Self-financing, Parental Transfer, and College Education

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February 16, 2019

Abstract

We study a college-financing problem by a family when children can self-finance by working. We develop and estimate a model in which children's human-capital accumulation depends on both monetary and time investment. The model explains how endogenous interactions between parental transfer, student loans, and self-financing lead to heterogeneous human-capital accumulation during college. Consumption smoothing is an important motive for self-financing if children can borrow only for education but not for consumption (the tied-to-investment constraint). When the constraint binds, parental transfer can increase children's monetary and time investment by reducing children's labor supply during college. This effect is more pronounced among high-ability students, and the model predicts the parental transfer in college financing increases by child ability, as observed in the data. Heterogeneous working hours by college students explain 14% of the standard deviation of the within-group-income inequality among four-year-college attendees. Work-study program with a cap in working hours can effectively reduce income inequalities without substantial crowd-out by parents. Expanding loans for consumption are more effective in reducing income inequalities, but it results in substantial crowd-out by parents.

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1 Introduction

College education in the economics literature is often considered 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 self-financing. Many college students in the US work to finance tuition and consumption. In our data, college students, on average, work 1,676 hours for the first two years of college, and their working hours are largely heterogeneous. Despite the empirical relevance of self-financing, little is known about the reasons behind it, how it affects parents' incentives to support their child's college education, and how it influences the child's labor-market outcomes. Understanding these questions can shed light on heterogeneous human-capital accumulation during college and upward mobility among college students.

Investigating a student's decision alone might not provide a comprehensive understanding of self-financing, because a student's self-financing is inevitably related to parental transfer. If parental transfer is sufficient to cover both educational spending and consumption, a child may not need to work during college. On the other hand, without parental transfer, a child has to finance tuition and consumption herself. In that case, working is an important way to make up the difference between college expenses (including consumption) and student loans. We find that self-financing substantially decreases by parental transfer in the data. Parental income itself does not have a significant impact on self-financing after controlling for parental transfer.

Recognizing that students' working decision and parents' monetary transfer are related to each other, we develop a framework in which those choices are endogenously chosen within a family. Specifically, we present a non-collective model of parents and a child that can explain heterogeneous parental transfer, student loans, and child's self-financing. In the model, the 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 the 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 government student loans. We estimate the model using the National Longitudinal Study of Youth 1997 (NLSY97).

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 the child's human capital without credit constraints. However, if a child is financially constrained, parental transfer, although not tied to educational investment, can increase the child's monetary and time investment in human capital. Because high-ability students have a greater opportunity cost of working during college, the marginal impact of parental transfer on the child's human capital increases with child ability. Thus, the interaction between credit constraint, self-financing, and time investment in human capital can generate the positive correlation between parental transfer during college and child ability. The estimated model suggests that without the tied-to-investment constraint, college students' average working hours decrease by 84% and parental transfer during the child's college period decreases by 69%.

Based on our estimated model, we quantify the role of heterogeneous self-financing and endogenous parental transfer in explaining within-group-income inequalities among four-year-college attendees. The impact of heterogeneous self-financing on income inequalities is not obvious a priori. On the one hand, self-financing can reduce inequalities associated with credit constraint by helping students relax the constraint. For students who have low effort cost of self-financing, the option of working during college can be an effective way to finance consumption without significantly reducing investment in education. On the other hand, for those who have large effort costs, financing consumption during college by self-financing can substantially reduce time investment in human capital, which can increase inequalities. In our counterfactual analysis, if all students work the mean level of working hours during the college period, the standard deviation of the distribution of the annual income at the beginning of the working period decreases by 14% from \$4,267 to \$3,686, and the 90th-10th income inequality decreases by 12% from \$11,374 to \$10,011. The change is more pronounced in the upper-tail inequality (90-50 inequality, 17% decrease from \$4,700 to \$3,903) than the lower-tail inequality (50-10 inequality, 8% decrease from \$6,674 to \$6,107).

Second, to quantify the role of endogenous interactions between parental transfer and child's self-financing in within-group-income inequality among four-year-college attendees, we compare income inequality of our baseline estimation to that in the counterfactual case in which the parental transfer is determined exogenously following a specific formula (Keane and Wolpin [2001], Hai and Heckman [2017]). We find that ignoring endogenous choice of parental transfer would overstate the income inequalities among college attendees. The standard deviation of the income distribution increase by 6% (from \$4,267 to \$4,514) if parental transfer is fixed at the estimated level.

We conduct two counterfactual policy analyses: (i) expanding the work-study program that can reduce effort cost of working during college; and (ii) increasing a loan to college students that is not tied to educational investment. The work-study program aims to promote part-time employment by students in financial need so that students can meet their educational costs. There are other important features of the program. First, the program aims to provide jobs that are closely related to student's course of study whenever possible. Second, many jobs are provided on-campus, which helps students to save more time for study while working. Off-campus jobs are also mostly in public sectors, thus, the quality of jobs provided through the Federal Work-Study Program is higher than typical jobs available to college students such as cashier or waiter/waitress. Finally, the work-study program imposes a clear limitation on the upper limit of earnings students can get from the program. This is also an important feature of the program that can prevent students from working too many hours which might hamper their study. To evaluate the impact of expanding work-study programs, in our counterfacutal analysis, we reduce the effort cost by 10%, while imposing a fixed upper bound in working hours. We find that expanding work-study program with a cap in working hours can effectively reduce income inequalities without substantial crowd-out by parents.

Second, to evaluate the impact of a loan expansion, we conduct a counterfactual policy analysis that increases student loans by $2,500 per year without the tied-to-investment constraint. Such a policy resembles small loans provided by universities to the student. For example, some universities allow credit purchases by students on and off campus during the enrollment periods. 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 the effect is substantially heterogeneous by child ability and parental income. Additional loans without the tied-to-investment constraint increases monetary investment of high-ability students by reducing their labor supply, but it substantially crowds out parental transfer from high-income families. As a result, low-income families with high-ability children increase their total monetary spending in their child's college education, whereas high-income families with low-ability children decrease their total spending for their child's college education.

This paper contributes to the literature on educational financing and income inequalities. Some papers focus on heterogeneous parental investment as a source of persistent income inequalities across generations, while abstracting from the child's role in human-capital accumulation such as time investment, borrowing, or self-financing (Becker and Tomes [1979] , Becker and Tomes [1986], and Restuccia and Urrutia [2004]). Other studies examine the impact of self-financing on the child's educational and labor market outcomes (Stinebrickner and Stinebrickner [2003], Hotz et al. [2002], Joensen and Mattana [2018], and Sauer [2004]), while taking parental transfer as an exogenously given endowment to a child. A few papers discuss the interactions between parents and the child in college financing (Abbott et al. [2013],Brown et al. [2006], and Brown et al. [2011]), but those studies abstract from the impact of self-financing on the human-capital accumulation. We contribute to this literature by accounting for endogenous interactions between parental transfer, students loan, and self-financing and discuss how heterogeneous financing behaviors of families result in unequal income distribution after college.

Our paper is also closely related to the literature on credit constraints and college education (Cameron and Taber [2004], Cameron and Heckman [1998, 2001], and Lochner and Monge-Naranjo [2011]). We add to the literature by estimating inefficiency associated with the tied-to-investment constraint, while accounting for the role and limitation of self-financing and parental transfer in relaxing such a constraint.

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. Section 6 concludes.

2 Data

2.1 Sample Construction

We use the NLSY97, a panel data set from a nationally representative sample of youths who were 12 to 16 years old as of December 31, 1996. The data include detailed information on how students finance the cost of post-secondary education from 1997 to 2013. We observe (i) the total amount of loans taken out by students,[1] (ii) the amount of transfer from the parents to children (which children are not supposed to repay), (iii) the amount of grants from either government or college, (iv) working hours (while enrolled in a college), and (v) labor earnings during and after college.[2] The data also include students' demographic characteristics, cognitive test scores (the AFQT score), parents' income, and students' enrollment history and the highest degree obtained. All monetary amounts are denominated in 1997 USD using the Consumer Price Index (CPI).

The original sample consists of 8,984 individuals born between 1980 and 1985. We first drop 1,891 individuals without valid AFQT scores. To focus on college students with similar characteristics, we use those who ever attended a four-year college, and drop 4,098 individuals who did not. We drop an additional 1,010 individuals without valid information on parental transfer, student loan, grants, and other types of financial assistance are dropped. We also drop 94 individuals who do not have valid information on the labor supply during the first two years

[1]The loan data from the NLSY97 represents 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?" We use the total amount of loans students take out for higher education (up to three institutions at one time) in our analysis.

[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 the annual data for the educational financing by multiplying the financing variable for the first term by the number of terms for each academic years. For example, if the college has a trimester system, we multiply the term-one financing variables by 3 to get the annual data.

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 parents' income during ages 18-25. The resulting sample consists of 1,795 individuals. The summary statistics for the final sample are presented in Table 1.

2.2 Self-financing during College

Despite increasing access to student loans for college education, they are often limited to educational spending. For instance, government student loans are strictly restricted to educational spending. However, college-education expenses are not limited to tuition, fees, and the cost for books and board, but also includes other consumption. Recent literature has shown short-run credit constraints, especially ones that limit consumption smoothing between the college and working period, contribute to poor academic performance and a higher college dropout rate (Stinebrickner and Stinebrickner [2003, 2008]).

Self-financing, working during the college period, is widely observed among college students and it might serve as a tool to address short-run credit constraints. Based on the NLSY97, we find that college students work a substantial number of hours during the college period. Table 2 shows college students on average work 769 hours during the first year of college: 1,676 hours for the first two years, and 3,867 hours during the first four years after they start college education.[3] Only 2% of students never work while enrolled in a four-year college.

Figure 1 documents the occupation composition of all jobs reported by college students

[3] If we instead look at the median, students work 627 hours for the first year, 1,445 hours for the first two years, and 3,532 for the first four years. We can also use more detailed data, weekly work hours and monthly enrollment status, to exclude working hours during which students are not enrolled in a program, such as vacations. The average working hours during the months in which students are actually enrolled in a four-year college program is 3,132 hours. Students work more during summer vacation, but the difference between working hours during August/September and other months is less than 60 hours.

when they 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.[4] Across 509 different occupations, 10 occupations account for 37% of jobs held by college students. The most frequently observed job is cashiers, followed by retail salesperson, waiters and waitresses, private tutors, and nannies. Those jobs are less likely related to college students' careers, whereas flexible work schedules that can fit a student's class time might be an important reason college students work at low-paying part-time jobs. This finding suggests most work experience during the college period can play a limited role, if any, in a student's career development.

Although self-financing can increase monetary resources during college, it might have an adverse impact on the outcome of the child (Ehrenberg and Sherman [1987], Stinebrickner and Stinebrickner [2003], and Kalenkoski and Pabilonia [2010]). Consistent with the previous findings, Table 3 shows that students who work more during the first two years of the college period tend to have worse educational and labor market outcomes. Controlling for the AFQT score, parental income, the sticker price,[5] and the internship dummy, additional working hours during the first two years of college significantly increase the college dropout rate, lower GPA, and increase the duration of the schooling period necessary to achieve the same degree.

Self-financing, measured by working hours during the first two years of the college period,[6] systematically differs across child ability and family income. In Figure 2, we plot self-financing with respect to ability quartile conditional on each family income quartile. Conditional on

[4]We exclude internships in this analysis, which account for 5.3% of jobs for college students.

[5]We do not directly observe which university the student attended in the publicly available data. As a proxy variable for the sticker price, we use the sum of student loans, parental transfer, grants, and other assistance observed in the data in this analysis.

[6]Freshmen and sophomores are more likely to work for financing but not for career development (e.g., internships). For this reason, we use working hours during the first two years of college period as a measure for self-financing. The findings documented in this section are robust even if we use working hours during the first four years of the college period as a measure of self-financing.

each family income quartile, the self-financing *decreases* by child ability. The self-financing also tends to decreases with respect to family income, especially among students in the highest ability quartile. Self-financing is also related with parental transfer. Figure 3 shows the binned scatter plot for self-financing and parental transfer during college. A negative relationship between self-financing and parental transfer is clearly observed.

To further investigate the determinants of self-financing, we regress self-financing on child ability, family income, and parental transfer. We also include grants as a control variable. Table 4 shows the results. Students who receive greater parental transfer work significantly fewer hours during college, whereas parental income itself does not have significant impact on the self-financing, controlling for parental transfer. This finding suggests that, to fully understand different levels of self-financing across college students, we need to understand parents' endogenous transfer decision during their children's college years.

2.3 Parental Transfer for College Education

Before discussing parental transfer for college education, we first document monetary resources available to students according to the sources in Table 5. Those resources might be used to finance both direct costs and consumption during the college period. The amount of parental transfer, student loans, grants, and other assistance are aggregated over the enrollment period (including graduate schools). Private expenditures that families make toward their child's college education is sizable and largely heterogeneous. Many students receive financial help from their parents ($14,029), but taking out student loans is another important method of financing educational costs ($13,980). College students' labor earnings account for a large share of financial resources available to college students. The average labor earnings of undergraduate students is $20,677, which is greater than the average amount of parental transfer or student loans.[7]

A substantial heterogeneity exists in parents' contribution in college financing. Figure 4 (a) shows the parental transfer *increases* by family income as well as child ability.[8] The positive correlation between the parental transfer and child ability is present across all income levels. This pattern cannot be easily explained by the fact that the return to monetary investment in human capital increases by child ability, because such a mechanism also encourages high-ability children to invest more in themselves. Moreover, altruistic parents have less incentive to compensate the consumption of high-ability children if the children can also finance tuition and consumption themselves.

3 The Model

In this section, we provide a theory that can rationalize the observed pattern of self-financing and parental transfer during a child's college years.

3.1 Environment

A family consists of parents and a child. They live two periods: a college period and a 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 period starts, and then the child decides how much money to take out in student loans and how

[7] We calculate labor earnings during college. Including labor earnings during graduate school would increase this number.

[8] This pattern is not entirely driven by the level of college tuition. Our finding is robust after controlling for the sum of parental transfer, student loans and grants, a proxy for college tuition. We also find similar patterns if we instead look at the share of parental transfer relative to the child's contribution (Figure 4 (b)) in which the share is measured by the fraction of parental transfer out of the sum of parental transfer and student loans.

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 will 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. The human-capital accumulation from college education (h) is a function of three components: the child's ability; monetary investment (m_k), which may capture the quantity/quality of a college education; and the time/effort the student put on the college education. In line with the Ben-Porath model, the child needs to invest time to accumulate human capital. We further assume child ability is complementary to monetary and time investment in the following form:

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

The child's time investment decreases as she works more toward self-financing. T represents the time available to the child, and n_k is the working hours during the college period. The extent to which working hours affect human-capital accumulation depends on ϵ, the unobservable characteristic of the child. We assume $\rho < \gamma$ to guarantee 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 child 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 and are referred to as the "tied-to-investment" constraint in Lochner and Monge-Naranjo [2011]. Thus, the child might face a credit constraint to finance consumption during the college period. The parents have access to a complete credit market.[9]

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

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

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

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

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

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 by choosing the first- and second- period consumption $\{C_{p1}, C_{p2}\}$, transfer (m_p), and amount of savings (a_p):

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

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

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

[9] Although parents have access to a complete credit market, they may not completely relax the borrowing constraint that their child faces, because their child will never pay them back. Parental transfers in our model are driven by an altruistic motive. For a low income parents, the marginal cost of transfer, which is the foregone marginal utility of consumption, is high, and therefore, the transfer of a low income parents is on average smaller than that of a high income parents even without financial constraints for parents.

where V_k is the value of the child. 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_k be the value of the child and let V_p be the value of the parents. 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 $s_p \neq s_p^*$.

Discussion

We impose a few assumptions to make our model tractable and parsimonious. Before characterizing the model, we discuss the limitation and justification for such assumptions. First, we assume parents are altruistic, abstracting from other motives such as the exchange motive (Light and McGarry [2004]).[10] Given that most models of intergenerational mobility use the same altruistic preference, 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 the upstream transfer made by the child is small; the median amount of transfer from the child is about $1,000 USD over two years.[11]

Second, a child's human capital increases in monetary investment and decreases in working hours. Monetary investment mainly increases by years of schooling, but it also increases by college quality. From the NLSY97, we find the average labor income between ages 26 and 30 is positively associated with the sum of student loans, parental transfer, grants, and other assistance, a proxy for monetary investment during college. To account for potentially hetero-

[10] Abbott et al. [2013], Stark and Zhang [2002], and Li et al. [2010]) include paternalism/favoritism as an additional motive for parental transfer.

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

geneous returns to monetary investment between public and private colleges, we allow such a difference and re-estimate the model in Appendix A as a robustness check.

The relationship between human capital and working during college may be non-monotonic. Working as a cashier can be a valuable experience for students, but if too many hours are spent in such job, a student may lose other opportunities to increase human capital. We only model this negative relationship. A heterogeneity in ϵ may reflect the extent to which a student benefits from working. For example, we can interpret a student with a lower ϵ as a student who learns more from working than a student with higher ϵ.

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 found a student's study time significantly decreases by working hours (Appendix B). As a robustness check, we incorporate leisure in our baseline model, and re-estimate the model in Appendix A.

Fourth, we abstract from contracts between parents and the child that allow informal lending and borrowing. The NLSY97 collects the information about lending from parents, separately from parental transfer. We find 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, and parents may not want to make a formal lending contract with their children.

Fifth, we abstract from parents' post-schooling transfer. As discussed in Brown et al. [2011], post-schooling transfer by parents generates strategic motives of the child known as the Samaritan's dilemma: The child will strategically underinvest in human capital to increase post-schooling transfer from the parents. To prevent such strategic behavior of the child, the parents make tied-transfer to the child's education and fully finance the child's educational spending if positive post-schooling transfer is optimal. We abstract from such strategic interaction to allow parents to partially contribute to college financing in the optimal case. Empirically, Haider and McGarry [2012] shows parental transfer made after the child's schooling period is not correlated with the transfer made during the schooling period.[12]

Finally, our model only focuses on the tied-to-investment constraint, while abstracting from the fixed borrowing constraint, which is usually discussed in the educational financing literature. Our mechanism still applies if we instead assume the fixed borrowing constraint. Also, we find that not many students in our data take up to the government loan limit: \$31,000 for dependent undergraduates, \$138,500 for independent graduates. For these reasons, we model credit constraint as the tied-to-investment constraint. As a robustness check, we allow borrowing that is not tied to educational investment, and re-estimate the model in Appendix A.

3.2 Equilibrium without Tied-to-Investment Constraints

We first analyze a situation in which the child does not face a borrowing constraint (the tied-to-investment constraint). In this case, the child can borrow beyond her educational investment to increase consumption. Assuming an interior solution, the optimality conditions imply

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

[12] Related, we assume parents cannot make tied-transfer to educational spending, which is different from Brown et al. [2011]. Including tied-transfer does not change the qualitative implication of our current model.

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 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. Also, self-financing by the child decreases as the total monetary investment in education increases.

The optimal monetary and time investments are

$$m_k^* = K_1 A^{\frac{1}{1-\rho}} \tag{2}$$

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

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) into the human-capital production function (1), we get the optimal human capital

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

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

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

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

where $\Omega = \beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}}$. Without credit constraints, parental transfer decreases by A because the child's life-time income $(h^*/R - m_k^* + wn_k^*)$ increases by A,[13] and therefore, the marginal utility from transfer decreases as ability increases.

3.3 Equilibrium with Tied-to-Investment Constraints

The optimal loan amount can be written as

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

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

[13]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 credit constraint, 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 credit 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 life-time 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 credit 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

$$\frac{\partial h}{\partial m_k} = R \tag{4}$$

$$wu'(wn_k + m_p) = \beta\big(-\frac{\partial h}{\partial n_k}\big)u'(h - Rm_k). \tag{5}$$

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 (4). However, importantly, the marginal return $\frac{\partial h}{\partial m_k}$ is endogenous, depending on the child's labor supply. Because the optimal consumption smoothing is not achieved, $-\frac{\partial h}{\partial n_k} > wR$. If the child cannot finance consumption from borrowing, the marginal return from self-financing increases, and the child works more to finance consumption.

As we can see in equations (4) and (5), with a binding tied-to-investment constraint, parental transfer can affect child investment and human capital. In particular, parental transfer can relax the child's credit constraints for financing consumption during the college period and reduce self-financing. 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

$$\frac{dV_k}{dm_p} = \underbrace{\frac{\partial V_k}{\partial m_p}}_{\text{(I)}} + \underbrace{\frac{\partial V_k}{\partial h}\frac{\partial h}{\partial m_p}}_{\text{(II)}> 0 \text{ if } d_k = m_k} \quad . \tag{6}$$

Compared to the one without the tied-to-investment constraint, the second term is added. Parental transfer can increase child utility by increasing child life-time income, and hence, consumption as described in part (I) of equation (6). 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 raising child investment and human capital as described in part (II) of equation (6). 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 5, we simulate a child's monetary investment and labor supply with respect to parental transfer when the tied-to-investment binds.[14] First, parental transfer, although it is not tied to educational investment, increases both monetary investment and effort by the child. Second, the marginal responses of the child's monetary investment and effort are higher as the child's ability increases. Therefore, $\frac{\partial h}{\partial m_p}$ increases as a child's ability increases in our model.

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. To see this, consider the following problem without the option of self-financing:

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

We assume $n_k = 0$. Hence, the consumption during college only depends on m_p when the tied-to-investment is binding.

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

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 child utility, but it does not affect child monetary investment. Thus, without the option of self-financing, part (II) in equation (6) is zero. On the other hand, part (I) in equation (6) 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 decrease because additional self-financing can decrease returns to monetary investment. (iii) If the tied-to-investment constraint binds, parental transfer can increase by child ability, because the rate of return on a child's human capital by parental transfer can increase by child ability.

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. 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.

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

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

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

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

$$\text{and equation (1).}$$

Without the tied-to-investment constraint, we have $C_{k+1} = (\beta R)^{\frac{1}{\sigma}} C_k$, for $k = 1, \cdots, N-1$. The child's problem can be written as

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

$$\text{subject to} \quad m_k > 0, \quad n_k \geq 0, \quad T - \epsilon n_k > 0,$$

$$\text{and equation (1).}$$

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 $\Sigma_C = \Big[\frac{1-(\beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}})^N}{1-\beta^{\frac{1}{\sigma}} R^{\frac{1-\sigma}{\sigma}}}\Big]^{\sigma}$. 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 without binding constraints.

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

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

$$\text{subject to} \quad m_k > 0, \quad n_k \geq 0, \quad T - \epsilon n_k > 0,$$

and equation (1).

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 $\Sigma_P = (\frac{1-\beta^{\frac{N_p}{\sigma}} R^{\frac{N_p(1-\sigma)}{\sigma}}}{1-\beta^{\frac{1}{\sigma}} R^{\frac{(1-\sigma)}{\sigma}}})^{\sigma}$, 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 Empirical Specification

Focusing on college education, we normalize time so that one period represents four calendar years. To generate the corresponding data for the college period, we aggregate all the variables over students' enrollment periods, except for self-financing. We double the working hours during the first two years of the college period and use it as a measure for self-financing.[15]

Following Cameron and Taber [2004], we set $\beta = 0.97$. We choose $\sigma = 2$, which belongs to the empirically supported range for the IES (Browning et al. [1999]). 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 \$18,904 per year (\$75,616 for four years). For the wage rate of college students, w, we use the average hourly wage of college students aged between 18 and 24 (8.125), focusing on earnings during the 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 by students' AFQT score and parental income.

The time endowment during college period T is set to be 20,900, which is hours available over four years, subtracting time spent sleeping and eating. We refer to the time-diary data from the American Time Use Survey 2004 to get the average time college students spend sleeping and eating, which is 580 minutes per day.[16] We do not adjust T for graduate attendees. In

[15] We get a very similar result when we use the aggregate working hours during enrollment periods as a measure of self-financing.

[16] Some students completed college education in more than four years. However, we do not adjust T for those students, because it is translated into increasing human capital in our model, which is unlikely to be the case in reality.

the data, students who attend graduate schools tend to have large monetary investments and fewer working hours, which translates into increasing human capital in our model. Therefore, in our model, attending graduate school is captured by a larger intensive-margin investment. Similarly, we do not model dropouts. In the data, students who drop out of college tend to have smaller monetary investments and more working hours, which translates into decreasing human capital in our model. Therefore, in our model, dropouts are captured by a smaller intensive-margin investment.[17]

In our life-cycle model, the child lives for $t = 1, \cdots, 15$ where $t = 1$ is the schooling period (investment period) and $t = 2, \cdots, 11$ 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 maturity begins from $t = 2$, similar to Lochner and Monge-Naranjo [2011]. For the gross interest rate, we use $R = \frac{1}{\beta} = 1.03$. For the growth rate of earnings, we use 1.7% following Lagakos et al. [2018]. For parents' life-time income x_p, we multiply the average annual income of parents by 20.[18]

We incorporate grants by assuming they are exogenously given and realized before the parents and the child make choices. The parents and the child maximize utility taking grants as given. Grants and child monetary investment m_k are perfect substitute. In our estimation, we take observed grants from the data for each individual.

[17] We might understate the foregone earnings of college dropouts if their wage is greater than w. However, the low employment rate of college dropouts over the life cycle, which is not incorporated in our model, would partially offset such effects.

[18] Multiplying by a number other than 20 to get parents' life-time income changes the mean of altruistic preference in the estimation, but it does not change our main findings.

4.3 Identification and Estimation

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, non-parametrically 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 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 $u_\alpha \sim N(0, \sigma_\alpha)$. The distribution of $F(\epsilon)$ can be identified by the distribution of working hours during the college period. With a similar reason for $F(\alpha)$, we impose a log-normal distribution for $F(\epsilon)$. Specifically, $\log \epsilon = \epsilon_0 + u_\epsilon$, where $u_\epsilon \sim N(0, \sigma_\epsilon)$.

The curvature of the human-capital production function, ρ, can be identified by the average post-schooling income and the average amount of student loans. Given other parameters, the ability gradient of the initial human capital, δ, is identified from the correlation between the AFQT score and income. γ, the parameter capturing the complementarity between monetary and time investment in the human-capital production function, is identified from the correlation between m_p and n_k. Finally, the correlation between altruistic preference and family income can be identified by the correlation between parental transfer and family income.

We estimate the structural parameters based on the simulated methods of moments.[19] We have eight structural parameters and use nine moment conditions. The choice of the moment conditions is based on the above identification argument: (1) the mean and variance of parental

[19] Parents' problem can be highly non-linear 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.

transfer; (2) the mean and variance of labor supply during the college period; (3) the average labor income after the college period, and the average student loan; (4) the correlation between labor income after the college period and ability; (5) the correlation between parental transfer and child labor supply; and (6) the correlation between parental transfer and family income. To see whether the model can generate a positive-ability gradient with respect to parental transfer, we do not target the parental transfer by ability level. For estimation, the weight matrix is constructed based on the sample variance of the moment conditions.

4.4 Model Fit

Table 6 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.

The model does not directly target correlations between (1) parental transfer and ability, (2) working hours and ability, and (3) working hours and parents' income. Thus, we can check the extent to which the model can also fit those variations in the data.

As discussed in section 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 7 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. Our model abstracts from other motives of parental transfer such as an exchange motive, 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. Finally, the model's prediction regarding the relationship between working hours and parents' income is also consistent with the data.

5 Results

5.1 Estimates

Table 8 shows the estimates for the model parameters. First, γ is negative (-0.298), which implies the monetary and time investment in human-capital accumulation are complements. This finding implies self-financing can be detrimental to the child's human-capital accumulation, because self-financing reduces both time and monetary investment. Second, parents' altruistic preferences show substantial heterogeneity. Although the amount of parental transfer increases by family income, the altruistic preference measured by α significantly decreases by family income ($\alpha_1 = -0.362$). 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: The mean and standard deviation of the log normal distribution are estimated at 1.744 and 0.589, respectively.

5.2 The Impact of the Tied-to-Investment Constraint

In this section, we quantify the role of the tied-to-investment constraint. Without a microfoundation 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 choices of parents and children.

Table 9 summarizes the results. We find that without the tied-to-investment constraint, the average parental transfer decreases by 69% (from \$13,766 to \$4,315), and the average working hours decrease by 84% (from 3,408 hours to 532 hours) while attending college. As a result, human capital, measured by the first four-year earnings, increases by 11% (from \$113,132 to \$125,534).[20] These results show that credit constraint for consumption during college is the main reason for self-financing and parental transfer.

From this exercise, we can also confirm the role of the binding tied-to-investment constraint in generating the positive-ability gradient regarding parental transfer. Figure 6 shows how parental transfer varies by the child's AFQT-score quartile with and without the tied-to-investment constraint. In the baseline model, with the binding constraint, parents of a child from the top quartile of the ability distribution transfer \$3,810 more than parents of a child from the bottom quartile of the ability distribution. Once we remove the tied-to-investment constraint, the parental transfer decreases by child ability so that the parents of a child from the top quartile of the ability distribution transfer \$1,880 less than parents of a child from the bottom quartile of the ability distribution. Table 9 also shows the correlation between parental transfer and child ability changes from 0.100 in the baseline model to -0.056 once the tied-to-investment constraint is removed.

[20] Relaxing the tied-to-investment constraint increases monetary investment by more than \$35,000 on average. Although the size is quite large, it can be interpreted as the result of attending higher-quality colleges or increasing education-related spending, such as buying text-books/computer, attending summer school, or participating in study abroad programs.

The estimated model suggests 97.8% of four-year-college attendees are constrained by the tied-to-investment constraint, because most students take out relatively small amounts in student loans compared to their lifetime income in the data. Our estimate could overstate the extent of the tied-to-investment constraint for the following reasons. First, the model does not take into account credit card loans, which can be useful to relieve short-term liquidity constraints that students might face within the college period. However, the interest rate for credit card loans is too high for students to roll over debts over a couple of years during the college period until they enter the labor market. Thus, the role of credit cards in consumption smoothing between the college and the working period can be limited. Second, some private loans might have looser restrictions than government student loans regarding how the students use the loans. However, taking out private loans incurs additional costs such as increased default risk and potential garnishment of future income, which also limits the role of such loans in students' consumption smoothing (Lochner and Monge-Naranjo [2011, 2016]).

5.3 Income Inequality

Based on our estimated model, we quantify the role of heterogeneous self-financing and endogenous parental transfer in income inequalities among college attendees. The first row in Table 10 shows the baseline income inequality among four-year college attendees. We document the gap in the annual income at the beginning of working period in our baseline estimation between individuals from the top and bottom 10th percentile of the income distribution (90th-10th inequality), the gap between individuals from the 90th and 50th percentiles of the income distribution (upper-tail inequality, 90th-50th inequality), the gap between individuals from the 50th and 10th percentile of the income distribution (lower-tail inequality, 50th-10th inequality), and the standard deviation of the income distribution.[21]

To evaluate the role of self-financing to explaining the within group inequalities among college attendees, we conduct a counterfactual analysis such that all students work the mean level of working hours during the college period. The impact of self-financing on the income inequalities among college attendees is not obvious a priori. On the one hand, self-financing can reduce inequalities associated with credit constraint by helping students relax the constraint. For students who have low effort cost of self-financing, the option of working during college can be an effective way to finance consumption without significantly reducing investment in education. On the other hand, for those who have large effort costs, financing consumption during college from self-financing can substantially reduce time investment in human capital, which can increase inequalities. The Panel A in Table 10 shows that without heterogeneous working hours among college students, the variance of the income distribution decreases by 14% from \$4,267 to \$3,686 and the 90th-10th income inequality decreases by 12% from \$11,374 to \$10,011. The change is more pronounced in the upper-tail inequality (90-50 inequality) as the inequality would decrease by 17% from \$4,700 to \$3,903, whereas the lower-tail inequality (50-10 inquality) decreaes by 8% from \$6,674 to %6,107. Thus, ignoring the impact of heterogeneous labor supply among college students would substantially understate the income inequalities, especially in the upper-tail inequality.

Second, to quantify the role of endogenous interactions between parental transfer and child's self-financing in income inequalities, we compare the income inequalities of our baseline estimation to that in the counterfactual analysis in which the parental transfer is determined following an exogenously given formula. We estimate parental transfer as a function of child's ability and

[21] Those measures are commonly used in literature on wage inequalities (Lemieux [2006b], Lemieux [2006a], and David et al. [2005]).

parental income and use the predicted value in the simulation. Panel B of Table 10 shows ignoring endogenous choice of parental transfer would overstate the income inequalities among college attendees. The standard deviation of the income distribution increase by 6% (from $4,267 to $4,514) if parental transfer is fixed at the estimated level. The 90-10 inequality also increases by 6% from $11,374 to $12,022. Using the fixed predicted value of parental transfer would substantially overstate inequalities especially in the upper tail of income distribution, the upper-tail inequality (90-50 inequality) increases by 10% (from $2,857 to $3,130) whereas the lower-tail inequalities (50-10 inequality) increases by 2% (from $6,674 to $6,809).

5.4 Counterfactual Policy Experiment

5.5 Work Study Program

The Federal Work-Study Program has been implemented as a "self-help" component of a student's financial aid since 1964 as a part of the Economic Opportunity Act. Although the size of the program is smaller than grants or loans, it is growing over time. In our sample of four-year college attendees who started college education during the early 2000s, 20% students received aid from a work-study program, whereas 80% of students received grants from either government or institution. The average amount of work-study program among those who participate the program is $4,323, about 1/5 of the amount of total grants awarded to students $20,894. The Federal Work-Study Program has been implemented as a "self-help" component of a student's financial aid since 1964 as a part of the Economic Opportunity Act. Although the size of the program is smaller than grants or loans, it is growing over time.

The work-study program aims to promote part-time employment by students in financial need so that students can meet their educational costs. There are other important features of the program. First, the program aims to provide jobs that are closely related to student's course of study whenever possible. Second, many jobs are provided On-Campus, which helps students to save more time for study while working. Off-Campus jobs are also mostly in public sectors, thus, the quality of jobs provided through the Federal Work-Study Program is higher than typical jobs available to college students such as cashier or waiter/waitress as discussed previously. Finally, the work-study program imposes a clear limitation on the upper limit of earnings students can get from the program. This is also an important feature of the program that can prevent students from working too many hours which might hamper their study. Thus, the Federal Work-Study Program does not simply increase the work opportunities to the students, but it also provides higher quality jobs to students who need self-financing and provides additional incentives not to derail students from study.

Our model provides a useful framework to evaluate the impact of work-study program on family's college financing behaviors and income inequalities among four-year college attendees. We focus on the feature that the work-study program provides higher quality of jobs which can reduce the opportunity cost of working in their human capital accumulation. We impose an upper limit on working hours to reflect its aim to limit over-work during the college period. In particular, we reduces ϵ, the unobservable heterogeneity that captures opportunity cost of working in human capital accumulation by 10% for all students. We change ϵ proportional to its initial value because ϵ is supposed to capture not only the job characteristics but also student's characteristics.[can rewrite.]

Because in our model, the decision of each family does not depend on that of other families, we change ϵ for all students, not restricting the benefit of work-study program on students from low-income families. To compare the impact of work-study program to the previous counterfactual analysis that provides small loans which are not tied to educational spending, we look at the same outcome measures.

Figure X shows how expanding the work-study program to students which reduces ϵ by 10% affect the total monetary spending on education by the parents and the child. The proportion of families that crowd-in private financing for college education is greater from families from the bottom quintile of the family income distribution (0.49) than families from the top quintile of the family income distribution (0.17). The proportion of families that reduces total monetary spending for child's college education increases by family income (0.11 for the families from the lowest quintile of the family income distribution and 0.34 for the families from the highest quintile of the family income distribution). Overall, the work-study program would induce more low-income families to increase total monetary spending on child'e education, whereas it would result in more rich families crowd-out from college financing. Thus, it is sensible to provide work-study program only for students from low-income families which would not crowd out much private financing. Compare to the policy that provides small loans without tied-to-investment constraint, the proportion of families that crowd-out college financing is substantially smaller with work-study program. The crowd-in and crowd-out of families college financing does not vary significantly by child's ability.

Figure XX shows the impact of the work-study program that reduces ϵ by 10% on choices of family members. First, the work-study program increases child's monetary investment in college significantly and the impact increases by child's ability. For students whose AFQT score belong to the highest quintile of the AFQT score distribution increase monetary investment in college by $2,925. Looking at the family income dimension, students from the second highest quintile of the family income distribution increase monetary investment in education mostly.

Students from the lowest quintile of distribution increase educational investment slightly, but they cannot increase monetary investment because of earning limits.(?). Work-study program will reduce parental transfer but the extent is much milder compared to the loan program (number). Because of the restriction on maximum hours to work, the working hours significantly decreases for the students from the lowest quintile of the family income distribution. All other students slightly increase working hours. Although reducing the opportunity cost of working in human capital accumulation increases working hours for certain group of students, the human capital increases by low-income students who have to reduce working hours significantly. If we look at change in human capital by ability, students from all ability levels have higher level of human capital although students except for those from the lowest quintile of the AFQT score distribution increased their labor supply. This highlights importance of the quality of jobs or opportunity cost of working in analyzing the impact of self-financing on human capital accumulation and income inequality.

5.6 Increasing Loans

Based on the estimated model, we conduct a counterfactual policy analysis evaluating the impact of providing loans that are not tied to educational investment on educational investment by families. Because consumption smoothing is an important motive for self-financing, having additional loans that are not tied to educational investment can affect students' human-capital accumulation. The policy can also affect parents' incentive to financially support their child's college education. On the one hand, the policy would crowd out parental transfer because the child can increase consumption during the college period from additional loans. On the other hand, relaxing the constraint can increase returns to monetary investment in human capital as students work less and study more. Depending on how the monetary investment of the child responds to parental transfer, the amount of crowding out by parents can differ. Our focus is to understand the heterogeneous impact of such a policy by parental income and child ability.

Understanding the impact of additional loans without the tied-to-investment constraint on educational spending by parents and children has important policy implications. First, from the policymaker's point of view, understanding how much such a policy reduces inefficiency, and how much it would crowd out private financing already made by families is important. Second, how the policy affects the relative contribution of parents to the child in college financing can be informative in designing other related policies, such as educational tax credits.

Specifically, we calculate the elasticity of parental transfer and the elasticity of the child's monetary investment to a $2,500 increase in annual loans over four-years that do not have the tied-to-investment constraint. Small loans provided by universities, allowing credit purchases by students on and off campus during the enrollment period, can be an example of such a policy.

First, we discuss how much the policy crowds out or crowds in families' private investment in college education. For private investment, we consider the sum of parental transfer and the child's monetary investment. We find that the additional loans can increase the total monetary investment by low-income families with high-ability children, but it reduces the total monetary investment by rich families with low-ability children. Figure 8 shows the proportion of families that increase/decrease the total monetary investment in their child's college education. The proportion of families that reduce total monetary investment significantly increases by family income. Seventy-three percent of families from the top quintile of the parental income distribution crowd out private investment in their child's college education, whereas only 17%

of families from the lowest qunitile of the parental income distribution do. On the other hand, some families increase total monetary investment in their child's college education. The share of families that increase total monetary investment in their child's college education significantly increases by child ability.

Figure 11 shows changes in parental transfer, child monetary investment, and self-financing by parental income (left) and by child ability (right). It shows parental transfer decreases substantially by family income: If the child can get additional loans of up to $2,500 per year during the college period without the tied-to-investment constraint, parents from the top quintile of the income distribution reduce their transfer by $4,310, whereas those from the lowest quintile of the income distribution reduce their transfer by $410 (second panel). This difference can be explained by two mechanisms. First, parental altruistic preference significantly decreases by family income. Second, high-income students are less constrained; hence, additional loans can decrease the marginal effect of parental transfer on the child's consumption and investment.

On the other hand, the child's monetary investment increases substantially by child ability. If students can take out additional loans of $2,500 per year during the college period without the tied-to-investment constraint, children from the highest quintile of the AFQT score distribution increase their monetary investment by $4,210, whereas the loan increase has a negligible impact on students from the lowest quintile of the AFQT score distribution. Consistent with a positive-ability gradient in the child's monetary investment, the child's working hours decrease substantially by ability. This finding highlights the interaction between monetary and time investment in human-capital accumulation. Finally, parental transfer does not show clear variations across different ability groups.

6 Conclusion

We study a family's college-financing problem when children can self-finance by working. We develop a model in which a child's human capital depends on both monetary and time investment during the college period, extending the Ben-Porath model into the college-financing problem. The model explains how endogenous interactions between parental transfer, student loans, and self-financing lead to heterogeneous human-capital accumulation during college. We estimate the model with the NLSY97. When a child's self-financing affects the returns to monetary investment, the child's credit constraint substantially increases parental contribution. Because the opportunity cost of self-financing regarding human-capital accumulation is higher for high-ability students, incorporating self-financing in human-capital accumulation generates a positive correlation between parental transfer and child ability. Abstracting the interaction between parental transfer and child's self-financing would overstate the gap in upward mobility by family income, because low-and middle-income families have relatively stronger incentives to support child's college education if the child has high ability. Additional loans without the tied-to-investment constraint increase the monetary investment of high-ability students by reducing their labor supply, but they substantially crowd out parental transfer from high-income families.

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Tables and Figures

Table 1: Summary Statistics

Variable	Mean	Std.
Black	0.21	(0.41)
Hispanic	0.14	(0.35)
Female	0.56	(0.50)
AFQT score	65.63	(24.83)
Parents' income	43,856	(36,408)
Average labor income (Age 26-30)	28,199	(17,687)
Highest grade completed (years)	15.48	(2.21)
College dropout	0.29	(0.46)
Attending graduate school	0.28	(0.45)

NOTE: This table shows the summary statistics for the main sample. The number of individuals is 1,795. Money value is normalized by 1 USD in 1997. The labor income after graduation is calculated as the average annual income between ages 26 and 30. When we calculate average annual income between ages 26 and 30, we remove zero annual earnings. We calculate the average annual income of the parents during the periods when the child is between ages 18 and 25.

Table 2: Working Hours during College

Working Hours by College Students	Mean	Std.	Median
During the first year of college	769	(664)	627
During the first two years of college	1,676	(1,241)	1,445
During the first four years of college	3,867	(2,518)	3,532

NOTE: This table shows the working hours during college. The proportion of students who never worked while enrolled in four year colleges is 2%.

Table 3: Self-financing and Child's Outcomes

	College Dropout	GPA	School-leaving Age
AFQT	-0.00405***	0.0112914***	-0.235***
	(0.000410)	(.0008201)	(0.00295)
Parents' Income	-1.15e-06***	3.86e-07	-5.84e-06***
	(2.77e-07)	(5.56e-07)	(1.93e-06)
Self-financing	5.35e-05***	-0.0000372**	0.000244***
	(8.14e-06)	(0.0000164)	(0.0000571)
Sticker Price	-1.49e-06***	9.21e-07**	3.27e-06**
	(2.17e-07)	(4.27e-07)	(1.52e-06)
Internship	-0.117***	0.0627783	-0.1075
	(0.0451)	(.090765)	(0.3133)
HGC			0.376***
			(0.034)
Constant	0.603***	2.209087***	20.080***
	(0.0350)	(0.0704233)	(0.529)
Observations	1,795	1,407	1,795
R-squared	0.138	0.136	0.0853

NOTE: This table shows the regression results for students' outcomes with respect to self-financing and other observable variables. Self-financing refers to working hours of students during the first two years of college. Sticker price refers to the sum of student loans, parental transfer, grants, and other assistance over the enrollment periods. HGC refers to Highest Grade Completed. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Self-financing, Child's Ability, and Parental Transfer

	Self-financing
AFQT	-2.704**
	(1.196)
Parental Income	-0.00121
	(0.000827)
Parental Transfer	-0.00491***
	(0.00115)
Grants	-0.00429***
	(0.00104)
Constant	2,065***
	(88.36)
Observations	1,795
R-squared	0.029

NOTE: This table shows the regression result for self-financing with respect to observable variables. Self-financing refers to working hours of students during the first two years of college. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: The Source of Financing for Higher Education

Variable	Mean	Std.
Parental transfer	14,029	(26,519)
Student loan	13,980	(18,681)
Grants	20,894	(27,944)
Labor earning during college	20,677	(27,100)
Other assistant	1,438	(4,935)
Share of parents' contribution	0.47	(0.41)
Share of students without student loan	0.25	(0.44)
Share of students without parental transfer	0.20	(0.40)

NOTE: This table shows the source of college financing. Money value is normalized by 1 USD in 1997. The amount of parental transfers, student loans, grants, and other assistance are aggregated over the enrollment period. The share of parents' contribution is measured by the fraction of parental transfer out of the sum of parental transfer and student loans.

Table 6: Moment Conditions and Model Fit

Moment Condition	Model Fit	
	Data	Model
$\frac{1}{N}\sum m_p$	0.5192	0.5291
$\frac{1}{N}\sum n_k$	1.3737	1.3512
$\frac{1}{N}\sum d_k$	0.7303	0.7485
$\frac{1}{N}\sum H$	1.5995	1.5947
$\frac{1}{N}\sum(m_p \cdot n_k)$	0.1144	0.3970
$\frac{1}{N}\sum(H \cdot A)$	1.1893	1.1928
$\frac{1}{N}\sum m_p \cdot x_p$	0.4588	0.3691
$var(m_p)$	0.1695	0.1354
$var(n_k)$	0.4602	0.4559

NOTE: This table compares the actual and the simulated moments.

Table 7: Out-of-Sample Fit

		Ability			
		1Q	2Q	3Q	4Q
m_p	Data	7,600	10,626	15,723	22,158
	Model	11,422	13,474	14,934	15,233
n_k	Data	3,518	3,500	3,405	2,985
	Model	3,781	3,432	3,294	3,124
		Family Income			
		1Q	2Q	3Q	4Q
n_k	Data	3,276	3,683	3,315	3,135
	Model	3,769	3,352	3,522	2,885

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

Table 8: Parameter Estimates

Variable	Estimate	Standard Error
α_0	2.385	(0.614)
α_1	-0.362	(0.025)
σ_α	1.866	(0.481)
ϵ_0	1.744	(0.047)
σ_ϵ	0.589	(0.026)
γ	-0.298	(0.032)
ρ	0.704	(0.009)
δ	0.443	(0.025)

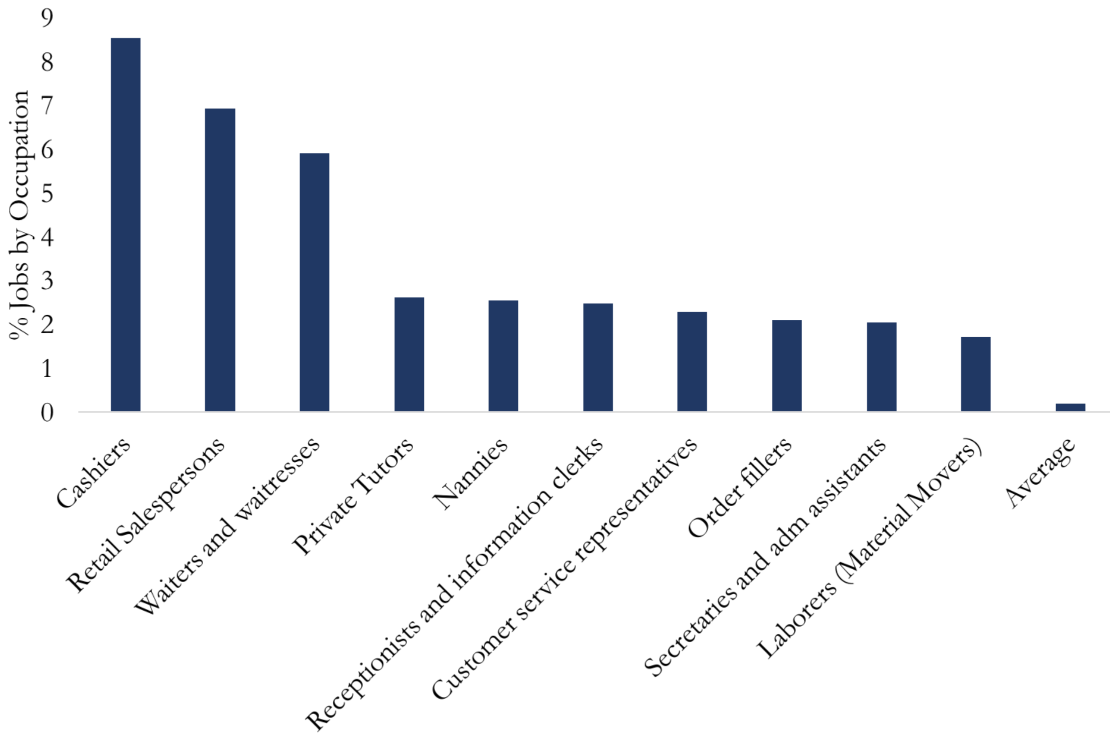
NOTE: This table shows the parameter estimates of the quantitative model.

Table 9: The Role of the Tied-to-Investment Constraint

	baseline	without constraint
average m_p	13,766	4,315
average m_k	14,254	49,913
average n_k	3,407	532
average d_k	13,638	150,539
average h	113,132	125,534
$cor(m_p, A)$	0.100	-0.056
$cor(n_k, A)$	-0.218	-0.679
$cor(m_p, n_k)$	-0.522	0.060
$cor(m_p, m_k)$	0.615	-0.023

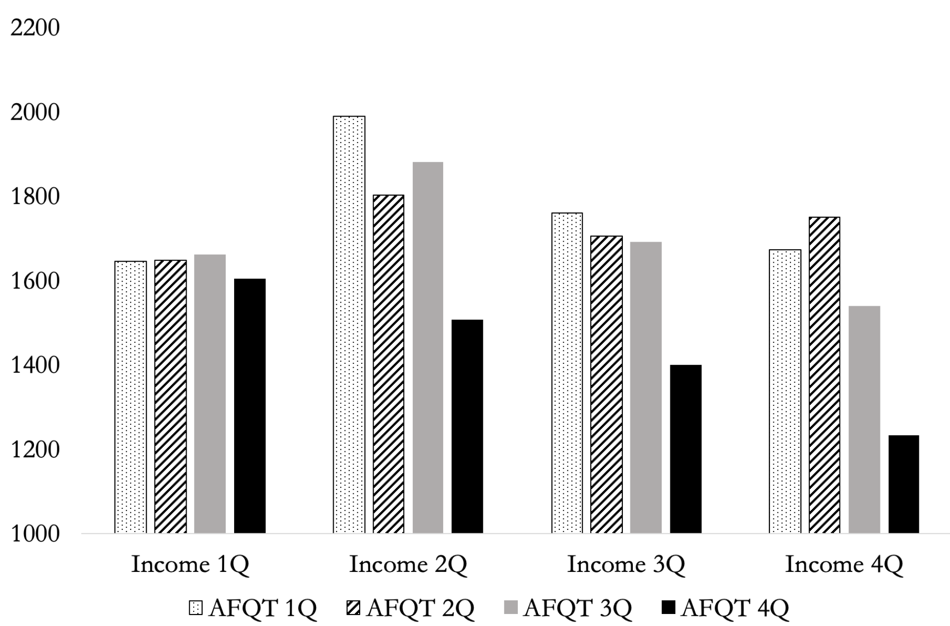
NOTE. The table summarizes model predictions with (baseline model) and without the tied-to-investment constraint. Because the unit interval of time in the model is four years, the average h refers to the first four-year earnings after the college period.

Figure 1: Jobs Held by College Students



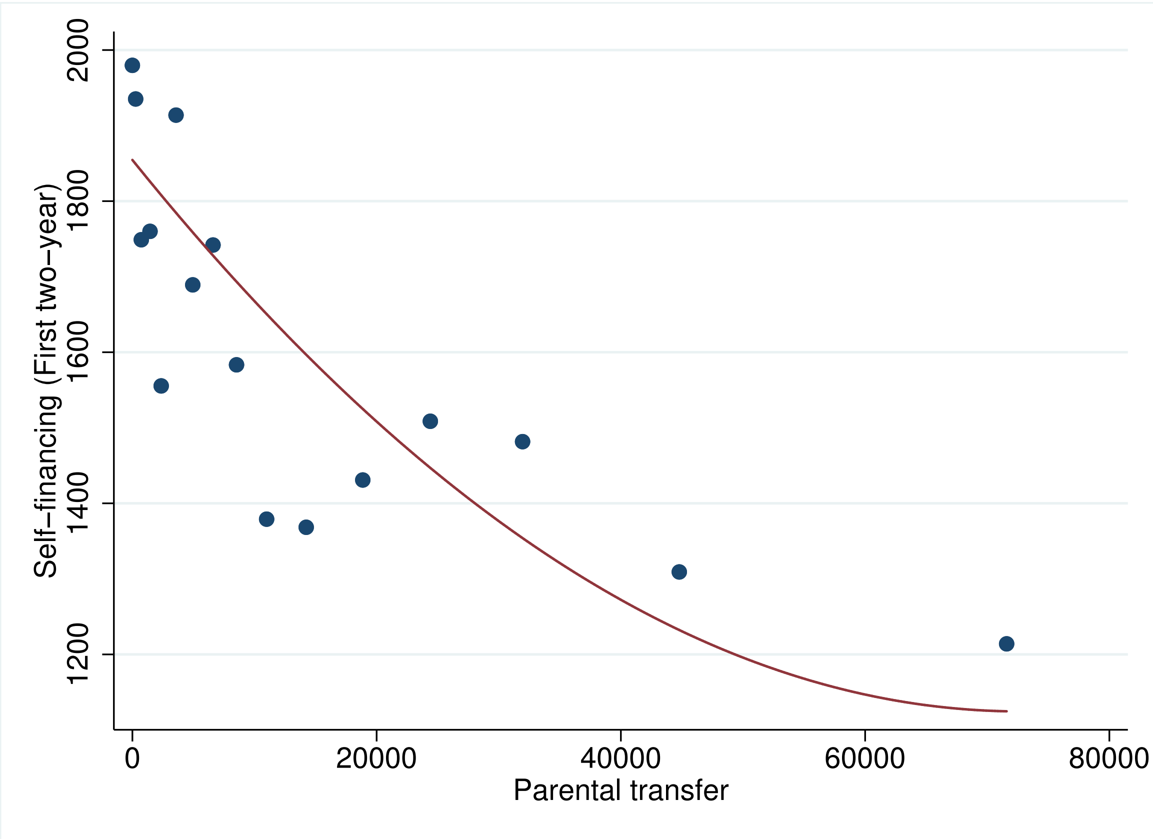
NOTE: The figure shows the most frequently chosen occupations for self-financing.

Figure 2: Self-financing by Family Income and Ability



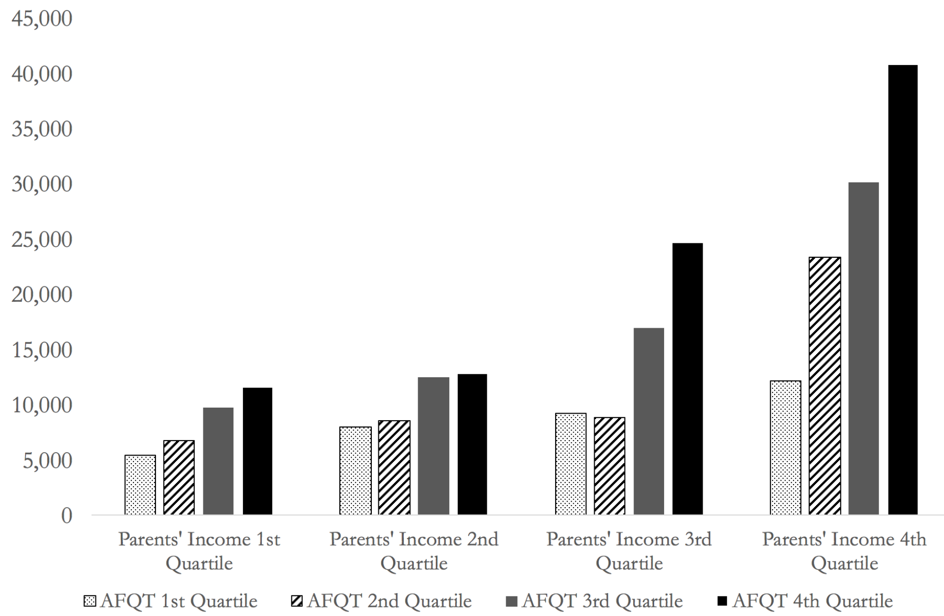
NOTE: The graph shows self-financing of college students for the first two years of college education by family income and child ability.

Figure 3: Self-financing and Parental Transfer

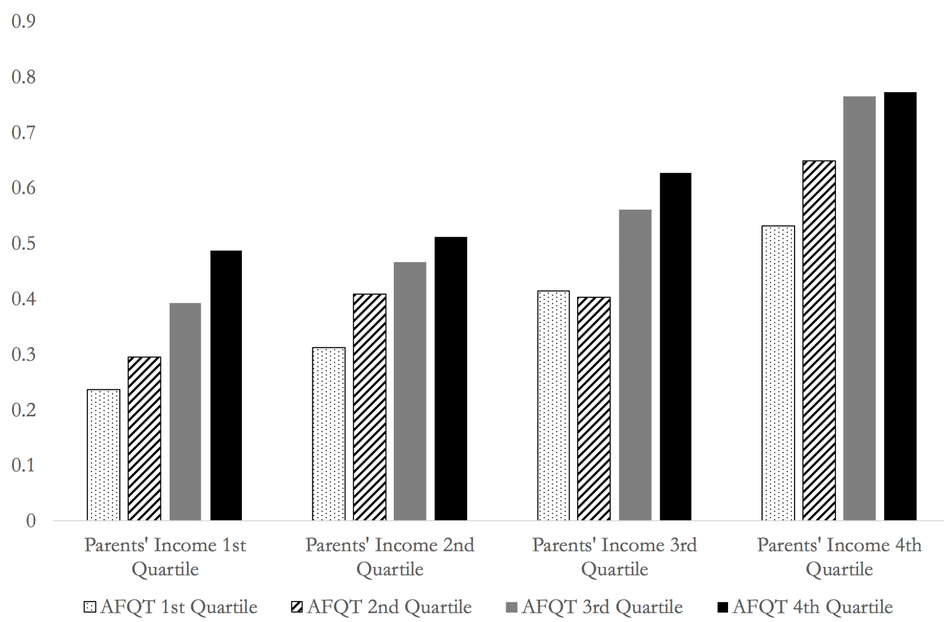


NOTE: The figure shows the binned scatter plot for self-financing and parental transfer.

Figure 4: Parental Transfer by Family Income and Ability



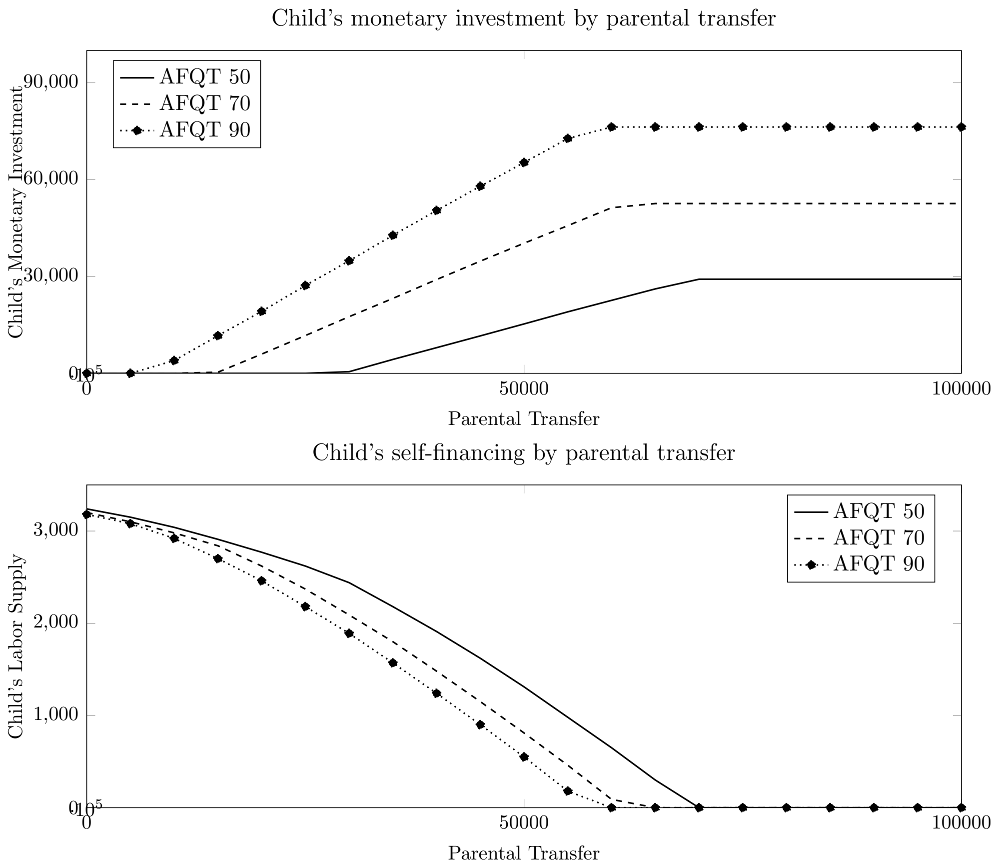
(a) Parental Transfer



(b) Share of Parental Transfer

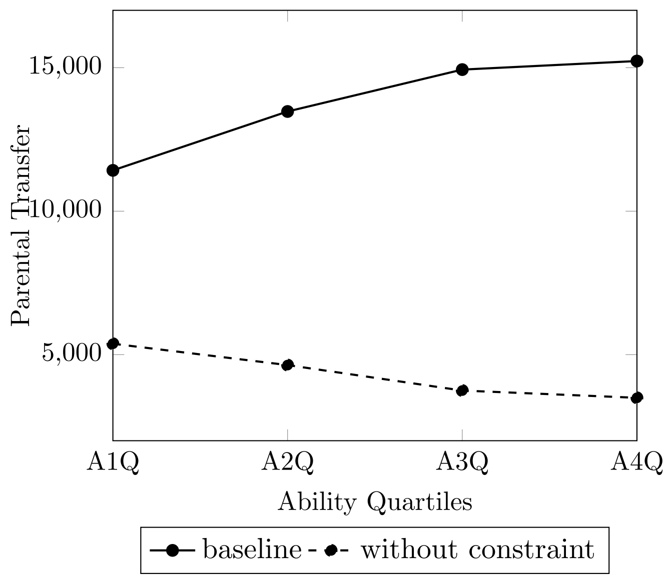
NOTE: Graph (a) shows how parental transfer varies by family income and the child's AFQT score. Graph (b) shows how the share of parental transfer out of the sum of student loans and parental transfer ($\frac{\text{parental transfer}}{\text{parental transfer + student loans}}$) varies by family income and child's ability.

Figure 5: Parental Transfer and Child's Investment



NOTE: The upper panel of this figure shows the relationship between parental transfer and the child's monetary investment simulated by the estimated model. The lower panel of this figure shows the relationship between parental transfer and the child's self-financing simulated by the estimated model.

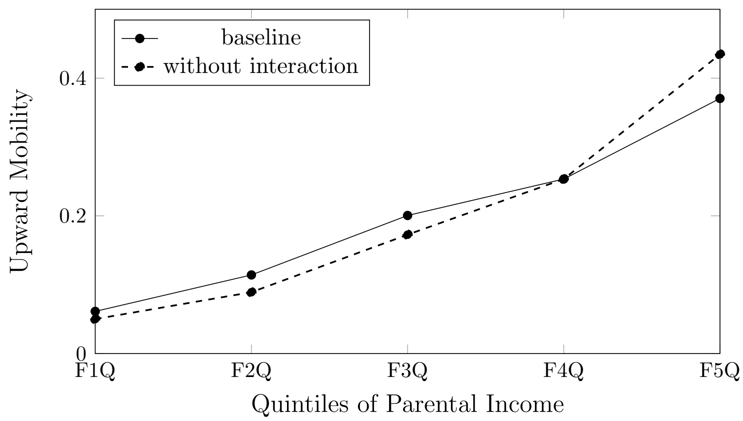
Figure 6: Impact of the Tied-to-Investment Constraint on Parental Transfer



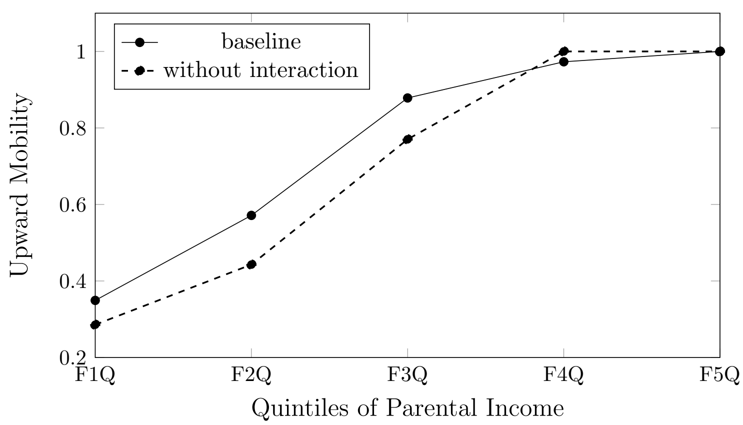
NOTE: This figure compares the parental transfer with respect to child ability quartiles with and without the tied-to-investment constraint in the estimated model.

Figure 7: Intergenerational Mobility

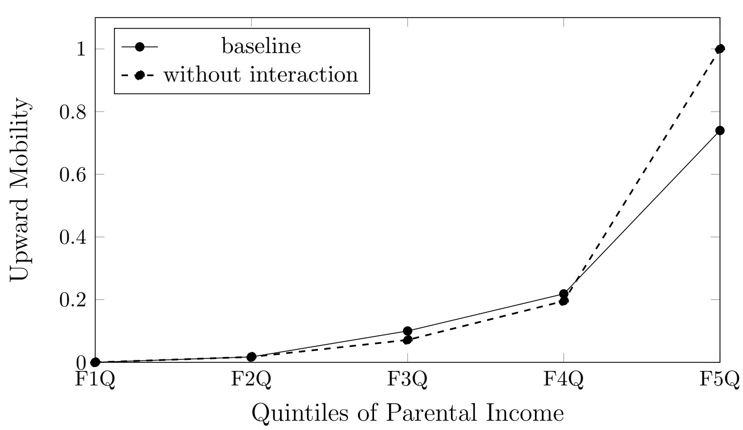
(a) All Ability Levels



(b) Highest Quintile of the AFQT Distribution

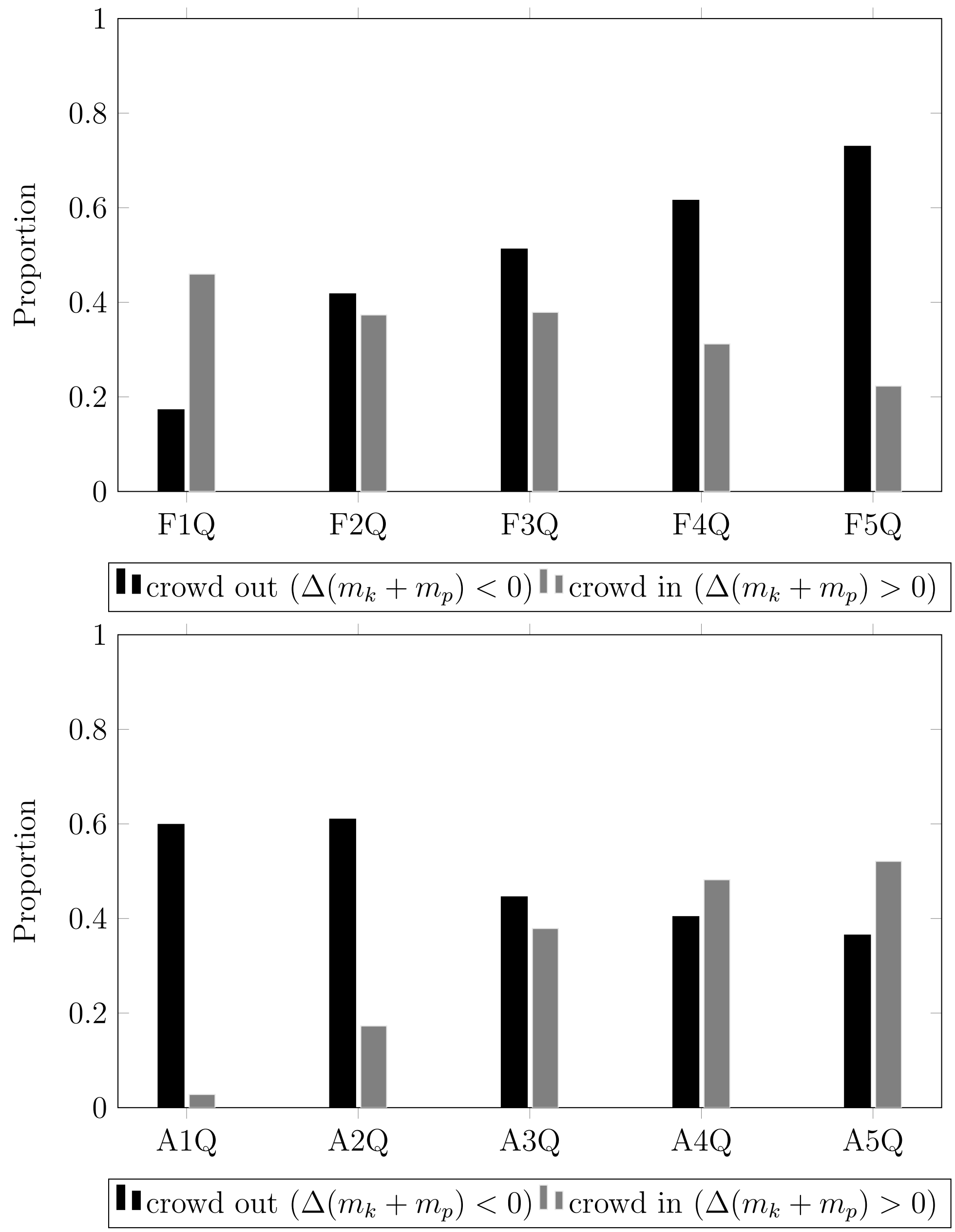


(c) Fourth Quintile of the AFQT Distribution



NOTE: These figures show the probability of the child being in the top quintile of the income distribution (upward mobility) for the baseline economy (solid line) and the fixed-transfer economy (dotted line) from each quintile of the parents' income distribution. Panel (a) depicts the upward mobility of the entire sample. Panels (b) and (c) depict the upward mobility conditional on the highest and second highest quintile of AFQT distribution, respectively.

Figure 8: Proportion of Families by $\Delta(m_k + m_p)$



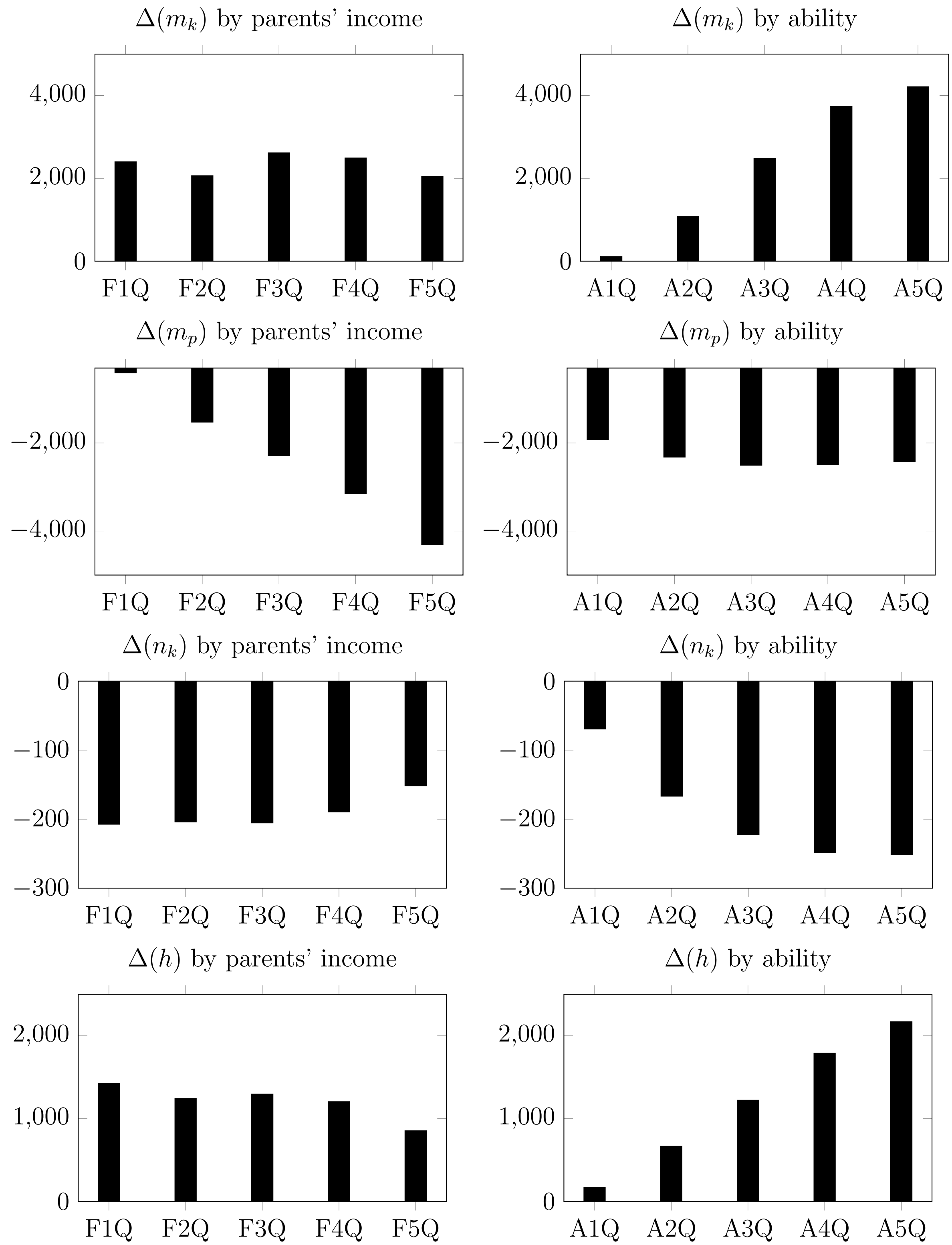
NOTE: The upper (lower) panel of this figure shows the proportion of families, with respect to parents' income (child's ability), which decreases or increases their educational investment after the counterfactual policy described in section 5.4 is implemented. In this policy, a child in each family receives in \$2,500 annual loans, which is not tied to educational investment, over four-years of college education.

Table 10: Income Inequality, Self-Financing, and Parental Transfer

	90th-10th	90th-50th	50th-10th	s.d.
baseline	11,374 (100)	4,700 (100)	6674 (100)	4267 (100)
exogenous parental transfer	12,022 (106)	5,213 (111)	6809 (102)	4514 (106)
mean self-financing	10,011 (88)	3,903 (83)	6107 (92)	3686 (86)

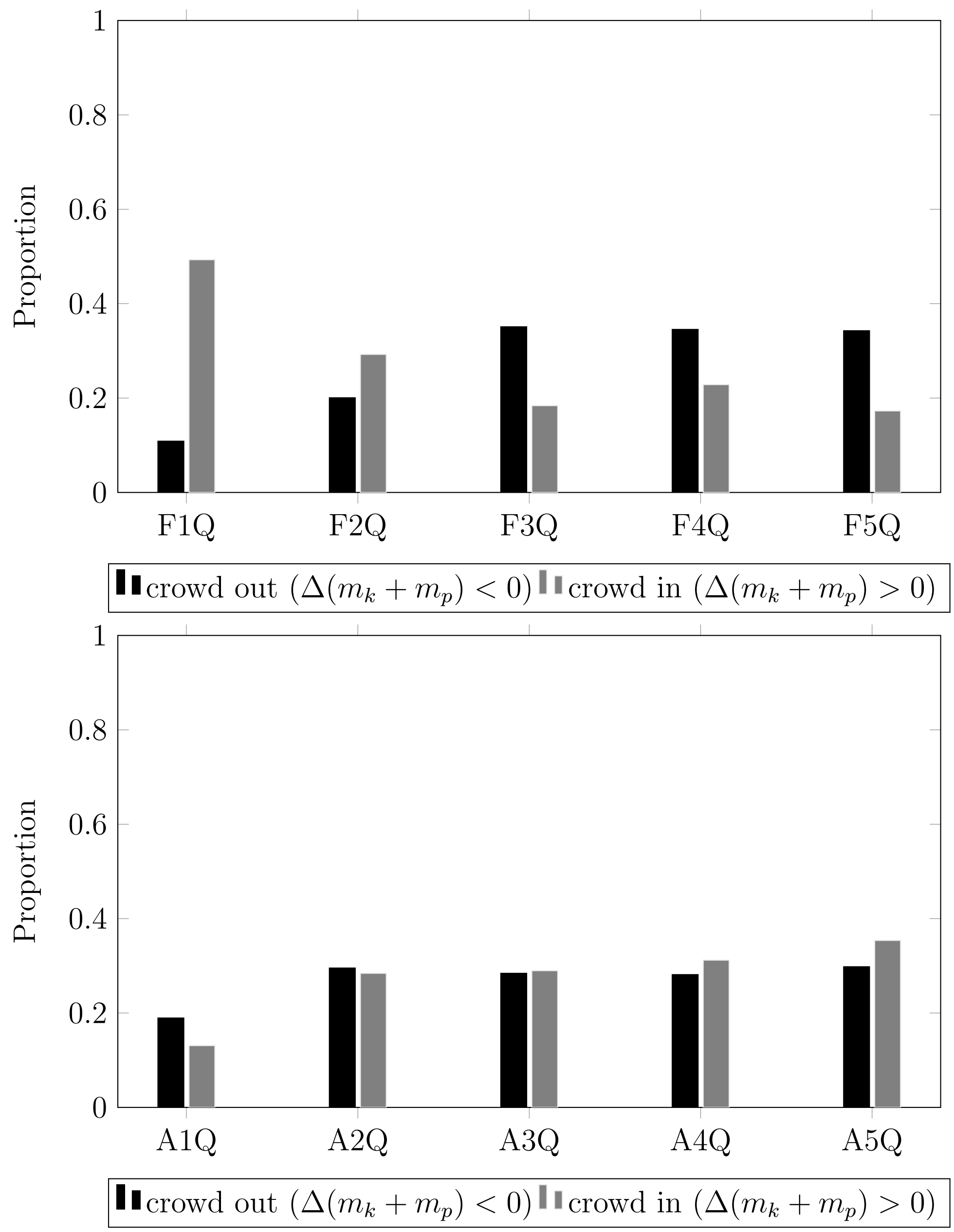
NOTE: This table shows the gap in the annual income after college graduation between top and bottom 10% of the income distribution, the gap between 90th and 50th percentile of the income distribution, and variance.

Figure 9: Impact of Additional Loan without the Tied-to-Investment Constraint in m_k, n_k, and m_p



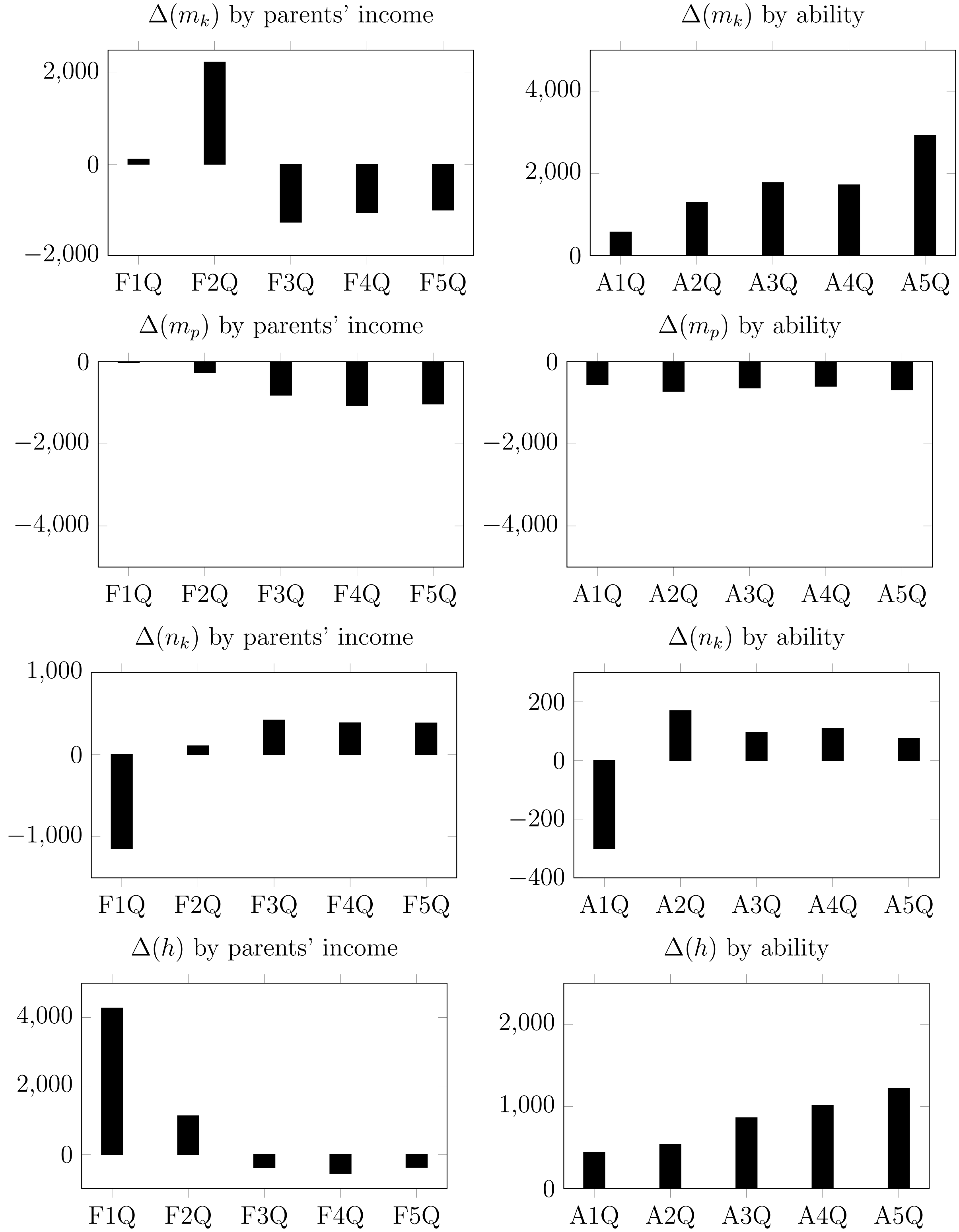
NOTE: The left (right) three panels of this figure show the change in (1) child's educational investment, (2) parents' transfer, and (3) child's self-financing, with respect to parents' income (child's ability), after the policy described in section 5.4 is implemented. In this policy, a child in each family can borrow up to $2,500 in annual loans over four years ($10,000 loans for four years), which is not tied to educational investment, over four years of college education.

Figure 10: Proportion of Families by $\Delta(m_k + m_p)$



NOTE: Impact of expanding work-study program.

Figure 11: Impact of Expanding Work-Study Program in m_k, n_k, and m_p



NOTE: The figure summarizes the impact of expanding work-study program on outcomes.

Appendix

A Robustness Check

To examine the robustness of our main findings, we modify our baseline model in three ways and re-estimate each model, and then compare how the main findings change according to different model specifications. 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. Second, we relax the tied-to-investment constraint by allowing students to take out additional loans without the constraint, totaling up to \$4,000 over four years of college education. Third, we introduce leisure during the college period so that students divide their time between study, work, and leisure. Table 11 shows the estimates of the structural parameters, model predictions, the impact of relaxing the tied-to-investment constraint. Table 12 shows the impact of the policy experiment, providing additional loans without the tied-to-investment constraint up to \$10,000 over four years of the college period. Column (1) of Tables 11 and 12 show the results from the baseline analysis.

First, column (2) of Tables 11 and 12 show how introducing college heterogeneity affects our results. Although tuition and fees for private colleges are far more expensive than those of 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 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. For simplicity, we consider college type as an individual fixed effect that reflects the non-pecuniary benefit of attending a certain type of college. Panel A in Table 11 shows $\psi_{private}$ is estimated as 0.852, which implies that the return from \$1,000 investment in a private college is the same as the return from \$852 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.

Next, column (3) of Tables 11 and 12 show the model predictions when we relax the tied-to-investment constraint by allowing students to take out additional loans without it, totaling up to \$4,000 during college. Panel A shows α_0 decreases from 2.385 to 2.296, whereas ρ decreases from 0.704 to 0.677. If students face less stringent constraints for financing their consumption during college, all else being equal, they would invest more in human capital than in the baseline model. This, in turn, would increase parental transfer, because parental transfer and a child's investment are complements in the presence of constraints. To counteract such an effect, the new estimates have a lower altruistic parameter α_0 and lower marginal productivity in human-capital investment ρ than in the baseline model. Panel B shows parental transfer and child ability are still positively correlated. The modified model predicts that average m_k is lower than in the baseline model (about 4,000 smaller), because now the model rationalizes observed student loans by both loans for educational investment and loans for consumption. Not surprisingly, because students can take out additional loans up to \$4,000, relaxing the tied-to-investment constraint entirely has less positive impacts on the child's investment and human capital. However, overall findings are similar to those in the baseline model.

Finally, column (4) in Tables 11 and 12 show model predictions when we introduce leisure (l_k) as the child's additional choice variable. Students divide their time between work, leisure, and study. The utility from leisure $u(l_k)$ is specified as $\tau \frac{l_k^{1-\sigma}}{1-\sigma}$, and the human-capital production function becomes $h_0 + A\{m_k^\gamma + (T - \epsilon n_k - l_k)^\gamma\}$. The modified child's problem is

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

$$\begin{aligned}
&C_{k1} + m_k \leq w n_k + d_k + m_p \\
&C_{k2} + R d_k \leq h_0 + A\{m_k^\gamma + (T - \epsilon n_k - l_k)^\gamma\}^{\frac{\rho}{\gamma}} \\
&d_k \leq m_k, \quad m_k > 0, \quad n_k \geq 0, \quad l_k \geq 0, \quad T - \epsilon n_k - l_k > 0.
\end{aligned}$$

To construct a moment condition that helps us identify τ, we use the average leisure spending by college students who are enrolled in a college from the American Time Use Survey 2004 (ATUS 2004).[22] Of 17 major categories of activities in the time-use data in 2004 ATUS, we add time spent on leisure and sports, which is about 260 minutes per day and 6,353 hours for the four years of the college period.

Panel A in Table 11 shows that introducing leisure reduces ϵ_0, which captures the marginal effect of self-financing on time investment from 1.744 to 1.319, as students also spend time on leisure. Having leisure reduces the time endowment for study and working. As a result, ρ, the parameter that affects the marginal return from investment, increases so that the model predicts a similar investment level as in the baseline model. Panel B in Table 11 shows 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. Column (4) in Table 12 shows that providing additional loans without the tied-to-investment constraint increases the child's investment, especially for high-ability students, and reduces parental transfer, similar to the baseline model. Because ρ is greater in the modified model, the policy has a greater positive impact on the child's investment and a less negative impact on parental transfer than in the baseline model. Overall, the low-income, high-ability students benefit most from that policy, consistent with the baseline model. To summarize, our results remain robust when we introduce leisure, although the baseline model tends to understate the impact of the tied-to-investment constraint than the model with leisure.

[22] The NLSY97 does not have corresponding information.

Table 11: Robustness Check

	(1) Baseline	(2) Private	(3) Relaxing tti	(4) Leisure
Panel A: Structural Parameters and Model Predictions				
α_0	2.385	2.495	2.296	1.734
α_1	-0.362	-0.365	-0.353	-0.418
σ_α	1.866	1.823	2.037	3.036
ϵ_0	1.744	1.739	1.753	1.319
σ_ϵ	0.589	0.576	0.579	0.618
γ	-0.297	-0.265	-0.307	-0.329
ρ	0.704	0.720	0.677	0.734
δ	0.443	0.435	0.465	0.3683
$\psi_{private}$	NA	0.852	NA	NA
τ	NA	NA	NA	0.076
Panel B: Model Prediction				
average m_p	13,766	14,015	13,988	12,521
average m_k	14,254	14,035	10,235	16,180
average n_k	3,407	3,407	3,403	3,530
average d_k	13,638	13,408	13,249	15,541
average h	113,132	112,336	113,030	110,195
$cor(m_p, A)$	0.100	0.101	0.090	0.078
$cor(n_k, A)$	-0.218	-0.219	-0.212	-0.235
$cor(m_p, n_k)$	-0.522	-0.535	-0.487	-0.558
$cor(m_p, m_k)$	0.615	0.625	0.571	0.512
Panel C: Relaxing Borrowing Constraints				
Δm_p	-9,451	-9,589	-8,077	-6,750
Δn_k	-2,876	-2,872	-2,694	-3,292
Δm_k	35,659	35,879	25,642	38,442
Δh	12,402	12,254	9,416	14,545
$cor(m_p, A)$	-0.056	-0.058	-0.057	-0.047
$cor(n_k, A)$	-0.679	-0.676	-0.705	-0.519
$cor(m_p, n_k)$	0.060	0.062	0.057	0.034
$cor(m_p, m_k)$	-0.023	-0.024	-0.005	-0.019

NOTE. The table summarizes results for each robustness-check analysis.

Table 12: Counterfactual Policy (Additional Loan without the Tied-to-Investment Constraint)

		(1) Baseline	(2) Private	(3) Relaxing tti	(4) Leisure
Panel A: Impacts on Choices/Outcomes					
Δm_p	low-income	-406	-405	-327	-343
	high-income	-4,305	-4,390	-3,698	-2,398
	low-ability	-1,922	-1,982	-1,607	-791
	high-ability	-2,429	-2,472	-2,128	-1,301
Δm_k	low-income	2,398	2,139	1,089	5,777
	high-income	2,050	1,893	685	5,070
	low-ability	110	86	153	1,019
	high-ability	4,212	3,836	1,739	13,981
Δn_k	low-income	-207	-200	-185	-544
	high-income	-151	-143	-135	-406
	low-ability	-69	-67	-67	-242
	high-ability	-251	-240	-228	-546
Δh	low-income	1,422	1,271	1,089	2,917
	high-income	853	802	685	2,168
	low-ability	170	161	153	390
	high-ability	2,169	2,033	1,739	10,011
Panel B: Proportion of Families, Crowd in and Crowd out $\Delta(m_p + m_k)$					
crowd in (%)	low-income	46	44	38	57
	high-income	22	20	17	57
	low-ability	3	2	2	12
	high-ability	52	51	46	77
crowd out (%)	low-income	17	18	16	11
	high-income	73	77	77	34
	low-ability	60	66	61	42
	high-ability	36	37	39	13

NOTE. The table summarizes counterfactual policy simulations for each robustness-check analysis. In this policy, a child in each family can borrow up to \$2,500 in annual loans over four years (\$10,000 in loans for four years), which is not tied to educational investment, over four years of college education. High (low) income refers to the top (bottom) quintile of the family income distribution. High (low) ability refers to the top (bottom) quintile of the AFQT score distribution.

B Additional Data: American Time Use Survey

To get the estimates for the child's time endowment during the college period, we use the American Time Use Survey 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. The time use is classified into 17 major categories, each with two additional levels of details.[23] 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 522 (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 per day not spent sleeping or eating, which results in about 20,900 hours over four years. If we focus on students who actually spend a positive amount of time on education-related activities, the average sleeping time is 498 minutes per day and the average eating time is 53 minutes per day, which leads to 551 minutes per day, which is very similar to our baseline estimate.

Students do spend time engaged in activities other than studying and working. Focusing on students who spend a positive amount of time on education-related activities, students, on average, spend 276 minutes per day on education-related activities, 178 minutes on leisure, and 217 minutes on work and work-related activities. Thus, students in a college program who spend a positive amount of time on educational activities spend about 11.18 hours per day on studying, leisure, and working, which amounts to 16,328 hours over four years.

The correlation between time spent on education and working is -0.3 without controlling for any other components. Working and leisure are also negative correlated (-0.31); thus, some students may reduce their leisure time if they have to work a lot. In Table 13, we project hours for education on working and leisure hours. We do not observe perfect substitution between leisure and working hours, and working hours are negatively correlated with study time. Hence, the data support the idea of a trade-off between time investment in education and self-financing.

[23]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 NonHH 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 13: Correlation between Time Spending on Study, Work, and Leisure

VARIABLES	Study	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 relationship between the time used for education and working hours. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1