Self-Financing, Parental Transfer, and College Education*

Jungho Lee   Sunha Myong

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Abstract

We show that borrowing constraints can affect the human capital accumulation of college students by influencing students' labor supply. We document that many college students work a substantial number of hours at low-skilled jobs, and students who have fewer financial resources (in particular, parental transfer) tend to work more. By estimating a model that incorporates college students' labor supply and its interaction with parental transfer in the presence of borrowing constraints, we show that borrowing constraints explain 67% of working hours by college students and 64% of parental transfer. We discuss the implications of different types of financial subsidies for college students.

Keywords: College Education, Parental Transfer, Labor Supply, Intergenerational Mobility, Financial Constraints

JEL classification number: I22, I23, I24

*Jungho Lee: School of Economics, Singapore Management University, 90 Stamford Road, Singapore, 178903. Email: jungholee@smu.edu.sg. Sunha Myong: School of Economics, Singapore Management University, 90 Stamford Road, Singapore, 178903. Email: sunhamyong@smu.edu.sg.

1 Introduction

College education in the economics literature is often considered a lumpy investment. Decisions made during the college period, which could generate different trajectories of post-college labor outcomes, are abstracted in many economics models. One such decision is college students' labor supply. Working hours by college students have increased substantially over the past 40 years. Babcock and Marks [2011] show that the proportion of full-time students at four-year colleges who work more than 20 hours per week increased from 5% in 1961 to 17% in 2003. Over the same time period, the average number of hours that full-time students at four-year colleges spent in class and studying decreased from 40 to 27 per week. Given that an increase in working hours can substitute for the time for human capital accumulation, understanding college students' labor supply can shed light on human capital accumulation during college.

In this paper, we argue that borrowing constraints play an important role in labor supply by college students. Using panel data based on the US population, we first document facts that suggest financial necessity, rather than career development, is an important motive for college students' labor supply. First, a large number of college students work a substantial number of hours at low-skilled jobs. In our data, college students, on average, work 1,676 hours for the first 2 years after college enrollment. The most frequently observed job is cashier, followed by retail salesperson, waiter or waitress, private tutor, and nanny. Second, students who have fewer financial resources during college tend to work more. In particular, students from low-income families tend to work longer hours. Using a father's job-loss shock as an instrumental variable, we show that lower parental income leads to more working hours by students. Parental transfer seems to be the key mechanism in this negative relationship; once parental transfer is controlled for, we observe no significant relationship between parental income and students' working hours.

To quantify the role of borrowing constraints on college students' working hours and human capital accumulation, we develop a theory that explains how the interaction between college students' labor supply for self-financing and their parents' endogenous decision for transfer lead to heterogeneous human capital accumulation during college in the presence of borrowing constraints. In the model, altruistic parents first make a monetary transfer to the child, who then decides how much to invest in education and how much to work to finance her consumption/educational cost. We extend the Ben-Porath model to the college-financing problem, assuming that human capital accumulation during college depends not only on monetary investment, but also on time investment. We assume students can borrow only for education and not for consumption (a tied-to-investment constraint), which is an important feature of US student loans. The model is estimated by the method of simulated moments.

We find that monetary investment and the child's time investment are complementary in the human-capital-accumulation process. When loans are tied to an educational investment, most students have difficulty financing consumption during college. As a result, financing consumption is an important reason for self-financing. Parental transfer does not affect a child's human capital if the child is not financially constrained. However, if the child is financially constrained, parental transfer, although not tied to educational investment, can increase the child's monetary and time investment in human capital. The estimated model suggests that the tied-to-investment constraint explains 67% of the observed working hours by college students and 64% of the observed transfers from their parents during the college period.

We conduct two counterfactual policy experiments. First, we evaluate the impact of increasing a loan to college students that is not tied to educational investment. Specifically, we consider a policy that increases student loans by 5,000 USD per year without the tied-to-investment constraint. Such a policy resembles small loans provided by universities to students. Because consumption smoothing is an important motive for self-financing, increasing loans that are not tied to investment can affect students' human capital accumulation. We find that additional loans for consumption decrease students' working hours and increase their human capital. This tendency is more pronounced for high-ability students from low-income families, because those students are previously most constrained. Parents know their transfer can be substituted for by the additional loans, and reduce the transfer accordingly.

The Federal Work-Study program in the US provides part-time jobs for students with financial needs, allowing them to earn money to help pay their education expenses. Government subsidy is essential for the work-study program, because the federal government finances a large fraction of wages.[1] As the second policy experiment, we consider a work-study program in the form of wage subsidy. Specifically, we provide a 2 USD subsidy for every working hour during college.

Different from the first policy, in which students from all family backgrounds reduce working hours, some students, especially from high-income families, increase their working hours in response to the wage subsidy. When the wage increases, two opposite forces come into play. First, the higher wage tends to substitute hours for human capital for hours for self-financing. Second, the higher wage means the income of the student increases, and hence decreases the marginal value of self-financing. For students from high-income families, the first effect (substitution effect) tends to dominate the second effect (income effect), and students tend to increase their working hours. Parental transfers decrease for all parental-income levels.

The reason behind parents' response, however, is quite different between the two policies. In the first loan policy, the marginal return of parental transfer decreases because relaxing borrowing constraints for consumption due to additional loans reduces students' need for self-financing, which, in turn, reduces the marginal impact of parental transfer on the child's utility and human capital. However, the child's response to the policy can partially counteract additional crowd-out by parents, because the child will work less (and hence invest *more* in human capital), which increases the return to parental investment on the child's human capital. On the other hand, when the wage subsidy is implemented, the marginal return of parental transfer decreases, not only because parents know

[1] Although the exact share varies by institution, the government can finance a maximum 75% of the salary paid to the student.

their children will need less financial help because of the increased labor earnings, but also because the children, especially from high-income families, will work more (and hence invest *less* in human capital). Overall, a wage subsidy, although intended to help college students, can be detrimental to the human capital of students from high-income families.

This paper is related to the literature on human capital investment and intergenerational mobility. Since Becker and Tomes [1979, 1986], the question of whether and how credit constraints affect human capital investment and intergenerational mobility has been central in the literature. Earlier findings indicate that credit constraints are not major determinants for college attendance (e.g., Cameron and Heckman [1998]; Keane and Wolpin [2001]; Cameron and Taber [2004]; Ionescu [2009]), whereas studies using recent data suggest that credit constraints play an important role in college enrollment (e.g., Lochner and Monge-Naranjo [2011, 2012, 2016]; Hai and Heckman [2017]). Most previous papers, however, do not consider the possibility that college students can self-finance by working while in college. Keane and Wolpin [2001] and Garriga and Keightley [2007] allow such a possibility, but they abstract from the endogenous response by parents when their child has to work in the presence of credit constraints. The main contribution of this paper is to show how credit constraints interact with parental transfer and labor supply by college students and contribute to heterogeneity in human capital accumulation during college. Relatedly, Brown et al. [2011] and Abbott et al. [2019] discuss the implications of endogenous parental transfer on college-enrollment decisions. Our paper complements their findings in two important ways. First, we show that the strategic interaction between parents and a child affects not only college enrollment but also human capital accumulation during college. Second, we show that understanding college students' labor supply is important for understanding the impact of financial aid policies on students' human capital accumulation and parental transfer.

The paper proceeds as follows. Section 2 discusses data and motivating facts. Section 3 describes the model. Section 4 explains estimation and identification of the model. Section 5 discusses results, and Section 6 concludes.

2 Facts about Labor Supply by College Students

In this section, we explain the data sets for this study and document some facts related to students' labor supply during college.

2.1 Data

National Longitudinal Survey of Youth 1997 (NLSY97)

We use the NLSY97 as our main data set. This is a panel data set from a nationally representative sample of youths who were 12 to 17 years old as of December 31, 1996. The data include detailed information on how students finance the cost of postsecondary education since 1997. First, we observe the total amount of loans taken out by students. Loan data from the NLSY97 represent the answer to the following question: "Other than assistance you received from relatives and friends, how much did you borrow in government subsidized loans or other types of loans while you attended this school/institution?" As the question clearly indicates, students are asked to report all student loans, including private loans obtained to attend the school. We use the total amount of loans students take out for higher education (up to three institutions at one time) in our analysis. Second, we also observe the amount of transfer from parents to children (which children are not supposed to repay). Note that the NLSY97 collects information on lending from parents, separately from parental transfer. Therefore, the amount of transfer from parents we focus on is not likely to be involved with the repayment commitment. Third, the NLSY97 provides the amount of grants from either government or college.[2]

In addition to funding information, the NLSY97 reports working hours and types of jobs while enrolled in college and labor earnings during and after college. The data also include students' demographic characteristics, cognitive test score (the Armed Forces Qualification Test (AFQT) score),

[2]The survey collected how students finance college education for each term, year, and college. Because financing information for other than the first term has too many missing observations, we impute annual data for educational financing by multiplying the financing variable for the first term by the number of terms for each academic year. For example, if the college has a trimester system, we multiply the term-one financing variables by 3 to construct the annual data.

parents' income, and students' enrollment history and the highest degree obtained.

To focus on college students with similar characteristics, we keep observations for those who ever attended a four-year college.[3] The original sample consists of 8,984 individuals born between 1980 and 1984. We first drop 1,891 individuals without valid AFQT scores. We drop 4,098 individuals who did not attend a four-year college. We drop an additional 1,010 individuals without valid information on parental transfer, student loans, grants, or other types of financial assistance. We also drop 94 individuals who do not have valid information on their labor supply during the first 2 years of college education. Finally, we drop 60 individuals who do not have valid information on labor earnings between ages 26 and 30, and drop 36 individuals without valid parental income during ages 18-25. The resulting sample consists of 1,795 individuals. All monetary amounts are denominated in 1997 USD using the Consumer Price Index (CPI).

Survey of Income and Program Participation (SIPP)

To supplement the NLSY97, we use the Survey of Income and Program Participation (SIPP), which is a nationally representative household-based survey of the US population. Each SIPP panel follows a large number of respondents, ranging from approximately 14,000 to 36,000, for 3 or 4 years. We use the 1996, 2001, 2004, and 2008 panels. In SIPP, eligible household members were interviewed every 4 months using questions about, for example, college-enrollment status, weekly working hours, monthly income, and demographic characteristics such as race and sex. Because the SIPP is a household-based survey, we can merge students' information with their parents' information. The SIPP also asks the main reason surveyed individuals stopped working, which we used to construct a parental-income shock we will explain later. We keep observations for those who were enrolled in either college or graduate school at the time of the interview. All monetary amounts are denominated in 1997 USD

[3]Students in two-year colleges often focus on vocational and technical education. While enrolled, they may work in jobs closely related to their career development. By contrast, four-year college students often work due to financial necessity, rather than for career development, as we document below.

using the CPI.

2.2 Working While in College

In Table 1, we first document the summary statistics for individuals' working hours after college enrollment. College students, on average, work 769 hours for the first year, 1,676 hours for the first 2 years, and 3,867 hours for the first 4 years after they start their college education. If we instead look at the median, students work 627 hours for the first year, 1,445 hours for the first 2 years, and 3,532 for the first 4 years. This finding implies that more than half of the students work more than 12 hours ($\frac{627}{52}$) per week over the first year after college enrollment, and the working hours are not concentrated within a particular year after college enrollment. We also check working hours during college by using more detailed data, such as weekly working hours and monthly enrollment status, to exclude working hours during which students are not enrolled in a program. We find a similar pattern in Table 1.[4]

Next, we document the type of jobs a typical student works. Figure 1 shows the occupation composition of all jobs reported by college students when they were enrolled in a four-year undergraduate program. Based on the 3-digit code of the 2000 Standard Occupation Classification, we calculate the share of jobs in each occupation. We exclude internships from this analysis, which account for 5.3% of jobs for college students. Across 509 occupations, 10 occupations account for 37% of jobs held by college students. The most frequently observed job is cashier, followed by retail salesperson, waiter or waitress, private tutor, and nanny.

To understand the source of heterogeneity in students' working hours, we conduct a linear regression for students' working hours with respect to students' ability (the AFQT score), parental income, and the amount of grants students receive. The first column of Table 2 shows the results. A student with

[4] A similar pattern is found in other data sets as well. By using the October Supplement of the Current Population Survey (CPS), Planty et al. [2007] find that about half of full-time students and 85% of part-time college students ages 16–24 were employed in 2005. In their analysis, full-time college students are defined as students who enroll in 2- or 4-year colleges and take at least 12 hours of classes per week. They also find that about 21% of full-time students work 20–34 hours per week, 9% of full-time students work 35 or more hours per week, and 47% of part-time students work more than 35 hours per week.

higher ability, more grants, or from a high-income family tends to work less. In the second column of Table 2, we additionally control for parental transfers. First, the magnitude of the coefficient for parental transfer is as high as the coefficient for grants. Second, as long as we control for parental transfers, no significant association exists between parental income and students' working hours. This finding implies that the negative relationship between parental income and working hours in the first column of Table 2 is mainly due to wealthy parents providing more transfers.

The relationship between parental transfer and working hours in Table 2 is in line with two explanations. First, some students work a lot because their parents give them fewer resources. Another interpretation for the negative correlation between parental transfer and students' working hours is that parents give more money to those who study more (or work less). If this is true, parental transfers are not the reason for the high number of working hours; rather, they are a consequence of students' working decisions.

To check whether a lack of parental transfer is indeed a reason for students' working, we use the SIPP. Every 4 months, the SIPP asks the main reason any surveyed individual stopped working. Possible answers include the following: (1) Discharged/fired, (2) Employer bankrupt, (3) Employer sold business, and (4) Slack work or business conditions.[5] We first construct a dummy variable (i.e., job-loss shock) that takes a value of 1 if the reason the individual stopped working is one of the four choices. Given that the SIPP does not provide parental transfer information, we use the father's job-loss shock in the previous 4 months as an instrumental variable (IV) for parents' monthly income.[6]

The first column of Table 3 shows the results from the first-stage regression. We also control for the year fixed effect, dummy variables for students' race and sex, and having a grant or not. The father's job-loss shock in the previous period, on average, leads to a 1,755 USD decrease in monthly

[5]Other answers include retirement or old age, childcare problems, other family/personal obligations, own illness, own injury, school/training, job was temporary and ended, quit to take another job, unsatisfactory work arrangement, and quit for some other reason.

[6]Stevens and Schaller [2011] construct a similar variable and investigate the short-run effects of parental job loss on children's academic achievement.

parental income in the current period. Note that the mean and median monthly parental income are 4,328 USD and 3,249 USD, respectively. Therefore, the magnitude of father's job-loss shock is about 41% ($\frac{1{,}755}{4{,}328} \times 100$) of the mean monthly parental income and 54% ($\frac{1{,}755}{3{,}249} \times 100$) of the median monthly parental income. To check whether the father's job-loss shock is random across families, we regress parents' income on the father's job-loss shock in the *future* (in the next 4-month period). Parental income for those who will be hit by the job-loss shock and those who will not do not differ in the current period, suggesting that the main reason parental income becomes smaller is the father's job-loss shock in the previous period.

In Table 4, we report IV regression estimates. The coefficient for parental income is estimated at -0.00186 and statistically significant, suggesting a 1,000 USD higher parental income leads to about 2 fewer weekly working hours. Overall, we conclude that parental income is an important determinant for students' working decisions during college. Combining this result with the findings in Table 2, we believe parental transfer is the key mechanism behind this result; those with fathers who hit a job-loss shock will receive less transfer from their parents and will need to work more.

In summary, a large number of college students work a substantial number of hours at low-skilled jobs, and students who have fewer resources (especially parental transfers) work more.

2.3 Discussion

Students may face financial constraints while enrolled in college. Government and private loans are available for college students, but these loans are explicitly tied to educational investment. Federal student loans cannot exceed the cost of attendance (including tuition, fees, costs for room and board, books, supplies, transportation, and rental or purchase of a personal computer) less any financial aid.[7] Students might take additional loans from the private sector, but the borrowing limits for most private

[7] The office of Federal Student Aid gives an example. Consider a student whose cost of attendance (COA) is $16,000 and who has received $4,000 in need-based aid and private scholarships. This student would be eligible for a maximum of $12,000 non-need-based aid from the government, such as unsubsidized student loans.

loans also do not exceed school-certified college cost net of financial aid from all sources (Ionescu and Simpson [2016]).[8] As a result, students may not be able to borrow more than the cost of attendance specified in the financial-award letter.

However, college expenses are not limited to the cost of attendance specified in the financial-award letter, but also include other consumption such as entertainment, travel unrelated to school, a car, and clothes. For example, Stinebrickner and Stinebrickner [2008] show that short-run credit constraints, especially those that limit consumption smoothing between the college and working period, contribute to a higher college dropout rate.[9] The empirical findings in Section 2.2 support the view that the reason college students work so many hours is to self-finance for consumption, in addition to tuition, during college.

When students have to work a substantial number of hours, the time for studying can be limited and the academic outcome can be negatively affected. In Figure 2, we depict the binned scatter plot for dropout probability (upper panel) and the probability of attending graduate school (lower panel) with respect to first-year working hours after college enrollment. The relationship between dropout probability and working hours is less pronounced for those who work fewer than the median hours, but dropout probability increases sharply for those who work more than the median hours. Similarly, the probability of attending graduate school decreases sharply for those who work more than the median hours.

The findings in Figure 2 are in line with previous studies on the relationship between labor supply during college and students' outcomes. By accounting for the dynamic selection problem associated with unobservable heterogeneity, Hotz et al. [2002] find a potentially detrimental effect (insignificant or negative effect) of working during college on the wage rate after graduation. On the other hand,

[8] According to a National Center for Education Statistics (NCES) report (Woo and Velez [2016]), the proportion of college students who took private student loans is about 5% in 2004, 14% in 2007-2008, and 6% in 2011-2012.

[9] Focusing on students from low-income families at Berea College, Stinebrickner and Stinebrickner [2008] find that about 20% of students are credit constrained and would like to take additional loans to increase consumption other than college-related costs. The estimated proportion of attrition by the beginning of the second year of college due to credit constraint ranges from 13% to 33%.

Ehrenberg and Sherman [1987] find that on-campus jobs have a positive effect on academic outcomes, whereas off-campus jobs have a negative effect, which suggests heterogeneous effects of self-financing by type of job.[10] More direct evidence is found in Stinebrickner and Stinebrickner [2003], who address the endogeneity problem regarding students' labor supply by using an IV based on the mandatory work-study program at Berea College (a liberal arts college in Kentucky). They find that additional working hours during college can have a quantitatively large and statistically significant negative effect on students' academic achievement.

Given that self-financing due to financial friction can be an important reason for students' working decisions, and that too many working hours can negatively affect students' academic outcome, a policy reducing students' labor supply could improve human capital accumulation during college. To better understand the policy implication and to quantify the role of borrowing constraints on students' working hours and human capital accumulation, we develop a theory of college students' working decisions in the next section.

3 The Model

In this section, we provide a theory that can rationalize the observed pattern of students' working hours during college. Because parental transfer is important in determining students' working hours, we explicitly model the interaction between college students' labor supply and their parents' endogenous decision to transfer in the presence of borrowing constraints.

3.1 Environment

A family consists of parents and a child. They live two periods: the child's college period and the child's working period. The parents are altruistic and hence receive utility from their child's utility, but the child cares only about herself. The parents first make a transfer to the child before the college

[10] Light [2001] finds that students gain skills not only from in-class experience, but also from on-the-job training in the labor market. Because Light's study is based on total work experience during the schooling period, including high school and college, isolating the impact of college-period labor supply on students' outcomes is difficult.

period starts, and then the child decides how much money to invest in college education, how many student loans to take out, and how many hours to work during the college period. We abstract from the post-schooling transfer from the parents to the child. The per-period utility from consumption (c) of the parents and the child is given by $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$. A child is characterized by her ability $A \in \mathbb{R}_+$ and an unobserved characteristics $\epsilon \in \mathbb{R}_+$ (which we explain below), and parents are characterized by their income $x_p \in \mathbb{R}_+$ and an altruistic preference $\alpha \in \mathbb{R}_+$.

The child's self-financing can reduce the financial burden of the child and the parents, but it may have a negative impact on the child's human capital accumulation. Human capital accumulation from a college education (h) is a function of three components: the child's ability, monetary investment (m_k),[11] and the time/effort the student puts into the college education. In line with the Ben-Porath model, the child needs to invest time to accumulate human capital. We further assume that child ability is complementary to monetary and time investment in the following form:

$$h = h_0 + A\big\{m_k^{\gamma} + (T - \epsilon n_k)^{\gamma}\big\}^{\frac{\rho}{\gamma}}, \quad \rho < 1. \tag{1}$$

T represents the time endowment for higher education, which is the same for all individuals. n_k is the working hours during the college period. The child's time investment decreases as she works more toward self-financing.[12] The extent to which working hours affect human capital accumulation depends on ϵ, the unobservable characteristic of the child. Stinebrickner and Stinebrickner [2003] emphasize the importance of controlling for unobserved heterogeneity that affects both working hours and academic outcome. We allow such unobserved heterogeneity in the form of ϵ, which can be interpreted as an individual's intrinsic "motivation": Highly motivated students (students with a low ϵ) learn better than students who are not motivated (students with a high ϵ), given the same number of working

[11] We will discuss possible interpretations of m_k in Section 3.2.

[12] The relationship between human capital and working during college may be nonmonotonic. Working as a cashier can be a valuable experience for students, but if too many hours are spent in such a job, a student may lose other opportunities to increase human capital. We only model this negative relationship.

hours. Therefore, the marginal cost of working is smaller for highly motivated students than for less motivated students, and highly motivated students tend to work more than less motivated students.

We assume $\rho < \gamma$ to guarantee that the optimal level of human capital is finite. h_0 is the initial human capital stock before the college education. We assume $h_0 = \overline{h} + \delta A$, so that the initial human capital stock depends on the child's ability.

To finance the college cost—both the direct cost and consumption—the child can take out student loans (d_k), but student loans are strictly tied to educational spending, which we call the "tied-to-investment constraint." Thus, the child might face a credit constraint to finance consumption during the college period. The parents have access to a complete credit market. Note that the novel mechanism in our model still applies to the conventional fixed borrowing constraint. The reason we model a financial constraint as tied to investment is because we consider it to be a more realistic and relevant constraint for college students, as discussed in Section 3.2.

We first consider the child's problem. Given her parents' transfer (m_p), the child maximizes her lifetime utility by choosing the first- and second-period consumption $\{C_{k1}, C_{k2}\}$ and $\{n_k, m_k, d_k\}$:

$$\max_{\{C_{k1}, C_{k2}, n_k, m_k, d_k\}} u(C_{k1}) + \beta u(C_{k2}) \quad \text{subject to}$$

$$C_{k1} + m_k \leq w n_k + d_k + m_p$$

$$C_{k2} + R d_k \leq h_0 + A\left\{m_k^\gamma + (T - \epsilon n_k)^\gamma\right\}^{\frac{\rho}{\gamma}}$$

$$d_k \leq m_k, \quad m_k > 0, \quad n_k \geq 0, \quad T - \epsilon n_k > 0.$$

R and w are the risk-free gross interest rate and wage, respectively. The tied-to-investment constraint is described as $d_k \leq m_k$.

Knowing how the child behaves given parental transfer, the parents maximize their lifetime utility and their child's value by choosing the first- and second-period consumption $\{C_{p1}, C_{p2}\}$, transfer (m_p), and amount of savings (a_p):

$$\max_{\{C_{p1},C_{p2},m_p,a_p\}} u(C_{p1}) + \beta u(C_{p2}) + \alpha V_k \quad \text{subject to}$$

$$C_{p1} + m_p + a_p \leq x_p$$

$$C_{p2} \leq Ra_p, \quad m_p \geq 0,$$

where V_k is the value from the child's problem. α captures the extent of the parents' altruistic preference.

Let $s_k = (m_k, n_k, d_k, C_{k1}, C_{k2})$ be the strategy of the child and let $s_p = (m_p, a_p, C_{p1}, C_{p2})$ be the strategy of the parents. Let V_p be the value from the parents' problem. Let $s_k(s_p)$ be the best response of the child given the parents' strategy s_p. The subgame perfect Nash equilibrium is $\{s_k^*, s_p^*\}$ such that $V_k(s_k^*, s_p^*) \geq V_k(s_k, s_p^*)$ for all $s_k \neq s_k^*$ and $V_p(s_p^*, s_k^*(s_p^*)) \geq V_p(s_p, s_k^*(s_p))$ for all $s_p \neq s_p^*$.

3.2 Discussion

We impose a few assumptions to render our model tractable and parsimonious. Before characterizing the model, we discuss the limitations and justifications for such assumptions.

First, we assume that human capital accumulation during college depends on the amount of monetary investment. Allowing heterogeneous monetary investment by college students is different from most previous studies, which take college education as a lumpy investment with a fixed amount of cost. We take a different approach, for the following reasons. First, the various choices student make about a college education, such as whether to graduate or drop out, which college to attend, how many credits to take, and how much to spend on books and supplies, lead to different educational spending. Second, heterogeneous monetary spending can be an important input for human capital accumulation during college. For instance, we find that college tuition is positively correlated with the quality of peers, as measured by the SAT score, the research capacity as measured by the highest degree offered by the institution, or the Carnegie Classification of Institutions of Higher Education (Figure 3).[13] Also, from the NLSY97, we find that the average labor income between ages 26 and 30 is positively correlated with a proxy for monetary investment during college, measured by the sum of student loans, parental transfer, grants, and other assistance. To account for potential differences in the returns to monetary investment by type of college, in Appendix A we allow the relationship between monetary investment and human capital accumulation to differ between public and private colleges.

Second, we assume parents are altruistic, but we abstract from other motives such as the exchange motive (Light and McGarry [2004]). Because most papers on inter vivos transfers mainly rely on altruism (e.g., Becker and Tomes [1986]; Restuccia and Urrutia [2004]; Brown et al. [2011]), we follow previous studies to emphasize our novel mechanism regarding self-financing and parental transfer. In addition, from the Health and Retirement Study (HRS), we find that the upstream transfer made by the child is small; The median amount of transfer from the child is about 1,000 USD over 2 years.[14] Also, the child with a higher opportunity cost in the labor market is less likely to provide informal care for elderly parents (McGarry [1998]). Thus, the exchange motive might not play a quantitatively important role in explaining parental transfer for the child's college education.[15]

Relatedly, we abstract from contracts between parents and child that allow informal lending and borrowing. As discussed in Section 2.1, the NLSY97 collects information on lending from parents separately from parental transfer. We find that the amount of lending from parents is negligible. Also, unlike formal lending, credible threats by lenders (parents) to borrowers (children) may not be feasible. Hence, the limited-commitment problem between parents and children can be substantial,

[13]For this analysis, we use the Integrated Postsecondary Education Data System (IPEDS) 2004.

[14]The distribution of monetary transfer from the adult child to parents is largely skewed to the right. Although the mean is 2,555 USD, due to less than 1% of children making a transfer of more than 25,000 USD to the parents, about 27% of children give less than 500 USD to parents over 2 years.

[15]Brown et al. [2011] consider parental transfers both during and after schooling periods. We abstract from parents' post-schooling transfer, given that information on parents' post-schooling transfer is not available in the NLSY97. Empirically, Haider and McGarry [2012] show that parental transfer made after the child's schooling period is not correlated with the transfer made during the schooling period.

and parents may not want to enter a formal lending contract with their children.

Third, we abstract from leisure. Although students work for financing, they may reduce their leisure time and not sacrifice study time. From the 2004 American Time Use Survey, however, we find that a student's study time significantly decreases with working hours (Appendix B). As a robustness check, we incorporate leisure in our baseline model and re-estimate the model in Appendix A.

Finally, our model focuses only on the tied-to-investment constraint. In doing so, we abstract the financial friction parents may face. In our model, although parents have access to a complete credit market, they may not completely relax the borrowing constraint their child faces, because their child will never pay them back. Parental transfers in our model are driven by an altruistic motive. For low-income parents, the marginal cost of transfer, which is the forgone marginal utility of consumption, is high; therefore the transfer of low-income parents is, on average, smaller than that of high-income parents, even without financial constraint for parents. Therefore, incorporating a fixed borrowing constraints for parents would not change our results significantly. Another simplification is that students cannot borrow for consumption. Although being tied to investment is the important feature of US student loans, in reality some students may use credit cards to finance additional consumption. However, the amount of credit-card borrowing during college is limited in the data. For example, in the SIPP 2004, we observe that 25% of students use credit cards, and the average credit-card borrowing is 2,785 USD for college students with positive credit-card debt. As a robustness check, we allow borrowing that is not tied to educational investment and re-estimate the model in Appendix A.

3.3 Equilibrium without Tied-to-investment Constraints

We first analyze a situation in which the tied-to-investment constraint is not binding. In this case, the child can borrow beyond her educational investment to increase consumption. To explain the key mechanism of our model clearly, we focus on an interior solution of the model. Assuming an interior solution, the optimality conditions imply

$$\frac{\partial h}{\partial m_k} = \rho A\big\{m_k^\gamma + (T - \epsilon n_k)^\gamma\big\}^{\frac{\rho}{\gamma}-1} m_k^{\gamma-1} = R$$
$$-\frac{\partial h}{\partial n_k} = \epsilon\rho A\big\{m_k^\gamma + (T - \epsilon n_k)^\gamma\big\}^{\frac{\rho}{\gamma}-1} (T - \epsilon n_k)^{\gamma-1} = Rw.$$

Combining the above two equations, we get

$$T - \epsilon n_k^* = \big(\frac{\epsilon}{w}\big)^{\frac{1}{1-\gamma}} m_k^*.$$

Without the constraint, the child chooses the m_k that equalizes the marginal gain in human capital to the interest rate. Similarly, the child chooses n_k so that the marginal cost of self-financing that reduces human capital is equalized to the marginal benefit of self-financing that increases income by Rw. Equalizing the marginal return from monetary and effort investment implies that labor supply during college by the child decreases as the total monetary investment in education increases.

The optimal monetary and time investments are

$$m_k^* = K_1 A^{\frac{1}{1-\rho}} \quad (2)$$

$$T - \epsilon n_k^* = \big(\frac{\epsilon}{w}\big)^{\frac{1}{1-\gamma}} K_1 A^{\frac{1}{1-\rho}}, \quad (3)$$

where $K_1 = \Big[\frac{\rho}{R}\Big\{1 + \big(\frac{\epsilon}{w}\big)^{\frac{\gamma}{1-\gamma}}\Big\}^{\frac{\rho}{\gamma}-1}\Big]^{\frac{1}{1-\rho}}$. The optimal monetary and time investments increase as ability increases. By combining (2) and (3) with the human capital production function (1), we get the optimal human capital

$$h^* = h_0 + K_2 A^{\frac{1}{1-\rho}},$$

where $K_2 = K_1^\rho\{1 + \big(\frac{\epsilon}{w}\big)^{\frac{\gamma}{1-\gamma}}\}^{\frac{\rho}{\gamma}}$. Note that the optimal level of human capital also increases as ability increases.

Now consider the parents' problem. Note that without borrowing constraints, the child can always optimally borrow to finance education and consumption. Therefore, without borrowing constraints, parental transfer does not affect the child's human capital. Altruistic parents make a transfer to equalize the marginal utility from consumption across generations:

$$u'(\frac{x_p - m_p}{1+\Omega}) = \alpha u'(\frac{h^*/R - m_k^* + wn_k^* + m_p}{1+\Omega}),$$

where $\Omega = \beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}}$. Without borrowing constraints, parental transfer is driven by the compensating motive. Because the child's lifetime income $(h^*/R - m_k^* + wn_k^*)$ increases by A,[16] parental transfer decreases by A, because the marginal utility from transfer decreases as ability increases. As a result, parental transfer decreases by the child's ability A without borrowing constraints.

3.4 Equilibrium with Tied-to-investment Constraints

The optimal loan amount can be written as

$$d_k^* = \frac{(\beta R)^{-\frac{1}{\sigma}} h^* + (m_k^* - wn_k^* - m_p)}{1+\Omega^{-1}}. \tag{4}$$

The child faces binding borrowing constraints if $d_k^* > m_k^*$, which is equivalent to

$$(\beta R)^{-\frac{1}{\sigma}} h_0 + K_3 A^{\frac{1}{1-\rho}} > \frac{wT}{\epsilon} + m_p,$$

where $K_3 = \{\left(\frac{\epsilon}{w}\right)^{\frac{\gamma}{1-\gamma}} - \Omega^{-1}\} K_1 + (\beta R)^{-\frac{1}{\sigma}} K_2$. It is straightforward to verify that K_3 is a positive number. Therefore, the tied-to-investment constraint is more likely to bind for high-ability students.

[16] Consider two individuals, A and B, who are identical except for their ability. Suppose B's ability is higher than A's. Denote $\{m_k^A, n_k^A\}$ to be the optimal choices of individual A, at which A is maximizing her lifetime utility. Note that without borrowing constraints, maximizing lifetime utility implies maximizing lifetime income. Suppose B's choice is the same as $\{m_k^A, n_k^A\}$, which is feasible for B without borrowing constraints. Even in this case, the lifetime income for B is greater than A because w is homogeneous and B's human capital is greater than A's with identical inputs. Because (m_k^B, n_k^B) maximizes B's lifetime income, whereas (m_k^A, n_k^A) is in the feasible set for B, (m_k^B, n_k^B) is weakly better than (m_k^A, n_k^A). Therefore, B's lifetime income is greater than A's lifetime income without borrowing constraints.

If the tied-to-investment constraint binds, $d_k = m_k$. Then the child's problem becomes

$$\max_{\{n_k, m_k\}} u(wn_k + m_p) + \beta u(h - Rm_k) \quad \text{subject to} \quad \text{equation (1)}.$$

The first-order conditions with respect to m_k and n_k are

$$\frac{\partial h}{\partial m_k} = R \tag{5}$$

$$wu'(wn_k + m_p) = \beta\big(-\frac{\partial h}{\partial n_k}\big)u'(h - Rm_k). \tag{6}$$

Because the tied-to-investment constraint does not limit educational borrowing by the child, the child always invests in education until the marginal return is equal to the interest rate, as shown in equation (5). However, importantly, the marginal return $\frac{\partial h}{\partial m_k}$ is endogenous, depending on the child's labor supply. Because optimal consumption smoothing is not achieved, the marginal benefit of working while in college is greater than wR ($-\frac{\partial h}{\partial n_k} > wR$). If the child cannot finance consumption from borrowing, the marginal return from self-financing increases, and the child works more than the optimal level to finance consumption.

As we can see in equations (5) and (6), with a binding tied-to-investment constraint, parental transfer can affect the child's investment and human capital. By relaxing borrowing constraints for the child's consumption, additional parental transfer reduces self-financing, which in turn increases time investment in human capital. Because the marginal return from monetary investment increases by the student's time/effort investment, additional parental transfer can also increase the child's monetary investment. Therefore, although parental transfer is not tied to educational spending, it can increase time and monetary investment in education.

Specifically, the marginal impact of parental transfer on child's value V_k, with a binding tied-to-investment constraint, can be represented as

$$\frac{dV_k}{dm_p} = \underbrace{\frac{\partial V_k}{\partial m_p}}_{\text{(I)}} + \underbrace{\frac{\partial V_k}{\partial h}\frac{\partial h}{\partial m_p}}_{\text{(II)}>0 \text{ if } d_k = m_k} . \tag{7}$$

In contrast to the one without the tied-to-investment constraint, the second term is added. Parental transfer can increase child utility by increasing child lifetime income, and hence consumption, as described in part (I) of equation (7). As discussed before, without the tied-to-investment constraint, the amount of parental transfer *decreases* as ability increases, because a high-ability child is relatively richer than the parents. However, when the constraint binds, parental transfer can increase child utility by increasing child investment and human capital, as described in part (II) of equation (7). If the second term is increasing with respect to child ability, the amount of parental transfer can *increase* as ability increases.

To illustrate the possibility that parental transfer can increase as child ability increases, in Figure 4 we simulate a child's monetary investment and labor supply with respect to parental transfer when the tied-to-investment constraint binds.[17] First, parental transfer, although not tied to educational investment, increases both monetary investment and effort by the child. Second, the elasticity of the child's investment (either monetary or effort) with respect to parental transfer is higher for high-ability students. As a result, $\frac{\partial h}{\partial m_p}$ can increase as a child's ability increases in our model.[18]

[17] We use the estimated model for the simulation.

[18] Self-financing is essential for generating the positive correlation between parental transfer and child ability. A binding tied-to-investment constraint without self-financing cannot create the positive-ability gradient of parental transfer. Consider the following problem without the option of self-financing (i.e., $n_k = 0$):

$$\max_{\{m_k\}} \quad u(m_p) + \beta u(h - Rm_k) \quad \text{subject to} \quad \text{equation (1)}.$$

Hence, consumption during college depends only on m_p when the tied-to-investment constraint is binding. The first-order condition with respect to the child's monetary investment implies $\frac{\partial h}{\partial m_k} = R$, which is independent of m_p. Parental transfer increases the child's utility, but it does not affect the child's monetary investment. Thus, without the option of self-financing, part (II) in equation (7) is zero. On the other hand, part (I) in equation (7) increases with the binding constraint, because parental transfer can relax the credit constraint for consumption and increase consumption during college. However, without self-financing, $\frac{\partial V_k}{\partial m_p} = u'(m_p)$, which is independent of A. Without self-financing, neither part (I) nor part (II) increases by child ability, even though the constraint binds. Therefore, the interaction between credit constraint, self-financing, and time investment in human capital accumulation is essential to the positive correlation between parental transfer and child ability.

To summarize, (i) without the tied-to-investment constraint, the parental transfer does not affect the child's human capital, and parental transfer decreases by child ability. (ii) If the tied-to-investment constraint binds, although the child can fully finance educational investment, monetary investment by the child will be lower than the one without borrowing constraints, because additional self-financing can decrease returns to monetary investment. (iii) If the tied-to-investment constraint binds, parental transfer can increase the child's human capital by making the child reduce self-financing and increase monetary investment, and this effect is more pronounced in high-ability students.

4 Quantitative Framework

4.1 Life-cycle Model

In our empirical analysis, we estimate the following life-cycle model. The child lives and consumes for $t = 1, \cdots, N$. The first period is the schooling period, and the child decides schooling investment m_k and labor supply n_k given parental transfer m_p. To account for grants, we modify the human capital function such that the total monetary investment is $m_k(1+s)$, where s represents the rate of grants per dollar investment: $h = h_0 + A\Big\{\big(m_k(1+s)\big)^\gamma + (T - \epsilon n_k)^\gamma\Big\}^{\frac{\rho}{\gamma}}$. The child works for $t = 2, \cdots, N_w$ and earns $h(1+g)^{t-2}$ in period t, where g is the growth rate of human capital associated with experience. The retirement period is $t = N_w + 1, \cdots, N$. The child can borrow only for educational investment during period 1, but has access to the complete credit market from $t \geq 2$. The child solves the following problem by choosing $\{C_{kt}\}_{t=1}^N$, m_k, d_k and n_k:

$$\max_{\{\{C_{kt}\}_{t=1}^N, m_k, d_k, n_k\}} \sum_{t=1}^{N} \beta^{t-1} u(C_{kt}) \quad \text{subject to}$$

$$C_{k1} + m_k \leq w n_k + d_k + m_p$$

$$\sum_{t=2}^{N} \frac{C_{kt}}{R^{t-2}} \leq \sum_{t=2}^{N_w} \frac{h(1+g)^{t-2}}{R^{t-2}} - R d_k$$

$$h = h_0 + A\Big\{\big(m_k(1+s)\big)^{\gamma} + (T - \epsilon n_k)^{\gamma}\Big\}^{\frac{\rho}{\gamma}}$$

$$d_k \leq m_k, \quad m_k > 0, \quad n_k \geq 0, \quad T - \epsilon n_k > 0.$$

Without the tied-to-investment constraint, we have $C_{kt+1} = (\beta R)^{\frac{1}{\sigma}} C_{kt}$, for $t = 1, \cdots, N-1$. The child's problem can be written as

$$\max_{\{m_k, d_k, n_k\}} u(w n_k + m_p + d_k - m_k) + \beta \Sigma_1 u(\frac{\Sigma_2 h - R d_k}{\Sigma_1})$$

$$\text{subject to}$$

$$h = h_0 + A\Big\{\big(m_k(1+s)\big)^{\gamma} + (T - \epsilon n_k)^{\gamma}\Big\}^{\frac{\rho}{\gamma}}$$

$$m_k > 0, \quad n_k \geq 0, \quad T - \epsilon n_k > 0,$$

where $\Sigma_1 = \frac{1-(\beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}})^{N-1}}{1-\beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}}}$ and $\Sigma_2 = \frac{(1-(\frac{1+g}{R})^{N_w-1})}{1-\frac{1+g}{R}}$. Then the optimal investment and human capital become

$$m_k^* = \Big[A\Sigma_2\Big]^{\frac{1}{1-\rho}} K_1$$

$$T - \epsilon n_k^* = (\frac{\epsilon}{w})^{\frac{1}{1-\gamma}} \Big[A\Sigma_2\Big]^{\frac{1}{1-\rho}} K_1$$

$$h^* = \Sigma_2^{\frac{\rho}{1-\rho}} A^{\frac{1}{1-\rho}} K_2.$$

Accordingly, the value of the child becomes

$$V_k = \Sigma_C \Big[\frac{wT}{\epsilon} + m_p + \{\frac{K_2}{R} - (1 + (\frac{\epsilon}{w})^{\frac{\gamma}{1-\gamma}}) K_1\} \Sigma_2^{\frac{1}{1-\rho}} A^{\frac{1}{1-\rho}}\Big]^{1-\sigma},$$

where $\Sigma_C = \left[\frac{1-(\beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}})^N}{1-\beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}}}\right]^{\sigma}$. Note that $\frac{K_2}{R} - (1+(\frac{\epsilon}{w})^{\frac{\gamma}{1-\gamma}})K_1 = (1+(\frac{\epsilon}{w})^{\frac{\gamma}{1-\gamma}})^{\frac{1-\gamma}{-\gamma}\frac{\rho}{1-\rho}}[(\frac{\rho}{R})^{\frac{\rho}{1-\rho}} - (\frac{\rho}{R})^{\frac{1}{1-\rho}}] >$ 0 with $\rho < 1$. Thus, V_k strictly increases by A if the constraint is not binding.

Note that

$$d_k^* = \frac{(\beta R)^{-\frac{1}{\sigma}} \Sigma_2 \Sigma_1^{-1} h^* + (m_k^* - w n_k^* - m_p)}{1 + \Omega^{-1} \Sigma_1^{-1}}.$$

The tied-to-investment constraint binds if and only if $d_k^* > m_k^*$, and rearranging the condition leads to

$$(\beta R)^{-\frac{1}{\sigma}} \Sigma_2 \Sigma_1^{-1} h_0 + A^{\frac{1}{1-\rho}} K_4 \geq m_p + \frac{wT}{\epsilon},$$

where $K_4 = \Sigma_2^{\frac{1}{1-\rho}} \left[\left\{(\frac{\epsilon}{w})^{\frac{\gamma}{1-\gamma}} - \Omega^{-1}\Sigma_1^{-1}\right\} K_1 + (\beta R)^{-\frac{1}{\sigma}} \Sigma_1^{-1} K_2\right]$. If the tied-to-investment constraint binds, the child's problem can be written as follows:

$$V_k = \max_{\{n_k, m_k\}} u(w n_k + m_p) + \beta \Sigma_1 u(\frac{\Sigma_2 h - R m_k}{\Sigma_1})$$

subject to

$$h = h_0 + A\Big\{\big(m_k(1+s)\big)^{\gamma} + (T - \epsilon n_k)^{\gamma}\Big\}^{\frac{\rho}{\gamma}}$$

$$m_k > 0, \quad n_k \geq 0, \quad T - \epsilon n_k > 0.$$

Parents live and consume for $t = 1, \cdots, N_p$. Given that parents have access to the complete credit market, they solve the following problem by choosing $\{C_{pt}\}_{t=1}^{N_p}$ and m_p:

$$\max_{\{\{C_{pt}\}_{t=1}^{N_p}, m_p\}} \sum_{t=1}^{N_p} \beta^{t-1} u(C_{pt}) + \alpha V_k \quad \text{subject to}$$

$$\sum_{t=1}^{N_p} \frac{C_{pt}}{R^{t-1}} \leq x_p - m_p, \quad m_p \geq 0.$$

Denoting $\Sigma_P = \left(\frac{1-\beta^{\frac{N_p}{\sigma}} R^{\frac{N_p(1-\sigma)}{\sigma}}}{1-\beta^{\frac{1}{\sigma}} R^{\frac{(1-\sigma)}{\sigma}}}\right)^{\sigma}$, the parents' problem can be written as

$$\max_{\{m_p\}} \quad \Sigma_P \frac{(x_p - m_p)^{1-\sigma}}{1-\sigma} + \alpha V_k \quad \text{subject to} \quad m_p \geq 0.$$

4.2 Predetermined Parameters

We first specify the predetermined parameters, which are summarized in Table 5. Focusing on college education, we normalize time so that one period represents 4 calendar years. In our life-cycle model, the child lives for $t = 1, \cdots, 15$ where $t = 1$ is the schooling period (investment period), $t = 2, \cdots, 11$ is the working period, and $t = 12, \cdots, 15$ is the retirement period. We abstract from the heterogeneous timing of labor market entrance across students, assuming the child starts working from $t = 2$, similar to Lochner and Monge-Naranjo [2011]. We choose $\sigma = 2$, which belongs to the empirically supported range for the intertemporal elasticity of substitution (IES) (Browning et al. [1999]). For the growth rate of earnings over 4 years, we use 7% following Lagakos et al. [2018].[19] Following Lochner and Monge-Naranjo [2011], we assume students receive a 0.8 dollar grant for every dollar investment. For the lower bound of the initial stock of human capital, $\overline{h}$, we use the average annual income of high school graduates, which is 19,000 USD. For the wage rate of college students, w, we use the average hourly wage of college students ages 18 - 24 (8 USD), focusing on earnings during enrollment periods and not from an internship. We use the same value of w for all students, because we find no systematic variation in w during the college period by students' AFQT score or parental income. The time endowment for higher education T is set to be 20,000, which is hours available over 4 years, subtracting time spent sleeping and eating; We use the time-diary data from the American Time Use Survey (ATUS) 2004 to get the average time college students spend sleeping and eating.[20] We set the discount factor as 0.95 and use the inverse of the discount factor for the gross interest rate.

[19] According to the experience-wage profile in Lagakos et al. [2018], the average wage for workers with 35-39 years of potential experience is 88% higher than for workers with 0-4 years of potential experience in the US, which translates into an annual growth rate of 1.7%.

[20] Some students completed college education in more than 4 years. However, we do not adjust T for those students, because doing so causes delayed graduation to translate into increasing human capital in our model, which is unlikely to reflect reality.

4.3 Identification

We have five structural components $\{F(\alpha), F(\epsilon), \rho, \gamma, \delta\}$ to be identified from the data. The distribution of altruistic preference, $F(\alpha)$, can be identified by the distribution of parental transfers. Given that the distribution of parental transfer is truncated below zero, nonparametrically recovering $F(\alpha)$ may not be feasible. We impose a log-normal distribution for $F(\alpha)$, by which we can generate a similar shape of parental-transfer distribution. In addition, we allow for the possibility that the altruistic preference is systematically different across different income levels. Specifically, we assume $\log \alpha = \alpha_0 + \alpha_1 \log x_p + u_\alpha$, where $u_\alpha \sim N(0, \sigma_\alpha)$. Accordingly, α_0 and σ_α can be identified by the mean and the variance of parental transfer, respectively. α_1 can be identified by the correlation between parental transfer and family income.

The distribution of $F(\epsilon)$ can be identified by the distribution of working hours during the college period. With similar reasoning for $F(\alpha)$, we impose a log-normal distribution for $F(\epsilon)$. Specifically, $\log \epsilon = \epsilon_0 + u_\epsilon$, where $u_\epsilon \sim N(0, \sigma_\epsilon)$. Thus, ϵ_0 and σ_ϵ can be identified by the mean and the variance of students' working hours, respectively.

The curvature of the human capital production function, ρ, can be identified by the average post-schooling income; a higher ρ tends to generate a higher post-schooling income. The average student loan can also help identify ρ; as ρ becomes higher, students tend to take out more student loans. On the other hand, as discussed in Section 3.4, when the tied-to-investment constraint is binding, parents have an additional incentive to transfer, and this incentive changes depending on the complementarity between monetary and time investment in the child's human capital production function. Therefore, γ, the parameter that captures the complementarity between monetary and time investment in the human capital production function, can be identified from the correlation between m_p and n_k. Given other parameters, the ability gradient of initial human capital, δ, is identified from the correlation between the AFQT score and income.

4.4 Estimation

The variables used for estimation are summarized in Table 6. For parents' lifetime income x_p, we multiply the average annual income of parents when their child is between 18 and 25 by 20.[21] To generate the total amount of student loans and parental transfers for college education, we aggregate the variables over students' enrollment periods. Working hours in the later periods in college may also include working to improve human capital (e.g., internships). To construct working hours for self-financing, we double the working hours during the first 2 years of college enrollment and use it for working hours for self-financing.

We estimate the structural parameters based on the method of simulated moments.[22] We have eight structural parameters and use nine moment conditions. The choice of moment conditions is based on the above identification argument: (1) the mean and variance of parental transfer; (2) the correlation between parental transfer and family income; (3) the mean and variance of labor supply during the college period; (4) the average labor income after the college period and the average student loan; (5) the correlation between parental transfer and child labor supply; and (6) the correlation between labor income after the college period and ability. For estimation, the weighting matrix is constructed as a diagonal matrix whose element is the inverse of the sample variance of the moment conditions.

4.5 Model Fit

Table 7 shows how the model fits the data with respect to the nine moment conditions. To normalize units across different moment conditions, we present weighted values by using the square roots of the sample variances. The model fits the data reasonably well.

We do not directly target correlations between (1) parental transfer and ability and (2) working hours and ability. Thus, we can check the extent to which the model can also fit those variations in

[21]Multiplying by a number other than 20 to get parents' lifetime income changes the mean of altruistic preferences in the estimation, but it does not change our main findings.

[22]Parents' problem can be highly nonlinear with respect to transfer, because the child's value function is included in their objective function. For this reason, we discretize the choice variables and find the global maximum.

the data. As discussed in Section 3.3, without the tied-to-investment constraint, altruistic parents have less incentive to transfer to the high-ability child, which implies a negative correlation between parental transfer and child ability. Table 8 shows that by introducing the tied-to-investment constraint and self-financing, the model can generate a positive correlation between parental transfer and child ability, as observed in the data. Our model abstracts from other motives of parental transfer, such as a paternalistic motive (e.g., Abbott et al. [2019]), which may be why our model cannot perfectly explain the positive gradient of parental transfer with respect to child ability. On the other hand, the model can also generate a negative correlation between child labor supply and ability, which is consistent with the idea that the opportunity cost of self-financing in human capital accumulation is greater for high-ability students.

5 Results

In this section, we present our results from the model estimation.

5.1 Estimates

Table 9 shows the estimates for model parameters. First, γ is negative (-0.323), which implies that the monetary and time investment in human capital accumulation are complements. Second, parents' altruistic preferences show substantial heterogeneity. Although the amount of parental transfer increases by family income, the altruistic preference measured by α decreases by family income ($\alpha_1 = -0.371$). Poor parents are estimated to be relatively more altruistic than rich parents, because they also contribute to financing their child's education, although the utility cost of doing so is much higher than for rich parents. Third, students' unobservable characteristic ϵ also shows substantial heterogeneity, which suggests that accounting for an unobserved heterogeneity is important in understanding the impact of students' working hours on the labor market outcome, consistent with previous findings (e.g., Stinebrickner and Stinebrickner [2003]).

5.2 The Role of the Tied-to-investment Constraint

With the estimated model, we first quantify the role of the tied-to-investment constraint. Without a micro-foundation for the tied-to-investment constraint, knowing whether fully relaxing the constraint is possible would be difficult. Nevertheless, our model allows us to evaluate the impact of the tied-to-investment constraint on various outcomes, and thereby provides a useful benchmark for understanding the role of the constraint on self-financing and parental transfers. To this end, we examine how removing the tied-to-investment constraint changes the child's working hours and parental transfer.

Table 10 summarizes the results. We find that without the tied-to-investment constraint, the average parental transfer decreases by 64% (from 14,172 USD to 5,108 USD), and average working hours decrease by 67% (from 3,448 hours to 1,136 hours) while attending college. These results show that borrowing constraints for consumption during college are an important factor in students' working decision and for parental transfer to their child.

To assess the impact of financial constraints with respect to parental income and students' ability, we present Figure 5. With the estimated parameters, we simulate two economies: (1) the estimated economy and (2) the economy without financial constraints. For each individual, we calculate the loss in labor income due to borrowing constraints, divided by additional working hours due to borrowing constraints compared with the optimal working hours without borrowing constraints. We then average such a number with respect to the AFQT quartile (AQ#) and parental-income quartile (FQ#). First, the marginal cost of self-financing due to borrowing constraints increases with the child's ability and decreases with parental income. The ability gradient is more pronounced than the parental-income gradient, suggesting that high-ability students are most affected by the tied-to-investment constraint. Note that parents assign more funds to the child with higher ability, as shown in Table 8. Despite the higher parental transfer, financial constraints have the greatest effect on high-ability students. For example, for students in the highest quartile of the AFQT score, 1 additional hour per year for self-financing leads to about 1.24 USD loss in annual labor income after college.

5.3 Policy Experiment

In this section, we conduct two counterfactural policy experiments. First, we provide additional loans that are not tied to educational investment. Second, we provide a wage subsidy for college students.

5.3.1 Loans without the Tied-to-investment Constraint

Based on the estimated model, we first conduct a counterfactual policy analysis to evaluate the impact of providing loans that are not tied to educational investment. Specifically, we allow for an additional 20,000 USD in loans over 4 years that do not have the tied-to-investment constraint. Small loans provided by universities that allow credit purchases by students on and off campus during the enrollment period are an example of such a policy.[23]

Given that the high-ability group is most affected by the tied-to-investment constraint, we present the results conditional on the highest quartile of AFQT scores. The results are shown in Figure 6. First, when students can access additional loans for consumption, self-financing for consumption decreases, and hence investment (both monetary and effort) in human capital increases. This tendency is more pronounced for students from low-income families, because those students were previously the most affectd by the tied-to-investment constraint. Parents know their transfer can be substituted for by the additional loans, and reduce the transfer accordingly. The magnitude of the crowd-out effect is smallest for the lowest parental-income quintile (less than 1,000 USD) and largest for the highest parental-income quintile (more than 8,000 USD).

[23]For example, Bear Bucks at Washington University in St. Louis allows students to add points to their student ID account before they pay the balance. Students are required to pay the balance before they graduate. By doing so, the university provides additional credit to students during their enrollment period so that they can purchase food and other goods both on campus and off campus at some private businesses.

5.3.2 Wage Subsidy

In the second policy experiment, we consider a wage subsidy. Specifically, we provide a 2 USD subsidy for every working hour during college.[24]

A wage subsidy is closely related to the federal work-study program. The federal work-study program in the US provides part-time jobs for undergraduate and graduate students with financial needs that allow them to earn money to help pay education expenses. Although the program has been implemented as a "self-help" component of financial aid, government subsidies play a vital role in the program. Although the share varies by institution, a maximum of 75% of the salary the student receives can be financed by the government. As a result, government spending on the work-study program is sizable: 0.96 billion USD in 2018.[25] Nevertheless, few studies have examined the impact of the work-study program.[26] Our framework can be useful for understanding the impact of the work-study program in the form of a wage subsidy.

The results are shown in Figure 7. As with the first loan policy, we present the results conditional on the highest quartile of AFQT scores. Different from the first policy, in which students from all family backgrounds reduce working hours, some students, especially from high-income families, increase working hours in response to the wage subsidy. Equation (6) can be helpful for understanding the different responses of working hours across different parental-income levels. When the wage increases, two opposite forces come into play. First, the higher wage tends to substitute hours for human capital for hours for self-financing. Second, the higher wage means that the income of the student increases, and hence reduces the marginal value of self-financing. For students from low-income families, the second effect (income effect) tends to dominate the first effect (substitution effect) and reduce

[24]Two dollars are roughly the difference between the maximum (9.32 in Washington) and the minimum (7.25 in Alaska) level of the minimum wage across states in the US in 2014.

[25]In the 2017-2018 academic year, the total amount of federal grants (loans) awarded to students was 41.7 billion (93.9 billion) USD, the total amount of education tax benefits amounted to 17.0 billion USD, and the total amount for the federal work-study program was 0.96 billion USD. Source: Trends in Student Aid 2018.

[26]Stinebrickner and Stinebrickner [2003] discuss the impact of the work-study program at Berea College, which aims to offer education to disadvantaged students by providing full-tuition scholarships and a mandatory work-study program.

self-financing. For students from high-income families, the substitution effect tends to dominate the income effect and increase working hours. As a consequence, the wage subsidy tends to increase the human capital of students from low-income families and decrease the human capital of students from high-income families.

In both policies, parents crowd out transfer for the child's college education. However, how students' responses to the policies affect parental transfer is quite different between the two policies. In the first loan policy, the marginal return of parental transfer decreases because relaxing borrowing constraints for consumption reduces students' need for self-financing, which, in turn reduces the marginal impact of parental transfer on the child's utility and human capital. However, the child's response to the policy can partially counteract additional crowd-out by parents, because the child will work less (and hence invest *more* in human capital), which increases the return to monetary investment in the child's human capital. On the other hand, when the wage subsidy is implemented, the marginal return of parental transfer decreases, not only because parents know their children will need less financial help because of the increased labor earnings, but also because children, especially from high-income families, will work more (and hence invest *less* in human capital).

6 Conclusion

We document that a large number of college students work a substantial number of hours at low-skilled jobs, and that students who have fewer resources (especially parental transfers) tend to work more. To quantify the role of borrowing constraints in college students' working hours and human capital accumulation, we develop a theory that shows how—in the presence of borrowing constraints—the interaction between college students' labor supply for self-financing and their parents' endogenous transfer decision leads to heterogeneous human capital accumulation during college. The estimated model shows that borrowing constraints explain a substantial portion of college students' working hours and their parental transfer during college. A loan policy and a wage subsidy can have different effects on college students' working hours and human capital across different parental-income levels. In particular, a wage subsidy—although intended to help college students—can be detrimental to the human capital of students from high-income families.

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Tables and Figures

Table 1: Working Hours during College

	Working hours during		
	First year	First 2 years	First 4 years
Mean	769	1,676	3,867
Std.	664	1,241	2,518
10th percentile	0	276	1,030
50th percentile	627	1,445	3,532
90th percentile	1,700	3,380	7,057
Obs.	1,795	1,795	1,701

NOTE: This table shows the summary statistics for individuals' working hours after college enrollment. We report working hours for the first 4 years after college enrollment for those individuals whose information is available.

Table 2: Regression Estimates for Working Hours

	(1)	(2)
VARIABLES	Working hrs (2-year)	Working hrs (2-year)
AFQT	-3.665***	-2.704**
	(1.180)	(1.196)
Grants	-0.00437***	-0.00429***
	(0.00105)	(0.00104)
Annual Parental Income	-0.00207**	-0.00121
	(0.000807)	(0.000827)
Parental Transfer		-0.00491***
		(0.00115)
Constant	2,098***	2,065***
	(88.44)	(88.36)
Observations	1,795	1,795
R-squared	0.020	0.029

NOTE: This table shows the regression estimates for working hours for the first 2 years after enrollment with respect to observable variables. The amounts of parental transfers and grants are aggregated over the enrollment period. Annual parental income refers to the average annual income of parents when a student's age is between 18 and 25. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Job-loss Shock and Parental Income (SIPP)

VARIABLES	(1) Parental Income (Monthly)	(2) Parental Income (Monthly)
Previous job-loss shock	-1,755***	
	(178.6)	
Future job-loss shock		307.7
		(259.6)
Year FE	Y	Y
Race/Sex	Y	Y
Grants dummy	Y	Y
Observations	64,036	61,604
R-squared	0.024	0.021

NOTE: This table compares parental job-loss shock and parental income from the SIPP. The previous (future) job-loss shock is a dummy variable taking a value of 1 if a student's father lost (will lose) his job in the previous (next) 4 months due to (1) Discharged/fired, (2) Employer bankrupt, (3) Employer sold business, or (4) Slack work or business conditions. We control for the year fixed effect, students' race and sex, and whether the student received grants for college education. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Regression Estimates for Working Hours (SIPP)

VARIABLES	OLS (1) Working Hours (Weekly)	2SLS (2) Working Hours (Weekly)
Grants Dummy	-1.713***	-3.502***
	(0.189)	(0.646)
Monthly Parental Income	-4.61e-05***	-0.00186***
	(1.74e-05)	(0.000612)
Constant	18.71***	27.30***
	(0.515)	(2.934)
Year FE	Y	Y
Race/Sex	Y	Y
IV for Parental Income		Y
Observations	64,036	64,036
R-squared	0.039	0.253

NOTE: This table shows regression estimates for the weekly working hours with respect to observable variables from the SIPP. We use the parental previous job-loss shock, a dummy variable taking a value of 1 if a student's father lost his job in the previous 4 months due to (1) Discharged/fired, (2) Employer bankrupt, (3) Employer sold business, or (4) Slack work or business conditions as an instrumental variable for monthly parental income. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Predetermined Parameters

Parameter	Value	Source
A period	4 years	Start working at age 26
N_w	11	40 yr working until age 65
N	15	20 yr retire up to age 85
N_p	10	Age 45 when child enters univ. Parents live 40 yr
σ	2	IES=0.5, Browning et al. [1999]
g	0.07	Lagakos et al. [2018]
s	0.8	Lochner and Monge-Naranjo [2011]
$\bar{h}$	19,000×4	Mean annual earnings for non-enrollees×4
w	8	Mean wage for enrollees (age 18-22)
T	20,000	Hours for 4 years, excluding sleeping and eating time
β	0.95	$\approx 0.99^4$
R	$1/\beta$	

Table 6: Data for Estimation

Variable	Data
x_p	$20\tilde{x}_p$, where $\tilde{x}_p$ is the mean annual earnings for parents when the child is between 18 and 25
n_k	$2\tilde{n}_k$, where $\tilde{n}_k$ is the first 2-year working hours
m_p	Parental transfers for each student
d_k	Student loans for each student
h	$4\tilde{h}$, where $\tilde{h}$ is the mean annual earnings for child when his/her age is between 26 and 30
A	AFQT score for each student

Table 7: Moment Conditions and Model Fit

Moments	Data	Simulation
mean(m_p)	0.5291	0.5345
mean(n_k)	1.3512	1.3900
mean(d_k)	0.7485	0.7129
mean(h)	1.5947	1.5980
var(m_p)	0.1354	0.1735
var(n_k)	0.4559	0.4378
mean($h \cdot A$)	1.1928	1.1867
mean($m_p \cdot n_k$)	0.3970	0.2028
mean($m_p \cdot x_p$)	0.3691	0.4655

NOTE: This table compares actual and simulated moments.

Table 8: Out-of-sample Fit

		Ability			
		1Q	2Q	3Q	4Q
m_p	Data	7,600	10,626	15,723	22,158
	Model	12,164	13,627	15,290	15,604
n_k	Data	3,518	3,500	3,405	2,985
	Model	3,702	3,508	3,387	3,195

NOTE: This table compares actual and simulated moments, which are not directly targeted for estimation.

Table 9: Parameter Estimates

Variable	Estimate	Standard Error
α_0	2.402	(0.900)
α_1	-0.371	(0.046)
σ_α	1.914	(0.386)
ϵ_0	1.805	(0.033)
σ_ϵ	0.574	(0.018)
γ	-0.323	(0.025)
ρ	0.726	(0.007)
$\bar{\delta}$	0.506	(0.023)

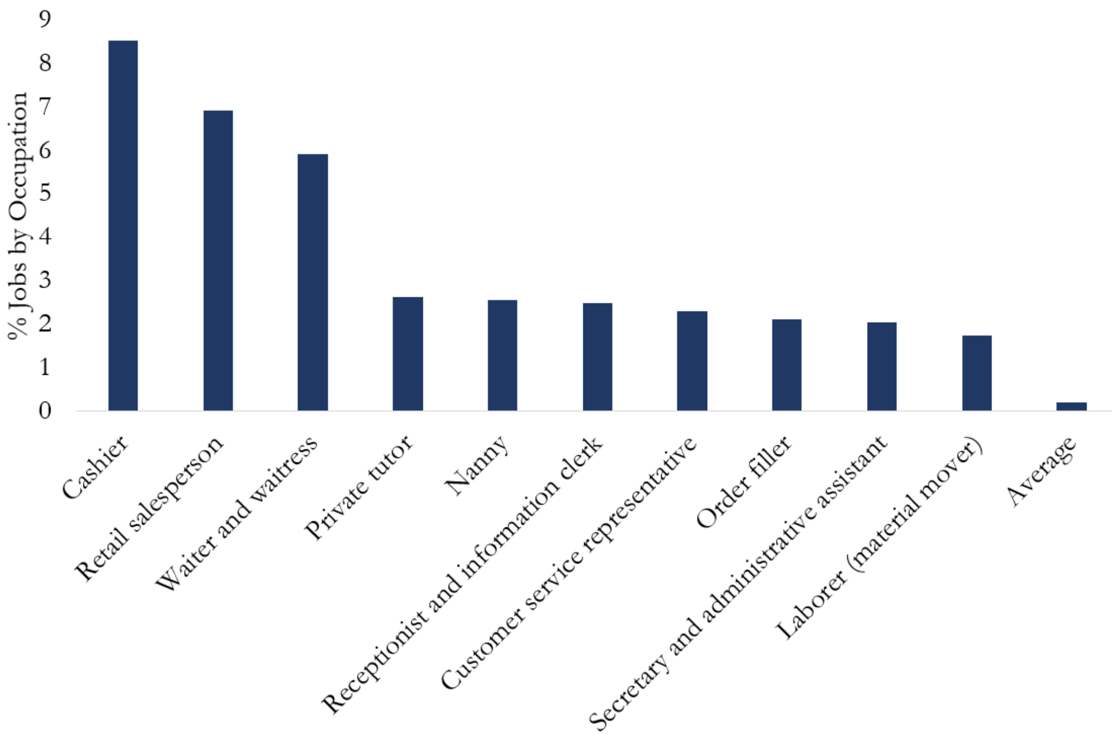
NOTE: This table shows parameter estimates for the quantitative model. $\bar{\delta}$ is δ divided by 1,000.

Table 10: Counterfactual Simulation: The Role of Financial Constraints

	Working hours	Parental transfer
Benchmark (a)	3,448	14,172
No constraint (b)	1,136	5,108
$\frac{a-b}{a} \times 100$	67%	64%

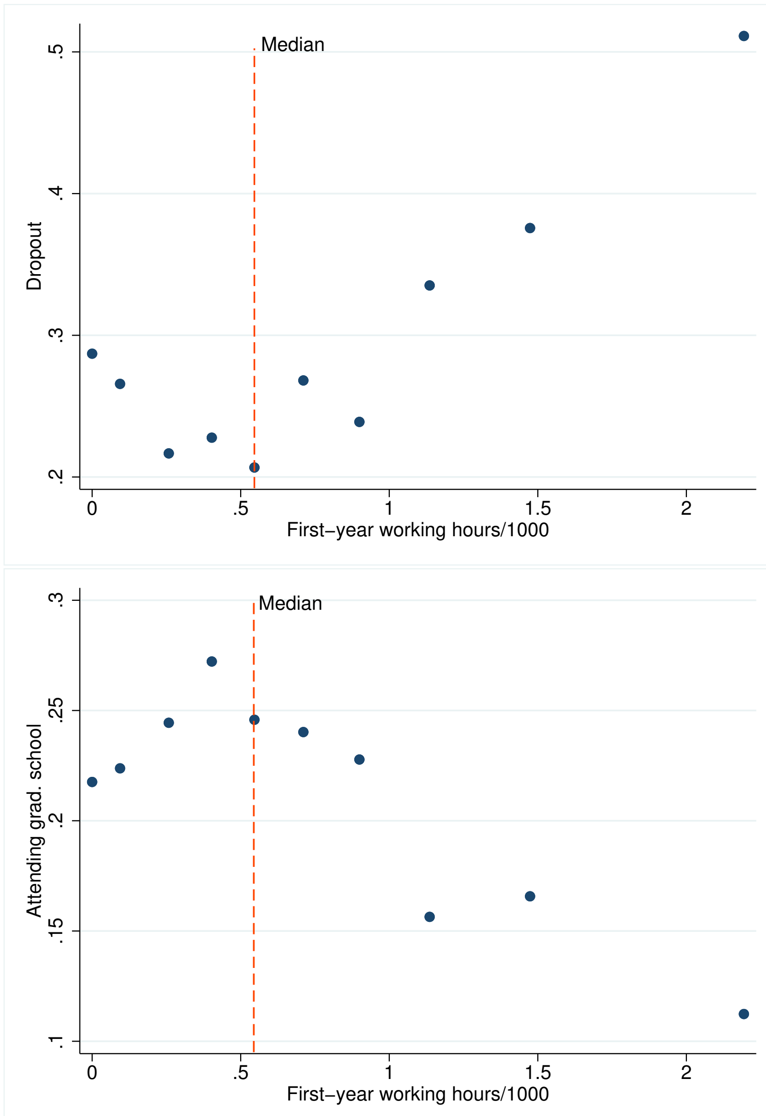
NOTE: This table compares working hours/parental transfer with and without financial constraints.

Figure 1: Jobs Held by College Students



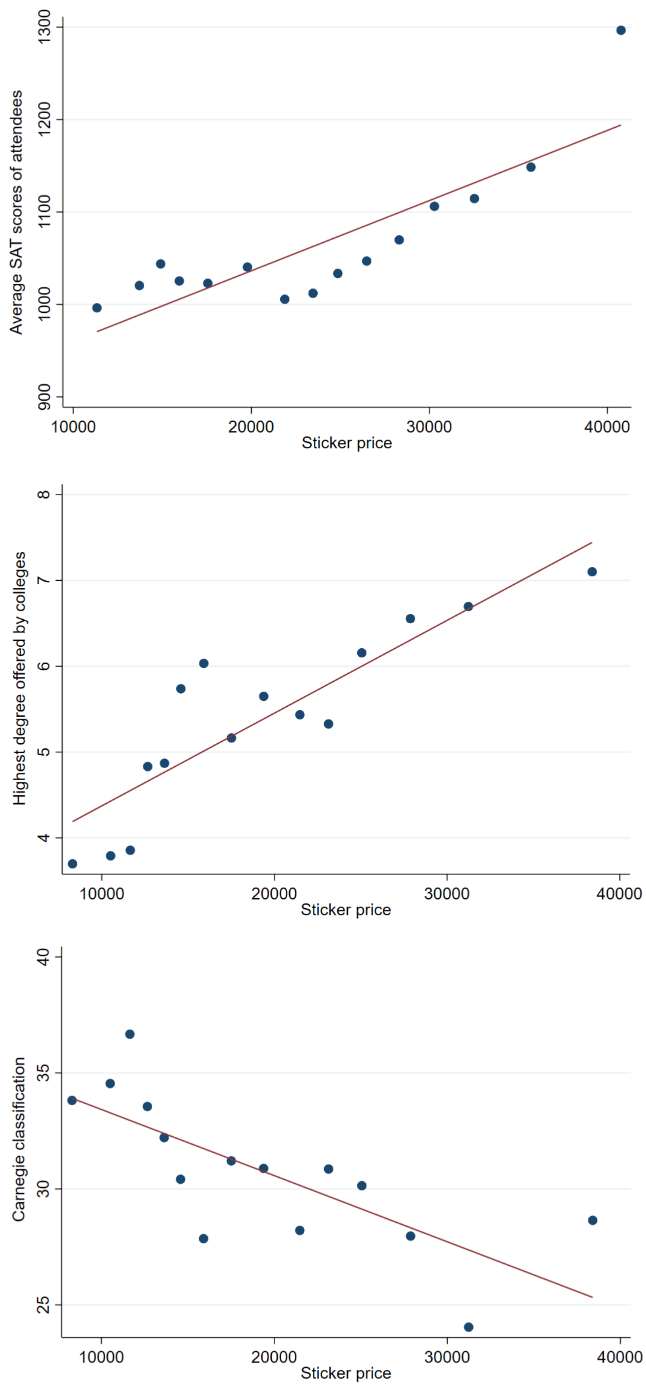
NOTE: The figure shows the most frequently chosen occupations by four-year college students.

Figure 2: Working Hours and Academic Outcome



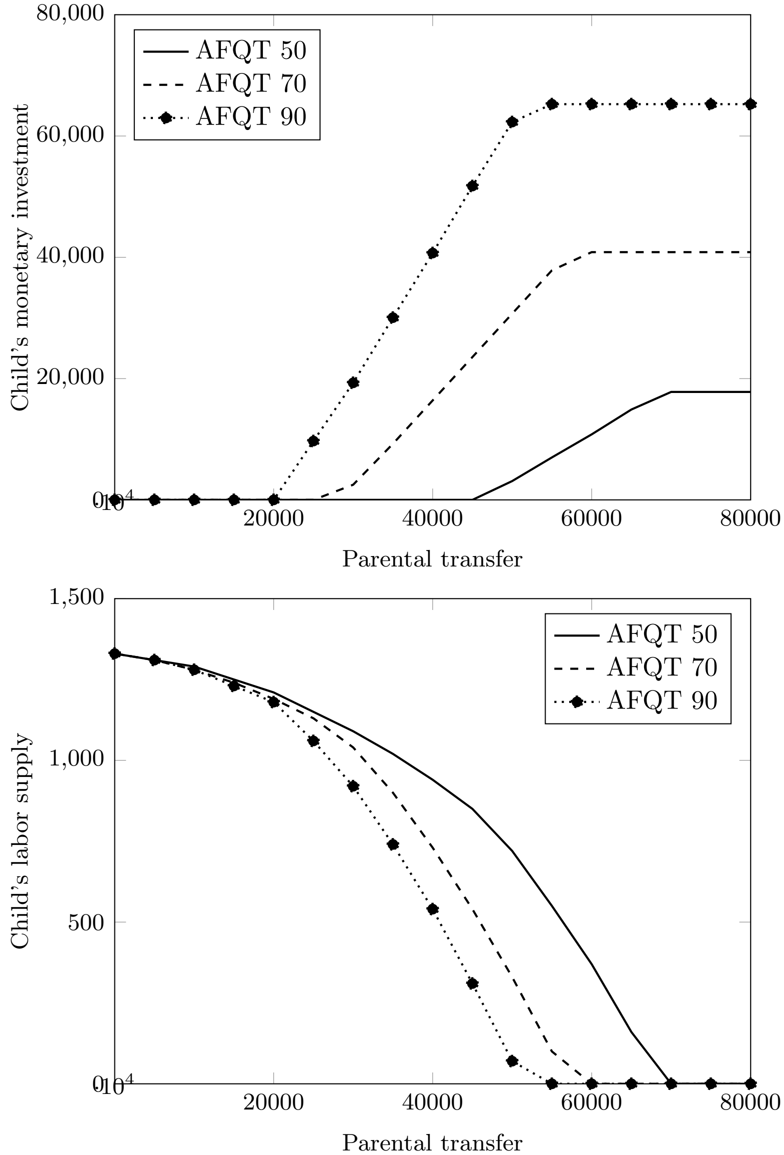
NOTE: The figure shows binned scatter plots for the probability of dropout (upper panel) and the probability of attending graduate school (lower panel) with respect to first-year working hours.

Figure 3: Sticker Prices and Quality of College Education



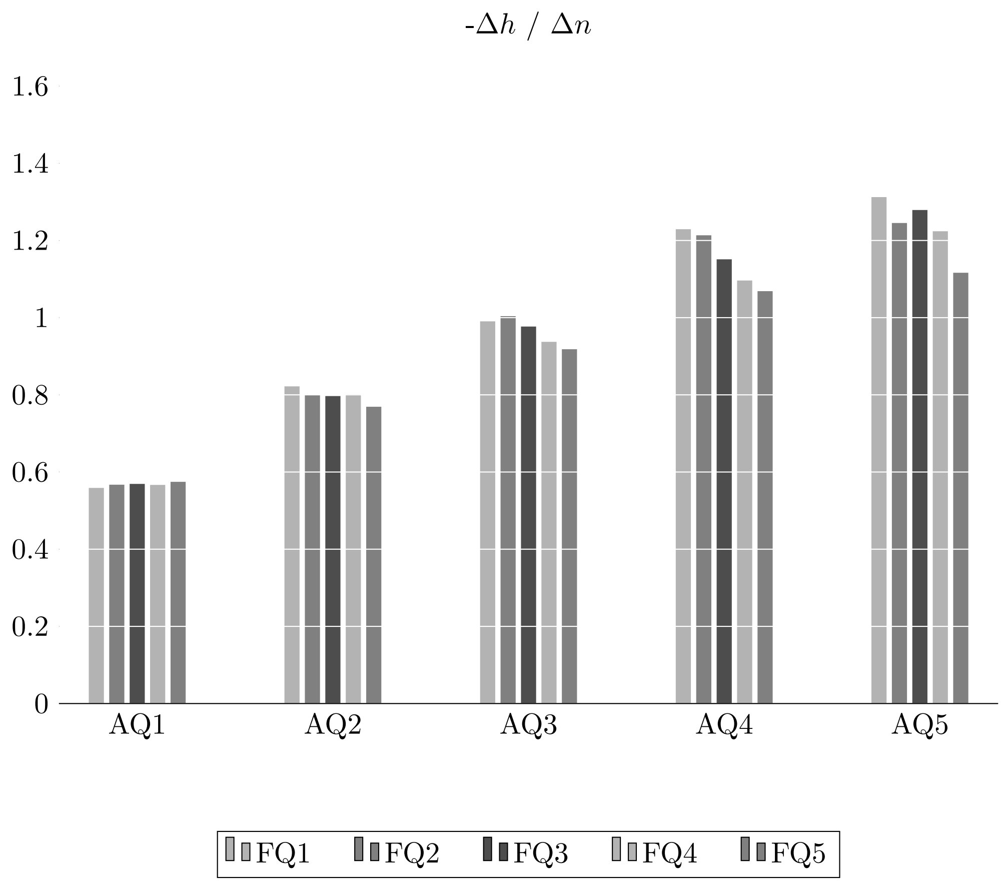
NOTE: The figure shows binned scatter plots for the quality of college (measured by the average SAT score), the highest degree offered, and the Carnegie Classification of the Institution for Higher Education, with respect to the sticker price of colleges (measured by the sum of tuition and fees, costs for room and board, costs for books and supplies, and other college-related expenses) from the IPEDS 2004.

Figure 4: Parental Transfer and Child's Investment



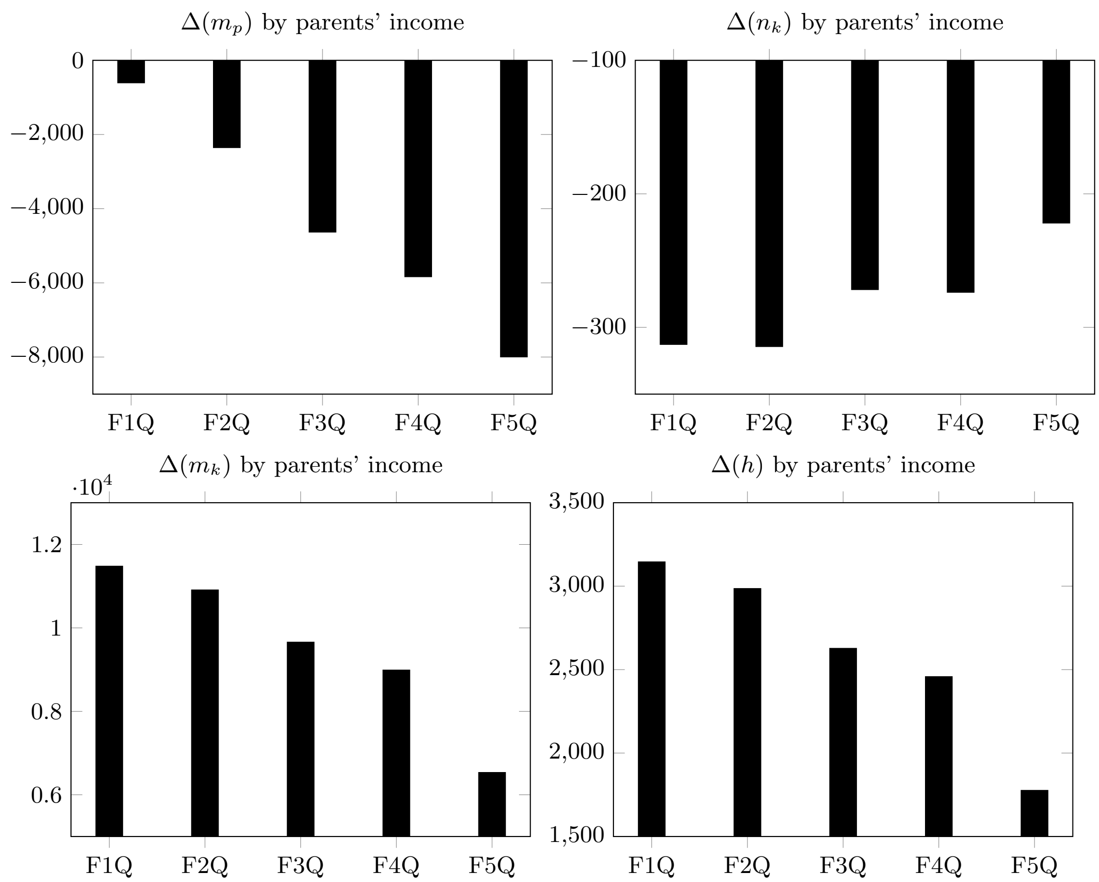
NOTE: The upper (lower) panel of this figure shows the relationship between parental transfer and the child's monetary investment (the child's labor supply) simulated by the estimated model with a fixed ϵ. AFQT# refers to the child with the #th percentile of AFQT score.

Figure 5: Cost of Extra Working Hour Measured by Labor Income



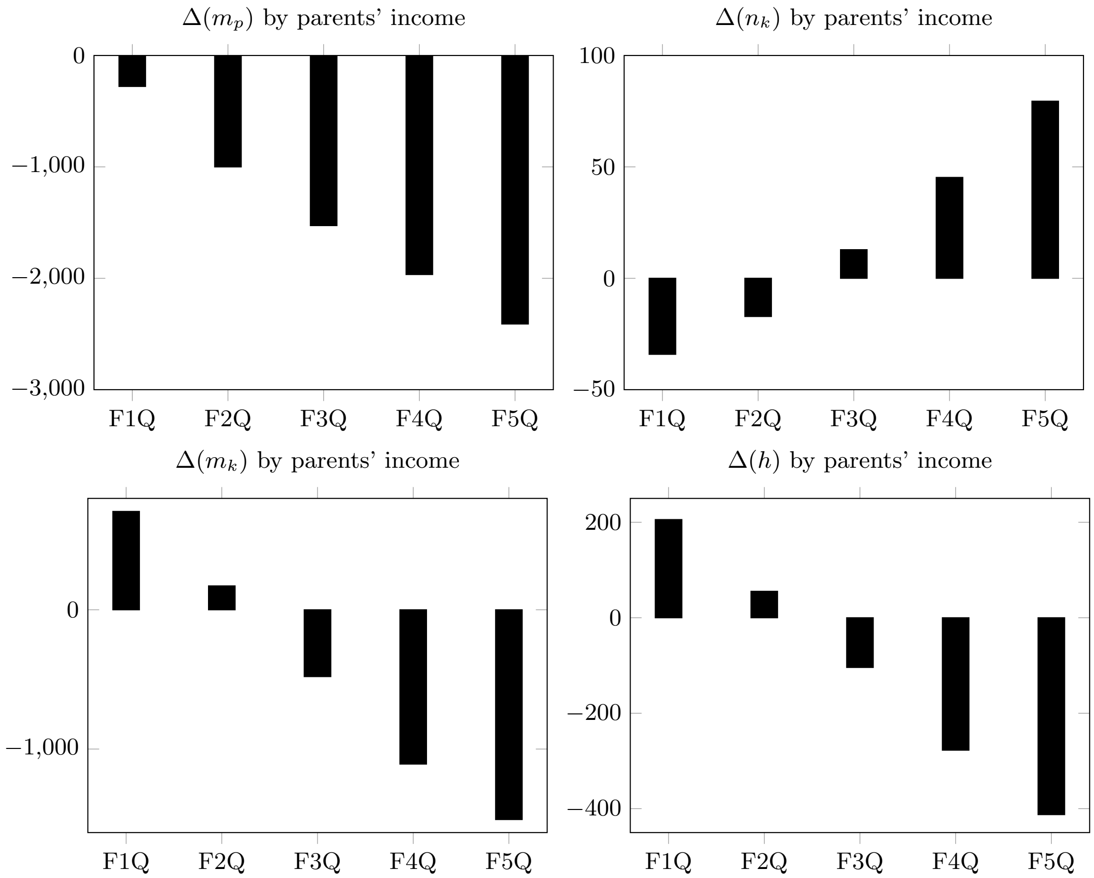
NOTE: The figure shows the opportunity cost of 1 additional working hour due to borrowing constraints (compared with the optimal working hours without borrowing constraints) measured by labor income after graduation. With the estimated parameters, we simulate two economies: (1) the estimated economy and (2) the economy without borrowing constraints. For each individual, we calculate the loss in the labor income (over 4 years) due to borrowing constraints, divided by additional working hours due to borrowing constraints compared with the optimal working hours without borrowing constraints during college. We then average such a number with respect to AFQT quartile (AQ#) and parental-income quartile (FQ#). The y-axis represents the loss in annual labor income (USD) after college with respect to 1 additional hour per year spent on self-financing during college.

Figure 6: Impact of Additional Loan without the Tied-to-investment Constraint



NOTE: The figure shows the impact of the policy described in Section 5.3.1. In this policy, a child in each family can borrow up to 5,000 USD in annual loans over 4 years (20,000 USD in loans for 4 years), which is not tied to educational investment. Conditional on the highest AFQT quartile, we present the heterogeneous effect with respect to parental-income quartile. m_p is parental transfer during college. n_k is working hours during college. m_k is students' monetary investment for college education. h refers to the level of human capital after graduation measured by labor income over the first 4 years.

Figure 7: Impact of Wage Subsidy



NOTE: The figure shows the impact of the policy described in Section 5.3.2. In this policy, students are subsidized 2 USD for every working hour. Conditional on the highest AFQT quartile, we present the heterogeneous effect with respect to parental-income quartile. m_p is parental transfer during college. n_k is working hours during college. m_k is students' monetary investment for college education. h refers to the level of human capital after graduation, measured by labor income over the first 4 years.

Appendix

A Robustness Check

To examine the robustness of our main findings, we modify the baseline model in three ways and re-estimate each model, then compare how the main findings change according to different model specifications. Table 11 shows estimates of the structural parameters, model predictions, and impact of relaxing the tied-to-investment constraint for each robustness check. Column (1) of Table 11 shows the results from the baseline analysis for comparison.

A.1 Private vs. Public College

First, we incorporate heterogeneity in college type by allowing the return to monetary investment in human capital to depend on whether the college is private or public. Although tuition and fees are far more expensive for private colleges than for public colleges, the cost difference may not fully reflect the quality difference in education. To account for heterogeneous returns to monetary investment in the child's human capital, we add one parameter, $\psi_{private}$, in our human capital production function (equation (1)) such that the effective monetary investment in human capital is $m_k = \{\psi_{private} \cdot I_{private} + (1 - I_{private})\}\overline{m}_k$, where $\overline{m}_k$ is the monetary expenditure on college education and $I_{private}$ is the dummy variable indicating whether the student attends a private college.

Column (2) of Table 11 shows how introducing college heterogeneity affects our results. Panel A shows that $\psi_{private}$ is estimated as 0.866, which implies the return from a 1,000 USD investment in a private college is the same as the return from an 866 USD investment in a public college. Estimates for parameters (Panel A) and model predictions (Panels B and C) remain robust when we introduce heterogeneous college types in our model.

A.2 Additional Loans for Consumption

Second, we relax the tied-to-investment constraint by allowing students to take out additional loans without the constraint, totaling up to 4,000 USD over 4 years of college education.[27] The student loans we targeted in the baseline estimation are from the answer to the question, "Other than assistance you received from relatives and friends, how much did you borrow in government subsidized loans or other types of loans while you attended this school/institution?" This amount likely only captures educational loans, not personal credit (e.g., credit cards) from commercial banks. Given that the NLSY97 does not provide the amount of personal credit, we assume that the total loan amount (which includes not only educational loans, but also personal credit) is 4,000 USD greater than the loan amount in the NLSY97.[28]

Column (3) of Table 11 shows the results. If students face less stringent constraints for financing their consumption during college, all else being equal, parents would crowd out their transfer as discussed in Section 5.3.1. To match the level and variance of the parental transfer observed in the data, the estimates for $F(\alpha)$ change. In particular, the new estimate has higher value for α_1, which can increase the mean of parental transfer conditional on the parental transfer being positive. Parental transfer and child ability are still positively correlated. The modified model predicts that students borrow more (about 4,000 greater d_k) than in the baseline model, because we assume the total amount borrowed is the sum of observed student loans and 4,000 USD. Overall findings are similar to those in the baseline model.

A.3 Including Leisure

Third, we introduce leisure during the college period so that students divide their time between study, work, and leisure. The utility from leisure $u(l_k)$ is specified as $\tau \frac{l_k^{1-\sigma}}{1-\sigma}$, and the human capital production

[27] We chose 4,000 USD because it is the top 5th percentile of credit-card debt for college students who reported positive credit-card debt (source: the SIPP 2004).

[28] We find similar results when we instead assume that the observed student loans in the NLSY97 also include loans that are not tied to educational expenses.

function becomes $h_0 + A\{(m_k(1+s))^\gamma + (T - \epsilon n_k - l_k)^\gamma\}^{\frac{\rho}{\gamma}}$. The modified child's problem is

$$\max_{\{C_{k1},C_{k2},n_k,m_k,d_k,l_k\}} u(C_{k1}) + \beta u(C_{k2}) + u(l_k) \quad \text{subject to}$$

$$C_{k1} + m_k \leq wn_k + d_k + m_p$$

$$C_{k2} + Rd_k \leq h_0 + A\{(m_k(1+s))^\gamma + (T - \epsilon n_k - l_k)^\gamma\}^{\frac{\rho}{\gamma}}$$

$$h_0 = \bar{h} + \delta A, \quad d_k \leq m_k, \quad m_k > 0, \quad n_k \geq 0, \quad l_k \geq 0, \quad T - \epsilon n_k - l_k > 0.$$

To construct a moment condition that helps us identify τ, we use the ATUS 2004 to determine average leisure hours for college students who are enrolled in a college.[29] Of 17 major categories of activities in the time-use data in ATUS 2004, we add time spent on leisure and sports, which is about 260 minutes per day and 6,353 hours for the 4 years of the college period.

Column (4) in Table 11 shows the results. When a portion of non-working hours is spent on leisure, all else being equal, the predicted labor earnings will be lower than the labor earnings in the data. To counteract such an effect, the new estimates have different parameter values for the human capital production function (e.g., ϵ_0, γ, and δ). The model's predictions on choice variables are similar to the baseline model. The model still generates a positive correlation between parental transfer and child ability. Overall, our results remain robust when we introduce leisure.

[29] The NLSY97 does not have corresponding information.

Table 11: Robustness Check

	(1) Baseline	(2) Private	(3) Relaxing tti	(4) Leisure
Panel A: Estimates				
α_0	2.402	2.376	2.138	1.318
α_1	-0.371	-0.372	-0.366	-0.407
σ_α	1.914	1.960	2.273	3.251
ϵ_0	1.805	1.818	1.816	1.350
σ_ϵ	0.574	0.588	0.593	0.583
γ	-0.323	-0.321	-0.323	-0.472
ρ	0.726	0.723	0.724	0.703
$\bar{\delta}$	0.506	0.505	0.507	0.387
$\psi_{private}$	N/A	0.866	N/A	N/A
τ	N/A	N/A	N/A	0.064
Panel B: Model Prediction				
average m_p	14,170	14,310	14,290	13,110
average m_k	14,080	14,120	14,700	16,090
average n_k	3,450	3,420	3,410	3,580
average d_k	13,310	13,310	17,500	15,355
average h	113,020	113,020	113,180	107,240
$corr(m_p, A)$	0.092	0.091	0.083	0.074
$corr(n_k, A)$	-0.163	-0.160	-0.175	-0.188
$corr(m_p, n_k)$	-0.415	-0.408	-0.388	-0.554
$corr(m_p, m_k)$	0.724	0.719	0.694	0.651
Panel C: Relaxing Borrowing Constraints				
Δm_p	-9,060	-9,050	-7,500	-6,260
Δn_k	-2,310	-2,290	-2,230	-3,210
Δm_k	38,740	37,880	37,250	38,264
Δh	9,540	9,480	9,130	12,180

NOTE. The table summarizes results for each robustness-check analysis. $\bar{\delta}$ is δ divided by 1,000.

B Additional Data: American Time Use Survey

To generate the child's time endowment for higher education (T in equation (1)), we use the American Time Use Survey (ATUS) 2004. We combine the time-diary data set with the ATUS-CPS file to get the average time spent sleeping and eating by enrollment status and educational attainment. Time use is classified into 17 major categories.[30] Focusing on college students who are enrolled in a program, we have 2,742 observations in the sample, whereas the original sample is size 38,404.

For the time endowment of students, we subtract time for sleeping and eating as fixed time costs for living. For sleeping, we use time for sleeping (t010101). For college students who are enrolled in a program, the average (median) sleeping time is 520 (510) minutes per day. We also subtract time for eating and drinking (t110101), which is, on average (median), 60 (55) minutes per day. College students spend in total about 580 minutes sleeping and eating; thus, for each day, they have 14.33 hours not spent sleeping or eating, which results in about 20,000 hours over 4 years.

The correlation between time spent on education and working is -0.3 without controlling for any other components. In Table 12, we run linear regressions for study time on working and leisure hours. We do not observe perfect substitution between leisure and working hours. Therefore, the data support the idea of a trade-off between study time and working hours.

[30] The 17 categories of activities are as follows. 1. Personal care, 2. Household Activities, 3. Caring for and Helping Household Members, 4. Caring for and Helping Non-household Members, 5. Work and Work-Related Activities, 6. Education, 7. Consumer Purchases, 8. Professional and Personal Care Service, 9. Household Services, 10. Government Services and Civic Obligations, 11. Eating and Drinking, 12. Socializing, Relaxing, and Leisure, 13. Sports, Exercise, and Recreation, 14. Religious and Spiritual Activities, 15. Volunteer Activities, 16. Telephone Calls, 17. Traveling.

Table 12: Regression Estimates for Study Time

VARIABLES	(1) Study	(2) Study
Working	-0.212***	-0.155***
	(0.0153)	(0.0157)
Leisure	-0.477***	
	(0.0394)	
Age	-0.466	0.794
	(0.619)	(0.655)
Female	-63.48***	-41.98***
	(11.52)	(12.24)
Constant	523.4***	355.0***
	(28.11)	(26.26)
Observations	941	941
R-squared	0.224	0.103

NOTE: This table shows the estimates for linear regressions for study time on working and leisure hours. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1