Cognitive Ability, Education, and Fertility Risk*

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Abstract

Teen pregnancy rates are nine times higher among women in the lowest cognitive ability quartile compared to those in the top quartile. This paper presents empirical evidence from the NLSY79 dataset on the relationship between cognitive ability, pregnancy timing, and intention. In addition, a life cycle model is developed and estimated to explore whether variations in opportunity in wage, marriage, and contraception efficiency by education account for the differences in fertility timing among women with different cognitive abilities. However, these mechanisms only account for half of the correlation between cognitive ability and teen pregnancy. Therefore, I add heterogeneity in contraception efficiency by cognitive ability to bridge this gap. The model reveals that policies that lower contraception costs reduce early pregnancies and enhance women's welfare. However, the model also shows that teen mothers' college attendance remains low, as college education is costly for low ability women, even without a teen pregnancy.

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1 Introduction

The decision of when to have children is one of the most crucial economic choices that individuals make, as it has significant implications for their welfare as well as that of their offspring. The consequences of fertility decisions extend beyond the household level and have far-reaching social and economic effects. Despite the availability of highly effective contraceptives, a significant fraction of pregnancies in the US are unplanned, with 41% of women reporting that they occur at an inappropriate time or are unwanted. This fraction is even higher for younger women, with 75% of teen pregnancies being unintended [1]. Teenage and out-of-wedlock pregnancies, which are often unintended, are disproportionately concentrated among women with lower cognitive abilities. Women in the lowest quartile of cognitive ability have nine times more teen pregnancies than those in the top quartile. This paper investigates the role of cognitive ability in teen and unintended pregnancies.

Previous research has established that cognitive and noncognitive abilities significantly impact various social outcomes, including teen pregnancies (Heckman et al., 2006). However, the specific mechanisms through which ability affects fertility remain unclear. In this paper, I examine whether the relationship between ability, formal education, and wages can entirely account for the role of ability in shaping fertility outcomes. Two widely studied explanations for the impact of education on fertility are the allocation of time theory (Becker, 1965) and differences in contraception efficiency among education groups (Rosenzweig and Schultz, 1989). The allocation of time theory suggests that highly educated women have a higher opportunity cost of having children early in terms of labor and marriage opportunities. This theory has been supported empirically by Caucutt et al. (2002); Rosenzweig (1999); Greenwood et al. (2000), among others. The theory of differences in contraception efficiency by education groups proposes that college-educated individuals are more efficient at using contraception, which has also been supported empirically by Rosenzweig and Schultz (1989); Musick et al. (2009). Although this paper finds that the relationship between ability and education explains half of the correlation between ability and fertility timing, the other half remains unexplained, necessitating further research.

The economic and social repercussions of unintended pregnancies are numerous. Women

[1] https://www.cdc.gov/reproductivehealth/contraception/unintendedpregnancy/index.htm

who experience an unintended first pregnancy are more likely to be single mothers or enter into shotgun marriages, which have a higher probability of ending in divorce (Kozlov, 2021). As a result, their children are more likely to grow up in single-parent households, which is associated with poorer educational and economic outcomes (Kearney and Levine, 2017). Furthermore, mothers with early or unintended pregnancies tend to have worse economic and social outcomes (Amador, 2017; Foster et al., 2018; Levine and Painter, 2003). Additionally, out-of-wedlock pregnancies are more prevalent among low-income women, which further reduces intergenerational mobility Seshadri and Zhou (2022).

This paper is related to various branches of economic literature. Firstly, it relates to the literature on dynamic models with endogenous family formation and fertility choices. For instance, Regalia et al. (2011) examine how changes in relative wages impact the number of single mothers, while Caucutt et al. (2002) explore how child investment, marriage, and labor market outcomes influence women's fertility timing. Choi (2017) demonstrate that to account for the observed heterogeneity in births and abortions across educational groups, differences in fertility risk by education are necessary. Additionally, Filote et al. (2019) study how the welfare state affects teenage childbearing behavior through a parental investment model with risky sexual behavior. Lastly, Kozlov (2021) investigate how unintended pregnancies impact marriage and divorce. The paper also contributes to the literature on intergenerational mobility, with Seshadri and Zhou (2022) analyzing how heterogeneity in fertility planning affects children's investment and shapes intergenerational mobility.

The paper is also related to the empirical literature on education and fertility. For instance, Rosenzweig and Schultz (1989) demonstrates that the efficiency of contraception methods increases with education, while Musick et al. (2009) finds that the gradient in fertility by education primarily arises from unintended childbearing, rather than differences in opportunity costs. Furthermore, the paper is related to the literature on the return on cognitive and noncognitive ability and education on behavioral outcomes. Heckman et al. (2006) establish that both cognitive and noncognitive abilities reduce the likelihood of teenage pregnancy, with those at the top of the ability distribution having almost zero chances of unintended pregnancy. Additionally, Heckman et al. (2018) find that increasing cognitive endowments positively impacts education, wages, smoking, and health outcomes, while increasing noncognitive endowments mainly affects smoking and health outcomes. Moreover, education affects the present value of health and smoking, with Hai and Heckman (2022) demonstrating that an extra year of schooling reduces smoking by 21%.

This paper makes two contributions. First, it establishes a positive correlation between cognitive ability, fertility timing, and intention, which decreases as women age. Second, the paper develops and estimates a dynamic choice model with endogenous fertility, education, and marriage, where contraception efficiency is influenced by cognitive ability. The model is used to quantify the effect of cognitive ability and education on women's fertility timing and risk. Moreover, the paper analyzes how reducing contraception costs affects educational outcomes, particularly college attendance among teenage mothers.

To investigate the link between cognitive ability and fertility, I utilize the National Longitudinal Survey of Youth 1979 (NLSY79), which provides data on cognitive ability, women's fertility, and labor outcomes until their late forties. As previously noted, women in the lowest quartile of cognitive ability are nine times more likely to experience their first pregnancy between ages 14 and 17 than women in the top quartile (29% vs. 3%). However, this gap disappears after the age of 22.

Next, I estimate a static linear model with ability as a latent variable, allowing for the control of measurement error and simultaneous causation bias (Hansen et al., 2004). The analysis reveals that the significance of cognitive ability in the first pregnancy decreases with age, and even changes sign. The magnitude of cognitive ability is quantitatively significant, with its interdecile range reducing the probability of pregnancy by 98% between ages 14-17 and by 65% between ages 18-22. Interestingly, women in the top decile of cognitive ability are 27% more likely to experience their first pregnancy between ages 22-29 than those in the bottom decile. However, they are 7% less likely to have an unintended pregnancy, consistent with research suggesting that cognitive ability improves women's fertility planning (Commendador, 2007).

Next, I construct and estimate a dynamic life cycle model with endogenous fertility, education, and marriage. The analysis shows that differences in opportunity cost by ability and differences in contraception cost by education are insufficient to explain the correlation between ability and fertility. These two factors only account for half of the correlation between ability and teen pregnancies. Finally, I utilize the model to show that, in line with empirical evidence, improvements in contraception have a minimal impact on college attendance. This is because women who experience teen pregnancies are already at a disadvantage, making it challenging to attend college, even without the added cost of a child.

2 Empirical Evidence

In this section, I present empirical evidence on the impact of cognitive ability on fertility using data from the National Longitudinal Survey of Youth (NLSY79). Firstly, I describe the dataset and provide an overview of its key characteristics. Secondly, I present descriptive statistics that relate cognitive ability, early pregnancies, education, and marriage. Finally, I estimate a linear static model at various ages to measure the influence of cognitive ability on fertility across the life cycle.

2.1 Data description

The National Longitudinal Survey of Youth 1979 tracks a representative sample of American youth born between 1957 and 1964 who were aged 14 to 22 when initially interviewed in 1979. This paper focuses on the observations of women whose first pregnancies resulted in live births. Therefore, in this paper, childbirth and pregnancy are used interchangeably. The survey is significant for this study for three reasons. Firstly, cognitive ability was assessed in 1980 through ten intelligence tests known as the Armed Services Vocational Aptitude Battery (ASVAB). Secondly, the participants have been monitored for over 40 years, and the women in the sample have already completed their reproductive years. Lastly, the survey asked mothers whether their pregnancies were intended at the time of conception.

Using a subset of the ASVAB test, an approximate score of a general cognitive ability test known as the Armed Forces Qualifications Test (AFQT) was computed in 1980. This test is the standard measure utilized in the literature to approximate cognitive ability. The resulting scores were used to rank women according to cognitive ability percentiles. After dropping the observations with missing ASVAB values, a panel of 5,939 women was utilized for the analysis.

Table 1. National Longitudinal Survey of Youth 1979 Sample Size Summary

	Low Ability			High Ability			
Age First Pregnancy	High School Drop.	High School	College	High School Drop.	High School	College	Total
14-17	233	425	19	13	126	22	838
18-21	178	818	52	12	434	54	1548
22-29	82	587	81	2	551	406	1709
No child at 30	67	528	93	11	544	601	1844
Total	560	2358	245	38	1655	1083	5939

Notes: Sample size by bins. Observations are bin by mother's age at first pregnancy, higher education achieved during the survey, and whether she is below or above the mean AFQT. The sample includes all NLSY79 women surveyed without missing AFQT scores and pregnancy information.

Women's fertility lifespan is divided into three periods for the analysis. The focus is on first-time births before the age of 30 since nearly 90% of firstborn children are delivered before this age. The first period comprises women in high school (aged 14 to 17). The second period encompasses women of college age (18 to 21 years old). Finally, in the third period, women are young adults aged between 22 and 29 years. The classification of individuals into high or low ability categories is based on whether they score above or below the sample mean. Table 1 presents the number of observations by age at first pregnancy, ability, and education. The relationship between ability and education outcomes is evident, as very few high-ability women drop out of high school, while a small percentage of low-ability women graduate from college.

2.2 Descriptive Statistics

This subsection outlines the data characteristics that are the main focus of this paper. The objective of this study is to investigate the relationship between cognitive ability and fertility. Since pregnancies influence education costs, labor supply, and marital status, the analysis focuses on data characteristics that link cognitive ability, pregnancy timing, education, wages, and marital outcomes.

2.2.1 Cognitive Ability and Age at First Childbirth

Table 2 displays the joint distribution between age groups, ability quartiles, and pregnancy outcomes conditional on not having childbirth in the previous age bin. For example, the interpretation of the first column, third row, is that half of the women in the first ability quartile who did not have childbirth before 22 years old had one between 22-29 years old.

Table 2. Joint Distribution First and Unwanted First Pregnancy by Age and Cognitive Ability

	Ability Quartile			
	First Quartile	Second Quartile	Third Quartile	Four Quartile
Age First Pregnancy	Pregnancy Probability			
14-17	26%	15%	9%	3%
18-21	54%	43%	28%	16%
22-29	48%	48%	45%	45%

Notes: Women are bin by cognitive ability scores and age. Women are separated by ability scores at the beginning of the sample. Each age-ability bin only considers the sample of women without a pregnancy before the initial age at the respective bin. The pregnancy probability is calculated as the ratio of women with a pregnancy at a particular age-ability bin over the total number of women in the respective bin.

There is a positive correlation between cognitive ability and age at first birth that diminishes as women age. Between the ages of 14 and 17, 26% of women in the lowest cognitive ability quartile have their first pregnancy, compared to only 3% of those in the highest quartile, indicating a ninefold difference in pregnancy rates. However, as women grow older, this ratio decreases to 3.37 between ages 18-21 and 1.06 between ages 22-29.

2.2.2 Pregnancy Timing and Education

Table 3 shows the joint distribution of women's age at first pregnancy and the highest educational level achieved. First, we observe that most pregnancies occur at ages when women are expected to have completed their final education level. For example, 82% of high school graduates had their first child after high school age, and 73% of college graduates had their first pregnancy after college age.

Table 3. Conditional Distribution Age First Pregnancy by Education Outcomes

	Education Outcome		
Age at First Pregnancy	High School Dropout	High School Graduate	College Graduate
14-17	48%	18%	6%
18-21	40%	50%	21%
22-29	12%	32%	73%

Notes: The table shows the fraction of women that had their first pregnancy at each respective age group by the highest education achievement reported in the sample. Each column sum 100.

The relationship between education outcomes and pregnancies is mutually causal. On one hand, pregnancies can be costly in terms of time and money, making women more likely to drop out or not pursue higher education, which creates a link between early pregnancies and lower educational attainment. On the other hand, women with lower cognitive ability tend to attain lower education levels, which makes them more likely to have children at a younger age, leading to a connection between cognitive ability and pregnancy timing. In the next section, a dynamic model is used to address the question of whether low-ability women have lower educational attainment because they are young mothers, or whether they have children at a young age because pursuing higher education is too expensive.

2.2.3 Early Pregnancies and Marriage

Becker (1991) argues that out-of-wedlock children decrease the likelihood of the mother's future marriage by reducing her net resources and raising the cost of searching for a husband. Bronars and Grogger (1994) find that women with unplanned births were, on average, 13 percentage points less likely to be married while their children were young, and this differential narrowed only by 4 percentage points by the time their children were preteenagers.

Although model tractability does not allow for studying the effects of out-of-wedlock pregnancies on marriage timing, I investigate the impact of such pregnancies on the probability of marriage during mothers' lifetime and the quality of their husbands, measured by their income. I find that women who have out-of-wedlock births have a similar probability of marriage during their lifetime as women without such births. However, on average, their husbands have lower wages.

Table 4. Probability of ever marriage single mother vs non single mothers

	High School Dropout	High School Graduate	College Graduate
Age at Pregnancy		Single Mothers	
14-17	77%	86%	91%
18-21	73%	84%	88%
22-29	48%	73%	83%
		Non Single Mothers	
	82%	83%	83%

Notes: The table shows the probability of ever marriage for women with and without out-of-wedlock childbirth. In the case of women with out-of-wedlock pregnancies, the probabilities are disaggregated by age at pregnancy. The probability is defined as the number of women who married at some point over the survey over the number of women in the respective bin. "Ever marriage" is defined as reporting at least one marriage during the survey.

Table 4 compares the probability of marriage for single mothers to non-single mothers. For single mothers, the marriage probability is analyzed conditional on their age at first pregnancy. The marriage probability for single mothers increases with education and decreases with age at childbirth. For example, 86% of high school graduate single mothers between 14 and 17 years old married after birth compared to 73% of single mothers between 22-29 years old with the same education level. In addition, 73% of 18 to 21 years old high school dropout single mothers got married compared to 88% of college graduates. For non-single mothers, the fraction who married is around 83% for the three education groups. Out-of-wedlock pregnancies only decrease the probability of finding a husband for high school dropouts.

Table 5. Average Husband Wage by Education and Women Children at Marriage.

	High School Dropout		High School Graduate		College Graduate	
Age Fir. Preg.	Out-Wed.	No Out-Wed.	Out-Wed.	No Out-Wed.	Out-Wed.	No Out-Wed.
14-17	36873	34546				
18-21	37473	41224	44785	48923		
22-29	43760	30448	47420	58889	63248	81521

Notes: The table shows husbands' average yearly wage for women with and without an out-of-wedlock pregnancy. Wages are deflated to 2016 prices. I only consider married women with husbands who make more than 2.5 dollars per hour and work more than 2000 hours a year.

Table 5 presents a comparison of husbands' yearly wages for women with and without out-of-wedlock childbirths after completing their highest level of education. The table provides information on the average income of husbands based on women's age at first childbirth, educational attainment, and the occurrence of an out-of-wedlock childbirth. Results show that women with high school and college degrees without out-of-wedlock childbirths have husbands with higher incomes. For high school dropouts, there is no significant difference in husband income. It is interesting to note that high school dropout women with out-of-wedlock children between 22-29 years old had higher income husbands on average, although this finding has few observations and could be a sample size issue. Women who had their first pregnancy between 18 and 21 years old with a high school degree face an average penalty of $4000 yearly due to out-of-wedlock childbirth, while those who had their first pregnancy between 22 and 29 years old face a penalty of $11000. College graduates face the highest penalty, with a reduction of approximately $18000 in annual husband income due to an out-of-wedlock childbirth.

2.3 The effect of cognitive ability on fertility

In subsection 2.2.1, I discussed the differences in fertility timing by cognitive ability. Two important mechanisms that delay childbirth are education and wages. Both increase the opportunity cost of having children young for high ability individuals. Additionally, high cognitive ability is related to family background. For this reason, I estimate a static linear model at three moments of the life cycle: teens (14-17 years old), college age (28-21 years old), and young adults (22-29 years old) to measure the direct effect of cognitive ability on fertility.

An additional concern is that the dataset provides an intelligence test. Measurement error and reverse causality generate bias as the test is affected by family background and formal education. As Heckman et al. (2006) argue *"we note that there is an important distinction between intelligence tests (i.e., IQ tests) and achievement tests. Although IQ is fairly well set by age 8, achievement tests have been demonstrated to be quite malleable"*. The simple least square model overpredicts the impact of ability tests and understates the contribution of formal education on different outcomes as it imputes the impact of family background and education on ability. I follow the method proposed by Cawley et al. (1996); Heckman et al. (2006); Hansen et al. (2004) to estimate ability as a latent variable correcting reverse causality bias and measurement error.

Individuals' decision-making process is affected by their forward-looking behavior, including the impact of future education and income on teenage fertility decisions. However, a static linear model does not fully capture the effect of future outcomes on current fertility decisions. To address this, I estimate the static model at three different points in time, as described earlier. The effect of ability is upwardly biased for teens, as future wages and marital opportunities are also captured in the estimated coefficients. While some education outcomes are already realized for women at college age, future income still affects the opportunity cost and biases the estimators. For young adults, education is entirely realized, and a significant proportion of wage realizations has already been observed, leading to a more accurate estimation of the effect of ability, education, and wage on fertility. Additionally, I also estimate the effect of ability on unintended childbirth, which provides further evidence on whether ability affects women's fertility control.

The estimated linear model at each age is:

$$Y_i^{14-17} = \beta_0 + \alpha_\theta \theta_i + \beta_X X_i + \epsilon_i$$

$$Y_i^{18-21} = \beta_0 + \alpha_\theta \theta_i + \beta_{HS} HS_i + \beta_{CA} CA_i + \beta_X X_i + \epsilon_i$$

$$Y_i^{22-29} = \beta_0 + \alpha_\theta \theta_i + \beta_w w_i + \beta_{HS} HS_i + \beta_C C_i + \beta_X X_i + \epsilon_i$$

where Y_i^{age} represents the outcome for individual i at a specific age, such as having a child or having an unintended child. The latent variable, θ, represents cognitive ability, while HS, CA, and C are dummies for graduating high school, attending college, and graduating college, respectively. Additionally, w represents the mean wage during the period, and X includes demographic controls such as race, both parent education, and broken home status at 14. To identify the latent variable θ, I use the following measurement system:

$$T_i = \beta_T X_{i,D} + \alpha_i + \epsilon_{i,T}$$

the vector of cognitive ability measures is denoted by T, while X_T is a vector of controls for each measure, including race, both parents' education, broken home at 14, and years of completed education at the moment of the test. The model is estimated by maximizing a likelihood function, which assumes that F_θ follows a mixture of normal distributions.

Table 6 presents the results of the models, showing that cognitive ability continues to have a significant effect on pregnancy timing and intention even after controlling for education and wages. Specifically, the data indicates that higher cognitive ability decreases the probability of pregnancy for teenagers and college-age women, but increases the probability for young adults. This finding supports the hypothesis that high-ability women are better at planning their pregnancies. Additionally, cognitive ability significantly reduces the probability of unintended pregnancies for all age groups, although the effect is relatively small for young adults. Teenagers in the top cognitive decile are 98% less likely to have a pregnancy and 65% less likely to have an unintended pregnancy compared to those in the bottom decile. For 18-21 year-olds, the difference in pregnancy and unintended pregnancy rates between the top and bottom deciles is 28% and 33%, respectively. Finally, women between 22-29 years old in the top decile are 27% more likely to have a pregnancy but 7% less likely to have an unintended pregnancy than those in the bottom decile.

Education and income are important determinants of fertility timing. Higher wages and college education decrease the probability of both pregnancy and unintended pregnancy. For women aged 18-21, the interdecile range effect of cognitive ability is a decrease of 28% in the probability of pregnancy, while attending college reduces the pregnancy probability by 80%. In the case of unintended pregnancies, the interdecile range effect of ability on pregnancy probability is a reduction of 33%, while college attendance reduces the probability by 72%. For women aged 22-29, a college education reduces the probability of pregnancy by 17% and the probability of unintended pregnancy by 14%. The interdecile range of wages is associated with a 42% decrease in pregnancies and a 90% decrease in unintended pregnancies. High school graduation does not affect pregnancy or unintended pregnancy once controlled for ability. However, attending college reduces the probability of pregnancy and unintended pregnancy to almost zero. The fact that college attendance remains relevant even after controlling for wages supports that college increases contraception efficiency.

The preceding results indicate that cognitive ability affects fertility even after accounting for opportunity costs associated with education and wages. However, the possibility remains that low-ability women have more pregnancies, which interferes with their educational outcomes, or that low-ability women have children earlier because pursuing higher education is too costly. To address this concern, in the following sections, I develop and estimate a dynamic model to determine the relative importance of cognitive ability and formal education in fertility decisions.

Table 6. Latent Factor Model: Pregnancies and Unintended Pregnancies

	(1)	(2)	(3)	(4)	(5)	(6)
	Preg.	Unint. Preg.	Preg.	Unint. Preg.	Preg.	Unint. Preg.
	14-17 yrs old	14-17 yrs old	18-21 yrs old	18-21 yrs old	22-29 yrs old	22-29 yrs old
Cog. Ab.	-.1049***	-.0414***	-.0774***	-.0391**	.1017***	-.0060
	(.0124)	(.0112)	(.0200)	(.0163)	(.0267)	(.0215)
Wage					-.0826***	-.0430***
					(.0117)	(.008)
HSG			.0435***	.003		
			(.0167)	(.0146)		
Att. Coll.			-.2706***	-.1038***		
			(.0175)	(.0152)		
College					-.0791***	-.0161
					(.0223)	(.0170)
Change in Probability						
$\Delta(d_{10} - d_1)$ Cog. Ab.	-98%	-65%	-28%	-33%	27%	-7%
$\Delta(d_{10} - d_1)$ Wage					-42%	-90%
HS			13%	2%		
Att. Col.			-80%	-72%		
College					-17%	-14%
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4390	3616	3801	3031	2412	1753

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

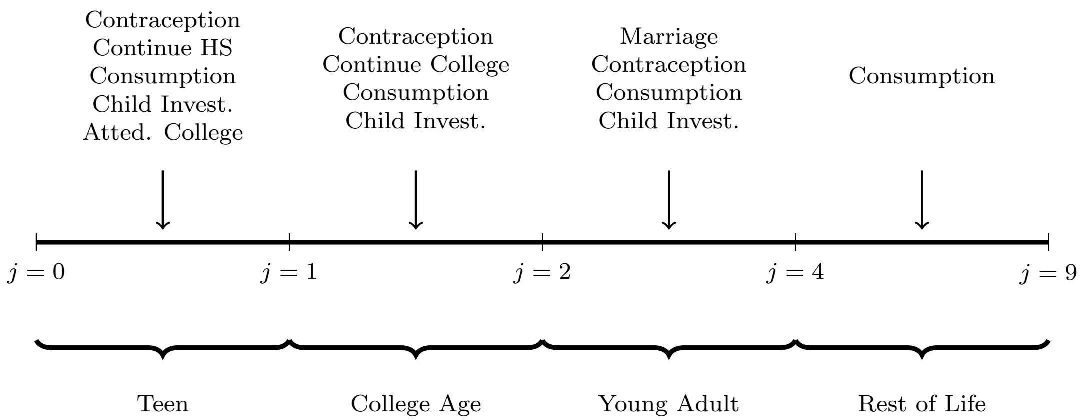
Notes: Static model estimated coefficients. Wage and test scores are standardized with a mean zero. Controls include race, both parent education, and broken home at 14. $\Delta(d_{10} - d_1)$ is the interdecile range for a particular variable showing the difference in probability between women at the top with women at the bottom of the respective variable. Each age group only considers women without a pregnancy at the initial age of each group.

3 Model

In this section, I present a life cycle model to investigate the extent to which cognitive ability affects fertility beyond its correlation with education, wages, and marriage. The model addresses the dynamic concerns arising from individuals being forward-looking, where childbearing affects future opportunities, and contraception choice depends on labor, marriage, and educational prospects. By analyzing how fertility, marital, and education outcomes change as future opportunities or contraception costs vary, the model provides insights into the interplay between cognitive ability, education, and fertility.

3.1 Environment and Timing

Figure 1. Women Attending College Life Cycle



Notes: The figure describes women's life cycle. The women's life cycle is divided into four stages: i) teen, ii) college age, iii) young adult, and iv) rest of life. Above the timeline, we can see women's decisions every period during each age.

In the life cycle model, time is discrete, and women live a finite number of periods. The women's life cycle is divided into nine periods, each spanning four years, as illustrated in Figure 1. All women start as 14-year-old teenagers with varying levels of cognitive ability, a, and remain fertile until the age of 29. In the sample, 90% of the first childbirth occurred between the ages of 14 and 29. During each fertile period, women make decisions regarding contraception, and if a child is born, they decide on the investment in their children. After their fertile years, individuals do not make any choices and only consume their income. As teenagers, they decide whether to continue high school, and if they do, they decide on attending college at the end of it. After determining their fertility outcomes, women attending college decide whether to continue or drop out and work as high school graduates. During each fertile period, when women are not attending school, they can meet a potential husband and choose to marry if the utility of being married is higher than that of being single. Husbands' only contribution is a wage, and women decide the allocation of household resources.

In this economy, each woman can only have one child who lives only during the period that the child was born. During that period, mothers can invest money to increase the child's human capital, and the utility of having a child is increasing in the child's human capital. As a result, children are a once-in-a-lifetime investment opportunity. The optimal age for having a child is when parents have higher resources, which incentivizes women to postpone pregnancies. However, waiting is costly, given the cost of contraception. The model includes a reduced form for child investment to incentivize high-income individuals to postpone parenthood. The investment function is consistent with the fact that child investment is increasing in income, but it does not model child investment realistically, as this is beyond the scope of the paper. To maintain tractability, the model does not include assets, income uncertainty, or divorce.

To capture the multi-dimensional nature of contraception, I include in the contraception cost both monetary and non-monetary components, such as physical, psychological, and social costs, associated with avoiding pregnancy, rather than focusing on specific contraceptive methods. In addition, contraception is imperfect, which always makes the probability of unintended pregnancy positive. By including the costs of contraception and the potential for imperfect contraception, the model aims to capture the complexity of this decision, which is crucial in understanding how women's fertility choices respond to changing economic opportunities and contraception costs.

The model notation is as follows. The indirect utility function is denoted by V_t^j, where t represents the period, and j is the sub-period. The state variables include ability, education, marital status, marital status at childbirth, and the period in which a child was born. Ability, $a \in [0,1]$, is continuous. Education is represented by three states, $e \in HSD, HS, C$, where HSD represents high school drop-out, HS represents high school graduate, and C represents college graduate. Marital status is denoted by $m \in 0,1$, where 0 represents single, and 1 represents married. The variable $sm \in 0,1$ represents whether a woman had an out-of-wedlock pregnancy. The variable $k_t \in 0,1,2,3,4$ tracks the period in which a child was born. If a woman has never been a mother, this state variable is zero. The decision variables are consumption $c \in [0,\infty]$, child monetary investment $i \in [0,\infty]$, and the amount of contraception $s \in [0,\infty]$, all of which are continuous. In the following sections, I introduce each period and its respective sub-period in reverse order to simplify the exposition.

3.2 Rest of Life: Fifth to Ninth Period (30-49 years old)

The model focuses on ages 14 to 29, as these are the ages when most childbirth and education decisions are made. However, since a significant fraction of college wages is backloaded after the age of 30, I also include ages between 30-49 in the model to avoid underestimating the value of college. During these periods, agents consume their household income and do not make any choices, so each period is composed of only one sub-period. The model is limited to 49 years old due to data constraints, as I will explain in the wage estimation section (4.2). Women are characterized by their age t, ability a, education e, marital status m, single motherhood sm, and maternal age at birth k_t. Therefore, a woman's utility at the beginning of each period is determined by the following Bellman equation:

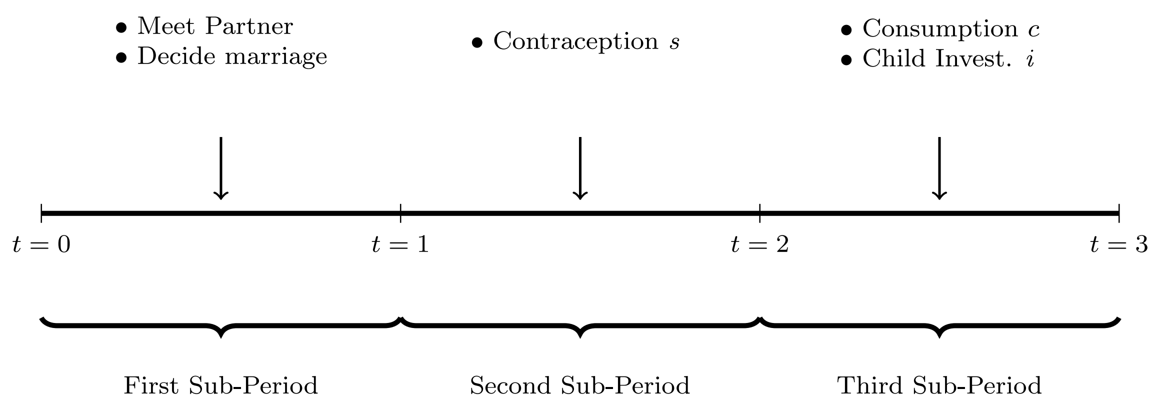
$$V_t(a, e, m, sm, k_t) = \max_{c} \; u(c) + \beta V_{t+1}(a, e, m, sm, k_t)$$

$$\phi_c(m, k_t) \cdot c = \; w(t, a, e, m, sm, k_t) + 1_{m=1} w^h(t, e, sm, k_t)$$

where $\phi_c(m, k_t)$ maps consumption expenditures and family composition into effective consumption. The women's wage $w(t, a, e, m, sm, k_t)$ is a function of several variables, including age, ability, education, marital status, single motherhood, and maternal age at birth. The indicator function $1_{m=1}$ is used to determine if the woman is married, and the husband's wage $w^h(t, e, sm, k_t)$ is a function that depends on age, the woman's education, and single motherhood, including the age at which she became a single mother.

3.3 Young Adult: Third and Fourth Period (22-29 years old)

Figure 2. No child, Single Women between 22-30 yr. old



Notes: The figure describes the decision timing for young adult women (22-29 years old). Each period is divided into three sub-periods, and a decision is made on each: i) marriage, ii)contraception, and iii) consumption-investment.

During this period, women make three sequential decisions, with each decision occurring in a sub-period. The decision timing within the period is illustrated in Figure 2. In the first sub-period, single women meet potential husbands and make the decision to marry or remain single. In the second sub-period, women without previous children decide on contraception. Finally, in the last sub-period, women consume and invest in their children, depending on whether a child is born.

3.3.1 Third Sub-Period: Consumption and Child Investment

In this sub-period, women must make decisions regarding both consumption and child investment, but this depends on whether they have a child within the period. If a child is born, they must decide on how much to invest in the child's human capital, in addition to their own consumption. The corresponding Bellman equation for this case is:

$$V_t^3(a,e,m,sm,k_t=t) = \max_{c,i}\ u(c) + V(i)^k + \beta V_{t+1}^1(a,e,m,sm,k_t=t)$$
$$\phi_c(m,k_t)\cdot c = \ w(t,a,e,m,sm,k_t) + 1_{m=1} w^h(t,e,sm,k_t) - i$$

where $V^k(i)$ is the utility that the child provides to the mother, which is increasing in the monetary investment i. The woman's wage is denoted by $w(t,a,e,m,sm,k_t)$, and $w^h(t,e,sm,k_t)$ represents the husband's wage if the woman is married. On the other hand, if the woman does not have a child during the period, her Bellman equation only includes the consumption choice:

$$V_t^3(a,e,m,sm,k_t) = \max_{c}\ u(c) + 1_{t=4\ \&\ k_t=0}\mu_{nk}(e) + \beta V_{t+1}^1(a,e,m,sm,k_t)$$
$$\phi_c(m,k_t)\cdot c = \ w(t,a,e,m,sm,k_t) + 1_{m=1} w^h(t,e,sm,k_t)$$

In this equation, $\mu_{nk}(e)$ is a utility value assigned to women who never have a child during their fertile life. The variable is necessary to reflect the fact that about 10% of women do not have a child at 30 years old, as seen in the data. The function $1_{t=4\ \&\ k_t=0}$ is an indicator that takes the value of 1 if the woman has never had a child and the current period is the last fertile one.

3.3.2 Second Sub-Period: Contraception

During the second sub-period, women who have not had a child at the beginning of the period decide on the amount of contraception s. The Bellman equation in this sub-period is as follows:

$$V_t^2(a,e,m,sm,k_t) = \max_{s} p(t,a,e,s)\cdot V_t^3(a,e,m,sm,k_t=t)$$
$$+\big(1-p(t,a,e,s)\big)\cdot V_t^3(a,e,m,sm,k_t=0) - \phi_s s$$

where ϕ_s is the utility cost associated with contraception, and $p(t,a,e,s)$ is the probability of having a pregnancy, which is decreasing in the amount of contraception. Higher ability implies a lower pregnancy risk for a given amount of contraception. If a woman has already had a child, she does not make a decision on contraception, and her indirect utility at the beginning of the sub-period is $V_t^2(a, e, m, sm, k_t) = V_t^3(a, e, m, sm, k_t)$.

3.3.3 First Sub-Period: Marriage

In the first sub-period, single women meet a potential husband with probability $\mu(e, t)$, which depends on the women's education achievement e and age t. If a woman meets a potential husband, she decides whether to marry or remain single. The woman will choose to marry if the utility of marriage is greater than remaining single. The Bellman equation in this sub-period is given by:

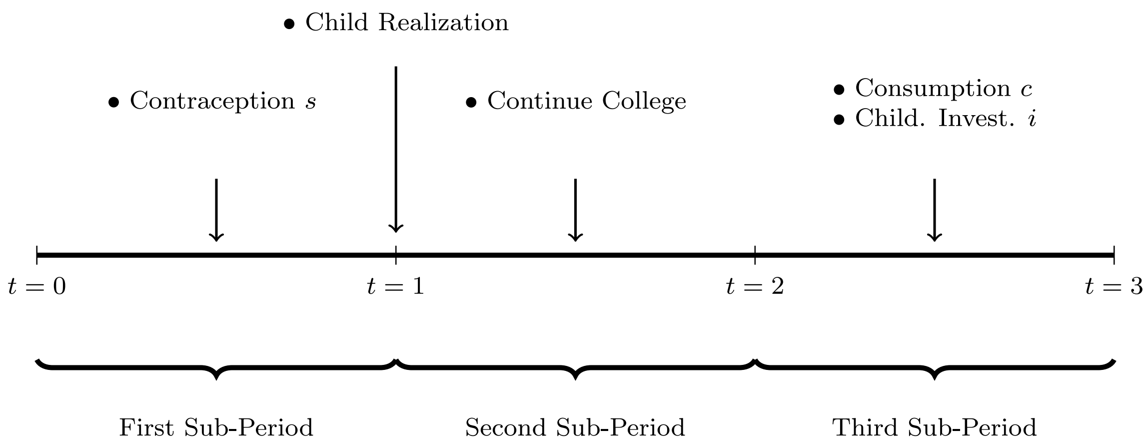
$$\begin{aligned} V_t^1(a, e, m = 0, sm, k_t) = \mu(e, t) \cdot \max\{V_t^2(a, coll, m = 1, sm, k_t), V_t^2(a, e, m = 0, sm, k_t)\} \\ +\big(1 - \mu(e, t)\big) \cdot V_t^2(a, e, m = 0, sm, k_t) \end{aligned}$$

Since the model does not account for divorces, women who are married do not make any marital decisions in the subsequent periods, and their utility is defined as $V_t^1(a, e, m = 1, sm, k_t) = V_t^2(a, e, m = 1, sm, k_t)$.

3.4 College Age: Second Period (18-21 years old)

This period focuses on the decision of whether to attend college or join the labor market. Women who choose not to attend college have the same decision sequence as in subsection 3.3. Women attending college make three sequential decisions. First, they decide on contraception. Second, after observing their pregnancy outcome, they decide whether to continue attending college. In the event of having a child during college, women face a double penalty: the cost of continuing college increases by $\kappa_{\mathrm{k,C}}$, and college students have limited monetary resources to invest in their child. Women who continue with their college education receive an allowance, denoted as w_c. College dropouts move to the last sub-period with the wage of high school graduates. Finally, in the third sub-period, women decide on consumption and child investment when having a child.

Figure 3. Attending College (18-21 years old)



Notes: The figure describes the decision timing for women attending college. Each period has three sub-periods, and a decision is made on each: i) contraception, ii) continuing college, and iii) consumption-investment.

3.4.1 Third Sub-Period 18-21: Consumption and Child Investment

The sub-period in which women attend college or work as high school graduates is the focus of this subsection. Women in college make consumption and child investment decisions. The Bellman equation for this sub-period is as follows:

$$V_2^{3,G}(a, k_t) = \max_{c,i} u(c) - \kappa_{\mathrm{k,C}} + V^k(i) + \beta V_3^1(a, e = \mathrm{C}, m, sm, k_t)$$
$$\phi_c(k) \cdot c = w(a, e = \text{attend-coll}, s, k_t) - i$$

where the value function of continuing college is denoted by G and the cost of attending college with a child is $\kappa_{\mathrm{k,C}}$. For women who dropped out of college in the previous sub-period, their problem is denoted by CD, and they face the consumption-investment problem of a high school graduate. Their Bellman equation is $V_2^{3,CD}(a, k_t) = V_2^3(a, e = \mathrm{HS}, m = 0, sm, k_t)$.

3.4.2 Second Sub-Period 18-21: Continue College

During this sub-period, women who are attending college must decide whether to continue their education. This decision is made after they have observed their pregnancy outcome. Their problem can be formulated as follows:

$$V_2^2(a, coll_a = 1, k_t) = \max_{i \in \{G, CD\}} \{V_2^{3,G}(a, k_t) + \sigma_{Coll}\epsilon_i, V_2^{3,CD}(a, k_t) + \sigma_{Coll}\epsilon_i\}$$

where $V^{3,G}$ and $V^{3,CD}$ represent continue college or drop out, respectively. The extreme value shock ϵ_i is i.i.d. and follows a Type I extreme value distribution, and σ_{Coll} is the scale parameter.

3.4.3 First Sub-Period 18-21: Contraception

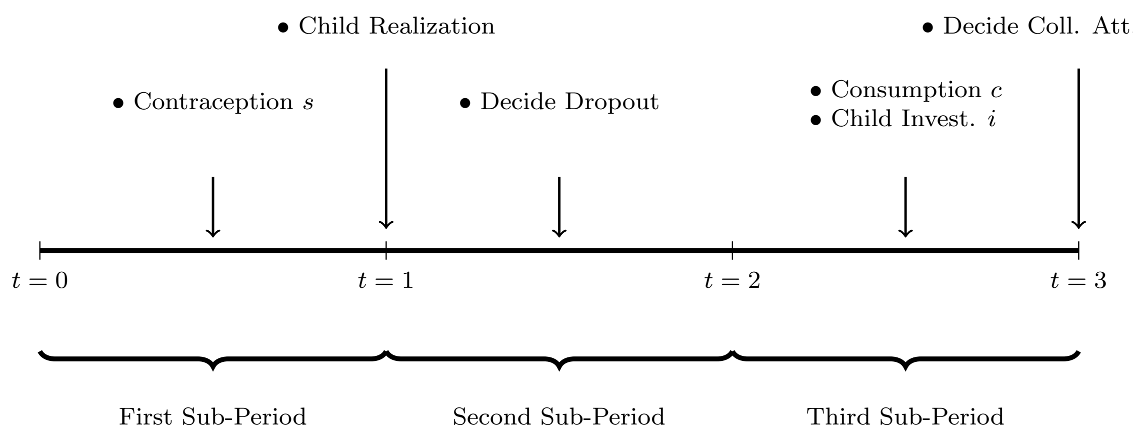
During the first sub-period, college women make a decision about the amount of contraception they choose to use. This decision is similar to the one they made in previous periods. The indirect utility function at the beginning of this sub-period is given by:

$$\begin{aligned} V_2^1(a, coll_a = 1, k_t = 2) = \max_s \; & p(t, a, e = coll_a, s) \cdot V_2^1(a, coll_a = 1, k_t) \\ & + \big(1 - p(t, a, e = coll_a, s)\big) \cdot V_2^1(a, coll_a = 1, k_t = 0) - \phi(s)s \end{aligned}$$

3.5 Teen: First Period (14-17 years)

The decision-making process for women aged 14-17 is as follows. At the beginning of the period, all attend high school and decide on contraception. After observing their fertility outcome in the second sub-period, they decide whether to continue high school. Those who choose to stay in school receive an allowance in the third sub-period. Those who drop out of high school work as high school dropouts. Finally, women who continue high school decide whether to attend college at the end of the third period.

Figure 4. Teens (14-17yr. old)



Notes: The figure describes the decision timing for teens. Each period has three sub-periods, and a decision is made on each: i) contraception, ii) continuing high school, and iii) consumption-investment. At the end of the third period, teens that finish high school decide on college attendance.

3.5.1 Third Sub-Period 14-17: Consumption, Child Investment, and College Attendance

At the end of the period, women who have graduated from high school face the decision of whether to attend college. The Bellman equation for this decision problem is given by:

$$V_1^{CD}(a, e = \text{hs}, sm, k_t) =$$
$$\max_{i \in \{C,NC\}} \{V_2^1(a, coll_a = 1, k_t) - \kappa_c(a, k_t) + \sigma_{CD}\epsilon_i, V_2^1(a, e = HS, m = 0, sm, k_t) + \sigma_{CD}\epsilon_i\}$$

where ϵ_i is an i.i.d. extreme value shock drawn from a Type I extreme value distribution, and σ_{CD} is the scale parameter. The psych cost $\kappa_c(a, k_t)$ of attending college depends on the woman's ability and whether she has a child. In the case of women attending high school with a child, the Bellman equation is:

$$V_1^{3,HSG}(a, HS_a = 1, sm = 1, k_t = 1) = \max_{c,i} \; u(c) + \kappa_{k,HS}$$
$$+V^k(i) + \beta V_1^{CD}(a, e = \text{HS}, sm, k_t)$$
$$\phi_c(k) \cdot c = w_{HS} - i$$

where κ_{HS} is the utility cost of attending high school with a child, w_{HS} is the parents' allowance, and V_1^{CD} is the value of deciding college attendance. When attending high school without a child, women consume their allowance w_{HS}.

Women who drop out of high school face the consumption-investment problem of a high school dropout. If they have a child during the period, they also decide on the amount of investment. Their Bellman equation is given by:

$$V_1^{3,HSD}(a, e = HSD, sm = 1, k_t = 1) = \max_{c,i} u(c) + V^k(i)$$
$$+\beta V_2^1(a, e = HSD, m = 0, sm = 1, k_t = 1)$$
$$\phi_c(k) \cdot c = w(t, a, HSD, k_t = 1) - i$$

where $w(t, a, HSD, k_t = 1)$ is the wage of a high school dropout. When dropping out without a child, women consume their wages.

The wage earned by women who drop out of high school is $w(t, a, HSD, k_t = 1)$. If they do not have a child, their decision problem in this sub-period is to choose their consumption level, given their wage.

3.5.2 Second Sub-Period 14-17: Continue High School

Once a teenager has observed the outcome of her pregnancy, she must decide whether to continue in high school. The decision depends on whether the value of graduating from high school is greater than the value of dropping out.

$$V_1^2(a, sm, k_t) = \max_{i \in HSD,HSD} \{V_1^{3,HSG} + \sigma_{HS}\epsilon_i, V_1^{3,HSD} + \sigma_{HS}\epsilon_i\}$$

where ϵ_i is an i.i.d. extreme value shock drew from a Type I extreme value distribution, and σ_{HS} is the scale parameter.

3.5.3 First Sub-Period 14-17: Contraception

In the first sub-period, all women attend high school, and the only heterogeneity among them is their ability. The decision in this stage is the amount of contraception, which is the same as the problem described in the previous sections. The corresponding Bellman equation is:

$$V_1^1(a) = \max_s \; p(1, a, s) \cdot V_2^1(a, sm, k_t = 1)$$
$$+\big(1 - p(1, a, s)\big) \cdot V_2^1(a, sm, k_t = 0) - \phi(s)s$$

The amount of contraception used by teens depends on their ability, as reflected in the contraception technology $p(1, a, s)$, and the difference in the value of continuing to the next sub-period with and without a child, as given by $\big(V_2^1(a, sm, k_t = 1) - V_2^1(a, sm, k_t = 0)\big)$. It is important to note that these factors play a crucial role in determining the optimal level of contraception use for each individual.

3.6 Functional Forms and Parameters

The functional forms in the model are chosen to align with the data. The model has 34 unknown parameters and an income process, which their estimation will be discussed in section 4.

3.6.1 Preferences (4)

Consumption (1)

Women's utility over consumption is modeled with constant relative risk aversion preferences, where $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$. This parameterization is motivated by the idea that parents smooth consumption over their children, as discussed in Regalia et al. (2011). However, if the curvature is above one, high-wage women would find children to be less costly, which is counterfactual since they tend to postpone motherhood. Therefore, the literature assumes that the level of risk aversion is below one.

Parent Child Utility (3)

The utility that parents derive from having a child is represented by $V^k(i) = \omega_0 + \omega_1 i^{\omega_2}$, where ω_0 represents the fixed utility or cost provided by children to their parents, ω_1 is a scale parameter that maps investment to utility units, and ω_2 determines the curvature at which child investment increases parent utility. To ensure an interior solution to the children's investment problem, it is assumed that ω_2 is below one.

3.6.2 Fertility (9)

In order to model the probability of having a child, this paper uses a modified logistic function to bound the probability at one, as done in Seshadri and Zhou (2022); Choi (2017). However, since the pregnancy probability in this paper depends on both contraception c and ability a, a constant elasticity of substitution (CES) production function is used to aggregate both inputs. The pregnancy probability also varies with age t and education e. Thus, the probability of having a child is given by:

$$p(t, a, e, s) = \frac{2\exp(-\lambda_{e,t}(\lambda_a \cdot a^\rho + (1-\lambda_a)\cdot s^\rho)^{\frac{1}{\rho}})}{1+\exp(-\lambda_{e,t}(\lambda_a \cdot a^\rho + (1-\lambda_a)\cdot s^\rho)^{\frac{1}{\rho}})} \tag{1}$$

The fertility decisions in the model are determined by four parameters: $\lambda_{e,t}$, λ_a, ρ, and $\phi(s)$. Since $\phi(s)$ and $\lambda_{e,t}$ determine the cost of contraception, $\phi(s)$ is normalized to 1. $\lambda_{e,t}$ determinate the difference in efficiency by education, λ_a determines the share of ability in the contraception function, while ρ gives the elasticity of substitution in the contraception technology.

3.6.3 Marriage Market (7)

The probability of women meeting a potential husband and getting is determined by the parameter $\mu(e,t)$, which is a function of a woman's education and age.

3.6.4 College Attendance and Graduation (6)

College attendance is determined by the psych cost of attending college, which is given by $\kappa_c(a,k_t) = \frac{\xi_c}{a^{\omega_c}} + 1_{k_t=1} \cdot \kappa_{kb}$. Here, ξ_c is the base psych cost of attending college, while ω_c determines how the psych cost decreases with cognitive ability. Women who continue college while having a child during that period face an additional cost, $\kappa_{k,\mathrm{C}}$. The extreme value shock scale parameters for attending and continuing college are given by σ_{Coll} and σ_{CD}, respectively.

3.6.5 High School Graduation (2)

The decision of whether to graduate from high school depends on the continuation values, which include the costs associated with attending high school with a child. In particular, the cost of attending high school with a child is represented by the parameter $\kappa_{k,HS}$, while the extreme value shock scale parameter that captures the randomness in the decision-making process is denoted by σ_{HS}.

4 Model Estimation

The model parameters can be categorized into three groups: first, those parameters that are taken from the literature; second, the wage process, which is estimated exogenously to the model; and third, the parameters that are estimated within the model using the simulated method of moments, conditioned on the previous two groups of parameters.

4.1 Exogenous Parameter

Table 7 presents the exogenous parameters used in the model, which are taken from the literature. These parameters include the discount factor, relative risk aversion, and economies of scale in consumption.

Table 7. Exogenous Parameters

Parameter	Interpretation	Value	Source
		Preferences	
β	Discount Factor	.96	Regalia et al. (2011)
γ	Relative Risk Aversion	.43	Regalia et al. (2011)
ϕ_s	Contraception Cost	1.00	Normalization
		Household Parameters	
$\phi_c(m,k)$	Economies of Scale in Consump.	$\{.5, .7\}$	OECD

Notes: Model parameters that take values from previous results in the literature.

4.2 Wages Profiles

Women's and husbands' wage profiles are crucial in the model as they determine the opportunity cost of early and out-of-wedlock pregnancies. Women's wages are determined by age, education, marital status, age at childbirth, and ability, while husbands' wages depend on the wife's education, marital status at childbirth, and the wife's age at birth. Since the NLSY79 individuals are currently in their early fifties, wage profiles are estimated using OLS for individuals aged 14 to 49 years old. While not including wages after their fifties may understate the value of college or the child penalty, later wages are discounted heavily in the model's fertility decisions. The wages are self-reported by the surveyed individuals in the NLSY79 and deflated to 2016 prices. I exclude individuals earning less than 2.5 dollars per hour or working less than 2000 hours per year. The estimated equations for women's and husbands' wages are as follows:

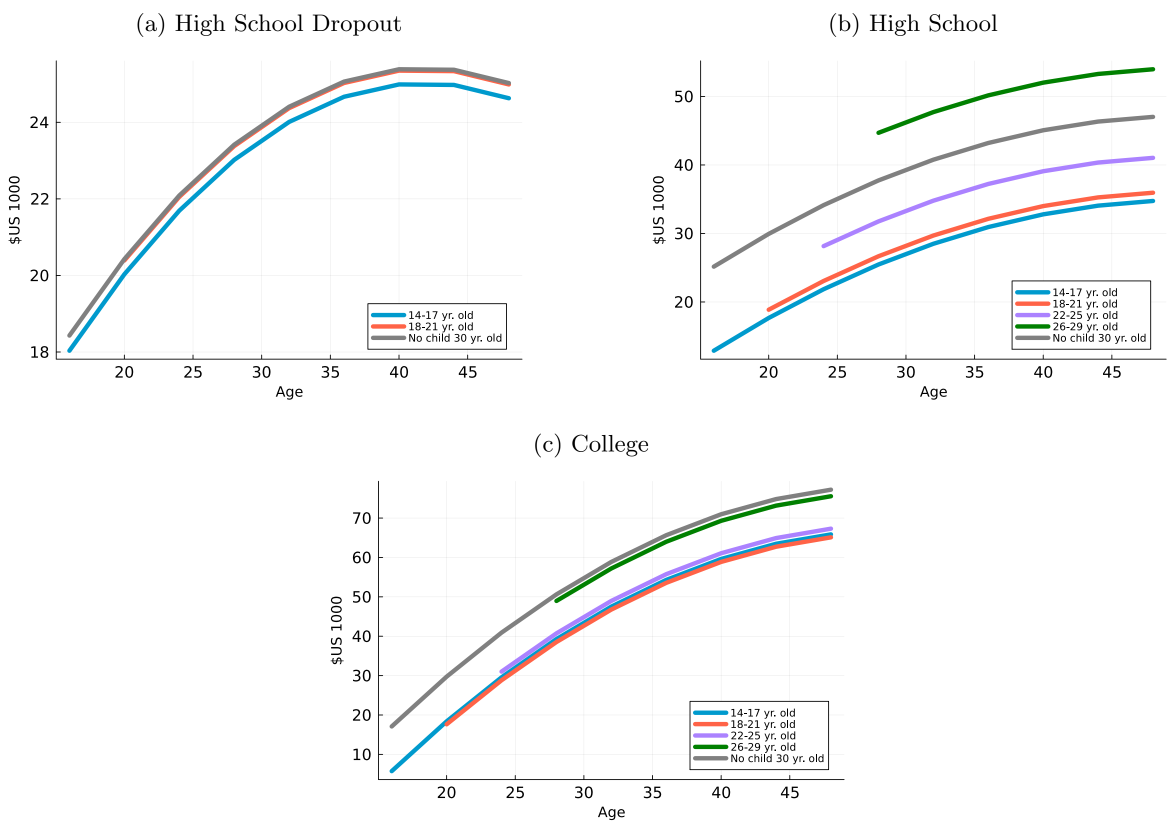
$$w_{i,t} = \alpha_0 + \alpha_t \cdot t + \alpha_{t^2} \cdot t^2 + \alpha_e e_i + \alpha_{\mathrm{HA}} \mathrm{HA}_i + \alpha_k k_i + \alpha_{et} \cdot e_i \cdot t +$$
$$\alpha_{et^2} \cdot e_i \cdot t^2 + \alpha_{e\mathrm{HA}} \cdot e_i \cdot \mathrm{HA}_i + \alpha_{k\mathrm{HA}} \cdot k_i \cdot \mathrm{HA}_i + \alpha_{e\mathrm{HA}} \cdot e_i \cdot \mathrm{HA}_i +$$
$$\alpha_{ek} \cdot e_i \cdot k_i + \alpha_{ek\mathrm{HA}} \cdot e_i \cdot k_i \cdot \mathrm{HA}_i + \alpha_m \cdot m_{i,t} + \epsilon_{i,t}$$

$$w^h_{i,t} = \gamma_0 + \gamma_t \cdot t + \gamma_{t^2} \cdot t^2 + \gamma_m \cdot m_i + \gamma_{e^f t} \cdot e^f_i \cdot t +$$
$$\gamma_{e^f t^2} \cdot e^f_i \cdot t^2 + \gamma_{e^f m} \cdot e^f_i m_i + \epsilon_{i,t}$$

The equation shows the variables used in the wage estimation process. The variables include the woman's wage w, the husband's wage w^h, the woman's age t, the individual i, the woman's education level e and e^f, a dummy variable indicating whether the individual scored above the mean on a cognitive ability test HA, a dummy variable indicating the woman's age at first childbirth k, a dummy variable indicating whether the woman is married m, and a dummy variable indicating whether the woman was married at the time of childbirth m^f.

Early pregnancies have a negative impact on women's wages across all education groups, with the wage penalty increasing as ability levels rise. Women who marry after experiencing an out-of-wedlock pregnancy have husbands with lower wages, and the size of the husband's wage penalty increases with the woman's age at childbirth. College-educated women bear the highest wage penalty, resulting in a higher cost of early pregnancy for high-ability women who are more likely to attend college and have a college graduate spouse.

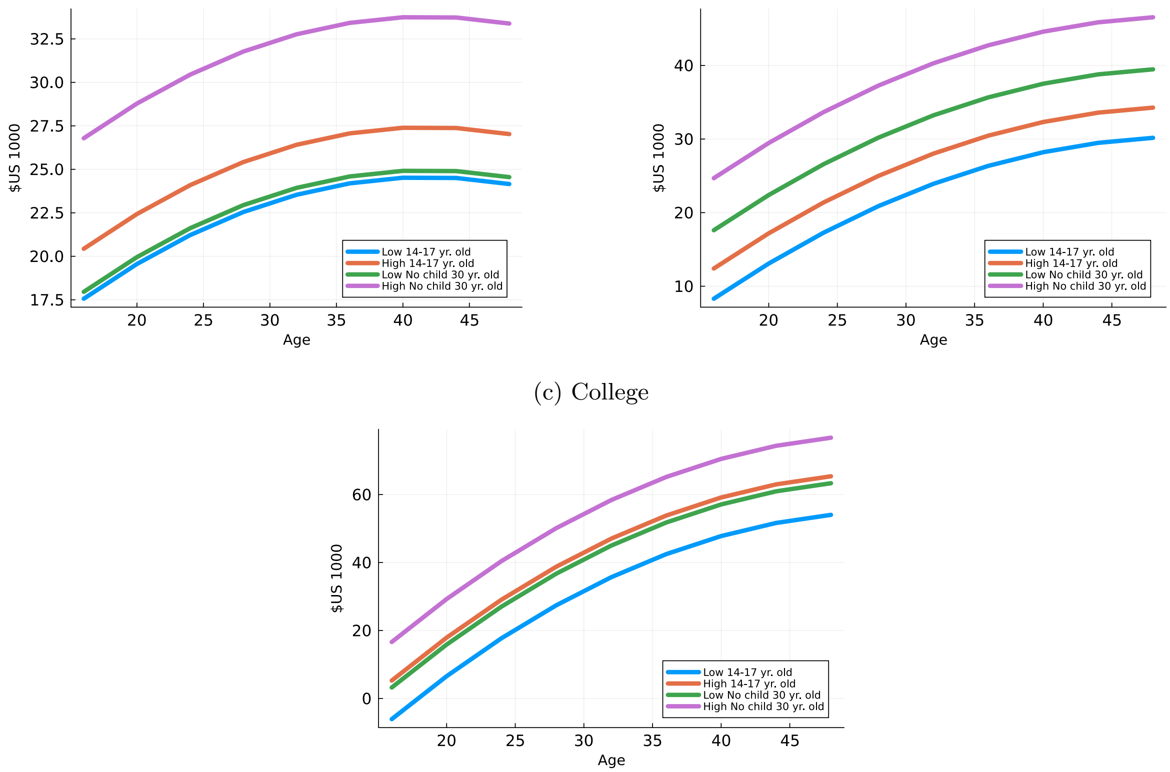
Figure 5. Women wage profile by education and age first birth



Notes: Wage profiles across age, education, and women's age at first child estimated as explained in section 4.2. Light blue lines show women with their first childbirth between 14-17 years old, red between 18-21, purple between 22-25, green between 26-29 years old, and grey no childbirth before 30 years old.

The figures showing women's wage profiles are breakdown by education and age at first childbirth. College-educated women have the highest earnings, followed by high school graduates, with high school dropouts having the lowest wages. In figure 5a, the wage profiles for high school dropouts show that early childbirth has a negligible effect on earnings, with birth between 14-17 years old reducing wages by only $400. The wage profiles for high school graduates in figure 5b indicate that women who have children between 26-29 years old have the highest wages, with early childbirth carrying a substantial wage penalty. For example, each year, women with a child between 14-17 years old earn $12,200 less than women with the first child between 26-29 years old. Finally, figure 5c shows the wage profiles for college women, with two wage paths for women who had a child before 26 and those who had a child after 26 or did not have one before 30. The first group earns around $12,000 less than the second. The child penalty for college and high school graduates is similar in monetary terms, but the relative magnitude is higher for high school graduates as they have lower wages.

Figure 6. Women wage profile by education and ability



(a) High School Dropout

(b) High School

(c) College

Notes: Wage profiles across age, education, women's age at first child, and ability type estimated as explained in section 4.2. Light blue lines show low ability and red high ability teen mothers. Green lines show low ability and purple high ability women without a child at 30 years old.

Figure 6 shows how cognitive ability affects women's wages by education level. The effect of ability on wage is increasing with education. I plotted four wage profiles for simplicity: high and low ability women with childbirth between 14-17 years old and high and low ability women without a child at 30. Cognitive ability increases wages in every education group.

Specifically, for high school dropouts (shown in Figure 6a), high ability women with childbirth between 14-17 years old earn $3000 more yearly than low ability. High ability women without a child at 30 years old earn $9000 more yearly than low ability.

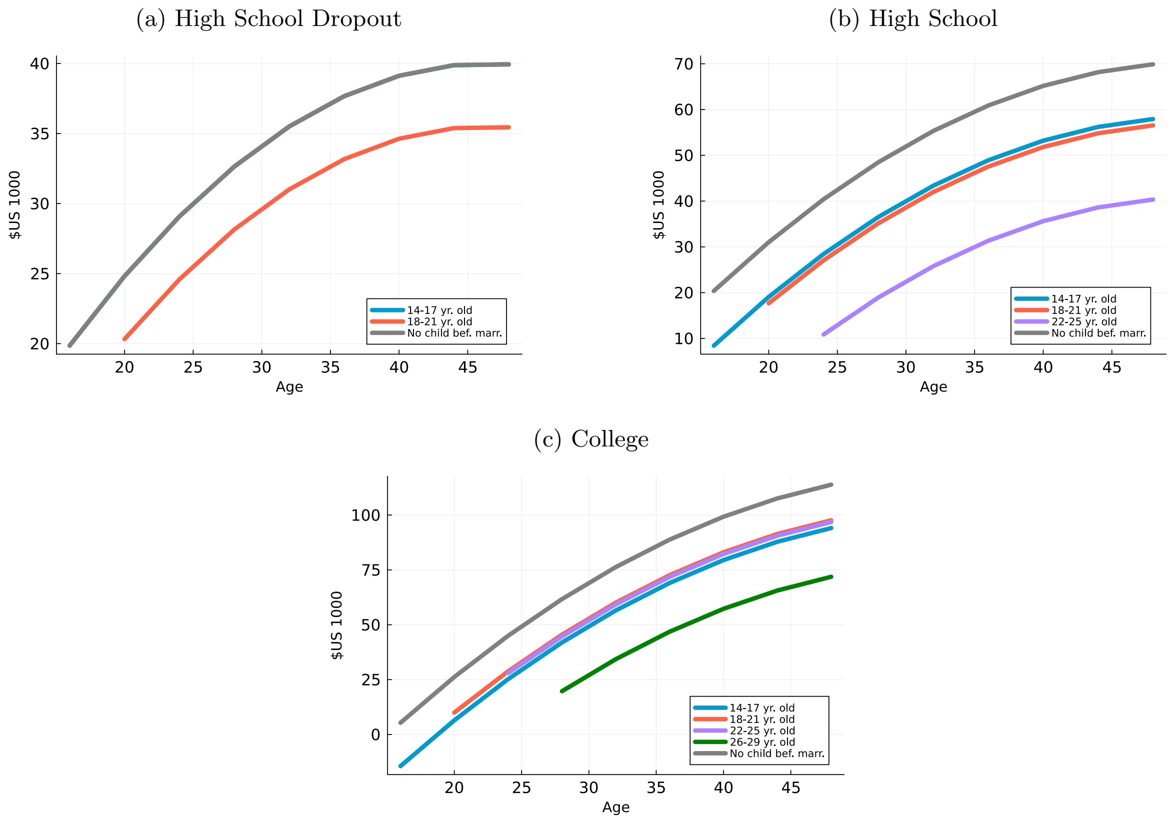
For high school graduates (shown in Figure 6b), the difference between high and low ability is $4000 yearly for women with childbirth between 14-17 years old, and $7000 yearly for women without childbirth at 30 years old.

For college graduates (shown in Figure 7), high ability women with childbirth between 14-17 make $11000 more yearly than low ability, and this difference is $13000 for women without a child at 30 years old.

The penalty wage associated with early pregnancy is increasing in ability. Low ability high school dropouts face an early pregnancy penalty of $400 yearly, while high ability dropouts face a penalty of $6300 yearly. Low ability high school graduates face an early pregnancy penalty of $6300 yearly, while high ability graduates face a penalty of $12200 yearly. For college graduates, the penalty for low ability is $9300 yearly, while high ability graduates face a penalty of $11340 yearly.

The impact of early pregnancies on husbands' wages is an important element of the model, as it affects the opportunity cost of having children. Figure 7 presents husbands' wages by education, marital status at childbirth, and the mother's age at birth in the case of out-of-wedlock pregnancies. As expected, single mothers have husbands with lower wages across all education groups, with the penalty increasing in age and education. The highest penalty is found among college-educated women who had an out-of-wedlock pregnancy between 26-29 years old. High school dropouts are shown in Figure 7a, where the husbands' wages are reduced by $4000 for an out-of-wedlock child between 18-21 years old. In Figure 7b, high school graduates have husbands with wages reduced by $12000 between 14-21 years old, and by $30000 between 23-26 years. Finally, college graduates face the highest penalty, with the husbands' wages reduced by $25000 and $42000 less, respectively, for out-of-wedlock pregnancies between 14-25 and 26-29 years old.

Figure 7. Husband wage profile by marital status at birth and age first birth



Notes: Husband wage profiles across women's age, education, and women's age at first child estimated as explained in section 4.2. Light blue lines show women with an out-of-wedlock child between 14-17 years old, red between 18-21, purple between 22-25, green between 26-29 years old, and grey are women without childbirth before marriage.

4.3 Endogenous Parameters

The remaining 30 unknown parameters are estimated by matching 38 data moments using the Simulated Method of Moments. These parameters govern the behavioral responses of individuals to the key determinants of fertility: ability, education, wages, and marriage. Thus, the model is estimated by selecting moments in the data that reflect the relationship between cognitive ability, education, marital status, and fertility outcomes. Table 8 provides an interpretation of each estimated parameter.

Table 8. Parameters estimated through the indirect method of moments

Parameter	Value	Interpretation
	Contraception Technology and Child Return	
Parameter	Value	Interpretation
λ_a (1)	.08	Ability Share Contr. Tech.
ρ (1)	$-.40$	Elasticity of Substitution Contr. Tech.
$\lambda_{e,t}$ (7)	Table A1	Scale Parameter by Ability and Education
ω_0 ω_1 ω_2 (3)	2.39, 0.09, .55	Child Return
	Marriage Outcomes	
Parameter	Value	Interpretation
$\mu(e,t)$ (5)	Table A2	Probability Meeting a Husband
	Education Outcomes	
Parameter	Value	Interpretation
$\kappa_{Coll.}$ ξ_c ω_c (3)	$-27, -201, 1.19$	College Psych Cost
κ_{HS}, κ_{kb} (2)	$-2, -16$	Cost Child Dif. Edu. Stages
$\mu_{nk}(e)$ (3)	34, 14, 1	Terminal Value no Child
$w(HS), w(Coll)$ (2)	US$48600, US$10000	Teen and Coll. Allowance
σ_{HS}, σ_{CD}, σ_C (3)	50, 68, 13	EV Shock HS, Attend Coll., Grad Coll.

Notes: Model parameters that are estimated using the Simulated Method of Moments.

Table 8 presents the estimated parameters, which shed light on how ability, education, wage, and marriage shape fertility. The share of ability in contraception is estimated at 0.08, a small but relevant value that explains the differences in pregnancies by ability, as discussed in section 5.2. The elasticity of substitution between ability and contraception is estimated at -0.4, indicating that ability and contraception are complements. The estimated cost of teen pregnancy during high school is low, suggesting that in the model, women drop out of high school not due to the child, but for other reasons. The estimated parent allowance during high school is $48,600, and during college is $10,000. In section 5.3, I discuss how contraception costs vary with education and ability.

5 Results

This section provides an overview of the estimation results. First, I discuss the goodness-of-fit of the model with the data. Second, I argue that ability is an essential input in the fertility function, as it cannot be fully explained by education and wages alone. Finally, I quantify the differences in contraception costs by education and ability, using equivalent consumption as the unit of measurement.

5.1 Model Fit

This subsection compares the fit of the model to the empirical data used to estimate its parameters. Overall, the model performs well given its simplicity and the use of 38 moments to estimate 30 parameters. For ease of presentation, the moments are grouped into three categories: those that link ability to pregnancies, those that relate to educational outcomes, and those that relate to marital outcomes.

5.1.1 Cognitive Ability and Pregnancies

Table 9. Fit Model Pregnancy and Ability

	Ability Quartile			
	First Quartile	Second Quartile	Third Quartile	Four Quartile
Age First Pregnancy	Pregnancy Probability | No Prev. Preg.			
14-17	30%	7%	5%	4%
	(26%)	(15%)	(9%)	(3%)
18-21	59%	32%	23%	21%
	(54%)	(43%)	(28%)	(16%)
22-29	64%	51%	33%	29%
	(48%)	(48%)	(45%)	(45%)

Notes: The table shows moments relating cognitive ability with age at first pregnancy. Values without parenthesis are moments generated by the model, and values in parenthesis are the data analogous.

Table 9 presents the moments that compare cognitive ability with pregnancy timing. These moments are the fractions of women who had their first child between 14-17, 18-21, and 22-29 years old by cognitive ability quartiles, conditional on being childless at the beginning of each age interval. Between 14-17 and 18-21 years old, the model can replicate the positive correlation between ability and pregnancy, and the fraction of pregnancies for the bottom and top quartiles is similar to the data. However, the relationship between ability and pregnancy is considerably more concave in the model than in the data. On the other hand, the model fails to replicate the data for women between 22-29 years old as it generates a positive relationship between ability and pregnancies considerably higher than in the data.

5.1.2 Education Outcomes

Table 10. Education Outcomes and Pregnancy Moments

Moments	Data	Model
Drop out High School | No Pregnancy (<18)	0.06	0.06
Drop out High School | Pregnancy (<18)	0.28	0.27
Attend College | No Pregnancy (<18)	0.41	0.38
Attend College | Pregnancy (<18)	0.08	0.08
Attend College | Ability Q1	0.12	0.10
Attend College | Ability Q2	0.25	0.32
Attend College | Ability Q3	0.40	0.46
Attend College | Ability Q4	0.67	0.50
Graduate College | No Pregnancy (<22)	0.62	0.51
Graduate College | Pregnancy (<22)	0.30	0.38

Notes: The table shows moments relating age at first pregnancy with education outcomes.

The model successfully captures the link between cognitive ability, pregnancy, and education attainment. Table 10 reveals that the model generates the same proportion of high school dropouts and college attendees as in the data. Although the model generates a lower college attendance rate for the top quartile of ability than in the data, it reproduces the right attendance rate for the lowest ability quartile, which is particularly interesting due to the high number of teen pregnancies in this group. Despite the lack of financial constraints to college attendance and the unmodeled relationship between ability and parental income, the model fits the association between ability and college attendance well. Finally, the model produces a gap in college graduation between women with and without children during college, but the gap is narrower than in the data.

5.1.3 Marital Outcomes

Table 11. Fit Marital Outcomes and Pregnancies by Education Group

Moments	Data	Model	Moments	Data	Model
Married 18-21 yr. old | HSD, NPP	0.39	0.34	Sing. Mom 22-29 yr. old | HS, NPP	0.12	0.10
Married 18-21 yr. old | HS, NPP	0.41	0.34	Sing. Mom 22-29 yr. old | Coll, NPP	0.02	0.02
Married 22-29 yr. old | HSD, NPP	0.61	0.50	Preg. 18-21 yr. old | HSD, NPP	0.42	0.47
Married 22-29 yr. old | HS, NPP	0.66	0.68	Preg. 18-21 yr. old | HS, NPP	0.35	0.40
Married 22-29 yr. old | Coll, NPP	0.68	0.64	Preg. 18-21 yr. old | Att. Coll, NPP.	0.16	0.17
Sing. Mom 18-21 yr. old | HSD, NPP	0.44	0.36	Preg. 22-29 yr. old | HSD, NPP	0.43	0.48
Sing. Mom 18-21 yr. old | HS, NPP	0.29	0.24	Preg. 22-29 yr. old | HS, NPP	0.43	0.37
Sing. Mom 22-29 yr. old | HSD, NPP	0.22	0.18	Preg. 22-29 yr. old | Coll, NPP	0.42	0.49

Notes: The table shows moments relating age at pregnancy with martial outcomes by education. All moments are conditional on no pregnancies before the respective age (NPP).

Moving on to moments related to contraception and marriage choices conditional on education and age, we have total pregnancies, single motherhood, and fraction married. Table 11 summarizes the model's performance in matching these moments with the empirical data. Overall, the model is able to capture the key features of these outcomes, with total pregnancies, single motherhood, and fraction married all falling within the range of the corresponding empirical data. However, there is one important discrepancy: the model significantly overpredicts the number of total pregnancies among high school graduates.

5.2 Mechanisms Decomposition and the Importance of Ability

In this section, I will analyze how the model performs when cognitive ability only affects fertility decisions through education and wage opportunity cost, and contraception is independent of cognitive ability. First, I estimate the model with homogeneous contraception technology in education and ability, which I call the "baseline model." In this case, the only heterogeneity in contraception is by age, with $\lambda^{HSD}1t = \lambda^{HS}1t = \lambda_{1t}^{Coll}, \lambda^a = 0$, and $\rho = 0$. Next, I make contraception depend on education, and finally, I make it depend on both education and ability, with $\lambda^a \geq 0$ and $\rho \neq 0$. Each model is estimated separately, and the fit with the data is assessed using the sum of squared errors (SSE) normalized by the data moment. The paper argues that cognitive ability affects pregnancy timing beyond education, wages, and marriage opportunities. Therefore, analyzing how the model performs when cognitive ability is not taken into account in the contraception technology provides insight into the importance of cognitive ability in fertility decisions.

$$\text{SSE} = \sum \left(\frac{m_i - m_i(\hat{\theta})}{m_i} \right)^2$$

where m_i is the data moments and $m_i(\hat{\theta})$ is the model moments for the parametrization θ. As in the previous section, I group the moments into three categories: Cognitive Ability and Pregnancies, Education, and Marital Moments. The top of table 12 shows the total SSE for each different version of the model. The bottom displays the percentual improvement in the model fit when each mechanism is added $(1 - \frac{\text{SSE}_1}{\text{SSE}_0})$ and the correlation between ability and teen pregnancies $Corr(P_{14-17}, ability)$. The full set of moments for each model specification is shown in table B1. Figure 8 shows the relationship between pregnancies and ability for women between 14-17 and 18-21 years old for the three model specification and the data.

Table 12. Decomposing the Model Fit

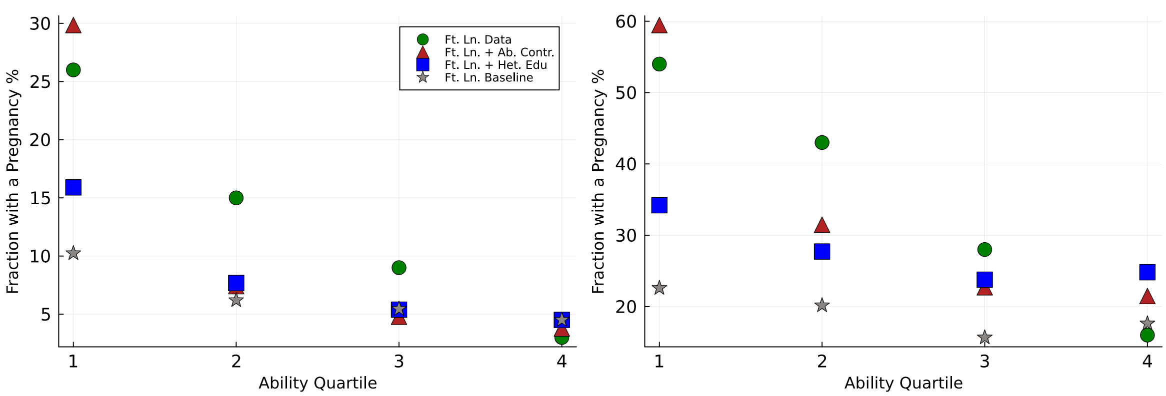
	(1)	(2)	(3)
	Baseline	Baseline	Baseline
		+ Educ. Het.	+ Educ. Het.
			+ Ab. Cont.
Total SSE	2.77	2.49	1.73
Pregnancies and Ability Moments SSE	1.61	1.41	1.12
Education Moments SSE	0.24	0.48	0.32
Marital Moments SSE	0.92	0.60	0.29
Fit Improvement $(1 - \frac{\text{SSE}_1}{\text{SSE}_0})$		+ Educ. Het.	+ Ab. Cont.
Total Fit		10%	30%
Pregnancies and Ability Moments		13%	21%
Education Moments		-103%	33%
Marital Moments		35%	51%
Corr(P_{14-17}, ability) Data=-.27	-.09	-.14	-.28

Notes: The table shows the sum of square moments (SSE) for each set of moments and the respective fit improvement at adding a layer of heterogeneity to the model. Corr(P_{14-17}, ability) is the correlation between teen pregnancies and ability generated in the model.

In the "baseline" model, the relationship between ability and pregnancies is almost flat, and it generates only a third of the correlation between ability and teen pregnancies. Adding heterogeneity by education increases the slope at which higher ability decreases teen pregnancies and improves the fit of the model by 10% and % in the moments relating ability with pregnancies. However, this improvement is at the expense of decreasing the model performance in fitting education moments by half. Finally, adding ability to the contraception technology generates the same correlation between ability and teen pregnancies as in the data and improves the total fit of the model by 30% and 21% in the moments that relate pregnancies with ability. The model replicates the pregnancy rates of the first and last ability quartiles but underpredicts pregnancy rates for the second and third. Figures 8a and 8b show that the model with ability and education heterogeneity and the model with ability heterogeneity have a much better fit in capturing the relationship between ability and pregnancies for women between 14-17 and 18-21 years old than the baseline model.

Figure 8. Fraction of Pregnancies by Age and Cognitive Ability Quartile

(a) First Period: Pregnancy between 14-17 years old (b) Second Period: Pregnancy between 18-21 years old

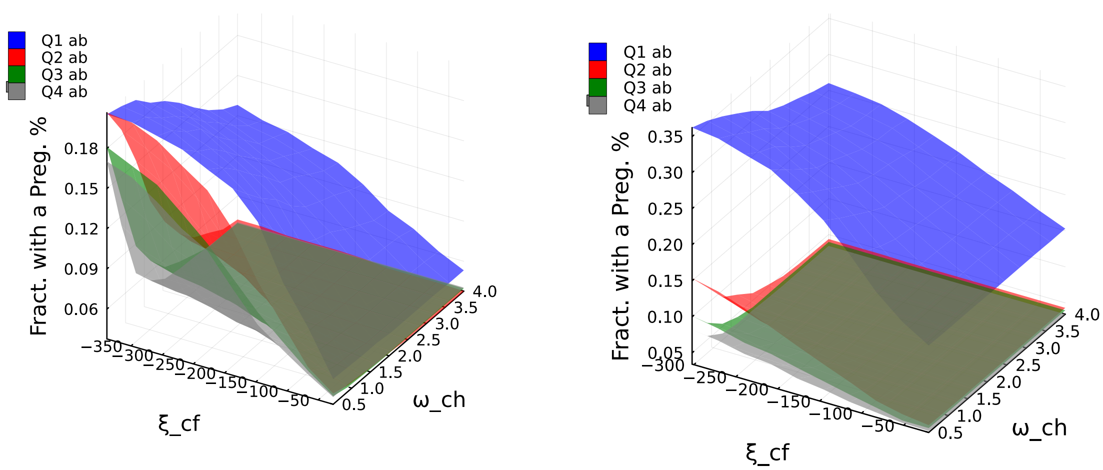


Notes: The left figure shows the fraction of women with teen pregnancy (14-17 years old) by ability quartile in the data and each model. The left side shows the fraction of women with pregnancies at college age (18-21 years old). Dots are the data, triangles are the full model, squares are the model with heterogeneity by education, and stars are the baseline model.

Three parameters play a key role in explaining the relationship between ability and pregnancies: the share of ability on the contraception function (λ_a), the cost of attending college (ξ_c), and ω_h, which determines the concavity of the college psych cost. In Figure 9a, I show how the cost of college affects pregnancies between 14-17 years old when the contraception technology is not dependent on ability ($\lambda_a = 0, \rho = 0$). Conversely, Figure 9b illustrates how the cost of college shapes pregnancies when the contraception technology depends on ability at the estimated parameters ($\lambda_a = 0.08, \rho = -0.4$). A decrease in college costs reduces pregnancies for all ability groups. However, no parameter combination in the grid generates a gap between low- and high-ability groups that match the magnitude seen in the data. In contrast, incorporating ability into the contraception technology produces a gap in the level of pregnancies between individuals with low and high abilities, as observed in the data.

Figure 9. Relationship between ability and pregnancies.

(a) $\lambda_a = 0, \rho = 0$ (b) $\lambda_a = 0.08, \rho = -0.4$

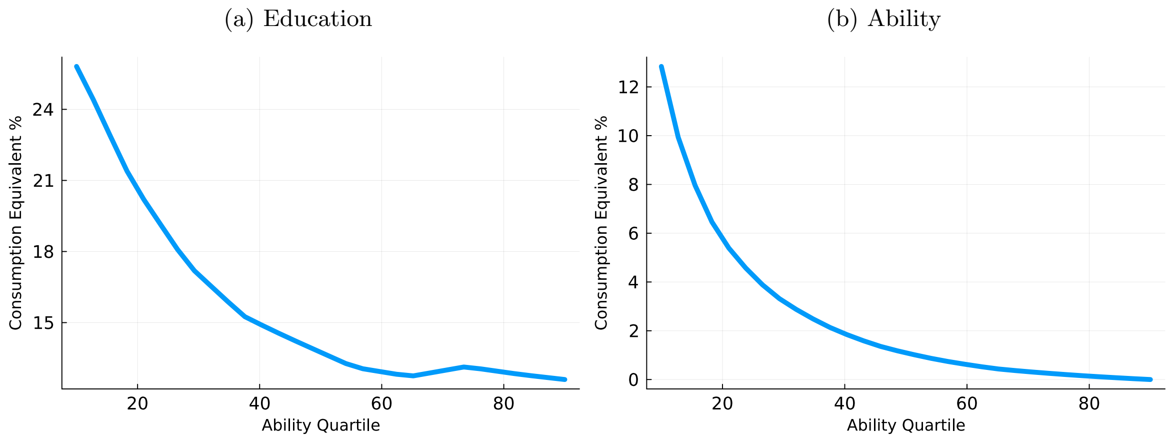


Notes: The left figure shows the fraction of teen pregnancies by ability quartiles for different college costs ξ_{cf} and convexity ω_{ch} in how ability decreases this cost in a model without ability heterogeneity in the contraception technology. The right figure shows the behavior in the fraction of teen pregnancies when we change the same parameters in a model with ability heterogeneity in the contraception technology. Both figures are calculated with the remaining parameters fixed in the estimated parameters.

5.3 Contraception Cost as Consumption Equivalent

In this subsection, I examine the consumption value of improvements in contraception technology—formal education and cognitive ability decrease contraception costs. First, estimate the value in consumption of the difference in contraception costs between high school graduates and college graduates. Next, I estimate the value in consumption of difference in contraception costs between individuals with high and low cognitive ability.

Figure 10. Equivalent Consumption by Ability Percentiles



Notes: The left figure shows the change in lifetime consumption required to make women indifferent between having the estimated contraception cost by education or all education groups having the same contraception cost as college. The right figure shows the increase in lifetime consumption require to make a teenager indifferent between using the amount of contraception necessary to have the same pregnancy probability as a teen in the top ability decile and her current choice.

To measure the difference in contraception cost by education, Figure 10a displays the increase in women's lifetime consumption if all education groups have the same contraception cost as college graduates. The results show that equalizing contraception cost by education groups is equivalent to an increase of 26% in lifetime consumption for women in the first ability decile, while it is around 10% for women in the top decile. Low-ability women benefit the most from this change as they are less likely to attend college; however, the top decile has a high college attendance, so the contraception cost remains the same for most women in that decile.

Furthermore, Figure 10b quantifies the difference in contraception cost by teenagers' ability. It does so by calculating the increase in lifetime consumption necessary to make a teenager indifferent between using the amount of contraception necessary to have the same pregnancy probability as a teenager in the top ability decile and her current choice. This exercise shows that the cost for a teenager in the bottom decile to avoid a pregnancy is around 12% of her lifetime consumption. The results indicate that teenagers with low cognitive ability face substantially higher costs of contraception, which could partially explain the higher incidence of early pregnancies in this group.

6 Contraception Cost and Education Opportunities

Single motherhood and teen pregnancy are critical policy concerns, as women in these situations are often significantly disadvantaged in many economic and social dimensions. For example, they may have lower levels of educational attainment, reduced labor force participation, and face greater economic insecurity. Additionally, the impact of mistiming in children's outcomes can be persistent over time, affecting multiple economic dimensions such as human capital accumulation, intergenerational inequality, and family formation. Addressing these issues is essential to promote social mobility and equality, as well as to improve the well-being of affected individuals and their families.

The impact of early pregnancies on mothers' outcomes and the underlying causes of their disadvantage is an open question that policymakers need to consider when designing policies to support them. Understanding whether early pregnancies cause disadvantages or whether women who have early pregnancies are already disadvantaged is crucial for policy design. For instance, if the cause of low education achievement among teen mothers is the timing of pregnancy, reducing contraception costs could have a significant impact on educational achievement. However, if early inequalities cause low education outcomes, policies that decrease the cost of children for teens and single mothers may not improve educational achievement and could even increase the number of early pregnancies. It is crucial to address the underlying causes of disadvantage to design effective policies that can help these women overcome their challenges and achieve better outcomes.

The effect of the U.S. welfare system on nonmarital and teenage pregnancies has been discussed since Becker (1991), who argue that at least part of the high number of nonmarital childbirth is caused by government aid. Rosenzweig (1999) find supportive evidence that welfare policies induce young women to choose to have a child outside of marriage. The relevance of this question is such that in 1996 the Personal Responsibility and Work Opportunity Reconciliation Act reformed the welfare system, stating that one of its goals was reducing nonmarital and teen pregnancies (Lichter and Jayakody, 2002).

While there is evidence linking early pregnancies to poor educational outcomes, previous research has suggested that this correlation may overstate the effect of the child on the mother's outcomes. For instance, Hotz et al. (2005), using miscarriages as an instrumental variable, found that teenage pregnancies had an insignificant effect on high school graduation at age 28. Similarly, Levine and Painter (2003) used propensity score matching to deal with endogeneity and found that only half of the correlation between teenage pregnancy and low educational attainment was causal. They also found that teenage pregnancy decreased college attendance by %, half of what is suggested by simple regression analysis. To further assess this question, I conduct three counterfactual analyses using the model.

1. High ability for contraception: All women are in the top ability percentile for contraception purposes.

2. High ability for education and wages: All women have the same college cost and income profile as women in the top ability percentile.

3. High ability for contraception, education, and wages: All women are in the top ability percentile for contraception, college cost, and wages.

Table 13. Counterfactual Results

	(1)	(2)	(3)
Moments	Same Cont. Ab.	Same Ab. Edu. + Same Ab. Wage	Same Cont. Ab. + Same Ab. Edu. + Same Ab. Wage
Attend Coll	5%	77%	83%
Preg < 18	-87%	-33%	-91%
Preg < 22	-46%	-30%	-49%

Notes: The table shows the change in college attendance, pregnancies before 18 years old, and pregnancies before 22 years old of three different policies: i) all women have are high ability for contraception, ii) all women are high ability for education and labor, and iii) all women are high ability for contraception, education, and labor.

The results of the counterfactual analysis are presented in Table 13. In the first column, we examine the effect of reducing contraception costs for low-ability women to the level of high-ability women. Consistent with previous empirical studies, we find that reducing contraception costs has little effect on college attendance. The model shows that giving low-ability women the same contraception cost as high-ability women increases college attendance by only 5%, as women who are teen mothers are concentrated in the lowest ability quartiles and may find attending college too costly even without a child. However, reducing contraception costs leads to a substantial decline in teen pregnancies, with an 87% reduction in teen pregnancies and a 46% reduction in pregnancies before age 22. Furthermore, as discussed in Subsection 5.3, we observe a significant increase in the welfare of low-ability women.

In the second column of the table, we investigate the effect of reducing the psych cost of attending college for low-ability individuals, while keeping the contraception cost fixed. The results show that this policy change increases college attendance by 77% and reduces teen pregnancies by one-third.

Finally, the third column of the table shows the effect of reducing both contraception and the psych cost of college attendance. This policy change leads to an 80% increase in college attendance and a nearly 50

In conclusion, this study highlights the importance of considering differences in contraception costs and education opportunities when analyzing the relationship between teen pregnancies and ability. The results show that policies aimed at reducing contraception costs can significantly decrease teen pregnancies, especially among low-ability individuals, leading to substantial welfare improvements, as shown in Figure 10. However, it is important to note that this alone is not sufficient to improve educational outcomes for low-ability individuals. Improving education opportunities for this group should also be a priority, as reducing contraception costs has little impact on educational outcomes, as shown in the model's counterfactual results.

7 Reduce Contraception Cost

In this section, I examine the impact of a policy that reduces the cost of contraception for all women to the level of a college graduate on educational outcomes, marriage, and pregnancies, using the model. Specifically, I set the contraception cost (λ) for high school dropouts to the same level as high school graduates between the ages of 18-21 and 22-29, while the contraception cost for both high school graduates and dropouts is set to the cost of a college graduate. This allows me to explore the effects of equalizing contraception costs across education levels.

Reducing the cost of contraception for all women to the level of college graduates is found to have a significant impact on educational outcomes, marriage, and pregnancies. The model predicts a decrease in pregnancies across all age groups, with a 24% decrease in teenage pregnancies, 15% decrease in pregnancies before age 22, and 42% decrease in pregnancies before age 29. Notably, the decrease in teenage pregnancy is driven by the expectation of future outcomes, given that the cost of contraception between ages 14-17 remains the same. However, the decrease in contraception costs also results in an increase in high school dropouts, as teenagers drop out of school primarily due to the cognitive cost of education rather than teen pregnancies. The model also suggests that better contraception technology is an important motivator for low-ability women to pursue education. In the absence of this motivation, education becomes less attractive, and high school dropouts double, while college attendance decreases by 12%. The decrease in the number of single mothers is also observed, with a 50% decrease among high school dropouts and a 35% decrease among high school graduates between ages 18-21. Among those aged 22-29, the number of single mothers almost disappears for college graduates, while it remains constant for non-college graduates, as their contraception costs remain unchanged. Finally, the number of marriages remains constant for high school graduates and college graduates but declines by 20% for high school dropouts, as marriage serves as insurance in case of pregnancy.

Table 14. Reduce Contraception Cost

Moments	Data	Coll. Cost	Moments	Data	Coll. Cost
Preg. < 18 yr. old	0.11	-24%	Pregnancy 18-21 yrs. old | HSD, NPP	0.47	-46%
Preg. < 22 yr. old	0.40	-15%	Pregnancy 18-21 yrs. old | HS, NPP	0.40	-38%
Preg. < 29 yr. old	0.64	-42%	Pregnancy 18-21 yrs. old | Attend Coll, NPP	0.17	-10%
Drop HS | No Preg	0.06	130%	Single Mom 22-29 yrs. old | HSD, NPP	0.18	-98%
Drop HS | Preg	0.27	-6%	Single Mom 22-29 yrs. old | HS, NPP	0.10	-94%
Attend Coll, NPP | No Preg	0.38	-12%	Single Mom 22-29 yrs. old | Coll, NPP	0.02	0%
Attend Coll, NPP | Preg	0.08	12%	Married 22-29 yrs. old | HSD, NPP	0.50	-16%
Grad. Coll., NPP | No Preg	0.51	-5%	Married 22-29 yrs. old | HS, NPP	0.68	3%
Grad. Coll., NPP | Preg	0.38	6%	Married 22-29 yrs. old | Coll, NPP	0.64	1%
Married 18-21 yrs. old | HSD, NPP	0.35	-2%	Pregnancy 22-29 yrs. old | HSD, NPP	0.48	-97%
Married 18-21 yrs. old | HS, NPP	0.34	-1%	Pregnancy 22-29 yrs. old | HS, NPP	0.37	-89%
Single Mom 18-21 yrs. old | HSD, NPP	0.36	-52%	Pregnancy 22-29 yrs. old | Coll, NPP	0.49	-2%
Single Mom 18-21 yrs. old | HS, NPP	0.24	-35%			

Notes: The table shows the changes in different model moments of decreasing the contraception cost to the level of a college graduate for all education groups. The moments are conditional on not having previous pregnancies (NPP).

8 Conclusion

The present paper contributes to the literature on the role of cognitive ability in fertility timing by empirically and quantitatively exploring its effects. The findings suggest that cognitive ability is an important determinant of fertility timing beyond the differences in time opportunity cost and fertility risk by education. The dynamic life-cycle model developed and estimated in this paper provides a framework to evaluate the welfare gains of improvements in contraception cost by ability and analyze the effects of policies targeting contraception cost and cognitive ability.

The results of the model show that improving contraception cost is welfare-improving, especially for low-ability individuals, and decreases pregnancies in all age groups. However, policies aimed solely at reducing contraception costs may have little impact on educational outcomes, as the cost of higher education is often too high for low-ability individuals even without the added cost of a child.

Moreover, the paper highlights the importance of cognitive ability in understanding fertility timing and intention, as well as its role in noneconomic outcomes. Future research could extend the model to incorporate children's human capital accumulation and assess the effect of early pregnancies on intergenerational inequality. Overall, this paper provides a framework for policymakers to understand the effects of policies targeting fertility and education and the potential gains from improving access to contraception technology by cognitive ability.

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A Calibration Parameters

Appendix Table A1. Contraception Cost by Education and Age Group

Education / Age Group	13-17 yr. old	18-21 yr. old	22-29 yr. old
High School Dropout	1.18	2.70	0.38
High School Graduate	1.18	0.63	0.91
College	1.18	0.57	6.28

Notes: Estimated contraception cost λ by age and education.

Appendix Table A2. Probability Meeting a Husband

Education / Age Group	18-21 yr. old	22-29 yr. old
High School Dropout	0.33	0.29
High School Graduate	0.48	0.31
College		0.33

Notes: Estimated probability of meeting a men μ by age and education.

B Model Mechanisms Contribution

Appendix Table B1. Pregnancy and Wages

Moments	Data	Baseline + Educ. Het + Ab. Cont.	Baseline + Educ. Het.	Baseline
% Preg AQ1 14-17 yrs. old	0.26	0.30	0.16	0.11
% Preg AQ2 14-17 yrs. old	0.15	0.07	0.08	0.07
% Preg AQ3 14-17 yrs. old	0.09	0.05	0.05	0.05
% Preg AQ4 14-17 yrs. old	0.03	0.04	0.05	0.05
Drop HS | No Preg	0.06	0.06	0.07	0.06
Drop HS | Preg	0.28	0.27	0.21	0.29
Att. Coll. | No Preg	0.41	0.38	0.35	0.35
Att. Coll. | Preg	0.08	0.08	0.09	0.07
Att. Coll. AQ1	0.12	0.10	0.07	0.11
Att. Coll. AQ2	0.25	0.32	0.30	0.29
Att. Coll. AQ3	0.40	0.46	0.46	0.44
Att. Coll. AQ4	0.67	0.49	0.49	0.48
Graduate College | No Preg	0.62	0.51	0.55	0.55
Graduate College | Preg	0.30	0.38	0.33	0.36
% Preg AQ1 18-21 yrs. old | NPP	0.54	0.59	0.34	0.30
% Preg AQ2 18-21 yrs. old | NPP	0.43	0.31	0.28	0.25
% Preg AQ3 18-21 yrs. old | NPP	0.28	0.23	0.24	0.20
% Preg AQ4 18-21 yrs. old | NPP	0.16	0.21	0.25	0.21

Notes: The table shows the moments generated by the full model, the model with heterogeneity by education, and the baseline model. Moments are conditional on not having previous pregnancies (NPP).

Appendix Table B2. Pregnancy and Wages

Moments	Data	Baseline + Educ. Het + Ab. Cont.	Baseline + Educ. Het.	Baseline
Married 18-21 yrs. old | HSD, NPP	0.39	0.35	0.29	0.44
Married 18-21 yrs. old | HS, NPP	0.41	0.34	0.32	0.36
Single Mom 18-21 yrs. old | HSD, NPP	0.44	0.36	0.36	0.35
Single Mom 18-21 yrs. old | HS, NPP	0.29	0.24	0.19	0.17
Pregnancy 18-21 yrs. old | HSD, NPP	0.42	0.47	0.48	0.57
Pregnancy 18-21 yrs. old | HS, NPP	0.35	0.40	0.33	0.29
Pregnancy 18-21 yrs. old | Attend Coll., NPP	0.16	0.17	0.15	0.11
% Preg AQ1 22-29 yrs. old | NPP	0.48	0.64	0.50	0.51
% Preg AQ2 22-29 yrs. old | NPP	0.48	0.51	0.47	0.49
% Preg AQ3 22-29 yrs. old | NPP	0.45	0.33	0.44	0.46
% Preg AQ4 22-29 yrs. old | NPP	0.45	0.29	0.39	0.45
Single Mom 22-29 yrs. old | HSD, NPP	0.22	0.18	0.14	0.18
Single Mom 22-29 yrs. old | HS, NPP	0.12	0.10	0.10	0.13
Single Mom 22-29 yrs. old | Coll., NPP	0.02	0.02	0.02	0.02
Married 22-29 yrs. old | HSD, NPP	0.61	0.50	0.56	0.51
Married 22-29 yrs. old | HS, NPP	0.66	0.68	0.57	0.83
Married 22-29 yrs. old | Coll., NPP	0.68	0.64	0.65	0.99
Pregnancy 22-29 yrs. old | HSD, NPP	0.43	0.48	0.57	0.40
Pregnancy 22-29 yrs. old | HS, NPP	0.43	0.37	0.45	0.52
Pregnancy 22-29 yrs. old | Coll., NPP	0.42	0.49	0.42	0.35

Notes: The table shows the moments generated by the full model, the model with heterogeneity by education, and the baseline model. Moments are conditional on not having previous pregnancies (NPP).