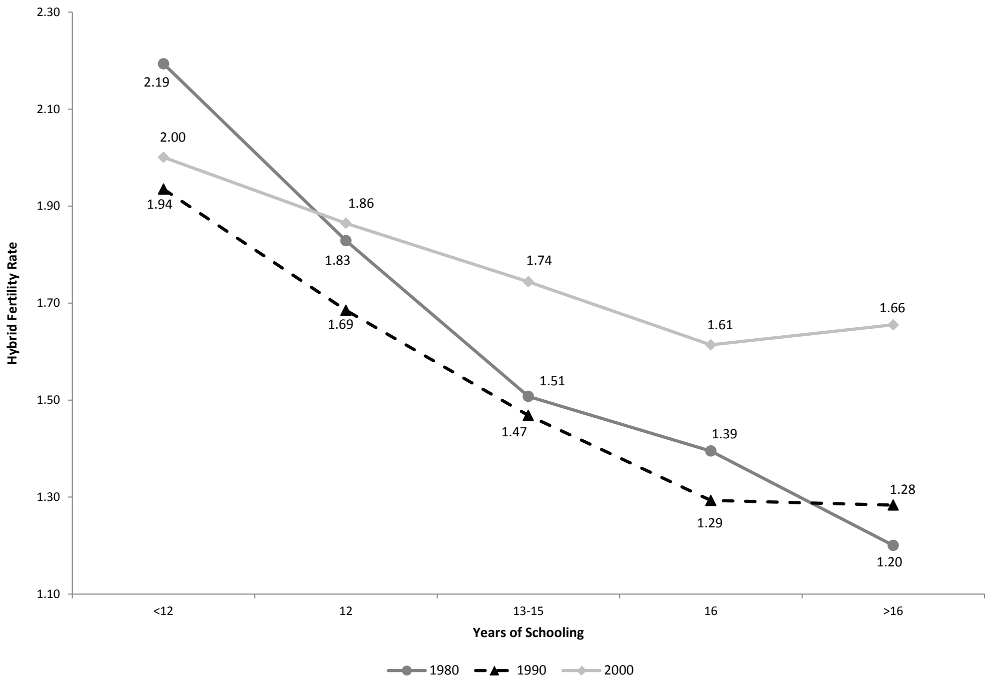

Figure 5: Hybrid Fertility Rate, 1980, 1990 & 2000. The hybrid fertility rate sums up the number of children ever born to women at age a and the age-specific-fertility rates from age $a + 1$ to 49. We assume $a = 24$. Authors' calculations using Census data.

exhibited in Figures 2, 3 and 5 are still not reflected in the completed fertility even for the youngest cohorts that have reached this age.

It is constructive, however, to look at the pattern of the completed fertility rate by education for cohorts who have recently reached the end of their fertile period. Using data from the 1990 census as well as data from the Fertility Supplement of the June Current Population Survey for the years 1995, 2000, 2004, and 2008, we estimate completed fertility by education for women aged 40-44. This covers the cohorts born between 1946 and 1968. These estimates are shown in Figure 6.

Two features in Figure 6 are worth mentioning. First, completed fertility monotonically declines across the educational groups for all cohorts. Second, across cohorts the curves shift counter clockwise around the some college group. This feature supports our conjecture as differential fertility between the least and the most educated groups of women contracts and the level of fertility for women

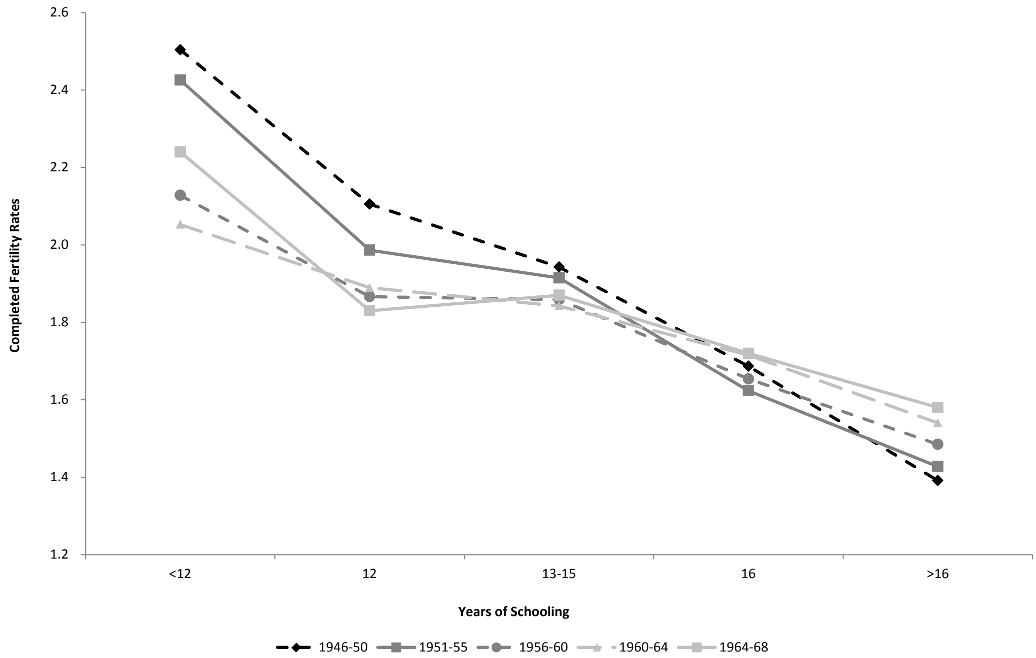

Figure 6: Completed Fertility Rates by Education for cohorts born between 1946 and 1968. Authors' calculations using data from the 1990 Census and the Fertility Supplement of the June Current Population Survey for the years 1995, 2000, 2004 and 2008.

with advanced degrees monotonically increases across cohorts.

3 The Model

3.1 Structure

There is a continuum of mass one of adult individuals that differ by their level of human capital. Each Individual forms a household, works, and chooses consumption and her number of children. Children are being raised and educated. Education is provided by the market through schools. To raise children, households combine the parent's time and time purchased in the market. Likewise, households combine parent's time, time purchased in the market along with a market good to produce the consumption good. This market good serves as the numeraire. Finally, the remaining time is allocated to labor market participation.

Let h_i denote the human capital of individual i, which also equals her market productivity. The preferences of household i are defined over consumption, c_i, and total full income of the children, $n_i h_i'$. They are represented by the utility function:

$$u_i = \ln(c_i) + \ln(n_i h_i'). \tag{1}$$

The budget constraint is:

$$h_i = p_{ci} c_i + p_{ni} n_i + n_i p_{ei} e_i, \tag{2}$$

where p_{ci}, p_{ni} and p_{ei} are the prices of consumption, quantity of children, and children's education, e_i, faced by parent i, respectively.

Children's human capital, h_i', is determined by their level of education, e_i ,and basic skills with which nature equips each child, $\eta > 0$, regardless of her parent's characteristics. The human capital production function is:

$$h_i' = (e_i + \eta)^{\theta}, \qquad \theta \in (0, 1). \tag{3}$$

Education is provided in schools. We assume that the average level of human capital among teachers is $\bar{h}$. We follow de la Croix and Doepke (2003) by assuming that $\bar{h}$ is the average human capital in the economy, $\bar{h} = \int_0^\infty h_i dF(h_i)$, where $F(h_i)$ is the distribution of human capital, although nothing hangs on this choice. As all parents face the same market price for education, $p_{ei} = p_e = \bar{h}$ the cost of educating n_i children at the level e_i is given by

$$TC_i^e = n_i p_e e_i = n_i \bar{h} e_i. \tag{4}$$

Raising children requires time independent of education. The time required to raise n children can be supplied by the parent or bought in the market, e.g., child-care or baby sitters. The production function of raising n children is:

$$n = (t_M^n)^{\phi}(t_B^n)^{1-\phi}, \qquad \phi \in (0,1) \tag{5}$$

where t_M^n is the time devoted by the mother and t_B^n is the time bought in the market, e.g., a babysitter.[20] We assume that the price of one unit of time bought in the market is some level of human capital denoted by $\underline{h}$. This implies that $\underline{h}$ is the average human capital among babysitters.

The cost of raising n children is, therefore, given by the cost function,

$$TC^n(n, \underline{h}, h^i) = \min_{t_M^n, t_B^n} \{t_M^n h_i + t_B^n \underline{h} : n = (t_M^n)^{\phi}(t_B^n)^{1-\phi}\}.$$

The optimal t_M^n and t_B^n are:

$$t_M^n = \left(\frac{\phi}{1-\phi}\frac{\underline{h}}{h_i}\right)^{1-\phi} n \tag{6}$$

and

$$t_B^n = \left(\frac{1-\phi}{\phi}\frac{h_i}{\underline{h}}\right)^{\phi} n. \tag{7}$$

Using these optimal levels we obtain the cost function:

$$TC^n(n, \underline{h}, h^i) = p_{ni} n = \varphi \underline{h}^{1-\phi} h_i^{\phi} n, \tag{8}$$

where $\varphi \equiv (\phi^{\phi}(1-\phi)^{1-\phi})^{-1}$.

Notice from (8) that the marginal cost of raising children is constant. Moreover, this marginal cost increases with the mother's human capital, although its elasticity with respect to the mother's human capital is $\phi < 1$.

[20]This modeling approach is similar to Greenwood, Seshadri and Vandenbroucke (2005).

Following Becker (1965), the consumption good that enters directly into the utility function is produced by combining time and a market good. However, our extension here is that the time allocated to this production can be either supplied by the mother or purchased in the market. The production function is:

$$c = m^{1-\alpha}\left[(t_M^c)^\sigma + (t_H^c)^\sigma\right]^{\alpha/\sigma}, \qquad \sigma \in (0,1)$$

where m is the market good and $\frac{1}{1-\sigma} > 1$ is the elasticity of substitution. That is, t_M^c and t_H^c are assumed to be gross substitutes. This assumption captures the idea that a mother's time and the time of a housekeeper is highly substitutable.[21] We assume that the price of one unit of time bought in the market is $\hat{h}$. This implies that $\hat{h}$ is the average human capital among housekeepers.

The cost of c units of consumption is, thus, given by the cost function,

$$TC^c(c, \hat{h}, h^i) = \min_{m, t_M^c, t_H^c} \{m + t_M^c h_i + t_H^c \hat{h} : c = m^{1-\alpha}\left[(t_M^c)^\sigma + (t_H^c)^\sigma\right]^{\alpha/\sigma}\}.$$

The optimal t_M^c and t_H^c are:

$$t_M^c = \frac{\left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha}}{h_i^{1-\alpha}\left(1 + \left(\frac{h_i}{\hat{h}}\right)^{\frac{\sigma}{1-\sigma}}\right)^{1+\alpha\left(\frac{1}{\sigma}-1\right)}} c \tag{9}$$

and

$$t_H^c = \frac{\left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha} h_i^{\alpha + \frac{\sigma}{1-\sigma}}}{\hat{h}^{\frac{1}{1-\sigma}}\left(1 + \left(\frac{h_i}{\hat{h}}\right)^{\frac{\sigma}{1-\sigma}}\right)^{1+\alpha\left(\frac{1}{\sigma}-1\right)}} c \tag{10}$$

[21]Notice that we assume that mother's time and housekeeper's time in producing the consumption good are more substitutable than mother's time and baby-sitter's time in raising children. This assumption can be justified by noting that pregnancy and breastfeeding are less substitutable than cleaning and cooking. For example, Sacks and Stevenson (2010) reporting that during the 2000s, mothers on average spend well over 2 hours a day breastfeeding their infants.

Substituting these optimal factors into the cost function yields:

$$TC^c(c,\hat{h},h^i) = p_c c = \frac{h_i^\alpha}{\omega\left(1+\left(\frac{h_i}{\hat{h}}\right)^{\frac{\sigma}{1-\sigma}}\right)^{\alpha\left(\frac{1}{\sigma}-1\right)}} c, \tag{11}$$

where $\omega = \alpha^\alpha(1-\alpha)^{1-\alpha}$.

3.2 Equilibrium

Given the prices of quality of children, quantity of children, and consumption in equations (4), (8) and (11), respectively, the solution to maximizing (1) subject to the budget constraint, (2) yields:

$$e_i = \begin{cases} 0 & if \quad h_i \leq \left(\frac{\eta\bar{h}}{\theta\varphi\underline{h}^{1-\phi}}\right)^{\frac{1}{\phi}} \equiv h_e \\ \frac{\theta\varphi\underline{h}^{1-\phi}h_i^\phi - \eta\bar{h}}{\bar{h}(1-\theta)} & otherwise. \end{cases} \tag{12}$$

Notice that for parents with low human capital, η could be large enough that the optimal level of education is zero. We ignore henceforth this corner solution by assuming that the lowest level of parental human capital is above h_e. Consequently, the optimal level of fertility is given by:

$$n_i = \frac{h_i(1-\theta)}{2(\varphi\underline{h}^{1-\phi}h_i^\phi - \eta\bar{h})}, \tag{13}$$

and

$$c_i = \frac{\omega}{2} h_i^{1-\alpha}\left(1+\left(\frac{h_i}{\hat{h}}\right)^{\frac{\sigma}{1-\sigma}}\right)^{\alpha\left(\frac{1}{\sigma}-1\right)}. \tag{14}$$

Equations (6), (7), (9), (10), (12), (13) and (14) yield the following seven propositions.

Proposition 1 *The educational choice, e^*, is strictly increasing in h_i for all $h_i > h_e$.*

Proof: Follows directly from differentiating equation (12) with respect to h_i. $\square$

The intuition behind this result is straightforward. With a log linear utility function from consumption and full income of the children, the optimal level of education is independent of the parent's human capital, since any additional unit of education is given to all children equally. Moreover, since any additional child will be given the same education as her siblings, the optimal level of education depends negatively on the price of education (quality) relative to fertility (quantity).

The value of parental time is equal to her human capital. While quality is bought in the market at a given cost, independently of the parents human capital, quantity requires some of the parent's time and, thus, its price positively depends on the parent's human capital. Consequently, the relative price of quality declines in the parent's human capital, yielding a higher investment in education.

Notice that as the parent's human capital increases, the share of income that is allocated to the quality of each child increases on the expense of the share of income allocated to quantity. The intuition for this is simple. For low income parents, the basic skill, η, which is equivalent to $\eta\bar{h}$ in terms of income, is relatively important. As a result, parents find it optimal to invest a large share of income in quantity and a low share in quality. In contrast, for high income parents, the value of the basic skill in term of income, $\eta\bar{h}$, is relatively small, which induces parents to allocate a higher share of income for quality on the expense of quantity.

Proposition 2 *The fertility choice, n^* is U-shaped as a function of h_i*

Proof: Differentiating (13) with respect to h_i yields:

$$\frac{\partial n^*}{\partial h_i} = \frac{(1-\theta)\left((1-\phi)\varphi\underline{h}^{1-\phi}h_i^{\phi} - \eta\bar{h}\right)}{2\left(\varphi\underline{h}^{1-\phi}h_i^{\phi} - \eta\bar{h}\right)^2}.$$

Thus,

$$\frac{\partial n^*}{\partial h_i} \begin{cases} < 0, & \text{for } h_i < \tilde{h} \\ = 0, & \text{for } h_i = \tilde{h} \\ > 0, & \text{for } h_i > \tilde{h} \end{cases}$$

Where $\tilde{h} = \left(\frac{\eta\bar{h}}{(1-\phi)\varphi\underline{h}^{(1-\phi)}}\right)^{\frac{1}{\phi}}$ □

The intuition behind this result is as follows. As described above, the optimal level of education depends on the relative price of quality and the basic skill. Fertility, however, depends on the share of income allocated to quantity and the price of an additional child. Above, we already explained that the share of income allocated to quantity decreases with the parent's human capital. We now turn to analyzing how the price for quantity changes with the parent's human capital to determine the optimal level of quantity.

Marketization is an essential element in our mechanism that yields the U-shaped fertility pattern. Let us ignore for the moment this marketization channel, and assume that quantity requires parents' time only. In this case, with an increase in parent's human capital, both the parent's income and the price for quantity increase by the same proportion. Since parents allocate a lower share of their income to quantity, the optimal number of children monotonically declines.

Marketization, however, affects the price for quantity that parents face. For parents with low levels of human capital, (i.e., low income), marketization is low and most of the child raising is done by parents. Thus, the intuition explained above holds. Parents with high levels of human capital, in contrast, outsource a major part of child raising, which, in turn, reduces the price of children from the parents' point of view. This reduction could be sufficiently large enough to induce an increase in fertility.

Notice from equation (8) that the price of quantity is $\varphi\underline{h}^{1-\phi}h_i^{\phi}$. Thus, although it increases with the parents' human capital, marketization causes this price to increase at a lower pace than income does.[22] Thus, for all $h_i > \tilde{h}$, marketization

[22]Notice that the Cobb-Douglas production function for quantity is not crucial for this result. The Appendix provides proof that this result holds for any CES production function.

implies that the share of income allocated to quantity decreases at a lower pace than the price does, causing fertility to increase.

Proposition 3 *Mother's time spent on raising children (quantity), t_M^n, is strictly decreasing with income, h_i.*

Proof: Substituting (13) into (6) gives:

$$t_M^n = \frac{(1-\theta)}{2}\left(\frac{\phi}{1-\phi}\right)^{1-\phi}\frac{\underline{h}^{1-\phi}h_i^{\phi}}{(\varphi\underline{h}^{1-\phi}h_i^{\phi}-\eta\bar{h})}, \tag{15}$$

differentiating (15) with respect to h_i, yields:

$$\frac{\partial t_M^n}{\partial h_i} = -\phi\left(\frac{\phi}{1-\phi}\right)^{1-\phi}\frac{(1-\theta)}{2}\frac{\eta\bar{h}\,(\underline{h}/h_i)^{1-\phi}}{\left(\varphi\underline{h}^{1-\phi}h_i^{\phi}-\eta\bar{h}\right)^2} < 0.$$

$\square$

The intuition here is straightforward. First, with a log linear utility function as given in (1), the share of resources allocated to children is one-half. Secondly, as discussed above, the share of income allocated to quantity is declining in h_i. Finally, since child-care and the mother's time are aggregated using a homothetic production function, the share of income allocated to each one of these two factors is independent of h_i. Thus, the parents' time that is allocated to quantity declines with the mother's education. In Section 3.3 below, we extend the model in such a way that the mother's time is also used for producing a child's quality and showing that the mother's total time spent on children can increase, which is consistent with the empirical findings from the time use data (e.g. Guryan et al. 2008, Ramey and Ramey 2010).

Proposition 4 *Mother's time spent on home production, t_M^c, is strictly decreasing with income, h_i.*

Proof: Substituting (14) into (9) yields

$$t_M^c = \frac{\alpha}{2\left(1 + \left(h_i/\hat{h}\right)^{\frac{\sigma}{1-\sigma}}\right)}, \tag{16}$$

which is, unambiguously, decreasing in h_i □

Since the consumption good is a Cobb-Douglas aggregate of the market good and time, the share of resources allocated to each one of these factors is independent of h_i. However, the assumed gross substitutability between a mother's time and a housekeeper's time yields a declining time spent by the mother as its price, h_i, increases.

Proposition 5 *The labor supply, $l^* \equiv 1 - t_M^n - t_M^c$, is strictly increasing with mother's income, h_i.*

Proof: Follows directly from propositions 3 and 4 □

Proposition 6 *The amount of baby-sitter services purchased in the market, t_B^{n*}, is strictly increasing with income for all $h_i \geq \left(\frac{(1+\phi)\eta\bar{h}}{\varphi\underline{h}^{1-\phi}}\right)^{\frac{1}{\phi}} \equiv h_B$.*

Proof: Follows directly by substituting (13) into (7) and differentiating with respect to h_i □

Proposition 7 *The amount of housekeeping services purchased in the market, t_H^{c*}, is strictly increasing with the mother's income, h_i.*

Proof: Follows directly from substituting (14) into (10) and differentiating with respect to h_i. □

As we will show in Section 4.2, purchase of child-care monotonically increases with women's education. Hence, we would like to verify that there exist a range of h_i in which our model can concurrently generate (i) $\frac{\partial e_i}{\partial h_i} > 0$, (ii) $\frac{\partial t_B^n}{\partial h_i} > 0$ and (iii)

n_t exhibits a U-shaped relationship with h_i. Notice that (i) requires that $h_i > h_e$, (ii) requires that $h_i > h_B$ and (iii) requires that $\tilde{h} > \max\{h_e, h_B\}$.

Comparing $\tilde{h}$ and h_B, it follows that $\tilde{h}$ is always larger than h_B. Thus, it is sufficient to require that h_e is smaller than h_B, a condition which is satisfied if and only if $\frac{1}{1+\phi} < \theta$. Hence, we assume that the lowest level of parental human capital is above h_B.[23]

3.3 Extensions

In this section we extend our basic model. We consider two separate extensions. The first extension is conducted to show that our model can account for the positive correlation between a mothers education and time spent with children observed in the data. The second extension incorporates husbands into our unitary household framework. The husbands time is optimally allocated between child raising and labor supply. It turns out that including husbands and assuming positive assortative matching does not change, qualitatively, any of our results.

3.3.1 Mother-Teacher Complementarity in Human Capital Acquisition

The model analyzed above is consistent with data on time allocated to the labor market and to home production (excluding childcare). However, it also suggests that a mother's time spent allocated to raising children decreases with the mother's education. This is because the increasing part of the U-shaped fertility pattern in our model is obtained from the availability of market services, which are relatively cheap for highly educated mothers. As discussed in the Introduction, Guryan et al. (2008) find that a mother's time allocated to childcare increases with the mother's education. As also discussed in the Introduction, however, Guryan et al. defined childcare as the sum of four primary time use components: "basic", "educational", "recreational", and "travel". Clearly, the educational and

[23]Finally, since h_B is a function of $\underline{h}$ and $\bar{h}$, we should assure that $\underline{h}$ and $\bar{h}$ are larger than h_B. From the definition of h_B, it follows that if $\frac{\bar{h}}{\underline{h}^{1-\phi}}$ is constant, then h_B is independent of $\underline{h}$ and $\bar{h}$.

recreational components and part of the travel component are an investment in the children's quality, a component which, in our model, is bought in the market.

Ramey and Ramey (2010) reconcile the seemingly paradoxical allocation of time, according to which mothers with a higher opportunity cost of time spend more, rather than less time, with their children despite the availability of market substitutes. They argue that as slots in elite postsecondary institutions have become scarcer, parents responded by investing more in their children's quality so that they appear more desirable to college admissions officers. Since more educated parents spend more of their own time and on market goods and services related to the child's quality, it implies that parental time and market goods and services are strong complements in the production of the children's quality.

To capture this idea, we extend our model by assuming that a child's quality requires not only education bought in schools but also parental time. Thus, consistent with our notation, let child's education be

$$e_i = \left[(t^e_{SC})^\zeta + (t^e_M)^\zeta\right]^{1/\zeta}, \tag{17}$$

where t^e_{SC} and t^e_M are the time invested in education provided by the school and parent, respectively; and $\zeta \in (-\infty, 0)$.[24]

To convey our idea in a simple example we assume that there is perfect complementarity between school time and parental time invested in children's education. Formally we assume that $\zeta = -\infty$ and (17) becomes $e_i = \min\{(t^e_{SC}), (t^e_M)\}$. This implies that at the optimum, for any unit of time provided by the school, a similar unit is provided by the parent in order to produce a unit of education:

$$e_i = t^e_{SC} = t^e_M, \tag{18}$$

[24] One may argue that more educated mothers and teachers are better able to produce educated children through tutoring. Formally, we can modify (17) to: $e_i = \left[\bar{h}(t^e_{SC})^\zeta + h_i(t^e_M)^\zeta\right]^{1/\zeta}$, which yields the following cost function: $TC^e_i = n_i p_e e_i = n_i(\bar{h} + h_i)^{1-\frac{1}{\zeta}} e_i$. As will become apparent momentarily as ζ approaching $-\infty$ this solution coincides with the solution shown in equation (19). More generally, for a sufficiently small ζ, the qualitative results presented in this section hold under this modification.

and the cost of education, equation (4), becomes:

$$TC_i^e = n_i p_e e_i = n_i(\bar{h} + h_i)e_i. \tag{19}$$

Given this new price for quality of children in equation (19), the price of quantity of children and consumption in equations (8) and (11), respectively, the solution to maximizing (1) subject to the budget constraint, (2) becomes:

$$e_i = \frac{\theta\varphi\underline{h}^{1-\phi}h_i^{\phi} - \eta(\bar{h} + h_i)}{(\bar{h} + h_i)(1-\theta)}, \tag{20}$$

$$n_i = \frac{h_i(1-\theta)}{2(\varphi\underline{h}^{1-\phi}h_i^{\phi} - \eta(\bar{h} + h_i))}. \tag{21}$$

Notice that as in the basic model, the economic forces that are behind the U-shaped fertility pattern and the increasing relationship between parental education and children's education are still at work: the decreasing part in fertility is due to a lower share of income that is allocated for quantity and the increasing part is due to the greater use of babysitter services as parental education increases. Likewise, children's education is positively affected by the price of quantity relative to the price of quality. However, the price of quality is now increasing with the parent's education and, therefore, some additional conditions are necessary. Secondly, the positive relationship between parental education and children's education along with the complementarity between parental time and schooling time in producing a child's education implies that the time invested by parents also increases with the parents' education. Finally, the steepness of the relationship between parental education and parental time spent on children's education can be sufficiently high enough that it dominates the reduction in parental time allocated to raising children induced by the existence of market substitutes such as babysitters and child-care. In this event, the total time spent by parents on children increases with parental education. Deriving analytical conditions under which the total time spent on children is increasing with the mother's education is complicated, however, and, consequently, we illustrate the ability of the model to account for this empirical fact, while maintaining all of the desired results of

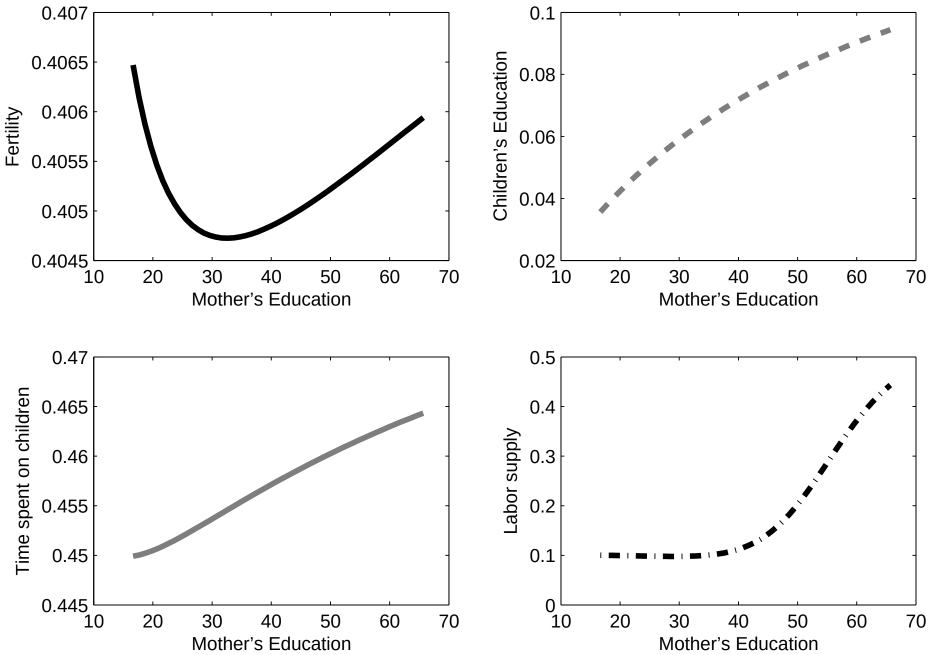

Figure 7: Numerical Example: Fertility, Children's Education, Mother's time Spent of Childcare and Labor Supply. Parameter values: $\hat{h} = 16.67, \underline{h} = 25, \bar{h} = 50, \alpha = 0.9, \theta = 0.15, \phi = 0.985, \sigma = 0.9, \eta = 0.0105$.

the model using a numerical example.

Specifically, Figure 7 shows that fertility is U-shaped as a function of the mother's education and that the children's education can increase with the mother's education, even when the marginal cost of education is increasing with the mother's education. The figure also shows that the sum of time devoted to both quantity and quality by the mother, that is the total time allocated to childcare, is increasing with the mother's education. Finally, labor supply is increasing with the mother's education. Notice that the margin that allows parents to spend more time with their children and supply more hours to the labor market is the availability of housekeeping services, a service which highly educated mothers use more than mothers with lesser education.

3.3.2 A Two Person Household

In this section we extend our household to include not only mothers but also fathers. Generally, we would like to check the robustness of our results to the inclusion of husbands into the household decision problem. Particularly, we would like to examine the extent to which husbands of more educated wives could substitute their wives in raising children.

Formally, our households' budget constraint given in (2) becomes

$$h_i + h_s = p_{ci}c_i + p_{ni}n_i + n_i p_{ei}e_i, \tag{22}$$

where h_s is the human capital of the spouse (husband). We assume that husbands can also raise children and thus modify (5) to become

$$n = (t^n_M)^{\phi}(t^n_s)^{\lambda}(t^n_B)^{1-\phi-\lambda}, \qquad \phi, \lambda > 0\ ;\ \phi + \lambda < 1,$$

where t^n_s is the time spent by the husband in raising children. Consequently, the cost function of raising n children becomes

$$TC^n(n, \underline{h}, h^i, h_s) = \min_{t^n_M, t^n_s, t^n_B} \{t^n_M h_i + t^n_s h_s + t^n_B \underline{h} : n = (t^n_M)^{\phi}(t^n_s)^{\lambda}(t^n_B)^{1-\phi-\lambda}\}.$$

The optimal levels of t^n_M, t^n_s and t^n_B are:

$$t^n_M = \frac{\phi^{1-\phi}}{\lambda^{\lambda}(1-\phi-\lambda)^{1-\phi-\lambda}} \frac{h_s^{\lambda}\underline{h}^{1-\phi-\lambda}}{h_i^{1-\phi}} n, \tag{23}$$

$$t^n_s = \frac{\lambda^{1-\lambda}}{\phi^{\phi}(1-\phi-\lambda)^{1-\phi-\lambda}} \frac{h_i^{\phi}\underline{h}^{1-\phi-\lambda}}{h_s^{1-\lambda}} n \tag{24}$$

and

$$t^n_B = \frac{(1-\phi-\lambda)^{\phi+\lambda}}{\lambda^{\lambda}\phi^{\phi}} \frac{h_i^{\phi}h_s^{\lambda}}{\underline{h}^{\phi+\lambda}} n. \tag{25}$$

Dividing (23) by (24) we get $t_M^n/t_s^n = (\phi/\lambda)\cdot(h_s/h_i)$. This reflects the substitutability between the spouses as a result of changes in relative opportunity cost of time. Notice that an increase in h_j, $j = \{i, s, B\}$ leads to a decrease in j's time spent on child-care and to an increase in the time spent on child-care by $-j$. Cherchye et al. (2012) found similar results in a collective model in which each spouse allocates its time to work, leisure, home production, and child-care.

A stylized fact of the marriage market is assortative matching on socioeconomic backgrounds such as parental wealth (Charles et al. 2013) and spousal education (Pencavel 1998). To keep our model simple, we abstract from the marriage market and assume that h_i and h_s are positively correlated. An extreme example would compare two couples whose h_i and h_s is the same up to a multiplicative constant. As evident from the above discussion, the ratio of time spent on raising children would be the same between the two couples. However, as apparent from (25), the richer couple would allocate less time for raising children and purchase more baby-sitting services. More generally, without making strong assumptions about the distributions of h_i and h_s and how exactly women and men are matched, our model cannot say much about the relationship between women's human capital and the time spent on child-care of mothers vis-a-vis fathers. Nevertheless, a positive correlation between h_i and h_s is sufficient to ensure that mothers with higher human capital will purchase more baby-sitting services. In Section 4.2 we provide direct evidence on purchases of child-care services and show that it monotonically increases with mothers' education.

Equations (23), (24) and (25) can be combined to yield the cost function:

$$TC^n(n, \underline{h}, h^i) = p_{ni}n = \pi\underline{h}^{1-\phi-\lambda}h_i^{\phi}h_s^{\lambda}n, \tag{26}$$

where $\pi \equiv (\phi^{\phi}\lambda^{\lambda}(1-\phi-\lambda)^{1-\phi-\lambda})^{-1}$.

Notice that when λ approaches zero, (23), (25) and (26) collapse to (6), (7) and (8), respectively.

Incorporating the new price of quantity, p_{ni} into the household's optimization problem yields

$$e_i = \frac{\theta\pi \underline{h}^{1-\phi-\lambda} h_i^{\phi} h_s^{\lambda} - \eta\bar{h}}{\bar{h}(1-\theta)}, \tag{27}$$

$$n_i = \frac{(h_i + h_s)(1-\theta)}{2(\pi \underline{h}^{1-\phi-\lambda} h_i^{\phi} h_s^{\lambda} - \eta\bar{h})}, \tag{28}$$

Notice that equations (27) and (28) reveal that the human capital of both spouses appears in a similar manner in the optimal solution of e_i and n_i. Thus, the inclusion of the husbands does not change the qualitative solution of the model. Like in the basic model, education monotonically increases with mothers' human capital, but now it also increases with the fathers' human capital. Similarly, the U-shaped fertility pattern is preserved with respect to the mothers' human capital. Finally, assuming assortative matching, the U-shaped pattern is preserved when comparing couples with different human capital.

4 Fertility and Child-Care Over Time

Our theory is able to fit the qualitative features of the period 2001-2011 quite well. Our explanation builds on the marketization hypothesis and emphasizes that child-care and housekeeping services, which are relatively cheaper for highly educated women, made it possible for these women to have more children and work more than women with intermediate levels of education. However, these services were available in earlier periods as well, when the relationship between fertility and education was monotonically decreasing. Thus, we need to explore if the key explanatory variables in our theory have changed over time in a way that can account for the changing relationship between fertility and education.

4.1 What Drives the Change in the Relationship Between Fertility and Education?

The relationship between fertility and education in our model is governed by the cost of child-care, $\underline{h}$, relative to mother's productivity, h_i. Specifically, the lower this ratio is, the larger optimal fertility is. To explore this idea in a systematic way, we construct a variable to measure this ratio. Using data from the March CPS for the period 1983-2012, we estimate the average hourly wage in the "child day care services" industry and allow it to vary by state and year. We denote this measure by w_{st}^{cc}.[25] This variable should proxy the (absolute) cost of child-care in state s and year t.[26] In addition, we compute the hourly wage of all women in the age group 25-50 years-old who reported a positive salary income and denote it by w_{ist}. We then compute the relative cost of child care by taking the ratio between the two variables.[27] Figure 8 presents the fitted values of the average of this variable for each of our five educational groups. As can be clearly seen from the figure, child-care has become relatively more expensive to women with less than a college degree, while it has become relatively cheaper for women with college or an advanced degree. Note that the changes are quantitatively large. Over the 30 years between 1983 and 2012, the relative child-care cost has increased by 33 percent, 16.5 percent and 5.2 percent for women with less than high-school degree, high-school degree and some college, respectively. In contrast, this relative cost decreased by 9 percent for women with college degrees and by 15.5 percent for women with advanced degrees.

With this measure in hands, we can estimate models, similar to the models in Section 2.2. Specifically, we estimate models of the form:

$$b_{ist} = \alpha + \beta \ln\left(\frac{w_{st}^{cc}}{w_{ist}}\right) + \kappa N_{ist} + X'_{ist} \cdot \gamma + \delta_a + \delta_m + \delta_t + \delta_s + \epsilon_{ist},$$

[25]The industry "Child day care services" is available only from 1983. In principal, we should have $51 \times 30 = 1,530$ year-state cells. In practice, we have only 1,520 because 10 state-year cells have no observations.

[26]We use the word proxy because this measures only the labor component of the cost of child-care services.

[27]To measure the change in the probability of giving birth in response to percentage change in the relative cost of child-care, we take the log of this ratio.

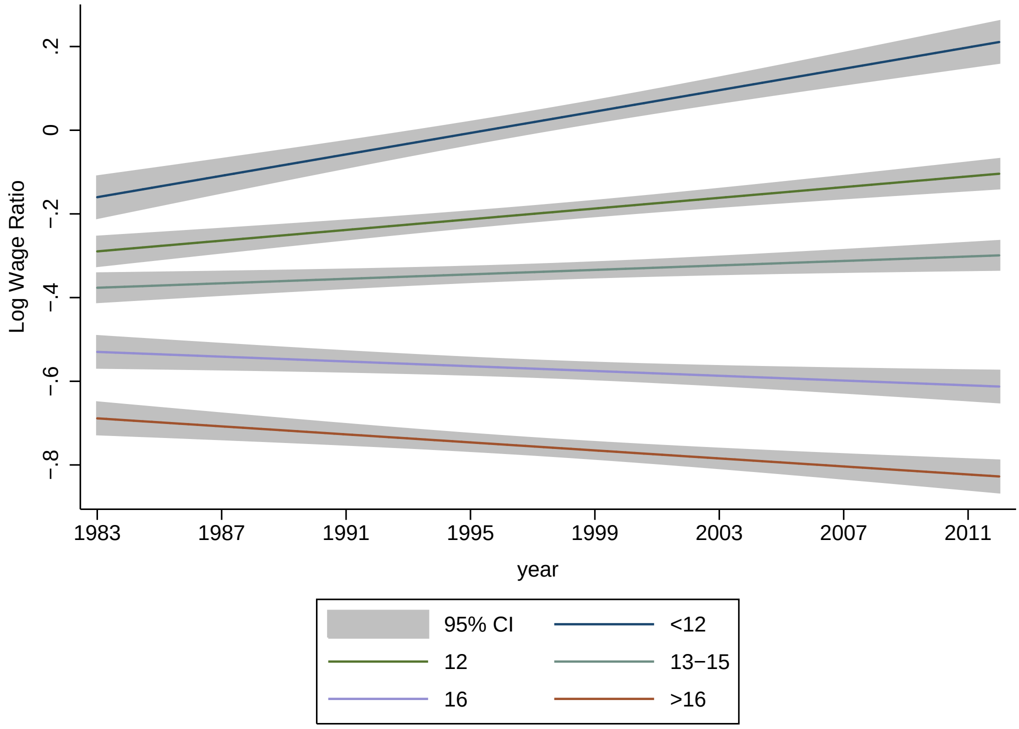

Figure 8: Linear prediction of the log of the ratio of average wage in the child-care services industry to average wage in the 5 educational groups 1983–2012. Authors' calculations using data from the March CPS.

where b_{ist} is a dummy equals to 1 if woman i living in state s gave birth in year t and 0 otherwise, $\ln\left(\frac{w^{cc}_{st}}{w_{ist}}\right)$ is the log of the ratio between the average wage paid to workers in the child-care industry in state s in year t and the wage of woman i, living in state s in year t. N_{ist} is the number of children woman i has, not including the current birth. X'_{ist} includes total personal income, total personal income square, and spouse's wage. δ_a, δ_m, δ_t and δ_s are age, marital status, year, and state dummies, respectively.

The key parameter of interest is β which measures the change in the probability of giving birth in response to a 1 percent change in the relative cost of child-care. Since the log of relative cost varies at the state-year level, we cluster the standard errors at the state level. Table 3 shows the result of estimating these models. As can be seen from models 1 through 5, the coefficient is nearly unchanged by the inclusion of age, marital status, year, and state dummies. In model (6) we include total personal income and total personal income square, measured in hundreds of thousands of 1999 dollars. Notice that controlling for total personal income roughly doubles β (in absolute terms). Finally, model (7), which controls for spouse's wage, expressed in thousands of 1999 dollars, further increases the magnitude of β by another 50 percent (in absolute terms).

While the results in Table 3 strongly support our theory, they suffer potentially from several problems. First, the fact that wages are observed only for working women raises a selection bias problem. Secondly, the wage we observe may be endogenous to the decision to have a baby. For example, the hourly wage during the year a woman is giving birth may be lower than her wage in other years because of a weaker attachment to the labor market or poorer health due to the pregnancy. Table 4 addresses both problems. Each column in Table 4 repeats the specification in Column 7 of Table 3, but uses a different measure for w_{ist} to overcome the selection bias and endogeneity problems. Mulligan and Rubinstein (2008) found that selection into the female workforce was positive since the 1990s. Accordingly, we correct for the selection bias problem by assigning a lower wage for non-working women than for working women, conditional on their characteristics. To overcome the endogeneity problem we predict wages for all women using a standard Mincerian regression. The regressors are years of schooling dummies, age dummies, and state dummies. We estimate the parameters of the wage regression for each year separately because returns to characteristics, such as female experience, have changed over the period 1983-2012 (Olivetti 2006). In Column 1 in Table 4 we take care of the endogeneity of wages by using predicted wages to all women. The coefficient on the relative cost of child care is very close to the one obtained in Column 7 in Table 3. In Column 2 of Table 4 we use wages for women who reported positive labor income and the predicted wages for women who did not report labor income. The coefficient on the relative cost of child care is negative and highly significant, although it is somewhat smaller. In Column 3 we take care of the selection bias problem by predicting wages for women who did not report labor income using a 25^{th} quantile regression, while using wages for women who report labor income.[28] As can be seen, the coeffi-

[28]We use the same regressors and estimate the parameters of the wage regression for each year

cient on the relative cost of child care is negative, highly significant, and almost identical to the coefficient in Column 2. Finally, in Column 4 we take care of the selection bias and endogeneity problem. We do so by predicting wages using a median regression for women who report positive labor income while predicting wages for non-working women using a 25$^{\text{th}}$ quantile regression. The coefficient on the relative cost of child care is negative, highly significant, and very close to the coefficients in Columns 2 and 3.

Another potential concern might be that we pool data for 30 years and that the relationship between the probability of giving a birth and the relative cost of child care we find is driven by a sub-period. Table 5 shows the results of estimating Column 7 in Table 3 separately for each three consecutive years from 1983-1985 to 2010-2012. As can be seen from the table, the estimated parameter of β is highly statistically significant and highly stable over these thirty years.[29]

We can use the estimates of β to estimate the counterfactual hybrid fertility rate in 2001-2011 under the 1983-1985 relative child-care cost. The change in the hybrid fertility rate for each educational group j that is due to the change in the relative cost of child care for this group is given by:

$$\Delta F_j = \beta \left[\ln \left(w^{cc}/w \right)_{jt_1} - \ln \left(w^{cc}/w \right)_{jt_0} \right] \cdot 26,$$

where ΔF_j is the change in hybrid fertility rate, t_1 is 2010-2012 and t_0 is 1983-1985. Recall that b_{ist} is the probability of giving a birth at a given age over a horizon of 26 years of a woman's fertile period.

Figure 9 shows our baseline hybrid fertility (the dark solid line) and adds the counterfactual hybrid fertility measure obtained by subtracting ΔF_j using the estimate of β from model 7 in Table 3 (the dark dashed line). The Figure shows that the counterfactual fertility curve is obtained by a clock-wise rotation of the hybrid fertility curve around the some college education group. Specifically, had child-care costs for women with a college degree and women with advanced

separately.

[29]We repeat the results reported in Table 5 using the measure of the relative cost of child care used in Column 4 of Table 4 and found a negative and statistically significant coefficient in each three-year sample. For brevity, these results are not reported but are available from the authors upon request.

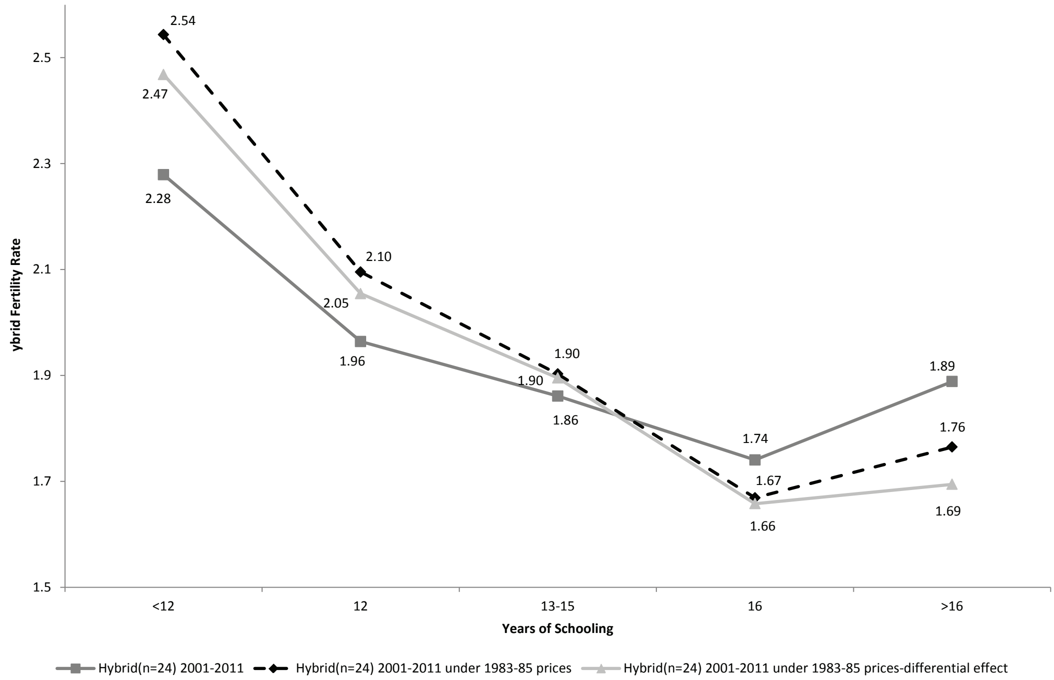

Figure 9: Hybrid Fertility 2001-2011, Counter-Factual: Hybrid Fertility 2001-2011 under 1983-85 prices, Counter-Factual: Hybrid Fertility 2001-2011 under 1983-85 prices – differential effects for each Educational Group. See text for more details.

degrees been constant, their fertility would have been lower by 0.07 and 0.13, respectively. Notice that while the counterfactual fertility is still U-shaped, it is less pronounced.

Our discussion above assumes that the impact of the relative child-care cost on a woman's decision to give birth is independent of their level of education. However, this restricted model ignores other dimensions that may affect the relationship between the decision to give birth and child-care costs. Indeed, one may assume that women care about pursuing a career and that this aspiration increases with women's education. To illustrate this, assume that there are two types of women: uneducated women who do not care about pursuing a career and educated women who do. For the first type, the reduction in the relative cost of child care has a pure price effect. For the second type there is an additional effect that stems from a reduction in the rivalry between children and career. Thus, a reduction in the child care cost should have a larger effect on the probability of having a birth for more educated women. To explore this possibility, we estimate models that allow for differential effects of child-care cost of the following form:

$$b_{ist} = \alpha + \sum_{j=2}^{5} \pi_j e^j_{ist} + \beta \ln\left(\frac{w^{cc}_{st}}{w_{ist}}\right) + \sum_{j=2}^{5} \gamma_j e^j_{ist} \ln\left(\frac{w^{cc}_{st}}{w_{ist}}\right) + \delta_a + \delta_m + \delta_t + \delta_s + \epsilon_{ist},$$

where e^j_{ist} are educational group dummies equal to 1 if woman i is in the j educational group and 0 otherwise. Now the partial association between the relative cost of child-care and the probability of giving a birth equals $\beta + \gamma_j$. Table 6 repeats Table 3. The only difference is the inclusion of the educational dummies and their interaction with the relative cost. As can be seen from the table, the effect increases with the level of education (in absolute terms) and the differences are quantitatively large. Column 7 of Table 6 suggests that the effect for women with advanced degrees is more than double the effect for women with up to some college education.

Figure 9 visualizes these estimates by translating them into the counterfactual hybrid fertility rate in 2001-2011 under the 1983-1985 relative child-care cost. As can be seen from the figure, the counterfactual fertility of women with college education is largely unchanged when we allow the effect to differ by educational groups, but for women with advanced degrees the drop increases by nearly 50 percent, making the cross-sectional relationship between fertility and education almost monotonically decreasing.

These results provide strong support for the marketization hypothesis. Accounting only for the change in the relative cost of child-care can nearly eliminate the U-shaped fertility. Plausibly, if we could take into account changes in the relative cost of other services such as housekeeping, laundry, and takeouts the counterfactual fertility would have looked even more like the cross-section before the 2000s.

4.2 Purchase of Child-Care Services

The previous section shows the response of fertility to the change in the relative cost of child-care. In this section we utilize the child-care module in the Survey of Income and Participation, (henceforth: SIPP) to show how the purchase of child-care services has changed over time across the five educational groups.[30]

We use the topical module of the micro data of the SIPP for the years 1990, 1996, 2001, 2004 and 2008.[31] In 1990, all women with children under 5 specified a main arrangement for child-care and only 4 percent did not specify any hours of child-care. In contrast, in 1996, 2001, 2004, and 2008, between 26 and 28 percent did not specify child-care hours. In all years, the fraction of women with children under 5 who did not specify child-care hours decreased with education. With these caveats in mind, we will now describe the evolution of the cross-sectional relationship between purchased child-care hours and women's education.

Figure 10 shows the average weekly hours of paid child-care by all women in the age group 25-50. Two important observations in this figure are worth mentioning. First, the cross-sectional relationship monotonically increases with education in all years. Second, while there has been a large increase in paid child-care hours by women with college and advanced degrees, there is no clear trend over time for lower educational groups.[32]

[30]Besharov, Morrow and Fengyan Shi (2006) list the major shortcoming of the child-care module in the SIPP. Perhaps the most severe problem is that the SIPP is supposed to interview at least one parent of each child in the household who is under age fifteen, but if a parent is not available, the SIPP allows proxy responses in order to reduce the "person nonresponse" rate. Proxy responses, however, are probably less complete and less accurate than those from the child's mother. Besharov et al. (2006) calculate that proxy respondents constitute between 30 to 40 percent of respondents during the 1990s and early 2000s.

[31]Data were downloaded from:
`http://www.nber.org/data/survey-of-income-and-program-participation-sipp-data.html`

[32]We also calculated expenditures on child-care across the educational groups for these years and found very similar patterns.

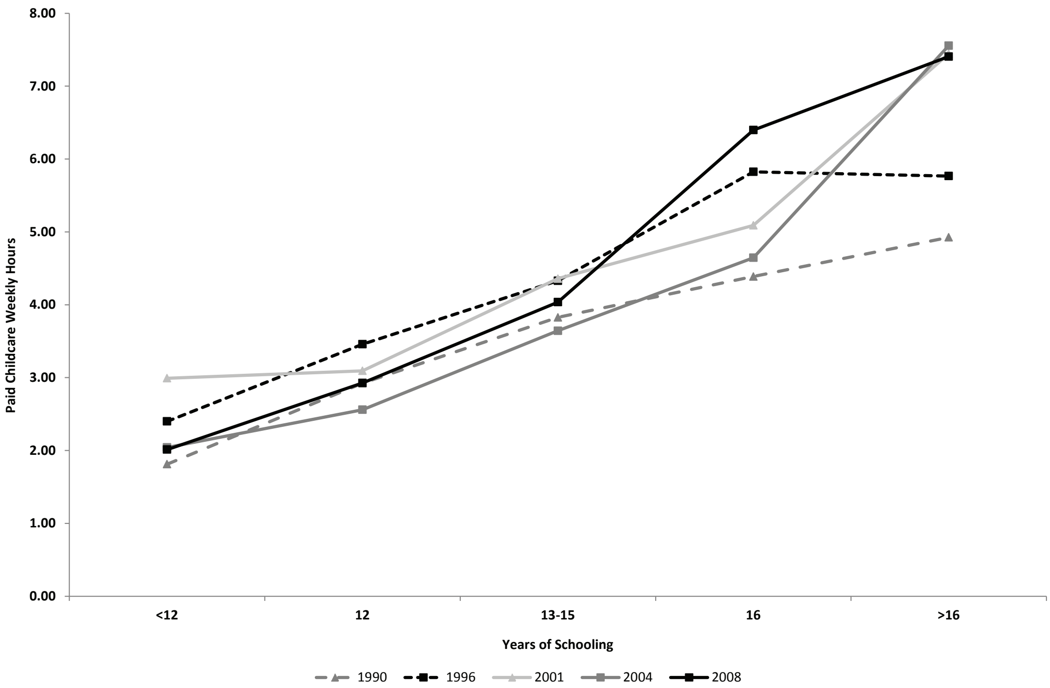

Figure 10: Paid Child-Care Weekly Hours per Woman aged 25-50

5 Supportive Evidence and Alternative Hypotheses

In this section, we provide supportive evidence for our theory and rule out alternative hypotheses. We begin by showing that the number of average hours worked increases monotonically with women's education and that this pattern is true for all women and mothers to newborns regardless of marital status. We then provide evidence against several competing hypotheses related to marriage rates, the role of husbands, and improvements in reproductive technology.

5.1 Labor Supply and Marriage Rates

In Section 2 we have established that the association between fertility and women's education is U-shaped. Using the ACS sample for the years 2001-2011, we present here evidence in support of our model. We begin with labor supply. It is well established that the cross-sectional relationship between female labor supply and education is upward sloping. Figure 11 shows that usual hours worked per week during the past 12 months by women aged 25-50 monotonically increases with education.[33] Notice that the difference across the educational groups is quantitatively large. Among all women aged 25-50, women lacking a high school diploma work somewhat less than 21 hours per week, while women with advanced degrees work more than 36 hours per week.

The positive correlation between fertility and labor supply for women with at least a college degree, however, does not necessarily imply that highly educated women work more and have more children. Since only a small fraction of women give birth in each year, it could be, for example, that women who gave birth in a given year do not work at all during that same year. To address this, Figure 11 also shows the cross-sectional relationship between education and usual hours worked for the sub-sample of women age 15-50 who gave birth during the reference period.[34] As can be seen from the figure, highly educated mothers of newborns work more hours per week than less educated mothers with newborns.

We have thus far shown that highly educated women have higher fertility rates and work more hours, and that among mothers to newborns, usual hours worked increases with education. However, in relation to our model, one concern might be that it is in fact the spouses who respond to a birth by lowering their labor supply and in particular, that fathers to newborns, who are married to highly educated women, reduce their labor supply by more than those who are married to women with lower levels of education. However, Figure 12 shows that this is not the case.

Figure 12 shows that men who are married to highly educated women work more than men who are married to women with lower levels of education, though men who are married to women with advanced degrees work slightly less than men who are married to women with a college degree. Interestingly, fathers to newborns work more than husbands who do not have a newborn at home, regardless of the education of their wives. More importantly, usual hours worked by

[33] We restrict the minimum age to 25 because women with advanced degrees might still be out of the labor market at younger ages.

[34] The figure remains intact if we restrict ages to 25-50, or if we report usual hours by all women for the age group 15-50.

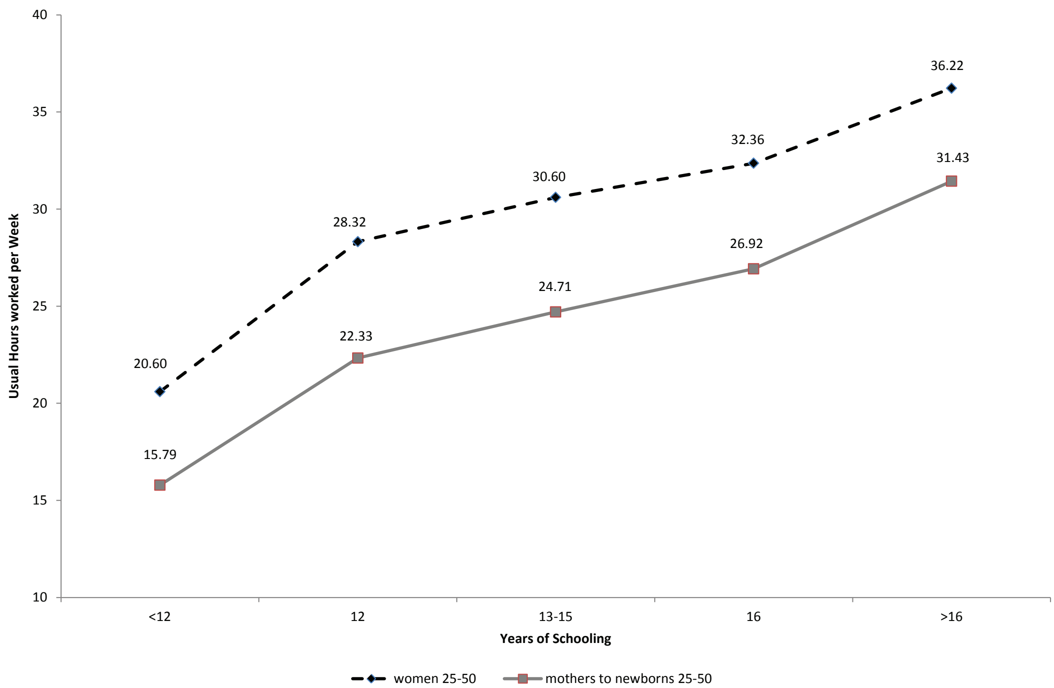

Figure 11: Usual hours worked by women aged 25-50 and women with newborns, 2001-2011. Authors' calculations using data from the American Community Survey.

fathers to newborns monotonically increased with their wives' education. Thus, the spouses of highly educated women are not the ones substituting in childcare for their working wives.

Another concern our model may raise is that marriage rates differ across different educational groups. If married women have higher fertility rates and if more educated women have higher marriage rates, more educated women's higher fertility rates may not be caused by the availability of relatively cheaper childcare and housekeeping services, but rather simply by their higher marriage rates. Figure 13 shows the fraction of currently married women by age-group and education.

As can be seen, the fraction of currently married women increases with age at any level of education and for women above age 30, it increases with educational attainment only through college degrees. Notice that the fraction of women with advanced degrees who are currently married is somewhat lower than that of women with a college degree. Thus, the increase in fertility between women with

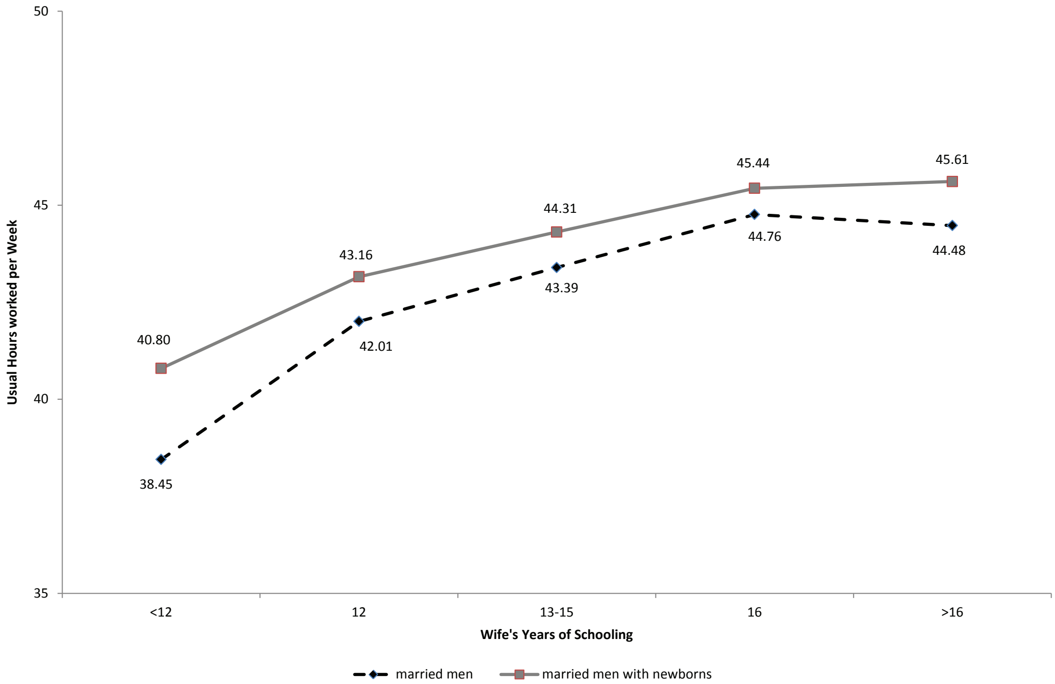

Figure 12: Usual Hours Worked per Week 2001-2011: Married Men by the Educational group of their Wives and Fathers to Newborns. Authors' calculations using data from the American Community Survey.

college degrees and advanced degrees cannot be attributed to marriage rates.

Another concern might be related to the mechanisms that govern these outcomes. For example, it might be that the increase in labor supply of mothers of newborns along the educational gradient, as shown in Figure 11, is driven by the pattern of unmarried mothers, while the reverse is true among married mothers. Figure 14 presents the number of usual hours worked for women aged 15-50 with a newborn by marital status.[35]

Two features stand out from the figure. First, at any level of education, unmarried mothers work more than married mothers. Second, and more importantly for our theory, is the fact that regardless of marital status, usual hours worked increase with women's education. In sum, Figures 12 and 14 imply that the household labor supply increases with the mother's education, regardless of marital status.

[35]Both curves remain intact if we restrict age to 25-50.

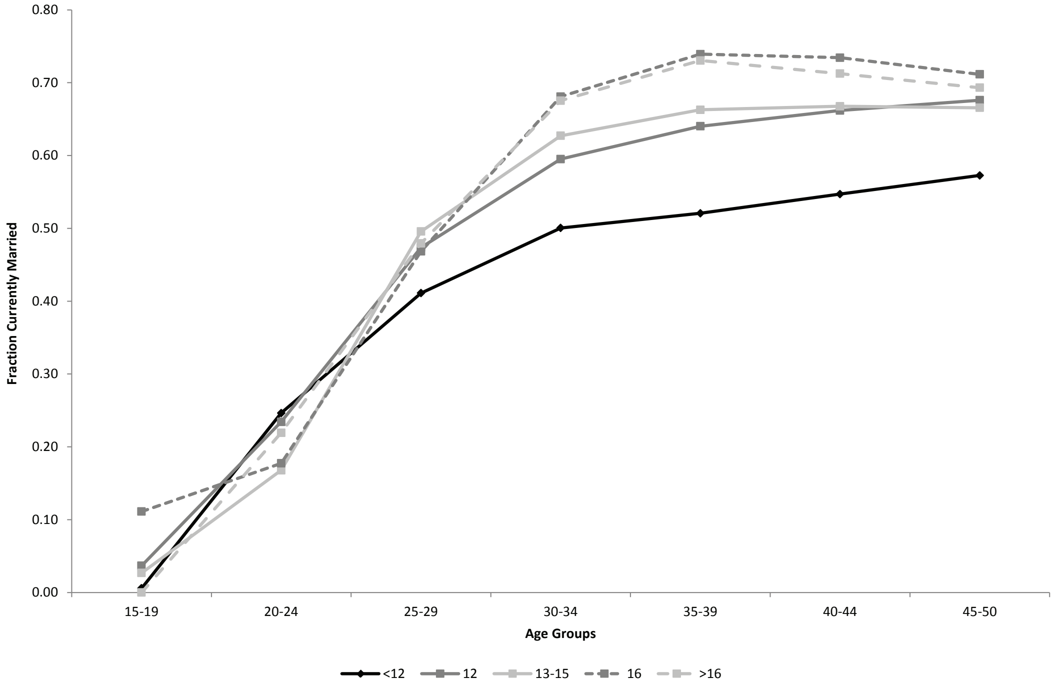

Figure 13: Fraction of currently married women by age and education, 2001-2011. Authors' calculations using data from the American Community Survey.

5.2 Improvement in Reproductive Technology

One possible hypothesis for the rise in fertility among highly educated women is that current reproductive technology allows women today to spend much of their fertile period in school and postpone fertility to relatively old ages, an option that was not available in the past. During the 2000s, the number of births per 1,000 white American women with advanced degrees in the age groups 35-39, 40-44, and 45-49 were 97.3, 24.4 and 4.2, respectively. Are these unprecedentedly high levels of fertility rates for women in these age groups? History suggests this is not the case. In 1920, the number of live births per 1,000 white American women in the age groups 35-39, 40-44 and 45-49 were 79.7, 31.9 and 3.8, respectively. For foreign born whites, the corresponding numbers were 107.4, 42.8 and 5.8, well above the current rates among highly educated women. In several states, fertility rates in 1920 among all white women were even higher. For example, in North Carolina, the number of live births per 1,000 white women in the age

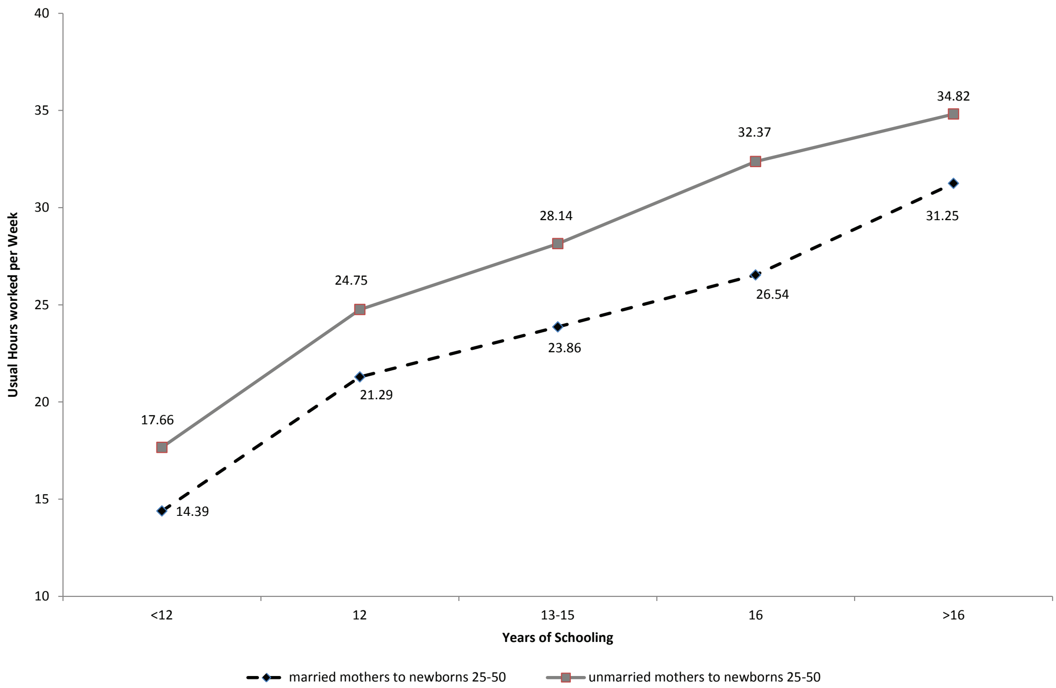

Figure 14: Usual hours worked of women with newborns by marital status, 2001-2011. Authors' calculations using data from the American Community Survey.

groups 35-39, 40-44, and 45-49 were 144.3, 62.1, and 9.9, respectively. The corresponding numbers for Utah are 128.4, 68.2, and 10.8, for South Carolina 114.5, 49.6, and 5.8, for Virginia 114.1, 43.4, and 6, and for Kentucky 100.5, 44.9, and 5.3, respectively.[36] These historical levels of fertility rates among women above age 35 suggest that the current level of fertility among the highly educated is not likely to be driven by reproductive technology that was not available for women at the time when the cross-sectional relationship between fertility and education was monotonically declining.

[36]This data is taken from the Vital Statistics Rates in the United States 1900-1940, Tables 47 and 48.

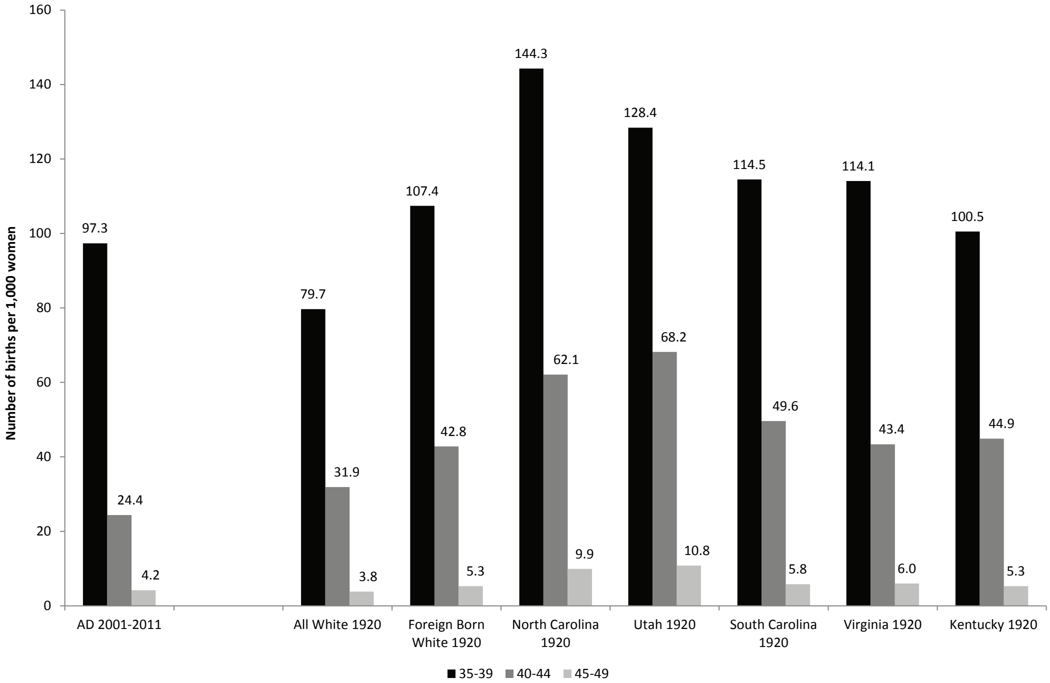

Figure 15: Number of Births per 1,000 White Women in the U.S.: Women with Advanced Degrees 2001-2011 and Historical Rates. Authors' calculations using data from the American Community Survey and Vital Statistics Rates in the United States 1900-1940, Tables 47 and 48.

6 Concluding Remarks

We present new evidence that between 2001 and 2011, the cross-sectional relationship between fertility and women's education in the U.S. is U-shaped. This pattern is robust to controlling for a host of covariates such as family income, marital and age dummies, year, and state of residence dummies. Our analysis of earlier periods shows that this pattern is new, which uncovers an emerging new pattern of cohort fertility. Studying the period 1983-2012, we find that child-care has become relatively more expensive to women with less than a college degree, while it has become relatively cheaper for women with college or advanced degrees. We then show that the association between the probability of giving birth and our measure of the relative cost of child-care services is negative, highly significant, and robust to the inclusions of various controls and different specifications that correct for endogeneity of women's wages and selection bias into the labor market. Moreover, we show that this structural relationship is stable over time and independent of the relative cost of child-care. Conducting a counterfactual exercise we show that the change in the relative cost of childcare over these thirty years accounts for much of the U-shaped pattern.

Our model demonstrates how parents can substitute their own parenting time for market-purchased childcare. We show that highly educated women substitute a significant part of their own parenting with childcare. This enables them to have more children and work longer hours, consistent with the evidence. Furthermore, we show that these highly educated women not only work more and have more children, they invest more in the education of each of their children. This result may have important implications for the relationship between inequality and economic growth . In particular, de la Croix and Doepke (2003) argue that because poorer individuals have more children and invest less in the education of each child, higher inequality leads to lower growth. The evidence presented here that highly educated women choose larger families than women with intermediate levels of education may weaken or even undo this result. Nevertheless, this inquiry is beyond the scope of the current paper and is left for future research.

Our model can also explain the differences in fertility and time allocation of women between the U.S. and Europe. European women spend more time on home production and less time in labor market activities than American women (Freeman and Schettkat 2005). They also give birth to less children. For example, in 2009, the gap in TFR between the U.S. and EU members amounts to nearly one-half of a child per woman. Another noticeable difference between the U.S. and Europe is in the degree of income inequality. For example, according to OECD stat, the Gini coefficient after tax and transfers in the mid 2000s for the working age population was 0.37 in the U.S. while it was 0.31 for all European OECD members. Similarly, the 90-10 ratio during that period in the U.S. was 5.91 while for all European OECD members it was 3.84. In Hazan and Zoabi (2011) we study the aggregate behavior of the current model. Specifically, we compute the average fertility and time allocated to labor market and home production in our model economy. We then analyze the effect of a mean preserving spread of the distribution of women's human capital. This is the model's analogy to the higher income inequality in the U.S. when compared to Europe. Consistent with the data, we find that an increase in inequality leads unambiguously to an increase in average fertility. The predictions of the model with respect to the average time allocated to home production and children depend on the model's parameters. We demonstrate, however, that the time allocated to the labor market and to childcare increase in inequality while the sum of time allocated to childcare and home production decrease in inequality. We believe that research investigating differences between the U.S. and Europe along these lines in greater depth will likely be rewarding.

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Table 1: The association between giving a birth and women's education: 2001-11

	(1)	(2)	(3)	(4)	(5)	(6)
High School Graduates	0.015***	-0.003***	-0.012***	-0.013***	-0.013***	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Some College	0.018***	0.001	-0.015***	-0.015***	-0.016***	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
College Graduates	0.031***	0.008***	-0.007***	-0.007***	-0.008***	
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	
Advanced Degrees	0.038***	0.012***	0.006***	0.006***	0.005***	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Number of children	0.001**	-0.012***	-0.010***	-0.010***	-0.011***	-0.018***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Female earnings: Q1						-0.019***
						(0.001)
Female earnings: Q2						-0.039***
						(0.001)
Female earnings: Q3						-0.041***
						(0.001)
Female earnings: Q4						-0.029***
						(0.001)
Spouse earnings						0.013***
						(0.001)
Other income						0.002**
						(0.001)
Martial Status	No	Yes	Yes	Yes	Yes	–
Age	No	No	Yes	Yes	Yes	Yes
Year	No	No	No	Yes	Yes	Yes
State	No	No	No	No	Yes	Yes
Obs.	4,046,532	4,046,532	4,046,532	4,046,532	4,046,532	2,166,054
R^2	0.003	0.022	0.071	0.071	0.071	0.089

NOTE. Linear probability models. Women aged 15-50. All models are weighted by ACS sampling weights. The main regressors in Columns 1-5 are education dummies and the omitted group is high-school dropouts. Column 6 focuses instead on female earnings. The omitted group is women without labor income and Q1-4 corresponds to the four quartiles of the earnings distribution. Robust standard errors adjusted for heteroscedasticity are reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: The association between giving a birth and women's education: 2001-11

	(1)	(2)	(3)	(4)	(5)	(6)
High School Graduates	0.206***	-0.012	-0.149***	-0.149***	-0.156***	
	(0.015)	(0.011)	(0.013)	(0.013)	(0.013)	
Some College	0.240***	0.021	-0.186***	-0.189***	-0.199***	
	(0.015)	(0.012)	(0.015)	(0.015)	(0.014)	
College Graduates	0.366***	0.080***	-0.119***	-0.122***	-0.134***	
	(0.016)	(0.013)	(0.018)	(0.018)	(0.017)	
Advanced Degrees	0.423***	0.106***	0.009	0.005	-0.008	
	(0.018)	(0.011)	(0.017)	(0.017)	(0.016)	
Number of children	0.015***	-0.099***	-0.072***	-0.073***	-0.074***	-0.168***
	(0.004)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
Female earnings: Q1						-0.171***
						(0.010)
Female earnings: Q2						-0.355***
						(0.012)
Female earnings: Q3						-0.376***
						(0.009)
Female earnings: Q4						-0.282***
						(0.008)
Spouse earnings						0.116***
						(0.007)
Other income						0.014*
						(0.007)
Martial Status	No	Yes	Yes	Yes	Yes	–
Age	No	No	Yes	Yes	Yes	Yes
Year	No	No	No	Yes	Yes	Yes
State	No	No	No	No	Yes	Yes
Obs.	4,046,532	4,046,532	4,046,532	4,046,532	4,046,532	2,166,054

NOTE. Probit models. Women aged 15-50. All models are weighted by ACS sampling weights. The main regressors in Columns 1-5 are education dummies and the omitted group is high-school dropouts. Column 6 focuses instead on female earnings. The omitted group is women without labor income and Q1-4 corresponds to the four quartiles of the earnings distribution. Robust standard errors adjusted for heteroscedasticity are reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: The association between giving a birth and Childcare relative cost: 1983-2012

Dependant Variable: Birth in the past 12 months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Childcare relative cost	-0.008***	-0.012***	-0.011***	-0.010***	-0.011***	-0.023***	-0.032***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.002)
Number of children	-0.008***	-0.003***	-0.014***	-0.014***	-0.015***	-0.015***	-0.020***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Total Personal Income						-0.075***	-0.108***
						(0.008)	(0.012)
Total Personal Income^2						0.025***	0.030**
						(0.006)	(0.010)
Spouse's Wage							0.402***
							(0.053)
Age Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Martial Status Dummies	No	No	Yes	Yes	Yes	Yes	Yes
Year Dummies	No	No	No	Yes	Yes	Yes	Yes
State Dummies	No	No	No	No	Yes	Yes	Yes
Obs.	514,829	514,829	514,829	514,829	514,829	514,829	305,847
R^2	0.003	0.038	0.064	0.065	0.066	0.068	0.079

NOTE. Linear probability models. All models are weighted by CPS sampling weights. Childcare relative cost is the log of the cost of childcare services, varied at the state-year level, relative to mother's wage. Robust standard errors adjusted for heteroscedasticity and clustered at the state level are reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: The association between giving a birth and Childcare relative cost: 1983-2012

Dependant Variable: Birth in the past 12 months

	(1)	(2)	(3)	(4)
Childcare relative cost	-0.035***	-0.024***	-0.023***	-0.020***
	(0.002)	(0.001)	(0.001)	(0.002)
Number of children	-0.018***	-0.019***	-0.018***	-0.018***
	(0.001)	(0.001)	(0.001)	(0.001)
Total Personal Income	-0.061***	-0.089***	-0.095***	-0.063***
	(0.003)	(0.004)	(0.004)	(0.003)
Total Personal Income^2	0.016***	0.020***	0.022***	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)
Spouse's Wage	0.519***	0.499***	0.543***	0.627***
	(0.037)	(0.035)	(0.035)	(0.034)
Obs.	418,347	418,347	418,347	418,347
R^2	0.079	0.080	0.079	0.078

NOTE. Linear probability models. All models are weighted by CPS sampling weights. Robust standard errors adjusted for heteroscedasticity and clustered at the state level are reported in parentheses. Column (1) uses predicted wages for all women. Column (2) uses own wages for women who reported positive wages and predicted wages for those who do not. Column (3) uses own wages for women who reported positive wage and predicted wages from a 25th quantile regression for those who do not. Column (4) uses predicted wages from a median regression for working women and from a 25th quantile regression for those who do not. All models include age, year, and state dummies. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. See note to Table 3 for further details.

Table 5: The association between giving a birth and Childcare relative cost: each three consecutive years 1983-2012

Dependant Variable: Birth in the past 12 months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	1983-85	1986-88	1989-91	1992-94	1995-97	1998-00	2001-03	2004-06	2007-09	2010-12
Childcare relative cost	-0.030***	-0.034***	-0.038***	-0.037***	-0.032***	-0.037***	-0.042***	-0.043***	-0.039***	-0.037***
	(0.005)	(0.003)	(0.005)	(0.004)	(0.004)	(0.005)	(0.003)	(0.003)	(0.005)	(0.004)
Number of children	-0.019***	-0.019***	-0.020***	-0.020***	-0.020***	-0.020***	-0.016***	-0.021***	-0.026***	-0.024***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Total Personal Income	-0.218***	-0.197***	-0.218***	-0.208***	-0.165***	-0.135***	-0.140***	-0.175***	-0.114***	-0.069***
	(0.028)	(0.025)	(0.028)	(0.026)	(0.025)	(0.028)	(0.012)	(0.017)	(0.018)	(0.016)
Total Personal Income^2	0.143***	0.131***	0.146***	0.157***	0.106***	0.049**	0.037***	0.079***	0.029***	0.009*
	(0.026)	(0.024)	(0.028)	(0.029)	(0.021)	(0.017)	(0.007)	(0.013)	(0.008)	(0.004)
Spouse's Wage	0.426*	0.415**	0.035	0.533**	0.428**	0.435*	0.247**	0.187	0.439**	0.283*
	(0.160)	(0.123)	(0.213)	(0.155)	(0.124)	(0.173)	(0.083)	(0.114)	(0.139)	(0.108)
Obs.	26,431	28,114	29,702	29,590	26,602	23,789	41,371	36,873	33,945	30,018
R^2	0.072	0.073	0.075	0.075	0.080	0.080	0.075	0.096	0.103	0.098

NOTE. Linear probability models. All models are weighted by CPS sampling weights. Robust standard errors adjusted for heteroscedasticity and clustered at the state level are reported in parentheses. All models include age, year, and state dummies. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. See note to Table 3 for further details.

Table 6: The association between giving a birth and Childcare relative cost: 1983-2012

Dependant Variable: Birth in the past 12 months

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	birth	birth	birth	birth	birth	birth	birth
Childcare relative cost	-0.002	-0.006***	-0.003**	-0.004***	-0.005***	-0.015***	-0.023***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Childcare relative cost	0.005**	0.003	0.003	0.003*	0.003*	0.001	0.001
× High School Graduates	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.003)
Childcare relative cost	0.002	-0.000	-0.000	-0.000	-0.000	-0.003*	-0.003
× Some College	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Childcare relative cost	-0.007***	-0.008***	-0.008***	-0.007***	-0.008***	-0.014***	-0.014***
× College Graduates	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Childcare relative cost	-0.011***	-0.014***	-0.014***	-0.013***	-0.013***	-0.021***	-0.027***
× Advanced Degrees	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Number of children	-0.008***	-0.003***	-0.014***	-0.014***	-0.014***	-0.015***	-0.020***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Total Personal Income						-0.093***	-0.131***
						(0.008)	(0.012)
Total Personal Income^2						0.026***	0.032**
						(0.006)	(0.010)
Spouse's Wage							0.196***
							(0.049)
Age Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Martial Status Dummies	No	No	Yes	Yes	Yes	Yes	Yes
Year Dummies	No	No	No	Yes	Yes	Yes	Yes
State Dummies	No	No	No	No	Yes	Yes	Yes
Obs.	514,829	514,829	514,829	514,829	514,829	514,829	305,847
R^2	0.005	0.039	0.066	0.067	0.068	0.070	0.082

NOTE. Linear probability models. All models are weighted by CPS sampling weights. Robust standard errors adjusted for heteroscedasticity and clustered at the state level are reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. See note to Table 3 for further details.

Appendix

We generalize the production function of raising children to a CES aggregate of parent's time and child-care from the form:

$$n = \left[(t_M)^\rho + (t_B)^\rho\right]^{1/\rho}, \qquad \rho \in (-\infty, 1]$$

Where the elasticity of substitution is $\frac{1}{1-\rho}$. t_M and t_B that minimize this cost function are:

$$t_M = \frac{\underline{h}^{\frac{1}{1-\rho}}}{\left(h_i^{\frac{\rho}{1-\rho}} + \underline{h}^{\frac{\rho}{1-\rho}}\right)^{\frac{1}{\rho}}} n$$

and

$$t_B = \frac{h_i^{\frac{1}{1-\rho}}}{\left(h_i^{\frac{\rho}{1-\rho}} + \underline{h}^{\frac{\rho}{1-\rho}}\right)^{\frac{1}{\rho}}} n$$

Substituting these optimal factors into the cost function yields:

$$C(n, \underline{h}, h^i) = \frac{\underline{h} h_i^{\frac{1}{1-\rho}} + h_i \underline{h}^{\frac{1}{1-\rho}}}{\left(h_i^{\frac{\rho}{1-\rho}} + \underline{h}^{\frac{\rho}{1-\rho}}\right)^{\frac{1}{\rho}}} n = p_n n$$

Where p_n is the price for quantity. Given the cost function, the solution to the optimization problem with regard to quantity is

$$n^* = \frac{h_i(1-\theta)}{2(p_n - \eta\bar{h})}.$$

Recall from the intuition described in the paper that marketization decreases the price for quantity for rich parents. Specifically, the engine for this result to emerge is that the price for quantity, p_n should at most increase with parent's income but at a slower pace than the parents income does. This implies that the ratio p_n/h_i should decline with h_i. Denote $R_i = p_n/h_i$. We get that

$$R_i = \frac{\underline{h} h_i^{\frac{\rho}{1-\rho}} + \underline{h}^{\frac{1}{1-\rho}}}{\left(h_i^{\frac{\rho}{1-\rho}} + \underline{h}^{\frac{\rho}{1-\rho}}\right)^{\frac{1}{\rho}}}$$

Differentiating this ratio with respect to h_i and rearranging yields:

$$\frac{\partial R_i}{\partial h_i} = -\underline{h} h_i^{\frac{2\rho-1}{1-\rho}} \left(h_i^{\frac{\rho}{1-\rho}} + \underline{h}^{\frac{\rho}{1-\rho}}\right)^{\frac{-1}{\rho}}$$

Which is always negative.