The Intergenerational Transmission of Credit Scores through the Market for Student Loans*

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Abstract

Traditionally, undergraduate students in the U.S. have borrowed from the government to finance college. However, as the price of college continues to rise, more students and their parents are turning to private credit markets to help cover the cost of college. Most private creditors in the student loan market use the credit history of both the student and the parents, who often serve as cosigners, to set the credit conditions of the loans. This is quite different than borrowing from the government, in which credit history does not matter. In this paper, we build a life-cycle model where agents that differ in parental contributions for college and credit scores can borrow from the government and private credit markets to finance their college investment. We find that the optimal level of college investment depends positively on the parent's credit score and the amount of parental contributions. In this framework, credit scores evolve over time, such that good repayment behavior on private student loans is rewarded by higher credit scores. We quantify the effects of the intergenerational transmission of credit scores on college investment, and analyze the trade-offs induced by alternative credit market arrangements.

JEL Codes: I22; J24

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1 Introduction

In recent decades, the cost of attending college in the U.S. has skyrocketed. However, financial aid has not kept pace: the net price of college (total student charges net of grants and tax benefits) for public and private four-year institutions increased by 43 and 27 percent, respectively, between 1997-98 and 2007-08 (College Board, 2008).[1]

Besides receiving grants and tax benefits, undergraduate students and their parents face various options to finance college. Students may have savings or current income to draw upon. Parents often contribute to their child's college education using their current income, college savings plans and retirement accounts. Students and their parents can also borrow to finance college, from the federal government or, more recently, from private credit markets.

While the cost of college has increased, the amount students can borrow from the federal government has not. The government borrowing limit for undergraduate students has remained constant since the early 1990's. And approximately one-half of undergraduate borrowers borrow the maximum amount from federal student loan programs (Berkner, 2000; Titus, 2002). In addition, parental contributions towards college education has decreased in real terms over time (NCES, 2004). All of this suggests that a majority of undergraduates are credit-constrained (Turner, 2004; Lochner and Monge-Naranjo, 2008): more undergraduates are hitting the government borrowing limit and are not able to finance their college education through traditional methods.

As a result, there has been an explosion of lending from private creditors for college: the volume of nonfederal, private student loans increased by an astonishing 592 percent during the last ten years (College Board, 2008), constituting a $17.6 billion industry in 2007-2008. This compares to a 70 percent increase in the volume of government student loans during the same period (College Board, 2008).

In this paper, we evaluate the three main sources of funding for undergraduate education: parental contributions, government loans and private loans. We develop a model in which parents can transfer money to their children, which is used to pay for college. The child can decide to borrow for college, from both the government and the private credit market. When borrowing from the private market, students can use the credit histories of their parents to help them qualify for loans and to set loan conditions (specifically interest rates). Children with parents with better credit scores qualify for lower interest rates on their student loans from the private market. This is quite different than government student loans, in which no credit history is required, such that interest rates are fixed across individuals.

[1] Total charges include tuition, fees, room and board; grants include federal, state, institutional and private grants.

Via the market for private student loans, the model generates a mechanism in which parents may transfer their credit history to their children. Lower interest rates on private school loans lead to lower debt levels. As a result, children whose parents have better credit scores may be more inclined to invest in their human capital. In addition, parental wealth affects the borrowing decision of students. Clearly, children with wealthier parents will receive more parental contributions, but they will also qualify for fewer government loans. Children from low-wealth households will be eligible for more government loans, but if they decide to use private credit markets to finance the rest, they may face higher interest rates if their parent's credit score is lower. Thus, children and parents in the model are linked through transfers of wealth and credit scores. We measure how this evolution of credit scores affects the college investment decision.

The college financing literature is rich, with significant contributions by Heckman et al. (1998), Keane & Wolpin (2001), Carneiro & Heckman (2002), Dynarski (2003) and Hoxby (2004). In recent years, the literature has focused on the effectiveness of government student loans, with important contributions by Garriga and Keightley (2007), Lucas and Moore (2007), Lochner & Monge (2008), Schiopu (2008) and Ionescu (2009). Of these, only Lochner & Monge-Naranjo (2008) incorporate a market for private school loans in which both the government and the private market charge penalties for default. In their framework, there is a limited commitment problem in the private student loan market, where creditors can reacquire part of the loan in the case of default. Thus, in the private market, credit constraints are endogenous and interest rates vary with the size of loan. Our framework is different in that interest rates vary with credit history, and credit limits are based on the cost of college less financial aid. In Lochner and Monge-Naranjo (2008), ability and family resources matter across generations, while we are most interested in exploiting the transmission of wealth and credit history across generations.

In related work, Altig and Davis (1989) and Soares (2008) consider the role of altruism (parental transfers) in an environment with exogenous credit constraints. Typically, government policies aimed at relaxing borrowing constraints (such as government school loans) would improve welfare, but Soares (2008) finds that this is not necessarily the case: looser credit constraints for children may lower parental transfers and reduce the child's savings, which lead to less investment in human capital, and reductions in welfare. Schiopu (2008) analyzes various higher education financing policies (including the federal student loan program) in an environment with altruistic parents who transfer resources to their children to finance higher education. Our analysis complements this work by showing how parental transfers of both financial assets and credit worthiness affects human capital accumulation.

Recent work has analyzed the usefulness of credit scores in capital markets. Athreya, Tam

and Young (2008) consider the amount of information that can be gleaned from credit scores to explain the rise of unsecured credit, bankruptcy rates and credit discounts. Chatterjee, Corbae and Rios-Rull (2008) develop a theory of unsecured debt and reputation which is motivated by facts regarding the role of credit scores in consumer credit and auto insurance markets.

The paper is organized as follows. In Section 2, we describe the institutional details of the government student loan program and the private market for student loans. We then develop a simple model in Section 3 in which students can borrow only from private credit markets for college so that we can isolate the transmission of credit scores from parents to child. We then develop a richer model in Section 4 that incorporates both government and private market borrowing for student loans, and calibrate it to match important features of these markets (Section 5). Our quantitative results are contained in Section 6. We include a sensitivity analysis of the model in Section 7, and Section 8 concludes.

2 Institutional Details of Student Loans and Credit Scores

As the costs of attending college rises, more families are sharing the burden of financing undergraduate education. Based on a 2008 study by Sallie Mae and Gallup of undergraduate students and their parents, parents contribute nearly half (48%) of the total amount paid for college, most of which comes from parental income and savings (covering 32% of total costs) and parental borrowing (16%). Students, on the other hand, are picking up 33% of the tab, most in the form of loans (23%) and student income/savings (10%). The remaining college costs are covered by grants and scholarships (15%) and contributions by friends and relatives (3%). Thus, the three largest sources of college financing (in rank order) are: 1) parental income/savings, 2) student borrowing, and 3) parental borrowing.

In our analysis, we focus on student borrowing from the government and private credit markets and abstract from parental borrowing. Parents borrow in several ways to help finance their child's undergraduate education, using the Federal Parent PLUS loan program (representing 5% of total cost of college)[2], home equity loans or lines of credit (3%), private student loans (2%), credit cards (1%), retirement plans (0.5%), and "other sources" of borrowing (4%). Since parental transfers and student borrowing (public and private) represent the largest sources of college financing, we will focus on these in this paper. We believe

[2]PLUS loans are quite similar to private student loans, in that they depend on credit worthiness (but credit requirements are far less stringent), and credit limits are generous. However, in recent years, fees and interest rates on PLUS loans have been higher than private student loans, making them less attractive.

extending our framework to allow for parental borrowing in public and private markets is an interesting avenue to pursue in future work.

2.1 Government Student Loans

Federal loans are administered through the U.S. Federal Student Loan Program (FSLP), and includes Perkins, Stafford and PLUS Loans. Complete details on the FSLP, including recent changes to the system, can be found in Ionescu (2009). However, some general features of the program are important in our set-up.[3] First, students and their families can borrow from the U.S. government at partially subsidized interest rates, which varied with the 91-day U.S. Treasury bill rate up until 2006.[4] Second, no credit history is required to obtain a government student loan. Third, Federal student loans are need-based that take into account both the cost of attendance (total charges) and the expected family contribution, which is determined by each college and university. However, there is a limit to how much students can borrow from the government. Lochner and Monge-Naranjo (2008) report that dependent students could borrow up to $23,000 over the course of their undergraduate career using Stafford loans, while independent students can borrow nearly twice that amount. This limit on government loans has remained constant since 1993. Borrowing from the government is quite common. Based on NPSAS 2007-08 data (Steele and Baum (2009)), nearly 50% of full-time college students borrow from the government, and the average amount borrowed was $5,432 (per borrower).

Typically, repayment of government student loans begins six months after college graduation, and can last up to ten years. In the past, the federal government has allowed for consolidation under certain circumstances, where borrowers could lock-in interest rates. This option no longer exists, however. Default in the FSLP is not defined in its traditional sense. Default can occur anytime during the repayment period if borrowers neglect to make a payment in 270 days. National default rates in the FSLP for the 2005 cohort were 4.6% (Department of Education).[5] Students cannot discharge their debt upon default. Dischargeability on public student loans was initially limited in 1990, with further limitations in 1998 unless default would cause "undue hardship" on the debtor. Thus, borrowers file for bankruptcy under Chapter 13, one of the reorganization chapters in which borrowers enter a repayment plan.[6] Penalties on defaulters in the FSLP include: garnishment of their wage, seizure of

[3] In our analysis, we focus on Stafford student loans, which represents 80% of the FSLP in recent years.

[4] Recent legislation changed the structure on interest rates for subsidized student loans to be declining, fixed rates over time. The rates on Stafford loans starting in July 2006 were fixed at 6.8%. The rates for loans dispersed starting in 2011 will be set at 3.4%, and then will be reset at 6.8% in July 2012.

[5] http://www.ed.gov/offices/OSFAP/defaultmanagement/cdr.html

[6] As a practical matter, it is very difficult to demonstrate undue hardship unless the defaulter is physically

federal tax refunds, possible hold on transcripts and ineligibility for future student loans.[7] Once the defaulter starts repaying his government loans, bad credit reports are erased and credit market participation is not restricted.

2.2 Private Student Loans

The system for obtaining private student loans is much different than the FSLP. First, credit history is important. Most private student loans require certain credit criteria, which can be met by enlisting a cosigner that meets the credit criteria. For Sallie Mae, the largest creditor of private student loans, approximately 60 percent of their applicants have a cosigner (in 2008). Second, loan limits in private school loans are set by the creditor and do not exceed the cost of college less any financial aid the student receives (from all possible sources). Third, interest rates and fees vary significantly across various levels of credit worthiness and interest accumulates while in college. For example, Sallie Mae's leading private loan for students is the Signature Student Loan, where interest rates begin at Libor + 4.8% and cap at Libor + 8.3%.[8] In pricing these loans, various credit characteristics matter, including credit scores, the number of delinquencies and bankruptcy filings within a certain period, debt-to-income ratios, and collections history. There are also some private student loan companies that use non-credit characteristics such as school attended, grade-point average, etc. in pricing a loan. In addition, it is possible to find "credit-ready" loans that are offered to applicants with no credit or a thin credit file. Many college students (especially first-time freshman) tend to fall into this category. These credit-ready loans tend to have higher interest rates and/or fees to compensate for the risk inherent in the population. For traditional private student loans, the unpaid interest is capitalized (i.e., added to the loan balance). For Sallie Mae, the most common reason for denial is creditworthiness. In particular, Sallie Mae does not grant private student loans when the FICO score of the applicant or the co-signer is less than 640 (in 2008).

Using a combination of public and private loans is quite common for many undergraduates. Based on the Sallie Mae/Gallup survey (2008), more than two-thirds of students who use private education loans also borrow from the federal government. This compares to approximately 27% of students who borrow only from private credit markets in that survey. However, in other reports, Sallie Mae and the College Board (2008) report that only 10% of college students participate in private student loans. More recently, based on the 2007-08

unable to work.

[7] For details, see Ionescu (2009).

[8] The margins represent weighted averages and are from June 2008; they were obtained from: http://www.salliemae.com/about/investors/

NPSAS data, 19% percent of full-time undergraduates borrow from private markets (Steele and Baum, 2009). Schools are not required to report these numbers, and since the private student loan market is relatively new, estimates vary by source. However, the average private student loan is almost 50% larger than the average government student loan: full-time students in 2007-08 borrowed $7,809 in private student loans (Steele and Baum, 2009).

Similar to government student loans, default in the private student loan market is rare. Sallie Mae reports that net charge-offs as a percentage of all of the private loans in repayment are 3.92% (annualized). Instead, lenders work with students to help them manage their student loan repayment responsibility. For example, lenders may offer a number of repayment plans to assist customers with managing their monthly payments. And those experiencing financial hardship may be offered, at the lender's discretion, a period of forbearance, an approved period of time when customers do not need to make payments on their loans. Similar to other credit markets, but unlike the public loans market, late payments, missed payments and default in the private student loan market will adversely affect the borrower's credit score, which will affect their ability to obtain credit in the future and the interest rates offered to them. Like government student loans, private student loans are not dischargeable in bankruptcy.

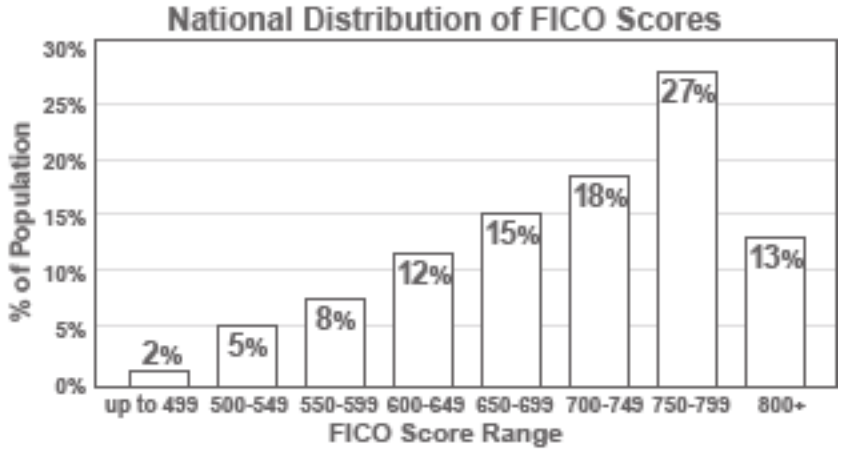
According to a 2006 report from the Institute of Higher Education Policy, private creditors are participating in the market for student loans for a variety of reasons. For most of the large market participants (Sallie Mae, Citigroup, Bank of America, etc.), credit is issued directly to college students in two distinct markets: the private market of school loans and government-guaranteed student loans (the Federal Family Education Loan Program, FFELP), some of which are subsidized by the federal government. Thus, large lenders typically have both types of assets in their portfolios. Initially, in order to maintain their status on preferred lending lists with colleges and universities, creditors often had to offer both types of loans, even though private loans were less profitable than the FFELP loans. In recent years, the profitability of private loans is outpacing the profitability in government-guaranteed school loans, making private student loans a lucrative business. In addition, the ability to sell these loans in capital markets as asset-backed securities makes it more attractive for creditors to issue private student loans since they do not have to hold onto the loans. Certainly, in light of the credit market tightening that occurred in 2008-09, private creditors have pulled back a bit, increasing the credit requirements for these loans (Sallie Mae now requires a 670 FICO score). Still, recent evidence confirms that private student loans are still big business.

2.3 Credit Scores

Credit scores of students and their parents play an important role in the market for private student loans. Similar to other forms of debt such as unsecured debt (i.e., credit cards), personal loans, and mortgages, interest rates are tied to the credit score of the applicant and the cosigner. Credit reporting agencies such as FICO calculate credit scores for individuals based on a large set of information about their past credit history. FICO reports that the following components form part of the credit score calculation: payment history (35%), amount of outstanding debt (30%), length of credit history (15%), new credit/recent credit inquiries (10%), and types of credit used (10%).[9] It is important to note that FICO scores are based on information found in credit reports, and do not explicitly depend on income, employment tenure, education, assets, etc. The national distribution of FICO scores is given in Figure 1.

While it is true that FICO scores are not the only credit bureau scores used to determine credit, FICO scores are by far the most commonly used for all types of credit. For student loans in particular, Sallie Mae uses FICO scores to determine the credit conditions for each borrower.

Figure 1: Credit Scores



Source: http://www.myfico.com/CreditEducation/CreditScores.aspx

[9] http://www.myfico.com/CreditEducation/WhatsInYourScore.aspx

3 A Simple Model of Credit Scores and College Investment

We start by building a simple model that incorporates a private student loan market for undergraduate students. We keep the model as simple as possible to focus on the trade-offs that parents face with respect to financing their child's college education. We abstract from government student loans for now.

Consider a model where people live for two periods, as young adults and parents. Agents are heterogeneous in two dimensions: a parental contribution for college, $b^0 \in B$, and parental credit score, $f^0 \in F$, which are drawn independently from the distributions $B(b^0)$ and $F(f^0)$. Parental contributions and credit scores are transferred from the parent to his only child. In doing so, the parent gets utility $x(b^1, f^1)$ which represents the discounted expected value of the child's value function. Thus, each young generation is composed of agents with different endowments of physical assets and intangible assets; intangible assets represent the credit scores of their parents. Both of these transfers are important in the young agent's human capital accumulation. Loan conditions are determined by the credit scores of their parents.

In the first period of life, agents consume c_1 and invest in human capital h using their parental contribution for college b^0. Given the fixed cost of college $\overline{d}$ and their endowment b^0, young agents may need to borrow the remaining amount, d, from private credit markets. As discussed above, the private market for school loans is where parents often serve as cosigners, such that the parental credit score, f^0, affects the conditions of the private student loan. Specifically, in the case the credit score is very poor, i.e. $f^0 = \underline{f}$, the agent cannot borrow. For any $f^0 > \underline{f}$, the agent is allowed to borrow the entire amount needed, i.e. $d = \overline{d} - b^0$ and the interest rate on his student loan, $R(f^0)$ is assumed to be a decreasing function of the credit score f^0. Thus the set of feasible debt levels is given by $D = \{0, \overline{d} - b^0\}$.[10]

In the second period, agents use their earnings to pay back their student loans p, consume c_2 and leave a parental contribution for education b^1 to their only child. The repayment p depends on the interest rate $R(f^0)$, the amount borrowed d, and the fraction of the school loan repaid $\alpha \in [0, 1]$. Thus, $p = R(f^0)d\alpha$. We assume that the borrower defaults on his loan when he delivers a very small payment $\alpha < \underline{\alpha}$. In this simple 2-period model, the first period of life consists of a decision about how much of the student loan to repay, while in the second period, the agent deals with the consequences of his repayment behavior. Based on the agent's payment, the credit history that the agent builds and leaves to his child is given by $f^1 = g(\alpha, f^0)$ with $g(\alpha, f^0) = \underline{f}$ for all $f^0 \in F$ and $\alpha < \underline{\alpha}$. We assume a linear evolution of the credit score, $g(\alpha, f^0) = \alpha a(f^0) + b(f^0)$, for all $\alpha \in [\underline{\alpha}, 1]$, where $a(f^0) > 0$ and $b(f^0) > 0$

[10] For now, we assume that $\overline{d}$ does not vary by h.

and $g(\underline{\alpha}, f^0) = f^0$. Our formulation is motivated by the evolution of the credit scores: the score is updated positively when payments are observed. This upgrade is done gradually: the higher the payment, the higher the upward revision. Eventually, the credit score can be upgraded to a higher range of credit scores, which translates into better credit conditions for one's child. Full repayment induces a jump in the credit history to the next range of credit scores. If a small payment ($\alpha < \underline{\alpha}$) is observed, the score is severely damaged.[11]

For now, we assume that agents cannot borrow from any other markets (such as a risk-free market), and there is no market uncertainty in interest rates for private student loans. Earnings in period 2 for an individual who invested h in human capital in the first period is given by $y(h)$ with $y^{'}(h) > 0$ and $y^{''}(h) = 0$.

Discounted lifetime utility for the agent consists of $u(c_1) + \beta u(c_2) + \rho x(b^1, f^1)$, where c_t represents the consumption of the agent during period t. The utility function satisfies $u'(.) > 0$ and $u''(.) < 0$. The discount factor is $\beta \in (0, 1)$ and $\rho \in (0, 1)$ reflects the degree of altruism. The function x represents the utility from transferring resources (b^1,f^1) to one's own child. We assume separability in b^1 and f^1: $x(b^1, f^1) = (1 - \phi)\ln(b^1) + \phi\nu(f^1)$ and $\nu' > 0$, $\nu'' = 0$.[12] The parameter $\phi \in (0, 1)$ measures the relative weighting that parents put on transferring funds to their child versus transferring their credit score.

We assume a logarithmic utility function. Thus, the agent solves the following problem:

$$\begin{aligned} \max_{c_1,,c_2,h,p,b^1} \quad & \ln(c_1) + \beta\ln(c_2) + \rho((1-\phi)\ln(b^1) + \phi\nu(f^1)) \\ s.t. \quad & c_1 + h \leq d + b^0 \\ & c_2 \leq y(h) - p - b^1 \\ & f^1 = g(\alpha, f^0) \\ & d \in D \end{aligned} \tag{1}$$

Based on the agent's problem in equation 1, we solve for the optimal levels of human capital investment h^*, loan payments α^*, and parental contributions b^{1*}. The optimal human capital investment is given by:

$$h^* = \overline{d} - \frac{R(f_0)(\overline{d} - b^0)}{y'(h)\rho\phi\nu_g a(f^0)} \tag{2}$$

which yields $\frac{\partial h^*}{\partial f^0} = -\frac{(\overline{d}-b^0)}{y'(h)\rho\phi\nu_g}\frac{R'(f_0)a(f^0)-R(f^0)a(f^0)}{a^2(f^0)}$. Since $R(f^0) < 0$ is decreasing in f^0, $a(f^0)$

[11] This minimum fraction $\underline{\alpha}$ can be interpreted as the per period fixed payment where the present value equals the total amount of the loan.

[12] For now, we assume that the credit score linearly translates into some utility for one's child, $\nu(f^1)$.

is increasing in f^0, and $y^{'}(h)\phi\nu_g a(f^0)$ and $\overline{d}-b^0$ are positive, it follows that h^* is increasing in f^0. A lower interest rate and a higher sensitivity of the new credit score to one's payment $a(f^0)$ will induce more human capital investment. Also, we get that $\frac{\partial h^*}{\partial b^0}=\frac{R(f^0)}{y'(h)\rho\phi\nu_g a(f^0)}>0$. Thus, agents with high initial parental contributions (b^0) and high parental credit scores (f^0) will invest more in their human capital.

In this model, agents with higher human capital investment will repay more of their loan. This is evident by writing the optimal payment α^* as a function of optimal human capital investment h^*:

$$\alpha^*=\frac{y^{'}(h^*)(1+\beta+\rho(1-\phi))(h^*-\overline{d})+\overline{d}}{R(f_0)(\overline{d}-b^0)}. \tag{3}$$

since $\phi\in(0,1)$. Furthermore, the effect of human capital investment on loan payments is larger when the returns to human capital accumulation $y^{'}(h^*)$ or parental contributions b^0 are higher. In addition, higher parental credit scores lead to higher loan payments since $R(f^0)$ is decreasing in f^0. Thus, the incentives to repay on private loans for college depend on the agent's characteristics, namely their inherited credit score and parental contributions, which affect the conditions of the loan (i.e., the menu of interest rates tied to credit scores and the sensitivity of credit scores to payments). This has important implications for credit scores.

Consider the optimal level of repayment:

$$\alpha^*=\frac{\overline{d}y^{'}(h)}{R(f^0)(\overline{d}-b^0)}-\frac{(1+\beta+\rho(1-\phi))}{\rho\phi\nu_g a(f^0)} \tag{4}$$

which implies $\frac{\partial\alpha^*}{\partial f^0}=-\frac{\overline{d}y^{'}(h^*)R'(f^0)}{R(f^0)^2(\overline{d}-b^0)}+\frac{(1+\beta+\rho(1-\phi))a'(f^0)}{\rho\phi\nu_g a^2(f^0)}$. Since $R'(f^0)<0$ and $a'(f^0)>0$, it follows that the payment α^* is increasing in f^0. Hence, the updated credit score f_1 is increasing in the inherited credit score f^0.[13] This result implies that parents who have relatively low credit scores hurt the borrowing conditions of their children since the parent's credit score determines the interest rate the child receives on his private loan for college. With worse borrowing conditions (i.e. higher interest rates), the child repays less of their loans, which leads to lower credit scores for the child. In this way, credit scores are transmitted from parent to children.

Furthermore, equation 4 yields $\frac{\partial\alpha^*}{\partial b_0}=\frac{\overline{d}y^{'}(h)}{R(f^0)(\overline{d}-b_0)^2}>0$, which implies that f_1 is an increasing function of b^0. Parents who contribute very little to their child for college hurt their child's borrowing conditions. With relatively low parental contributions, the child needs to borrow more for college. Loan repayment is more difficult in this situation, leading to a lower credit score for the child.

[13]The updated credit score is $f_1=g(\alpha^*(f^0,b^0),f_0)$. Then $\frac{\partial f^1}{\partial f^0}=g_1\frac{\partial\alpha}{\partial f^0}+g_2$ and $\frac{\partial f^1}{\partial b_0}=g_1\frac{\partial\alpha}{\partial b^0}$.

From equation 3, note that the agent will deliver higher loan payments when the additional returns to his human capital investment $y^{'}(h)$ are high enough relative to loan conditions, captured by interest rates, the sensitivity of one's payment to the updates of the credit score, etc. The immediate implication of this observation is that students with low parental credit scores and contributions can make up for it, but only if the returns to human capital investment are high enough.

In this environment, parents face a trade-off between credit scores and contributions for their child's education. Agents leave a better credit history f_1 when they inherit a higher credit score f^0 or higher education funds b^0. The optimal choice for parental contributions is given by $b^{1*} = \frac{(1-\phi)R(f^0)(\overline{d}-b^0)}{\phi\nu_g a(f^0)}$, which delivers that b^{1*} is decreasing in both the inherited credit score f^0 and initial parental contribution b^0. An agent who puts more weight on leaving a good credit score than more contributions (i.e., a higher ϕ) will leave funds to their child (observe that b^{1*} decreases in ϕ) but will leave a higher credit score (since f^1 increases in ϕ). An agent with a lower ϕ will leave more funds to their child but a lower credit score.

This model, even though simplified in many respects, provides several interesting results about how private loans for college affect the college investment decision and the transfer of credit scores across generations. First, we find that college investment is increasing in both the parental credit score and the parental contribution of funds for college. Children with parents with higher credit scores receive lower interest rates on their private student loans, making them more likely to repay their college debt. As such, the credit score of the child is increasing in parental credit scores, our second main finding. Thus, this model delivers an intergenerational transfer of credit scores through the private market for school loans. We next consider a richer model, that more closely replicates what we observe in the student loan market.

4 Full Model Description

Building on the model in Section 3, we extend the model to incorporate government student loans and individual savings in a risk-free market. To more closely mimic an agent's life cycle, we consider a life-cycle economy where agents live for T periods. Time is discrete and indexed by $t = 1, ..., T$ where t represents the time after high school graduation. Each agent's life is characterized by four phases: college, young adult, parent, and retirement. Table 1 illustrates the life-cycle for a typical agent in the model.

The first phase represents the time spent in college. For simplicity, we assume that all agents in the model are college-bound (i.e, we do not analyze those who do not attend

college.)[14] During this phase, young agents consume and invest in education. To finance their consumption and human capital accumulation, young agents receive parental contributions for college and can borrow from the government and the private market. Agents in their second phase of life are young, working adults who use their labor earnings to consume, pay off their school loans (both public and private), and save (or borrow). In the parent phase, agents use their labor income similarly (to consume and save). Each agent in this phase has one child that goes to college and may transfer some of their resources to their child to use for their child's human capital accumulation (i.e., college education). Also, the credit score in this phase matters for their child's student loans.[15] In the last phase of life, retired agents live off of their savings. We assume that old agents die with certainty at the end of this period.

Table 1: Phases of the life-cycle

College ($t = T_1$)	Young Adult ($T_1 + 1, ..., T_2$)	Parent ($T_2 + 1, .., T_3$)	Retirement ($T_3 + 1, .., T$)
Consumption (c_t)	Consumption (c_t)	Consumption (c_t)	Consumption (c_t)
Investment in education (h)	Earnings ($y_t(h)$)	Earnings ($y_t(h)$)	Interest Earnings
Earnings ($y_t(h)$	Borrow/Lend (s_{t+1})	Borrow/Lend (s_{t+1})	
Borrow for school $\left(d_t^g + d_t^p\right)$	Repay student loans (p_t)	Transfers (b^1, f^1) at $t = T_{child}$	
Parental contributions (b^0)	Credit score (f_t)		
Credit score (f^0)			

As in the simple model, agents are heterogeneous in parental contributions b^0 and credit scores f^0, which are drawn independently from the distributions $B(b^0)$ and $F(f^0)$. Discounted lifetime utility consists of:

$$\sum_{t=1}^{T} \beta^{t-1}[u(c_t) + \rho x(b^1, f^1)] \tag{5}$$

where c_t represents the consumption of the agent during period t. All of the parameters have the same properties as in the simple model. We assume constant relative risk aversion such that $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ where $\sigma > 0$. Note that during the parent phase, altruistic agents have children who go to college and derive utility from transferring resources to their child, (b^1, f^1). Once again, we assume separability in b^1 and f^1 such that $x(b^1, f^1) = (1-\phi)\omega(b^1) + \phi\nu(f^1)$ and $\nu', \omega' > 0$, $\nu'', \omega'' < 0$. The parameter ϕ measures the relative weighting that parents

[14]Since the goal of the paper is to consider the transmission of credit scores via the private student loan market, we feel this is a reasonable assumption. Having agents in the model that do not attend college only complicates the computations and does not add anything in terms of qualitative findings.

[15]Since this is a model of college education, we assume the costs and benefits of each child to their parent are 0 until they start college.

put on transferring funds to their child versus transferring their credit score. The agent's problem is to maximize his utility (equation 5) subject to his budget constraints.

In the first phase of life, the college student consumes c_t, invests in human capital h, receives contributions from his parents b^0 and borrows from the government d_t^g and the private market d_t^p. Thus, the budget constraint for the college student is:

$$c_t + h \leq b^0 + d_t^g + d_t^p + y_t(h) -; \quad t = T_1. \tag{6}$$

With regards to human capital accumulation, we allow students to choose to complete 4 years of college, h_4, or 2 years of college, that is attend college for half of this period, h_2. Agents who complete only 2 years of college will earn labor income ($y_t(h_2)$). If the agent completes 4 years of college, the opportunity cost of college completion is his foregone earnings minus earnings that he gets from working during college, ($y_t(h_2)$).[16] Agents who complete 2 years of college should be interpreted as students who complete 2-year colleges and those who drop-out from 4-year colleges. In addition, we assume all students attend college full-time.[17]

The rate at which the college student borrows from the government R_t^g is exogenous and does not vary across individuals, but evolves stochastically over time. The amount the student can borrow from the government d_t^g depends on the cost of college per period in college $\overline{d}(h)$ and the parental contribution b^0. The cost of college reflects the actual cost of college (i.e., tuition and fees), and depends on how much college is obtained (h_2,h_4).[18] In this environment, the college investment decision is purely a financial decision. Based on the cost of college and the return to college (i.e., lifetime earnings), students make a decision whether to complete two or four years of college. The cost of obtaining four years of college is the weighted average of the price of public and private colleges for four years. The cost of obtaining two years of college is the weighted average of the price of public, two-year colleges and the price that drop-outs paid at their public and private colleges for two years. Thus, we are explicitly considering drop-outs of four-year colleges since they represent a significant portion of all borrowers; Gladieux and Perna (2005) find that 20% of all student borrowers drop-out.

Parental contributions for college depend on parental income and assets. Thus, the borrowing limit for a young agent from the government is: $d_t^g(h, b_0) = \max[\min\{\bar{d}(h) - b^0, d_{\max}(h)\}, 0]$, where $d_{\max}(h)$ is the exogenous borrowing limit imposed by the government

[16]For a nice paper that considers how borrowing constraints affect labor supply decisions for college students, see Garriga and Keightley (2007).

[17]Since most of the data on participation in student loans programs (both private and public) significantly vary with full-time and part-time enrollment, we needed to focus on one group.

[18]Recall in the simple model that $\overline{d}$ was constant. Relaxing this assumption to better capture observed differences in college costs and hence debt limits will have important implications in this model.

for each period in college, where $h \in (h_2, h_4)$.

The college student can also borrow from private credit markets d_t^p at the interest rate R_t^p. The rate students pay for private school loans depends on the credit score of their parents, such that $R^p(f^0)$ with $R^{p'}(f^0) < 0$. The interest rate on private loans evolves stochastically over time according to a two-stage Markov process. The transition probability matrix is the same for all agents. The mean of the process, and thus, the actual interest rates are adjusted by credit score. Since interest rates and the supply of loans are exogenous, this is a partial equilibrium analysis.[19] The amount students can borrow from private credit markets for school is the difference between the cost of college $\overline{d}(h)$ and what they receive in government loans. Thus, the borrowing limit in private credit markets is: $d_t^p \leq \overline{d}(h) - d_t^g(h, b_0)$. It is important to note that our model assumes private creditors will meet the demand of student loans (which is a strong assumption, especially in the recent financial environment).

In the next phase of life as young adults, agents consume c_t, save/borrow s_{t+1}, earn labor income and pay back part or all of their school loans p_t. They also face wage garnishment in the case of default on government or private student loans (μ_g, μ_p). Hence, the budget constraint is:

$$\begin{aligned} c_t + s_{t+1} &\leq y_t(h)(1 - \mu_g - \mu_p) - p_t; \quad i \in g, p; t = T_1 + 1, ..., T_2; \\ \mu_i &= 0 \qquad \text{if } p_t^i \geq \underline{p}^i \end{aligned} \tag{7}$$

Labor income depends on the human capital accumulated during college such that $y_t'(h) > 0$, $y_t''(h) < 0$.[20] The agent enters repayment on both the public and the private loans. The loan amounts at the beginning of this repayment period are given by d_t^g for government loans and $d_t^p R_t^p$ for private loans. Note that the interest on government loans does not accumulate during college, but it does accumulate for private loans. This is consistent with what we observe in the data.[21] We assume α_t^i is the share of total debt the agent pays in period t toward loan i, where $i \in g, p$ and $\alpha_t^i \in [0, 1]$. Thus, the size of payment on student loans (both government and private) at time t is represented by:

$$p_t = \sum_i \alpha_t^i d_t^i; \quad i \in g, p. \tag{8}$$

[19] Considering the various mechanisms that could affect the supply of private student loans is beyond the scope of this paper. However, we conduct robustness checks on this assumption in the Section 7 of the paper.

[20] We abstract from modeling human capital accumulation after college in order to focus on the role of parental funds and credit scores in the college investment decision.

[21] In some cases, students pay interest on their private student loans while in college (to shorten the life of the loan). We abstract from this possibility.

Consequently the debt evolves according to:

$$d^i_{t+1} = d^i_t(1 - \alpha^i_t)R^i_t; \tag{9}$$

where R^i_t represents the interest rate in period t for market $i = \{g, p\}$. When the agent chooses to make no payment to his school loans in period t, $\alpha^g_t = \alpha^p_t = 0$. When the agent repays all of his remaining school loans in period t (both government and private), $\alpha^g_t = \alpha^p_t = 1$.

Agents default on government student loans when payments are less than the required amount, $p^g_t < \underline{p}^g$. In period t, the agent is required to pay the fraction $\underline{\alpha}^g_t$ which depends on the principal of the loan p^g_t, the interest rate R^g_t, and the time left until the end of the repayment phase, $T_2 - t$. Thus, default occurs if the fraction that he chooses to repay, $\alpha^g_t < \underline{\alpha}^g_t$. In this case, there are consequences to default captured by the wage garnishment μ_g, but there is no effect on credit scores when students default on government student loans, which is consistent with what we observe in the data. When the agent makes the required minimum payment on government student loans ($p^g_t \geq \underline{p}^g$) , there is no wage garnishment, thus $\mu_g = 0$.

Similarly, agents default on private student loans when payments in each period are less than the required amount, $p^p_t < \underline{p}^p$. In period t, the agent is required to pay the fraction $\underline{\alpha}^p_t$ which depends on the principal of the loan p^p_t, the interest rate R^p_t, and the time left until the end of the repayment phase, $T_2 - t$. Thus, default occurs if the fraction that he chooses to repay, $\alpha^p_t < \underline{\alpha}^p_t$. In this case, wages are garnished at the rate $\mu_p > 0$. In addition, the default is reported to credit agencies. As a result, credit scores are revised downward in the case of default. Thus, when the agent chooses $\alpha^p_t < \underline{\alpha}^p_t$, the score becomes $g(\alpha^p_t, f^0) = \underline{f}$. When the borrower pays the exact amount that it is required ($\alpha^p_t = \underline{\alpha}^p_t$), his score does not change, $g(\underline{\alpha}^p_t, f^0) = f^0$. For any payment $\alpha^p_t \in (\underline{\alpha}^p_t, 1])$, the score is gradually updated according to the function $g(\alpha^p_t, f^0) = \alpha^p_t a(f^0) + b(f^0)$, where $a(f^0) > 0$ and $b(f^0) > 0$. When he pays his entire loan in period t ($\alpha^p_t = 1$), his score improves to the next bin, $g(1, f^i) = f^{i+1}$ for $i \in \{1, ..., 6\}$. We require that agents must pay off their school loans at the end of this period; thus, for $t = T_2$, $p_{t+1} = \sum_i (d^i_t - p^i_t)R^i_{t+1}$; $i \in g, p$.

As a parent, agents consume c_t, borrow/lend s_{t+1}, earn labor income $y_t(h)$, and earn/pay the risk-free rate on their last period savings/borrowings, according to:

$$c_t + s_{t+1} \leq y_t(h) + R^f s_t; \quad t = T_2 + 1, ...T_{child} - 1, T_{child} + 1, ...T_3. \tag{10}$$

Additionally, in period $t = T_{child}$, the parent transfers funds to their child b^1 so that the budget constraint is:

$$c_t + s_{t+1} \leq y_t(h) - b^1 + R^f s_t - p_{t+1}; \quad t = T_{child}. \tag{11}$$

Finally, the budget constraint in the last phase of life (retirement) is:

$$c_t + s_{t+1} \leq R^f s_t; \quad t = T_3 + 1, ..., T \tag{12}$$

where the agent consumes c_t using his return on past period savings s_t.

Thus, the agent maximizes utility (equation 5) subject to his budget constraints (equations 6 - 12) by choosing $\{c_t, s_{t+1}, h, \alpha_t^g, \alpha_t^p, b^1, f^1\}$ taking prices $\{y_t, R^f, R_t^g, R_t^p, \mu_g, \mu_p\}$ as given. We recast the problem in a dynamic programming framework and solve backwardly for of all the choices in the model. The value functions for the four phases in the life-cycle are given below. For the retirement phase, the value function is:

$$V_4(s,t) = \max_{s'} u(s(1+r) - s') + \beta V_4(s', t+1).$$

For the parent phase, there are three value functions:[22]

$$\begin{aligned}
V_3^{post}(h,s,t) &= \max_{s'} u(y_t(h) + s(1+r) - s') + \beta V_3^{post}(h, s', t+1); \\
V_3^{child}(h,s,f,Tchild) &= \max_{s',b'} u(y_t(h) + s(1+r) - s' - b') + \beta V_3^{post}(h, s', Tchild+1) \\
&\quad + \beta\rho[(1-\phi)V_3^{child_b}(b') + \phi V_3^{child_f}(f)]; \\
V_3^{pre}(h,s,f,t) &= \max_{s'} u(y_t(h) + s(1+r) - s') + \beta V_3^{pre}(h, s', f, t+1).
\end{aligned}$$

with $V_3^{child_b}(b') = b'^{(1-\sigma)}/(1-\sigma)$ and $V_3^{child_f}(f) = d(f)^{(1-\sigma)}/(1-\sigma)$.

For the young adult, the value function is given by:

$$\begin{aligned}
V_2(h,s,f,d_p,d_g,r_p,r_g,t) &= \max_{\alpha_p,\alpha_g,s'} u(y_t(h) + s(1+r) - s' - \alpha_i d_i) + \\
&\quad \beta E_{r_i'} V_2(h, s', f'(\alpha_p), d_p'(\alpha_p), d_g'(\alpha_g), r_{p,}' r_g', t+1),
\end{aligned}$$

with $i \in \{g, p\}$. Finally, for the college phase, the value function is given by:

$$V_1(b,f,r_p(f),r_g,1) = \max_h u(b - h + d_p(b,f,h) + d_g(b,h) + I(y_t(h)) + \beta E_{r_i'} V_2(h, f'(\alpha_p), d_p', d_g', r_{p,}' r_g', 1).$$

[22] In the computations, we divide the problem for the parent phase into three sub-phases: post-child, child, and pre-child. Also, we introduce an extra feature for the young adult phase: a finer grid for the credit scores (other than the 6 bins mentioned above), which are needed for the evolution of credit scores over time.

5 Calibration

The model period and phases are detailed in Table 2. Each model period represents one year, and agents live for 55 years ($T = 55$). The first phase (college) lasts 4 years, the young adult phase lasts 10 years, the parent phase lasts 24 years, and the retirement phase lasts 20 years. Thus, $T_1 = 1$, $T_2 = 11$, $T_3 = 35$, $T = 55$. The period when parental transfers are made to their child is $T_{child} = 22$ and is set to match the average parental age of college students (which is 43 years old).

Table 2: Model periods and phases

Phase	Age	Years	Periods (t)
College	18-22	4	1
Young Adult	23-32	10	2-11
Parent	33-56	24	12-35
Retirement	57-76	20	36-55

The parameter values are given in Table 3. We calibrate five parameters (wage garnishment for government and private loans, the mean and standard deviation from the initial distribution of parental contributions, and earnings during college) to match five targets: the default rates in both the government and private student loan market (5.5%,4.0%), the 4-year college completion rate (55.5%), and participation rates in the government and private student loan market (50%, 20%). In addition, the following conditions had to be met (to be consistent with the data): initial parental contributions had to be larger for the college graduates than for the 2-year college students and both 2-year students and 4-year college graduates had to participate in the private student loan market.

The remaining parameters of the model are set as follows. The discount factor is set to match the risk free rate (R^f) of 4%, thus β =0.96. The coefficient of risk aversion is standard in the literature, $\sigma = 2$.

In setting the parameter for altruism, ρ, we use estimates from Nishiyama (2002). He calibrates the altruism parameter in a inter-generational model where agents live 4 periods, each lasting 15 years. He sets the parameter to match the relative size of inter-generational transfers (both the sum of bequests and inter vivos transfers), as a percentage of total household wealth, which is 1.32%. His calibrated altruism parameter varies with the level of relative risk aversion. For a coefficient of relative risk aversion of 1, the altruism parameter is set to 0.792. For a coefficient of relative risk aversion of 2, the altruism parameter is 0.626.

Recall that the utility function of a parent depends on how much they transfer to their child in the form of college funds and credit scores, $x(b^1, f^1) = (1 - \phi)\omega(b^1) + \phi\nu(f^1)$. The parameter ϕ measures the relative weighting that parents put on transferring funds to their

Table 3: Parameter Values

Parameter	Name	Value	Target/Source
β	Discount factor	0.96	Real avg rate=4%
σ	Risk aversion coeff	2	Literature
ρ	Coef of altruism	0.626	Nishiyama (2002)
ϕ	Weighting of credit scores	0.5	—
T_{child}	Transfer period	22	Avg age of college students' parents
$\overline{d}(h_4)$	Net price of 4-year college	\$58,654	College Board (2007a)
$\overline{d}(h_2)$	Net price of 2-year college	\$20,535	College Board (2007a)
d_{max_4}	Limits on govt loans (4 yr)	\$23,000	Lochner and Monge-Naranjo (2008)
d_{max_2}	Limits on govt loans (2 yr)	\$6,125	Lochner and Monge-Naranjo (2008)
R^f	Risk-free rate	1.04	Average rate in 2000-2008
μ_g	Wage garnish for govt loans	0.045	Default rate for govt loans (5.4%)
μ_p	Wage garnish for private loans	0.022	Default rate for private loans (3.9%)
y_c	Earnings during college	\$4,543	College completion rate (55.5%)

Figures are in 2007 dollars.

child versus transferring their credit score, and we set it to $\phi = 0.5$.

5.1 College Costs, Grants and Loan Limits

Recall that the amount agents can borrow from the government is represented by: $d_0^g = \max[\min\{\bar{d}(h) - b, d_{\max}(h)\}, 0]$, where $\bar{d}(h)$ is the net price of college, b represents parental contributions to college, and $d_{\max}(h)$ is the exogenous borrowing limit imposed by the government.

To set the appropriate borrowing limits for government school loans, we need the net price of college, which is total student charges (tuition, fees, room and board) net of grants and education credits, as reported by the College Board (2007a). We calibrate the model to match the academic years 2003-2004 through 2007-2008. The net price of college for these four years was \$88,380 for private universities and \$38,080 for public universities (in 2007 dollars). The net price for a 2-year college was \$13,920 (for two years). Since agents in the model pay for college as a consumption good (h), we must also calculate the total direct cost of college in terms of tuition and fees. For the academic years 2003-2004 through 2007-2008, total tuition and fees for four-year private and public colleges and two-year public colleges were \$90,657, \$23,541, and \$4,671 (for two years), respectively.

Recall that in the model students choose to attend four years of college or two years of college. To match the model to the data, the 4-year college group consists of college graduates. Those who drop-out of 4-year colleges are put into the 2-year college group. The 2-year college group also includes those who complete a 2-year degree (those who drop-out

of 2-year colleges are not considered). To match the actual costs of attending four years and two years of college, we obtain drop-out rates and completion rates for 4-year and 2-year colleges, from the National Center for Education Statistics for the cohort of students starting college in 1995-96 (the most recent data available for drop-outs). We calculate that 55.5% of students completed a 4-year degree (32.8% at a public institution and 22.7% at a private institution) and 44.5% completed a 2-year degree (31.7% were drop-outs from 4-year colleges and 12.8% completed a 2-year degree).[23] Using these weights and assuming they have been constant over time, the average net price for getting a four-year degree is $58,654. For two years of college, the net price is $20,535.[24]The average direct costs (tuition and fees) using the same weights are: $50,993 for a four-year degree and $18,762 for two years of college.

With respect to government student loans, the Stafford loan limit for dependent undergraduates is $23,000 for up to five years of post-secondary education. Dependent students who enroll in college for two years are eligible for $6,125 in Stafford loans during this period. As a percent of net college price, students attending 4-year institutions could therefore borrow approximately 40% of the net college price from the federal government. Students attending college for two years could borrow 30% of the net price from the government.

Loan limits in the private market for school loans are set by the creditor and do not exceed the cost of college less any financial aid the student receives, including government student loans. Thus, the borrowing limit in private credit markets is: $d_0^p \leq \overline{d} - d_0^g$. (Recall that the supply of loans is fixed in our model.)

5.2 Initial Distribution of Parental Transfers and Credit Scores

We assume a normal distribution for the initial parental contribution for college, $B(b^0) \sim (\mu_b, \sigma_b)$. We estimate the moments of initial parental funds to match participation rates in the government market and the private market (50% and 20%). Recall that the family contribution determines the mass of people who are eligible to borrow under the government market and also those for whom the borrowing limit binds. We assume that all borrowers who face this borrowing limit in the government market will turn to the private market. Based on our calibration, we obtain $\mu_b = \$40,773$ and $\sigma_b = \$37,972$ in 2007 constant dollars, which are consistent with the High School and Beyond data from the U.S. Department of Education that yields a mean expected parental contribution of $52,250 (over four years of college) and a standard deviation of $37,943.[25]

[23]http://nces.ed.gov/programs/coe/2004/section3/table.asp?tableID=61

[24]Note that for drop-outs of 4-year colleges, we assume they pay the net price of attending a 4-year college (public and private) for 2 years. Thus, our 2-year net cost is higher than the cost of 2-year colleges since it includes drop-outs from 4-year colleges that paid a much higher net price.

[25]http://nces.ed.gov/surveys/hsb/index.asp

For the distribution of credit scores, $F(f^0)$, we use the national distribution of FICO scores provided in Section 2.3 and assume a normal distribution, $F \sim (730, 45)$.

5.3 Interest Rates, Default and Credit Score Evolution

The interest rate on government loans and private loans follow a stochastic process, given by a 2 by 2 transition matrix $\Pi(R^{g'}, R^g)$ on $\{\underline{R^g}, \overline{R^g}\}$ and $\Pi(R^{p'}, R^p)$ on $\{\underline{R^p}, \overline{R^p}\}$. As stated before, the interest rates on private loans depend on credit scores, whereas the interest rate on government loans do not.

The government sets the interest rates based on the 91-day Treasury-bill rates plus a margin of 3.1%. We use the time series for 91-day Treasury-bill rates for 2000-2007, adjusted for inflation. We fit the time series with an AR(1) process: $R_t = \mu(1-\rho) + \rho R_{t-1} + \varepsilon$, $\varepsilon \sim N(0, \sigma^2)$. The estimates of the two moments are given by $\rho = 0.9902$ and $\sigma = 0.2097$ and the mean is 2.56%. We aggregate this to annual data; the autocorrelation is given by 0.213 and the unconditional standard deviation by 1.49. We approximate this process as a two-state Markov chain. The support is $R^g \in \{1.033, 1.063\}$. The transition matrix is $\begin{bmatrix} 0.7 & 0.3 \\ 0.3 & 0.7 \end{bmatrix}$.

Sallie Mae sets the interest rates based on the 3-month LIBOR rates plus a margin that differs across credit scores, which are described in Table 4.[26] We consider 6 bins of credit scores on the set $F = [\underline{f}, \overline{f}]$ corresponding to the 5 groups of FICO scores in Table 4, including the group with FICO scores less than 640.[27] The minimum FICO score that Sallie Mae would accept for private student loans was 640 in 2008; thus, for any credit scores below 640, $d^p = 0$. We use the time series for 3-month LIBOR rates between 2002-2007 and fit it with an AR(1) process. The estimates of the two moments are given by $\rho = 0.9888$ and $\sigma = 0.2117$ and the mean is 2.65%. We aggregate this to annual data; the autocorrelation is given by 0.227 and the unconditional standard deviation by 1.4114. We have approximated this process as a two-state Markov chain. The support for each of the bins of credit scores is $R_1^p \in \{1.071, 1.096\}, R_2^p \in \{1.089, 1.114\}, R_3^p \in \{1.095, 1.12\}, R_4^p \in \{1.105, 1.13\}$, and $R_5^p \in \{1.106, 1.131\}$. The transition matrix is $\begin{bmatrix} 0.71 & 0.29 \\ 0.29 & 0.71 \end{bmatrix}$.

We calibrate the evolution of the credit score to mimic the one in the data. Recall that the fraction of the private student loan that is paid in period t is α_t^p. When the agent chooses α_t^p such that $p_t^p = \alpha_t^p d_t^p < \underline{p}^p = \underline{\alpha}_t^p d_t^p$, the score is severely damaged and becomes

[26] The margins are from June 2008 and were obtained from: http://www.salliemae.com/about/investors/

[27] We compute the interest rate on private college loans based on the mean of 3-month LIBOR rate for the period December 2000-December 2007.

Table 4: Credit Scores and Interest Rates

FICO	Margin	R^p	% of loans
640-669	8.3	10.95%	16%
670-699	8.2	10.85%	21%
700-729	7.2	9.85%	19%
730-759	6.6	9.25%	17%
760-850	4.8	7.45%	27%

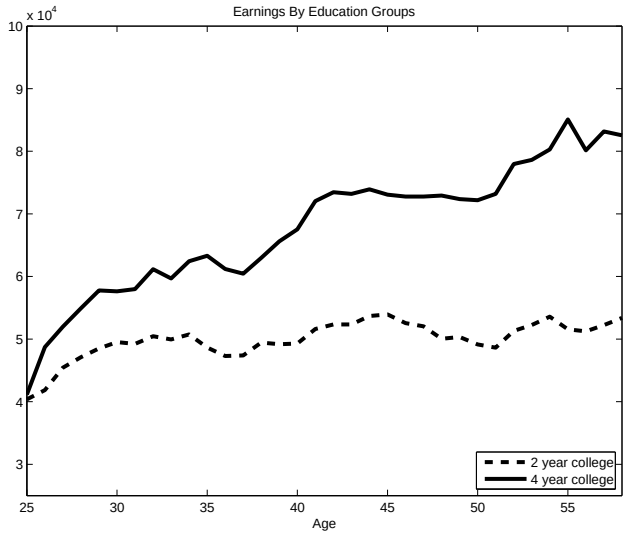
$\underline{f}$. For any payment $\alpha_t^p \in [\underline{\alpha}_t^p, 1])$, the score is gradually updated according to the function $g(\alpha, f^i) = \alpha a(f^i) + b(f^i)$. When the borrower pays the exact amount that it is required, his score does not change, $g(\underline{\alpha}_t^p, f^i) = f^i$ and when he pays his entire loan in period t, his score improves to the next bin, $g(1, f^i) = f^{i+1}$ for $i \in \{1, ..., 6\}$. We use these upper and lower bounds for each bin of credit scores and compute the linear function for the credit score evolution on a finer grid of credit scores: $g(\alpha_t^p, f_t^i) = \frac{\alpha_t^p(f_t^{i+1} - f^i) + (f_t^i - \underline{\alpha}_t^p f^{i+1})}{1 - \underline{\alpha}_t^p}$. Note that this function depends on the minimum required payment, which depends on the loan amount due each period, which in turn depends on the inherited parental funds and credit score. In fact, this evolution delivers that the cut-offs of payments that induce an improvement in the credit score are decreasing in the inherited parental funds and increasing in the inherited score. This implies that a lower payment is required from individuals with low credit scores in order to increase their credit score relative to the payment required from individuals with high credit scores. This feature of the model is consistent with the fact that people with low credit scores can improve their credit scores more than people with high credit scores with the same repayment behavior (see Chatterjee et. al. (2008)).

We set the wage garnishment for default in the government student loan market as $\mu_g = 0.045$ to match the default rate for government student loans of 5.4% in 2007. In practice this punishment varies across agents, depending on collection and attorney's fees, and can be as high as 15%.[28] The wage garnishment for private student loans $\mu_p = 0.022$ is set to match the default rate for private student loans, which is 3.92%.

Finally, for the value functions associated with leaving funds and credit scores to one's child, we assume CRRA utility functions (with $\sigma = 2$) that one derives from consuming the inherited funds and from consuming the level of debt one can obtain in the private market for the inherited credit score, evaluated at the interest rate R_i^p. We assume a uniform grid for these debt levels from 0 debt to maximum that can be obtained in the private market at the average level of funds. We run robustness checks on these debt levels and results are not sensitive to the chosen levels as long as credit scores induce heterogeneity in the amounts that one can borrow.

[28]The Debt Collection Improvement Act of 1996 raised the wage garnishment limit to 15%.

Figure 2: Lifetime Earnings - CPS data



5.4 Lifetime Earnings and Ability

Lifetime earnings are based on earnings data from the 1969-2002 CPS. We generate synthetic cohorts for each year in the CPS, by using earnings for the heads of households age 25 in 1969, age 26 in 1970, and so on until age 58 in 2002. We consider a five-year bin to allow for more observations, i.e., by age 25 at 1969, we include high school graduates in the sample that are 23 to 27 years old. We include all adults who have completed at least 12 years of schooling. There are an average of 5,000 observations in each year's sample. People with 16 and 17 years of education are classified as people with 4 years of college in the model. For individuals with 2 years of college in the model, we use earnings for people with more than 12 years and less than 16 years of education in the data. The life-cycle profiles for the two education groups are given in Figure 2. Real values of earnings are calculated using the CPI 2007. We set the earnings in the first period in the model to $\$68,788$ in 2007 dollars for people who attend two years of college. This matches the earnings for people with some college education (i.e., less than 4 years of college) from the CPS data for heads of households age 23 in 1967 and age 24 in 1968. We obtain a lifetime earnings premium of 1.35 for those with a 4 years of college compared to those with two years of college, which is consistent with empirical estimates (Cheeseman Day and Newburger, 2002). In addition, college students can work during college. We estimate earnings during college for the 4 years path to match the fraction of people enrolling and completing 4 years of college. Our estimate is \$4,543 (in 2007 dollars).

6 Quantitative Results

6.1 Benchmark

To understand the main mechanisms in the model, we first analyze how well the model does in replicating the data with respect to college completion rates, participation in the government and private markets for school loans, and default rates in each market. Table 5 reports the results. Since the model was calibrated to match these facts, we were able to get close to all of our targets. It is important to note that the model produces participation rates in 4-year colleges that will look high when compared to national enrollment rates, for example, since students in the model comprise those who complete 2 or 4 years of college. Thus, completion rates in our model should be interpreted as the percent of students who complete 4 years of college, out of the pool of all college students (i.e., those who complete 2 and 4 years of college). In the model, students who complete 2 years of college include students who complete a 2-year degree and drop-outs from 4-year colleges.

Table 5: Model Predictions vs. Data

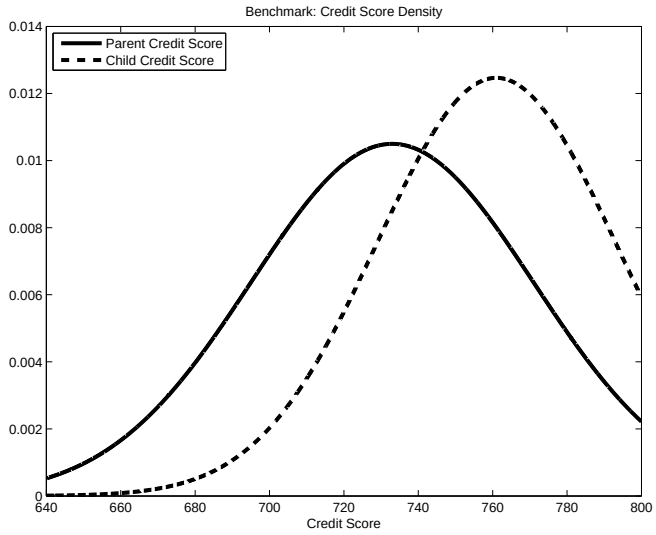
Variables	Model	Data
4-year college completion rates	60.9%	55.5%
Participation rate in private market	25.2%	20%
Participation rate in govt market	52.8%	50%
Default rate in private market	3.6%	3.9%
Default rate in govt market	5.5%	5.4%

Consistent with the qualitative findings from the simple model, we find that college investment is increasing in both parental credit scores and parental contributions for college. However, our quantitative results indicate that parental contributions have a much larger effect on the college decision than parental credit scores. Agents who complete 4 years of college receive $36,378 (in 2007 dollars) more from their parents compared to those who invest in 2 years of college, however, the parental credit score is only 1 FICO point higher (727 versus 728). Thus, parental contributions seem to matter more for the college investment decision than parental credit scores. This seems reasonable since family income has long been considered an important input to college investment (Becker, 1975; Keane and Wolpin, 2001) and even more so in recent years (Belley and Lochner, 2007).

Even though parental credit scores do not play a large role in the college investment decision, they are an important determinant of their child's credit score. A child whose parent has a relatively low credit score (between 640-700) will have a credit score of 727 in the model; this compares to a child whose parent has a relatively high credit score (above

760) having a credit score of 786. Overall, the distribution of credit scores shift right, as evident in Figure 3. Mean parental credit scores are 733, while mean child credit scores are 761 (child).[29]

Figure 3: Evolution of credit scores



Credit scores improve over time, but more so for students with 2 years of college. Since the cost of college is much lower for this group (compared to students with 4 years of college), they are eligible for fewer student loans. As a result, they borrow less: average debt levels are $5,281 in government debt and $10,025 in private debt, compared to $14,958 and $19,000 for students with 4 years of college. Despite their lower lifetime earnings, students with 2 years of college do not default in the benchmark economy. As a result, they face no penalties (such as a reduction in their credit scores), allowing their credit scores to improve more than students with 4 years of college. The fact that these students use the private credit markets, but borrow at low enough levels to ensure repayment, leads to an improvement in their credit scores.

Similarly, we find that students with relatively low levels of parental contributions experience larger improvements in their credit scores, compared to students with high parental contributions. Since parental contributions are low, they qualify for both government and private student loans. However, very few students from the poorest families in the model complete 4 years of college. Instead, they borrow, but at lower amounts, to finance only 2 years of college. Since their borrowing levels are lower than students with higher amounts of parental contributions, they default less, resulting in larger increases in their credit scores.

In the model, parents face a trade-off between credit scores and parental contributions

[29]The standard deviation for parental credit scores is 38, and for child credit scores is 32.

for college. Since we find a quantitatively significant intergenerational transmission of credit scores from parent to child, parents with low contributions for their child's college can make up for it through higher credit scores. The private market for school loans provides parents with another mechanism to help their child fund college.

Defaulters look very different than non-defaulters in the benchmark economy. Defaulters in the government student loan program have twice as much student loan debt as non-defaulters, while defaulters in the private markets have three times as much debt as non-defaulters. In addition, students who default in the private credit market receive much less in terms of parental contributions for college than non-defaulters. This makes sense: low parental contributions imply more debt and hence more default. However, the reverse in true for defaulters in the government student loan program. For college students with relatively high parental contributions, the student has every incentive to attend 4 years of college (rather than 2) since the parent is covering part of the college cost. Most of these students still qualify for government student loans, and hence borrow at relatively high levels to finance 4 years of college. This leads to more default. Thus, the model predicts that defaulters in the government program come from wealthier families than non-defaulters. Based on conversations with financial aid offices, this does not seem unrealistic. They cite that often those who default most from government student loans are middle and upper-middle income students who are used to a certain standard of living and are less responsible when it comes to financial decisions, compared to low-income students.

Students who default in the government student loan program have higher credit scores than students who default in the private market for school loans (732 versus 722). Since credit scores are not damaged when students default in the government program, students with higher credit scores have more to lose from defaulting in the private market, and hence prefer to default in the government program. Thus, the existence of private credit markets is actually making default in the government loan market more attractive (or at least less costly) for agents with high parental credit scores. Students with relatively low parental credit scores default in the private market early on (in the first few periods of repayment). Then, as they begin repayment, their credit scores improve significantly (since they were low to start with). While they will experience significant upward revisions of their credit scores, their credit scores will not catch up to the students who started with much higher parental credit scores.

Next, we consider how the college financing decision in the model varies for students with different parental contributions and credit scores. Table 6 reports the results. Several interesting findings emerge. First, 4-year college completion rates are higher for students who receive more parental contributions, while participation rates in both private and government

student loan programs are lower. If we assume higher parental contributions are associated with higher parental income, these results are consistent with the data that says wealthier households have more college education and participate less in student loan programs (College Board, 2007b). Second, notice that participation rates in both private and government student loan programs increase as parental contributions and credit scores increase, suggesting that these two programs are complements rather than substitutes. Students do not seem to be substituting government loans with private loans to finance college. Instead, having access to both markets pushes some students to acquire more college education.

Third, participation rates in the private credit market rise with parental credit scores. This is not surprising given that those with higher parental credit scores receive better loan conditions and hence are more likely to borrow from private creditors. We find that approximately 27% of students with high parental credit scores (above 760) borrow from private markets, compared to only 19% of students with low credit scores (between 640 and 700). Based on SallieMae financial reports, these figures are in line with the data.[30] As a result, students with high credit scores invest in more college education since they have access to better loan conditions in the private market.

Table 6: Variation in initial characteristics: Benchmark

	4-year college completion rate	Participation rates in govt market	Participation rates in private market	Debt levels (govt/private)
Parental Contributions (b_0)				
Low	14%	99%	89%	\$8,570/\$14,283
Medium	31%	44%	10%	\$17,388/\$9,9981
High	99%	36%	0%	\$12,917/ NA
Parental credit score (f_0)				
Low	60%	56%	19%	\$9,812/\$11,799
Medium	60%	54%	26%	\$10,060/\$10,805
High	63%	52%	27%	\$9,532/\$9,626

Note: The low group represents the first quartile, the medium group represents the second quartile, and the high group consists of the third and fourth quartiles.

Based on average debt levels, Table 6 indicates that most of the action in the model is for middle-income students (i.e., the second quartile of parental contributions). Students with low parental contributions tend to complete only two years of college in the model, and thus have low levels of debt. Students with high parental contributions are eligible for fewer student loans, thus their debt levels are relatively low (in fact, they do not participate in the

[30]SallieMae reports that in 2007 approximately 37% of their private loans meet the selection criteria for creditors with FICO scores between 640-699, 19% with scores of 700-729, and 44% with scores above 730. Source: http://www.salliemae.com/about/investors/

private market). However, students with modest parental contributions (i.e., in the second quartile) are eligible for student loans to the extent that it influences them to complete more college (i.e., 4 years); they seem to take on more risk in the college investment decision. Thus, they borrow at high levels to finance the cost of college, which leads to some default that adversely affects their credit score. This contrasts to students with 2 years of college whose credit scores improve over time as a result of good repayment behavior (i.e., no default).

To recap, the benchmark economy delivers several interesting findings. First, we find that the transmission of credit scores from parent to child is quantitatively significant, such that parents with low contributions for their child's college education can make up for it by transferring a good credit score to their child. Second, students with higher parental credit scores prefer to default in the government student loan market (compared to students with low credit scores) since they have more to lose if they default in the private credit market. The downward revision of credit scores is more severe for people with high credit scores, making the government student loan program more attractive to them. Finally, we document that middle-income students (those with modest parental contributions) face the toughest decisions regarding how much to invest in college and how to finance it. Since they receive some support from their parents and are eligible for student loans, they are more likely to invest in more college and acquire more debt to finance it. Default rates in both the government program and private markets are highest for this group, making them the most risky creditors.

6.2 Policy Experiments

We next use the model to conduct several experiments. First, we shut down the government student loan program. Second, we consider the case in which the government increases the maximum borrowing limit on government student loans. Lastly, we tighten the conditions for obtaining student loans from the private market. Table 7 summarizes the results for all of the experiments.

6.2.1 No Government Student Loans

In this experiment, we consider the case in which the government decides to let private markets fully supply student loans (which is similar to the simple model presented in Section 3). We find that more students borrow from the private market (36% of all students, up from 25.2% in the benchmark), and students take on more debt.

Interestingly, without a government student loan program, college investment increases:

63.6% of students complete 4 years of college, up from 60.9% in the benchmark.[31] To finance this additional college investment, students borrow more from the private market which leads to more default (default rates skyrocket to 20%). Higher default rates lead to more penalties, which in the private market, turns into a downward revision of average credit scores for students (from 761 in the benchmark to 756).

Even though students end up with lower credit scores when no government student loan program exists, credit scores are still transmitted from parent to child in a positive way. Students with parents with relatively high credit scores will invest more in college (compared to students with low parental credit scores) since they have access to lower interest rates. More college investment leads to higher lifetime earnings and better repayment behavior, which leads to higher credit scores for the student. Thus, the distribution of credit scores shifts to the right (from parent to child), but not as much as in the benchmark case, as depicted in Figure 4.

Table 7: Model Predictions: Experiments

Variables	Benchmark	No Govt Loans	Higher Govt Limits	Higher Elig Criteria
4-year college completion	60.9%	63.6%	70.0%	59.3%
Participation in private mkt	25.2%	36%	22.6%	17.4%
Participation in govt mkt	52.8%	0%	65.8%	53.4%
Default rate in private mkt	3.6%	20%	0%	2.8%
Default rate in govt mkt	5.5%	0%	11.7%	3.3%
Average debt (govt + private)	$22,828	$25,439	$21,471	$22,602
Average student credit score	761	756	764	777

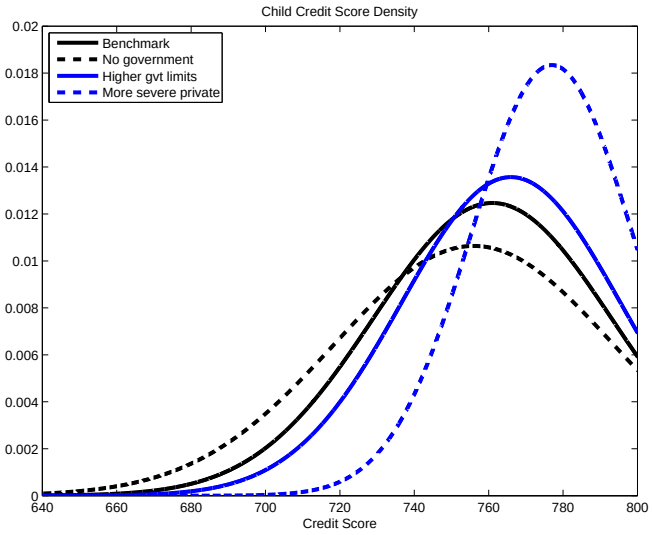
In this experiment, the increase in college investment is coming from students with medium and high parental credit scores. Recall from the benchmark that these students prefer to borrow from the government since the penalties to default are high for them in the private market. With no government student loan program, however, these students must borrow from the private market in order to finance their college costs. Since they have relatively high credit scores, they get good loan conditions (i.e., low interest rates), influencing more of them to complete 4 years of college. Forcing them into the private market leads to more college investment, albeit at the cost of high default rates in the private market.

The observed increase in college investment hinges on the fact that more borrowing occurs in this environment (compared to the benchmark). Recall that we do not impose any borrowing limit in the model, assuming that private creditors fully meet the demand for

[31]Recall that we abstract from the decision to enroll in college in our model. Thus, we are missing the margin in which government student loan programs attract more college students.

loans. If private creditors decide to restrict borrowing, college investment will be lower.

Figure 4: Credit scores of students: Benchmark vs Experiments



6.2.2 Higher Limits on Government Student Loans

For the first time since the early 1990's, the U.S. government in 2008 increased the amount undergraduates can borrow. Independent undergraduate students can now borrow up to $31,000 total for college (up from $23,000) and $12,000 (up from $6,125) for the first two years of college.[32] We analyze the effects of this policy in our model economy.

As evident in Table 7, a more generous government student loan program attracts more students: now 65.8% of students borrow from the government. This in turns leads to fewer students borrowing from private markets. Higher government borrowing limits lead to a significant (46%) increase in government debt levels and a large (50%) reduction in private debt. As a result, default rates on government student loans increase to 11.7%, while no default occurs in the private market.

More borrowing from the government leads to a significant increase in college investment: now 70% of students invest in 4 years of college. However, much of the increase is coming from students with parents in the middle of the income distribution (i.e., the second quartile of parental contributions). As illustrated in Table 8, more students with medium levels of parental contributions complete 4 years of college (an increase of 45% from the benchmark). Thus, a more generous government student loan program entices middle-income students to invest in more college, by borrowing more, and especially from the government (an additional 45% of middle-income students borrow from the government now). This contrasts to low-

[32] A large part of this increase consisted of unsubsidized student loans.

income students (those with parental contributions in the first quartile) who have no incentive to go to 4 years of college in this environment. With the large increase in borrowing limits for 2 years of college[33], fewer low-income students borrow from private markets to finance their college education. As a result, low-income students are being channeled into 2 year degree programs.[34]

Table 8: Variation in initial characteristics: Higher government limits

	4-year college completion rates	Participation rates in govt market	Participation rates in private market	Debt levels (govt/private)
Parental Contributions (b_0)				
Low	0% (-14%)	99% (0%)	72% (-17%)	\$10,821/\$6,880
Medium	76% (+45%)	89% (+45%)	16% (+6%)	\$12,413/\$31,050
High	99% (0%)	36% (0%)	0% (0%)	\$14,969/ NA

Note: Numbers in parenthesis represent changes from the benchmark.

In addition to an increase in college investment, a more generous government student loan program improves student credit scores. Since students are using private markets less, default in the private market is non-existent. As a result, the credit scores of students improve more over time, shifting the distribution of student credit scores farther to the right than in the benchmark (Figure 4). The mean FICO score of college students is 3 points higher in this experiment than in the benchmark.

The main finding from this experiment is that an increase in government borrowing limits leads to more college investment. However, all of the increase in college investment comes from middle-income students; in fact, we find that fewer low-income students invest in 4 years of college. The policy comes with other costs, namely a doubling of default rates in the government student loan program. Still, credit scores of students improve as a result of this policy, since default rates in the private credit market go to zero and fewer low-income students borrow from private markets.

6.2.3 More Severe Eligibility Criteria in the Private Market for Student Loans

As credit markets have tightened in recent years, creditors have increased the minimum credit score required to borrow in the private market for student loans. For example, Sallie Mae increased the minimum credit score required to obtain a student loan from 640 to 670 in 2008. In the model, we assume a minimum of credit score of 700 is required to obtain a student loan from a private creditor (in the benchmark, the minimum was 640).

[33]The increase in the borrowing limit was larger in percent change for those attending 2 years of college compared to those attending 4 years of college.

[34]Another goal of this policy may be to get more students into college. Our model does not address this issue since all students in our model are already in college.

The results are straightforward and are presented in Table 7. We find that fewer students borrow from private markets and more students borrow from the government, suggesting that students are using government student loans to make up for less access to private loans. However, for those who borrow from the private market, average debt levels increase slightly. In this experiment, only students with relatively high credit scores borrow from private creditors, and since they get lower interest rates on loans, they are willing to take on more debt.

With less access to private credit to finance college, fewer students complete 4 years of college. We find that most of the drop in college investment is for students with low and medium levels of parental contributions. Thus, by restricting access to private capital markets, creditors are reducing the incentive for low and middle-income students to invest in more college. This leads to a significant reduction in default rates for both the government and private student loans, by 1.9 and 0.9 percentage points, respectively. Certainly, the primary goal of this policy is for private creditors to reduce default rates in the private market, but by curtailing college investment, private creditors are effectively lowering the default rate on government student loans as well.

By cutting off the lower tail of the credit score distribution, this policy leads to a significant increase in student credit scores. Students who borrow in the private market now have on average a FICO score of 777, compared to the benchmark FICO score of 761. Thus, the transmission of credit scores from parent to child is strengthened by removing students with low credit scores from the pool of debtors. Figure 4 illustrates that the distribution of student credit scores is much farther to the right compared to any of the other experiments.

As suspected, less access to private credit will reduce college investment, especially for low and middle-income students. However, for those who borrow, credit scores improve more (as a result of less default). A somewhat surprising result is that default rates in government student loan programs decrease as private creditors make it more difficult for some students (and especially those who are more likely to default) to get a private student loan.

7 Sensitivity Analysis

In this section we first run robustness check on the parameter ϕ, which measures the relative weighting that parents put on transferring funds to their child versus transferring their credit score. Second, we relax the assumption of unlimited private credit supply and discuss its implications. Finally, we run robustness checks on the default punishment parameters. TO BE COMPLETED.

8 Summary

As the cost of college continues to increase and government borrowing limits remain constant, more students turn to private credit markets to borrow for college. In this paper, we explore the link between credit scores and college investment in an environment where children finance college through parental contributions, government student loans, and private credit markets. The model mimics what we observe in the data, in that the credit scores of the parents determine the conditions of the loan. Thus, parents can help their child invest in college through two mechanisms: by contributing resources to the child's college education and through credit scores.

We find that students with higher parental credit scores receive better loan conditions (i.e., lower interest rates) on private student loans, which improves repayment behavior. The more the student repays on his student loan, the better his credit score will be. Thus, credit scores are positively transmitted from parent to child through the private market for school loans. This is the first model that we know of that delivers an intergenerational link of credit scores.

Our analysis indicates that the transmission of credit scores from parent to child is quantitatively significant. The private market for school loans provides parents with another mechanism to help their child fund college. This allows parents with low contributions for their child's college education to make up for it through higher credit scores. Through the use of parental credit scores, private credit markets relax credit constraints felt by the child in financing college.

Interestingly, we find that students with high parental credit scores prefer to default on their government student loan before defaulting on their private student loan, since those with high credit scores face a significant downward revision of their credit score when defaulting in private markets. However, if private creditors tighten the conditions for acquiring a student loan (such as increasing the minimum required credit score), fewer students will default on both their private and government student loans.

If the government disbands its student loan program, students will be forced to use private markets to finance their college education. This results in more borrowing from private markets, lower overall credit scores, but an increase in college investment, especially for middle and high-income students. Alternatively, if the government increases the amount students can borrow for college, middle-income students will invest in college at higher rates, but since they are borrowing less from private markets (and hence defaulting less), credit scores of college students will improve.

Our results confirm the findings of Keane and Wolpin (2001), Turner (2004), Lochner and

Monge-Naranjo (2008), and others that highlight the importance of binding credit constraints for college students. In our model, the cost of college and the borrowing limits students face in government loans have significant impact on the college investment decision. As a result, more students are using private credit markets to make up the difference, and this will have a significant impact on how much college education they acquire, their repayment behavior on their student loans, their credit scores, and ultimately their future financial health.

Certainly, extensions of this model could be used to consider the role of parental borrowing, for example, in financing college. The fact that families have been using private credit markets more than federal programs for parents (such as PLUS) has mystified both policy makers and financial aid offices. We leave this and other related ideas for future work.

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