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Agustin Diaz Casanueva

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Supervisor of Dissertation

Jose Victor Rios Rull, Professor of Economics, Department of Economics

Graduate Group Chairperson

David Dillenberger, Professor of Economics, Department of Economics

Dissertation Committee

Dirk Krueger, Professor of Economics, Department of Economics
Jose Victor Rios Rull, Professor of Economics, Department of Economics
Andrew Shephard, Associate Professor of Economics, Department of Economics

ESSAYS ON MACROECONOMICS AND FAMILY ECONOMICS

to Daniela

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ABSTRACT

ESSAYS ON MACROECONOMICS AND FAMILY ECONOMICS

Agustin Diaz Casanueva

Jose Victor Rios Rull

In the first chapter titled *"Cognitive Ability, Education, and Fertility Risk"*, I explore the role of cognitive ability in fertility timing. Women in the bottom quartile of the cognitive ability distribution are nine times more likely to have their first child as a teenager. First, I document the differences in age at childbirth by cognitive abilities and the fact that this relationship persists after controlling for wage, education, demographics, and measurement errors. Subsequently, utilizing NLSY79 data, I build and estimate a life cycle model to jointly study the relationship between contraception efficiency, age at childbirth, education, wages, and marriage. Then, I answer through the model's lens whether low educational outcomes among teenage mothers are due to the cost of attending college with a child or if they have children earlier because they do not attend college. I find that college is too costly for teen mothers, even without a child, so postponing maternity does not lead to higher college attendance. Finally, I explore the 32% reduction in teen pregnancies during the 1990s and 2000s. According to the model, the decline in teen pregnancies was primarily driven by an increase in women's wages, contraception efficiency, and a reduction in the cost of attending college.

In the second chapter *"The Role of Parental Altruism in Parents' Consumption, College Financial Support, and Outcomes in Higher Education"*, I analyze how parent-child interactions and parents' altruism impact college financial support and outcomes. Firstly, I document how wealthy parents with poor children change their consumption patterns. Finding that a poor child reduces parent consumption by 2000 dollars annually. Then I use a dynamic altruistic overlapping generations model, in which parents and children interact each period to study if parents use college financial aid as a mechanism to reduce future overconsumption, helping to explain the highest graduation rates for low-ability children with wealthy parents, compared to low-ability children with non-wealthy parents. The model explains 60% of the college graduation gap among low-ability students

of different parental wealth.

Finally, in the third chapter, *"Fiscal and Generational Imbalances in the U.S. Federal Budget"*, joint with Jagadeesh Gokhale and Kent A. Smetters, we use the Penn Wharton Budget Model's microsimulation and U.S. demographic projections to estimate federal fiscal and generational imbalances. First, we utilized survey data to estimate the average per-capita payments of each type of government tax and transfer by education, age, race, and cohort. Next, we used the Congressional Budget Office's (CBO) aggregate payment projections to estimate per capita government taxes and benefits for each group until 2030. As the CBO only submits forecasts until 2030, we assumed that tax and transfer growth would continue at the labor productivity rate thereafter. Finally, we aggregated all taxes and transfers, accounting for population growth and demographic changes. Based on our analysis, the federal government's fiscal imbalance (FI) under current fiscal laws and purchase policies over the next 75 years is 7.0 percent of the present value of projected GDP (PVGDP), and calculated in perpetuity, it is 8.2 percent of PVGDP. Furthermore, the FI as a share of the present value of federal expenditures over the next 75 years equals 29.8 percent, while it equals 38.6 percent as a share of the present value of federal revenues implying that to keep the fiscal balance, the government should reduce expenditures or increase taxes in the previous magnitudes. We also measure the generational imbalance (GI) for Social Security and Medicare Part A, which shows the present value of net benefits in excess of taxes paid by past and currently alive generations. Our findings indicate that the imbalance for past and current generations amount to $44.7 trillion, while the imbalance for future-born generations is $38.4 trillion.

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CHAPTER 1

Cognitive Ability, Education, and Fertility Risk

1.1. 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 the pregnancy occurred at an inappropriate time or was completely 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., 2006b). 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

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

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 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 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 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 (26% 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).

Later, 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. Then, 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.

In the last section, I analyze the decline in teen pregnancies that occurred in the US during the 1990s using the model. I use data from women surveyed in the NLSY97 who were teenagers during this time and find a significant decrease in the cost of contraception. Furthermore, the cost of attending college decreased for all women, including those with lower cognitive abilities, which increased the cost of early pregnancies.

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. (2006b) 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%.

1.2. 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.

1.2.1. 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 1.1: 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 1.1 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.

1.2.2. 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.

Cognitive Ability and Age at First Childbirth

Table 1.2 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 1.2: Joint Distribution First and Unwanted First Pregnancy by Age and Cognitive Ability

	Ability Quartile			
	First Quartile	Second Quartile	Third Quartile	Four Quartile
Age	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.

Pregnancy Timing and Education

Table 1.3 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 1.3: 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 subsection, 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.

Early Pregnancies and Marriage

In his seminal work 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 1.4: 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 1.4 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 1.5: 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 1.5 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 $4,000 yearly due to out-of-wedlock childbirth, while those who had their first pregnancy between 22 and 29 years old face a penalty of $11,000. College graduates face the highest penalty, with a reduction of approximately $18,000 in annual husband income due to an out-of-wedlock childbirth.

1.2.3. The Effect of Cognitive Ability on Fertility

In subsection 1.2.2, 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 (18-21 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. (2006b) 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. (2006b); 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. A static linear model captures the effect of future outcomes on current fertility decisions, which upwardly biased the impact of ability for teens, as the estimated coefficients also capture future wages and marital opportunities. To address this, I estimate the static model at three different points in time, as described earlier. While high school education outcomes are already realized for most college-age women, future income and marriage affect the opportunity cost and bias 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:

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

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 1.6 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 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 1.6: Latent Factor Model: Pregnancies and Unintended Pregnancies

	(1) Preg. 14-17 yrs old	(2) Unint. Preg. 14-17 yrs old	(3) Preg. 18-21 yrs old	(4) Unint. Preg. 18-21 yrs old	(5) Preg. 22-29 yrs old	(6) Unint. Preg. 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 $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

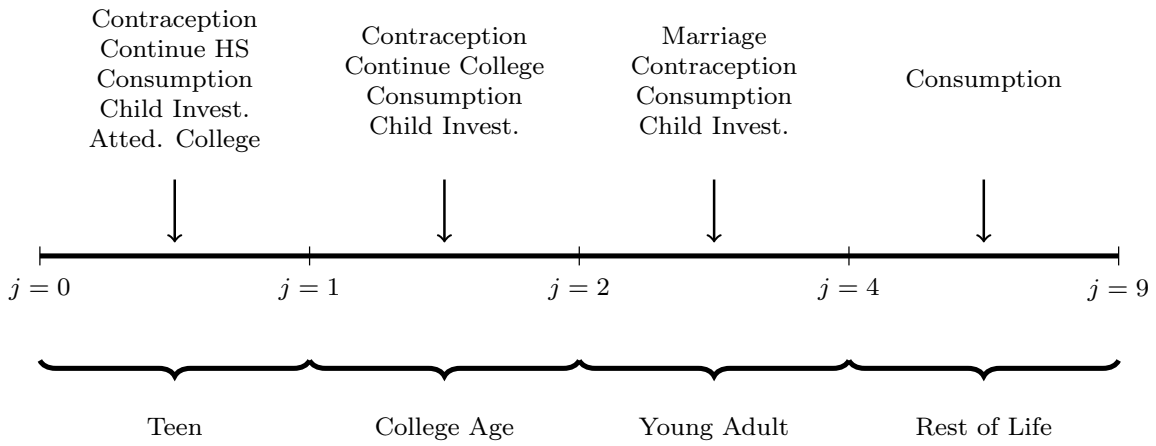
Notes: Static model estimated coefficients. Wage and test scores are standardized with a mean zero. Controls include race, both parent education, and broken home at 14. $\Delta(d_{10} - d_1)$ is the interdecile range for a particular variable showing the difference in probability between women at the 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.

1.3. 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.

1.3.1. Environment and Timing

Figure 1.1: 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 this 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 1.1. 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.

1.3.2. 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 1.4.2. 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:

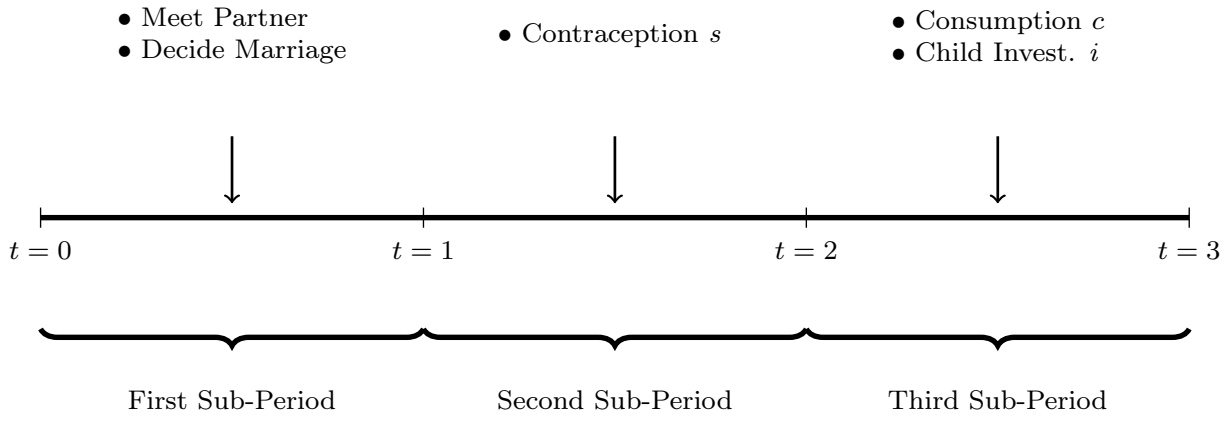
$$V_t(a, e, m, sm, k_t) = \max_c \; u(c) + \beta V_{t+1}(a, e, m, sm, k_t)$$
$$\phi_c(m, k_t) \cdot c = \; w(t, a, e, m, sm, k_t) + 1_{m=1} w^h(t, e, sm, k_t)$$

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.

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

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 1.2. 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.

Figure 1.2: 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.

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.

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 $V_t^2(a,e,m,sm,k_t) = V_t^3(a,e,m,sm,k_t)$.

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

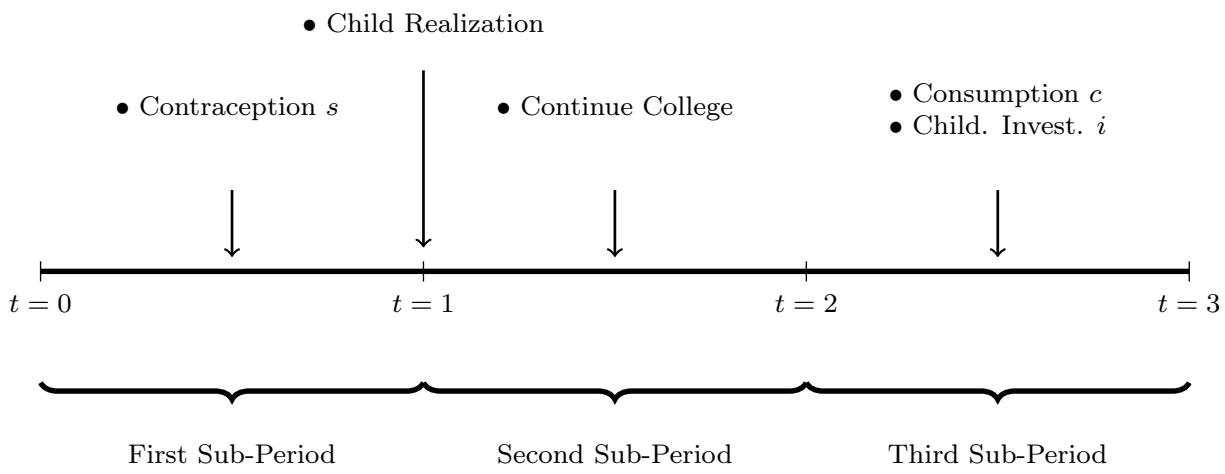
marriage is greater than remaining single. The Bellman equation in this sub-period is given by:

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

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 $V_t^1(a, e, m = 1, sm, k_t) = V_t^2(a, e, m = 1, sm, k_t)$.

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

Figure 1.3: 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.

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 1.3.3. 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 $\kappa_{\text{k,C}}$, 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.

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:

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

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

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 shock ϵ_i is i.i.d. and follows a Type I extreme value distribution, and σ_{Coll} is the scale parameter.

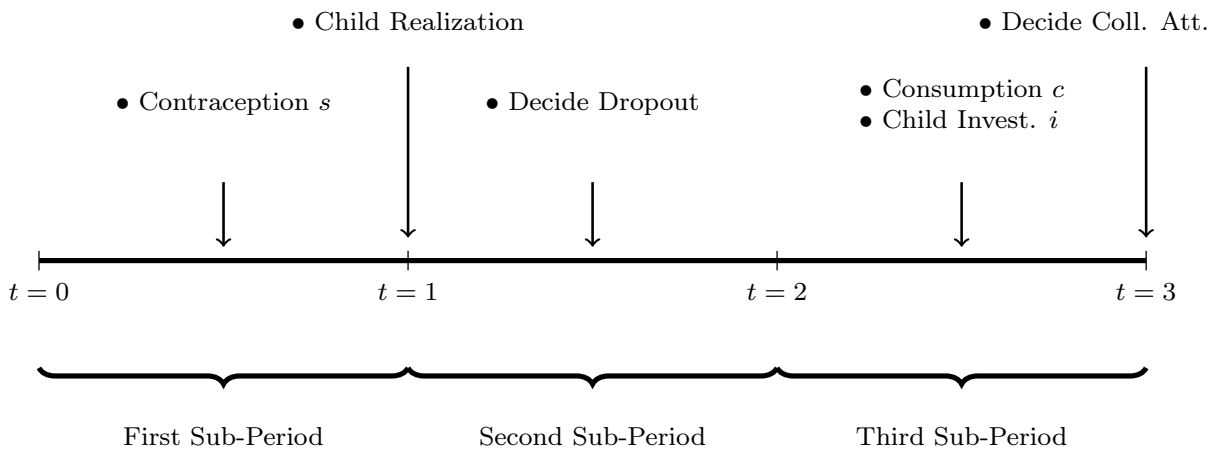
First Sub-Period 18-21: Contraception

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:

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

1.3.5. Teen: First Period (14-17 years)

Figure 1.4: 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.

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.

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.

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.

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 $\big(V_2^1(a, sm, k_t = 1) - V_2^1(a, sm, k_t = 0)\big)$.

1.3.6. Functional Forms and Parameters

The functional forms in the model are chosen to allow the mode to replicate the data. The model has 34 unknown parameters and an income process, which their estimation will be discussed in section 1.4.

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.

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 s 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:

$$p(t, a, e, s) = \frac{2 \exp(-\lambda_{e,t}(\lambda_a \cdot a^\rho + (1 - \lambda_a) \cdot s^\rho)^{\frac{1}{\rho}})}{1 + \exp(-\lambda_{e,t}(\lambda_a \cdot a^\rho + (1 - \lambda_a) \cdot s^\rho)^{\frac{1}{\rho}})} \tag{1.1}$$

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.

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.

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 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.

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 unobserved in the decision-making process is denoted by σ_{HS}.

1.4. 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.

1.4.1. Exogenous Parameter

Table 1.7 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 1.7: 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.

1.4.2. 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:

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

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

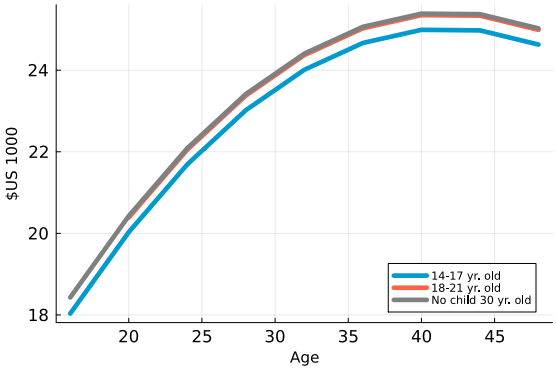
The equation shows the variables used in the wage estimation process. The variables include the woman's wage w, the husband's wage w^h, the woman's age t, the individual i, the woman's education level e and e^f, a dummy variable HA indicating whether the individual scored above the mean on the cognitive ability test (AFQT), 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

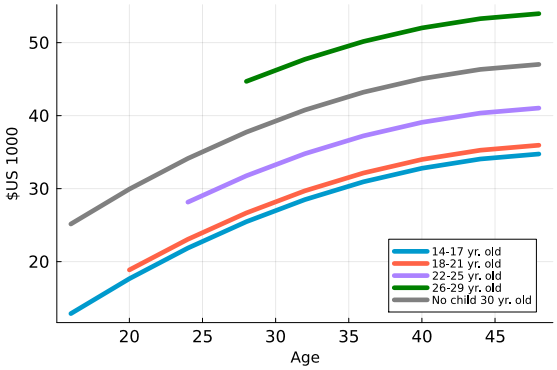
wage penalty increasing as ability levels rise. Women who marry after experiencing an out-of-wedlock pregnancy have husbands with lower wages, and the size of the husband's wage penalty increases with the woman's age at childbirth. College-educated women bear the highest wage penalty, resulting in a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

Figure 1.5: Women wage profile by education and age first birth

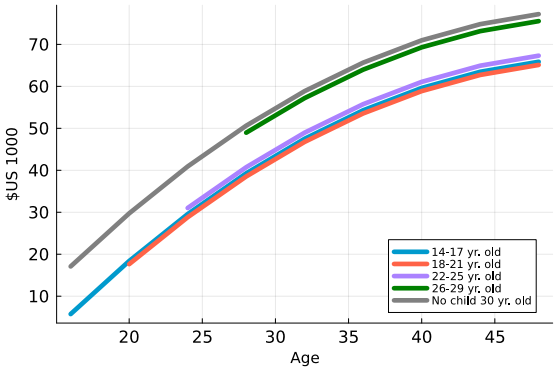
(a) High School Dropout



(b) High School



(c) College



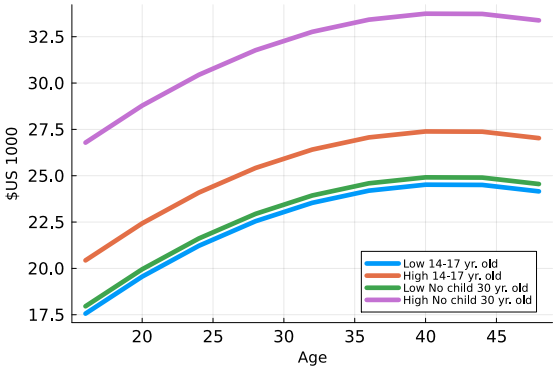
Notes: Wage profiles across age, education, and women's age at first child estimated as explained in section 1.4.2. Light blue lines show women with their first childbirth between 14-17 years old, red between 18-21, purple between 22-25, green between 26-29 years old, and grey no childbirth before 30 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, and high school dropouts have the lowest wages. In figure 1.5a, the wage profiles for high school dropouts show that early childbirth has a negligible effect on earnings, with birth between 14-17 years old

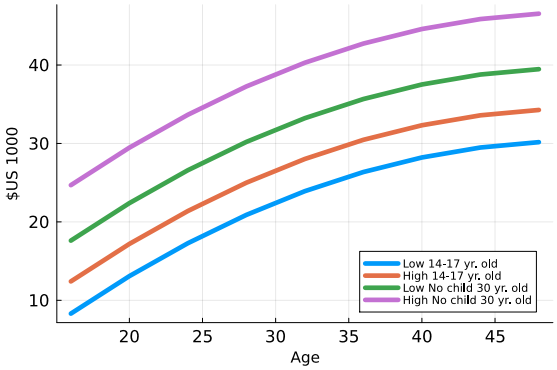
reducing wages by only \$400. The wage profiles for high school graduates in figure 1.5b indicate that women who have children between 26-29 years old have the highest wages, with early childbirth carrying a substantial wage penalty. For example, each year, women with a child between 14-17 years old earn \$12,200 less than women with a first child between 26-29 years old. Finally, figure 1.5c shows the wage profiles for college women. We observe 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 1.6: Women wage profile by education and ability

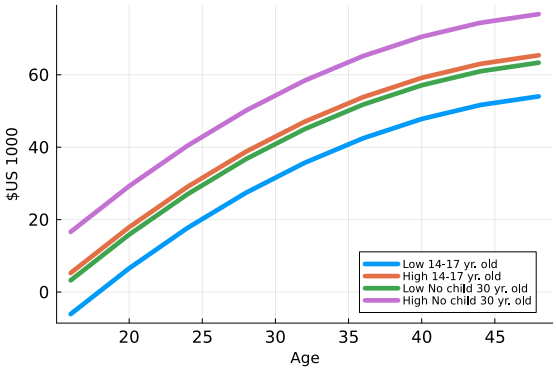
(a) High School Dropout



(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 1.4.2. 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 1.6 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 1.6a), high ability women with childbirth between 14-17 years old earn $3,000 more yearly than low ability. High ability women without a child at 30 years old earn $9,000 more yearly than low ability. For high school graduates (shown in Figure 1.6b), the difference between high and low ability is $4,000 yearly for women with childbirth between 14-17 years old, and $7,000 yearly for women without childbirth at 30 years old. For college graduates (shown in Figure 1.7), high ability women with childbirth between 14-17 make $11,000 more yearly than low ability, and this difference is $13,000 for women without a child at 30 years old.

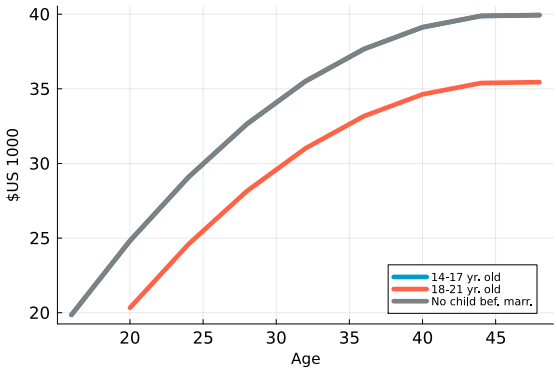
The penalty wage associated with early pregnancy is increasing in ability. Low ability high school dropouts face an early pregnancy penalty of $400 yearly, while high ability dropouts face a penalty of $6,300 yearly. Low ability high school graduates face an early pregnancy penalty of $6,300 yearly, while high ability graduates face a penalty of $12,200 yearly. For college graduates, the penalty for low ability is $9,300 yearly, while high ability graduates face a penalty of $11,340 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 1.7 presents husbands' wages by education, marital status at childbirth, and the mother's age at birth in the case of out-of-wedlock pregnancies. 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 with out-of-wedlock pregnancies between 26 and 29 years old. High school dropouts are shown in Figure 1.7a, where the husbands' wages are reduced by $4,000 for an out-of-wedlock child between 18-21 years old. In Figure 1.7b, high school graduates have husbands with wages reduced by $12,000 between 14-21 years old and by $30,000 between 23-26 years. Finally, college graduates face the highest penalty, as they marry men earning $25,000 and $42,000 less if they have an out-of-wedlock

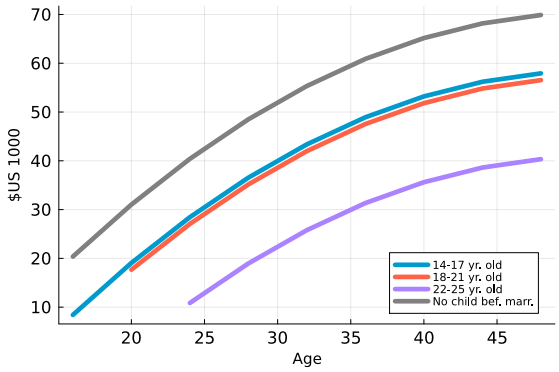
pregnancy between 14-25 and 26-29 years old, respectively.

Figure 1.7: Husband wage profile by marital status at birth and age first birth

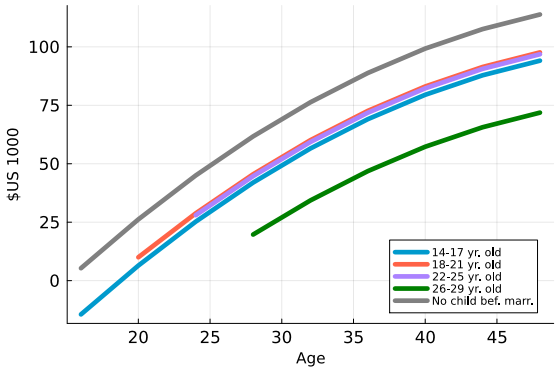
(a) High School Dropout



(b) High School



(c) College



Notes: Husband wage profiles across women's age, education, and women's age at first child estimated as explained in section 1.4.2. 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.

1.4.3. Endogenous Parameters

The remaining 30 unknown parameters are estimated with 38 data moments using the Simulated Method of Moments. These parameters govern the responses of individuals to the key determinants of fertility in the model: 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 1.8 provides an interpretation of each estimated parameter.

Table 1.8: Parameters estimated through the indirect method of moments

Contraception Technology and Child Return Parameters		
Parameter	Value	Interpretation
λ_a (1)	.08	Ability Share Contr. Tech.
ρ (1)	$-.40$	Elasticity of Substitution Contr. Tech.
$\lambda_{e,t}$ (7)	Table 1.17	Scale Parameter by Ability and Education
ω_0 ω_1 ω_2 (3)	2.39, 0.09, .55	Child Return
Marriage Parameters		
Parameter	Value	Interpretation
$\mu(e,t)$ (5)	Table 1.18	Probability Meeting a Husband
Education Parameters		
Parameter	Value	Interpretation
ξ_c ω_c (3)	$-201, 1.19$	College Psych Cost
$\kappa_{HS}, \kappa_{kb}, \kappa_{Coll.}$ (2)	$-2, -16, -27$	Cost Child Dif. Edu. Stages
$\mu_{nk}(e)$ (3)	34, 14, 1	Terminal Value no Child
$w(HS), w(Coll)$ (2)	US$48k, US$10k	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 1.8 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 1.5.2. 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 1.5.3, I discuss how contraception costs vary with education and ability.

1.5. 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.

1.5.1. 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.

Cognitive Ability and Pregnancies

Table 1.9: Fit Model Pregnancy and Ability

	Ability Quartile			
	First Quartile	Second Quartile	Third Quartile	Four Quartile
Age	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 1.9 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.

Education Outcomes

Table 1.10: 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 1.10 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 relationship 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.

Marital Outcomes

Table 1.11: 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 1.11 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.

1.5.2. 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 $\lambda_{1t}^{HSD} = \lambda_{1t}^{HS} = \lambda_{1t}^{Coll}, \lambda^a = 0$, 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.

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

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 1.12 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 $Corr(P_{14-17}, \text{ability})$. The full set of moments for each model specification is shown in table 1.19. Figure 1.8 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.

In the “baseline model" 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 total fit of the model by 10% and 13% 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 1.8a and 1.8b 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.

Table 1.12: Decomposing the Model Fit

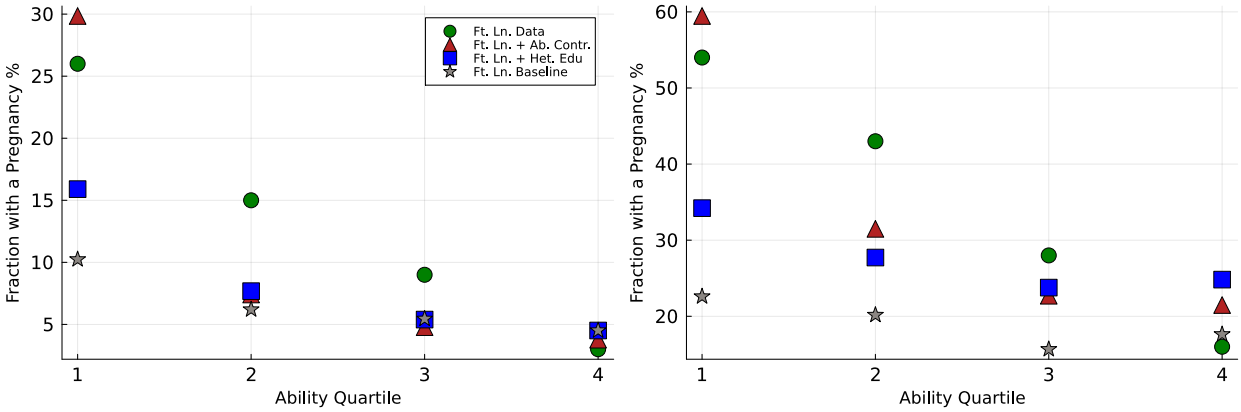
	(1) Baseline	(2) Baseline + Educ. Het.	(3) Baseline + Educ. Het. + Ab. Cont.
Total SSE	2.77	2.49	1.73
Pregnancies and Ability Moments SSE	1.61	1.41	1.12
Education Moments SSE	0.24	0.48	0.32
Marital Moments SSE	0.92	0.60	0.29
Fit Improvement $(1 - \frac{\text{SSE}_1}{\text{SSE}_0})$		+ Educ. Het.	+ Ab. 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.

Figure 1.8: 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

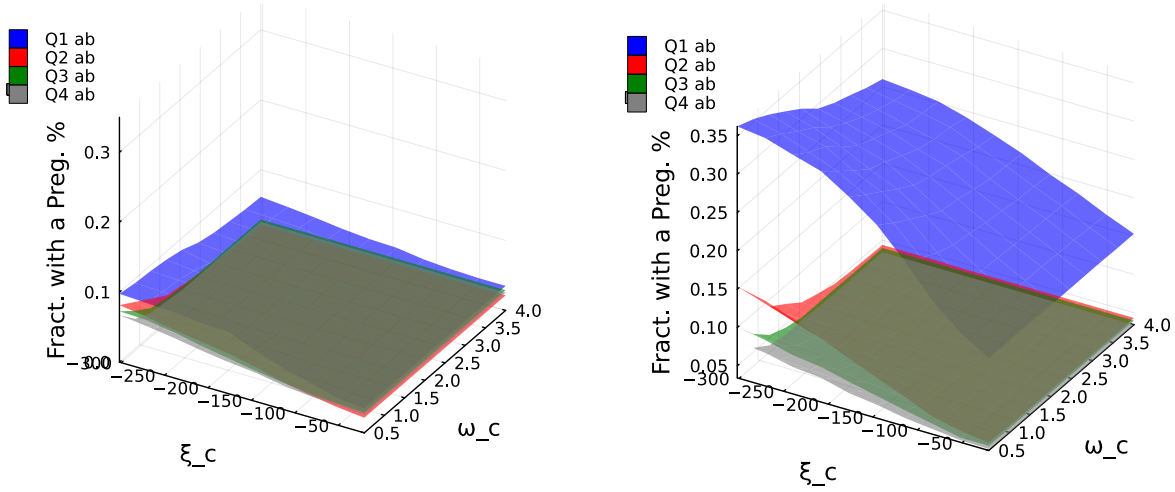


Notes: The left figure shows the fraction of women with teen pregnancy (14-17 years old) by ability quartile in the data and each model. The left side shows the fraction of women with pregnancies at college age (18-21 years old). Dots are the data, triangles are the full model, squares are the model 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 1.9a, 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 1.9b 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 1.9: Relationship between ability and pregnancies.

(a) $\lambda_a = 0, \rho = 1$ (b) $\lambda_a = 0.08, \rho = -0.4$

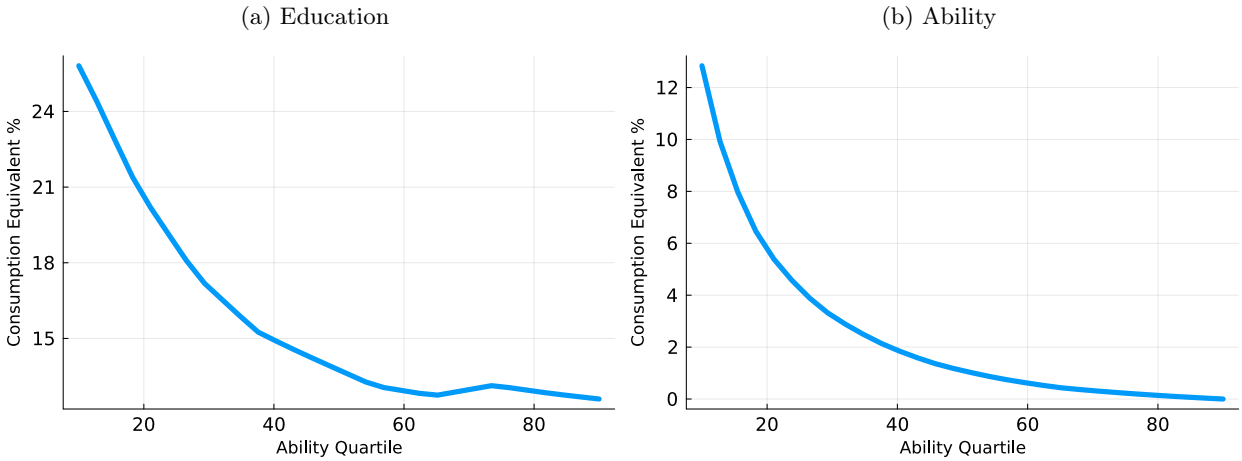


Notes: The left figure shows the fraction of teen pregnancies by ability quartiles for different college costs ξ_c and convexity ω_c in how ability decreases this cost in a model without ability heterogeneity in the contraception technology. The right figure shows the behavior in the fraction of teen 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.

1.5.3. Contraception Costs as Consumption Equivalent

In this subsection, I analyze the consumption value of lower contraception costs by education and cognitive ability. Specifically, I estimate the value in women's lifetime consumption resulting from the difference in contraception costs between high school graduates and college graduates. I then quantify the value in consumption of the difference in contraception costs between individuals with high and low cognitive ability.

Figure 1.10: 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 1.10a 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 1.10b 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.

1.6. Teen Pregnancies and Education Outcomes

This section addresses two questions. First, I use the model to investigate whether teen pregnancies cause lower educational achievement or if it's the other way around, where low-ability women leave education early and become pregnant given a low opportunity cost. Second, I examine the impact of reducing contraception costs on educational outcomes, marriage, and pregnancies.

My findings suggest that teen pregnancies do not cause the poor educational outcomes observed in low-ability women. These women do not attend college because it is too costly, even without a child. Therefore, policies aimed at reducing teen pregnancies may not necessarily lead to increased educational achievement.

1.6.1. Do Teen Pregnancies Lead to Lower Academic Performance or Vice-versa?

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, 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.

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 20%, 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.

The results of the counterfactual analysis are presented in table 1.16. 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 1.5.3, we observe a significant increase in the welfare of low-ability women.

Table 1.13: Counterfactual Results

Moments	(1) Same Cont. Ab.	(2) Same Ab. Edu. + Same Ab. Wage	(3) 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.

In the second column of the table, I 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% reduction in teen pregnancies.

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 1.10. 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.

1.6.2. The Effects of Reduce Contraception Cost

In this subsection, 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. 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 1.14: Reduce Contraception Costs

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).

1.7. The Decline in Teen Pregnancies During the '90s

Between 1990 and 2005, there was a decrease of 32% in teen births in the US (Santelli and Melnikas, 2010). To comprehend the reasons behind this trend, I utilized the previously developed model and re-estimated it using data from the NLSY97 survey. Individuals in this survey were born between 1980 and 1984 and were teenagers during the 1990s and early 2000s. The model indicates that the decline in pregnancies is linked to a significant reduction in contraception costs across all ages, particularly for teenagers. Additionally, the psych cost of attending college decreased, which has increased incentives for avoiding early pregnancies, particularly for low-ability women.

Table 1.15 presents the data moments concerning pregnancy timing, education, and marriage in both cohorts. Consistent with previous studies, there is a substantial decline in pregnancies between both cohorts. Moreover, this decrease is observable in all cognitive ability groups. While the correlation between teen pregnancy and cognitive ability decreased from -.27 to -.21, the relationship between the two remains substantial. The data also show a significant reduction in pregnancies among women aged 18-21 and 22-29. In addition, women without a history of teen pregnancy showed a substantial increase in college attendance, from 41% to 69%. The trend of higher education attainment was consistent across all cognitive ability levels, with college attendance increasing from 36% to 66%. Moreover, marriage rates among women under 29 decreased, across all education levels, especially

among high school dropouts. Finally, the data shows an increase in single motherhood among women aged 18 and older across all education groups.

Table 1.15: Pregnancy, Marital and Education Outcomes Cohorts NLSY 79 and 97

Moments	NLSY 79	NLSY97	Moments	NLSY 79	NLSY97
Cognitive Ability and Pregnancies			Education Outcomes		
Pregnancy 14-17 | Ability Q1	0.26	0.15	Drop HS | No Preg	0.06	0.13
Pregnancy 14-17 | Ability Q2	0.15	0.06	Drop HS | Preg	0.28	0.47
Pregnancy 14-17 | Ability Q3	0.09	0.03	Attend College | No Preg	0.41	0.69
Pregnancy 14-17 | Ability Q4	0.03	0.00	Attend College | Preg	0.08	0.37
Pregnancy 18-21 | Ability Q1, NPP	0.54	0.36	Attend College| Ability Q1	0.12	0.33
Pregnancy 18-21 | Ability Q2, NPP	0.43	0.25	Attend College| Ability Q2	0.25	0.61
Pregnancy 18-21 | Ability Q3, NPP	0.28	0.14	Attend College| Ability Q3	0.40	0.81
Pregnancy 18-21 | Ability Q4, NPP	0.16	0.07	Attend College| Ability Q4	0.67	0.91
Pregnancy 22-29 | Ability Q1, NPP	0.48	0.41	Graduate College | No Preg	0.62	0.49
Pregnancy 22-29 | Ability Q2, NPP	0.48	0.40	Graduate College | Preg	0.30	0.18
Pregnancy 22-29 | Ability Q3, NPP	0.45	0.33			
Pregnancy 22-29 | Ability Q4, NPP	0.45	0.29			
Marital Outcomes					
Pregnancy 18-21 | High School Drop., NPP	0.42	0.40	Married 22-29 | High School, NPP	0.66	0.44
Pregnancy 18-21 | High School, NPP	0.35	0.28	Married 22-29 | College, NPP	0.68	0.49
Pregnancy 18-21 | Attend College, NPP	0.16	0.14	Pregnancy 22-29 | High, NPP School Drop.	0.43	0.28
Married 18-21 | High School Drop., NPP	0.39	0.21	Pregnancy 22-29 | High School, NPP	0.43	0.41
Married 18-21 | High School, NPP	0.41	0.22	Pregnancy 22-29 | College, NPP	0.42	0.31
Single Mom 18-21 | High School Drop., NPP	0.44	0.74	Single Mom 22-29 | High, NPP School Drop.	0.22	0.62
Single Mom 18-21 | High School, NPP	0.29	0.65	Single Mom 22-29 | High, NPP School	0.12	0.54
Married 22-29 | High School Drop., NPP	0.61	0.33	Single Mom 22-29 | College, NPP	0.02	0.33

Notes: The table shows the data moments that summarize the relationship between pregnancies, education, and marriage for the NLSY79 and NLSY97 cohorts. The moments are conditional on not having previous pregnancies (NPP).

To estimate the model using NLSY97 data, I adopt the same parameters used in section 1.4.1 from the literature. I then estimate the income process and other parameters using the same methodology and data moments as in sections 1.4.2 and 1.4.3. In the remaining part of this section, I present the estimation results and highlight the differences observed in this young cohort compared to the previous one. The estimated parameters that determine contraception costs are presented in section 1.9.3 in the appendix. The model reveals a significant reduction in these costs for for teenagers between the NLSY79 and NLSY97 and similar contraception cost later in life. Additionally, there has been a significant decline in the psych cost of attending college (ξ_c), and the rate at which ability reduces this cost (ω_c) has increased.

In order to quantify the importance of each factor, I change the set of parameters that influence each outcome one at a time, starting from the NLSY79 estimation until I arrive at the NLSY97.

The order that I follow is as follows:

1. Use the wage process estimated for the NLSY97 cohort.

2. Child Return $(\omega_0, \omega_1, \omega_2)$

3. College Cost (ξ_c, ω_c).

4. Contraception Cost $(\lambda_{e,t}, \lambda_a, \rho)$

5. Other Factors

Table 1.16: Factor Contribution

	(1)	(2)	(3)	(4)	(5)
Moments	Wages	Child Return	College Cost	Contraception	Other Factors
Teen Pregnancies	17%	-2%	63%	27%	-5%
Attend Coll	-3%	0%	80%	0%	23%

Notes: The table shows the change in college attendance and teen pregnancies explained by each factor: i) wages, ii) Child Return,, iii) College Cost iv) Contraception Cost, v) Other Factors.

Table 1.16 shows the contribution of each factor to the decrease in teen pregnancies. We observe that 20% of the decline in teen pregnancies is explained by wages, 60% by the lower cost of attending college, and 30% by the decrease in contraception cost. In the case of college attendance, 80% is explained by a decline in the psych cost of college and the other 20% by other factors.

1.8. Conclusion

The 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 model results show that improving contraception costs 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 higher education costs are often too high for low-ability individuals, even without the added cost of a child. In future research, I expect to extend the model to incorporate children's human capital accumulation and evaluate the effect of early pregnancies on intergenerational inequality.

1.9. Appendix: Cognitive Ability, Education, and Fertility Risk

1.9.1. Calibration Parameters

Table 1.17: 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.

Table 1.18: 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.

1.9.2. Model Mechanisms Contribution

Table 1.19: 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).

Table 1.20: 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).

1.9.3. Estimated Parameters NLSY79 vs NLSY97

Table 1.21: Contraception Technology and Education Parameters (NLSY79 vs. NLSY97)

Contraception Technology and Child Return Parameters			
Parameter	NLSY79	NLSY97	Interpretation
λ_a	.08	.20	Ability Share Contr. Tech.
ρ	$-.40$	-.34	Elasticity of Substitution Contr. Tech.
$\omega_0\ \omega_1\ \omega_2$	2.39, 0.09, .55	5.0, .98, .7	Child Return
Education Parameters			
Parameter	NLSY79	NLSY97	Interpretation
$\xi_c\ \omega_c$	$-201, 1.19$	-39, 1.75	College Psych Cost
$\kappa_{HS}, \kappa_{kb}, \kappa_{Coll.}$	$-27, -2, -16$	-12, -4, -130	Cost Child Dif. Edu. Stages
$\mu_{nk}(e)$	34, 14, 1	64, 46, 30	Terminal Value no Child
$w(HS), w(Coll)$	US$48k, US$10k	US$35k, US$50k	Teen and Coll. Allowance
σ_{HS}, σ_{CD}, σ_C (3)	50, 68, 13	16, 67, 29	EV Shock HS, Attend Coll., Grad Coll.

Notes: Estimated contraception technology, education and child return parameter using NlSY79 and NLSY97, respectively.

Table 1.22: Contraception Cost by Education and Age Group (NLSY79 vs. NLSY97)

Education / Age Group	13-17 yr. old		18-21 yr. old		22-29 yr. old	
	NLSY79	NLSY97	NLSY79	NLSY97	NLSY79	NLSY97
High School Dropout	1.18	3.51	2.70	0.68	0.38	0.66
High School Graduate	1.18	3.51	0.63	1.57	0.91	0.93
College	1.18	3.51	0.57	0.78	6.28	0.55

Notes: Estimated contraception cost λ by age and education using NlSY79 and NLSY97, respectively.

Table 1.23: Probability Meeting a Husband (NLSY79 vs. NLSY97)

Education / Age Group	18-21 yr. old		22-29 yr. old	
	NLSY79	NLSY97	NLSY79	NLSY97
High School Dropout	0.33	0.20	0.29	0.05
High School Graduate	0.48	0.21	0.31	0.20
College			0.33	0.24

Notes: Estimated probability of meeting a men μ by age and education using NlSY79 and NLSY97, respectively.

CHAPTER 2

The Role of Parental Altruism in Parents Consumption, College Financial Support, and Outcomes in Higher Education

2.1. Introduction

In the United States, parents play a fundamental role in financing their children's college education. Although in the year 2017, the government spent $248 billion in college aids[2], the average household with two dependent children is expected to contribute $6500 per child annually[3].

The paper explores whether financial support from parents serves as a commitment device to avoid higher future transfers to their children in a setting in which a parent a child interact strategically. In this setting, the poor children overspend anticipating their parent's help, and the parent anticipating the child's behavior overconsume relative to the first-best. I begin by examining how poor children affect their parent consumption. Then, I develop and estimate a dynastic altruistic overlapped generations model where parents are altruistic to their children to determine if college financial support can be rationalized as a mechanism to create a commitment, and this could explain part of the higher graduation rates among low-ability children with wealthy parents compared to those with poor parents.

In order to understand the impact of parent-child interactions on college financial support and outcomes, I analyze consumption data from the Panel Study of Income Dynamics (PSID). My findings show that parents adjust their consumption depending on their children's relative position in the income distribution. However, reported inter-vivos transfers and bequests between parents and children can only partially explain the change in consumption.

Then I examine the relationship between cognitive ability, parent wealth, and college graduation. Table 2.1 shows the proportion of children who graduate from college, classified by their cognitive

[2]https://research.collegeboard.org/pdf/trends-student-aid-2019-full-report.pdf

[3]https://www.forbes.com/sites/troyonink/2017/01/08/2017-guide-to-college-financial-aid-the-fafsa-and-css-profile/6ee3d28f4cd4

ability quartile and parent's wealth quartile, using data from the National Longitudinal Survey of Youth 1997 (NLSY97). First, we observe that graduation rates increase with the child's ability. Second, holding ability constant, college graduation rates are higher for children with wealthier parents. For example, children in the lowest ability quartile with parents in the highest wealth quartile are 74% more likely to graduate from college than children with parents in the bottom wealth quartile. Although this advantage decreases to 39% for children in the top ability quartile, it remains substantial.

The previous result is consistent with Belley and Lochner (2007), which shows that parental income and wealth are important for college graduation. Brown et al. (2012) finds that children's college attendance depends on their parents' willingness to support their college education, and the heterogeneity in parents' altruism is a relevant factor in how college aid would affect college graduation under borrowing constraints. In contrast, Heckman and Mosso (2014) argues that the college enrollment of more affluent children may result from paternalism if education is a normal good and not necessarily due to borrowing constraints. In this paper, I explore an alternative hypothesis that wealthy parents influence graduation rates by reducing their children's college costs through higher monetary transfers even when the return of college is low, to decrease future transfers and bequests, as college act as an illiquid asset which reduces children over-consumption increasing their parent's consumption later in life.

Table 2.1: Children College Attainment by Parent Wealth and Child Ability (NLSY97)

Parents' Wealth\Child's Ability	1	2	3	4
1	0.19	0.24	0.33	0.53
2	0.24	0.30	0.42	0.53
3	0.26	0.40	0.51	0.63
4	0.33	0.46	0.62	0.74
$\Delta\%(Q4-Q1)$	74%	91%	87%	39%

Notes: The table shows the college graduation rate by parents' wealth quartiles and children's ability quartiles. We can observe that the difference in graduation rate between high and low ability children decreases with parents' wealth.

The consumption of both older parents and adult children is closely linked. My analysis reveals that parents with high incomes and low-earning children consume about $2,000 less per year than

those with high-earning children. In contrast, parents with low incomes and high-earning children consume up to $3,400 more per year than those with low-earning children. I examine if this difference in consumption level is explained for changes in inter-vivos transfers and bequests between children and parents, finding that they only partially account for this change in consumption, but survey data may under report or consider them as gifts. Furthermore, I analyze whether parents insure their children's consumption against shocks and find evidence that they do so for consumption shocks, but not for income shocks. Specifically, a 1% change in children's consumption results in a 0.09% change in their parents' consumption.

Finally, I extend the analysis by building and estimating a dynamic dynastic overlapped generation model that incorporates college decisions into a similar framework to Nishiyama (2002); Barczyk and Kredler (2018, 2014a,b); Boar (2020). The model accounts for 60% of the gap in college graduation rates between low-ability children by parent wealth, as parents find it optimal to reduce their children's college attendance costs by transferring money today rather than later in case of a negative shock.

Parents have a significant impact on funding their children's education, and this relationship influences both parties throughout their lifetime. Therefore, the implications of college attainment should be examined not only from a student perspective but also from a household perspective. Analyzing the effects of changes in college costs and policies that alleviate financial constraints or enhance college attainment can provide a better understanding of the returns to education for both parents and children.

2.2. Literature

This paper contributes to various branches of literature. First, it connects with the research exploring the influence of parents' investment in their children's education and college attainment, as well as their impact on inter-generational persistence in income and wealth. Relevant studies include Ríos-Rull and Sanchez-Marcos (2002); Lee and Seshadri (2019); Abbott et al. (2019); Daruich and Kozlowski (2019).

Second, the paper is related to the literature on the disparity in college attainment based on cognitive ability and parental wealth. Belley and Lochner (2007); Bailey and Dynarski (2011); Lochner and Monge-Naranjo (2011); Brown et al. (2012) are among the studies that find liquidity constraints affecting college attendance, particularly for low-ability students.

Third, the paper relates to the literature on consumption insurance within families. While studies such as Altonji et al. (1992); Hayashi et al. (1996) reject perfect insurance within families, Attanasio et al. (2018) found significant potential insurance between parents and children. This paper contributes to this literature by studying the insurance parents provide to their children and how it shapes college attendance. This paper also relates to the literature on inter-vivos transfers, bequests, and parents' consumption after retirement. Relevant studies include Nishiyama and Smetters (2002); Lockwood (2018); De Nardi et al. (2016); Kopczuk (2007); Barczyk and Kredler (2018); Barczyk et al. (2019); Haider and McGarry (2018)

Finally, on the quantitative side, this paper is related to the literature that studies family dynamics models without commitment in non-cooperative settings, such as Attanasio and Ríos-Rull (2000); Nishiyama (2002); Barczyk and Kredler (2014a,b); Boar (2020), among others.

2.3. Empirical Evidence

In this section, I present the empirical evidence of how parents' position in wealth distribution relative to their adult children impacts their consumption. I find that parents who have children above them in the wealth distribution increase their consumption. In contrast, those with children below them in the distribution decrease it. This change in consumption can be attributed, at least in part, to the transfer of resources between parents and children and changes in bequests from parents to their children.

2.3.1. Data

To investigate how adult children impact their parents' household consumption, I utilize data from the Panel Study of Income Dynamics (PSID) from the year 1999 onward, when consumption data was first collected. I restrict the sample to parents over 50 years old and children over 26 years old,

as the focus is on the impact of adult children on parental consumption. Additionally, to ensure a sufficient sample size, I drop parents and children born in years with less than 100 individuals, and rank individuals by cohort based on their wealth and income. To link parents with their children in the survey, I utilize the FIMS file provided by PSID. This results in a sample size of 8,944 observations representing 2,338 parent-child pairs. Lastly, I deflate all nominal variables to 2016 prices for consistency.

Additionally, I employ The National Longitudinal Survey of Youth 1997 (NLSY97) to investigate college attainment among children and wages after college. The NLSY97 is a longitudinal survey that tracks Americans born between 1980-84, and provides comprehensive information on individuals during their college years. The final sample size for this analysis includes 5,400 individuals with complete data on parents' wealth and children's cognitive ability, comprising a total of 97,434 observations.

2.3.2. Parents' Consumption and Children's Position in the Income Distribution.

In this subsection, I examine the impact of adult children's income on their parents' household consumption. I begin by ranking parents by their wealth relative to individuals born in the same year. As many are retired, labor income is not reported, and wealth better predicts their well-being. For children, I rank them by both income and wealth but find that only the child's income position significantly affects their parent's consumption. Given that young adults are beginning to accumulate assets, income is a better welfare indicator. From now onward, I will refer to the difference between parents' position in wealth distribution and their children's position in income distribution as the wealth-income distribution difference.

Since children's position in the income distribution is influenced by their parent's decisions and their inherited characteristics, I focus on the effect of this difference on parents' consumption when their children are older than 26 years old. At this point, I assume that parents have completed investing in their children and cannot directly influence their children's relative position in the income distribution. Nonetheless, parents may still affect their children's welfare through financial support or bequests, which can impact their and their children's consumption.

To measure the difference between parents and children in the wealth-income distribution, I construct a rank-rank variable that measures the relative distance between them following the next steps:

1. I rank parents in quartiles by wealth relative to all individuals born in the same year.

2. I rank children in quartiles by income or wealth depending on the specification, relative to all individuals born in the same year.

3. Then, I construct a variable $T^{Q_i^p - Q_j^c}$, which is the rank-rank difference between the parents and each of their children in a given year.

For example, for a parent in the fourth quartile who has a child in the first quartile, then $T^{(Q_4^p - Q_1^c)}$ is equal to three. So then, I estimate the following regression:

$$C_{i,t} = \beta_0 + \sum_{q=-3}^{3} \beta_q T_{i,t}^q + \beta_X \mathbf{X_{i,t}} + \varepsilon_t + \epsilon_{i,t}$$

where C is household consumption in dollars, i is the parent household, $T_{i,t}^q$ is the variable described before, $\mathbf{X_{it}}$ is a set of controls (parents' total wealth, parents' non-financial wealth, parents' household income, parents' quartile in the wealth distribution, parents household head in the labor force, number of people in the parents household, parents head born year, parents head education years, parents household US state, parents head age four order polynomial, rent or own house, parents' race and parents' religion), and ε_t is a year fixed effect.

The results are presented in Table 2.2. The first column shows the ranking of children by wealth, where the relative position of parents with respect to their children does not affect their consumption. In contrast, the second column displays the ranking of children by income, revealing that the relative position of a child in the income distribution to their parents in the wealth distribution significantly affects parental consumption. For instance, a parent in the first quartile with a child in the fourth

quartile consumes an average of $3400 more per year than a parent in the first quartile with a child in the same quartile. Conversely, a parent in the fourth quartile with a child in the first quartile consumes an average of $2000 less per year than a parent in the same quartile with a child in the same quartile. To support the robustness of my findings, I also estimate the same model using HRS data, as presented in Appendix 2.9.1. Both surveys lead to the same conclusion: children's position in the income distribution above or below their parents affects parental consumption. However, the magnitude of the effects differs between the surveys. Specifically, the increase in consumption of poor parents with rich children is higher in PSID than in HRS, while the decrease in consumption of wealthy parents with poor children is higher in HRS than in PSID. I use PSID as a benchmark, given that children and parents report their wealth and income, in contrast to HRS, where parents report their children's income.

Then, I examine how the effect of having a child above or below parents in the wealth distribution varies with parent age. To conduct this analysis, I introduce a third-order polynomial of age and interact it with the relative position between parents and children. Specifically, I estimate the following linear model:

$$C_{i,t} = \beta_0 + \sum_{q=-3}^{3} \beta_q T_{i,t}^q f(Age_t) + \beta_X \mathbf{X_{i,t}} + \varepsilon_t + \epsilon_{i,t}$$

By including a polynomial of age in the model, I can capture potential non-linearities in the relationship between parent age and the effect of child position on parental consumption. The interaction term allows us to examine how the effect of child position on parental consumption changes with parent age.

Table 2.2: Parent Consumption Given Kids Transition using PSID data

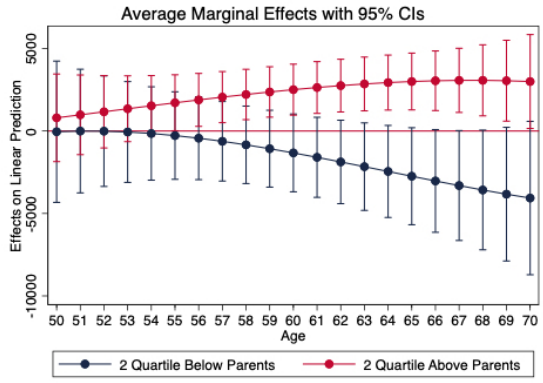
	(1) Ranking by Children's Wealth Parent Consumption	(2) Ranking by Children's Income Parent Consumption
Child 3 Quartiles Below Parents	718	-1969
	(0.44)	(-0.86)
Child 2 Quartiles Below Parents	-380	-1387
	(-0.34)	(-1.23)
Child 1 Quartiles Below Parents	-246	-1446**
	(-0.30)	(-2.04)
Child Same Quartiles Below Parents	-170	91
	(-0.27)	(0.14)
Child 1 Quartile Above Parent	332	1371**
	(0.50)	(2.25)
Child 2 Quartile Above Parent	1492**	2414***
	(2.18)	(3.60)
Child 3 Quartile Above Parent	1145	3393***
	(1.08)	(2.93)
Observations	7083	7083

Notes: The table shows the results of regressing parent household consumption in dollars to the relative position of their children in the income distribution T and demographic controls X using PSID data. t statistics in parentheses, standard error cluster by household. * $p < .10$, ** $p < .05$, *** $p < .01$.

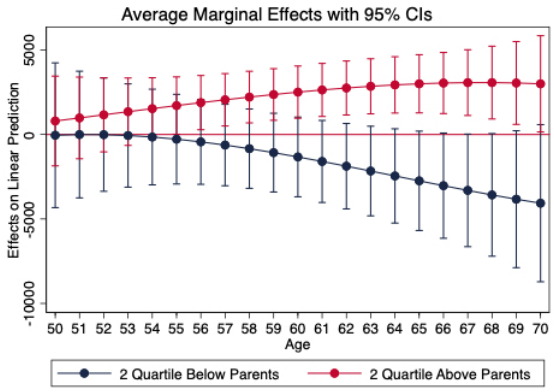
I present the results in Figure 2.1, which displays the marginal effect of having a child above or below a parent's quartile, controlling for observables. Specifically, Figure 2.1a shows the effect of having a child two quartiles above or below the parent's quartile, while Figure 2.1b examines the same relationship without differentiating by the number of quartiles. My analysis reveals that the relative position of a child in parental consumption is not significant until age 60, after which a gap emerges between parents with poor and rich children. Wealthy parents with poor children significantly decrease their consumption compared to parents with children in the same quartile. Conversely, the difference in consumption between poor parents with rich children and those with children in the same quartile is stable across ages.

Figure 2.1: Effect of children position in the income distribution across age

(a) Effect of children position in the income distribution across age (2 Quartiles Above or Below)



(b) Effect of children position in the income distribution across age (Above or Below)



Notes: The figures show the average marginal effect by age on parent household consumption in dollars of having a child in a different part of the wealth distribution than theirs. The left figure displays the difference between parents that are two quartiles above or below their children. The right figure displays the average consumption difference between parents with children above and below them on the income distribution.

2.3.3. Inter-vivos Transfers, Bequests and Income Distribution.

This section aims to investigate the potential role of inter-vivos transfers and bequests in shaping the consumption behavior of parents and children, and whether they could explain why parents adjust their consumption depending on the relative position of their children in the income distribution. To conduct this analysis, I utilize data from the Health and Retirement Study (HRS), which provides more detailed information on transfers and has a larger sample of older parent-child pairs than the PSID.

To examine the relationship between transfers and the relative position of children in the income distribution, I use differences in transfers between siblings through the following specification:

$$IVT_{ijt} = \beta_0 + \sum_{q=-3}^{3} \beta_q T_{ij,t}^{q} + \beta_X \mathbf{X_j} + \varepsilon_i + \epsilon_{jt}$$

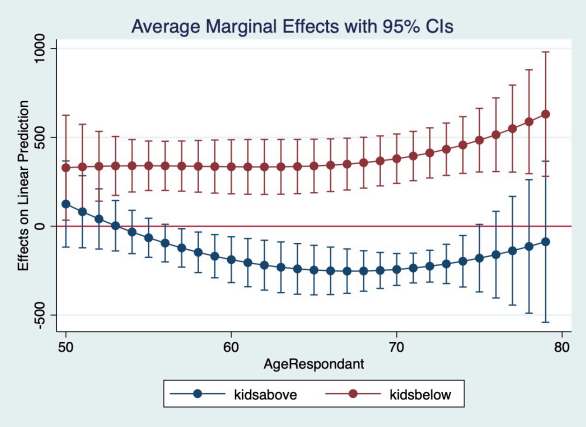
where IVT are intervivos transfers between parent and children, i is the parent household, j is the child, $T^q_{ij,t}$ is the relative position of the child i to his parents j, $\mathbf{X_j}$ is a set of controls (the year that child born and child blood relationship) and ε_i is a family fixed effect.

Table 2.3 presents the estimation results. In column 1, we observe that children with higher income than their parents transfer slightly more than those whose income is similar to their parents. However, these transfer differences are not statistically significant at conventional levels, and the magnitudes are economically small. For instance, the average transfer from a child in the fourth quartile to a parent in the first quartile is only $100 more per year than a transfer from a child in the fourth quartile to a parent in the same quartile. In contrast, parents transfer more to children in a lower income-wealth position relative to them. Specifically, a parent in the fourth quartile transfers approximately $500 more per year to a child in the first quartile compared to a child in the fourth quartile. Despite these differences, these transfer amounts are insufficient to explain the observed changes in parent consumption.

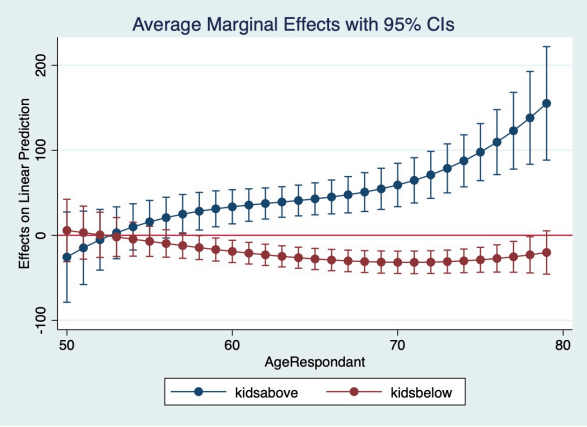
Next, I investigate how transfers change across parents' age by interacting a third-order polynomial with the parent-child relative position, as in subsection 2.3.2. The results are displayed in figure 2.2. Figure 2.2a shows transfers from parents to children, while figure 2.2b displays transfers from children to parents. The findings suggest that transfers from wealthy parents to poorer children remain flat between 50 and 70 but increase after 70. In contrast, transfers from poor parents to rich children decrease with age. Moreover, the difference in transfers from rich children to poor parents increases after 70. In contrast, the difference in transfer from poor children to wealthy parents is not significantly different from zero and remains flat over time. These results support that parents with poor children consume less than parents with rich children as they transfer resources to their children. On the other hand, wealthy children support parents more in their later years, which are usually particularly expensive given health and care expenditures which could allow parents to save less for their last years.

Figure 2.2: Effect of children position in the income distribution in transfers from parents to children and children to parents

(a) Parents to Children



(b) Children to Parents



Notes: The figures show the average marginal effect by age on intervivos transfer between parents and children of the relative position on wealth distribution. The left figure displays the effect of age on the transfer from parents to children. The correct figure displays the effect of age on transfers from children to parents.

In Appendix 2.9.2, I investigate whether parents receive in-kind support from their children depending on the relative position of their children in the wealth-income distribution. The analysis reveals that children above their parents in the income distribution are slightly more likely to provide financial assistance for health-related expenses but less likely to help with daily life activities compared to children in the same position as their parents. Additionally, parents expect more help from children above them in the wealth-income distribution than those in the same position.

Table 2.3: Parent Transfers and bequest by Relative Position in the Income Distribution

	(1) Annual Transfer Kids to Parents US$	(2) Annual Transfer Parents to Kids US$	(3) Total Wealth Last Period US$
Child 3 Quartiles Below Parents	-32***	512***	-31175
	(-2.73)	(6.18)	(-0.97)
Child 2 Quartiles Below Parents	-21***	306***	19839
	(-5.28)	(7.77)	(1.20)
Child 1 Quartile Below Parents	-18***	90***	5838
	(-4.26)	(2.93)	(0.28)
Child Same Quartile Parents			5052
			(0.56)
Child 1 Quartile Above Parents	14***	-94***	-25682***
	(4.27)	(-6.56)	(-3.43)
Child 2 Quartile Above Parents	51***	-127***	-17497*
	(7.17)	(-7.78)	(-1.85)
Child 3 Quartile Above Parents	105***	-179***	-13380
	(6.40)	(-8.85)	(-1.61)
Observations	76374	79136	5197

Notes: The table shows the results of regressing intervivos transfer between parent and children on the relative position of their children in the income distribution T, controls X, and household fixes effect using PSID data. t statistics in parentheses, standard error cluster by household. * $p < .10$, ** $p < .05$, *** $p < .01$.

In the third column of table 2.3, I examine the effect of relative child position on parents' assets in the last survey before death, which serves as a proxy for bequests. The results show that parents with a child above them in the income distribution have fewer assets than parents with a child in the same quartile. However, as before, these results only partially explain the consumption differences between parents with children in different positions of the income distribution. For instance, a parent with a child one quartile above them has $25,000 less in assets in the last survey before dying.

Several possible explanations exist for why transfers and bequests cannot fully account for consumption differences. One possibility is measurement error, as transfers are self-reported by parents, and they may forget to report some transfers. Another explanation is that parents and children engage in transfers that they do not consider as transfers when reporting them in the survey, such as gifts. Another plausible explanation, which I explore later in the model, is that part of the decrease in parent consumption is due to spending more on the college education of low-skill children, who are likely to have a lower position in the wealth-income distribution than their parents in the future reducing parents' savings and future consumption.

2.3.4. Transmission of Children Income Shocks to Parent Consumption

In this subsection, I examine whether parents' consumption is influenced by their children's income shocks, using the framework presented in Blundell et al. (2008). To accomplish this, I begin by conducting regression analysis on the log income and log consumption of both parents and children, controlling for individual education, gender, household size, race, labor force status, states and parents, and interactions of year dummies with education, race, employment, labor force status, and parents fix effects. I also incorporate parents-year fix effects to account for any income shocks the family may share. I then utilize the residuals as a measure of the unpredictable portions of both consumption and income, represented as $\hat{c_{jt}}$ and $\hat{y_{jt}}$, respectively, as shown below:

$$\hat{c_{jt}} = \log c_{jt} - \beta_t \mathbf{Z_{jt}}$$
$$\hat{y_{jt}} = \log y_{jt} - \beta_t \mathbf{Z_{jt}}$$

where variable c refers to consumption, while y denotes income. The variable j indicates the individual under consideration, i.e., either a parent or a child. Finally, as explained in the previous paragraph, the variable $\mathbf{Z_{jt}}$ represents the predictable portion of income. Next, I estimate the first differences of the unpredictable consumption component with respect to the first differences of the unpredictable portion of parent and child incomes. This analysis provides insights into how parents' consumption responds to their and their children's income shocks, as shown below:

$$\Delta\hat{c_{pt}} = \delta_p \Delta\hat{y_{pt}} + \delta_k \Delta\hat{y_{kt}} + \epsilon_{it}$$

Here, we use the subscripts p and k to distinguish between parents and children, respectively. $\Delta\hat{c}$ represents the first difference in the consumption residual, while $\Delta\hat{y}$ denotes the first difference in the

income residual. To address potential endogeneity, I follow the approach suggested by Kaplan et al. (2014) and use future differences in income residuals as instruments.

Table 2.4: Consumption Pass-Through of Children Income Shocks

	(1)	(2)	(3)
	Δ Consumption Parents	Δ Consumption Parents	Δ Consumption Parents
Δ Income Parents	0.11***	0.11***	0.10***
	(5.26)	(5.29)	(3.80)
Δ Income Children		-0.01	-0.03
		(-0.89)	(-1.44)
Δ Consumption Children			0.09***
			(6.55)
Constant	-0.00	-0.00	0.00
	(-0.39)	(-0.13)	(0.47)
Observations	7945	7945	5499

Notes: The table shows the results of regressing changes in parents' consumption on their and their children's income shocks. In the last column, I add the parent consumption response to changes in children's consumption. t statistics in parentheses, standard error cluster by household. * $p < .10$, ** $p < .05$, *** $p < .01$.

Table 2.4 presents the estimation results. It shows that children's income shocks do not significantly impact parent consumption. In contrast, parent income shocks affect their consumption, with an income-consumption pass-through rate of 0.11. This finding aligns with the results of Attanasio et al. (2018), who found that consumption does not respond equally to personal or family income shocks in the PSID dataset from 1999 to 2008. In column 3 of the table, I add unpredictable changes in children's consumption corrected by parent income shocks finding a positive correlation of 0.09 between changes in children's consumption and parent consumption, indicating that a 1% increase or decrease in child consumption leads to a corresponding 0.09% increase or decrease in parent consumption. The results suggest that parents do not offer insurance for children's income shocks but provide insurance for consumption shocks. This conclusion is consistent with the observation that most transfers between parents and children occur when they face significant shocks such as divorce or unemployment.

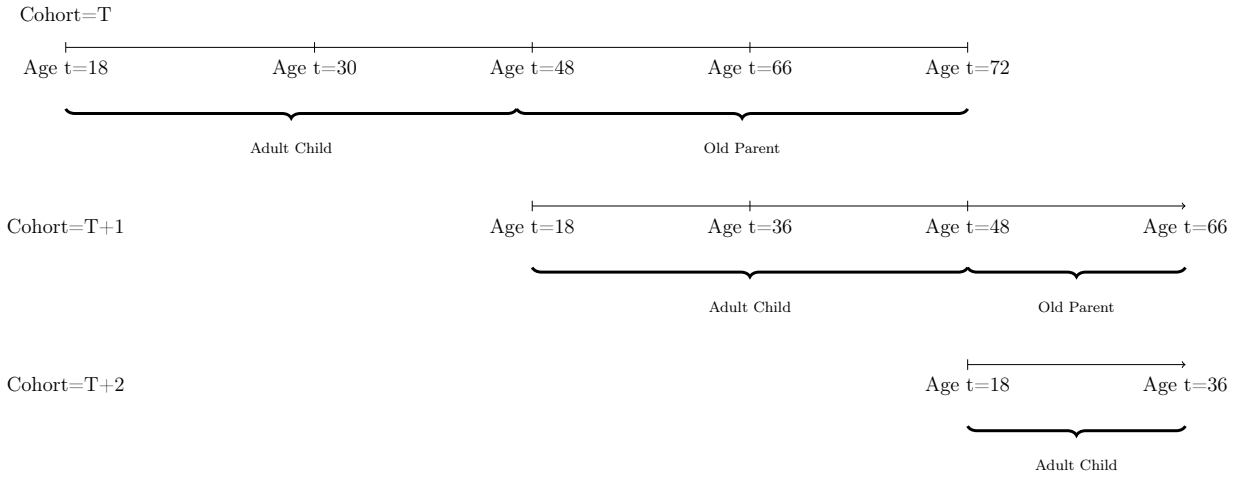
2.4. The Model

This section presents a non-cooperative and without-commitment model that captures the interactions between parents and adult children, quantifying how family transfers and bequests affect college financial support, graduation, and parent retirement consumption. The model is a heterogeneous dynastic overlapped generation model, similar to Nishiyama (2002); Boar (2020), adding endogenous college decisions. The dynasties in the model are formed by one parent and one child, where parents are altruistic towards their children's current and future utility. The dynasty separately decides on consumption, savings, transfers, bequests, and college education. Parents can realize monetary transfers each period and leave a bequest in the last period, leading to strategic behavior by parents and children. The equilibrium properties of the model are derived in appendix 2.9.3. It is shown that parents and children have incentives to over-consume, as children's savings reduce future transfers, and parent savings reduce children's savings. This phenomenon is known as the *Samaritan's dilemma* (Barczyk and Kredler, 2014a).

2.4.1. Model Demographics

In this model, the economy is divided into six-year periods, and each agent overlaps with their parents between the ages of 18 and 42, as illustrated in Figure 2.3. At 42, each child becomes a parent and has an 18-year-old child. The agent retires at 66, receiving social security transfers until their death at 72. During each period, parents can transfer money to their children, and to simplify the model, parents' income between the ages of 46 and 67 is determined only by their level of education. The population is evenly split between parents and children, and households face incomplete markets as they can only save in a non-contingent bond. Parents can transfer money to their children each period and decide on a bequest in the final period before their death, which their child receives in the subsequent period when they become a parent.

Figure 2.3: Dynasty Time Line



Notes: The figure illustrates the overlap between different generations. In this model, each period consists of a dynasty composed of an older parent and their adult children.

2.4.2. Model Decision Timing

The paper adopts a two-stage game, where the parent makes the first move, and children respond, conditional on the parent's decision, similar to the approach taken by Boar (2020). This is in contrast to a simultaneous game setup adopted by Nishiyama (2002); Barczyk and Kredler (2014a). This simplification is motivated by computational tractability. However, the fact that parents' and children's decisions depend on each other's choices is critical, as children's education, consumption, and savings decisions depend on the expected support they receive from their parents. At the same time, parents cannot force their children to attend college, nor can they commit not to support them in the future, making the game non-cooperative and without commitment.

The parent-child game is divided into periods and subperiods, where each decision is made. College attendance is decided in the first period, which is divided into three stages or subperiods. In the first stage, the child, who is born as a high school graduate, decides whether to enroll in college. The model assumes that children who attend college will become college graduates ($e_c = C$), while those who do not attend will continue as high school graduates ($e_c = HS$). In the second stage, the parent, knowing the child's college decision, decides on their consumption c_p, saving a_p, and

the money transfer to the child t_p. Finally, in the third and last stage of the first period, the child decides on their consumption c_c and saving a_c, given their parent's previous decisions.

After the first period, the game comprises two stages. In the first stage, the parent decides on their consumption c_p, saving a_p, and the money transfer to the child t_p. In the second stage, the child decides on their consumption c_c and savings a_c, given their parent's choices. In the last period, the parent's savings a_p become a bequest b_p that the child receives in the next period.

The sequential nature of the game is essential because children's decisions on education, consumption, and savings are based on how much support they expect from their parents in the future. Parents cannot force their children to attend college, nor can they commit to not supporting them in the future. Thus, both parents and children must make strategic decisions in each period, taking into account the other's expected behavior.

The economic model includes several endogenous state variables that determine the behavior of parents and children, including the dynasty assets a_c and a_p, which represent the savings of the child and parent, respectively, and the education level of each generation, denoted by e_p and e_c, which can take two values: high school graduate (HS) or college graduate (C). The labor income of the child w is determined by four exogenous factors: their ability θ, education level e, an idiosyncratic income shock z, and age j. Parents receive a deterministic income $y(e)$ that depends only on their education level. Additionally, the ability is transmitted between generations through an AR(1) process with persistence parameter ρ_θ.

2.4.3. Parent-Child Decision Problem

Parent-Child Problem in the Last Parent Period

The child's last period coincides with their parent's last period, as the child will become a parent themselves in the next period. We denote this period as $j = T_c$, representing the child being 18 years old and the parent being 72 years old. The parent and child engage in a two-stage game where the parent knows with certainty that they will pass away this period, and the child will receive all of the parent's remaining assets as a bequest in the next period.

In the second subperiod, the child faces the following Bellman equation:

$$V^c_{j=T_c}(a_c, e_c, e_p, \theta, z, t_p, a'_p) = \max_{c_c, a'_c} \{u(c_c) + \beta \int V^c_{j=T_c+1}(b_p + a'_c, 0, e'_c, e_c, \theta', 0) f(\theta'|\theta) d\theta\}$$

$$s.t: \ a'_c + c = w\epsilon_{j=T_c} + (1+r)a_c + t_p$$

$$\log \epsilon = \log(\alpha_e \theta^{\beta_e}) + A_{e_c, j=T_c} + z$$

$$\log \theta' = \rho_\theta \log \theta + \epsilon_\theta$$

$$\epsilon_\theta \sim N(0, \sigma_\theta), a'_c \geq 0$$

In the child's second sub-period, their consumption is denoted by c_c, their assets by a_c, and their education level by e_c. The parent's education level is denoted by e_p. The child's income is determined by their cognitive ability, denoted by θ, which affects income through the parameter α_e and β_e. The life cycle component of income is denoted by A, and the idiosyncratic labor productivity shock is denoted by z. Additionally, the child receives a bequest b_p that was decided by the parent in the first stage and will be received in the next period, and a transfer t_p that was decided by the parent in the previous sub-period and will be received by the child in this sub-period. The cognitive ability of the next generation, denoted by θ', follows an AR(1) process with persistence ρ_θ and normally distributed idiosyncratic shocks with variance σ^2_θ. Finally, agents are only able to save on an asset that pays with certainty in the next period.

In the first stage, parents are aware of how their children will respond to their transfer and bequest decisions in the following stage. Consequently, parents must solve the following Bellman equation:

$$V^p_{j=T_c}(a_p, a_c, e_c, e_p, \theta, z) = \max_{c_p, b_p, t_p} \{u(c_p) + \eta u(c^*_c(a_p, a_c, e_c, e_p, \theta, z, t_p, b_p))$$

$$+\eta_d \beta \int V^c_{T_c+1}(b_p + a^{'*}_c(a_p, a_c, e_c, e_p, z, \theta, t_p, b_p), a'_c, e'_c, e_c, \theta', z') f(\theta'|\theta) d\theta\}$$

$$s.t: \ c_p + b_p = w\text{SS}(e_p) + (1+r)a_p - t_p$$

$$\log \theta' = \rho_\theta \log \theta + \epsilon_\theta$$

$$\epsilon_\theta \sim N(0, \sigma_\theta), b_p \geq 0$$

$$a'_c = 0, z' = 0$$

In this equation, c_p represents the parent consumption, a_p denotes the parent assets, η is the parent's altruism towards their child during the current period, and η_d represents their altruism towards the child after their death. During this stage, parents are retired and receive a social security transfer that depends on their education level, denoted as $\text{SS}(e_p)$. It is worth noting that the child's savings a'^*_c is a function of the parents' choices, as the parents consider the child's behavior when deciding on consumption, savings, transfers, and bequests.

Parent-Child Problem After College and Before Parent Last Period

The dynasty plays a two-stage game when parents are between 48 to 72 years old, and their children are between 18 to 48 years old. Parents decide on consumption, transfers, and saving in the first stage. In the second stage, the child decides on consumption and saving based on their parents' decisions. Unlike the period described above, parents do not make decisions on bequests. The Bellman equation of the child in the second stage is:

$$V_j(a_c, e_c, e_p, \theta, z, t_p, a'_p) = \max_{c_c, a'_c} \{u(c_c)$$
$$+\beta \int V_{j+1}(a'_c, e_c, e_p, \theta, z', t'^{*}_p(a'_p, a'_c, e_c, e_p, \theta, z'), a^{*''}_p(a'_p, a'_c, e_c, e_p, \theta, z'))f(z'|z)dz'\}$$
$$s.t: \ a'_c + c_c = w\epsilon_j + (1+r)a_c + t_p$$
$$\log \epsilon_j = \log(\alpha_e \theta^{\beta_e}) + A_{e_c,j} + z$$
$$z' = \rho_z z + \epsilon_z, \epsilon_z \sim N(0, \sigma_{z,e_c}), a'_c \geq 0$$

where t_p and a'_p are the transfer and savings decisions made by the parents in the previous stage. However, the transfer decision of the parents for tomorrow, t'^{*}_p, and their savings decision for tomorrow, a''^{*}_p, are determined by the children's current choices. As a result, the children consider the impact of their consumption and saving decisions today on their parents' transfer and saving decisions tomorrow when making their own decisions.

When parents decide at the beginning of the period, they consider how their decision will affect their children's tomorrow behaviors. Therefore, the parent Bellman equation in this stage is:

$$V_j(a_p, a_c, e_c, e_p, \theta, z) = \max_{c_p, a'_p, t_p} \{u(c_p) + \eta u(c^*_c(a_c, e_c, e_p, \theta, z, t_p, a'_p))$$
$$+\beta \int V_{j+1}(a'_p, a'^{*}_c(a_c, e_c, e_p, \theta, z, t_p, a'_p), e_c, e_p, \theta, z')f(z'|z)dz'\}$$
$$s.t: \ c_p + a'_p = wy(e_p, j) + (1+r)a_p - t_p$$
$$y(e_p, j) = \begin{cases} y(e_p, j) & j < j_{ret} \\ \text{SS}(e_p) & \text{o.w} \end{cases}$$
$$a'_p \geq 0, z' \sim N(0, \sigma_{z,e_c})$$

To simplify the model, parents are assumed to have a fixed income with no uncertainty. However,

they take into account the income risk their children face, denoted by the variable z, when making decisions about transfers t_p and savings a'_p. Before retirement, parents receive income $y(e_p, j)$ that is a function of their education and age. Following retirement, their income consists of a fixed social security transfer determined solely by their level of education.

Parent-Child Problem at College Decision

The child is born as a high school graduate in the first period. The decision-making process unfolds in three stages. First, the child decides whether or not to attend college. Second, the parent determines their consumption, savings, and transfers, considering the child's decision regarding college attendance. Finally, the child decides on consumption and savings based on the parent's savings and transfers.

In the third subperiod, the children face the following Bellman equation:

$$V_{j=1}(a_c, e_c, e_p, \theta, z, t_p, a'_p) = \max_{c_c, a'_c} \{u(c_c)$$
$$+\beta \int V_{j=2}(a'_c, e_c, e_p, \theta, z', t'^{*}_p(a'_p, a'_c, e_c, e_p, \theta, z'), a^{*''}_p(a'_p, a'_c, e_c, e_p, \theta, z'))f(z'|z)dz'\}$$
$$s.t: \ a'_c + c_c = \tau(e_c)w\theta - \phi 1_{e_c=C} + t_p$$
$$\log\theta = \log(\alpha_e \theta^{\beta_e}) + \gamma_{e_c,1} + z$$
$$z' \sim N(0, \sigma_{z,e_c}), a'_c \geq 0, c_c \geq 0$$
$$a_c = 0, z = 0$$

where t'_p and a''_p represent the parent transfer and saving policies functions in the next period, respectively. The variable ϕ represents the monetary cost of college, while A captures life cycle effects on wages. Additionally, $\tau(e_c)$ denotes the percentage of hours that a college student can work relative to a high-school graduate, while α_e and β_e are parameters that shape the return on ability associated with attending college. Finally, each child starts with the mean productivity level ($z = 0$), and their income is subjected to idiosyncratic income shocks that depend on their education

level.

In the second stage of the model, parents make decisions about how much to save and consume based on their children's education decisions, following the follow Bellman equation:

$$V_j(a_p, a_c, e_c, e_p, \theta, z) = \max_{c_p, a'_p, t_p} \{u(c_p) + \eta u(c^*_c(a_c, e_c, e_p, \theta, z, t_p, a'_p))$$
$$+\beta \int V_{j+1}(a'_p, a^{'*}_c(a_c, e_c, e_p, \theta, z, t_p, a'_p), e_c, e_p, \theta, z') f(z'|z) dz'\}$$
$$\text{s.t: } c_p + a'_p = wy(e_p, j) + (1+r)(a_p + b_p) - t_p$$
$$z = 0, a'_p \geq 0, z' \sim N(0, \sigma_{z,e_c})$$

where c^*_c and $a^{'*}_p$ are the child policy function determined in the third stage. Additionally, to their saving from the previous period a_p, the new parents have the bequest that their parents left to them. Finally, in the first stage, children decide whether attend college or not; then, their Bellman equation is:

$$\hat{V}^*_1(a_p, a_c, e_p, \theta, z) = \max_{i \in [HS, C]} \{V_1(a_c, i, e_p, \theta, z, t^*_p(a_p, a_c, i, e_p, \theta, z), a^{*'}_p(a_p, a_c, i, e_p, \theta, z)$$
$$+1_{e_c = C} \kappa(\theta) + \epsilon_i)\}$$

The psych cost of attending college, $\kappa(\theta)$, is a decreasing function of ability, and the child's decision to attend college is subject to an i.i.d type I extreme value shock ϵ, with a scale parameter σ_{cd}. Parents can influence their children's college, consumption, and saving decisions through their current and expected future financial support.

2.4.4. Equilibrium Definition

The recursive equilibrium is a set of value functions, denoted by $V_t(s)_{t=1}^T$, and policy functions, denoted by $\{c_p^t(s), a_p'^t(s), t_p^t(s), c_c^t(s), a_c'^t(s)\}_{t=1}^T$, and $e_c^T(a_p, a_k, e_p, \theta, z)$, where T represents the number of periods that a cohort lives and $s = (a_p, a_k, e_p, e_c, \theta, z)$ are the dynasty state variables. This equilibrium is also a Markov-Perfect equilibrium.

In each repetition of the parent-child stage game, the equilibrium is characterized by the following steps:

1. In period $t = 1$, when the children decide whether to attend college or not:
   (a) Solve the children's college attendance problem.
   (b) Solve the parents' problem given their children and their state variables.
   (c) Solve the children's problem, given their parents and their state variables, after seeing their parents' decisions and receiving the transfer.
2. In period $t = 2$ to $t = J - 1$, where there is no college decision:
   (a) Solve the parents' problem, given the children's state variables and their state variables.
   (b) Solve the children's problem, given their parent and their state variables, after seeing their parents' decisions and receiving the transfer.
3. In period $t = J$, the parents die with certainty:
   (a) Solve the parents' problem, given their children's and their state variables.
   (b) Solve children's problem, given their parents and their state variables, after seeing their parents' decision about bequests and receiving the transfer.

2.5. Estimation

To estimate the model parameters, I followed a three-stage approach. In the first stage, I use parameters from the literature. In the second stage, I estimated the income process independently using the available data. Finally, I estimate the remaining parameters using the indirect method of moments using 20 data moments to estimate 11 parameters. Table 2.5 and 2.6 lists the parameters estimated in the first two stages. Finally, the parameters estimated in the last stage are listed in table 2.7.

Table 2.5: Parameters from the data or estimated outside the model

Parameter	Description	Value	Source
	Preferences		
r	Interest Rate	0.03	Daruich and Kozlowski (2019)
γ	Risk Aversion	1.5	Abbott et al. (2019)
	College Cost		
ϕ_C	Annual College Cost	\$12200	NLSY97
$\tau(e_c)$	Fraction of Time Work In College	0.56	Census
	Income Process		
ρ_c	College Graduate Income Persistence	0.90	NLSY97
σ_c	College Graduate Income Variance	0.049	NLSY97
ρ_{HC}	High School Graduate Income Persistence	0.93	NLSY97
σ_{HC}	High School Graduate Income Variance	.032	NLSY97
$\overline{w}$	Average Income	\$70000	Census
	Retirement Income		
SS_{HC}	Retirement Income High-School Graduate	\$25500	HRS
SS_C	Retirement Income College Graduate	\$31200	HRS

Notes: The table displays the parameters estimated outside the model.

2.5.1. Functional Forms and Preferences

Consumption: Parents and Children utility function is modeled using a Constant Relative Risk Aversion (CRRA) with a relative risk aversion equal to 1.5 following Abbott et al. (2019).

Psych Cost: Psychic costs are an important consideration in schooling decisions Cunha et al. (2005); Heckman et al. (2006a). To model the psych cost of attending college, we use a cost function that decreases with cognitive ability: $\kappa(\theta) = \frac{\omega_{c_1}}{\theta^{\omega_{c_2}}}$. This means that the cost of attending college is lower for individuals with higher cognitive ability, reflecting that they may find cognitive tasks less effortful or have a higher taste for education.

Impatience: The discount factor β is estimated using the average wealth to average income ratio set to 6.218 following Boar (2020).

2.5.2. College Cost

In the model, all nominal quantities are deflated to 2016 dollars using the Consumer Price Index (CPI) to adjust for inflation. The annual cost of attending college in the model is set at $12,200, based on the average tuition cost reported by college students at the NLSY97 survey after grants and scholarships have been considered. We do not find a significant difference in the net cost of attending college for students from different income backgrounds, which is consistent with the findings of Abbott et al. (2019) based on data from the National Center for Education Statistics. This lack of difference may be due to high-income students receiving more merit-based financial aid, compensating for their higher tuition costs.

2.5.3. Retirement Income

I estimated retirement income using data from households where the respondent is retired and over 67 years old. Specifically, I computed the average sum of Retirement Social Security Income, Supplemental Security Income, Disability Income, and Employer Pension programs for each education group. This approach allows me to examine how retirement income varies by education level. The results are presented in Table 2.5, which shows each education group's estimated retirement income levels.

2.5.4. Income Process

In the model income process is given by $\log \epsilon_j = \log(\alpha_e \theta^{\beta_e}) + \gamma_{e,j} + z_j$, where ϵ_j represents an individual's labor earnings, α_e and β_e are parameters that vary by education level. To estimate this process, I use data from the National Longitudinal Survey of Youth 1997 (NLSY97) households, as described in Abbott et al. (2019). Since the NLSY97 sample consists primarily of young individuals, with the oldest being 37 years old in the last survey, I estimate the income-age profile using data from the Panel Study of Income Dynamics (PSID) for households where the head is between 18-67 for high school graduates and 23-67 for college graduates. I present the results of this estimation in Table 2.6. I then control for ability differences by regressing the part of household income not

explained by the age profile on the Armed Forces Qualification Test (AFQT) score, allowing me to measure the impact of ability on household income. Income shocks are estimated using the residuals from this regression. Specifically, I assume that the process governing the log income residuals follows:

$$z^e_{iat} = \log y_{it} - \widehat{f^e(a_{it})} - \hat{\beta}_0 - \hat{\beta}_1 \text{AFQT}_i$$

$$z^e_{iat} = \rho_e z^e_{i,a-1,t-1} + \eta^e_{iat}$$

$$\eta^e_{iat} \sim N(0, \sigma^e_\eta), \;\; z^e_{i0t} \sim N(0, \sigma^e_{z_0})$$

where y_{it} denotes individual i's income at age t, $\widehat{f^e(a_{it})}$ is the age profile of income estimated previously from the Panel Study of Income Dynamics (PSID), z_{it} represents the initial income shock with a persistence of ρ_e and an initial dispersion of $\sigma^e_{z_0}$, and η_{it} is an innovation of the income shock with a standard deviation of σ^e_η. I estimate the parameters ρ_e, σ^e_η and $\sigma^e_{z_0}$ using the Minimum Distance Estimator for the covariance of wage residuals for all possible lags by age and education group. The estimated results are presented in Table 2.6, which displays the estimates for the persistence of income shocks, the standard deviation of the initial income shock, and the standard deviation of the innovation shock.

2.5.5. Return on Ability

To estimate the return to ability by education group, denoted as $\alpha_e \theta^{\beta_e}$, I first estimate the parameters $\gamma_{e,t}$ and the exogenous shock process z, as described in the previous subsection. Then, following Daruich and Kozlowski (2019), I estimate the parameters α_e and β_e using the college premium and income volatility for high school and college graduates aged between 36-42 years old. I assume NLSY97 participants have the same college premium and income variance as the PSID sample. The estimated parameters are presented in Table 2.7.

Table 2.6: Income Process and Age-Profile

Age Profile		
	High-School	College Graduate
β_A	0.067	0.115
$\beta_{A^2} * 1000$	-6.831	-11.97
Income Process		
	High-School	College Graduate
ρ_z	0.93	0.90
σ_{eta}	0.032	0.049
σ_{z_0}	0.14	0.16

Notes: The table shows the estimated income process from NLSY79 and PSID data. In the Age Profile, we observe the estimated parameters of regressing $\log y_{t,i} = \beta_0 + \beta_A Age_{t,i} + \beta_{A^2} Age_{t,i}^2$ by education groups. In the bottom, we observe the income process parameters ρ_e, σ_η^e and $\sigma_{z_0}^e$ using the Minimum Distance Estimator for the co-variance of wage residual for all possible lags by age and education group.

Table 2.7: Parameters Estimated Using the Indirect Method of Moments

Parameter	Description	Value
	Preferences	
β	Discount Factor	0.88
σ_{cd}	EV Scale Parameter	0.027
	Parent Altruism	
η	Parent Altruism Before Death	0.26
η_d	Parent Altruism After Death	η
	Return to Ability	
α_c	College Level	1.79
α_{HS}	High School Level	0.35
β_c	College Concavity	0.12
β_{HS}	High School Concavity	0.23
ω_{c_1}, ω_{c_2}	College Psych Cost	0.6, 4.6
	Intergenational Transmission of Ability	
ρ_H	Human Capital Persistence	0.06
σ_H	Human Capital Standard Deviation	0.46

Notes: The table displays the parameters estimated from the data using the indirect method of moments.

2.5.6. Ability, Parent Altruism, and Psych College Cost

The intergenerational ability process is represented by $\log \theta_c = \rho_\theta \log \theta_p + \epsilon_{h_0}$ and $\epsilon_{h_0} \sim N(0, \sigma_{h_0})$. Then ρ_θ, σ_{h_0}, parent altruism η, and college psych cost parameters ω_{c_1} and ω_{c_2} are estimated using data on college attainment by children's ability quartile and their parents' wealth quartile.

2.6. Model Results

Table 2.8 displays the results of the model fitting on college attainment, parent college transfers, and income moments. The model captures the data's primary characteristics, showing that college attainment increases with ability and parent wealth. However, it underpredicts the college attainment of high-ability children. Additionally, the model closely matches the observed college premium and the income-wealth ratio. However, it over-predicts income volatility for both high school and college graduates. The model achieves higher graduation rates among low-ability high-income children. Specifically, children with parents in the highest wealth quartile have a 73% higher college graduation rate than low-ability children with parents in the first wealth quartile, explaining 60% of the graduation gap by parent income.

In the model, parents use college financial support to reduce their children's college costs and increase attendance. As a result, the transfer amount increases with parents' wealth but decreases with their children's ability as parents use transfers to affect their low-ability children's college attendance decision today instead of transferring money later to increase their consumption level in the case that they didn't attend college. In contrast, high-ability children attend college even without the financial support of their parents, so parents do not need to influence their decisions. Only wealthy parents transfer money to increase their children's consumption levels to make it closer to them.

Table 2.8: Targeted Moments

College Attainment by HH Wealth and AFQT Quartile (NLSY97) v/s Model College Attainment				
Parents' Wealth Quartile \ Child's Ability Quartile	1	2	3	4
1	0.15	0.31	0.41	0.45
	(0.19)	(0.24)	(0.33)	(0.53)
2	0.15	0.33	0.43	0.45
	(0.24)	(0.30)	(0.42)	(0.53)
3	0.19	0.36	0.41	0.45
	(0.26)	(0.40)	(0.51)	(0.63)
4	0.26	0.36	0.43	0.45
	(0.33)	(0.46)	(0.62)	(0.74)
Transfer + Allowances Yearly, Model v/s Data (NLSY97)				
Parents' Wealth Quartile\Child's Ability Quartile	1	2	3	4
1	4256	985	0	0
2	6620	1400	0	0
3	10869	2051	0	0
4	14998	5055	1589	521
Income Moments				
	Model	Data		
High-School/College mean Income Ratio	0.46	0.57		
High-School HH Income S.D	134000	39600		
College HH Income S.D	200000	60000		
Income-Wealth Ratio	5.90	6.22		

Notes: Used moments to estimate the unknown parameters using the Indirect Method of Moments. The first group of moments is college graduation rates by age and ability used to estimate parents' altruism and inter-generational ability persistence. The numbers without parenthesis are the model moments, and those with parenthesis are the data moments. In the bottom half of the table, we observe the moments used to estimate the income process and the discount factor.

2.7. The Role of Parent Transfers on Education Achievement

Table 2.9: College Attainment Model with Dynamic Altruistic Transfers vs without Dynamic Altruistic Transfers

College Attainment with Altruist Parents				
Parents' Wealth Quartile\ Child's Ability Quartile	1	2	3	4
1	0.15	0.31	0.41	0.45
2	0.15	0.33	0.43	0.45
3	0.19	0.36	0.41	0.45
4	0.26	0.36	0.43	0.45
College Attainment with Non Altruist Parents				
Child's Ability Quartile	1	2	3	4
	0.17	0.34	0.42	0.45

Notes: The table compares college attendance when parents are altruistic with a model without altruism. At the top of the table is college graduation with altruist parents ($\eta = .26$). At the bottom, we observe when parents are not altruistic to their children ($\eta = 0$).

In this section, I examine the role of parent transfers in shaping children's college achievement. To do this, I set the parameter $\eta = 0$, which implies that parents do not care about their children, so they do not transfer or bequest them. As a result, we can compare the educational outcomes with and without altruist parents to understand the role of altruism in educational achievement. The model indicates that parent transfers significantly impact college attendance and graduation rates, particularly for low-ability children. Parent transfers during college increase college attendance rates by reducing children's college costs.

The exercise results are at the bottom of Table 2.9. College attendance does not depend on parents' wealth, and low-ability children with rich or poor parents attend at the same rate. Parent altruism shapes college attendance by increasing attendance rates through parent transfers that decrease the cost of college to the children and make college less attractive by providing consumption insurance. Specifically, the model suggests that without parents' altruism, college attendance would decrease for low-ability children by 43%. On the other hand, high-ability children attend college independent of their parents' wealth. These suggest that parent altruism significantly impacts college attendance and graduation rates for low-income students from wealthy families but does not affect high-ability college attendance.

2.8. Conclusion

In this paper, I have examined how interactions between parents and adult children can affect parents' financial college support and the role of parental altruism in shaping children's college outcomes.

In the first part of the paper, I empirically assessed the effect of having richer or poorer children on parents' consumption behavior. I found that parents with children above them in the wealth-income distribution consume more than those in the same quartile. This effect can be partially explained by parents increasing inter-vivos transfers to poor children while decreasing them to wealthy children. Additionally, parents with rich children reduce bequests and increase consumption, especially among poor parents. However, the inter-vivos transfers and bequests only partially explain the changes in parents' consumption given their children's position in the wealth-income distribution.

In the second part of the paper, I built and estimated a dynastic overlapped generation model with endogenous college decisions to explore how parental investment in college varies by their children's ability. I found that parental altruism increases college attendance and graduation rates for low-ability children from high-income families. These findings highlight the importance of parent transfers in shaping children's educational outcomes and the relevance of intra-family interaction in designing government policies that target college financial support and retirement income.

2.9. Appendix: The Role of Parental Altruism in Parents Consumption, College Financial Support, and Outcomes in Higher Education.

2.9.1. HRS Consumption Data

As a robustness exercise, I realize the same estimation as in section 2.3.2 using the Health Retirement Survey (HRS) that collects information on consumption information through the Consumption and Activities Mail Survey (CAMS), which measures household expenditure over the previous 12 months.

First, I use the household consumption measures built by RAND, which comprise the sum of all household consumption, including durable consumption, housing consumption, transportation consumption, and non-durable spending. I also use household spending, which is defined as the sum of all household expenses, including durables, non-durables, transportation, and housing spending. The difference between spending and consumption is that the last incorporates durable goods and housing, bought in one period but consumed for an extended time. Next, I link the CAMS file with the HRS Longitudinal File, which has detailed information on individuals' demographics, income, wealth, and health. Finally, I merge this data to the RAND Family Data, which has information on respondent adult children's income, in-kind transfers, and inter-vivos transfers from 1992-2014. Like before, I only consider children above 26 years old and parents older than 50, dropping parents and children born in years when less than 100 individuals were born. After this, I have a sample size of 19179 parent-child pairs and 98861 observations.

Unlike PSID, in HRS, children's household income is reported by parents, which answers in which of eight brackets are their children. Unfortunately, parents do not report their children's income in every survey. For this reason, I take the average income of each child and rank them to the individuals born in the same year. To construct my variable of the relative position of children to their parents, I average parent total wealth during the observed sample period. Then I rank their respect to all parents born in the same year. As before I realize the following estimation:

$$C_{i,t} = \beta_0 + \sum_{q=-3}^{3} \beta_q T_{i,t}^q + \beta_X \mathbf{X_{i,t}} + \varepsilon_t + \epsilon_{i,t}$$

where C is household consumption in dollars, i is the parent household, $T_{i,t}^q$ is the variable described before, $\mathbf{X_{it}}$ is a set of controls (parents' total wealth, parents' non-financial wealth, parents' household income, parents' quartile in the wealth distribution, parents household head in the labor force, number of people in the parents household, parents head born year, parents head education years, parents household US state, parents head age four order polynomial, rent or own house, parents' race and parents' religion), and ε_t is a year fixed effect.

The results are displayed in table 2.10. Column 1 shows the results using RAND consumption measure, and column 2 uses household expenditure. PSID and HRS consumption measures differ because the first does not impute durable consumption. However, this is a small fraction of HRS's total consumption, and both measures give the same conclusion. Parents with a child three quartiles below them in the income distribution reduce consumption in \$4600 each year (vs. \$2000 in PSID) to a parent in the same quartile. Parents with a child three quartiles above them increase consumption in \$2200 (vs. \$3400 in PSID) to a parent with a child in the same quartile. As in PSID, the effect on parent consumption increases with the relative distance between parents and children in the wealth-income distribution. Even when both surveys give the same conclusions, the magnitude of the results differs. In PSID, the increase in consumption of poor parents with rich children is higher than in HRS. On the other hand, in HRS, the decrease in consumption of wealthy parents with poor children is higher than in PSID.

Table 2.10: Parent Consumption Given Kids Transition

	(1) Total HH Consumption	(2) Total HH Expenditure
Child 3 Quartiles Below Parents	-4636***	-2431*
	(-3.56)	(-1.84)
Child 2 Quartiles Below Parents	-1055*	-457
	(-1.85)	(-0.76)
Child 1 Quartile Below Parents	-44	83
	(-0.12)	(0.22)
Child Same Quartile Parents	914***	906***
	(3.09)	(3.10)
Child 1 Quartile Above Parent	1273***	1469***
	(4.01)	(4.22)
Child 2 Quartiles Above Parents	1325***	1764***
	(3.38)	(3.83)
Child 3 Quartiles Above Parents	2113***	2556***
	(3.49)	(3.98)
Observations	19033	19033

Notes: The table shows the results of regressing parent household consumption in dollars to the relative position of their children in the income distribution T and demographic controls X using HRS data. t statistics in parentheses, standard error cluster by household. * $p < .10$, ** $p < .05$, *** $p < .01$.

2.9.2. In-Kind Transfer

This appendix examines the impact of children's relative position in the wealth-income distribution on in-kind transfers from children to parents. In order to measure this impact, I estimate the following model:

$$\mathrm{y}_{i,t} = \beta_0 + \sum_{q=-3}^{3} \beta_q T_{i,t}^{q} + \beta_X \mathbf{X_{i,t}} + \alpha_p + \varepsilon_t + \epsilon_{i,t}$$

where y representing a discrete variable indicating whether child i provides a particular type of assistance to their parent (with the exception of hours of help). The variable $T_{i,t}^{q}$ reflects the position of child i in the income wealth-distribution relative to their parent. Additionally, the model includes a set of controls denoted by $\mathbf{X_{it}}$, which contains factors such as the parent's total wealth, non-financial wealth, household income, and demographic information such as the number of people in the parent's household and their location. Other controls include the child's education degree, marital status, and gender, as well as the frequency of contact between the parent and child, and their blood relationship. Furthermore, the model incorporates a parent fixed effect, denoted by α_p, and a year fixed effect, represented by ε_t.

The results of the estimation are presented in Table 2.11, with coefficients representing probabilities multiplied by 100. Consistent with previous findings, Column 1 indicates that children who rank higher than their parents in the wealth-income distribution are more likely to provide financial assistance than those in the same quartile. Column 2 reveals wealthier children are more likely to help cover their parents' healthcare costs. In Columns 3 and 4, no notable difference is observed in assistance with daily activities. Column 5 highlights the most significant discrepancy, the parental expectations of support, with wealthier children expected to provide more aid, potentially affecting their parents' insurance demand. Finally, Column 6 shows that less affluent children spent more time assisting their parents, with children one quartile below spending approximately 20 more hours per month. The previous result suggests that parents may transfer more resources to their lower-income

children as compensation for their caregiving efforts.

Table 2.11: Transfer from Kids to Parents

	(1) Prob Transfer	(2) Prob Help Health Cost	(3) Prob Help ADL	(4) Prob Help IADL	(5) Prob Help in Future	(6) Mothly Helped Hours
Child 3 Quartiles Below Parents	1.30***	0.37***	0.08	0.08	-1.95**	10.46
	(5.22)	(3.12)	(0.35)	(0.28)	(-2.01)	(0.81)
Child 2 Quartiles Below Parents	0.36**	0.07	0.12	-0.08	-1.16**	10.04
	(2.20)	(0.98)	(1.20)	(-0.67)	(-1.98)	(1.05)
Child 1 Quartile Below Parents	0.10	0.05	-0.05	0.07	-0.20	19.32**
	(0.86)	(0.80)	(-0.75)	(0.77)	(-0.52)	(2.45)
Child 1 Quartile Above Parents	0.82***	0.04	-0.15*	-0.21*	0.66*	-3.79
	(5.19)	(0.64)	(-1.69)	(-1.85)	(1.72)	(-0.54)
Child 2 Quartiles Above Parents	2.42***	0.40***	-0.24*	-0.41**	0.71	-12.90
	(8.00)	(2.63)	(-1.66)	(-2.17)	(1.22)	(-1.46)
Child 3 Quartiles Above Parents	5.45***	0.90***	-0.57	-0.82**	2.65**	-9.90
	(8.07)	(3.07)	(-1.53)	(-2.05)	(2.57)	(-0.64)
Professional Degree	0.92***	0.17**	-0.05	0.19	-0.85*	8.77
	(5.15)	(2.20)	(-0.50)	(1.52)	(-1.87)	(1.35)
Bachelor Degree	-0.13	0.05	0.09	-0.00	0.77*	-0.64
	(-0.78)	(0.80)	(1.16)	(-0.02)	(1.89)	(-0.13)
College DropOut	-0.68***	-0.10	0.11	0.25**	2.26***	0.61
	(-4.04)	(-1.35)	(1.40)	(2.26)	(5.16)	(0.10)
Married	-0.61***	-0.09	-0.27***	-0.20**	1.21***	-12.13*
	(-5.16)	(-1.62)	(-3.90)	(-2.21)	(3.94)	(-1.87)
Partnered	-0.19	-0.25**	-0.09	0.04	0.53	0.12
	(-1.07)	(-2.45)	(-0.81)	(0.28)	(1.07)	(0.01)
Parent Real Total Wealth	-0.00	0.00	-0.00	-0.00	-0.00	-0.00
	(-0.28)	(0.89)	(-0.50)	(-1.22)	(-0.88)	(-1.13)
Parent Real Total Household Income	-0.00***	-0.00	0.00	0.00	0.00	-0.00*
	(-3.29)	(-0.41)	(1.34)	(1.11)	(0.56)	(-1.77)
Parent Real Non Housing Fin. Wealth	-0.00	-0.00	-0.00	0.00	0.00	0.00
	(-1.34)	(-1.23)	(-0.33)	(0.39)	(0.14)	(0.96)
Child Work	-0.08	0.10	-0.04	0.04	0.91*	4.05
	(-0.50)	(1.06)	(-0.30)	(0.27)	(1.92)	(0.42)
Child Work Partime	0.09	0.16**	-0.13	-0.16	-1.00***	-5.95
	(0.76)	(2.54)	(-1.57)	(-1.48)	(-2.98)	(-1.25)
Contact Frequency	0.00***	0.00***	0.00***	0.00***	0.01***	0.01
	(5.24)	(3.37)	(5.52)	(7.45)	(10.00)	(1.30)
Female	0.19**	0.09**	0.61***	0.91***	9.92***	9.57*
	(2.13)	(2.10)	(10.79)	(12.55)	(37.27)	(1.87)
Step-kid	-0.79***	-0.21***	-0.39***	-0.53***	-16.34***	0.03
	(-5.93)	(-3.49)	(-5.06)	(-5.30)	(-31.83)	(0.00)
Constant	-286.65***	-26.55	113.27	36.43	-133.52	-930.19
	(-2.63)	(-0.26)	(1.31)	(0.40)	(-0.40)	(-0.22)
Observations	156979	128183	157216	157204	153013	2999

Notes: The table shows the results of regressing in-kind transfers from children to parents to the relative position of their children in the income distribution T and demographic controls X using HRS data. t statistics in parentheses, standard error cluster by household. * $p < .10$, ** $p < .05$, *** $p < .01$.

2.9.3. Equilibrium Properties

This section aims to examine the equilibrium properties of the household problem in order to shed light on the decision-making processes of parents and children.

Parent-Child Problem when the Child Decides College

The model used in this analysis considers three distinct stages when children are deciding whether or not to attend college. In the first stage, the child must decide on college attendance, while taking into account the parent's transfers and savings. The second stage involves the parents, who must then decide on their consumption, savings, and transfers, based on their child's education decisions. Finally, in the third stage, given the previous decisions made by the parent and the child's own college decision, the child must decide on their savings and consumption. To facilitate the modeling of strategic interactions between parents and children, an interior solution is assumed, allowing for the use of first-order conditions. To simplify the analysis, the optimization problem is characterized in reverse order.

Child Problem

At the beginning of the model, the child is born with zero assets and must make decisions about their consumption and assets in the third and final stage, based on both their parents' and their own previous decisions. To formalize this problem, the optimization problem can be defined as follows:

$$V_1(a_c, e_c, e_p, \theta, z, t_p, a'_p) = \max_{c_c, a'_c} u(c_c)$$

$$+\beta E\left[V_2(a'_c, e_c, e_p, \theta, z', t'^{*}_p(a'_p, a'_c, e_c, e_p, \theta, z'), a^{*''}_p(a'_p, a'_c, e_c, e_p, \theta, z'))|z\right]$$

$$\text{s.t: } a'_c + c_c = \tau_e y(1, 0, \theta) - \phi 1_{e_c=C} + t_p$$

$$z = 0, a_c = 0$$

$$a'_c \geq 0, c_c \geq 0$$

In this equation, the symbol $*$ is used to indicate the policies that serve as equilibrium objects, while E represents the expectation for future child income productivity, based on the child's current income productivity. The first-order conditions (F.O.C) for this problem can be expressed as follows:

$$c_c : u'(c_c) - \lambda = 0$$

$$a'_c : \beta E V^{t+1}_{a'_c} + \beta E V^{t+1}_{t'^{*}_p} \frac{\partial t'_p}{\partial a'_c} + \beta E V^{t+1}_{a''^{*}_p} \frac{\partial a''^{*}_p}{\partial a'_c} - \lambda = 0$$

The envelope theorem is used to derive the following result:

$$V^{t+1}_{a'_c} = (1 + r)u'(c'_c)$$

$$V^{t+1}_{t'_p} = u'(c'_c)$$

$$V^{t+1}_{a''_p} = \beta E[{V_{a''_p}}^{t+2}] = 0$$

By rearranging these equations, we can derive the Generalized Euler Equation for the child:

$$u'(c_c) = \beta(1+r)E[u'(c_c')] + \beta E[u'(c_c')\frac{\partial t_p'}{\partial a_c'}] \tag{2.1}$$

The additional term in the Generalized Euler Equation captures the impact of savings on children, as it ultimately reduces the transfers they receive from their parents in the future. When the partial derivative of t_p' with respect to a_c' is negative, children's savings decrease future parental transfers, leading to a reduction in future consumption and creating what is referred to as the "Good Samaritan Problem". As a result of this phenomenon, children tend to under-save and overconsume each period, compared to the case where parents have full commitment. To avoid this distortion, parents seek to set $\frac{\partial a_c'^*}{\partial t_p} = 0$, thereby ensuring that their own savings do not have an adverse effect on their children's saving behavior.

Parent Problem

During the period in which children must decide on college attendance, parents are faced with the following problem:

$$V_{1+j_k}(a_p, a_c, e_p, \theta, z) = \max_{c_p, a_p', t_p} u(c_p) + \eta u(c_c^*(a_c, e_c, e_p, \theta, z, t_p, a_p'))$$
$$+\beta E\left[V_{1+j_k+1}(a_p', a_c'^*(a_c, e_c, e_p, \theta, z, t_p, a_p'), e_c, e_p, \theta, z')|z'\right]$$
$$\text{s.t } a_p' + c_p = y(1+j_k, e_p) - t_p + (1+r)a_p$$
$$z = 0, a_c = 0$$
$$a_p' \geq 0, c_p, t_p \geq 0$$

Since parents make transfer decisions only after their children have decided whether or not to attend

college, the child's education level is known to the parents. As a result, the first-order conditions for this problem can be expressed as follows:

$$c_p : u'(c_p) - \lambda = 0$$
$$a'_p : \eta u'(c^*_c)\frac{\partial c^*_c}{\partial a'_p} + \beta E V^{t+1}_{a'_p} + \beta E V^{t+1}_{a^{'*}_c}\frac{\partial a^{'*}_c}{\partial a'_p} - \lambda = 0$$
$$t_p : \eta u'(c^*_c)\frac{\partial c^*_c}{\partial t_p} + \eta\beta E V^{t+1}_{a^{'*}_c}\frac{\partial a^{'*}_c}{\partial t_p} - \lambda = 0$$

Similar to the previous case, the Envelope Theorem is used to derive the following result:

$$V^{t+1}_{a'_p} = (1+r)\lambda' = u'(c'_p)(1+r)$$
$$V^{t+1}_{a^{'*}_c} = \eta u'(c^{'*}_c)\frac{\partial c^{'*}_c}{\partial a^{'*}_c}$$

The equation system can be rewritten as follows:

$$u'(c_p) = \eta u'(c^*_c)\frac{\partial c^*_c}{\partial a'_p} + \beta E[u'(c'_p)(1+r)] + \beta E[\eta u'(c^{'*}_c)\frac{\partial c^{'*}_c}{\partial a^{'*}_c}]\frac{\partial a^{'*}_c}{\partial a'_p} \tag{2.2}$$
$$u'(c_p) = \eta u'(c^*_c)\frac{\partial c^*_c}{\partial t_p} + \eta\beta E[\eta u'(c^{'*}_c)\frac{\partial c^{'*}_c}{\partial a^{'*}_c}]\frac{\partial a^{'*}_c}{\partial t_p} \tag{2.3}$$

Equation 2.2 represents the parent Generalized Euler Equation, reflecting the impact of parental saving behavior on both their own and their children's utility. It is worth noting that the derivative of the child budget constraint can be expressed as $\frac{\partial c_c}{\partial a'_p} = -\frac{\partial a^{'*}_c}{\partial a'_p}$, while the derivative of the child consumption in the next period is given by $\frac{\partial c^{'*}_c}{\partial a'_c} = (1+r) - \frac{\partial a''_c}{\partial a^{'*}_c}$. With these equations, we can rewrite the parent Generalized Euler Equation as follows:

$$u'(c_p) = \beta E[u'(c_p')(1+r)] - \eta \frac{\partial c_c^*}{\partial a_p'} \left(u'(c_c^*) - \beta E \left[\left(1 + r - \frac{\partial a_c''^*}{\partial a_c'^*} \right) u'(c_c'^*) \right] \right)$$

The first term on the right side of the equation represents the standard trade-off between parent consumption today and in the future, as reflected in the parent Euler Equation. The second term represents the trade-off that parents face when deciding whether to increase their savings. When parents increase their savings, they receive an additional utility today as their child increases their own consumption through a decrease in savings. However, this comes at the expense of reducing the child's consumption in the future, which can ultimately lead to a reduction in both the child's and parent's utility. Therefore, the second term captures the tension that arises between the benefits of saving for the parent's own consumption and the potential negative impact on their child's consumption in the future.

Equation 2.3 represents the trade-off that parents face when deciding how much to transfer to their children. By using the child budget constraint, we can derive the expression $\frac{\partial c_c^*}{\partial t_p} = 1 - \frac{\partial a_c'}{\partial t_p}$. This relationship enables us to rewrite the transfer equation as follows:

$$u'(c_p) = \eta u'(c_c^*) - \eta \frac{\partial a_c'^*}{\partial t_p} \left(u'(c_c^*) - \beta E \left[\left(1 + r - \frac{\partial a_c''^*}{\partial a_c'^*} \right) u'(c_c'^*) \right] \right)$$

The first term in the equation represents the marginal benefit that a parent receives from an additional unit of child consumption. It reflects the positive impact that a transfer can have on the parent's own utility, as their child's increased consumption can lead to greater satisfaction for the parent. The second term captures the trade-off that parents face between lower child consumption today and higher consumption in the future, given an increase in their child's savings. This occurs because a higher transfer to the child would decrease their current consumption, but the child's increased savings would lead to higher consumption in the future. Therefore, parents must weigh

the benefits of a higher transfer against the potential cost of lower current child savings.

Child College Decision

The first stage of the model involves the college attendance decision, in which children are faced with the following problem:

$$\hat{V}_1^*(a_p, a_c, e_p, \theta, z) = \max_{i \in [HS,C]} \{V_1(a_c, i, e_p, \theta, z, t_p^*(a_p, a_c, i, e_p, \theta, z), a_p^{*'}(a_p, a_c, i, e_p, \theta, z) + 1_{e_c=C}\kappa(\theta) + \epsilon_i)\}$$

The optimization problem faced by the child during the college attendance decision considers not only the impact of attending college on their consumption but also the potential effects on their parents' transfer and wealth. As a result, altruist parents can influence their children's decision to attend college by adjusting their transfer and savings behavior. By doing so, they can increase their child's likelihood of attending college, thereby improving their prospects and opportunities.

Parent-Child Problem After College and Before Parent Last Period

During these periods, parents always make their decisions first, in terms of their consumption, savings, and transfers. Then, based on these decisions, children must decide on their own savings and consumption. The optimization problem faced by parents and children during this period is identical to the problem that arises in the second and third stages, which occur when the college attendance decision is made. As a result, the trade-offs between consumption, saving, and transfers are the same across these different periods.

Parent-Child Problem During Parent Last Period

In this subsection, I focus on the last period of the parent's life, during which they are aware of their imminent death and must decide how to allocate their savings as a bequest to their children

in the following period.

Child Problem

This period represents the final stage for the children before they become parents themselves, and they must solve the following problem:

$$V_{j_k}^{coh}(a_c, \theta^{coh}, e_c, e_p, z, t_p, a'_p) = \max_{c_c, a'_c} u(c_c) + \beta E\left[\hat{V}_{j_k}^{coh}(b_p^* + a'_c, 0, \theta^{coh+1}, e_c, z_0)|\theta^{coh}\right]$$
$$\text{s.t. } a'_c + c_c = y(j_k, e_c, z) + t_p + (1+r)a_c$$
$$a'_c \geq 0, c_p \geq 0$$

In this equation, *coh* represents a specific cohort, while $coh+1$ refers to the variables associated with the next generation. The child's decisions do not affect future transfers since they occur after the parent's death. As a result, the first-order conditions for this problem can be expressed as follows:

$$c_c : u'(c_c) - \lambda = 0$$
$$a'_c : \beta E[V_{a'_c}^{j_k}] - \lambda = 0$$

By applying the Envelope Theorem, we obtain the expression $V_{a'c}^{j_k} : (1+r)\lambda' = u'(c'_c)(1+r)$. Using this result, we can derive the standard Euler Equation for the children, which is given by $u'(c_c) = \beta(1+r)E[u'(c'_c)]$. This equation indicates that the children's saving behavior is not influenced by future parent decisions.

Parent Problem

During the last period, parents must decide how much to transfer to their children during this

period and how much to leave as a bequest. To do so, they must solve the following optimization problem:

$$V_J^{coh}(a_p, a_c, e_c, e_p, \theta, z) = \max_{c_p, b_p, t_p} u(c_p) + \eta u(c_c^*(a_p, a_c, e_c, e_p, \theta, z, t_p, b_p))$$

$$+\eta_d \beta E\left[V_{j_k+1}^{coh+1}(b_p + a_c^{'*}(a_p, a_c, e_c, e_p, \theta, z, t_p, b_p), 0, e_c^{coh+1}, e_c, \theta^{coh+1}, 0)|\theta^j\right]$$

$$\text{s.t: } c_p + b_p = \text{S.S.}(e_c) - t_p + (1+r)a_p$$

$$t_p, b_p, c_p \geq 0$$

The first-order conditions for this problem can be expressed as follows:

$$c_p : u'(c_p) - \lambda = 0$$

$$b_p : \eta u'(c_c)\frac{\partial c_c^*}{\partial b_p} + \eta_d \beta E[V_{b_p}^{coh,j_k+1}(1 + \frac{\partial a_c^{'*}}{\partial b_p})] - \lambda = 0$$

$$t_p : \eta u'(c_c^*)\frac{\partial c_c^*}{\partial t_p} + \eta_d \beta E[V_{b_p}^{coh,j_k+1}\frac{\partial a_c^{*'}}{\partial t_p}] - \lambda = 0$$

By applying the Envelope Theorem, we can derive the following expression: $V_{bp}^{coh,j_k+1} : (1+r)\lambda' = u'(c_c^{'})(1+r)$. Based on this result, we can establish the following system of equations:

$$u'(c_p) = \eta u'(c_c^*)\frac{\partial c_c^*}{\partial b_p} + \eta_d \beta E[u'(c_c')(1+r)(1 + \frac{\partial a_c'}{\partial b_p})] \tag{2.4}$$

$$u'(c_p) = \eta u'(c_p)\frac{\partial c_c^*}{\partial t_p} + \eta_d \beta (1+r) E[u'(c_c')\frac{\partial a_c^{'*}}{\partial t_p}] \tag{2.5}$$

Equation 2.4 provides insight into the trade-off faced by parents when deciding how much of their

assets to leave as a bequest. The first term on the right side of the equation reflects the increase in utility that parents derive from higher child consumption today, as a result of leaving a larger bequest. The second term represents the trade-off between higher consumption in the future, given the bequest received, and lower consumption in the future due to reduced savings on the part of the child.

Similarly, equation 2.5 characterizes the trade-off faced by parents when making their final transfer decisions. Once again, the first term on the right side of the equation reflects the increase in utility derived from higher child consumption today. The second term represents the decreased utility associated with lower consumption in the future, which arises due to the reduction in child savings that results from the transfer.

2.9.4. Model Solution Algorithm

To address the computational challenges associated with this problem, I adopt the solution algorithm developed by Boar (2020):

1. To begin, I set up a grid on assets (a), ability (θ), education (e), and income (z). As a result, the size of the state space is determined by the product of T, A^2, H, E^2, and Y. To discretize the ability and income processes, I employ the Tauchen method.

2. Solve the problem for generation J which is not altruistic: $V^T(a_p, a_c, e_c, e_p, \theta, z)_{t=1}^T$.

3. To obtain $V^{J-1}(a_p, a_c, e_c, e_p, \theta, z)_{t=1}^T$, I work backward through the parent-child pairs, beginning with the previous generation solved in the previous step. Specifically, I solve the problem for each cohort from T to 1, using the previous solution as the continuation value for the next cohort in T.

   (a) Solve the child optimization problem $c_c^{'**}(t, a_c, e_c, e_p, \theta, z, a_p')$, $a_c^{'**}(t, a_c, e_c, e_p, \theta, z, a_p')$ without parent transfers.

   (b) Solve the parent optimization problem in two steps to get the policy functions $c_p^*(t, a_p, a_c, e_c, e_p, \theta, z)$, $a_p^{'*}(t, a_p, a_c, e_c, e_p, \theta, z)$ and $t_p^*(t, a_p, a_c, e_c, e_p, \theta, z)$:
   First, solve the optimal transfer t_p conditional on a_p. Second, solve the optimal parental policy saving a_p' given the optimal transfer $t_p^{**}(t, a_p, a_c, e_c, e_p, \theta, z, a_p')$. Then using linear interpolation recover $t_p^*(t, a_p, a_c, e_c, e_p, \theta, z)$ and child policies $c_c^*(t, a_p, a_c, e_c, e_p, \theta, z)$, $a_c^{'*}(t, a_p, a_c, e_c, e_p, \theta, z)$.

4. Solve the problem backward until the difference between V^{T-j} and V^{T-j-1} is small enough.

CHAPTER 3

Fiscal and Generational Imbalances in the U.S. Federal Budget

with Jagadeesh Gokhale and Kent A. Smetters

3.1. Introduction

The United States' federal government performs many functions: delivering public goods and services such as national defense and social insurance to the population and safety net transfers to the economically vulnerable. A key question about federal finances is whether government spending commitments could be met out of resources generated under current fiscal laws. If projected government spending significantly exceeds government receipts under current laws, those laws contain a structural imbalance, which we call the fiscal imbalance (FI).

The measurement of FI involves comparing the present discounted value of all projected social transfers and federal purchases of public goods and services with the sum of the government's net assets plus the present discounted value of government receipts (taxes, tolls, fines, premiums etc.). Budget balance need not hold in every year: Expenditures may be partly funded out of borrowing. But the debt created must be repaid or serviced through future surpluses of receipts over non-interest expenditures. Comparing projected non-interest expenditures and receipts in present-value terms and including the government's current net assets accounts for the interest costs on government debt.

Our projection of government expenditures and resources produces a value of FI equal to $202.9 trillion, which is 8.2 percent of the present value of GDP when both figures are calculated in perpetuity. This federal resource shortfall must eventually be addressed by changing laws governing federal expenditures and receipts. The size of FI relative to the present value of national output (alternatively, of expenditures or receipts) indicates the extent of fiscal adjustments needed. The following sections describe the construction of the FI for the U.S. government and report its components. The measurement of FI is based on federal expenditures and receipts projected by assuming that current fiscal laws and public goods share of national output will remain unchanged through

the measurement's time horizon. As such, it does not represent an unconditional forecast of future fiscal outcomes[4]

3.2. The Fiscal Imbalance Measure

Our construction of FI is based on U.S. demographic and economic projections of PWBM's microsimulation, which projects the evolution of the U.S. population along many dimensions[5]. In addition, calculations are based on data on federal debt from the U.S. Treasury, budget projections from the U.S. Congressional Budget Office (CBO), and profiles of tax and transfer distributions by age, gender, race, and lifetime educational attainment. The latter are developed from various U.S. micro-data surveys. The construction of these elements is described in a number of Appendices. Federal budget projections and FI measures are compared to GDP projections, which are benchmarked to the Congressional Budget Office's projections through the year 2030, are also based on PWBM's microsimulation as described in Appendix 3.6.4.

From these inputs, we calculate FI as the sum of four components: The first is the government's initial net assets. Since federal debt outstanding – the sum total of annual budget deficits accrued from the past – is positive, the government's initial net asset position is negative. United States' federal debt stood at 79.2 percent of annual U.S. Gross Domestic Product (GDP) at the end of 2019. Debt-funded expenditures to counter the negative economic effects of Covid-19 during 2020-21 boosted federal debt to beyond 100 percent of annual GDP by the end of 2021[6].

[4]For instance, lawmakers may change fiscal laws upon learning that current laws imply a large FI, thereby invalidating the basis of the pre law-change FI measurement.

[5]The PWBM microsimulation projects future births, deaths, immigration, immigration status (legal and undocumented), fertility, emigration, spatial population distribution and migration within the United States, family formation and dissolution (marriage and divorce), family size distributions, race and ethnicity, education, employment type (wage worker or self-employed), labor supply (hours worked), labor earnings, disability, retirement, and many other demographic features. A detailed technical description of the microsimulation is available at: https://budgetmodel.wharton.upenn.edu/microsim/documentation.

[6]The onset of Covid-19 during early 2020 prompted the federal government to enact massive economic-support packages to curb surging unemployment, sustain production, produce and purchase vaccines, and develop therapies to strengthen infection and disease mitigation. Anti-Covid-19 legislation enacted since early 2020 includes P.L. 116-123: Coronavirus Preparedness and Response Supplemental Appropriations Act of 2020; P.L. 116-127: Families First Coronavirus Response Act (FFCRA); P.L. 116-136: Coronavirus Aid, Relief, and Economic Security Act (CARES Act); P.L. 116-139: Paycheck Protection Program and Health Care Enhancement Act (PPPHCE Act); P.L. 116-260: Consolidated Appropriations Act, 2021 (CAA); and P.L. 117-2: American Rescue Plan Act of 2021 (ARP). The debt-to-GDP ratios cited in the text are those reported by the Congressional Budget Office.

The second component of FI is the present value of the government's expenditure obligations net of dedicated resources for two of the largest social insurance programs: Social Security Old Age, Survivors and Disability Insurance and Medicare Hospital Insurance (collectively OASDHI). Expenditures on OASDHI benefits are paid for out of dedicated resources: Payroll taxes, income taxes on OASDHI benefits, and redemptions, when needed, of treasury securities held in those programs' trust funds. The FI measure includes the present valued difference between current-law OASDHI expenditures and current-law resources dedicated to OASDHI[7].

A noteworthy feature of the OASDHI component is Medicare Part A's expenditure growth. Historically, prices of health care goods and services have increased faster than those of other goods and services. The differential rate of health care price increases relative to general inflation is 1.9 percent per year[8,9].The key reasons for faster price increases of health care goods and services are in rising demand from income growth, broader coverage under government health insurance programs, and population aging. In addition, technological advances that generate better but more expensive health care treatments promote faster price increases in the health care sector. Since these factors appear unlikely to abate in the near future, we assume that faster health care inflation will continue through the year 2040. Thereafter, excess health care costs per capita are assumed to decline gradually until 2060. After year 2060, health care expenditures per capita are assumed to grow at the same rate as other federal expenditures – at the rate of labor productivity growth. The eventual reduction in excess health care cost growth is predicated on limits to technological advancements, eventual reluctance by consumers to spend ever-larger shares of their budgets on health care goods and services, and the adoption of cost control measures by policymakers to prevent health care expenditures from crowding out other federal spending.[10]

[7]The FI measure encompasses all federal accounts. The OASDHI component of FI includes assets (nonmarketable treasury securities) held in OASDHI trust funds. However, those trust fund assets, being liabilities of the U.S. Treasury, cancel out under federal-government-wide calculation of FI.

[8]Calculated from the U.S. Bureau of Economic Analysis between 1982 and 2021. These data suggest that inflation in health care goods and services has exceed general inflation at the rate of 1.87 percent per year since the early 1980s.

[9]This study's projections assume that excess growth of Medicare Part A and other health care outlays (Medicare Parts B, C, and D and Medicaid) will grow at the same rate through 2030 as incorporated in CBO's 10-year budget projections (from February 2021). Excess health outlay's cost growth is assumed to be 1.87 percent through 2040 and then to decline linearly to zero by the year 2060.

[10]These assumption of continuing excess health care cost growth in the near term and its eventual abatement are

The third component of FI includes the difference between federal non-OASDHI transfers and non-OASDHI receipts: Non OASDHI transfers are governed by current laws about eligibility and benefit levels but are funded out of federal general-account tax revenues, program-specific premiums ("offsetting receipts") and other non-tax receipts. FI includes the difference between projected non-OASDHI expenditures and general-account (non-OASDHI) receipts, both projected under current fiscal laws. One noteworthy feature of the Congressional Budget Offices' projections of several non-OASDHI expenditures is the inclusion of expenditures not yet appropriated by Congress. For example, the Supplemental Nutritional Assistance Program is scheduled to expire in 2023 but is expected to be reauthorized in 2022. Such expenditures are included in CBO's baseline 10-year projections under the assumption that "current laws governing taxes and spending would generally remain in place" during the current fiscal year and for the ensuing 10 years[11].We use CBO's baseline budget projections during the first decade for distribution across PWBM's projected U.S. population by race, gender, and lifetime education.

The fourth component of FI is the present value of "discretionary" public goods and services purchases. These include expenditures on national defense, infrastructure, research and development, administration, foreign affairs, and other government functions. These "public purchases" levels are determined by Congress and the Administration through the annual appropriations process. We characterize current policy on purchases as increasing spending per capita at the rate of projected labor productivity growth. Since labor productivity growth is the main driver of GDP growth, projected growth in federal public purchases (under our characterization of current policy) keeps pace with GDP growth. The present value of public goods and services purchases is netted against particular (mostly non-tax) receipts associated with that provision (service charges, tolls, fines, premiums, etc.).

similar to those made by other budget-projection studies, notably those of the Congressional Budget Office.

[11] See "CBO's Process for Developing and Reviewing Baseline Projections" https://www.cbo.gov/publication/53532. The CBO reports supplemental information on the budgetary effects of programs that require reauthorizations in the future.

3.2.1. U.S. Fiscal Imbalance Measured under Current Law

Table 3.1 shows our estimates of FI and its components as present discounted values in constant 2021 dollars. Present discounted values are calculated over two time horizons – through 2095 and in perpetuity. The Table also shows FI and its components as a share of the present discounted value of projected U.S. Gross Domestic Product (PVGDP). PWBM's projection of GDP and its discounted present value (PVGDP) are based on its projections of annual efficiency-adjusted labor hours and the U.S. productive capital stock as described in Appendix 3.6.4[12].

Table 3.1: 75-year and infinite horizon FI measures under current fiscal laws and purchases policies.

	75-year Projections				Infinite Horizon Projections			
	Assets(+)/Debt(-) (A)	Receipts (R)	Expenditures (E)	FI (E-R-A)	Assets(+)/Debt(-) (A)	Receipts (R)	Expenditures (E)	FI (E-R-A)
Present values in trillions of constant 2021 dollars*								
U.S. Treasury	-27.5***		27.5	-27.5***		27.5		
OASDHI	3.0**	83.6	116.9	30.2	3.0**	150.6	236.8	83.1
non-OASDHI	3.1**	157.3	121.6	-38.8	3.1**	286.1	246.5	-42.7
Public Purchases		1.8	76.7	74.9		3.2	138.2	135.0
Net Value	-21.4	242.7	315.1	93.8	-21.4	440.0	621.5	202.9
Memo: OASDI	2.9	60.8	81.7	17.9	2.9	109.8	161.8	49.0
As a percent of PVGDP*								
U.S. Treasury	-2.1**		2.1	-1.1***		1.1		
OASDHI	0.2**	6.2	8.7	2.3	0.1**	6.1	9.5	3.3
non-OASDHI	0.2**	11.8	9.1	-2.9	0.1**	11.5	9.9	-1.7
Public Purchases		0.1	5.7	5.6		0.1	5.6	5.4
Net Value/PVGDP	-1.6	18.1	23.5	7.0	-0.9	17.7	25.0	8.2
Memo: OASDI	0.2	4.5	6.1	1.3	0.1**	4.4	6.5	2.0
Memo: PVGDP		1,338.2				2,481.1		

Source: Authors' calculations. * Present values calculated at a nominal discount rate of 4.4 percent. ** Intragovernmental debt for Social Security, Medicare, and other programs. *** Gross federal debt.

FI Measured over the next 75 Years

According to our estimates, the federal government faces a financial shortfall equal to $93.8 trillion through the next 75 years (2021-95), or 7.0 percent of the present value of GDP (PVGDP) over that time span. The programmatic view of components of the total shortfall is obtained by considering entries under the FI column of Table 1. Consider, first, projections through 2095. Public purchases at current rates out of GDP constitute the largest amount – $74.9 trillion in present value through 2095 or 5.6 percent of PVGDP. This provision would be paid for out of resources that remain after funding all federal transfer commitments under current fiscal laws. The OASDHI component, however, contains a resource shortfall ($30.2 trillion or 2.3 percent of PVGDP). The balance on

[12]See the Appendix, section 3.6.5, for details on projecting U.S. GDP.

current-law non-OASDHI transfers net of non-payroll tax and non-tax revenues (except the small amounts of offsetting receipts on public purchases) generates a surplus ($38.8 trillion, or 2.9 percent of PVGDP). This amount simply offsets the shortfall on account of OASDHI with nothing remaining to pay for debt service and public purchases at current levels as a share of GDP. The total resource shortfall amounts to $93.8 trillion or 7.0 percent of PVGDP.

The unified budget view of FI is obtained by considering column totals shown in the "Net Value" row. Outstanding debt held by the public ($21.4 trillion or 1.6 percent of PVGDP) plus federal expenditures on all FI components ($315.1 trillion or 23.5 percent of PVGDP) amounts to $336.5 trillion (25.1 percent of PVGDP) whereas all tax and non-tax revenues generate only $242.7 trillion (18.1 percent of PVGDP) in federal resources under current federal fiscal laws and public purchases policy.

Comparison of the 75-year FI measure with Federal Agency Estimates

Our FI measure calculated over 75 years (through 2095) is slightly larger than that reported in the Financial Report ("Report") of the federal government for fiscal year 2021. The Report's Statement of Long-Term Fiscal Projections (SLTFP) shows that the "present value (PV) of total "noninterest spending over the next 75 years under current policy is projected to exceed the PV of total receipts by $97.6 trillion." This estimate is similar in size to that reported in this study ($93.8 trillion)[13].

Our measure of OASDHI's FI can be split into those for OASDI and HI. Our 75-year FI estimate for OASDI is $17.9 trillion (or 1.3 percent of the 75-year PVGDP; see Memo lines in Table 1) – similar in magnitude to the $19.8 trillion reported by the Social Security Trustees in 2021. Finally, our 75-year FI estimate for Medicare Part A is $12.3 trillion, considerably larger than the official estimate of $10.0 trillion reported by the Medicare Trustees[14].

[13]See United States Department of the Treasury (2022).

[14]See Annual Report of the Medicare Board of Trustees (2021), Table V.G2. The Medicare trustees' estimates for all parts of Medicare are qualified by the statement of actuarial opinion at the end of their Annual Report. That opinion strongly questions the sustainability of the current system of Medicare provider reimbursements, implying that official estimates severely understate the sizes of Medicare's 75-year and infinite horizon financial shortfalls. However, Medicare's actuaries do not provide FI estimates in present valued dollars or as a share of PVGDP under their illustrative alternative scenario.

Fiscal Imbalance Measured in Perpetuity

The FI measure calculated in perpetuity – which presents a comprehensive measure of the budget's structural resource shortfall – is even larger. The infinite horizon FI equals $202.9 trillion or 8.2 percent of PVGDP. Over the longer horizon, the non-OASDHI surplus of 42.7 trillion is considerably smaller than the sum of shortfalls in OASDHI ($83.1 trillion), public purchases at current rates ($135.0 trillion) and outstanding federal debt ($27.5 trillion). The reasons for the larger total shortfall over the longer time horizon become clear when we consider trajectories of accruing annual budget shortfalls even just though the year 2095.

Panel-A of Figure 3.1 shows time profiles of projected annual federal non-interest expenditures, receipts, and deficits (non-interest expenditures minus receipts) through year 2095 as percentages of annual GDP. Panel-B of the Figure shows annual deficits as a share of annual non-interest expenditures and receipts.

The relatively high GDP shares of non-interest expenditures and the deficit and the low GDP share of revenues during 2021 emerged from anti-Covid-19 federal spending and depressed employment and income. The Congressional Budget Office projects that the post-Covid-19 economic recovery will reduce the deficit-GDP ratio during the next few years. However, a structural misalignment in projected long term expenditures and receipts is evident from Panel-A of Figure 3.1 . Continuing population aging combined with current laws on taxes, transfers, and purchases lead to increasing deficit-GDP ratios for many decades after the mid-2020s

Panel-B of the Figure shows that the deficit-expenditure and deficit-revenues shares continue to increase after the mid-2020s. The deficit-expenditure share increases from a (projected) low of 11.7 percent in 2026 to 29.8 percent by 2095. And the deficit-revenue share increases from 13.3 percent in 2027 to 42.5 percent by 2095. Each year's deficit-expenditure and deficit-revenue ratios indicate the annual percentage changes in each (expenditure cuts or revenue increases) that would be needed to maintain budget balance for each year relative to their projected trajectories under current laws and purchases policy. Increases in both ratios imply that U.S. treasury debt would increase over

time. Under PWBM's fiscal projections, debt held by the public would increase as a share of GDP from 97.3 percent in 2021 to 225 percent by 2050 and 731 percent by 2095.

Panel-A of Figure 3.1 shows slower growth of the expenditure-to-GDP and receipts-to-GDP ratios during the latter part of the 75-year horizon. This causes the deficit-to-GDP ratio (also shown in Panel A of Figure 1) to also stabilize after the 2070s. The assumed abatement and eventual elimination of excess health care cost growth is the reason for this result. Although the deficit-to-GDP ratio stabilizes, it remains large and positive for many years after 2095, causing the infinite horizon FI measure to exceed the 75-year measure.

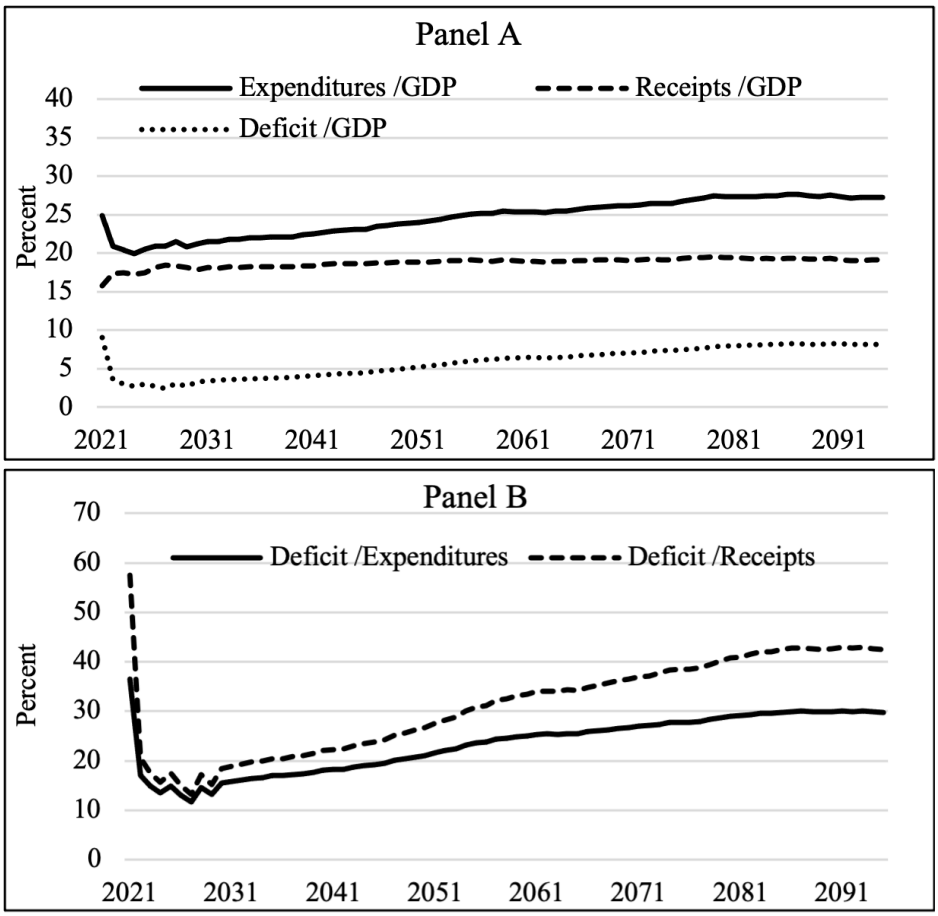


Figure 3.1: Projected federal deficits as shares of GDP, federal receipts, and noninterest expenditures under current fiscal laws and purchases policy.

Because projection uncertainty increases over time, the FI estimates are more uncertain over longer

than over shorter time horizons. However, because they are anchored to the continuation of current laws and policies, they inform us about the long term direction of the federal government's financial conditions from making no fiscal adjustments in the short term. Longer-term FI estimates also provide useful information about the sustainability of policy adjustments that target achieving budget balance over a limited time horizon[15].

Fiscal Imbalance under continuation of fiscal laws and purchases policy applicable in 2021 ("no-sunset" of expiring provisions).

	75-year Projections			Infinite Horizon Projections				
Assets(+)/Debt(-) (A)	Receipts (R)	Expenditures (E)	FI (E-R-A)	Assets(+)/Debt(-) (A)	Receipts (R)	Expenditures (E)	FI (E-R-A)	
Present values in trillions of constant 2021 dollars*								
U.S. Treasury	-27.5***		27.5	-27.5***		-76.5		
OASDHI	3.0**	83.7	116.9	30.2	3.0**	150.7	236.8	-34.0
non-OASDHI	3.1**	141.1	121.6	-22.6	3.1**	256.1	246.5	12.6
Public Purchases		1.8	76.7	74.9		3.2	138.2	135.0
Net Value	-21.4	226.5	315.1	110.0	-21.4	410.0	621.5	232.9
Memo: OASDI	2.9	63.2	87.9	21.8	2.9	109.9	161.8	49.0
As a percent of PVGDP*								
U.S. Treasury	-2.1***		2.1	-1.2***		-3.1		
OASDHI	0.2**	6.3	8.7	2.3	0.1**	6.1	9.5	-1.4
non-OASDHI	0.2**	10.5	9.1	-1.7	0.1**	10.3	9.9	0.5
Public Purchases		0.1	5.7	5.6		0.1	5.6	5.4
Net Value/PVGDP	-1.7	16.9	23.5	8.2	-0.9	16.5	25.0	9.4
Memo: OASDI	0.2**	4.5	6.1	1.3	0.1**	4.4	6.5	2.0
Memo: PVGDP			1338.3			1338.3		

Table 3.2: 75-Year and infinite horizon FI measures under continuation of fiscal laws and purchases policies applicable in 2021 ("no-sunset" of expiring provisions).

Source: Authors' calculations. * Present values calculated at a nominal discount rate of 4.4 percent. ** Intragovernmental debt for Social Security, Medicare, and other programs. *** Gross federal debt.

Table 3.2 shows FI under the alternative assumption that fiscal laws and purchases policy applicable in 2021 are continued in perpetuity. Under this "no-sunset" alternative, future changes by way of expirations of particular tax policies – mostly those enacted under the Tax Cuts and Jobs Act (TCJA) of 2017 that are built into today's fiscal laws – are left unimplemented. The non-expiration of expiring TCJA tax provisions would reduce federal revenues relative to those under current fiscal laws. Under the "no-sunset" case, FI through 2095 equals $110.0 trillion or 8.2 percent of PVGDP. Under the infinite horizon projection the FI is estimated to be 232.9 trillion, which equals 9.4 percent of the PVGDP.

[15]When deficits continue to accrue beyond any finite time window, policy adjustments that achieve present-valued budget balance over that time window would be thrown out of balance simply because of the passage of time.

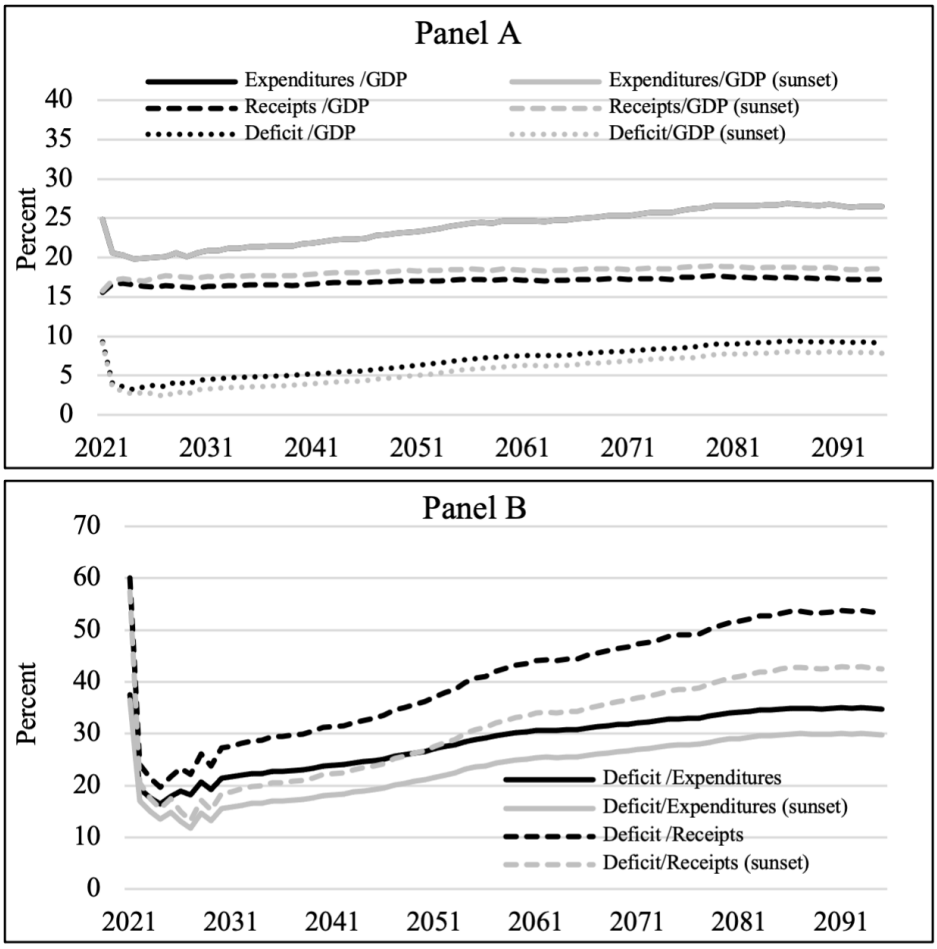


Figure 3.2: Projected federal deficits as shares of GDP, federal receipts, and non-interest expenditures under continuation of fiscal laws applicable in 2021 ("no-sunset" of expiring provisions).

Source: Authors' calculations.

Panel-A of Figure 3.2 shows projected annual federal receipts, non-interest expenditures and deficits as a share of GDP under the "no-sunset" alternative. Under it, annual budget deficits are larger, as are deficit-GDP ratios compared to current-law-and-purchases-policy ("sunset") scenario. The latter projections are shown in gray lines for comparison in Figure 2. Expenditure time series under the "sunset" and "no-sunset" cases overlap as there are no expiring expenditure provisions. All of the deficit increase under the "no-sunset" policy emerges from maintaining the revenue changes enacted under TCJA laws. Panel-B of Figure 3.2 shows that "no-sunset" deficit-expenditure and deficit-revenues shares are considerably higher compared to those under current-laws-and-purchases

policy. The deficit-to-expenditure share now reaches 34.7 percent of GDP by 2095 (compared to 29.8 percent under current-laws-and-purchases policy). And the deficit-receipts share reaches 53.2 percent by 2095 (compared to 42.5 percent under current laws and purchases policy). The increase in the deficit ratios through time indicates that, absent policy adjustments, U.S. treasury debt will increase to 261 percent of GDP by 2050 (instead of 225 percent under the current law and purchases policy), and to 859 percent by 2095 (compared to 731 percent under the current law and purchases policy).

Figure 3 splits projected annual deficits (as shares of GDP) under current fiscal laws and purchases policy into three components – those arising from OASDHI and non-OASDHI transfers net of receipts and from discretionary public goods' purchases net of premiums, tolls and other receipts associated with those purchases. In the Figure, time profiles under current-law-and-purchases policy ("sunset" case) are shown in darker lines and those under continuation of fiscal laws applicable in 2021 ("no-sunset" of expiring provisions) are shown as light gray lines in corresponding line styles (unbroken, dashed, dotted etc.).

The non-OASDHI component (dotted lines in Figure 3.3) contributes a surplus that, under current laws and purchases policy, declines over time from just under 5 percent of GDP during the late-2020s to 2.9 percent in 2050 and to 1.6 percent by 2095. An important reason for the reduction of non-OASDHI surplus is growing health care costs on account of Medicare (excluding Part A) and Medicaid programs.

In contrast, OASDHI's deficit-GDP ratio (short dashed lines Figure 3.3, which are identical under both the "sunset" and "no-sunset" cases), increases rapidly from just under one percent of GDP during the early 2020s to 2.1 percent by 2050 and to 3.9 percent by 2095. Finally, public goods and services purchases in GDP (also identical under the two cases) decline from recent highs of 7-plus percent to 5.6 percent of GDP by 2095. These projections show that non-OASDHI component's surplus is insufficient to cover the combined deficit emerging from OASDHI and public goods purchases. As a result, the total deficit (unbroken line in Figure) as a share of GDP under current law and purchases policy ("sunset" case) increases from a low of 2.4 percent (projected for 2027) to 7.9

percent by 2095.

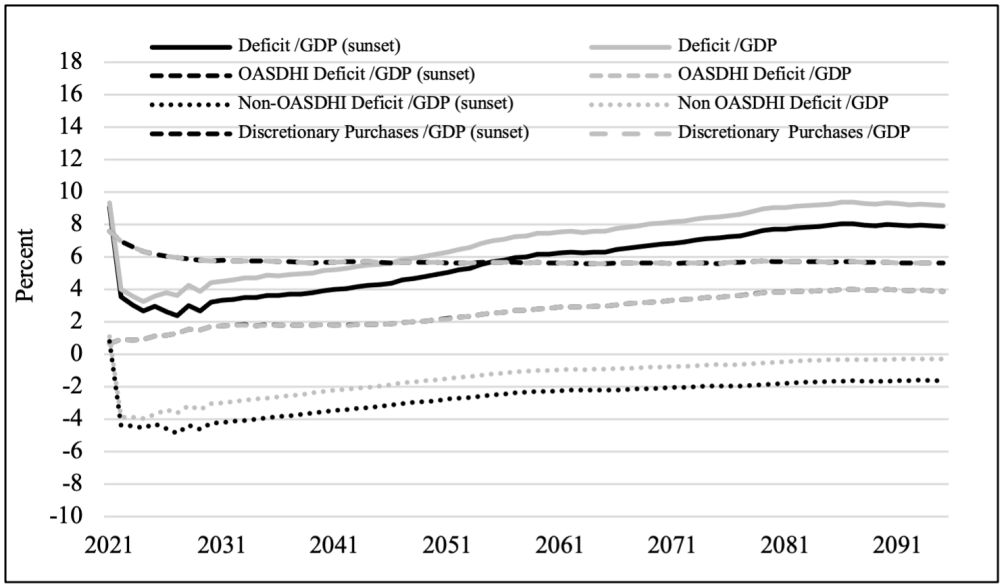


Figure 3.3: Deficit components as shares of GDP: OASDHI, non-OASDHI, and public purchases under current laws including scheduled expirations ("sunset") and under continuation of fiscal laws applicable in 2021 ("no sunset" of expiring provisions).

Source: Authors' calculations.

The gray lines of Figure 3.3 show the evolution of these components under continuation of fiscal laws applicable in 2021 ("no-sunset" case without expiration of certain tax and spending provisions). Here, today's non-OASDHI surplus declines from 1.1 percent to only 0.3 percent as a share of GDP by 2095. As a result, the total deficit (unbroken line) as a share of GDP increases from a low of 3.3 percent during the early-2020s to 9.2 percent by 2095.

Panel-A of Figure 3.5 shows OASDHI receipts, expenditures, and deficit as a share of GDP under current-law OASDHI benefits and tax projections. Panel-B of the Figure shows the same information for non-OASDHI transfers and receipts. The increase in OASDHI deficit result from a faster growth of benefits relative to the growth of OASDHI receipts. As noted above, a key contributors to the increasing resource gap in OASDHI is the (assumed) continuation of excess growth in Medicare Part A expenditures per capita through year 2060. In contrast, receipts exceed expenditures in the non-OASDHI component but the surplus is projected to decline during the next several decades

under current fiscal laws and purchases policy.

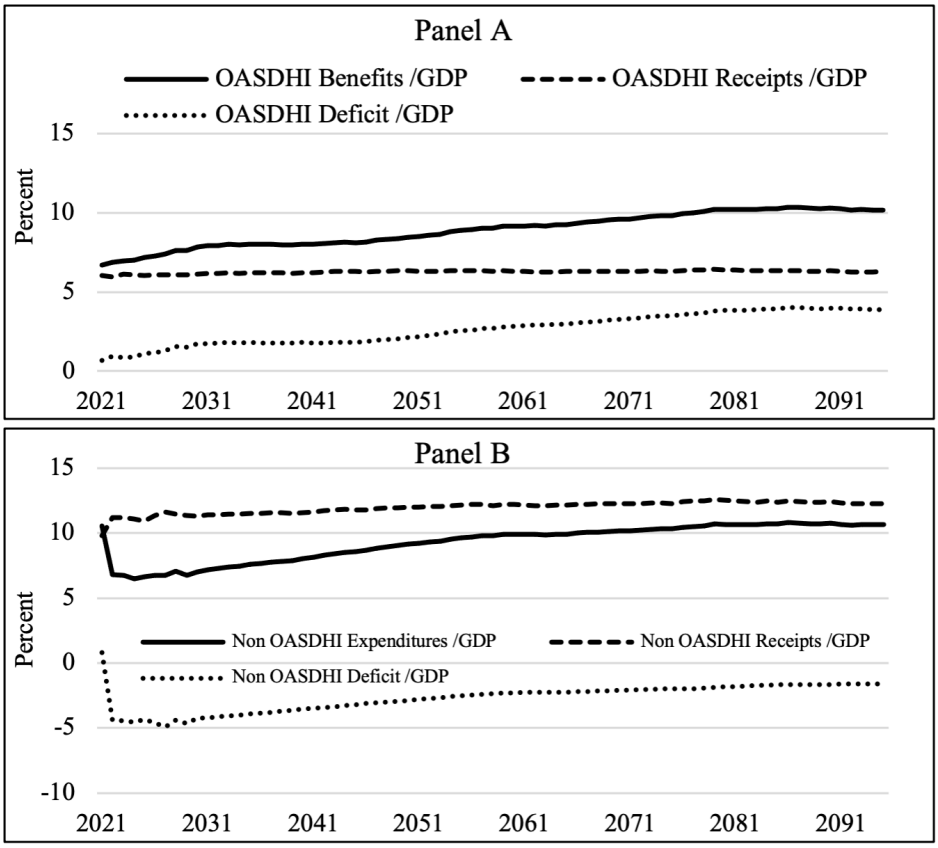


Figure 3.4: Federal receipts, expenditures, and deficits in OASDHI and non-OASDHI programs as shares of GDP under current laws.

3.3. The Generational Imbalance Measure for OASDHI

OASDHI expenditures are funded solely out of dedicated payroll tax revenues and income taxes on Social Security benefits of high income retirees. OASDHI revenues and expenditures can both be allocated to particular cohorts (by birth year, gender, race, and education levels) that pay those taxes and receive Social Security and Medicare benefits. By assigning OASDHI trust funds' assets to net tax payments of past cohorts and adding prospective net tax payments of those currently alive, we can calculate the portion of OASDHI's FI that arises from taxes and transfers of the "closed group" of past and current generations.

		Present Values in Trillions of Constant 2021 Dollars				As a Percent of PVGDP			
		Trust Fund	Receipts	Expenditures	Imbalance	Trust Fund	Receipts	Expenditures	Imbalance
		Panel-A: Through the Infinite Horizon							
Social Security (OASDI)	FI	2.9	109.8	161.8	49	0.1	4.4	6.5	2
	GI	2.9	73.5	101	27.5	0.1	3	4.1	1.1
	FI-GI	0	36.4	60.7	21.5	0	1.5	2.4	0.9
Medicare Part A (HI)	FI	0.1	40.8	75	34.1	0	1.6	3	1.4
	GI	0.1	27.5	44.6	17.2	0	1.1	1.8	0.7
	FI-GI	0	13.3	30.4	16.9	0	0.5	1.2	0.7
Social Security and Medicare Part A (OASDHI)	FI	3	150.6	236.8	83.1	0.1	6.1	9.5	3.3
	GI	3	100.9	145.7	44.7	0.1	4.1	5.9	1.8
	FI-GI	0	49.7	91.1	38.4	0	2	3.7	1.5
		Panel-B: Through 2095							
Social Security (OASDI)	FI	2.9	60.8	81.7	17.9	0.2	4.5	6.1	1.3
	GI	2.9	22.7	53.8	31.1	0.2	1.7	4	2.3
	FI-GI	0	38.1	27.9	-13.2	0	2.8	2.1	-1
Medicare Part A (HI)	FI	0.1	22.8	35.2	12.3	0	1.7	2.6	0.9
	GI	0.1	7.9	23	15.2	0	0.6	1.7	1.1
	FI-GI	0	14.9	12.2	-2.9	0	1.1	0.9	-0.2
Social Security and Medicare Part A (OASDHI)	FI	3	83.6	116.9	30.2	0.2	6.2	8.7	2.3
	GI	3	30.6	76.8	46.2	0.2	2.3	5.7	3.5
	FI-GI	0	53	40	-16	0	4	3	-1.2

Table 3.3: OASDHI's FI attributable to past and current generations (GI) and future generations (FI-GI).

We call the closed group's contribution to the overall FI the Generational Imbalance (GI). By construction, the imbalance accruing to future generations (under current OASDHI laws) equals FI–GI. Table 3.3 shows the decomposition of OASDHI's FI into GI and FI-GI, both overall and separately for Social Security (OASDI) and Medicare Part-A (HI).

Panel-A of Table 3.3 shows that FI for OASDHI as a whole equals $83.1 trillion over the infinite horizon – the sum of $49.0 trillion on account of Social Security and $34.1 trillion on account of Medicare Part A. Past and current generations contribute $27.5 trillion on account of Social Security and $17.2 trillion on account of Medicare Part A to total FI. These GI amounts represent excess benefits in present value that the closed-group cohort will receive over the present value of their payroll taxes and income taxes on Social Security benefits assuming maintenance of current OASDHI laws and income tax laws on Social Security benefits during their remaining lifetimes. Keeping those laws in place indefinitely implies granting net benefits to future generations as well (FIGI), to the tune of $21.5 trillion on account of Social Security and $16.9 trillion on account of Medicare Part A.

OASDHI's net benefits to past, current, and future generations under current laws amount to 3.3 percent of PVGDP through the infinite horizon – 2.0 percent on account of Social Security and 1.4

percent on account of Medicare Part A. Of the total OASDHI imbalance of 3.3 percent of PVGDP, 1.8 percent arises on account of past and current generations and 1.5 percent on account of future ones. Panel-B of Table 3 shows that more than one-third of the total OASDHI imbalance ($30.2 trillion out of $83.1 trillion), accrues during the next 75 years. Of this amount, about 40 percent ($12.3 trillion) accrues on account of Medicare Part A.

3.4. Cost of Delaying Fiscal Adjustments to Restore Fiscal Balance

Panel A of Figure 3.1 indicates that current federal tax and spending policies embody a large and growing fiscal imbalance. Besides choosing which tax and spending policies to change, policymakers must also decide on when to begin fiscal adjustments to reduce or eliminate the federal fiscal imbalance.

Year	75-Year Fiscal Imbalance Ratio					Infinite Horizon Fiscal Imbalance Ratio				
	Gross Federal Debt	OASDHI	Non-OASDHI	Federal Purchases	FI	Gross Federal Debt	OASDHI	Non-OASDHI	Federal Purchases	FI
2021	2.07	2.24	-2.92	5.6	7	1.11	3.35	-1.72	5.44	8.18
2022	2.11	2.28	-2.96	5.69	7.12	1.12	3.38	-1.74	5.49	8.25
2023	1.89	2.53	-2.72	5.55	7.24	1.13	3.41	-1.75	5.54	8.33
2024	1.97	2.56	-2.69	5.53	7.37	1.14	3.44	-1.77	5.59	8.4
2025	2.05	2.59	-2.66	5.52	7.5	1.15	3.47	-1.78	5.64	8.48
2026	2.15	2.61	-2.63	5.51	7.64	1.16	3.51	-1.8	5.69	8.56
2027	2.23	2.64	-2.6	5.51	7.78	1.17	3.54	-1.82	5.75	8.64
2028	2.32	2.66	-2.56	5.5	7.92	1.18	3.57	-1.84	5.8	8.72
2029	2.42	2.69	-2.53	5.5	8.07	1.19	3.61	-1.85	5.86	8.8
2030	2.52	2.71	-2.49	5.49	8.23	1.2	3.64	-1.87	5.91	8.89

Table 3.4: OASDHI's FI attributable to past and current generations (GI) and future generations (FI-GI).

It's worth noting that, over time, federal debt will grow according to interest accruals on existing debt plus primary federal deficits (federal non-interest expenditures minus receipts) whereas GDP will grow at the rate of population plus productivity growth. Since during normal economic times, the (long-term) interest rate exceeds the GDP growth rate, the ratio of the fiscal imbalance to GDP will grow larger each year that fiscal adjustments are postponed. Table 3.4 shows how components of and total federal fiscal would change over time if current fiscal policies are maintained through each of the years shown (up to year 2030).

Not engaging in fiscal adjustments through the year 2028, for example, would increase the 75-year U.S. federal fiscal imbalance to 7.92 percent (from its current value of 7.0 percent). The infinite

horizon fiscal imbalance would increase to 8.72 percent (from its current value of 8.18 percent. A higher fiscal imbalance means that tax increases, spending cuts, or both in combination to reduce the imbalance to a given target ratio to the present value of GDP (or to eliminate it) would have to be larger.

3.5. Generational Accounts by Education, Gender and Race

FI and GI measures are a version of generational accounting (GA), which estimates the direct incidence of lifetime net taxes on various population cohorts distinguished by their attributes. A generational account shows the actuarial present value of prospective net taxes (taxes minus transfers) per person, again under the assumption that current federal fiscal laws will remain unchanged in the future. Previous generational accounting studies separated cohorts by birth year (or age as of the base year, here 2021) and gender (see Auerbach et al. (1991)). The GAs reported here identify population subgroups by birth-year, gender, race (white, nonwhite) and highest education attained over the lifetime (less than college, college or more)[16]. The advantage of a more granular decomposition lies in more accurately capturing correlations between lifetime taxes and transfers with average longevity[17].

[16]It is possible to identify highest lifetime education because the PWBM's projection of the future population provides prospective life-histories of all simulated individuals.

[17]For example, distinguishing by gender alone would not capture (1) correlation between average transfers and longevity by race and education and (2) correlations between average taxes and longevity by race and education.

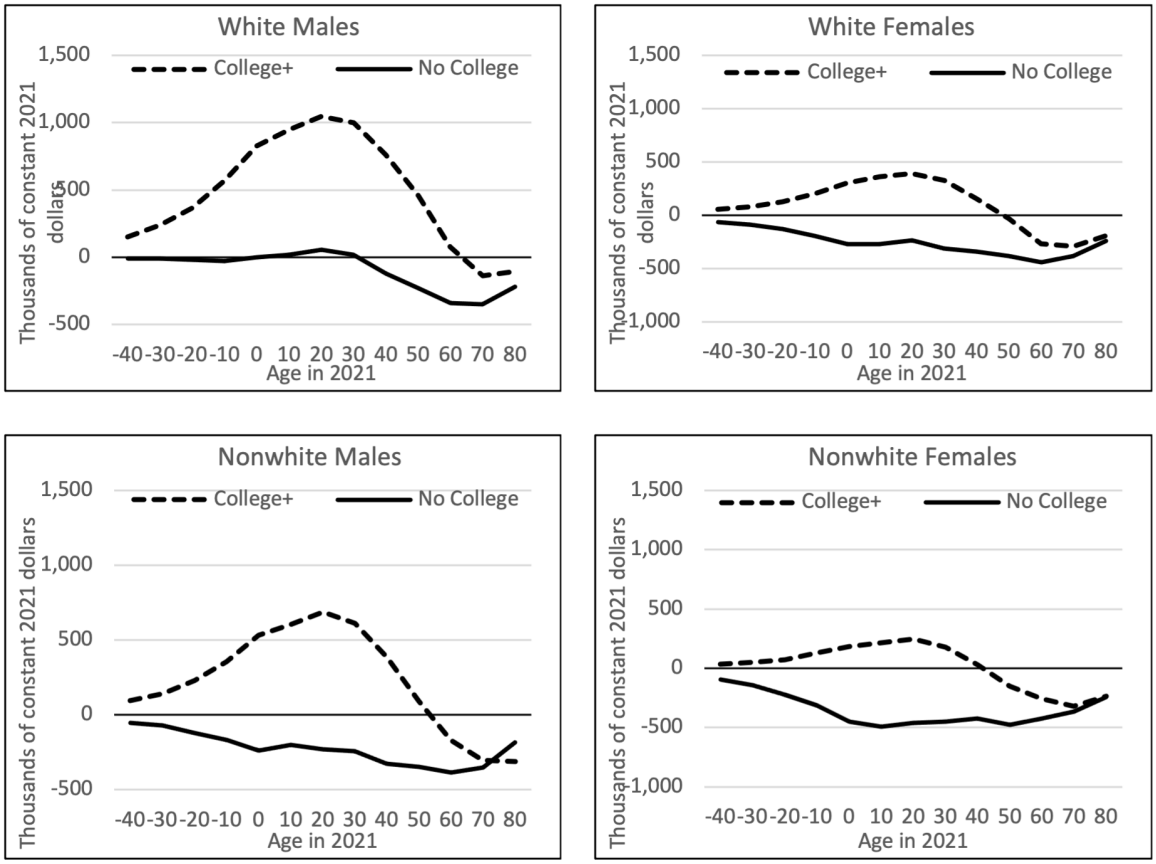


Figure 3.5: Generational accounts: Present values of prospective net taxes per capita for current and future generations by birth year, gender, race, and lifetime educational attainment.

Source: Author's calculations. Negative ages on the X-axis indicate future birth years. For projected future-born cohorts, present values are calculated by actuarially discounting annual net tax payments back to birth year and discounting the result back to 2021 using the nominal productivity discount rate of 3.5 percent per year.

In general, GA metrics are designed to reveal how much each cohort (by birth-year, gender, and other attributes) would contribute under current federal tax and transfer laws during its expected (remaining) lifetime toward funding the government's prospective provision of public goods and services at current rates out of GDP. Each cohort's projected net tax payments (taxes minus transfers) per capita are actuarially discounted back to the cohort's birth year. Actuarial calculations take account of differential mortality rates across demographic groups by race, gender, birth-year and education levels. For future-born generations, age-0 present values are additionally discounted back to the base year (2021 in this study) at the rate of annual productivity growth to account for the

fact that they would be alive during future periods when labor productivity levels are higher than for those born earlier. Calculation details for GA metrics are provided in Appendix 3.6.1.

Figure 3.5 shows GA profiles for population subgroups distinguished by birth-year, gender, race, and lifetime educational attainment. Negative ages indicate cohorts born after the base year 2021. Table 5 shows the dollar values (in constant 2021 dollars) underlying the charts of Figure 5.

In general, Figure 3.5 and Table 3.5 show that college educated cohorts pay positive amounts of net taxes and the non-college-educated receive transfers, on net, during their prospective lifetimes; that those in the early stages of their working lifetimes pay the highest net taxes in present value, and those in pre-retirement lifecycle stages receive the highest net transfers in present value. The following paragraphs describe GA differences by particular demographic attributes.

Birth Year	Age in 2021*	White				Nonwhite			
		College+		No College		College+		No College	
		Male	Female	Male	Female	Male	Female	Male	Female
2061	-40	151,737	53,852	-9,839	-63,027	94,002	31,965	-54,550	-97,616
2051	-30	237,342	80,982	-10,591	-87,092	143,342	49,775	-71,785	-145,805
2041	-20	365,921	123,676	-17,591	-132,955	229,701	71,900	-119,835	-223,640
2031	-10	570,085	201,848	-26,573	-193,929	354,120	129,863	-166,217	-315,412
2021	0	826,727	300,240	-316	-272,455	531,864	185,296	-240,232	-451,504
2011	10	950,522	359,941	20,078	-269,261	604,568	216,670	-200,560	-491,451
2001	20	1,046,725	388,151	55,425	-238,103	687,157	244,605	-230,614	-460,953
1991	30	1,001,961	323,742	20,176	-310,482	612,518	176,322	-242,656	-450,959
1981	40	760,077	157,915	-121,496	-342,167	385,907	26,757	-325,337	-424,188
1971	50	458,630	-35,112	-228,318	-386,342	92,705	-148,470	-347,856	-476,225
1961	60	77,897	-267,079	-340,699	-441,687	-170,196	-257,585	-384,944	-424,820
1951	70	-138,414	-294,290	-348,356	-383,518	-304,402	-319,816	-352,595	-363,364
1941	80	-99734	-181990	-205470	-220753	-288044	-254248	-167784	-225726

Table 3.5: Generational Accounts: Present values of future net taxes per capita in constant 2021 dollars by birth year, race, gender, and lifetime educational attainment.

Source: Author's calculations. * Negative ages indicate birth in the future. For projected future born cohorts, present values calculated by actuarially discounting net taxes to birth year and discounting the result back to 2021 using the productivity discount rate of 3.5 percent per year.

3.5.1. College educated white and nonwhite males

Among the college educated, white and nonwhite males in early-career stages are slated to pay significant amounts of federal net taxes during their remaining lifetimes. The top left chart of

Figure 3.5 shows that "early-career" white college-educated males (aged 10-30 in 2021) may expect to pay more than $1,000,000 (in constant 2021 dollars) over their lifetimes in net taxes. The bottom left Panel of Figure 3.5 shows that similarly aged nonwhite college-educated males would pay about one-half of the net taxes of their white counterparts. The reason for their lower net taxes are lower career labor-force attachments, lower efficiency-adjusted work hours and, therefore, lower earnings than white college-educated males. The working- and tax-paying lifecycle stages of college-educated cohorts' (age 10-30) is current or close in time and their benefit-receipt lifecycle stages – late career and retirements – are in the distant future. As expected, both white college- and non-college-educated males in their late fifties and older receive benefits on net. College educated white males, although they receive more in Social Security benefits, pay even more income and other taxes during retirement compared to their college educated nonwhite counterparts.

3.5.2. White college- and non-college-educated males

Younger white males with less than college education receive lifetime transfers in the $0- $200 range whereas those aged 40 and older receive substantially more in transfers, on net, in present value. Compared to college educated white males, non-college-educated white males pay fewer income, payroll, indirect, estate, and other taxes. Although the latter also receive fewer health care and other transfers (because of shorter lifespans) their GAs are negative unlike those of their college-educated white counterparts.

3.5.3. Nonwhite college and non-college educated males

Younger non-college educated nonwhite males receive considerable transfer benefits on net, whereas their college-educated counterparts pay substantial amounts in net taxes. The contrast is highlighted among newborns in 2021: College educated nonwhite males would expect to pay more than $500,000 in net taxes whereas non-college-educated males would receive between $200,000 and $400,000 in net transfers during their lifetimes.

3.5.4. College educated white and nonwhite females

White college educated females pay slightly more in net taxes compared to nonwhite college-educated females, mainly because of earnings differences. Both cohorts currently have about the same degree

of labor force attachments, and receive comparable amounts in social and health care transfers. But college educated women work for more hours per year, earn more and, therefore, pay more taxes than non-college educated women.

3.5.5. Nonwhite college- and non-college-educated females

Similar to their educated white counterparts, younger college educated nonwhite females enjoy higher earnings and pay more taxes compared to younger nonwhite females without a college education. The latter, in contrast, receive substantially more in federal transfers. Indeed, whereas college educated nonwhite women aged 20 in 2021 will pay almost $250,000 in lifetime net taxes, on average, their non-college-educated counterparts, will receive more than $450,000 in lifetime transfers, on average, mostly from Social Security, Medicare, and Medicaid.

3.6. Appendix: Calculating Generational Accounts and Fiscal and Generational Imbalance Measures

3.6.1. Overview

Fiscal imbalance and generational accounting metrics take as their starting point the government's present-valued (intertemporal) budget constraint. This constraint may be written as

$$\mathrm{PVG}_t = \mathrm{NWG}_t + \mathrm{PVTL}_t + \mathrm{PVTF}_t. \tag{3.1}$$

Equation 3.1 is a financing constraint. It says that at time t (the initial year), the present value of all prospective government purchases of goods and services, PVG_t, must be paid for out of its total resources: the net wealth of the government, NWG_t plus the present value of prospective net tax payments by current generations, PVTL_t, and plus the present value of aggregate net tax payments by future-born generations, PVTF_t. Net taxes are calculated as tax payments net of transfer receipts in each period.

Equation 3.1 may be satisfied under many different configurations of government tax and spending laws. For example, low (high) PVG_t implies that prospective net tax payments of living and future generations must be correspondingly lower (higher) for the two sides of 3.1 to balance; and given PVG_t, low net taxes levied on living generations must be offset by higher net tax levies on future ones, and so on.

In general, prospective government spending and net taxes of living and future generations under current law (denoted as PVG_t^c, PVTL_t^c, and PVTF_t^c), which includes scheduled future changes such as expirations of particular spending, tax, and transfer laws, the two sides of 3.1 usually would not be equal. The present valued difference between the government's current-law spending and resources equals the current-law fiscal imbalance, FI_t^c.

$$\mathrm{FI}_t^c = \mathrm{PVG}_t^c - [\mathrm{NWG}_t + \mathrm{PVTL}_t^c + \mathrm{PVTF}_t^c] \tag{3.2}$$

Since resources actually on hand today, NWG_t, are already accounted for and fixed from past accruals, the present valued dollar amount, FI_t^c, shows the additional resources needed for the government to fully fund current-law purchases, PVG_t^c. A positive value of FI_t^c indicates a funding shortfall that must be resolved either by levying additional net taxes (increasing taxes or cutting transfers from current-law levels) or by reducing government purchases themselves below current-law levels. That is eliminating the imbalance shown in 3.2 involves changing fiscal laws to establish equality of the two sides of equation 3.1.

3.6.2. Computation Method

Estimation of the two present-valued terms within square brackets in equation (A1.1) can be accomplished by calculating generational accounts. A "generational account" (GA) is the dollar amount, defined as the actuarially discounted present value of per capita net tax payments (under a given fiscal policy) of a population cohort over the rest of its expected lifetime. Adding up the population-weighted GAs of all birth cohorts alive today yields the term $PVTL_t^c$. Similarly, calculating the GAs of yet-to-be-born population cohorts over their expected lifetimes (by using future population projections) and adding their population-weighted present-discounted values yields the term $PVTF_t^c$. Generational accounts and fiscal imbalance measures can be calculated under any given set of fiscal laws or policies, p, to reveal the extent of tax- and spending-law adjustments needed to restore intertemporal budget balance ($FI_t^p = 0$). It also reveals the extent of trade-offs in distributing the adjustments on spending and net taxes on living and future generations.

The term NWG_t is simply the total contractual asset/debt position of the government vis-à-vis the rest of the world. As noted above, the sum of generational accounts over all members of living generations yields the term $PVTL_t^c$. This sum is: $PVTL_t^c = \sum_{j_t=0}^{D} \sum_x GA_{j_t,t}^{c,x} p_{j_t,t}^x$, where x represents a combination of gender, education, and race attributes [gender (male, female), education (college degree, no-college degree) and race (white, nonwhite)], D is the maximum age of life (assumed to be 120 years), $p_{j_t,t}^x$ represents the populations of type x aged j in year t, and $GA_{j_t,t}^{c,x}$ represents current-law generational account in year t of person-types x aged j in year t (indexed by j_t) – that is, the present values as of year t of the per capita net taxes that each generation would pay under

current law during its expected lifetime.

The generational account, $GA^{c,x}_{j_t,t}$, is calculated as

$$GA^{c,x}_{j_t,t} = \frac{1}{p^x_{j_t,t}} \sum_{s=t}^{t+D-j_t} \sum_{x} p^x_{j_t,s} \left(\sum_{i=1}^{k} q^{c,x}_{i,j_t,s} \right) R^{s-t} \tag{3.3}$$

where $R = \frac{1}{1+r}$, and r is the discount rate. Equation 3.3 expresses the actuarially discounted value of prospective per capita net payments of a generation aged j at year t. The account for each generation is calculated by:

1. Finding the algebraic sum of the per capita taxes and transfers paid in each year s, by the members surviving in that year (including people of that age and person-type who have immigrated since year t).

2. Multiplying that sum by the population in year s.

3. Discounting the result back to year t.

4. Aggregating such discounted values over the generation's lifetime.

5. Dividing the result by the generation's population in the initial year, t.

In equation 3.3, $q^{c,x}_{i,j_t,s}$ stands for the current-law per capita payment (or receipt, when q is negative) of type i in year $s(> t)$ by a generation of person-type x aged j in year t. The per capita net payment, after accounting for all (k) types of taxes and transfers in year s, is given by the sum in parentheses in 3.3. This term, multiplied by the population of such persons in year s, $p^x_{j_t,s}$, yields the aggregate net payment that individuals of type x aged j in year t make in year s. U.S. population projections are taken from PWBM's microsimulation, which is calibrated to many features of the United States demography and demographic projections. Summing such discounted values for each year s over the remaining life of individuals aged j in year t (from t to $+D-j_t$) yields the discounted value of their aggregate net tax payments. Division by $p^x_{j_t,t}$, the population of such persons in year

t, converts this actuarially discounted sum to a per capita amount and represents the generational account of the generation of person-type x, aged j in year t, under current fiscal laws (denoted by superscript c).

Prospective per capita payments of each type of tax (or transfer) are estimated by distributing projected aggregate payments of that type by age and person-type categories. In making the distribution, generational accounting begins with projections of the U.S. population and of aggregate federal taxes and transfers. To each type of aggregate tax or transfer projection, it applies a relative profile by age and person-type normalized to a 40-year-old male. The exception is child-SCHIP benefits that are allocated only to children aged 0-17 with relative profiles normalized to male children aged 12. The relative profile value for a 38-year-old woman is the ratio of her per capita payment to that of a 40-year-old man.

Relative profiles for various taxes and transfers are estimated from survey data and the latest available profiles are used to distribute projected aggregate payments by age and person-type in future years. For the United States, these estimates are taken from the Census Bureau's Current Population Survey (Annual Social and Economic Survey), the Social Security Administration's Annual Statistical Supplement to the Social Security Bulletin, the Federal Reserve's Survey of Consumer Finances and the Census Bureau's Survey of Consumer Expenditures.

The Congressional Budget Office's projections of aggregate payments are available only through the year 2030. For years 2021-2030, the relative tax/transfer profiles are used to distribute by age and person-type, projected aggregate federal revenues and transfer expenditures. This yields per capita payments by age and person-type for those years. Per capita values for later years are obtained by growing per capita values for the last available year (2030) at the rate of labor productivity (g). Hence, if the last available tax and expenditure aggregate is for year l,

$$q^{c,x}_{i,j_t,l+u} = q^{c,x}_{i,j_t,l}(1+g)^u, \quad i = 1,\ldots,k;\ u = 1,\ldots,T. \tag{3.4}$$

Relative tax and transfer profiles and associated aggregate payments and receipts specify the pattern of prospective per capita taxes levied on and receipts provided to various generations living at year t and, therefore, collectively embody the generational pattern of fiscal policy at year t. Because all relative profiles are normalized to average payments by z-year-old males (40-year-old males in general and 12-year-old male children in the case of SCHIP benefits), the per capita payment of the z-aged normalizing individuals can be expressed as

$$q^{c,m}_{i,z,t} = \frac{Q^c_{i,t}}{\sum_{j_t=0}^{D}(r^m_{i,j_t,t}p^m_{j_t,t} + r^f_{i,j_t,t}p^f_{j_t,t})}, \tag{3.5}$$

where $r^m_{i,j_t,t}$ represents the per capita payment (or receipt, if negative) of type i that a person aged j in year t makes relative to the payment of a 40-year-old male in year t, and $Q^c_{i,t}$ represents the aggregate current-law payment or receipt of type i made in year t. Of course,

$$q^{c,x}_{i,j_t,t} = q^{c,m}_{i,z,t}r^x_{i,j_t,t}. \tag{3.6}$$

The present value of government purchases, PVG_t, is estimated by discounting prospective aggregate government purchases back to year t. If projections of aggregate purchases are unavailable, or if they need to be extended, they are estimated by distributing the per capita purchases in the last year (actual or projected) for which an aggregate figure is available by making the per capita purchases by age grow at the same rate as labor productivity. Finally, a population projection is used to aggregate the per capita figures. Many yearly government purchases, such as those for defense and general administration, cannot be assigned to specific age groups and are prorated to all individuals alive in that year. Note that the generational accounting methodology uses estimates of government purchases by age only to mechanically extend the projections of those purchases. It does not try to assign the benefits of such purchases by age and person-type. The estimates for purchases assume a constant relative profile by age, which represents empirically determined ratios and an element of the current generational stance of fiscal policy.

Government net wealth, NWG_t, is estimated by cumulating the sum of past government surpluses (or deficits, if negative). The government's existing tangible assets, such as parks and infrastructure, are excluded from NWG_t, and their prospective service flows, which represent the consumption of public goods, are excluded from PVG_t^c. If these assets were included in NWG_t, their service flows would have to be included in PVG_t^c. Because the value of the assets must, by definition, equal the present value of their service flows, they would cancel each other if they were included in equation 3.2. Thus, the exclusion of these items does not affect the trade-off between $PVTL_t^c$ and $PVTF_t^c$.

3.6.3. Generational Imbalance (GI)

Programs such as Social Security and Medicare Part 1 (Hospital Insurance) are purely redistributive in that all dedicated payroll and other taxes are eventually paid out as benefits. The social insurance these programs provide occasions an on-going redistribution from workers to retirees and other beneficiaries. Generational accounting estimates and incorporates the dollars paid and received by various birth-cohorts.

The fiscal imbalance for such programs can be written as the negative of existing assets in the program's trust fund (NWTF_t) and the sum of the actuarially discounted present values of net payroll and other taxes projected for living and future generations: negative lifetime net tax payments (taxes-benefits < 0 in present value over remaining lifetime) increase the program's fiscal imbalance.

$$\text{FI}_t^c = -(\text{NWTF}_t + \text{PVTL}_t^c + \text{PVTF}_t^c). \tag{3.7}$$

Calculations of the terms PVTL_t^c and PVTF_t^c are restricted to program revenues and expenditures and follow the same steps as described above. In the case of programs with dedicated revenue sources, the term $-(\text{NWTF}_t+\text{PVTL}_t^c)$ on the right hand-side of Equation 3.7 shows the Generational Imbalance (GI_t^c) on account of past and living generations.

A positive FI_t^c indicates a shortfall of resources that must eventually be made up through a change in current tax and benefit laws. Given NWTF_t, which is fixed from the past, the change in GI_t^c

following a change in the laws indicates how much of the policy adjustment is levied on living generations.

3.6.4. PWBM's Estimation of FI, GI and GAs.

Generations are distinguished by single-year of birth, age, gender, race (white and nonwhite) and educational attainment (college degree and no college degree). Relative tax and transfer profiles are calculated from micro-data surveys, one for each combination of these attributes. That is, for each age, we distinguish 12 person-types as shown in Table 3.6. Earlier generational accounting calculations distinguished generations by age and gender only. That's because demographic projections of the Social Security Administration that are used in those studies do not decompose population projections by race and education. The PWBM microsimulation, which is calibrated to demographic and economic features of the United States, projects race and education (among other) attributes of the projected population.

Name	Gender (M, F)	Education (N, C)	Race (W, N)
MCW	Male	College degree or more	White
FCW	Female	College degree or more	White
MNW	Male	No college degree	White
FNW	Female	No college degree	White
MCN	Male	College degree or more	Nonwhite
FCN	Female	College degree or more	Nonwhite
MNN	Male	No college degree	Nonwhite
FNN	Female	No college degree	Nonwhite

Table 3.6: Person-Type Characteristics Distinguished for Calculating Labor Efficiency

Because mortality, fertility, and immigration rates (and their evolution through many interactive socio-economic processes such as ages and frequencies of marriage, childbearing, and divorce, patterns of assortative mating, and processes of family formation and dissolution etc.) differ significantly across individuals by race and education, the demographic composition of the future population is projected to change according to trends in those variables observed in the past. The PWBM microsimulation builds in those trends to deliver an evolving future demographic profile. Differential base-period tax and transfer distributions by race and education in addition to age and gender, interact with differential sub-population growth and mortality rates. Table 3.6 shows

the classification of sub-populations by gender, race, and education (maximum attainment over the lifetime). Fiscal Imbalance and generational account calculations made under a more granular demographic decomposition yield estimates that account for the correlation between benefit receipts, tax payments, and survival rates. It turns out that within each gender, sub-populations that predominantly receive benefits, on net, during their lifetimes (nonwhite and the less educated) are also those with higher mortality rates. And subpopulations that earn more, retire later, and pay taxes, on net, during their lifetimes (white and with more education) experience greater longevity. Distinguishing age profiles of relative taxes and benefits by gender alone would miss this correlation between the size of lifetime net taxes and longevity.

3.6.5. Projecting U.S. Gross Domestic Product (GDP)

Production Function Framework

PWBM's projection of U.S. GDP utilizes a production function framework that specifies how inputs of labor and capital are converted to output each year. The production function for each year t is given by Equation 3.8:

$$Y_t = P_t A_t K_t^{\alpha} L_t^{1-\alpha} \tag{3.8}$$

where

- Y_t: Nominal national output
- P_t: Price level
- A_t: Multifactor productivity
- K_t: Capital services input
- L_t: Efficiency-adjusted labor services input
- α: Output elasticity of capital

Decomposing $L_t = h_t \times H_t$ where H_t is total hours (FTEH) and h_t is average worker efficiency per FTEH, we get:

$$Y_t = P_t A_t K_t^{\alpha} (h_t H_t)^{1-\alpha} \tag{3.9}$$

Total labor productivity, η_t, which is output per hour, is given by:

$$\eta_t = \frac{Y_t}{H_t} = A_t K_t^{\alpha} h_t^{1-\alpha} H_t^{-\alpha} = A_t k_t^{\alpha} h_t^{1-\alpha} \tag{3.10}$$

where $k_t = K_t / H_t$.

Expressed in terms of growth rates:

$$\frac{d\eta_t}{\eta_t} = g^{\eta} = \frac{dA_t}{A_t} + \alpha \frac{dk_t}{k_t} + (1-\alpha)\frac{dh_t}{h_t} = g^A + \alpha g^k + (1-\alpha) g^h \tag{3.11}$$

Equation 3.11 shows the components of labor productivity growth. Of these, multifactor productivity growth dA_t/A_t is measured as the excess growth in GDP from technological improvements after accounting for growth of labor and capital inputs. This growth component is assumed to continue at its historical rate of 0.63 percent per year. The output elasticity of capital is also estimated from BLS productivity data and set at 0.367.

Production Factor Inputs

Labor productivity growth from higher capital intensity, k_t, is measured by the growth of the productive capital stock relative to labor hours. Productive capital equals non-residential fixed assets (equipment, structures, and intellectual property products) plus non-owner-occupied and other residential structures owned by households, corporates, sole-proprietorships and partnerships, and non-profit institutions. The total for 2020 is 40.6 trillion.

Capital stock projections are made by distributing the initial year's (2021) capital stock (40.6 trillion) among holders of claims on the nation's capital. The distributions of holdings by the 12 person-types are calculated by using the Federal Reserve's 2019 Survey of Consumer Finances. This survey identifies the distribution of asset holdings. Liquid assets, which represent transactions balances (cash and money market accounts and other liquid assets) are excluded, and remaining assets are distributed across the 12 person types noted earlier. Figure 3.6 shows these distributions.

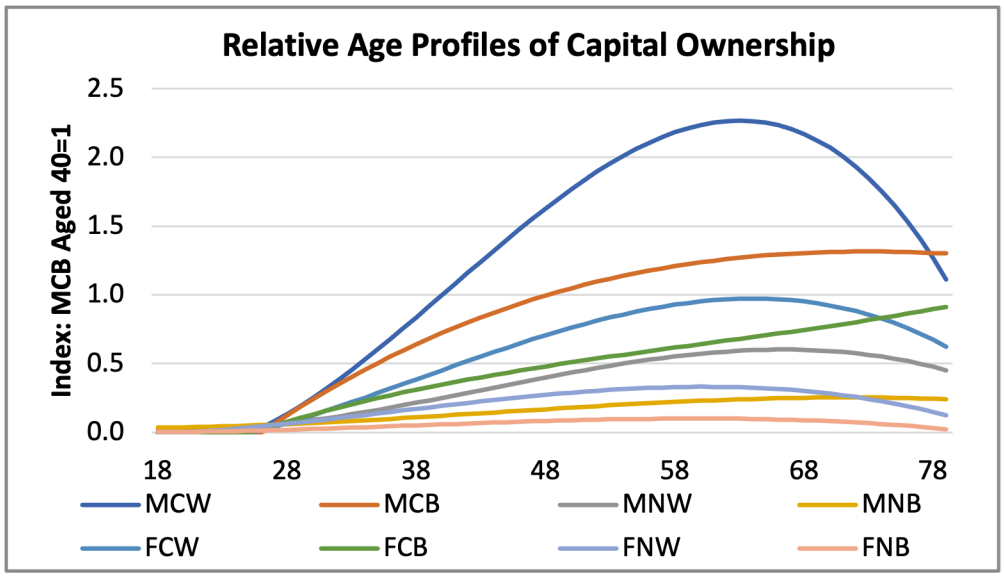


Figure 3.6: Relative Age Profiles of Fixed Capital Ownership by Person Type.

Source: Authors' calculations from the Federal Reserve's Survey of Consumer Finances.

Projection of the productive capital stock for future years assumes that relative holding patterns of claims on that stock will remain constant and changes in population's size and in the relative proportions of person-types in the population will drive the evolution of the stock. Projecting aggregate productive capital in this manner yields an average annual growth rate of 1.3 percent per year through the year 2100. In the very long term, that growth rate averages to just over 1 percent per year.

Efficient labor, L, growth is calculated by first finding relative average hourly wages in the base year (2021) by person-type from the PWBM Microsim's annual wage and work hours variables. These

relative average hourly wages are considered to be the efficiency rates of the different person types. Table 3.7 provides the relative ratios, normalized to the average hourly wage of a nonwhite female with less than high-school education (FC1N).

Person Type	MCW	FCW	MNW	FNW	MCN	FCN	MNN	FNN
Av. Wage: $ Per Hour	58.70	36.71	24.01	17.73	45.56	31.53	18.72	15.28
Rel. Labor Eff. FC1N=1	3.84	2.40	1.57	1.16	2.98	2.06	1.22	1.00

Table 3.7: Index of Relative Work-Efficiency per Hour by Person type in 2021: FC1N=1.0.

Growth in total hours through the year 2100 is projected by the Microsim to be almost zero – a consequence of growth in the relative proportion of worker-types with low attachment to the labor force, population aging and a shift in the age distribution of workers toward older (pre-retirement) ages, and a general trend toward reduced hours by all groups of workers. The countervailing factor is an increase in the share of better-educated workers in the overall workforce. Figure A5.2 shows projected changes in the U.S. total and worker populations (right axis) by person-type and changes in their total hours and efficiency-adjusted hours worked (left axis).

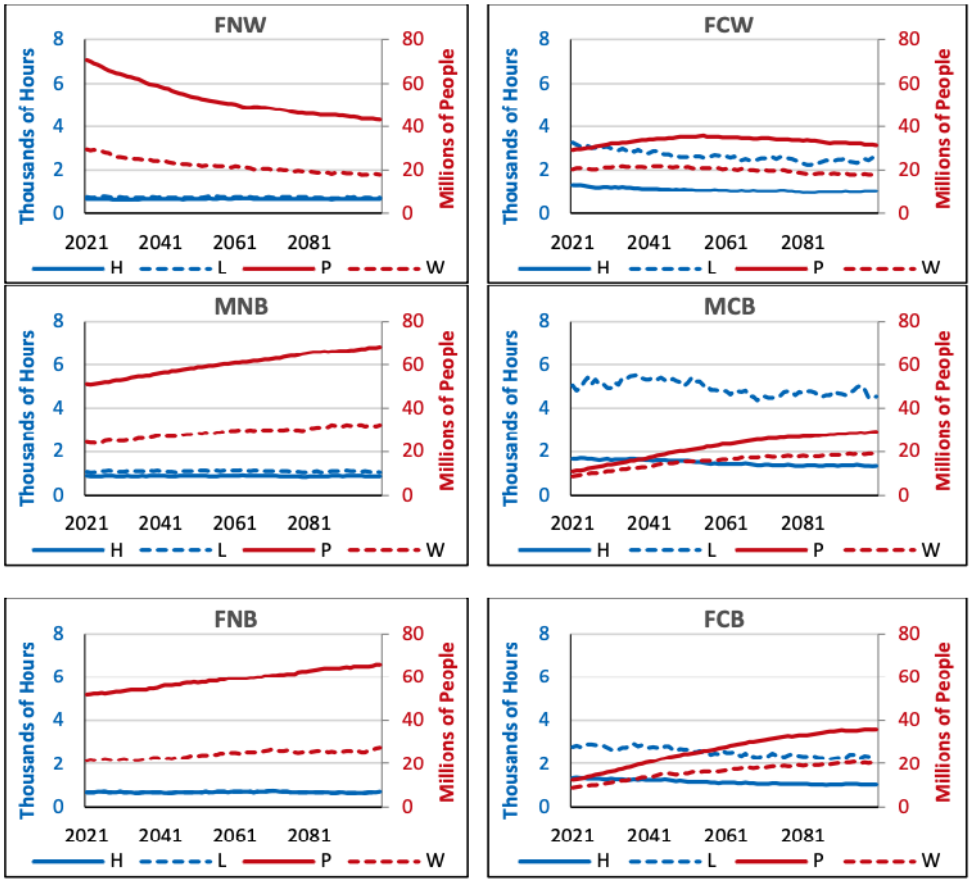


Figure 3.7: Projected total population (P), worker population (W), average hours per worker (H), and average efficiency-adjusted hours per worker (L) by person type through 2095.

Source: Author's calculations from the PWBM Microsim. Title legend: Person types: Gender: M=Male F=Female; Education: N=Less than College, C=College or More; Race: W=White, N=Nonwhite.

As is evident from Figure 3.7, total and worker populations (red lines) of whites of both genders with less than college education levels is projected to decline and the populations of whites with college or more education are projected to remain stable. The latter have greater labor force attachment as seen in the hours/worker and efficiency-hours per worker profiles (blue lines). Projected shifts in total and worker populations result from lower projected fertility and immigration and also higher education attainment over time for whites. In contrast, populations of both college and less than college educated nonwhites are projected to increase over time from higher fertility and immigration rates. Among nonwhites, each gender-education group has lower hours and efficiency-adjusted hours

relative to their white counterparts.

3.6.6. Projecting production function parameters and U.S. GDP from PWBM's Microsimulation.

The PWBM Microsim's output includes the "class of worker" variable, which distinguishes between private sector, federal, and state and local workers. Since the Microsim reports nominal wages for all workers and not total compensation, the latter is estimated by estimating the benefits component of employee compensation from historical data. A power regression of the ratio of total benefits to total wages using U.S. national income and product accounts data (U.S. Bureau of Economic Analysis, Table 2.1) is implemented to extrapolate the benefits/wages ratio for future years. The benefits/wages ratio stood at 21.8 percent in 2021. Extrapolating the share using estimated power regression coefficients has the ratio increasing to 23.2 percent by 2050 and to 24.5 percent by 2095. These projected benefits/wages ratios are applied to microsim private and government sector total wages to obtain projected future private and government sector total compensation series.

The private sector contribution to GDP is calculated via equation (3). Government sector's GDP contribution is assumed to equal the sum of government employee compensation plus government capital depreciation. The latter is projected in two steps: First, government capital depreciation is estimated using a time-trend power regression on the depreciation rate using historical data on the ratio of government capital depreciation to government capital stock. Next a power regression is estimated on the historical ratio of the government capital stock to total government employee compensation. Both ratios are historically quite stable and the power regressions point to stable long-term values for both. The depreciation rate is estimated to decrease very slightly from 3.9 percent in 2020 to 3.8 percent by 2050 and to 3.7 percent by 2095. The ratio of the government capital stock to government employee compensation is projected to increase slightly from 1.28 percent in 2020 to 1.29 percent by 2050 and to remain at that value thereafter.

The product of projected government compensation and the capital-compensation ratio yields the projected stock of government capital. And the product of the capital depreciation rate with the government capital stock yields projected government depreciation. Finally, total U.S. GDP is projected as the sum of private sector and government contributions to GDP.

Figure 3.8 depicts projected U.S. nominal GDP through the year 2095. To calculate FI in perpetuity, The PWBM simulation was implemented through the year 2500 – long enough to allow present discounted values of out-year deficits to not influence the present valued FI measure. The simulation through year 2500 also enables the calculation of GDP in perpetuity.

In order to ensure that our GDP estimates are consistent with those of the Congressional Budget Offices' (CBO) projections (since the budget aggregates through the year 2030 are those of the CBO), we benchmark our GDP projections to those of the CBO in 2030. Nominal GDP projections after 2030 are based on PWBM's calculations described above.

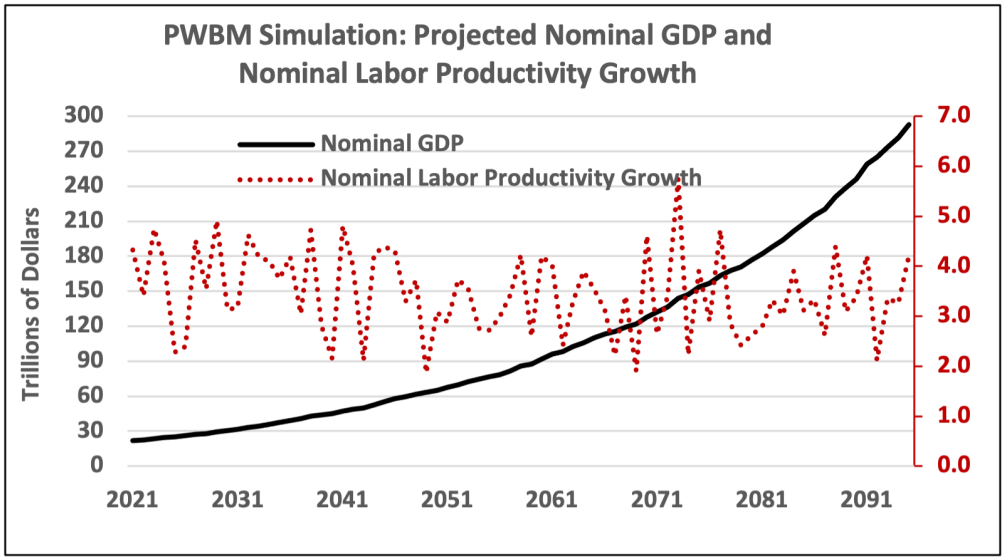


Figure 3.8: Projected nominal GDP and nominal labor productivity growth.

Source: Author's calculations from the PWBM Microsim.

Finally, nominal projected GDP values are discounted using the interest discount factor of 4.4 percent per year. Table 3.8 below reports PVGDP, estimated as described above (in trillions of constant 2021 dollars) over two alternative time horizons: 2020-95 and 2020-2500.

Present discounted value of projected U.S. GDP in trillions of constant 2021 dollars

	Microsim	Through 2095	Through the infinite horizon
Scaled to 2015 U.S. H.H. Pop.		1,338.3	2,481.1

Table 3.8: Present Value of Projected GDP under Current Fiscal Laws.

3.6.7. Adjusting Generational Accounts for the Incidence of Taxes on Owners of Capital.

Tax policy changes introduced by the Tax Cuts and Jobs Act of 2017 imply changes to the incidence of capital income taxes across generations. That law reduced the corporate tax rate from 35 percent to 21 percent and introduced investment incentives by way of expensing of equipment and software, amortization of research expenditures, expansion of bonus depreciation, and other provisions that alter the timing of capital income accruals relative to tax payments. In addition, future taxes may be capitalized into asset values and changes in tax rates and expensing provisions for new investments may shift tax burdens away from (or toward) future capital owners – who pay the taxes – and toward (or away from) current holders of capital who bear capital losses (or enjoy capital gains). For example, prior scheduled depreciation deductions no longer apply under TCJA's accelerated depreciation schedule as implied by full expensing provisions: Under pre-TCJA law many capital investments that would have been depreciated gradually over the following decade are taken at once, producing lower effective tax rates immediately. On the other hand, expensing provisions for new investments would induce tax arbitrage to reduce the value of older capital assets, imposing losses on current capital owners. Auerbach et al. (1991) describe the adjustments needed to GAs in order to correctly allocate capital taxes to generations that bear them rather than those who pay them. The adjustments needed depend upon the particular configurations of capital taxation provisions, applicable parameters on investment growth, depreciation rates, after-tax interest rates and other factors. The adjustments require estimates of two rates, Q and Δ, the former indicating the amount of additional tax burdens on current owners of capital from capital asset revaluations, and the latter showing the percentage reduction in projected capital income taxes paid by future capital owners. The formulae for the two adjustment factors are:

$$Q = \tau z \left(1 - \frac{n+\delta}{n+\tau+\varphi}\right)$$
$$\Delta = (r+\delta)\tau z \left[1 - \frac{(r+\pi+\varphi)(n+\delta)}{(n+\pi+\varphi)(r+\delta)}\right].$$

Table below provides the legend and rates of the parameters used to calculate Q and Δ:

Parameter	Description	Value
r	Post-tax rate of return	2.3%
δ	Economic depreciation rate	8.0%
π	Inflation rate	2.0%
τ	Investor marginal tax rate	21.0%
n	Growth rate of investment	1.1
z	Present value of depreciation allowances $\delta/(r+\delta)$	0.65
φ	Geometric rate of investment write-off $(r+\pi)z/(1-z)$	0.12

These parameters generate a value of Q = 0.08 and $\Delta = 0.001$. Hence, GAs reported in the text are calculated by distributing a capital loss of 8 percent on current owners of capital (those alive in 2021) and a reduction in future flows of capital income taxes by 0.001 percent[18].

3.6.8. Adjusting Generational Accounts for the Incidence of Taxes on Owners of Capital

The FI measures reported above are based on discounting projections of nominal future dollar flows of federal taxes and expenditures. Nominal future dollar flows are projected by (1) distributing CBO budget aggregates for various programs through the year 2030 across population subgroups distinguished by age, gender, race and education, (2) growing per-capita values annually for years after 2030 by applying a labor productivity growth rate, and applying an actuarial discount rate based on population survival rates to find present values as of 2021. Labor productivity growth rates are projected based on the PWBM microsimulation. These year-specific growth rates are derived by estimating national output based on the microsimulation's annual projections of the efficiency-adjusted labor input and capital services, and dividing by the unadjusted labor input (total work hours). The resulting time series of (nominal) labor productivity growth is 3.51 percent per year.

[18]See the Appendix in Auerbach et al. (1991) for the derivation of the formulae for Q and .

	2021-95			Infinite Horizon		
	$g - 0.5\%$	$g = 3.51\%$	$g + 0.5\%$	$g - 0.5\%$	$g = 3.51\%$	$g + 0.5\%$
			PVGDP			
$r - 1.0\%$	1527.1	1828.6	2212.1	4163.3	10406.3	40718.5
$r = 4.39\%$	1109.6	1300.3	1539.4	1635.3	2410.0	4316.7
$r + 1.0\%$	841.4	966.4	1120.5	1001.6	1254.8	1671.7
			FI			
$r - 1.0\%$	113.0	129.5	150.2	392.5	1022.1	4033.2
$r = 4.39\%$	83.9	93.8	105.9	136.6	202.9	374.8
$r + 1.0\%$	66.0	72.0	79.4	81.5	99.1	129.9
			FI/PVGDP			
$r - 1.0\%$	7.2%	6.8%	6.5%	8.9%	9.1%	9.0%
$r = 4.39\%$	7.4%	7.0%	6.7%	8.2%	8.2%	8.5%
$r + 1.0\%$	7.8%	7.4%	7.0%	8.1%	7.9%	7.8%

Table 3.9: Sensitivity of FI to alternative discount rate and productivity growth rate assumptions.

To account for future uncertainty on productivity and interest discount rates, we report FI measures under alternative values for these parameters. Table 3.9 shows FI measured under a $+/-$ 0.5 percent variation in the productivity growth rates (in each future year) and a $+/-$ 1.0 percent variation in the interest discount factor. The FI measure is shown in present value dollars and as a share of PVGDP estimated under the same parametric variations of productivity and interest rates. The Table shows that FI estimates in present value (in constant 2021 dollars) are quite variable across alternative labor productivity growth and discount rates. But ratio FI/PVGDP is quite stable because variations in the two parameters change the numerator and denominator in the same direction and approximately in the same proportion.

3.6.9. Faster Labor Productivity Growth and the Ratio of FI to the Present Value of GDP

Over the 2021-95 time window, FI/PVGDP ratios shown in Table 5 decline when assumed labor productivity growth, g, is increased. This result challenges conventional wisdom that a higher growth rate would ease the federal government's financial condition. The conventional view, however, appears to be based on finite horizon estimates of the federal financial condition. A fuller picture, under infinite horizon estimates suggests that higher labor productivity growth rate would

worsen the federal government's financial condition. That's because the largest government transfer programs (Medicare and Social Security) provide benefits to older populations financed by taxes levied on younger populations in each period. When the population is not aging rapidly, productivity growth effects on the numerator and denominator of the FI/PVGDP ratio cancel out. However, when the population is aging rapidly, the numerator (the difference between federal outlays and receipts) increases more than proportionally than the increase in the denominator. Stated briefly, when labor productivity (output per worker) is higher, annual increases in GDP follow the growth rate $(1+g)(1+n^w)$, where n^w is the growth rate of workers. However, the growth rate of FI is determined by $(1+g)(n^w-n^b)$, where n^b is growth in the population transfer recipients. Over time, an increase in g spurs both tax payments and transfer receipts. However, because of population aging, the transfer-recipient population (predominantly retirees) increases faster compared to the population that provides labor input and pays taxes – mainly working-aged individuals.

Figure 3.9 shows projected aged dependency ratios calculated from the PWBM microsimulation as the population of retirement aged (65+) individuals divided by the working-aged (15-64) individuals. This ratio is projected to increase during future decades, and to continue increasing well beyond the year 2095 – suggesting a near-stationary worker population and a growing retiree population. Hence, when g is increased, the positive interaction between higher g and the larger future population of (retiree) beneficiaries is stronger than that between higher g and the number of workers who produce GDP. Hence, a higher value of g increases future deficits by more than in proportion to the increase in GDP, causing the FI/PVGDP ratio to increase. From Table 5, the differential interaction effect of g with worker and beneficiary populations is not explicitly visible over the shorter 75-year time window because it takes a long time for the positive interaction of g with net beneficiary recipients to grow significantly larger than the interaction of higher g with net tax payers. Over the infinite horizon, however, the dominance of the positive interaction of g with net transfer recipients is clearly visible – and it is stronger at low values of r, which confers larger weights on deficits accruing in the more distant future.

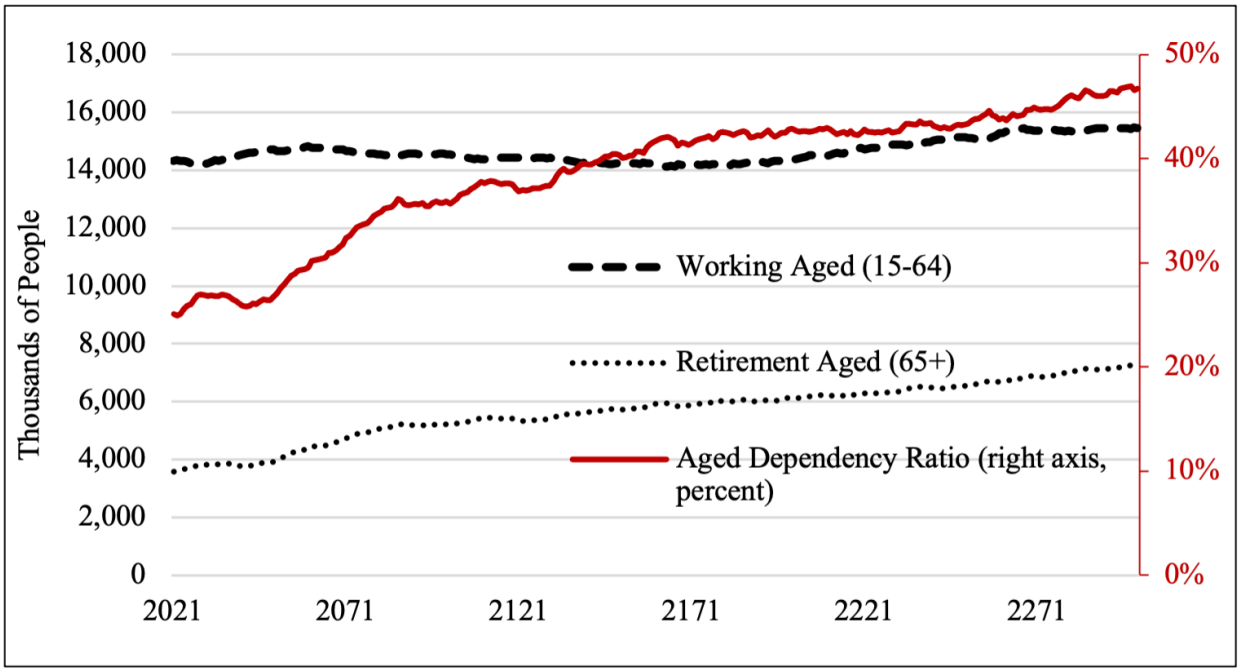


Figure 3.9: Projected populations of the working aged (15-64), retirement aged (65+) and the aged dependency ratio (right axis, percent).

To verify that it is indeed the interaction of higher productivity growth with population aging, we recalculate the FI/PVGDP ratios of Table 3.10 by allowing the (microsimulation) population's to grow as projected but hold its age distribution constant after the year 2021.

	FI/PVGDP Infinite Horizon Base Case			FI/PVGDP Infinite Horizon Fixed age distribution		
	$g-0.5\%$	$g=3.51\%$	$g+0.5\%$	$g-0.5\%$	$g=3.51\%$	$g+0.5\%$
$r-1.0\%$	8.9	9.1	9.0	5.4	4.9	4.5
$r=4.39\%$	8.2	8.2	8.5	6.1	5.6	5.1
$r+1.0\%$	8.1	7.9	7.8	6.9	6.3	5.8

Table 3.10: FI-to-PVGDP ratios under alternative population aging scenarios.

In Table 6, the first panel repeats the infinite horizon FI/PVGDP ratios of Table 5 – the "base case." The 2nd panel shows the same calculations under the case of constant population age distribution after 2021. Under the latter case, all FI/PVGDP ratios are considerably smaller than under the base case. The reason is simply that with no population aging, the relative size of older net transfer

recipients does not grow as fast as under the base case relative to the size of the population of workers who are predominantly taxpayers. Moreover, for each value of the discount rate (each row of Table 5), the FI/PVGDP ratio declines at higher values of labor productivity growth. This is because the deficit-increasing effect of faster labor productivity growth is not boosted by interaction with population aging. This interaction effect is formally described below.

Labor Productivity Growth, Population Aging, and the Share of FI in the Present Value of GDP

Let Y denote Output (GDP); W the number of workers/hours; n^w the worker population/hours growth rate; $\frac{Y}{W}$ labor productivity; g labor productivity growth rate $\frac{Y}{W} = \frac{d(Y/W)}{dt}$. This yields the expression for total output: $Y = \frac{Y}{W} \cdot W$, and output growth $\frac{1}{Y}\frac{dY}{dt} = \frac{1}{Y/W}\frac{d(Y/W)}{dt} + \frac{1}{W}\frac{dW}{dt} = g + n^w$. Then, the present value of all future output is given by

$$PV_Y = Y_0 \sum_{s=0}^{\infty} (1 + g + n^w)(1 + r)^{-s} \tag{3.12}$$

Similarly, let τ^w represent taxes per worker, which are assumed to grow at rate g, and which makes revenue $\tau^w W$ and revenue growth equals $g + n^w$.

Let b^r represent benefits per retiree, also assumed to grow at rate g. Let R be the number of retirees and n^r the retiree population growth rate. Thus, benefit outlays are $b^r R$ and the benefit growth rate equals $g + n^r$.

Debt, D, accumulates from period to period - accruing service charges on prior debt plus the current deficit:

$$D_1 = D_0(1 + r) + (E_0 - R_0) \tag{3.13}$$

Where E_t denotes non-interest expenditures and R_t denotes revenues. Successive period's debts can

be expressed by manipulating the debt transition equation 3.13 as follows:

$$D_2 = D_1(1+r) + (E_1 - R_1) = D_0(1+r)^2 + (E_0 - R_0)(1+r) + (E_1 - R_1) \tag{3.14}$$

$$D_n = D_0(1+r)^n + \sum_{s=0}^{n-1}(E_s - R_s)(1+r)^{n-1-s} \tag{3.15}$$

Since $E_s = E_0(1+g+n^r)^s$ and $R_s = R_0(1+g+n^w)^s$, $s = 0 \ldots n-1$, we can write

$$D_n = D_0(1+r)^n + \sum_{s=0}^{n-1} E_0(1+g+n^r)^s - R_0(1+g+n^w)^{sn-1-s} \tag{3.16}$$

With the population's age structure in a steady state, that is, with $n^r = n^w = n$, the term inside the square brackets collapses to $(E_0 - R_0)(1+g+n)^s$

$$D_n = D_0(1+r)^n + (E_0 - R_0)\sum_{s=1}^{n}(1+g+n)^s(1+r)^{n-s} \tag{3.17}$$

Dividing both sides by $(1+r)^n$:

$$D_n(1+r)^{-n} = D_0 + (E_0 - R_0)\sum_{s=1}^{n}(1+g+n)^s(1+r)^{-s} \tag{3.18}$$

Letting $n \to \infty$, write

$$FI = D_0 + (E_0 - R_0)\sum_{s=1}^{\infty}(1+g+n)^s(1+r)^{-s} \tag{3.19}$$

However, when $n^r > n^w$, that is, when the population is aging, the invariance result does not obtain as the numerator grows faster than the denominator.

$$\frac{FI}{PV_Y} = \frac{\sum_{s=1}^{n} E_0(1+g+n^r)^s - R_0(1+g+n^w)^{sn-s}}{Y_0 \sum_{s=1}^{\infty}(1+g+n^w)^s(1+r)^{-s}}$$

With non-zero initial debt, if it is small relative to the future component of FI, then the response of FI to changes in g would be in the same ballpark. If initial debt is huge, then the response would be closer to the invariance type.

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