# The Long-Run Effects of Federal Student Loans on Fertility and Social Mobility

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**Abstract**

Federal student loans relax borrowing constraints in college years but also increase indebtedness in early adulthood, a period when fertility and child investment decisions are also made. I use a lifecycle model with credit constraints, endogenous fertility, and human capital investment to evaluate the long-run effects of federal student loans. I estimate the model to match features of U.S. household survey data in the 2000s. I find that federal student loans reduce fertility rates, but increase college attendance rates and income and have no discernible effects on social mobility.

# 1 Introduction

Federal student loans relax a key borrowing constraint – the difficulty to borrow against future earnings to finance college. Since students from poorer families face larger constraints in financing college education, we expect federal student loans to have positive impacts on both output and social mobility across generations. In recent years, both the prevalence and the average size of federal student loans have increased dramatically. This trend raises concerns about the lifelong impacts of student loan debt, as studies link federal student loans to significant declines in transition to marriage and first birth (Addo 2014, Min and Taylor 2018). A policy evaluation of federal student loans should take into account both potential benefits in terms of output and social mobility, as well as potential costs in terms of fertility and child investment.

To study the long-term effects of student loans on individual lifecycle choices, I adopt a heterogeneous-agent, lifecycle OLG model augmented with endogenous fertility and human capital accumulation decisions. I estimate the model to match features of U.S. household survey data in the 2000s. To evaluate the impact of federal student loans on individual households and the aggregate economy, I study the counterfactual economy where individuals can only take student loans from private lenders at a higher interest rate. I investigate how different types of households change their behavior on college attendance, fertility, child investment, and intergenerational transfers when I remove federal student loans. I also compare key statistics related to aggregate output levels and social mobility in both the factual and the counterfactual economy.

I find that, even after taking into account fertility and child investment, federal student loans still have positive effects on aggregate output. On the other hand, federal student loans marginally decrease fertility and have no significant effects on social mobility. To understand these results, it is crucial to understanding different individuals' behavioral responses in terms of fertility and child investment.

The near-zero effect of federal student loans on fertility rate masks three underlying economic forces, each of which has previously been studied individually but never jointly. The income effect suggests student borrowers' lifetime income increases, they spend more on total child expenditure, leading to a positive effect of student loans on fertility. The substitution effect, or the quantity-quality tradeoff à la Becker and Tomes (1976, 1979), suggests richer parents will substitute away from fertility (quantity) towards higher investment in each child (quality), as long as quality is more income-elastic than quantity. Lastly, the credit constraint effect (à la Keane and Wolpin 2001, Caucutt and Lochner 2020) suggests that borrowing constraints during parenthood raise the relative price of early investment and lower the returns to late investment, i.e., college. This effect leads to parents substituting away from quality into quantity, but also away from child expenditure into own consumption, resulting in an ambiguous effect of student loans on fertility. I show that all three effects must co-exist to rationalize the empirical relationship between debt and fertility and that ignoring any of the effects lead to policy implications that are both qualitatively and quantitatively different.

I also find that federal student loans have no significant effects on social mobility, because of the heterogeneous effects on different subgroups of the population. For students borrowers who would not go to college without federal student loans, the policy raises their earnings but lowers their children's earnings, as they become more credit-constrained as parents. On the other hand, for students who would have borrowed privately to finance college, federal student loans instead relaxed their credit constraints by offering a lower interest rate. For the latter group of students, federal student loans do not significantly affect their own earnings through education but increase their children's earnings by allowing them to invest more in their children. I find that these opposing forces jointly lead to an insignificant effect of federal student loans on social mobility.

My paper is built on previous literature focusing on the short-run effects of federal student loans (Abbott, Gallipoli, Meghir, and Violante 2019, Ionescu and Simpson 2016, Lochner and Monge-Naranjo 2011, Hai and Heckman 2017), on the effects of credit constraints on human capital formation (Caucutt and Lochner 2020, Andolfatto and Gervais 2006, Keane and Wolpin 2001), and on endogenous fertility (Cooley and Henriksen 2018, Boldrin, De Nardi, and Jones 2015, Manuelli and Seshadri 2009, Galor and Moav 2004). I bring the mechanisms studied in the latter two strands of literature into evaluating the long-run effects of federal student loans, which, to my knowledge, has not been done before. I show that the inclusion of these long-run mechanisms changes the policy implications on previously studied outcomes, such as college rate and lifetime earnings, as well as allow me to study other outcomes, including demographic change and intergenerational mobility.

I provide background information and motivating evidence on student loans and the relationship between debt and fertility in Section 2. I describe the quantitative model in Section 3 and the procedure I use to discipline the model to match data patterns in Section 4. I describe the policy analysis and results in Section 5. I provide concluding remarks and directions for future research in Section 6.

## 2 Motivation: student loans and fertility

In this section, I provide a brief introduction to the market for student loans and evidence related to debt and fertility. I only focus on aspects that are relevant to my research question and the approach I take. More detailed summaries of student loans can be found in Abbott et al. (2019).

## 2.1 History of federal student loans

Federal student loans were introduced in the 1960s under the Higher Education Act. In the beginning, only students with financial needs are eligible. Loans were issued by private lenders but guaranteed by the federal government. In the 1990s, the federal government began to directly issue loans. Unsubsidized loans were also introduced to all students regardless of need and for students who exceed the loan limit for subsidized student loans.

The introduction and expansion of federal student loans are concurrent with the rising college attendance rate and college costs.

Federal student loans have two uniform interest rates, one for subsidized loans and one for unsubsidized, for all borrowers regardless of credit history, individual characteristics, or parental characteristics. Federal student loans stipulate upper limits for the amount borrowed for each semester as well as for the entire period of study.

All students enrolled in an undergraduate program are eligible to apply for unsubsidized loans, yet on. In 2004, the fraction of undergraduate students who have taken student loans is 46.7% (NPSAS:UG, 2004). The majority of borrowing comes from the federal government.

The fraction of private loans is increasing in recent years because more and more students exhaust loan limits for even unsubsidized student loans and must resort to private lenders. Yet, federal student loans still remain the major source of funding and account for about 80% of all existing student loans.

## 2.2 Trends in student loan debt

Student loan debt is the major source of indebtedness among college-educated young adults. Using the Survey of Consumer Finances from year 1989 to 2019, I observe that the fraction of college households aged 25 to 35 with negative net worth increased from 15% to 30% (Figure 1). During the same period, the fraction with negative net worth for non-college-educated households has first stayed constant and later decreased. The sharp contrast between non-college and college households in the prevalence of indebtedness suggests that the source of debt maybe something related to education. I confirm this hypothesis by decomposing the type of debt for households with negative net worth.

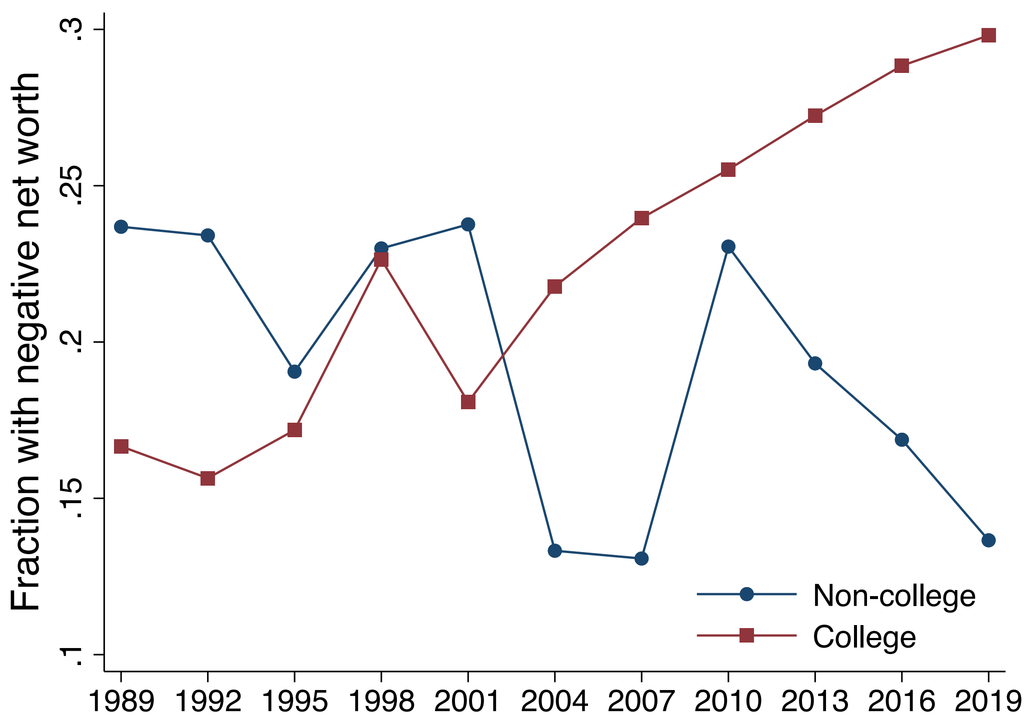



Figure 1: Fraction of households aged 25-35 with negative net worth by college degree

To further understand the types of loans indebted college young adults are holding, I look at the fraction of individuals holding each type of loan, as well as the mean debt level.

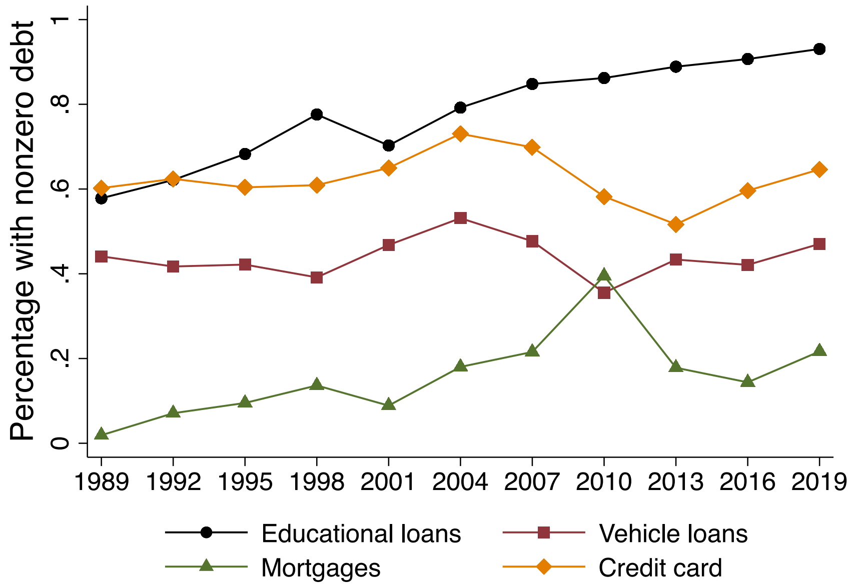
Among the college-educated households with negative net worth, almost all had a non-zero amount of student loan debt, and more than half of the total debt is attributed to student loans (see Figure 2). Both figures show that student loan debt is the dominant type of loan for indebted college individuals, even above mortgage loans.

This finding is not surprising, since both mortgages and vehicle loans require collateral, which is typically associated with positive net worth, except maybe during the 2008-09 financial crisis. Credit card loans, while not requiring collaterals, typically have a much smaller loan limit than student loans. Student loans are the most significant uncollateralized loans a young individual has access to and it is directly affected by public policy, namely the federal student loans program. Therefore, it is crucial to understand how they will affect the indebted individuals' future behaviors, including fertility and child investment decisions.

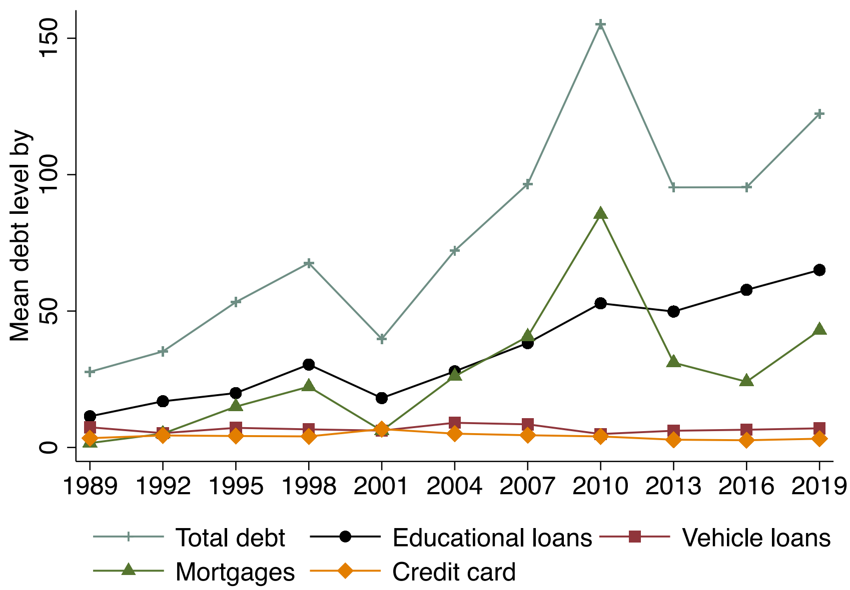
## 2.3 The relationship between debt and fertility

It is difficult to directly link student loan debt to complete fertility, mainly because most of the increase in student loan debt occurred after the 1990s, and these past borrowers have not reached the end of their fertility cycles. I use the NLSY79 cohort who went through college years in the 1980s. This cohort has a lower level of student loan debt on average but have a completed history of fertility.

Figure 3 shows the relationship between net worth at age 25 and completed fertility rate, conditional on college attendance. Fertility is lower conditional on net worth for college-educated individuals. This result is consistent with past findings that fertility is negatively associated with education and permanent income. Yet, when I study the relationship between net worth and fertility among college educated individuals by looking at the bottom line in Figure 3, I find the slope of the line is not statistically different from zero except at the very




(a) Percentage of individuals holding nonzero amount of loans by type




(b) Men debt level (including zeros; 1,000 US dollars in 2005)

Figure 2: Decompositon by loan type

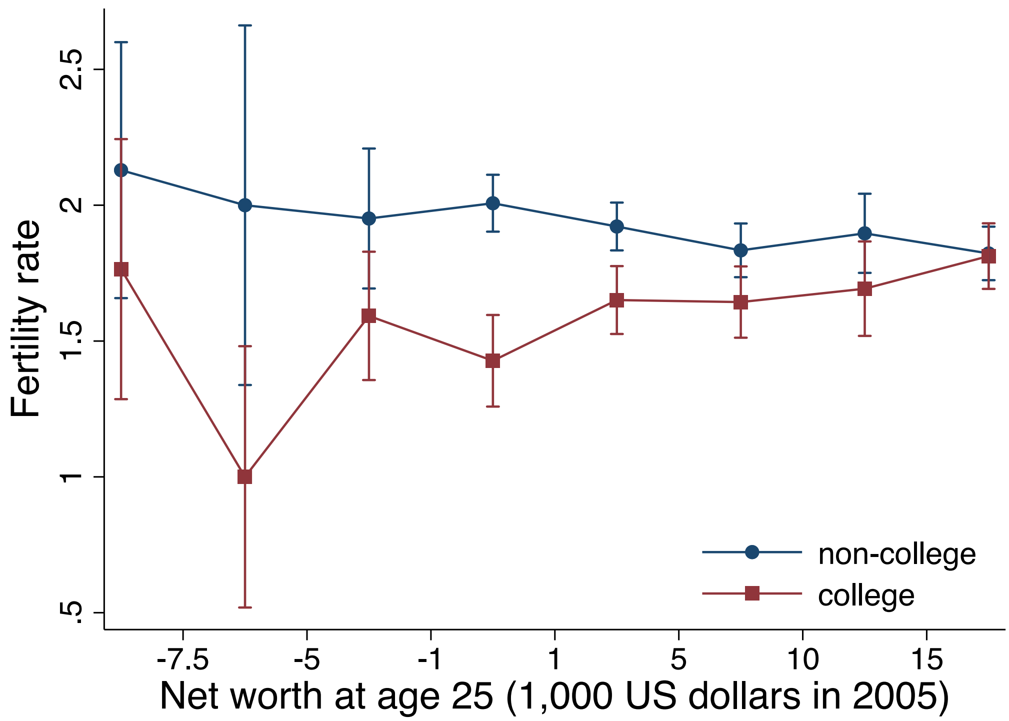



Figure 3: Fertility rates by college and net worth at 25, NLSY79

top of the distribution.

To robustly test the relationship between net worth at age 25 and complete fertility rate, I regress fertility rate on dummies for each bin of net worth, for both non-college and college individuals (see Table 1). I omit the dummy associated with having net worth between -\$1,000 and \$1,000 as the default. Both slopes for the non-college group and the college group are not significantly different from zero except at the top of the wealth distribution. When I test whether the levels for all wealth bins except the one at the op are equal, the null hypothesis cannot be rejected for either the non-college or the college group. The $p$-values are reported at the bottom role in Table 1.

Table 1: Complete fertility rate by net worth group at age 25

| **Dependent Variable** | **Fertility rate** | |
|---|---|---|
| | Non-college | College |
| Net worth bin 1 | 0.122 | 0.337 |
| | (0.261) | (0.239) |
| Net worth bin 2 | -0.00732 | -0.427 |
| | (0.372) | (0.327) |
| Net worth bin 3 | -0.0563 | 0.165 |
| | (0.128) | (0.152) |
| Net worth bin 5 | -0.0857 | 0.224** |
| | (0.0640) | (0.106) |
| Net worth bin 6 | -0.173** | 0.216** |
| | (0.0736) | (0.110) |
| Net worth bin 7 | -0.111 | 0.265** |
| | (0.0960) | (0.127) |
| Net worth bin 8 | -0.185** | 0.385*** |
| | (0.0740) | (0.105) |
| Observations | 3721 | 1856 |
| $p$-val: $\delta_1 = \delta_2 = ... = \delta_7 = 0$ | 0.373 | 0.117 |

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The zero slope of the fertility-wealth relationship suggests that the quantity-quality tradeoff and the credit constraint channel roughly cancels each other out. If we only consider the quantity-quality tradeoff channel, we would expect a negative slope in Figure 3. As I will show in section 5.3, if the model fits a counterfactual negative slope, the policy implications of federal student loans will be different both qualitatively and quantitatively.

# 3 Model

In this section, I build a structural model that captures the various mechanisms where debt can affect fertility. I consider individual heterogeneity in productivity and fertility preferences. I endegenously generate differences in rates of returns to schooling using a human capital production function based on Cunha, Heckman, and Schennach (2010). I also show that, in the model, debt can affect fertility both through the quantity-quality tradeoff channel and the credit constraint channel.

## 3.1 Model overview

**Timeline.** I divide an individual's life cycle into four stages: childhood ($c$), student ($s$), parent ($p$), and middle-aged ($m$). During the parent stage, the individual can choose to have children. She invests in her children during parenthood and make parental transfers at the beginning of middle age, and will have no more interactions with her children afterward.

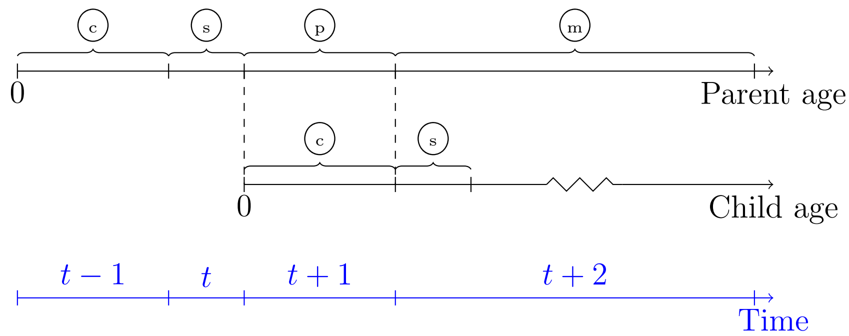



Figure 4: Timeline

**Preference.** An individual values her own consumption. She is also altruistic towards her children, which means she also derives utility from her children's consumption in the future. Her degree of altruism in increasing in the number of children she has, analogous to that of Barro & Becker 1988. Specifically, the lifetime utility of a student at time $t$ can be expressed as:

$$U_t = u(c_t^s) + \beta^s \left\{ u(c_{t+1}^p) + \beta^p \left[ u(c_{t+2}^m) + \rho(n_{t+1}^p) U_{t+2} \right] \right\} \tag{1}$$

$c_t^s$, $c_{t+1}^p$, and $c_{t+2}^m$ are her own consumption during student, parent, and middle-aged stage. $n_{t+1}^p$ is the number of children she chooses to have at parent stage. $U_{t+2}$ is the lifetime utility of her children. I assume $\rho(\cdot)$ is increasing and concave.

**Fertility choice.** An individual chooses the number of children, from 0 to 3, at the start of the parent stage. She maximizes the sum of her child-specific lifetime utility and stochastic preference shocks. The preference shock allows individuals with the same earnings and education to choose different family size.

**Human capital accumulation.** Investment can be done during the childhood and the student stage to increase an individual's future earnings. Investment during childhood is chosen by the child's parent. Investment during the student stage is chosen by the student herself.

A child at time $t$ receives investment expenditure $i_t^c$ from her parent. At time $t+1$, she decides whether to attend college ($e_{t+1}^s = 1$) or not ($e_{t+1}^s = 0$). If she attends college, she can also choose the level of investment $i_{t+1}^s$. Her future earnings is determined by her human capital stock $f(i_t^c, e_{t+1}^s i_{t+1}^s)$, as well as earnings shocks she receives throughout her life cycle.

**Earnings process.** Consider a student at time $t$. At the beginning of time $t$, she learns her earnings potential $y_t^s$ in this stage. She only receives $y_t^s$ if she decides not to go to college ($e_t^s = 0$). Otherwise, the earnings is foregone.

At time $t+1$, the student enters the parent stage. Her earnings $y_{t+1}^p$ is determined by

$$y_{t+1}^p = \bar{y}^p \left[\rho_y y_t^s + (1-\rho_y) f(i_{t-1}^c, e_t^s i_t^s) + \epsilon_{t+1}^p\right] \tag{2}$$

$\bar{y}^s$ is the common age component for the parent stage. $\rho$ represents the relative important of student stage earnings shock. $\epsilon_{t+1}^p$ is an exogenous shock independent of all other variables.

At time $t+2$, the student is now at the middle-aged stage. Her earnings process is analogous to that in the parent stage.

$$y_{t+2}^m = \bar{y}^m \left[\rho_y y_t^s + (1-\rho_y) f(i_{t-1}^c, e_t^s i_t^s) + \epsilon_{t+2}^m\right] \tag{3}$$

The coefficient $\bar{y}^m$ is the common age component for the middle-aged stage. The first two terms inside the bracket is the same as in the parent stage. The individual receives another exogenous shock $\epsilon_{t+2}^m$, independent of all other variables.

## 3.2 Life cycle stages

### 3.2.1 Childhood stage

Suppose an individual is born at the beginning of time $t$. During childhood, the individual is part of her parent's household and makes no decisions. She receives childhood investment $i_t^c$, chosen by her parent. I will describe how the parent chooses $i_t^c$ when describing the parent stage.

### 3.2.2 Student stage

At the beginning of time $t$, a student receives monetary tranasfer $a_t^s$ from her parent. She makes three choices: college attendence $e_t^s \in \{0, 1\}$, the amount of college investment $i_t^s$, and the amount of savings or borrowing $a_{t+1}^p$.

At the beginning of the student stage, the student learns about her earnings potential $y_t^s \sim \ln \mathcal{N}(\mu^s, \sigma^s)$. If the student chooses not to attend college ($e = 0$), she receives full-time earnings $y_t^s$. If she chooses to go to college, she receives part-time earnings $\zeta y_t^s$, where $\zeta$ is an exogenous parameter.

With probability $\pi$, the student is aware of the option of student loans if he chooses to attend college, denoted as $A = 1$. With probability $1 - \pi$, the student is not aware of the option and cannot borrow as a result, denoted as $A = 0$. Let $\mathbf{y}_t^s = \{y_t^s, i_{t-1}^c\}$ denote the set of state variables directly relevant to the student's lifetime earnings.

The student's optimization problem is:

$$\tilde{V}_t^s(a_t^s, \mathbf{y}_t^s, A) = \max_{c_t^s, a_{t+1}^p, e_t^s, i_t^s} u(c_t^s) + \beta^s \mathbb{E} V_{t+1}^p(a_{t+1}^p, \mathbf{y}_{t+1}^p)$$

Subject to

$$c_t^s + a_{t+1}^p + e_t^s i_t^s = a_t^s + [\zeta + (1-\zeta)(1-e_t^s)]\, y_t^s$$

$$a_{t+1}^p \geq \begin{cases} 0 & \text{if } A = 0 \\ -e_t i_t^s & \text{if } A = 1 \end{cases}$$

$$i_t^s \geq 0$$

$$e_t^s \in \{0, 1\}$$

The ex-ante lifetime utility function is

$$V_t^s(a_t^s, \mathbf{y}_t^s) = (1-\pi)\tilde{V}_t^s(a_t^s, \mathbf{y}_t^s, 0) + \pi \tilde{V}_t^s(a_t^s, \mathbf{y}_t^s, 1)$$

### 3.2.3 Parent stage

At time $t$, a student at time $t-1$ reaches the parent stage. She no longer accumulates human capital at this stage. Her earnings is determined exogenously according to (2). Let $\mathbf{y}_t^p = \{y_t^p, \rho y_{t-1}^s + (1-\rho) f(i_{t-2}^c, e_{t-1}^s i_{t-1}^s)\}$ denote a collection of all state variables relevant to the parent's present and future earnings.

The most important decisions for a parent is the level of fertility and child investment. The parent is altruistic towards her children and benefits from her children's lifetime utility. On the other hand, the parent also bears the cost of the children's consumption and human capital investment.

At the beginning of time $t$, the parent first realizes her earnings in this period, $y_t^p$, determined by equation (2), and her fertility preference shock $\nu_n \sim EV(0, 1)$, for $n \in$

$\{0, 1, 2, 3\}$. She chooses the number of children $n \in \{0, 1, 2, 3\}$ by solving

$$V_t^p(a_t^p, \mathbf{y}_t^p) = \mathbb{E}\left\{\max_n \left[\tilde{V}_t^p(a_t^p, \mathbf{y}_t^p, n) + \mathbf{1}_{\{n=0\}}\tilde{\nu}_0 + \sigma_n \nu_n\right]\right\}$$

Where $\tilde{V}_t^p$ is the child-specific lifetime utility, to be specified below; $\tilde{\nu}_0$ a constant representing the utility (or disutility if $\tilde{\nu}_0 < 0$) of not having children; and $\sigma_n$ is the standard deviation of the fertility preference shock.

After the number of children $n$ is determined, the parent then chooses the level of child investment $i_t^c$, saving $a_{t+1}^m$, and consumption $c_t^p$ by solving

$$\tilde{V}_t^p(a_t^p, \mathbf{y}_t^p, n_t^p) = \max_{c_t^p, a_{t+1}^m, i_t^c} u(c_t^p) + \beta^p \mathbb{E} V_{t+1}^m(a_{t+1}^m, \mathbf{y}_{t+1}^m, n_{t+1}^m)$$

Subject to

$$\begin{aligned} c_t^p[1 + \delta(n_t^p)] + a_{t+1}^m + n_t^p i_t^c &= a_t^p + y_t^p + r^p(a_t^p)a_t^p \\ a_{t+1}^m &\geq -\lambda \frac{\min(y_{t+1}^m)}{1 + r^m(a_{t+1}^m)} \\ i_t^c &\geq 0 \\ n_{t+1}^m &= n_t^p \end{aligned}$$

### 3.2.4 Middle-aged stage

The middle-aged stage is the last stage of the life cycle. It encompasses the entire time from the time when an individual's children make college decisions until the end of life. In this stage, the individual decides the amount of parental transfer $a_t^s$ to make to their children.

The earnings process of the middle-aged stage is analogous to that of the parent stage.

Equation (3) described the specific formula. Let $\mathbf{y}_t^m = \{y_t^m, i_{t-1}^c\}$ denote a collection of all state variables relevant to the middle-aged individual's and her children's present and future earnings.

After receiving the earnings shock, the middle-aged allocates her income between own consumption $c_t^m$ and parental transfers $a_t^s$ by solving

$$V_t^m(a_t^m, \mathbf{y}_t^m, n_t^m) = \max_{c_t^m, a_t^s} u(c_t^m) + \rho(n_t^m)\beta^m \mathbb{E}\left[V_t^s(a_t^s, \mathbf{y}_t^s)\right]$$

Subject to

$$c_t^m + n_t^m a_t^s = a_t^m + y_t^m + r^m(a_t^m)a_t^m$$
$$a_t^s \geq 0$$
$$\mathbf{y}_t^s = \{y_t^s, i_{t-1}^c\}$$

## 3.3 Aggregation & government

I denote the cumulative distribution function of individuals in life cycle stage $j$ at time $t$ as $\Psi_t^j$. The arguments for $\psi_t^j$ are the relevant state variables for each stage, which I suppress here to simplify notations. Furthermore, I use the same notations both for individuals choice variables and policy functions whenever there is no risk of confusion. Appendix B provides a full description of the notations and formula used.

The government balances budget in each period. The expenditure side of the budget constraint includes educational subsidy for both children and students as well as new federal student loan issuance. The revenue side of the budget constraint includes earnings tax from parents and the middle-aged, as well as repayments of federal student loans.

$$\text{Expenditure} = \frac{1}{2}\int n_t^p S^c(i_t^c) d\Psi_t^p + \int S^s(i_t^s) d\Psi_t^s + \int a_{t+1}^p \mathbf{1}_{\{-L \leq a_{t+1^p} < 0\}} d\Psi_t^s \cdot \Sigma^s$$

$$\text{Revenue} = \tau \left[ \int y_t^s \mathbf{1}_{e_t^s=1} d\Psi_t^s + \int y_t^p d\Psi_t^p + \int y_t^m d\psi_t^m \right] + \int \left[1 + r(a_t^p)\right] a_t^p d\Psi_t^p \cdot \Sigma^p$$

## 3.4 Analysis

The central tradeoff in the model for parents is between fertility $n_t^p$, childhood investment $i_t^c$, and transfers $a_{t+1}^s$ (which finances their off-springs' college expenditure $i_{t+1}^s$, if any). In this section, I discuss heuristically how the tradeoffs are affected by income and debt. To simplify the notations, I abstract from all uncertainties, including fertility preference shocks and earnings shocks, in this section.

In the simplified model, the first-order conditions for parents regarding fertility, investment, and transfer are as follows. I write the marginal costs on the left-hand side and the marginal benefits on the right-hand side.

$$\begin{aligned} \lambda_t^p[\delta'(n_t^p)c_t^p + i_t^c] + \lambda_{t+1}^m a_{t+1}^s &= \beta\rho'(n_t^p)V_{t+1}^s && [n_t^p] \\ \lambda_t^p n_t^p &= \beta\rho(n_t^p)\frac{\partial V_{t+1}^s}{\partial i_t^c} && [i_t^c] \\ \lambda_{t+1}^m n_t^p &= \beta\rho(n_t^p)\frac{\partial V_{t+1}^s}{\partial a_{t+1}^s} && [a_{t+1}^s] \end{aligned}$$

The first equation captures the quantity-quality tradeoff that leads to the negative income-fertility relationship that is observed in data. As income increase, parents spend more on their children, increasing $c_t^p$, $i_t^c$, and $a_{t+1}^s$, raising the marginal cost for fertility. Children's lifetime utility $V_{t+1}^s$ also increases as a result of higher expenditures by the parent, thus raising the value of the right-hand side if fertility is unchanged. The model is able to generate the negative correlation because of the curvature in altruism $\rho'(n_t^p)$. As long as parents' utility derived from their children's future welfare do not increase too quickly as the number of children increases, richer parents will choose to have fewer children as well as hjgher investment and transfers for each child.

The second and third equations can help explain how parents choose between investment and transfers when credit constrained. When parents are credit-constrained, the shadow price for parent stage $\lambda_t^p$ becomes higher than the shadow price in middle-aged stage $\lambda_{t+1}^m$. Thus, the marginal cost for childhood investment $i_t^c$ becomes higher while the marginal cost for parental transfers at middle-age $a_{t+1}^s$ becomes lower. Conditional on the same lifetime income and fertility level, constrained parents invest less during their offspring's childhood stage but make more transfer during their offsprings' college years. Since the investment is not allocated optimally, the lifetime utility of the constrained parents' children will also be lower than those of the unconstrained parents'.

Constrained parents also have fewer children than unconstrained ones, because the marginal benefit for fertility is lower. Given the same level expenditures, the children of constrained parents enjoy lower lifetime utility $V_{t+1}$, as their human capital inputs are not allocated efficiently over time. In the first equation, the marginal benefit decreases while the marginal cost remains roughly unchanged. As a result, constrained parents choose to lower fertility level $n_t^p$.

# 4 Estimation

I employ the two-step estimation strategy. First, I estimate any parameters that can be directly determined without solving the model. Then, I pin down the remaining parameters using the Method of Simulated Moments (MSM).

## 4.1 Functional forms

**Per-period utility.** The per-period utility function I use in the model takes the form of the following

$$u(c) = \frac{(c + \underline{c})^{1-\sigma}}{1-\sigma} - \frac{\underline{c}^{1-\sigma}}{1-\sigma}$$

This is the standard CRRA utility function translated by the vector $(-\underline{c}, -\underline{c}^{1-\sigma}/(1-\sigma))$, where $\underline{c}$ is the consumption floor. This utility function ensures $u(0) = 0$ and $u(c) > 0$ for $c > 0$, while preserving other desirable properties of the CRRA utility function.

**Altruism.** In the model, the parent receives her children's lifetime utility, discounted by $\rho(n)$. I use the functional form

$$\rho(n) = \alpha_0 \left[1 - \exp(-\alpha_1 n)\right] \text{ for } n \in [0, \infty]$$

This function is strictly increasing, concave, and satisfied $\rho(0) = 0$ and $\lim_{n \to \infty} \rho(n) = \alpha_0$.

**Human capital production function.** The human capital production function I use is similar to that of Caucutt & Lochner (2020). The adulthood human capital at time $t$ is determined by $f(i^c_{t-2}, i^s_{t-1})$, which takes the form of a decreasing-returns-to-scale, CES production function.

$$f(i_{t-2}^c, i_{t-1}^s) = \theta \left\{ a \left[ i_{t-2}^c + S^c(i_{t-2}^c)) \right]^b + (1-a) \left[ i_{t-1}^s + S^s(i_{t-1}^s) \right]^b \right\}^{\frac{d}{b}}$$

The functions $S^c$ and $S^s$ are public educational investment that depends on the amounts of private investments $i_{t-2}^c$ and $i_{t-1}^s$. For simplicity, I take both $S^c$ and $S^s$ to be affine functions, i.e., $S^k(i^k) = \phi_0^k + \phi_1^k i^k, k \in \{c, s\}$.

**Interest rates.** In the model, the interest rates in both parent and middle-aged stage depends on the level of asset holdings. In the parental stage, the interest rates are determined using the following rule,

$$a_t^p + r(a_t^p) = \begin{cases} (1 + r^{pd}) a_t^p, & \text{if } a_t^p \in [0, \infty) \\ (1 + r^{ps}) a_t^p, & \text{if } a_t^p \in [-L^s, 0) \\ (1 + r^{pb})(a_t^p + L^u) - (1 + r^{ps}) L^s, & \text{if } a_t^p \in (-\infty, -L^s) \end{cases}$$

With $r^{pd} < r^{ps} < r^{pb}$. If the individual chose to save at the student stage, she faces the deposit rate $r^{pd}$, which is the lowest. $r^{ps}$ is the interest rate for federal student loans, which is higher than the deposit rate, but lower than the private loan rate $r^{pb}$. Since there are loan limits for federal student loans, the student must borrow at the higher private rate if her borrowing exceeds the loan limit. Figure 5 illustrated the marginal interest rate by net worth position.

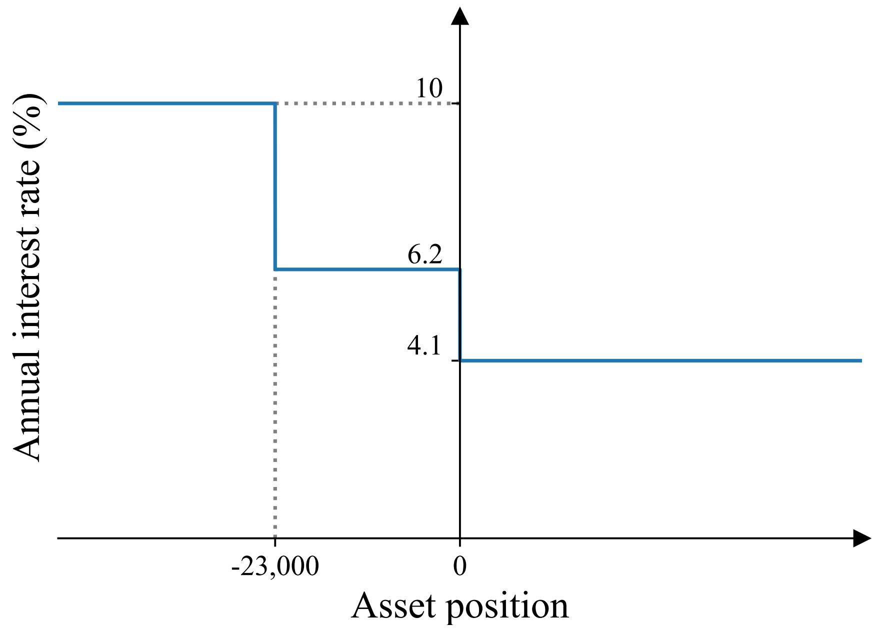


Figure 5: Marginal interest rates faced by students by asset position

In the middle-aged stage, the individual faces either deposit rate if she chooses $a_t^m \geq 0$ or the private borrowing rate if she chooses $a_t^m < 0$.

$$a_t^m + r^m(a_t^m) = \begin{cases} (1 + r^{md})a_t^m & \text{if } a_t^m \in [0, \infty) \\ (1 + r^{mb})a_t^m & \text{if } a_t^m \in (-\infty, 0) \end{cases}$$

**Length of life cycle stages.** Each stage of the life cycle corresponds to different numbers of years in the data. I take the childhood stage to be 16 years (age 0-15), student stage to be 8 years (age 16-23), parent stage to be 16 years (age 24-39), and middle-aged stage to be 37 years (age 40-78). All variables I use in the main text are in units of $1,000 annually. I describe the technical details of annualization in Appendix A.

## 4.2 Parameters estimated externally

Since I want to study the long-run policy effects of federal student loans, I will match the model to the US economy in the 2000s. I avoid using data during or after the 2008-09 Great Recession to avoid any convolution from unmodelled business cycle factors.

Table 2 summarizes the data sources I use for all externally estimated parameters and the corresponding parameter values.

Table 2: Parameters chosen or estimated outside the model

| Parameter | Value | Source |
|---|---|---|
| $\sigma$ | 2 | Standard in literature |
| $\underline{c}$ | 9.31 | 2004 HHS Poverty Guidelines |
| $r^{pd}$ | 4.08% (ann.) | 3-month CD rate, 1997-2007 |
| $r^{ps}$ | 6.18% (ann.) | Federal subsidized rate, 1997-2007 |
| $r^{pb}$ | 10% (ann.) | Arbitrary |
| $r^{md}$ | 4.08% (ann.) | 3-month CD rate, 1997-2007 |
| $r^{mb}$ | 7% (ann.) | Average mortgage rate, Freddie Mac |
| $L^s$ | 23 | Federal subsidized limit since 2008 |
| $\beta^s$ | 0.96 (ann.) | $1/(1+r^{pd})$ |
| $\beta^p$ | 0.96 (ann.) | $1/(1+r^{pd})$ |
| $\beta^m$ | 0.96 (ann.) | $1/(1+r^{pd})$ |
| $\phi_0^c$ | 5.49 | Digest of Edu. Stat. 2003 |
| $\phi_1^c$ | 0. | Digest of Edu. Stat. 2003 |
| $\phi_0^s$ | 2.11 | Digest of Edu. Stat. 2003 |
| $\phi_1^s$ | 2.57 | Digest of Edu. Stat. 2003 |
| $\zeta$ | 0.55 | College attendants earnings fraction |
| $\bar{y}^p$ | 1 | Normalization |
| $\bar{y}^m$ | 1.09 | Own estimation using NLSY79 |
| $\delta(1)$ | 0.63 | USDA report |
| $\delta(2)$ | 1 | Normalization |
| $\delta(3)$ | 1.14 | USDA report |

For the CRRA utility function, I choose the CRRA parameter to be 2. It is a commonly used parameter value in the literature. I take the consumption floor to be 9.31, which corresponds to the HHS poverty threshold for one-person households of $9,310 in 2004.

The interest rates I use in the model are directly measured in the data. For the deposit interest rates $r^{pd}$ and $r^{md}$, I use the average 3-month rates for certificates of deposit between year 1997 and 2007. For private loan rates $r^{pb}$ and $r^{mb}$, I arbitrarily set the rate to be 10% annually. In reality, loan rates are highly heterogeneous, depending on individual characteristics. I abstract from this aspect and just let private rate to be higher than both the deposit rate and the student loan rate. For student loan rate $r^{ps}$, I use the average federal interest rate of 6.18% annually. This interest rate is the same for all students borrowing from federal student loans and does not depend on individual characteristics. I set the discount rate $\beta$ to satisfy $\beta(1+r^d) = 1$. The interest rates and discount rates listed here are all annualized. Appendix A describes how to transform annualized variables to ones actually used in the model.

For educational subsidies, I maintain the same assumptions made in Caucutt & Lochner (2020). I assume only lump sum subsidies for the childhood stage, i.e. $\phi_0^c = 0$. I use the data listed in the Digest of Educational Statistics 2003 to measure the rest of the coefficients. For $\phi_0^s$, I use the annual public expenditure on secondary education multiplied for age 16-18. Additionally, I use the fraction of private versus public educational expenditure for primary and secondary stage to pin down coefficients $\phi_1^c$ and $\phi_1^s$.

For the age profile of earnings $\bar{y}^p$ and $\bar{y}^m$, I first normalize $\bar{y}^p$ to be 1. This is without loss of generality, because other parameters determining earnings process are internally calibrated. Then, I use earnings observed of the NLSY79 cohort in all survey years to find $\bar{y}^m$. I use the NLSY79 cohort because we observe their earnings as early as age 18 and as late as age 60, which provides a better measure of age profile earnings than other NLS cohorts or cross sectional datasets. I also measured $\bar{y}^m$ using the CPS march supplement cross section and found similar values.

For consumption multipliers $\delta$, I take them to be the same as what is used in USDA Annual Report on Expenditures on Children by Families in 2004.

## 4.3 Parameters calibrated internally

For internal calibration using MSM, I target five sets of data moments: conditional and unconditional distribution of education, asset holdings, earnings, fertility rate, childhood investment, and college expenditure. Table 3 summarizes the parameters that need to be estimated in the second step as well as how each group of parameters conceptually links to the data moments. Appendix C.2 describes in detail how each data moment is measured.

Table 3: Parameters-moment correspondence

| Parameters | Descriptions | Moments | Data sources |
|---|---|---|---|
| $\mu_\eta, \sigma_\eta,$ $\rho_y, \mu_\epsilon, \sigma_\epsilon$ | Earnings process | Means and variances of earnings profiles | NLSY79, CPS |
| $\theta, a, b, d$ | Human capital production function | Home scores, college attendance, & college expenditure | NLSYCA, NLSY97, NPSAS |
| $\alpha_0, \alpha_1,$ $\sigma_n, \hat{\nu}$ | Altruism & fertility preference | Fertility rate by education & wealth | NLSY79 |
| $\pi, \lambda$ | Borrowing constraints | Fraction with student loans or negative net worth | NLSY97, SCF, NPSAS |

Table 4 lists the values for all internally calibrated parameters.

Table 4: Calibrated parameters

| Parameter | Description | Value |
|---|---|---|
| $\mu_\eta$ | Mean of $\ln(y_t^s)$ | 2.00 |
| $\sigma_\eta$ | Sd of $\ln(y_t^s)$ | 0.79 |
| $\rho_y$ | Earnings autocorrelation | 0.57 |
| $\mu_\epsilon$ | Mean of $\ln(\epsilon_t^s)$ | 1.69 |
| $\sigma_\epsilon$ | Sd of $\ln(\epsilon_t^s)$ | 1.51 |
| $\theta$ | HC tech, TFP | 4.80 |
| $a$ | HC, early investment weight | 0.50 |
| $b$ | HC, elasticity of sub. | -0.49 |
| $d$ | HC, returns to scale | 0.80 |
| $\alpha_0$ | Altruism, level | 0.99 |
| $\alpha_1$ | Altruism, curvature | 2.46 |
| $\sigma_n$ | Sd of fert. pref. shock | 0.0041 |
| $\hat{\nu}$ | Childless utility constant | 0.068 |
| $\pi$ | Prob. aware of FSL | 0.68 |
| $\lambda$ | Parent credit constraint | 0.11 |

### 4.3.1 Earnings process

For parameters related to the earnings process, I need to pin down the means and variances for student-stage earnings potential $\mu_\eta$, $\sigma_\eta$; the persistance $\rho_y$ of student stage earnings shock; and the means and variances of student-stage earnings $\mu_\epsilon$ and $\sigma_\epsilon$. I use the means and variances of earnings at the student and parent stages. During the student stage, since only those who are not in college are working full-time, I only match the moments for those not attending college. During the parent stage, I match both the unconditional moments and the ones conditional on having attended college.

Table 5: Earnings

| Moment | Data | Model |
|---|---|---|
| $\mathbb{E}[y_t^s \mid e_t^s = 0]$ | 15.32 | 15.43 |
| $\mathbb{E}[y_{t+1}^p \mid e_t^s = 0]$ | 27.26 | 28.92 |
| $\mathbb{E}[y_{t+1}^p \mid e_t^s = 1]$ | 43.04 | 41.93 |
| $V[\ln(y_t^s) \mid e_t^s = 0]$ | 0.91 | 0.76 |
| $V[\ln(y_{t+1}^p)]$ | 0.52 | 0.46 |
| $V[\ln(y_{t+1}^p) \mid e_t^s = 1]$ | 0.41 | 0.34 |

As can be seen in Table 5, the model can replicate data moments pretty closely. The model produces slightly lower mean and variance for the student stage earnings potential.

#### 4.3.2 Human capital production function

For parameters governing human capital production function, including productivity $\theta$, weight on childhood investment $a$, elasticity $b$, and returns to scale $d$, I use the distribution of home scores, college attendance, and college expenditures, both unconditional and conditional on maternal college attendance and asset level.

Table 6: College attendance

| Moment | Data | Model |
|---|---|---|
| $Pr(e_t^s = 1)$ | 0.39 | 0.53 |
| $Pr(e_{t+2}^s = 1 \mid e_t^s = 1)$ | 0.56 | 0.67 |

Table 7: Childhood Investment

| Moment | Data | Model |
|---|---|---|
| $\mathbb{E}[\phi(i_{t+1}^c) \mid e_t^s = 0]$ | -0.24 | -0.24 |
| $\mathbb{E}[\phi(i_{t+1}^c) \mid e_t^s = 1]$ | 0.47 | 0.40 |
| $\mathbb{E}[\phi(i_{t+1}^c) \mid e_t^s = 1, a_{t+1}^p < 0]$ | 0.24 | 0.28 |
| $\mathbb{E}[\phi(i_{t+1}^c) \mid e_t^s = 1, a_{t+1}^p \geq 0]$ | 0.52 | 0.56 |

Table 8: College Expenditure

| Moment | Data | Model |
|---|---|---|
| $\mathbb{E}[i^s_t \vert e^s_t = 1]$ | 5.64 | 4.94 |
| $\mathbb{E}[i^s_{t+2} \vert e^s_{t+2} = 1, e^s_t = 1]$ | 8.23 | 10.14 |

#### 4.3.3 Fertility

To calibrate fertility-related parameters, including $\alpha_0$, $\alpha_1$, $\sigma_n$, and $\hat{\nu}$, I use the total fertility rate by education and asset.

Table 9: Fertility

| Moment | Data | Model |
|---|---|---|
| $\mathbb{E}[n^p_{t+1} \vert e^s_t = 0]$ | 1.90 | 1.80 |
| $\mathbb{E}[n^p_{t+1} \vert e^s_t = 1]$ | 1.65 | 1.63 |
| $\mathbb{E}[n^p_{t+1} \vert e^s_t = 1, a^p_{t+1} < 0]$ | 1.47 | 1.65 |
| $\mathbb{E}[n^p_{t+1} \vert e^s_t = 1, a^p_{t+1} \geq 0]$ | 1.69 | 1.60 |

#### 4.3.4 Borrowing constraints

Lastly, for parameters on tightness of credit constraints, $\zeta$ and $\lambda$, I use fraction of population with either student loan debt or negative net worth, conditional on college attendance.

Table 10: Net worth

| Moment | Data | Model |
|---|---|---|
| $Pr(a^p_{t+1} < 0 \vert e^s_t = 1)$ | 0.47 | 0.57 |
| $Pr(a^m_{t+2} < 0)$ | 0.14 | 0.31 |
| $Pr(a^m_{t+2} < 0 \vert e^s_t = 1)$ | 0.17 | 0.27 |

## 4.4 Mechanism

### 4.4.1 Household behaviors

I now compare the life-cycle behaviors of individuals who made different college decisions during the student stage. The behaviors I observe in the quantitative model are consistent with the theoretical predictions in Section 3.4.

I divide all parents into four categories – non-college-educated($e^s_t = 0$); college-educated with both federal student loans, and private student loans ($e^s_t = 0$ and $a^s_{t+1} < -L$); college-educated with only federal student loans ($e^s_t = 0$ and $-L \leq a^s_{t+1} < 0$); college-educated with no loans ($e^s_t = 0$ and $a^s_{t+1} \geq 0$). I compare their behaviors in the four columns in Table 11.

Table 11: Model-generated statistics

| | Non-college | College | | |
|---|---|---|---|---|
| | | Private | FSL only | No loans |
| Fraction (%) | 46.71 | 7.76 | 22.37 | 23.16 |
| Parental transfers $a^s_t$ | 2.20 | 21.21 | 17.15 | 40.51 |
| Childhood investment $i^c_{t-1}$ | 0.02 | 9.49 | 3.99 | 6.12 |
| Student earnings $y^s_t$ | 11.55 | 8.65 | 7.79 | 8.59 |
| College exp. $i^s_t$ | 0.00 | 10.18 | 7.39 | 10.80 |
| Earnings $y^p_{t+1}$ | 28.92 | 46.65 | 38.88 | 43.29 |
| Fertility $n^p_{t+1}$ | 1.80 | 1.58 | 1.68 | 1.60 |
| Child investment $a^c_{t+1}$ | 2.48 | 6.48 | 4.63 | 9.09 |
| Transfers $a^c_{t+2}$ | 14.71 | 28.24 | 21.69 | 29.18 |
| Child attends college (%) | 39.17 | 79.45 | 57.15 | 72.72 |
| Child college exp. $i^s_{t+2}$ | 7.75 | 9.35 | 9.03 | 11.31 |
| Child earnings $y^p_{t+3}$ | 32.69 | 39.83 | 36.15 | 41.39 |

Parents who borrowed both from federal and private sources during their student stage earn about five thousand dollars more than those who don't have any loans., as seen in the second row of the table. Yet, the children of the two types of parents earn almost the same amount, as seen in the last row of the table. The reason for that is children of indebted parents receive less investment in the childhood stage and more in the student stage and end up having the same level of human capital when they grow up. Indebted parents also have lower fertility rates, since raising children and ensuring their future lifetime utility is more costly when parents cannot invest early on because of the credit constraint.

## 4.5 Validation

### 4.5.1 Fertility rates

I only use fertility rate divided by college attendance and whether net worth is negative to as targeted moments, but the model also matches the general distribution of fertility across earnings and income relatively well. Figure 6 compares the fertility rates observed in the NLSY79 cohort and the fertility rates generated by the quantitative model.

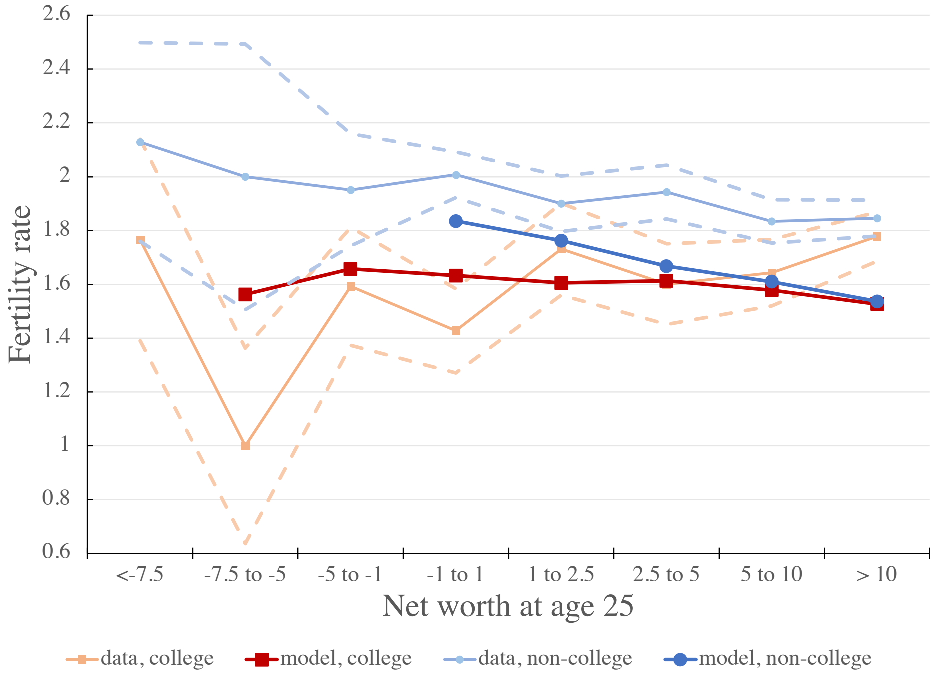



Figure 6: Data & model generated fertility by net worth

The model cannot fully replicate the difference in fertility rate between college and non-college individuals. This is mainly due to the fact that the model does not capture other differences between college and non-college parents, such as difference in child ability and preferences in family size. The model cannot generate the desirable asset distribution and the size of the educational differential at the same time. If I choose another figuration where the fertility-education differential is completely matched, both lines in the graph will be downward sloping.

### 4.5.2 Intergenerational elasticity of earnings (IGE)

In the model, I define intergenerational elasticity as the slope coefficient of the following regression equation, following Chetty et. al. (2014).

$$\ln(y^p_{t+2}) = \beta_0 + \beta_1 \ln(y^p_t) + \varepsilon_{t+2}$$

In model, the measure $\beta_1 = 0.499$. Despite not targeting this moment in my simulation, the estimate is still consistent with existing literature.

To further understand what drives intergenerational correlation of earnings, I compare each type of household's behavior using the Figures 7 and 8 below.

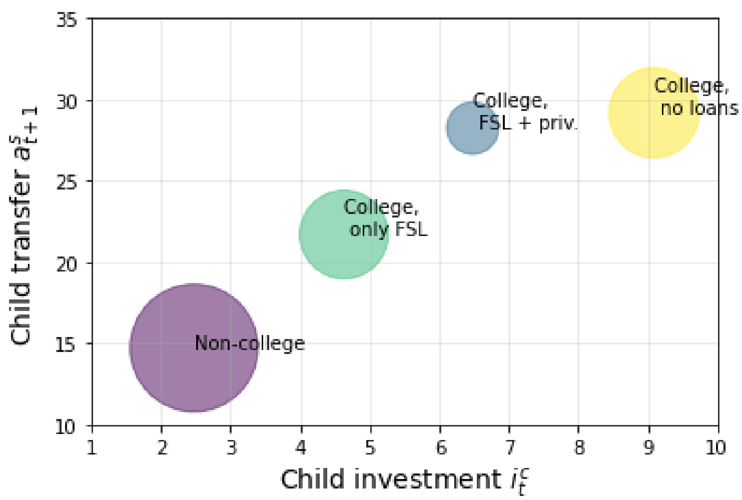



Figure 7: Childhood investment and parental transfers, by parent type

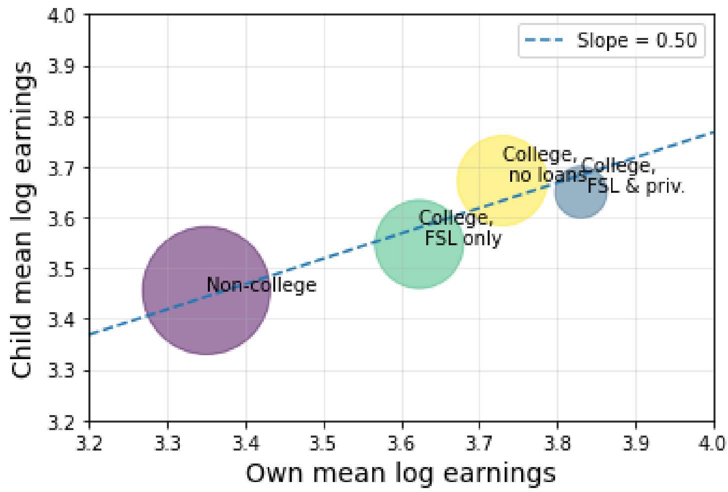



Figure 8: Mean parent and child earnings, by parent type

# 5 Policy analysis

For policy analysis, I compare the factual economy with the counterfactual one where there are no federal student loans. In the counterfactual economy, I set the federal loan limit in the model to be 0. Therefore, students can still borrow but must face the higher private interest rate. Figure 9 shows the marginal interest rates faced by students. The only difference between the actual and the counterfactual interest rates is the middle section where the federal loan rate is raised to be the same as the private interest rate.

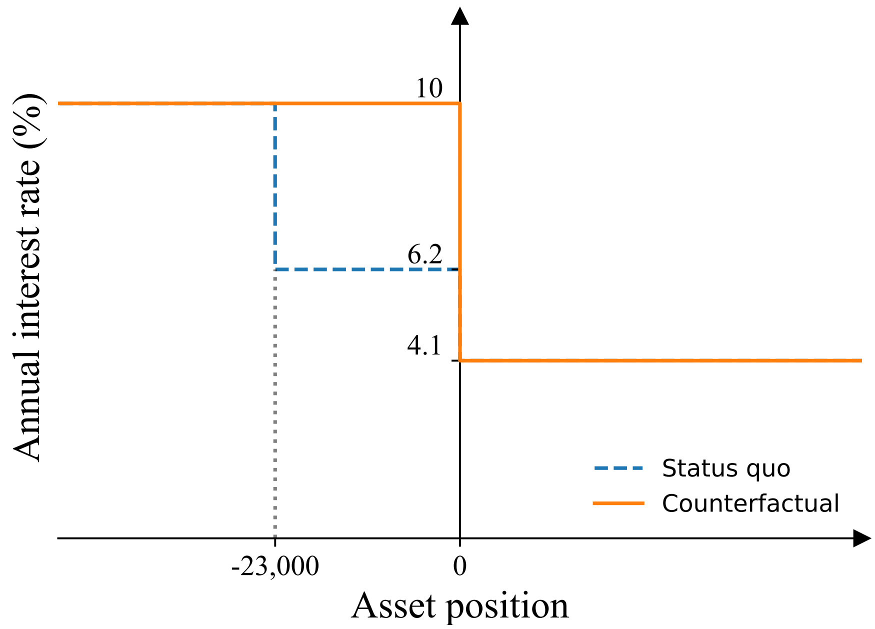



Figure 9: Marginal interest rates faced by students by asset position

Since the federal student loans are funded by the government, it makes sense to consider both the expenditure and the revenue side when simulating counterfactual economy. In my policy experiment, I adjust the earnings tax rate to balance government budget for both economies. I also compute the results where the tax rate does not change to decompose the policy effects into one from relaxing borrowing constraint and one from changing after-tax earnings.

## 5.1 Results

First, I compare household behaviors in the benchmark model with those in the counterfactual after I remove federal student loans. I focus on the borrowers since they are the ones most directly impacted. In Table 13, I compare the behaviors of borrowers in the benchmark model and after I remove federal student loans. I decompose the borrowers into two types – those who take both federal and private loans and those who borrow from federal loans only.

Table 12: Changes in composition of student borrowers

| | Benchmark | | No FSL | |
|---|---|---|---|---|
| | Private | FSL only | Private | FSL only |
| Fraction attending college (%) | 100 | 100 | 100 | 88.6 |
| Fraction with debt (%), parent-stage | 100 | 100 | 100 | 85.4 |
| Fraction with debt (%), middle-age-stage | 25.2 | 40.2 | 26.4 | 38.2 |

Table 13: Changes in behaviors of student borrowers

| | Benchmark | | No FSL | |
|---|---|---|---|---|
| | Private | FSL only | Private | FSL only |
| Earnings $y^p_{t+1}$ | 44.7 | 33.9 | 34.6 | 33.0 |
| Fertility $n^p_t$ | 1.49 | 1.66 | 1.50 | 1.68 |
| Child investment $a^c_{t+1}$ | 6.86 | 3.60 | 6.64 | 3.63 |
| Transfers $a^c_{t+2}$ | 26.8 | 17.4 | 27.0 | 17.0 |
| Child earnings | 37.9 | 32.0 | 37.3 | 31.5 |

From Table 13, we can see that the two types of borrowers behave differently. Some of those who borrowed from only from federal sources chose to not go to college instead.

I also compare how behaviors of each household type change before and after the policy experiment in Figures 10 and 11. As expected, parents who borrowed from FSL are those that are affected the most, yet the effects are heterogeneous depending on the amount borrowed.

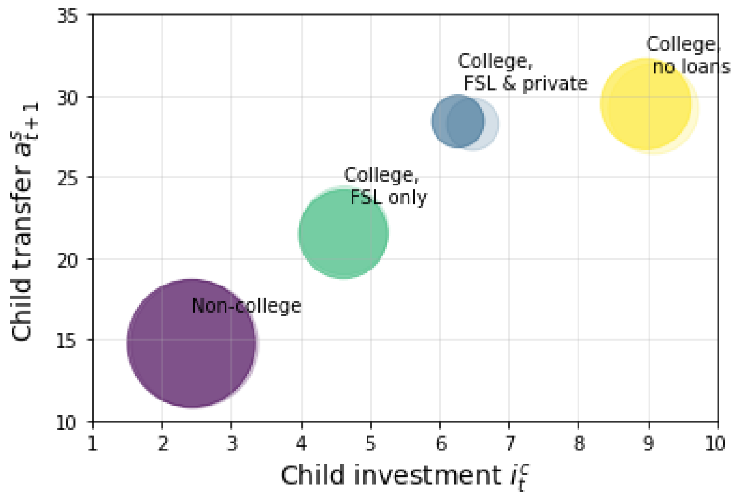



Figure 10: Childhood investment and parental transfers, by parent type

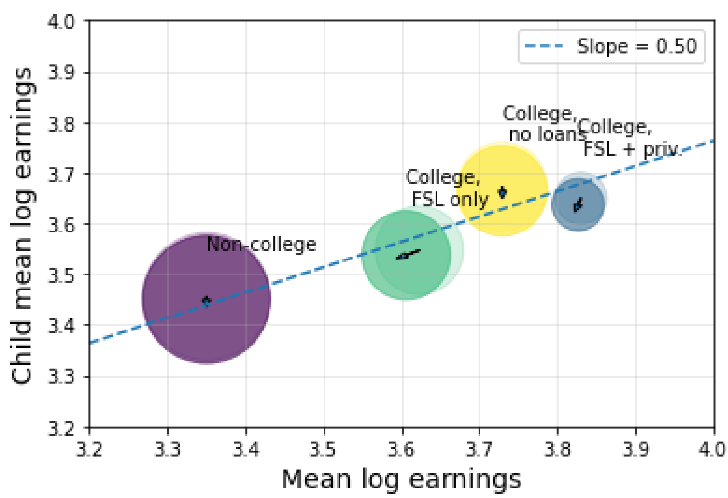



Figure 11: Mean parent and child earnings, by parent type

Tables 14 and 15 summarizes key statistics related to growth and social mobility.

Table 14: Output-related statistics

| Indicators | | Status quo | No FSL | No FSL (adj. tax) |
|---|---|---|---|---|
| College rate (%) | | 53.32 | -2.49 | -3.73 |
| Earnings ($1,000) | Non-col | 28.92 | -0.05 | -1.66 |
| | Col | 41.99 | 0.02 | -2.47 |
| Pop'n growth (‰) | | -6.59 | 0.16 | -0.20 |
| Avg consumption | | 33.43 | -0.22 | -2.37 |

Table 15: Mobility-related statistics

| Indicators | | Status quo | No FSL | No FSL (adj. tax) |
|---|---|---|---|---|
| IGE | | 0.499 | 0.004 | -0.001 |
| Earnings share (%) | Top 10% | 24.152 | 0.361 | 0.312 |
| | Bottom 50% | 29.183 | 0.197 | 0.766 |
| Cons. edu. premium | | 13.186 | 0.285 | 0.154 |

## 5.2 Comparing with exogenous-fertility model

To understand the role of fertility choice, I compare the results of the benchmark model with one where fertility is taken to be exogenous and homogeneous among all individuals. I take $p_n$, the probability of having $n$ children, to be exogenous and equal to the steady state levels in the benchmark model.

Table 16: Policy effects under exogenous-fertility model

| Indicators | | Benchmark | No FSL | No FSL (adj. tax) |
|---|---|---|---|---|
| College rate (%) | | 57.93 | -3.86 | -7.14 |
| Earnings ($1,000) | Non-col | 25.77 | -0.14 | -1.74 |
| | Col | 36.90 | +0.15 | -3.27 |
| Pop'n growth (‰) | | -7.14 | -0.00 | -0.00 |
| Avg consumption | | 55.61 | -0.34 | -5.77 |
| IGE | | 0.41 | -0.00 | -0.05 |
| Earnings share | Top 10% | 0.27 | -0.00 | -0.00 |
| | Bottom 50% | 0.27 | +0.00 | +0.01 |
| Cons. edu. premium | | 16.72 | +1.05 | -0.49 |

Compared with endogenous fertility model, exogenous fertility model overestimates the effect of student loans on growth and social mobility.

## 5.3 Changing targeted moments related to fertility

To test whether the moment related to fertility rates conditional on wealth is indeed informative, I calibrate the model using two other sets of hypothetical targeted moments. In both hypothetical scenarios, I artificially set the fertility rate for college, negative-net-worth parents to be equal to 1 and that of college, positive-net-worth parents to be equal to 2. In the first case, I still target the fertility rates conditional on education. In the second case, I only target the wealth gradient and ignore the education gradient. I keep all other targeted data moments unchanged.

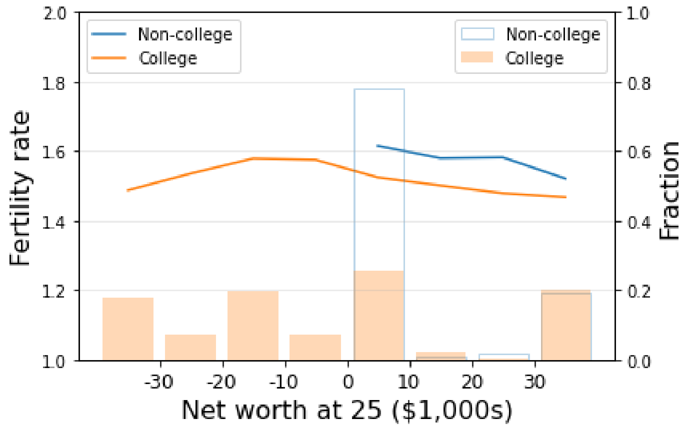
Table 17 shows the data and model moments for the benchmark model as well as two counterfactual models. It is difficult to replicate both the decreasing fertility-education relationship and the increasing fertility-wealth relation seen in the data.

Table 17: Data and model moments under three specifications

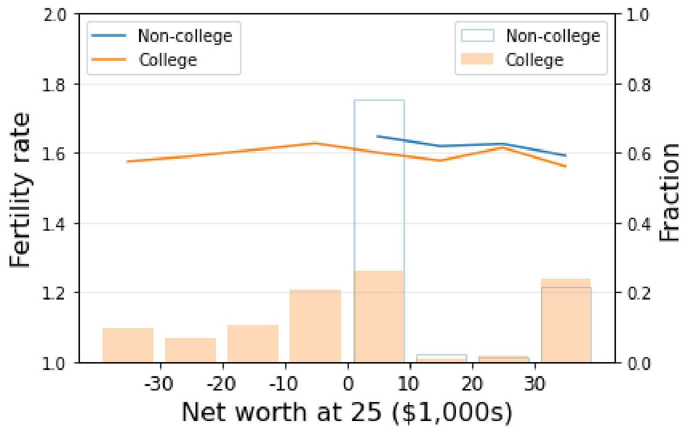
| | (1) | | (2) | | (3) | |
|---|---|---|---|---|---|---|
| | Data | Model | "Data" | Model | "Data" | Model |
| $\mathbb{E}[n^p_{t+1} \mid e^s_t = 1, a^p_{t+1} < 0]$ | 1.47 | 1.65 | 1.00 | 1.61 | 2.00 | 1.62 |
| $\mathbb{E}[n^p_{t+1} \mid e^s_t = 1, a^p_{t+1} \geq 0]$ | 1.69 | 1.60 | 2.00 | 1.58 | 1.00 | 1.37 |

The main parameters driving the fertility-wealth gradient are the curvature of altruism parameter $\alpha_1$ and the utility shock for not having children $\hat{\nu}$. The altruism parameter $\alpha_1$ governs how strong the quantity-quality tradeoff mechanism is, whereas utility shock $\hat{\nu}$ governs the tradeoff between expenditure on children and on own consumption. In addition, the dynamic complementary of the human capital production function $b$ and the parenthood credit constraint $\lambda$ is also relevant, but I do not find the model moments to be very elastic regarding these parameters.

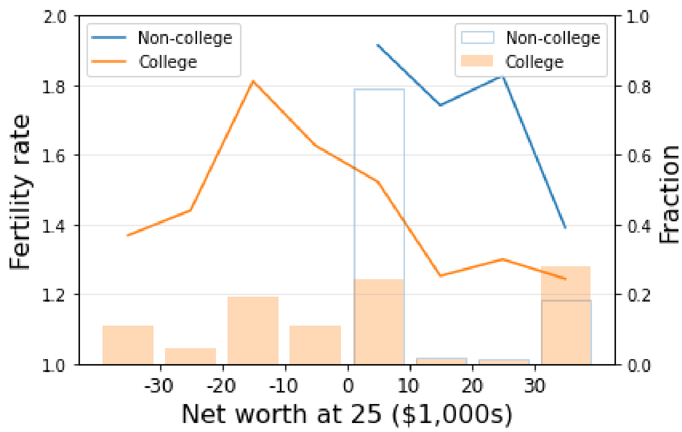
Figure 12 shows the education and net worth gradient for the three configurations.




(a) Benchmark configuration




(b) Targeting increasing fertility in net worth




(c) Targeting decreasing fertility in net worth

Figure 12: Fertility patterns under three configurations

Table 18: Policy effects on student borrower behaviors

| | Status Quo | No FSL | | |
|---|---|---|---|---|
| Indicators | | (1) | (2) | (3) |
| Fraction (%) | 29.0 | - | - | - |
| College rate (%) | 100.0 | -3.1 | -0.1 | -10.1 |
| College expenditure $i_t^s$ | 8.1 | -6.4 | -2.6 | -8.8 |
| Earnings $y_{t+1}^p$ | 40.8 | -1.1 | -0.2 | -1.6 |
| Fertility $n_{t+1}^p$ | 1.7 | +0.4 | -0.1 | -0.0 |
| Child investment $i_{t+1}^c$ | 5.1 | -1.7 | +0.4 | +0.4 |
| Transfers $a_{t+2}^c$ | 23.5 | -0.7 | +0.7 | +0.2 |
| Child college rate (%) | 62.4 | -2.9 | -0.1 | -3.0 |
| Child college expenditure $i_{t+2}^s$ | 9.1 | -0.5 | -0.5 | +3.7 |
| Child earnings $y_{t+3}^p$ | 37.0 | -1.0 | -0.0 | -0.4 |

Note: All monetary variables are in units of $1,000's of 2005 dollars. Changes reported are percentage changes for monetary variables and percentage-point changes for percentages.

Table 19: Policy effects on steady-state, aggregate economy

| | Status Quo | No FSL | | |
|---|---|---|---|---|
| Indicators | | (1) | (2) | (3) |
| College rate (%) | 53.32 | -2.49 | -0.35 | -2.75 |
| Avg earnings ($1,000) | 35.89 | -0.34 | -0.10 | -0.21 |
| Pop'n growth (‰) | -6.59 | +0.16 | -0.01 | +0.06 |
| Avg consumption | 33.43 | -0.22 | -0.13 | -0.04 |
| IGE (×100) | 50.57 | +0.31 | -0.00 | +0.64 |
| 1st-gen college rate (%) | 66.98 | -1.67 | -0.27 | -0.26 |
| Top 10% earnings share | 24.15 | +0.36 | -0.33 | -0.10 |
| Bottom 50% earnings share | 29.18 | +0.20 | +0.14 | +0.21 |
| College premium | 13.07 | +0.29 | -0.08 | +0.71 |

Table 19 compares the estimated policy effects under three configurations. In both columns (2) and (3), where I target counterfactual moments, the estimated policy effects on growth-related statistics are much smaller. Under none of the three cases, removing federal student loans has a noticeable impact of intergenerational elasticity of earnings. For other statistics related to mobility, the counterfactual economies also tend to generate smaller policy effects. In all three cases, the effect of student loans on mobility is economically insignificant.

## 6 Conclusions

In this paper, I evaluate the long run effects of federal student loans on borrower's future behaviors including fertility and investment in their children. I also evaluate the importance of incorporating this channel for policy evaluation on aggregate economic output and social mobility. I adds to the existing literature by incorporating the relationship between debt and fertility into my quantitative model. I discipline this new mechanism by matching empirical relationships found in the data. I found that the relationship between debt and fertility is driven by the combination of two countervailing mechanism, the quantity-quality trade-off and the effects of credit constraint, which roughly cancels each other out, leaving a zero correlation between debt and fertility. Ignoring either mechanism will lead to under- or over-estimation of federal student loans' effects both on borrower behaviors and, to a smaller extent, to key statistics of the aggregate economy, including college rate, population growth, and intergenerational mobility of earnings.

For future research, the previously unstudied relationship between credit-constraint, human capital investment, and fertility can be extended beyond the study of federal student loans. Studying the relationship between mortgage loans and fertility patterns is one natural extension to my current research. My study is also relevant in the secular trend of population aging and can be extended to understand the causes of demographic change and its effects on inequality and mobility.

In this paper, I abstract from general equilibrium effects of removing student loans when studying policy analysis. While including general equilibrium effects may require simplification of the current model, it may be worthwhile in order to understand how removing student loans affect interest rates in the student loan market.

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# Appendix A Annualization

This section records how I transform between the benchmark model and the annualized model.

Let $\hat{x}$ denote variables exclusively in the annualized model. $\hat{r} = 0.042$ and $\hat{\beta} = 1/(1+\hat{r})$. To simplify notation, I ignore the differences between deposit and loan rates in this section.

## A.1 Student:

$$\hat{V}_t^s(\hat{a}_t^s, \mathbf{y}_t^s) = \max \sum_{\tau=0}^{T^s} \beta^\tau u(c_t^s) + \hat{\beta}^{T^s} \mathbb{E}\hat{V}_{t+1}^p(a_{t+1}^p, \mathbf{y}_{t+1}^p)$$

Subject to

$$\sum_{\tau=0}^{T^s} \frac{c_t^s}{(1+\hat{r})^\tau} + \hat{a}_{t+1}^p + e_t^s \sum_{\tau=0}^{T^s} \frac{i_t^s}{(1+\hat{r})^\tau} = \hat{a}_t^s + \sum_{\tau=0}^{T^s} \frac{y_t^s}{(1+\hat{r})^\tau}(1-e_t^s)$$

$$\hat{a}_{t+1}^p \geq -\sum_{\tau=0}^{T^s} \frac{i_t^s}{(1+\hat{r})^\tau}$$

## A.2 Parent:

$$\hat{\hat{V}}_t^p(\hat{a}_t^p, \mathbf{y}_t^p, n_t^p) = \max \sum_{\tau=0}^{T^p} \beta^\tau u(c_t^p) + \hat{\beta}^{T^p} \mathbb{E}\hat{V}_{t+1}^m(\hat{a}_{t+1}^m, \mathbf{y}_{t+1}^m, n_{t+1}^m)$$

Subject to

$$\sum_{\tau=0}^{T^p} \frac{c_t^p}{(1+\hat{r})^\tau}[1+\delta(n_t^p)] + \hat{a}_{t+1}^m + \sum_{\tau=0}^{T^p} \frac{i_t^c}{(1+\hat{r})^\tau} = (1+\hat{r})^{T^s}\hat{a}_t^p + \sum_{\tau=0}^{T^p} \frac{y_t^p}{(1+\hat{r})^\tau}$$

$$\hat{a}_{t+1}^m \geq -\lambda \frac{1}{(1+\hat{r})^{T^p}} \sum_{\tau=0}^{T^m} \frac{\min(y_{t+1}^m)}{(1+\hat{r})^\tau}$$

## A.3 Middle-aged:

$$\hat{V}_t^m(\hat{a}_t^m, \mathbf{y}_t^m, n_t^m) = \max \sum_{\tau=0}^{T^m} \beta^\tau u(c_t^m) + \rho(n_t^m)\hat{\beta}^{T^m}\mathbb{E}\left[\hat{V}_t^s(\hat{a}_t^s, \mathbf{y}_t^s)\right]$$

Subject to

$$\sum_{\tau=0}^{T^p} \frac{c_t^m}{(1+\hat{r})^\tau} + n_t^m \hat{a}_t^s = (1+\hat{r})^{T^p}\hat{a}_t^m + \sum_{\tau=0}^{T^m} \frac{y_t^m}{(1+\hat{r})^\tau}$$

## A.4 Transforming back to benchmark

Let

$$\Sigma^s = \sum_{\tau=0}^{T^s} \beta^\tau = \sum_{\tau=0}^{T^s} \frac{1}{(1+\hat{r})^\tau}$$
$$\Sigma^p = \sum_{\tau=0}^{T^p} \beta^\tau = \sum_{\tau=0}^{T^p} \frac{1}{(1+\hat{r})^\tau}$$
$$\Sigma^m = \sum_{\tau=0}^{T^m} \beta^\tau = \sum_{\tau=0}^{T^m} \frac{1}{(1+\hat{r})^\tau}$$

Let $V_t = \hat{V}_t^j / \Sigma^j$, for $j \in \{s, p, m\}$. Then we have

$$\beta^s = \frac{\Sigma^p}{\Sigma^s}\tilde{\beta}^{T^s}$$
$$\beta^p = \frac{\Sigma^m}{\Sigma^p}\tilde{\beta}^{T^p}$$
$$\beta^m = \frac{\Sigma^s}{\Sigma^m}$$

Next, to change variables in the budget constraints, let

$$a_t^s = \frac{\hat{a}_t^s}{\Sigma^s}$$
$$a_t^p = \frac{\hat{a}_t^p}{\Sigma^p}$$
$$a_t^m = \frac{\hat{a}_t^m}{\Sigma^m}$$

Then, interest rates can be expressed as

$$1 + r^p = \frac{\Sigma^s}{\Sigma^p}(1+\hat{r})^{T^s}$$
$$1 + r^m = \frac{\Sigma^p}{\Sigma^m}(1+\hat{r})^{T^p}$$

The two borrowing constraints actually used in the model is

$$a_{t+1}^p \geq -i_t^s \cdot \frac{\Sigma^s}{\Sigma^p}$$
$$a_{t+1}^m \geq -\lambda \frac{\min(y_{t+1}^s)}{1+r^m} \cdot \frac{\Sigma^p}{\Sigma^m}$$

# Appendix B Aggregation

At any time $t$, the student-stage cdf $\Psi_t^s$ is a function of states $(a_t^s, i_{t-1}^c, y_t^s)$, parent-stage density $\Psi_t^p$ over $(a_t^p, y_t^p, h_t^p, n_t^p)$, and middle-aged stage density $\Psi_t^m$ over $(a_t^m, y_t^m, n_t^p, i_{t-1}^c)$.

The annual population growth rate $g_n$ is calculated using:

$$g_n = \left(\frac{1}{2}\int n_t^p d\Psi_t^p\right)^{1/24} - 1$$

The coefficient 1/2 exists because I map the model to the data using married couples. A married couple having $n_t^p$ children translates to $n_t^p/2$ parents at time $t+2$ per parent at time $t$.,

# Appendix C Data

## C.1 Data cleaning process

### C.1.1 Current Population Survey (CPS)

I use the Annual Social and Economic Supplement of the Current Population Survey for years 1997-2007, downloaded through IPUMS. I use this dataset to measure unconditional distribution of educational attainment and earnings.

For college attendance, I take all individuals aged 28-30 in the sample and use ASEC weights. I treat those with an associate degree, either vocational or academic, or higher as having attended college ($e_t^s = 1$) and others as not having attended college. To measure average earnings by college attendance, I use earnings weight and only consider men working full-time. I deflate earnings using CPI-U and discount using annual interest rate 4.08% measured in section 4.2.

### C.1.2 National Longitudinal Surveys (NLS)

I compute most conditional moments using panel data from the NLS. I use three cohorts from the National Longitudinal Surveys: Youth 1979 cohort, Children of the NLSY79, and Youth 1997 cohort.

### C.1.3 Survey of Consumer Finances (SCF)

I use SCF data from all years for empirical evidence and mainly use the 2004 survey when computing data moments. I follow the procedure used in the Federal Reserve Bulletin when computing net worth and divide by two to get net worth per person for all married individuals. I sum the number of children living in the household and the number of children living elsewhere when computing total number of children. As with all other data, I deflate any monetary amount to 2005 dollars using CPI-U.

### C.1.4 National Postsecondary Student Aid Study (NPSAS)

I use National Postsecondary Student Aid Study, Undergraduate, in survey year 2004 to measure statistics on student loan debt and college expenditures. I calculate the data moments I need using NCES DataLab.

## C.2 Data moments

### C.2.1 College attendance

In the model, college attendance decision is a simple discrete choice between $e_t^s = 0$ or 1. Yet in the data, multiple ways can be used to define college attendance. I calculate different measures of college attendance using both NLSY97 and CPS individuals aged 28-30, shown in Table 20. The statistics I found are consistent across datasets but varies depending on what measure is used. To keep in line with the concept in the model, where a fraction of earnings is foregone and expenditure can be adjusted, I define individuals who receive at least an Associate's degree as having attended college, shown in the third row of the table.

Table 20: Various measures of percentage of college attendance using NLSY97 and CPS

| | NLSY97 | CPS |
|---|---|---|
| 1+ year | 59.7 | 58.7 |
| | (0.6) | (0.2) |
| 2+ year | 52.7 | - |
| | (0.6) | - |
| Associate's degree | 38.9 | 39.2 |
| | (0.6) | (0.2) |
| 4+ year | 35.0 | - |
| | (0.6) | - |
| Bachelor's degree | 30.6 | 30.3 |
| | (0.6) | (0.2) |

I also measure college attendance conditional on parental college attendance using the NLSY97 cohort. For parental attendance, I consider the maximum between the respondent's father and mother. I use the self-reported answer, and use residential or biological parents if no self report is available.

In Table 21, I compare the conditional moments using different NLS cohorts. The difference between college rate between non-college and college parent is the smalles for the NLSY97 cohort.

Table 21: Fraction with college degree by parental education

| | NLSY79 | NLSY97 | NLSYCA |
|---|---|---|---|
| Non-college parent | 21.2 | 35.1 | 28.9 |
| | (0.6) | (0.7) | (0.8) |
| College parent | 62.6 | 55.8 | 53.4 |
| | (1.3) | (1.4) | (1.3) |

### C.2.2 Earnings process

I mainly use the NLSY79 cohort to estimate moments related to earnings profiles because I observe their entire earnings history. The moment I target are means and variances of earnings at each life cycle, conditional on college attendance.

I deflate earnings to 2005 dollars using CPI-U, discard observations lower than 250 or higher than 250,000, and discount back to age 16, 24, and 40 for student, parent, and middle-aged stage using 4.08% annual interest rate. For student stage, I only consider those not attending college. For each individual, I take the average for his/her earnings in each life cycle stage as my measure of the model variables $y_t^s$, $y_{t+1}^p$, and $y_{t+2}^m$.

I also computed the same statistics using CPS ASEC 1997-2007 sample. The two measures are roughly consistent. CPS produces higher means for student and parent stage and lower means for middle-aged stage, possibly due to cohort effects. I use data moments calculated using NLSY79 sample for SMM estimation.

Tables 22, 23, and 24 compares the data moments calculated using the two samples. There are some differences that are expected, since NLSY79 is a panel sample following one cohort and CPS is a cross-sectional sample combining multiple cohorts during the same period of time.

Table 22: Means of earnings process

| Life cycle | Education | NLSY79 | CPS |
|---|---|---|---|
| Student | Non-college | 12.35 | 15.32 |
| | | (0.20) | (0.14) |
| Parent | Total | 28.52 | 33.21 |
| | | (0.33) | (0.11) |
| | Non-college | 24.97 | 27.26 |
| | | (0.34) | (0.11) |
| | College | 36.35 | 43.04 |
| | | (0.67) | (0.20) |
| Middle-aged | Total | 43.63 | 41.67 |
| | | (0.79) | (0.13) |
| | Non-college | 32.75 | 33.41 |
| | | (0.62) | (0.13) |
| | College | 67.65 | 53.58 |
| | | (1.84) | (0.24) |

Table 23: Variances of log earnings process

| Life cycle | Education | NLSY79 | CPS |
|---|---|---|---|
| Student | Non-college | 0.62 | 0.91 |
| Parent | Total | 0.39 | 0.52 |
| | Non-college | 0.38 | 0.49 |
| | College | 0.32 | 0.40 |
| Middle-aged | Total | 0.71 | 0.61 |
| | Non-college | 0.62 | 0.55 |
| | College | 0.57 | 0.56 |

Table 24: Correlation of log earnings process

| | Student | Parent |
|---|---|---|
| Parent | 0.52 | - |
| Middle-aged | 0.35 | 0.64 |

### C.2.3 Wealth distribution

In student stage, the only borrowing allowed in my model are student loans for those who attend college. Therefore, I use amount still owed on student loan debt instead of net worth as my measure of asset level. I use the NPSAS 2004 sample, accessed through NCES Datalab[1]. I only consider respondents in an associate or bachelor degree's program. The fraction with positive amount still owed on student loan debt in the NPSAS:UG 2004 sample is 46.7%. I also computed the fraction with non-zero educational loans in SCF 2004 for individuals aged 22 to 28. The two estimates are consistent with each other.

I also computed the percentages conditional on parental education. While the fraction with student loan debt is slight higher for students with non-college parents, the difference is not large, only around 2 percentage points.

Table 25: Percentage with student loan debt by parental education

| | NPSAS | SCF |
|---|---|---|
| Total | 46.7 | 47.4 |
| | (0.31) | (1.67) |
| Non-college parent | 47.9 | - |
| | (0.46) | - |
| College parent | 45.7 | - |
| | (0.43) | - |

For the parent stage, I used total family net worth as my measure of asset level. I use the NLSY97 cross-sectional sample and use their total family net worth around age 40. I divide net worth by two for married households and measure the fraction with negative net worth. I also calculate the fraction for college and non-college individuals.

I also compare the fraction using two different cohorts – NLSY79 and NLSY97. The

[1]https://nces.ed.gov/datalab/

fraction with negative net worth is higher for the NLSY97 cohort. In the NLSY79 cohort, the fraction indebted is lower for college-educated, but the same fraction is high, although not statistically significant, for the NLSY97 cohort. This finding is also consistent with the model implication that student loan debt increases likelihood of being indebted in later adulthood.

Table 26: Percentage with negative net worth during middle age by own education

| | NLSY79 | NLSY97 |
|---|---|---|
| Total | 9.4 | 15.0 |
| | (0.40) | (0.69) |
| Non-college | 11.5 | 13.9 |
| | (0.53) | (0.87) |
| College | 5.1 | 16.8 |
| | (0.52) | (1.13) |

To further investigate this findings, I also calculate the fraction with negative net worth during middle age depending on whether the individual had negative net worth around age 25. For both NLSY79 and NLSY97 cohorts, those who already have negative net worth at age 25. The fraction of individuals with negative net worth is higher for those who are already in debt at age 25 for both cohorts.

Table 27: Percentage with negative net worth during middle age by net worth at age 25, college individuals

| | NLSY79 | NLSY97 |
|---|---|---|
| Total | 5.1 | 16.8 |
| | (0.54) | (1.25) |
| Negative net worth | 15.8 | 29.4 |
| at age 25 | (2.39) | (2.86) |
| Positive net worth | 3.37 | 10.4 |
| at age 25 | (0.47) | (1.24) |

### C.2.4 Fertility

I use the NLSY79 cohort to estimate the data moments related to fertility since they have already gone through their child-bearing age.

### C.2.5 Home scores

I follow the procedure in Caucutt & Lochner (2020) to compute moments related to childhood investment using home score measures in the NLSY79 cohort. Since the home score is not linked to monetary values, I use a quadratic function to approximate the relation between childhood investment in dollars and the home score.

Following Caucutt & Lochner (2020), I denote the normalized home scores by $\phi$ and assume that home scores $\phi$ are determined by childhood investment $i_t^c$ (in units of dollars) by the quadratic function $\phi = \varphi_0 + \varphi_1 i_t^c + \varphi_2 (i_t^c)^2$. I include $\varphi_0$, $\varphi_1$, and $\varphi_2$ in SMM estimation.

### C.2.6 College expenditure

I use the NPSAS:UG 2004 sample to estimate college expenditures conditional on parental education. I use the average net price after all aid (including zeros). Table 28 summarizes the statistics by parental education and earnings. I use the expenditures conditional on parental education for my SMM estimation.

Table 28: College expenditures by parent characteristics

| | Net price after all aids (thousands of 2004 dollars) |
|---|---|
| By parent education | |
| Non-college | 5.64 |
| | (0.07) |
| College | 8.23 |
| | (0.10) |
| By parent income percentile | |
| 0 - 50 | 6.42 |
| | (0.09) |
| 50-90 | 9.55 |
| | (0.12) |
| 90-99 | 12.19 |
| | (0.27) |
| 99-100 | 14.07 |
| | (0.55) |
| Total | 6.89 |
| | (0.07) |