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Felicia Ionescu

Colgate University, fionescu@colgate.edu

Nicole Simpson

Colgate University, nsimpson@colgate.edu

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Credit Scores and College Investment*

Felicia Ionescu[†]
Colgate University

Nicole Simpson[‡]
Colgate University

August 4, 2010

Abstract

The private market of student loans has become an important source of college financing in the U.S. Unlike government student loans, the terms on private student loans (i.e., credit limits and interest rates) are based on credit scores. We quantify the effects of credit scores on college investment in a heterogeneous life-cycle economy that exhibits a government and private market for student loans. We find that students with higher credit scores invest in more college education. Furthermore, we find that the relationship between credit scores and college investment has important policy implications. For example, when government borrowing limits are relaxed, college investment increases but so does the riskiness of the pool of borrowers, leading to higher default rates in the private market. If private creditors react to the government policy (by adjusting loan terms to minimize default risk), college investment is offset, with poor students experiencing the largest reductions. The effects of credit scores on college investment are more pronounced when taking into account the recent drop in financial wealth for U.S. households.

JEL Codes: E21; E24; I22; I28

Keywords: College Investment; Credit Scores; Student Loans

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[†] Department of Economics, 13 Oak Drive, Hamilton, New York, 13346; (315)228-7955, Fax: (315)228-7033, fionescu@colgate.edu.

[‡] Department of Economics, 13 Oak Drive, Hamilton, New York, 13346; (315)228-7991, Fax: (315)228-7033, nsimpson@colgate.edu.

1 Introduction

There is a new phenomena in college financing: undergraduate students and their parents are borrowing from the private market for student loans to finance college. The volume of nonfederal, private student loans is now \$17.6 billion (in 2007-08), which represents 20 percent of total student loan volume; this compares to \$2.5 billion just ten years ago (College Board, 2008). Borrowing from the private market for college is very different than borrowing from the government: credit scores determine loan eligibility in the private market, whereas no credit history is required for government student loans. Furthermore, interest rates depend on credit scores, as evident in Table 1. The main contribution of our paper is to measure the extent to which credit scores affect college investment via the private market for student loans and to explore the policy implications of this relationship.

Table 1: Credit Scores and Interest Rates on Private Student Loans

FICO score	Interest rate
<640	no loans
640-669	15.41%
670-699	13.91%
700-729	11.91%
730-759	9.91%
760-850	7.41%

Note: Interest rates are based on the 3-month LIBOR rate plus a margin that varies with credit scores.

We develop a heterogeneous life-cycle model where agents differ with respect to family contributions for college, credit scores (as measured by FICO scores), and an observable index of college ability (as measured by SAT scores); all of which affects the college investment decision. The model displays important features of the government student loan program and the private market for student loans. Our main finding is that students with better credit scores invest in more college. We consider several different policies, and find that changes in the government student loan program induce changes in market risk for both private and government student loans which leads to more default in private markets. Consequently, private creditors may react to the market risk in order to minimize default. We show that taking this reaction into account when designing government student loan policies is important in order to accurately account for the effects on college investment.

In the model, students choose between enrolling in college or not; if they enroll, they can invest in two or four years of college. Students who enroll in college use family contributions and student loans to finance college, as well as their employment income while in college. Students borrow first from the government program, where eligibility conditions depend on their family contributions and the cost of college. There is a limit on the amount that

students can borrow from the government, such that students with relatively low levels of family contributions may face a binding government borrowing constraint. Once students exhaust the funds available from the government, they turn to the private credit market to finance the rest of their college costs. However, those with very low credit scores are excluded from private markets. For those who are eligible to borrow in the private market, students with high credit scores get relatively low interest rates and high loan limits in the private market. As a result, high credit scores may relax the government borrowing constraint that some students face when financing college (and in particular, for students with high financial need).

Our analysis delivers that credit scores are quantitatively important for the amount of college investment (the intensive margin), but not for the college enrollment decision (the extensive margin). Specifically, students who complete four years of college have credit scores that are 26 FICO point higher than students who complete two years of college. Our results are confirmed with data from the Survey of Consumer Finances (SCF): people with better credit status are more likely to have a four-year college degree, compared to those with worse credit status, and credit status does not affect the likelihood of enrolling in college.

The importance of credit scores in the intensive margin but not the extensive margin of college investment is driven by two features: two-year colleges are relatively less expensive than four-year colleges (per year of college) and the government limit is relatively more generous during the first two years of college. Thus, students who invest in two years of college borrow very little from the private market since the government limit does not bind for them; in this case, credit scores do not have a significant effect on the college enrollment decision. However, students who invest in four years of college are more likely to hit the borrowing limit from the government and hence rely on the private market to finance college, providing an important role for credit scores in the intensive margin.

We find that the importance of credit scores for college investment varies across different types of students: high credit scores have the largest impact on low-income students and students with medium levels of abilities. These students are the most likely to borrow from both the government and the private market to finance college since they have high financial need. This, combined with their relatively high returns to their college investment, provides them with the incentive to invest in more college.¹ Consequently, better loan conditions in the private market induced by high credit scores are quite valuable for these students.

We report borrowing behavior for students that differ in income, ability and credit scores. We find that low-income students borrow more from both the government and the private market to finance college than high-income students, facts that are consistent with the Col-

¹Our model accounts for the observed variation in earnings for college graduates of different ability levels.

lege Board (2007b). In addition, students with relatively low levels of ability are more likely to participate in the private market for student loans. However, students with average ability levels use the government student loan program the most, which is consistent with findings from the Beyond Post-secondary Survey (produced by the National Center of Education Statistics) and contrasts with the implications of other papers that study the student loan market (Garriga and Keitly, 2007; Lochner and Monge-Naranjo, 2008; Ionescu, 2009). Finally, students with low credit scores participate in the government student loan program at high rates, whereas students with average credit scores participate in the private market the most.

We then conduct a series of experiments to analyze the role of credit scores on college investment in alternative environments. We first increase the government borrowing limit (as recently implemented by the U.S. government). Ignoring any reaction from the private market, we find that higher government limits induce an increase in college investment, with the largest effects felt by poor students and students with relatively low credit scores, who face high borrowing costs in the private market. In addition, students with medium and high levels of ability experience significant gains in college investment with higher government borrowing limits.

However, the generous government program also induces a change in the riskiness of the pool of borrowers, which adversely affects the private student loan market. Students shift their borrowing away from the private market and towards the government, and this effect is particularly large for students with relatively high levels of family contributions (and thus low financial need and default risk). Since family contributions and the student's ability are positively correlated, students with relatively high ability levels also shift away from the private to the government market. The remaining borrowers in the private market consist of low-ability and low-income students (compared to the benchmark), who have lower earnings profiles after college and high debt levels. A high debt-to-income ratio induces these borrowers to default at higher rates in the private market (from 3.9% in the benchmark economy to 10.1%).

Consequently, private creditors may react to offset the high default risk induced by the government policy. Typically, private creditors use credit scores as a signal of the likelihood of default and adjust loan terms according to credit scores to minimize default. Thus, we extend our policy analysis by endogenizing the reaction of the private sector and re-evaluate the effects of the government loan policy. We find that tighter loan conditions are needed in the private market to keep default risk in the private market unchanged from the benchmark economy. Since it is more difficult for some students (and especially those who are more likely to default) to get private student loans, debt burdens are lower on average, compared

to the benchmark. As a result, default rates decrease in the government market. However, we find that college investment falls back to the benchmark level. Tougher eligibility conditions in the private market have significant adverse effects on college investment for the poorest students and students with average credit scores. In particular, students with low family contributions for college invest even less in college than in the benchmark. Students with medium and high ability levels invest relatively less when the private sector's reaction is endogenized compared to the case where it is not, but still relatively more compared to the benchmark case.

Lastly, we consider the effects of credit scores on college investment in the context of the recent 23 percent decline in financial wealth of U.S. households (excluding real estate). This reduction in wealth induces a decline in family contributions for college and, as a result, the government limit on student loans binds for more college-going students. Consequently, the effects of credit scores on college investment are large. In addition, we find a change in the composition of students going to college: the drop in wealth causes a larger reduction in college investment for poor students and students with relatively high levels of ability.

1.1 Contribution to the Literature

Our paper is the first to document a link between credit scores and college investment, but it adds to the rich literature on the determinants of college investment. The role of family contributions in the college investment decision has been extensively studied, with important contributions by Becker (1975), Keane and Wolpin (2001), Carneiro and Heckman (2002), Cameron and Taber (2004), and more recently by Belley and Lochner (2007) and Stinebrickner and Stinebrickner (2007). College preparedness (or ability) has long been considered an important determinant of college investment, as documented in Heckman and Vytlačil (2001) and Cunha et al. (2005). Our analysis complements this work by showing how credit scores affect college investment in addition to differences in income and ability. In addition, our model includes two other important components that are consistent with the data: we assume that income and credit scores are positively correlated (as we will document using 2004 SCF data), as are income and ability (College Board, 2009).

In recent years, the focus in the higher education literature has been on the effectiveness of financial aid in promoting college investment, and specifically student loans. Papers that study the implications of student loan policies within a quantitative macroeconomic approach include Garriga and Keightley (2007), Gallipoli, Meghir and Violante (2008), Lochner and Monge-Naranjo (2008), Schiopu (2008), Chatterjee and Ionescu (2009), and Ionescu (2009). For example, Chatterjee and Ionescu (2009) examine the value of offering insurance against

the risk of taking a student loan and failing to graduate from college. Schiopu (2008) and Ionescu (2009) analyze the effects of alternative student loan policies on human capital investment. Garriga and Keightley (2007) and Gallipoli et al. (2008) extend the analysis beyond student loan policies and study the effects of need-based versus merit-based tuition subsidies on education choices and earnings. Our analysis complements this work by accounting for the role of credit scores in the college investment decision when analyzing the implications of various student loan policies.

The only paper that incorporates both the private and government student loan markets is Lochner and Monge-Naranjo (2008). They consider an environment where credit constraints arise endogenously from a limited commitment problem for borrowers, and use this framework to explain the recent increase in the use of private credit to finance college as a market response to the rising returns to school. In their paper, as in ours, interest rates in the private market for student loans are not derived endogenously from a general equilibrium profit condition. However, our framework is different in that we model various dimensions of uncertainty associated with college investment, including earnings and interest rate uncertainty, that allows us to capture default behavior in the student loan market. Furthermore, we model a menu of interest rates tied to credit scores and a feedback of default behavior into credit scores and interest rates, such that default in the private market for student loans lowers credit scores and raises interest rates. This allows the interest rate in the private market to reflect default risk in equilibrium.² More importantly, we take into account the response of private markets to government policies, which proves to be important in providing insights for ongoing policy changes in the Federal Student Loan Program.

Capturing default risk is a crucial feature of models that analyze investment and borrowing behavior under various credit market arrangements as advocated by quantitative theories of default. Our paper is related to studies that focus on the role of credit worthiness in unsecured credit markets, and in particular Athreya, Tam and Young (2008) and Chatterjee, Corbae and Rios-Rull (2008). The first paper considers the amount of information that can be gleaned from credit scores to explain the rise of unsecured credit, bankruptcy rates and credit discounts, while the second paper develops a theory of unsecured credit and credit scoring consistent with the data and emphasizes the importance of correctly pricing default risk.

Our paper is organized as follows. In Section 2, we describe several important facts about credit scores, college education and student loans that motivate our study and provide important details for our model. We then develop our model in Section 3 and calibrate it to

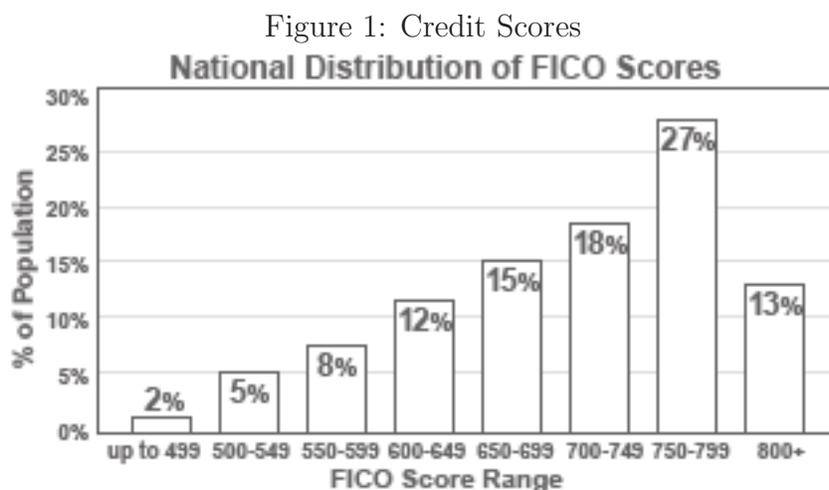
²Several unique features of the student loan market allow us to take this approach. Details are discussed in Section 3.

match important features of the markets for government and private student loans in Section 4. Our quantitative results are contained in Section 5, and we conclude in Section 6.

2 Facts about Credit Scores, College Education and Student Loans

2.1 Credit Scores

Similar to other forms of debt such as unsecured debt (i.e., credit cards), personal loans, and mortgages, interest rates in the private market for student loans 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%).³ 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.



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

³<http://www.myfico.com/CreditEducation/WhatsInYourScore.aspx>

2.2 Credit Status and College Education

Using data from the Survey of Consumer Finances (SCF), we document three facts that are important in our model: (1) people with better credit are more likely to have a bachelor’s degree than people with worse credit, (2) better credit does not increase the likelihood of enrolling in college, and (3) income and credit status are positively correlated.⁴ We analyze a sample of 1,228 individuals from the SCF between the ages of 18 and 30, and classify individuals into three groups: those with no college, those with some college (which includes an associates degree), and those with a bachelor’s degree.⁵ While the SCF does not explicitly report credit scores, it contains detailed information about the various types of credit that individuals use (including student loans) and information related to the credit status of individuals. We use four different measures of credit status reported in the SCF. For example, the SCF asks if respondents have been turned down for any type of credit in the last five years, and if so, if it was due to having bad credit. The SCF also provides some insight into repayment behavior and outstanding debt, which are the two most important components that enter the credit score calculation. Individuals are asked how frequently they repay the total balance owed on their credit cards each month, and the amount of outstanding debt on credit cards, in addition to their respective credit limits. The SCF also contains detailed information about outstanding student loans, including the amount borrowed and the interest rate on the loan. Approximately 48% of the 2004 sample has an outstanding student loan at the time of survey.

Using the subsample of individuals with student loans, we examine if credit status affects the likelihood of getting a bachelors degree.⁶ Table 2 reports the estimated probability of having a bachelor’s degree (compared to having some college), after controlling for differences in individual and household characteristics. Three different measures of credit status reveal that credit status has a significant effect on college investment, even after controlling for differences in income, household size, total borrowed, etc. Overall, our results show that a worse credit status is associated with a lower likelihood of having a bachelor’s degree.

We do a similar exercise comparing people with no college education to those with some

⁴For brevity, we provide a snapshot of our data analysis. The full set of empirical results can be obtained from the authors.

⁵We focus on young adults since we are most interested in how credit scores affect college investment and college investment typically occurs during these ages. This also helps us identify the direction of causality: it is not likely that college investment affects credit scores to a large extent this early in life. However, we are careful in not assuming the direction of causality.

⁶Specifically, we run probit regressions with the dependent variable being a binary variable that takes the value 1 if the person has a bachelor’s degree and 0 if they have some college. The independent variables include the various credit status measures and the following controls: household wage income, sex, marital status, household size, age, total amount borrowed in student loans, the interest rate on the student loan, and if the student loan was borrowed from the private market.

Table 2: Percent of College Students with a Bachelor’s Degree, by Credit Status

Credit Status	% with a Bachelor’s Degree
Turned down for credit	52.3%
Not turned down for credit	66.5%
Having bad credit	41.3%
Not having bad credit	63.8%
Hardly ever paying balance	73.2%*
Almost always paying balance	67.0%*
Having high debt/limit ratio	59.1%
Having low debt/limit ratio	71.8%

Estimated means. * denotes that the means are not significantly different at the 10% level.

college education, and find that three of the four credit status measures are not significantly different across the two groups or have the opposite sign (only the ‘debt/limit ratio’ was statistically significant with the right sign). Thus, the empirical evidence indicates that high-school graduates with relatively good credit status are as likely to enroll in college as high-school graduates with worse credit status.

In Table 3, we report the correlation between household wage income and credit status for all individuals in the SCF between the age of 18 and 64.⁷ We find a robust, negative correlation between household wage income and bad credit status for all four measures of credit status after controlling for education, gender, marital status, household size, and age. The estimated coefficients range from -0.04 (for debt/limit ratios) to -0.22 (for hardly ever repaying their debt).

Table 3: Correlation between Income and Credit Status

	Turned down for credit	Bad credit	Hardly ever repay	Debt/Limit Ratio
Income	-0.183	-0.080	-0.222	-0.043

Point estimates on natural logarithm of household wage income. * denotes that coefficient is not significant at the 10% level.

2.3 Student Loans

2.3.1 Government Student Loans

Federal loans are administered through the U.S. Federal Student Loan Program (FSLP), and include Perkins, Stafford and PLUS Loans. Government student loans come in two forms: (1) direct loans issued by the Federal government, and (2) indirect loans which are

⁷We run probit and OLS regressions in which the various credit status measures are the dependent variables, and the natural logarithm of household wage income is the independent variable, in addition to education, gender, marital status, household size, and age. Here, we consider a larger sample of individuals by age since credit scores and income are likely related during the entire working life of an individual.

administered by private credit institutions but are guaranteed by the U.S. government.⁸ 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. 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 2006.⁹ 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. In turn, family contributions for college depend on parental income and assets. However, there is a limit to how much students can borrow from the government. 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 (U.S. Department of Education).¹⁰ This limit on government loans has remained constant since 1993. Borrowing from the government is quite common, with nearly 50% of full-time college students borrowing from the government in recent years (Steele and Baum, 2009). Of those who borrow from the government, approximately one-half borrow the maximum amount (Berkner, 2000; Titus, 2002).

Typically, repayment of government student loans begins six months after college graduation, and can last up to ten years. If a student fails to make a payment on their student loan in 270 days, they are considered to be in default. National two-year cohort default rates in the FSLP for the 2004 cohort were 5.4% (U.S. Department of Education).¹¹ Students cannot typically discharge their FSLP debt upon default, and penalties on defaulters include: garnishment of their wage, seizure of federal tax refunds, possible hold on transcripts and ineligibility for future student loans. Default status on a government student loan may appear on a credit report. However, the U.S. Department of Education reports that the default status is deleted from a credit report when the defaulter rehabilitates the loan, and most defaulters have the incentive to rehabilitate their loans given IRS tax withholdings.¹²

2.3.2 Private Student Loans

The system for obtaining private student loans is much different than the FSLP. First, most private student loans require certain credit criteria, which can be met by enlisting a cosigner. Second, loan limits in private loans are set by the creditor and do not exceed the cost of

⁸In our analysis, we focus on Stafford student loans, which represents 80% of the FSLP in recent years.

⁹Recent legislation changed the structure on interest rates for subsidized student loans to be declining, fixed rates over time.

¹⁰<http://studentaid.ed.gov/PORTALSWebApp/students/english/studentloans.jsp#03>

¹¹<http://www.ed.gov/offices/OSFAP/defaultmanagement/cdr.html>

¹²<http://www.ed.gov/offices/OSFAP/DCS/rehabilitation.html>

college less any financial aid the student receives (from all possible sources). Third, interest rates and fees vary significantly by credit status, and interest accumulates while in college.¹³ Based on conversations with Sallie Mae, which is the largest creditor of private student loans, 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). In light of the credit market tightening that occurred in 2008-09, private creditors have increased the credit requirements for these loans; Sallie Mae now requires a 670 FICO score (in 2009). Lastly, private student loans are not guaranteed by the government.

Borrowing from the private student loan market is more prevalent, especially in recent years. Based on a Sallie Mae/Gallup survey (2008), approximately 27% of students who borrow from private credit markets to finance college. 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 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.

Similar to other credit markets, private student lenders report information to credit bureaus, including the total amount of loans extended, the remaining balance, repayment behavior and the date of default. In addition, 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). Private student loans are also not dischargeable in bankruptcy.

3 Model Description

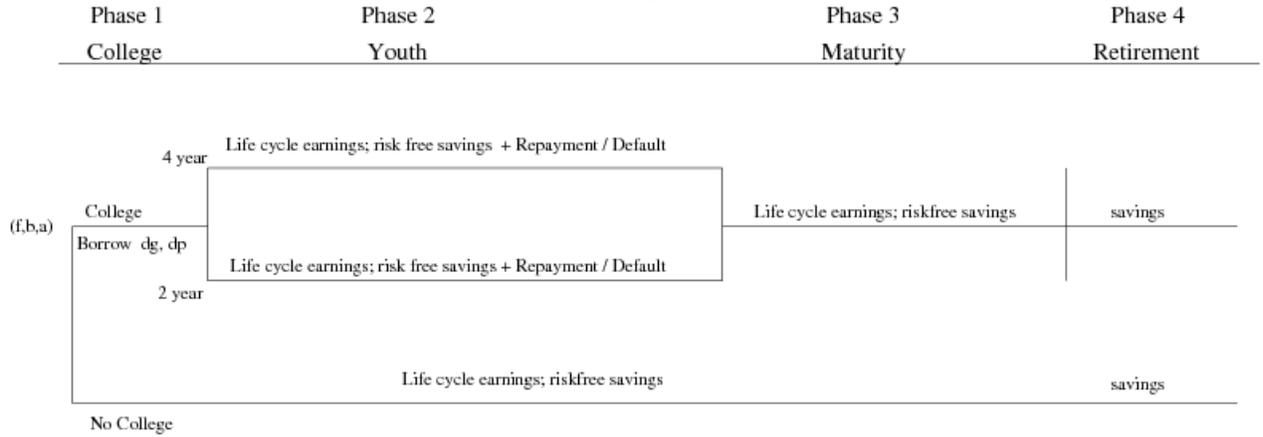
3.1 Environment

We consider a life-cycle economy where agents live for $T + 1$ periods. Time is discrete and indexed by $t = 0, \dots, T$ where t represents the time after high school graduation. Each agent's life is characterized by four phases: college/young worker, young adult, maturity, and retirement. Figure 2 illustrates the timing of decisions for a typical agent in the model.

Agents are heterogeneous in family contributions $b \in B$, credit scores $f^0 \in F$, and ability $a \in A$, which are jointly drawn from the distributions $F(b, f^0, a)$ on $B \times F \times A$. In the first period, agents make a one-time decision of enrolling in college or going directly to work as

¹³There are also student loan companies that use non-credit characteristics such as school attended, grade-point average, etc., in pricing a loan.

Figure 2: Timing of decisions



non-college workers. When they decide to enroll in college, they choose between going to two or four years of college. During this phase, young agents consume and invest in education. To finance their consumption and college investment, young agents receive family 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). The repayment behavior for private loans will induce an evolution of credit scores. People care about their credit score because it makes certain transactions harder and/or more expensive. In the third phase (‘maturity’), agents use their labor income to consume and save and encounter a loss from having a bad credit score (which is described in detail below). 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.

Discounted lifetime utility consists of:

$$\sum_{t=1}^T \beta^{t-1} u(c_t) \quad (1)$$

where c_t represents the consumption of the agent during period t , $\beta \in (0, 1)$. We assume a constant relative risk aversion such that $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ where $\sigma > 0$. The agent’s problem is to maximize his utility (equation 1) subject to his budget constraints (provided below).

3.1.1 College

Table 4 provides details of the life-cycle for an agent who decides to go to college. Phases three and four are common to agents who do not go to college.

In the first phase of life, the college student consumes c_t , invests in human capital h ,

Table 4: Phases of the life-cycle

College ($t = 0$)	Young Adult ($1, \dots, T_2$)	Maturity ($T_2 + 1, \dots, T_3$)	Retirement ($T_3 + 1, \dots, T$)
Consumption (c_0)	Consumption (c_t)	Consumption (c_t)	Consumption (c_t)
Investment in education (h)	Earnings ($z_t y_t$)	Earnings ($z_t y_t$)	Interest Earnings
Earnings (y_0)	Borrow/Lend (s_{t+1})	Borrow/Lend (s_{t+1})	
Borrow for school ($d_0^g + d_0^p$)	Repay student loans (p_t)	Credit score f_{T_2+1}	
Family contributions (b^0)	Credit score (f_t)		
Credit score (f^0)			

receives family contributions b , and borrows from the government d_0^g and the private market d_0^p . Thus, the budget constraint for the college student is:

$$c_t + h \leq b + d_t^g + d_t^p + y_t(h); \quad t = 0. \quad (2)$$

In this environment, the college investment decision is purely a financial decision. Based on the cost of college and the returns to college (i.e., lifetime earnings), students make a one-time decision to complete four years of college, h_4 , or two years of college, h_2 (i.e., attend college for half of this period). The human capital choice is in terms of length, not quality. However, we allow for college heterogeneity conditional on schooling length $h \in \{h_2, h_4\}$ in the sense that the college cost, $\bar{d}(b, h)$ increases in b given h . People from lower income groups tend to enroll in relatively less expensive colleges regardless of the type of the institution (two-year versus four-year). Furthermore, we assume that the relative cost of four-year college to two-year college declines in b . Both of these two features are consistent with our findings from the BPS data (see section 4 for details).¹⁴

Agents who complete two years of college will earn labor income $y_0(h_2)$. Agents who complete four years of college work during college (and receive $y_0(h_4)$), but since they attend college the entire period, they forgo earnings $y_0(h_2)$. We assume that earnings during college do not depend on the ability of the student. The types of jobs that students have during college do not necessarily value student's skills or college preparedness (see Autor et al., 2003). However, in the calibration section, we will allow earnings during college to vary with b and estimate the levels of earnings $y_0(h_4, b_i)$ to match four-year college participation rates for income group i . Our model delivers that people from low income backgrounds tend to work more during college, which is consistent with empirical findings (see Stinebrickner and Stinebrickner, 2003).¹⁵ Agents who complete two years of college should be interpreted as

¹⁴Note that $\bar{d}(b, h)$ represents the net college cost which is the sum of tuition, h , and room, board and other consumption expenditures during college captured in c .

¹⁵In addition, for a nice paper that considers how borrowing constraints affect labor supply decisions across

students who complete two-year colleges and those who drop-out from four-year colleges. Thus, we are explicitly considering drop-outs of four-year colleges since they represent a significant portion of college students (Gladieux and Perna, 2005). In addition, we assume that all students attend college full-time.¹⁶

Students borrow first from the government to finance their college investment and then turn to the private market for the rest of the funds needed to finance college. 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_0^g depends on the cost of college $\bar{d}(h, b)$, which reflects the actual cost of college (i.e., tuition and fees) and the family contribution b . Thus, the borrowing limit for a young agent from the government is: $d_0^g(h, b) = \max[\min\{\bar{d}(h, b) - b, d_{\max}(h)\}, 0]$, where $d_{\max}(h)$ is the exogenous borrowing limit imposed by the government for each period in college, where $h \in \{h_2, h_4\}$. This limit only depends on the length of schooling.

The college student may borrow from private credit markets d_0^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 $R^p(f_0)$ declines in f_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. The amount students can borrow from private credit markets for school cannot exceed the difference between the cost of college $\bar{d}(h, b)$ and what they receive in government loans. In addition, students with very low credit scores cannot borrow at all in the private market and students with low credit scores may not be able to borrow the entire amount. Thus, the borrowing limit in private credit markets is: $d_{t_0}^p(h, b, f_0) \leq \min\{\bar{d}(h, b) - d_{t_0}^g, d_{\max}(f_0)\}$ with $d'_{\max}(f_0) > 0$. It is important to note that our model assumes private creditors will meet the demand of student loans for borrowers with sufficiently high credit scores.

In the next phase of life as young adults, agents consume c_t , save/borrow s_{t+1} , earn labor income $z_t y_t(h, a)$ 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:

$$\begin{aligned} c_t + s_{t+1} &\leq z_t y_t(h, a)(1 - \mu_g - \mu_p) - p_t^i; & i \in g, p; t = 1, \dots, T_2; \\ \mu_i &= 0 & \text{if } p_t^i \geq \underline{p}^i \end{aligned} \quad (3)$$

different groups of college students, see Garriga and Keightley (2007).

¹⁶Since most of the data on participation in student loans programs (both private and public) significantly vary with full-time and part-time enrollment, we need to focus on one group. Also, eligibility for the maximum amount of government student loans is contingent on full-time college enrollment.

Labor income is given by the product between the deterministic component, $y_t(h, a)$ and the stochastic component z_t . The deterministic component depends on the human capital accumulated during college such that $y_t(h_4, a) > y_t(h_2, a)$ for any t and a . Also, for both education groups, earnings increase in the ability level of the student. In particular, the premium from investing in four years of college relative to two years of college increases in a , which is consistent with the data (details are provided in Section 4). Earnings increase over time at a declining rate $y'_t(t) > 0$ and $y''_t(t) < 0$.¹⁷ The idiosyncratic shocks to earnings each period z_t evolve according to a Markov process with support $Z=[\underline{z}, \bar{z}]$, where \underline{z} represents a bad productivity shock and \bar{z} represents a good productivity shock. The Markov process is characterized by the transition function Q_z and it is assumed to be the same for all agents.

In this environment, agents face three types of uncertainty: shocks to income and shocks to interest rates on government and private loans, all of which affect the default/repayment decision. Our modeling choice is justified with the following reasoning. First, earnings uncertainty is one of the main reasons why borrowers default together with expense shocks (such as divorce and health expenses); however, the latter is not common among young households (Sullivan et. al., 2000). Second, credit scores have an important role in an environment with earnings uncertainty. For students who borrow from the private market, interest rates can be twice as high for someone in the lowest range of credit scores compared to someone in the highest range of scores. Thus, the cost of a student loan, especially when financed over ten or more years, can be significantly higher for students with low credit scores. Earnings uncertainty in this model amplifies the effects that credit scores have on college investment, compared to an environment without earnings uncertainty. Finally, in an environment with non-dischargeability of loans, interest rate uncertainty plays an important role for default incentives.¹⁸

When the agent enters repayment for the public and the private loans, the loan amounts at the beginning of this period are given by d_0^g for government loans and $d_0^p(R_t^p)^j$, where $j = 2, 4$ given h_j 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.¹⁹ 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 payment on student loans (both government and private) at time t is represented by:

¹⁷We 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.

¹⁸For the importance of these sources of uncertainty on the default decision, see Ionescu (2009).

¹⁹In 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.

$$p_t = \sum_i p_t^i = \sum_i \alpha_t^i d_t^i; \quad i \in g, p. \quad (4)$$

Consequently debt evolves according to:

$$d_{t+1}^g = d_t^g(1 - \alpha_t^g)R_t^g \text{ and } d_{t+1}^p = d_t^p(1 - \alpha_t^p)R_t^p(f_t). \quad (5)$$

Default consequences

Recall that student loans are not dischargeable in bankruptcy. Thus agents need to reorganize their debt and repay the loan in the period following default. Agents may choose (and are allowed) to default again. This feature is common in both government and private student loans. However, there are important differences between the consequences to default in the two markets.

- Private loans

Agents default on private student loans when payments in each period are less than the required amount, $p_t^p < \underline{p}_t^p$. In period t , the agent is required to pay the fraction $\underline{\alpha}_t^p$ which depends on the principal of the loan d_t^p , the interest rate R_t^p , 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 is less than the required amount, $\alpha_t^p < \underline{\alpha}_t^p$. In this case, wages are garnished at the rate $\mu_p > 0$. In addition, the default is reported to credit agencies and credit scores are revised downward. Given the choice of α_t^p , the evolution of f_t is given via an exogenous function $g(\alpha_t^p, f_t^i)$ for $t = 2, \dots, T_2$:

$$f_{t+1} = g(\alpha^p, f_t^i) = \begin{cases} \underline{f} & \text{if } \alpha^p < \underline{\alpha}^p \\ f^i & \text{if } \alpha^p = \underline{\alpha}^p \\ \alpha^p a(f_t) + b(f_t) & \text{if } \alpha^p \in (\underline{\alpha}^p, 1) \\ f^{i+1} & \text{if } \alpha^p = 1 \end{cases}$$

When the agent pays less than the required amount, the credit score is set to the lower bound, \underline{f} . When the borrower pays the exact amount that it is required, his score does not change. For any payment above the minimum requirement, the score is gradually updated according to the function $g^p(\alpha_t^p, f_t) = \alpha_t^p a(f_t) + b(f_t)$, where $a(f_t) > 0$ and $b(f_t) > 0$. When he pays his entire loan, his score improves to the next bin, $g^p(1, f^i) = f^{i+1}$ for bins $i \in \{1, \dots, 6\}$.

This mechanism captures the feedback of the repayment behavior in private student loans on credit scores.²⁰ In this framework, default is severely punished, whereas good repayment behavior is gradually rewarded. Thus, the model produces variation in credit scores across adults later in the life-cycle.

Our modeling captures the fact that people care about credit scores later in life. At the beginning of the third stage in the model (i.e., maturity), agents incur some cost from having a bad credit score. Their credit score at this point is the result of their repayment behavior on private student loans from the previous phase (i.e., as young adults). Thus, credit scores evolve over time and that evolution is specific to each agent. In addition, the interest rate on private student loans depends on credit scores via an exogenous function $R^p(f)$ which is updated each period for each agent and depends on their repayment behavior in the past. Thus, defaulting on private loans triggers an additional cost in the form of higher student loan expenses.

Finally, the borrower may be excluded from borrowing in the risk-free market during the period of default. This penalty captures the immediate impact of bad repayment behavior on participation in other markets and is quite common in models of default; however, in the current environment, it is not a crucial feature of the model given the severity of the other consequences of default.

- Government loans

Agents default on government student loans when payments are less than the required amount, $p_t^g < \underline{p}_t^g$. In period t , the agent is required to pay the fraction $\underline{\alpha}_t^g$ which depends on the principal of the loan d_t^g , the interest rate R_t^g , 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 is lower than the required amount, $\alpha_t^g < \underline{\alpha}_t^g$. In this case, default leads to wage garnishment μ_g .²¹ When the agent makes the required minimum payment on government student loans ($p_t^g \geq \underline{p}_t^g$), there is no wage garnishment, thus $\mu_g = 0$. We require that agents must pay off their government student loans at the end of this period; thus, for $t = T_2$, $p_t^g = d_t^g$.²²

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

²⁰Our model is not a theory of credit scores. Assessing the impact of credit market participation on credit scores and explaining observed variation in credit scores across individuals is beyond the scope of this paper.

²¹We assume that default in the government market does not affect future credit scores which is consistent with the fact that default status does not typically show up on credit reports (as described in Section 2.3.1).

²²In practice, the U.S. government uses income tax withholdings as the enforcement mechanism for borrowers to repay their student loan in full over the life of the loan. We enforce full repayment in the model in the terminal period T_2 .

to:

$$c_t + s_{t+1} \leq z_t y_t(h, a) + R^f s_t; \quad t = T_2 + 2, \dots, T_3. \quad (6)$$

As mentioned before, in period $t = T_2 + 1$, the agent incurs some cost from having a bad credit score after the repayment phase, $\lambda(f_{T_2+1})$, that is proportional to his income, so that the budget constraint is:

$$c_t + s_{t+1} \leq z_t y_t(h, a)(1 - \lambda(f_{T_2+1})) + R^f s_t; \quad t = T_2 + 1. \quad (7)$$

with $\lambda(f_{T_2+1})$ decreasing in the credit score at period T_2+1 , which is delivered by the evolution of credit scores during the young adult/repayment phase. In the case where the agent has not borrowed from the private market, $f_{T_2+1} = f_0$.

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

$$c_t + s_{t+1} \leq R^f s_t; \quad t = T_3 + 1, \dots, T \quad (8)$$

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

3.1.2 No college

On the no-college path, there are no student loans and thus no repayment/default behavior. There is also no uncertainty in interest rates. However, there is earnings uncertainty, which is modeled similarly as the college path. Earnings are given by $z_t y_t(h_0)$ where h_0 represents no investment in college. We assume that $y_t(h_0) < y_t(h_2, a)$ for all ability levels a . Agents with no college education earn less than those with some college education. Agents who do not go to college solve a consumption-savings problem subject to earnings uncertainty for the first three phases of their lives, similar to the problem solved by agents who go to college. On the no-college path, as well as the college path, agents incur some loss from having a bad credit score at period T_2+1 . In the no-college case, this score is simply the initial score f_0 since they do not borrow from the private student loan market and hence do not experience adjustments in their credit score over time. After period T_3 , agents retire and consume their savings. We assume that agents may allocate the initial family contributions to consumption or savings in the first period. The budget constraints are given by:

$$\begin{aligned} c_t + s_{t+1} &\leq z_t y_t(h_0) + b; & t = 1 \\ c_t + s_{t+1} &\leq z_t y_t(h_0) + R^f s_t; & t = 2, \dots, T_3 \\ c_t + s_{t+1} &\leq z_t y_t(h_0)(1 - \lambda(f_0)) + R^f s_t; & t = T_2 + 1 \\ c_t + s_{t+1} &\leq R^f s_t; & t = T_3 + 1, \dots, T \end{aligned} \quad (9)$$

3.2 Equilibrium

On the college path, the agent $i \in B \times F \times A$ maximizes utility (equation 1) subject to his budget constraints (equations 2 - 8) by choosing $\{h, c_t, s_{t+1}, \alpha_t^g, \alpha_t^p, d_{t+1}^g, d_{t+1}^p, f_t\}$ taking prices $\{z_t y_t, R^f, R_t^g, R_t^p(f_t)\}$ and policy parameters $\{d_{\max}, \mu_g, \mu_p\}$ as given. On the no-college path, the agent $i \in B \times F \times A$ maximizes utility (equation 1) subject to the budget constraints (equation 9) by choosing $\{c_t, s_{t+1}\}$ and taking prices $\{z_t y_t, R^f\}$ as given. Then, the agent optimally chooses between these two paths.

Our economy is a partial equilibrium analysis in the sense that the supply of loans is exogenous and the average interest rates on student loans in both the government and private markets do not arise endogenously from an equilibrium profit condition. While this is certainly the case for the government market in the real world, our framework may seem restrictive for the private student loan market. By design, the interest rate in the private market is how private creditors cover the cost of default. Even though we do not model a general equilibrium framework, we claim that the average interest rate in the private market captures default risk.²³ Our model is consistent with the fact that in a riskier environment, as measured by a higher default rate, the average interest rate in the market charged by the private creditor is higher. This happens for the following reasons. First, our economy features a menu of interest rates for private loans which depend on the borrowers' credit scores along with a feedback of the repayment behavior on credit scores. Thus, the interest rate that the borrower faces each period depends on the risk of default in that period, which in turn evolves over time given the borrower's past repayment behavior in the private market. Second, student loans are not dischargeable after default. In our model, agents need to repay their loans in the first period after default and they will do so at a higher interest rate since their credit scores are severely damaged. As a result, the interest rate charged by the private creditor increases with the average risk in the market. Nondischargeability is a key difference between student loans and other types of unsecured credit (such as credit cards) that allows us to take this approach.²⁴ In our economy, agents repay their student loans eventually since they care about their scores later in life. The loss from having a bad credit score prevents our agents from not repaying their loans. Thus, the incentive to default declines over time. This discussion can be conveniently explained using the present-value profit condition for

²³A standard GE setup will be intensive computationally given the high dimension of the state space and the number of periods for the repayment phase in which the credit scores evolve. For a nice paper on the importance of general equilibrium effects in the analysis of education policies, see Gallipoli, Meghir and Violante (2008).

²⁴Chatterjee et al. (2007) presents a nice theory of the terms of credit and credit scoring where the pricing of default risk is generated out of the zero-profit condition in a general equilibrium framework with dischargeability rules. Also, for a study on the reorganization versus liquidation bankruptcy regimes in unsecured credit, refer to Livshits et. al. (2007).

the private creditor in the economy. The functional form is given by:

$$PV_\pi = \int_{d_p > 0} \left[\sum_{t=1}^{T_2} \beta^{t-1} \left[\int \int_{\alpha_t^p \geq \underline{\alpha}_t^p} (\alpha_t^p d_t) d\alpha dR^p + \int_{\alpha_t^p < \underline{\alpha}_t^p} \int (\mu_p z_t y_t) dz d\alpha \right] - d_0^p \right] df$$

Note that the private creditor collects a wage garnishment from defaulters during the period when default occurs and collects repayments every period until the loan is paid in full from all participants in the private market, including defaulters (except for the period when default occurs). We assume that the private creditor borrows in the risk-free capital market. In the results section, we calculate total profit for the private creditor in the policy experiments and compare them to the benchmark economy, and show that the average interest rate is increasing in the default rate. This indicates that interest rates in the private credit market are capturing most of the default risk compared to the wage garnishment.

We recast the problem in a dynamic programming framework and solve backwardly for all of the choices in the model. On the college path, 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 maturity phase, there are two value functions:²⁵

$$\begin{aligned} V_3^{post}(a, h, s, z, t) &= \max_{s'} u(zy(h, a) + s(1+r) - s') + \beta E_{z'} V_3^{post}(a, h, s', z', t+1); \\ V_3^{score}(a, h, s, f^1, z, T_2+1) &= \max_{s', b'} u(zy(h, a)(1-\lambda(f)) + s(1+r) - s') + \beta E_{z'} V_3^{post}(a, h, s', z', T_2+2) \end{aligned}$$

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

$$\begin{aligned} V_2(a, h, s, f, d_p, d_g, r_p, r_g, z, t) &= \max_{\alpha_p, \alpha_g, s'} u(zy(h, a) + s(1+r) - s' - \sum_i \alpha_i d_i) + \\ &\quad \beta E_{r'_i, z'} V_2(a, h, s', f', d'_p, d'_g, r'_p, r'_g, z', t+1), \end{aligned}$$

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

$$V_1(a, b, f, r_p, r_g, 1) = \max_h u(b-h + d_p(b, f, h) + d_g(b, h) + y(h) + \beta^j E_{r'_i, z'} V_2(a, h, f', d'_p, d'_g, r'_p, r'_g, z', 2))$$

where $j \in \{1, 2\}$ in case $h \in \{h_2, h_4\}$.

Consider $V^{Col}(a, b, f_0, r_p, r_f)$, the value function associated with the college path, which

²⁵In the computations, we divide the problem for the maturity phase into two sub-phases: post-score and score period. 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.

equals $V_1(a, b, f, r_p, r_g, 1)$. Also, $V^{NoCol}(a, b, f_0)$ is the value function associated with the no-college path. Thus, agents solve:

$$\max\{V^{Col}(a, b, f_0, r_p, r_f), V^{NoCol}(a, b, f_0)\}.$$

4 Parametrization

The model period and phases are detailed in Table 5. 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 maturity phase lasts 24 years, and the retirement phase lasts 20 years. Thus, $T_1 = 1$, $T_2 = 11$, $T_3 = 35$, $T = 55$.

Table 5: Model periods and phases

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

There are four sets of parameters that we calibrate: 1) standard parameters such as the discount factor, the coefficient of risk aversion, the risk free interest rate; 2) parameters for the initial distribution of characteristics: family contributions for college, credit scores and student’s ability; 3) parameters specific to student loan markets such as college costs, tuition, borrowing limits, default consequences, interest rates on student loans, etc.; and 4) parameters for the earnings dynamics of individuals by education and ability groups. Our approach includes a combination of setting some parameters to values that are standard in the literature, calibrating some parameters directly to data, and jointly estimating the parameters that we do not observe in the data by matching moments for several observable implications of the model. More specifically, we jointly estimate eight parameters: the wage garnishment for government and private loans, the mean and standard deviation from the initial distribution of family contributions, earnings during college by income terciles, and the forgone earnings during college. These eight parameters are set to match eight targets: the national two-year cohort default rates in both the government and private student loan market (5.4% and 3.92%), the four-year college participation rate by income terciles from BPS data (57%, 64.6% and 82.7%), the college enrollment rate (73%) and the participation rates in the government and private student loan market from the College Board (50% and 30%). Table 6 reports how well the model does in replicating the eight data points. We provide details on the procedure in the following subsections.

Table 6: Model Predictions vs. Data

Parameter	Name	Value	Variables Targeted	Data	Model
	Earnings during college for:		4-year college investment rate:		
$y_{T_1,1}(h_4)$	1st trecile of income	\$18,009	1st trecile of income	57%	50.1%
$y_{T_1,2}(h_4)$	2nd trecile of income	\$6,552	2nd trecile of income	64.6%	65.4%
$y_{T_1,3}(h_4)$	3rd trecile of income	\$4,968	3rd trecile of income	82.7%	81%
$y_{nc}(h_0)$	Earnings for no college	\$123,760	College enrollment rate	73%	73%
μ_b	Mean of family contribution	\$41,245	Participation rate in govt mk	50%	51%
σ_b	St. dev. of family contribution	\$38,839	Participation rate in private mk	30%	29%
μ_g	Wage garnishment govt mk	3.5%	Default rate in govt mk	5.4%	5.4%
μ_p	Wage garnishment private mk	5.0%	Default rate in private mk	3.9%	3.9%

Figures are in 2007 dollars.

The discount factor is set to match the risk free rate (R^f) of 4%, thus $\beta = 0.96$. We assume a CRRA utility function with the coefficient of risk aversion as standard in the literature, $\sigma = 2$. In what follows, we discuss in detail the parametrization of the initial distribution of individual characteristics, the parameters specific to the student loan market, and the earnings dynamics.

4.1 Initial Distribution of Family Contributions, Credit Scores and Ability

For family contributions for college, we consider a uniform grid, $B = [0, 62,000]$ in 2007 dollars with 20 levels of b . For initial credit scores, we set six bins corresponding to the bins used by Sallie Mae to determine the conditions on student loans, $F = \{< 640, 640 - 669, 670 - 699, 700 - 729, 730 - 759, 760 - 850\}$. We measure the ability level, a , by the SAT scores of students and consider 3 groups of SAT scores: $A = \{< 900, 900 - 1100, 1100 - 1600\}$ corresponding to treciles of SAT scores.

We estimate a joint distribution of family contribution, credit scores, and ability accounting for correlations between all three characteristics. We assume a normal distribution for family contributions for college, $B(b) \sim (\mu_b, \sigma_b)$. While the expected family contribution is a good predictor for the actual family contribution for college, differences may arise between the two. Rather than using an exogenous distribution for the expected family contribution for college, we estimate the moments of the distribution of family contributions to match participation rates in the government student loan and the private student loan market (50% and 30%). We obtain $\mu_b = \$41,245$ and $\sigma_b = \$38,839$ in 2007 constant dollars, which are consistent with the Baccalaureate and Beyond (B&B 1992/93) data from the U.S. Department of Education that yields a mean expected family contribution of \$52,250 (for four years

of college) and a standard deviation of \$37,943.²⁶

For the distribution of credit scores, $F(f_0)$, we use the national distribution of FICO scores provided in Section 2.1 and assume a normal distribution where $F \sim (716, 54)$. For the distribution of ability, $A(a)$, we use the national distribution of SAT scores and assume a normal distribution with a mean of 1016 and a standard deviation of 226 (College Board, 2007).

Our model assumes a positive correlation between all three initial characteristics. Based on the results in section 2.2, there is a small, positive correlation between various measures of credit status and wage income that range from 0.04 and 0.22 for working-age individuals in the SCF. Using those measures of credit status as proxies for credit scores and assuming income is highly correlated with family contributions for college, we assume that the credit scores of students and family contributions for college have a correlation coefficient of $\rho(b, f_0) = 0.15$. In addition, data suggest a strong positive correlation between SAT scores and parental income (College Board, 2009). We therefore assume $\rho(b, a) = 0.4$, which is in the middle of the estimates (Ionescu, 2010).

4.2 Student Loan Parameters

4.2.1 College Costs and Loan Limits

To set the appropriate borrowing limits for government school loans, we obtain 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 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 two-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. 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, using the same College Board data.

To match the actual costs of attending four years and two years of college, we use the BPS data on drop-out and completion rates for the cohort of students starting college in 1995-1996. Our sample consists of high school graduates who enroll full-time in four-year and two-year colleges without a delay after graduating from high school. Also, we consider students with SAT scores above 700.²⁷ The four-year college group consists of college graduates,

²⁶<http://nces.ed.gov/surveys/hsb/index.asp>

²⁷Fewer than 8% of students have scores below 700. Also according to the BPS data, 56% of these students

i.e. students who obtained their bachelor degree by 2001. Those who drop-out of four-year colleges are put into the two-year college group. The two-year college group also includes those who complete a two-year degree (those who drop-out of two-year colleges are not considered). We find that 67% of students completed a four-year degree (59.1% of these students attended a public institution and 40.9% a private institution) and 33% completed a two-year degree (71.2% of these students were drop-outs from four-year colleges and 28.8% completed a two-year degree).²⁸ Using these weights and assuming they have been constant over time, the average net price for four years of college is \$58,654. For two years of college, the net price is \$20,535.²⁹ The average direct costs (tuition and fees) using the same weights are \$50,993 for four years of college and \$18,762 for two years of college.

Our framework focuses on the duration of college investment while ignoring college heterogeneity in other dimensions, such as school quality. However, we recognize the fact that students from different family backgrounds may sort into different types of schools and thereby allow the cost of college to vary with student income. In particular, our findings from the 1996 BPS sample show that the cost of college increases in the income of students. An interesting finding is that the cost of four years of college relative to two years of college declines in the parental income of students. We use expected family contributions as a proxy for parental income, and obtain relative differences in the cost of college from the BPS data for students with two and four years of college across income terciles. This yields college costs of: \$57,716, \$56,777, and \$60,942 for students with four years of college; and costs of \$19,180, \$20,535, and \$24,231 for students with two years of college.³⁰

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 (\$2,625 for the first year and \$3,500 for the second year of college). Note that unlike the cost of college, these limits do not vary with the income of students. As a result, the limits represent a higher percentage of net college cost for low-income students than for high-income students.

Loan limits in the private market for school loans are set by the creditor and do not

enrolled in less than two years of college or enrolled into two-year colleges and dropped out, 45% delayed their enrollment in college and 55% did not enroll full-time in the first semester when they enrolled in college and thus were not eligible for student loans and are excluded from the model.

²⁸<http://nces.ed.gov/programs/coe/2004/section3/table.asp?tableID=61>

²⁹Note that for drop-outs of four-year colleges, we assume they pay the net price of attending a four-year college (public and private) for two years. Thus, our two-year net cost is higher than the cost of two-year colleges since it includes drop-outs from four-year colleges that paid a much higher net price.

³⁰We assume the weighted costs for private and public schools are the same across income groups of students.

exceed the cost of college less any financial aid the student receives, including government student loans. In addition, borrowers with credit scores lower than 640 cannot borrow in the private market and borrowers with credit scores lower than 700 cannot borrow more than the median amount that it is borrowed in the private market (\$7,825). Thus, the borrowing limit in the private credit market is: $d_t^p(h, b, f_0) \leq \min\{\bar{d}(h, b) - d_t^g, d_{\max}(f_0)\}$ with $d_{\max}(f_0) = 0$ if $f_0 < 640$, $d_{\max}(f_0) = \text{median}(d^p)$ if $640 \leq f_0 < 700$ and $d_{\max}(f_0) = \bar{d}(h, b)$ if $700 \leq f_0$.

4.2.2 Student Loan Interest Rates and Default Penalties

The interest rates on government and private student 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 $\{\underline{R}^p, \overline{R}^p\}$. 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: $R_t = \mu(1 - \rho) + \rho R_{t-1} + \varepsilon$, $\varepsilon \sim N(0, \sigma^2)$, which yield estimates of $\rho = 0.9902$ and $\sigma = 0.2097$ and mean 3.11%. We aggregate this to annual data; the autocorrelation is given by 0.89 and the unconditional standard deviation by 1.511. We approximate this process as a two-state Markov chain. The support is $R^g \in \{1.047, 1.0772\}$, and the transition matrix is $\begin{bmatrix} 0.7037 & 0.2963 \\ 0.2963 & 0.7037 \end{bmatrix}$.

Sallie Mae sets the interest rates based on the 3-month LIBOR rates plus a margin that differs across credit scores, given by $\{12, 10.5, 8.5, 6.4, 4\}$ corresponding to the five bins of credit scores reported in Table 1.³¹ 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 3.41%. We aggregate this to annual data; the autocorrelation is given by 0.872 and the unconditional standard deviation by 1.408. We have approximated this process as a two-state Markov chain. The support for each of the bins of credit scores is $R_1^p \in \{1.06, 1.0882\}$, $R_2^p \in \{1.085, 1.1132\}$, $R_3^p \in \{1.105, 1.1332\}$, $R_4^p \in \{1.125, 1.1532\}$, and $R_5^p \in \{1.14, 1.1682\}$. The transition matrix is $\begin{bmatrix} 0.7003 & 0.2997 \\ 0.2997 & 0.7003 \end{bmatrix}$.

We calibrate the default punishments to match the repayment behavior in the data. We set the wage garnishment for default in the government student loan market as $\mu_g = 0.035$ to match the default rate for government student loans, which was 5.4% in 2004. In practice this punishment varies across agents, depending on collection and attorney's fees, and can be as high as 15%. The wage garnishment for private student loans $\mu_p = 0.05$ is set to match

³¹The margins are from June 2008 and were obtained from: <http://www.salliemae.com/about/investors/>

the default rate for private student loans, which is 3.92%.

Also, recall that the repayment behavior in the private market affects the credit score of the individual. The fraction of the student loan that is paid in period t is α_t^p for private loans. When the agent chooses α_t^p such that $p_t^p = \alpha_t^p d_t^p < \underline{p} = \underline{\alpha}_t^p d_t^p$, the score is severely damaged and becomes \underline{f} . For any payment greater or equal than the minimum require in each market, the score is gradually updated according to the function $g^p(\alpha_t^p, f_t) = \alpha_t^p a(f_t) + b(f_t)$. When the borrower pays the exact amount that it is required in the private market, his score does not change, f^i and when he pays his entire loan in period t , his score improves to the next bin, f^{i+1} for $i \in \{1, \dots, 6\}$. 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: $g^p(\alpha_t^p, f_t^i) = \frac{\alpha_t^p (f_t^{i+1} - f_t^i) + (f_t^i - \underline{\alpha}_t^p f_t^{i+1})}{1 - \underline{\alpha}_t^p}$. Note that this function depends on the minimum required payment, which depends on the loan amount due each period to the private creditor, which in turn depends on family contributions and credit score.

Finally, we estimate the cost function from having a bad credit score at the end of the repayment phase $\lambda(f)$ as a linear decreasing function on $[0, \mu_p]$. The individual with the highest credit score does not incur any cost later in life, $\lambda(\bar{f}) = 0$, whereas the individual with the lowest credit score incurs the worst punishment, which we set as the wage garnishment in the case default occurs, $\lambda(\underline{f}) = \mu_p$. We run robustness checks on this estimation and our results are not sensitive to the levels of these penalties.

4.3 Earnings

The deterministic component of lifetime earnings $y_t(h, a)$ is 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 four years of college (BA) in the model. For individuals with some college in the model, we use earnings for people with more than 12 years and less than 16 years of education in the data. For people who do not go to college, we use earnings of people with 12 years of education. For individuals with two years of college, earnings during college $y_t(h_2)$ are set to \$68,788 (in 2007 dollars), which matches two years of earnings for people with some college education (i.e., less than four 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 four-year college degree compared to those with some college, which is consistent with empirical estimates (Cheeseman Day and Newburger, 2002). Note that we do not distinguish (in terms of earnings) between people with some college and no degree and people with an associate’s degree. In our model, what matters for earnings differences by education groups is the duration of college education rather than the acquired degree. Kane and Rouse (1993) find that degree recipients do not earn more than non-degree recipients with the same number of credits. Bound, Lovenheim and Turner (2009) document that the average number of years of college for people with a bachelor’s degree is 5.3 years. Thus, the college degree premium that we use delivers an average return per additional year of college education of roughly 10%, which is consistent with estimates in the literature (Willis, 1986; Restuccia and Urrutia, 2004).

Earnings also vary with ability, as measured by SAT scores. We use annual earnings by education groups in the fifth year after acquiring the highest degree for college-going high school graduates in the National Education Longitudinal Study of 1988 (NELS:88) data set. Similar to our analysis using BPS data, we construct a sample of high school graduates that enrolled in college full-time without a delay (the cohort of 1992). We group individuals by terciles of SAT scores, i.e. ≤ 900 , $900 - 1100$, and > 1100 . We find that earnings increase in the SAT score regardless of the education level of the individual. Furthermore, the premium from completing four years of college relative to two years increases in the ability level, but at a declining rate. We apply these earnings differences between students with four years and two years of college by SAT scores. We obtain the following differences in premia from acquiring a college degree over the life-cycle: 1.272, 1.338 and 1.341 across the three ability groups. Our calibration is consistent with empirical evidence showing individuals of higher ability levels experience higher returns to their education investment (Rosen and Willis, 1979; Heckman and Vytlačil, 2001; Cuhna et al., 2005). Also, most of the increase in returns is captured by the difference between the first and the second tercile of ability, which is consistent with the findings in Ashenfelter and Rouse (1998) and Hendricks and Schoellman (2009). An important observation is whether these returns are due to the innate ability of the individual, the quality of the school these individuals attend before college, the quality of college itself, or family characteristics. In our case, we directly consider a measure of ability that embodies both innate ability and acquired ability since we think of ability as college preparedness. Empirical findings show that returns to schooling are mostly driven by the ability of the student and length of schooling rather than the quality of the school.³²

Finally, students in the model earn exogenous labor income during college. We choose

³²Dale and Krueger (1999) find that students who attend more selective colleges do not earn more than other students who were accepted and rejected by comparable schools but attended less selective colleges.

the value of earnings during college across income groups in the model to match the fraction of college students that complete four years of college across expected family contributions in the BPS sample. The four-year college participation rates for each tercile of expected family contributions are 57%, 64.6% and 82.7%, which yields earnings during college of \$18,009, \$6,552, and \$4,968, respectively. Our calibration produces the fact that some students may use earnings during college to supplement their college investment and that these earnings are highest for students from the poorest families. These facts are consistent with findings in Garriga and Keightley (2007) and reports from the NCES data (Berkner, He, and Cataldi (2002)).

In the parametrization of the stochastic idiosyncratic labor productivity process, we follow Storesletten, Yaron and Telmer (2001) who build a panel from the Panel Study of Income Dynamics (PSID) to estimate the idiosyncratic component of labor earnings. They use annual data from the PSID for years 1968 to 1991. With $u_{ij} = \ln(z_{ij})$, the stochastic part of the labor income process for household i at time j , the estimated model is $u_{ij} = y_{ij} + \epsilon_{ij}$ and $y_{ij} = \rho y_{i,j-1} + \nu_{ij}$, where $\epsilon_{ij} \sim N(0, \sigma_\epsilon^2)$ and $\nu_{ij} \sim N(0, \sigma_\nu^2)$ are innovation processes. The variables y_{ij} and ϵ_{ij} are realized at each period over the life cycle and are referred to as persistent and transitory “life-cycle shocks”, respectively. Fernández-Villaverde and Krueger (2002) report $\rho = 0.935$, $\sigma_\epsilon^2 = 0.017$, and $\sigma_\nu^2 = 0.061$. We have approximated this process as a two-state Markov Chain, normalizing the average value for the idiosyncratic shock to be 1. The resulting support is the set $Z = \{0.8266, 1.1734\}$ with the transition probability matrix given by $\begin{bmatrix} 0.89 & 0.11 \\ 0.11 & 0.89 \end{bmatrix}$.

5 Quantitative Results

We first analyze the benchmark economy and compare the model’s predictions regarding college investment and borrowing behavior to the data. We then quantify the role of credit scores in college investment. We consider how credit scores interact with family contributions and student ability to affect the college investment decision. We study borrowing behavior across individual characteristics, and depict the relationship between the government student loan program and the private market for student loans in the benchmark economy. Then, we consider three experiments: 1) an increase in the borrowing limit under the government student loan program while ignoring any reaction from the private creditor; 2) an endogenous reaction of the private market for student loans such that the credit score requirement for participating in this market is higher, and 3) the recent drop in financial wealth of U.S. households. We analyze the importance of credit scores on college investment in these envi-

ronments.

5.1 Benchmark

In the benchmark economy, the enrollment rate is 73 percent and the four-year college participation rate conditional on enrolling in college is 65.6 percent.³³ This represents the percentage of students who complete four years of college, out of the pool of all college students (i.e., those who complete two and four years of college). In equilibrium, students in the model borrow on average \$31,050 (in 2007 dollars) to finance college: \$15,028 from the government and \$16,022 from the private market. Not surprisingly, since the cost of financing four years of college is significantly higher than financing two years of college, students with four years of college borrow \$39,682 (from both sources) compared to \$12,458 for students with two years of college. However, in both cases, more than half of borrowed funds is from the private student loan market, which is consistent with data from the College Board (2009).³⁴ Thus, the private student loan market is an important source of funds for college students in the model, and especially for students who invest in four years of college.

The importance of the private student loan market suggests that credit scores have a significant quantitative effect on college investment. This is exactly what we find: our model delivers that students with four years of college have credit scores that are 26 FICO points higher than students with two years of college (723 versus 697). Students with relatively low credit scores are either excluded from the private market or face very high interest rates, while students with higher credit scores can borrow from the private market at lower interest rates and higher levels. The lower cost of borrowing for students with higher credit scores influences more borrowing from the private market which leads to more college investment. However, credit scores do not differ across agents with no college and two-years of college. These results are confirmed by our findings from the SCF 2004, presented in Section 2.

In addition to credit scores, our model produces the well-known fact that both family contributions and ability are important determinants of college investment. Family contributions are nearly 60 percent higher for students who complete four years of college compared to those who complete two years of college. In addition, the average ability level of students completing four years of college is 279 SAT points higher than the average ability of those completing two years of college. Similar results are obtained for no-college versus college-educated agents. Once again, these results are consistent with BPS data, as shown in the

³³These two numbers are targeted to match their counterparts in the data.

³⁴The average amount borrowed by graduating seniors in 2007-2008 is \$23,186 (excluding PLUS Loans but including Stafford, Perkins, state, college and private loans), with the majority coming from the private sector.

next section.

5.1.1 College Investment, Borrowing and Default: Model versus Data

Table 7 presents the model's predictions regarding college investment, borrowing and default behavior across students with different levels of family contributions, credit scores and ability, while Table 8 presents their counterparts in the data. We use the BPS data set for the cohort of students enrolling in two- and four-year colleges full-time in the 1995-96 academic year, the most recent data available.³⁵ Given that the data represent an earlier cohort of students than what the model produces (recall that the model economy is calibrated to the 2003/2004 cohort of entering college students), our numbers will not exactly match. For instance, borrowing rates were much lower in 1995/1996 compared to recent cohorts. While we do not aim to match these numbers, a comparison of our results with the data is helpful to validate the model's predictions with respect to observable behavior across different groups of students.

Overall, the model does a good job in explaining college investment and borrowing behavior. The model predicts that college enrollment and four-year college participation rates are higher for students who receive more family contributions which is consistent with the data (recall that we target four-year college participation rates across family income, but not college enrollment rates). At the same time, the model predicts that participation rates in both private and government student loan programs are lower for students in the top one-third of family contributions. This result is consistent with the data that show wealthier households participate less in student loan programs. In fact, the model predicts that the wealthiest households (those in the highest b group) do not borrow from the private market and borrow very little from the government since most of them are not eligible. However, middle-income students heavily rely on the government student loan market, as evidenced by their 56 percent participation rate and \$15,400 average government loan. Approximately one-half of the poorest students in the model (those in the lowest b group) complete four years of college. As previously argued, these students need to borrow a lot and most likely at high interest rates since income and credit scores are positively correlated. In addition, ability and income are positively correlated in our framework, as are earnings and ability. Thus, the poor students in the model experience relatively low returns to college investment. The combination of low returns and high costs of college investment explains the low four-

³⁵Data are not available for all the predictions of the model by initial characteristics or for more recent years, except for borrowing rates by family income, for which we use the College Board (2007b). As in the model, participation rates in four-year colleges are calculated as the number of bachelor-degree recipients out of the pool of students who enroll in college, while two-year participation rates are calculated using the number of students who enroll in two year colleges and drop out of four-year colleges.

Table 7: Variation in Initial Characteristics: Benchmark Economy

	College enrollment rate	4-year college participation rate	Participation rates (govt/private)	Average debt (govt/private)	Default rates (govt/private)
Family contributions (<i>b</i>)				for those who borrow	
Low	65%	50.1%	97.8%/77.4%	\$14,780/\$17,326	7.8/4.4
Medium	71.3%	65.4%	55.5%/9.6%	\$15,400/\$5,216	1.3/0
High	83%	81%	5.4%/0%	\$2,664/0	0/-
Ability of the student (<i>a</i>)					
Low	20%	27.6%	47%/38%	\$15,462/\$18,816	13.2/4.5
Medium	95%	79.8%	66%/33%	\$14,780/\$13,538	2.3/2.4
High	100%	89.1%	40%/16%	\$14,966/\$14,345	1.5/5.7
Credit score (<i>f₀</i>)					
Low	78%	51%	56.7%/23.7%	\$10,557/\$7,204	3.8/0
Medium	70%	67.2%	51.3%/33.6%	\$15,525/\$14,221	5.1/5.4
High	72%	78.3%	45.3%/29.7%	\$19,996/\$24,026	8/5.5

Note: For family contributions, the low group ranges from \$0-\$25,337, the medium group from \$25,338-\$58,622, and the high group over \$58,622. For ability, the low group ranges consists of ability index less than an SAT score of 900, the medium group from 900-1,100 SAT scores, and the high group greater than an SAT of 1,100. For credit scores, the low group ranges from 640-689, the medium group from 690-735, and the high group from 736-850.

year college participation rate for poor students. However, they earn the most in the form of supplemental income during college (consistent with the data), which is key for them to invest in college.

In fact, if we impose the same earnings during college for agents with different family contributions and estimate these earnings to match the aggregate four-year college participation rate, the model delivers that only nine percent of low-income students invest in four years of college (compared to 50 percent in the benchmark). In addition, 100 percent of high-income students invest in four years of college in this case. Thus, the importance of family contributions for college is overestimated in an environment where earnings during college are assumed to be the same across groups of students. This confirms the fact that students from poor backgrounds heavily rely on earnings during college to finance their college education. A similar result is obtained in an experiment where the cost of college is assumed to be the same across family contributions, as opposed to the benchmark economy where poor students go to less expensive colleges. These two features of the model (differences in college costs and earnings during college across students with different family contributions) are important to produce accurate predictions for college investment behavior across family contributions. This is important in our model economy in order to accurately assess the importance of credit scores for college investment vis-a-vis the role of family contributions.

Notice that poor students take on the most student loan debt (more than \$32,000 for the

Table 8: Variation in Initial Characteristics: Data

	College enrollment rate	4-year college participation rate	Participation rates (govt)
Family contributions (<i>b</i>)			
Low	65%	57%	48%
Medium	71.3%	64.5%	47%
High	83%	82.7%	37%
Ability of the student (<i>a</i>)			
Low	79.5%	60.1%	35.9%
Medium	89.4%	72%	38%
High	94.9%	84.4%	37%

Source: All data come from the 1995/1996 cohort of entering college students. The exception is for borrowing rates by family income, which is from the College Board (2007b). Note that little to no data exists about college participation rates and borrowing behaviors across credit scores.

average borrower). High student loan debt and low lifetime earnings lead to high default rates for this group, making them the most risky borrowers in the model.

We report significant differences in borrowing behavior across ability types that are consistent with the data: students with the lowest abilities have the highest participation rates in the private market, whereas medium-ability students participate in the government program the most.³⁶ Due to the large increase in relative earnings between low- and medium-ability agents (as discussed in Section 4), college enrollment and four-year college investment rates are much higher for medium-ability students (95 and 80 percent) than for low-ability students (20 and 28 percent). Medium-ability students have earnings that are high enough to warrant college investment, but their family contributions are low enough so that they qualify for large government student loans. Not surprisingly, high-ability students have the highest four-year college participation rates, at 89 percent, but borrow from the government and the private market at relatively low rates; they most likely have sufficient family contributions to invest in college. Overall, high participation rates in the government student loan market by medium-ability agents and their consequent high four-year college participation rates suggest that the government student loan program is effective in promoting college investment for this group of students.

The model predictions for college investment and borrowing rates are consistent with our findings from the BPS data where high-ability students enroll in college more frequently, and once enrolled, they invest in more college and are more likely to acquire their bachelor's degree than low-ability and low-income students. Also, medium-ability students borrow the

³⁶The 2003 cohort of the BPS shows that borrowing rates and levels from the government were highest for students in the middle third of the ability distribution, as measured by SAT scores. We are the first to capture this non-linear relationship between ability and borrowing behavior.

most from the government. Note that the model overstates the importance of ability for college investment relative to the data despite the fact that we take a conservative approach in estimating differences in returns to college investment across students of different ability. This may be due to the fact that students of different ability levels in the model pay the same cost of college whereas in the data students of higher ability levels enroll in more expensive colleges (see Chatterjee and Ionescu, 2009).³⁷

5.1.2 The Importance of Credit Scores for College Investment

In addition to family contributions and ability, we find an important role for credit scores in the college investment decision. Table 7 illustrates that credit scores affect four-year participation rates (i.e., the intensive margin of college investment), but do not affect college enrollment (i.e., the extensive margin of college investment). Thus, credit scores and private student loans do not affect the college enrollment decision. This is confirmed by studies that suggest the decision to enroll in college is made early on (during high school). Furthermore, a majority (85%) of college-qualified students who did not enroll in college did not apply for college and even more (88%) did not apply for financial aid (Hahn and Price, 2008).

A central feature of our model is the interaction between family contributions, ability and credit scores. Table 9 displays college enrollment and four-year participation rates by terciles of credit scores and family contributions for medium-ability agents. We find that four-year college participation rates increase in both family contributions and credit scores, whereas college enrollment rates increase only in family contributions. The intuition is as follows. High-school graduates have the option to invest in two years of college, which is relatively cheaper than investing in four years of college. The government limit on student loans is more generous for two years of college. Thus, the government limit for students investing in two years of college binds only for a small fraction of high-school graduates. As a result, the effect of credit scores via the terms on private student loans is not quantitatively significant for two-year college investment.³⁸ However, the government borrowing constraint binds for a significant amount of college students who invest in four-year colleges, and notably students with very low family contributions. High credit scores relax the government constraint associated with investment in four years of college for students with low family contributions

³⁷Recall, however, that college costs are heterogeneous in family contributions in the model and family contributions and ability are positively correlated, indicating that the model is capturing some heterogeneity in college costs across ability levels.

³⁸It is important to note that in our model two-year students include students who go to two-year colleges and dropouts from four-year colleges; our calibration of college costs and government loan limits adjust for this fact. A more detailed college investment decision that distinguishes between no enrollment, enrollment in two year colleges, enrollment in four year colleges with separate paths for dropouts and graduates would deliver an even smaller effect of credit scores on the college-going decision.

Table 9: College Investment Rates

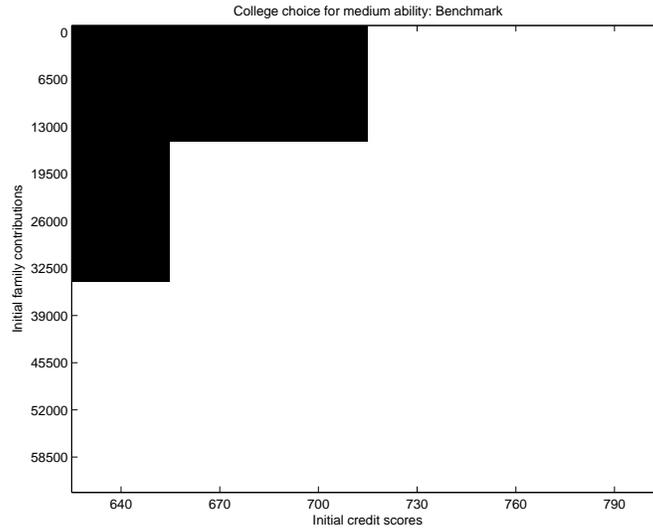
Four-Year College Participation Rates					College Enrollment Rates				
FICO (f_0)		<670	670-730	>730	FICO (f_0)		<670	670-730	>730
b	<\$22,360	31%	52%	82%	b	<\$22,360	83%	85%	84%
	\$22,360-\$43,470	81%	86%	93%		\$22,360-\$43,470	92%	91%	93%
	>\$43,470	97%	96%	97%		>\$43,470	98%	97%	98%

and medium levels of ability. Poor students are most likely to hit the government borrowing limit in the case they wish to invest in four years of college and must turn to the private market to finance college. However, in the case they have very low credit scores, they cannot borrow in this market or will borrow limited amounts; in addition, they face relatively high interest rates. The differences in four-year college enrollment rates across credit scores for poor students is significant. For the students with medium levels of parental funds, credit scores have a small positive effect on four-year college investment since some of these students hit the borrowing limit in the government market and turn to private creditors. There is no effect for students with low financial need since they do not need the private market to finance college.

Figure 3 illustrates the model predictions for four-year (in white) versus two-year college participation (in black) for college-bound students with medium levels of ability across different levels of credit scores (horizontal axis) and family contributions (vertical axis). Note that students with relatively low levels of family contributions and credit scores choose two years of college education, whereas students with relatively low levels of family contributions and relatively high credit scores choose to invest in four years of college. The figure shows combinations of family contributions and credit scores for which a student with medium ability is indifferent between more or less college education: these combinations range from the lowest credit score (<640) and \$33,913 in family contributions to a credit score of 715 FICO points and the lowest family contribution (\$0). The indifference line presents a negative relationship between family contributions and credit scores, which implies a trade-off between these two characteristics when deciding the amount of college investment. This trade-off is present for relatively poor students where high credit scores relax the government constraint. For students with relatively high levels of family contributions, there is no trade-off since they are not constrained and invest in four years of college regardless of their credit scores (as long as their ability level is high enough).

While credit scores positively affect college investment at the intensive margin but not at the extensive margin, participation rates in the private market do not increase in credit scores. Students with the highest credit scores participate in the private market less often

Figure 3: College participation by family contributions and credit scores



Note: White is four-year college and black is two-year college participation

than students with medium credit scores, despite getting better loan conditions. This is somewhat surprising, but can be reconciled by thinking about the costs associated with borrowing from the private market. Agents with the highest credit scores have the most to lose from defaulting in the private market: if they default, their credit scores will be severely revised downward. As a result, students with high credit scores participate a little less in the private market. However, for those who borrow from the private market, the quantity borrowed is quite high. Given these high debt levels, students with relatively high credit scores have a large incentive to default in both markets. However, there is a larger incentive to default in the government market since their credit score will not be adversely affected when they default.

Since credit scores are important determinants of college investment, our results imply that poor students can achieve relatively high four-year college participation rates, as long as their parent’s credit score is high enough. In addition, we document that good credit scores have significant effects on the college investment decision for students with medium levels of abilities. Thus, the private market for student loans provides students with another mechanism to fund college through the use of credit scores, and this market may be especially important for low-income and medium-ability students. However, credit scores are not as important in the college investment decision for wealthy students since their high levels of family contributions lead to high four-year college participation rates.

Our analysis documents a complementary relationship between the government student loan program and the private market for student loans. Notice that, in general, students

are using the private market for student loans in conjunction with the government student loan program. Students with better credit scores borrow more (in levels) from both the private and government market compared to students with low credit scores. Similarly, poor students use both student loan markets more than rich students. Thus, students use a mix of family contributions and private and public loans to finance college, which is consistent with Lochner and Monge-Naranjo (2008).

5.2 Policy Experiments

For the first time since the early 1990's, the U.S. government in 2008 increased the amount undergraduates can borrow. 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.³⁹ The increase in the government loan limits is more generous in the early stages of a college education: loan limits for the first and second year of college are now \$6,000 per year (up from \$2,625 the first year and \$3,500 the second year); the increase in the loan limits for additional years of college are now \$7,000 per year (up from \$5,500).⁴⁰

Additionally, there has been a recent drop in financial wealth of U.S. households: according to the flow of funds reports, financial wealth dropped by 23 percent (excluding real estate) during 2008.⁴¹ This in turn induces a proportional decline in family contributions for college (which is based on financial assets).

We conduct three policy experiments. First, we consider the case in which the government increases the maximum borrowing limit on government student loans (as in the data) while ignoring the reaction from the private sector. Second, we endogenize the reaction from the private creditor by adjusting the terms on student loans in the private market to keep the default rate unchanged from the benchmark. Third, we consider the recent drop in financial wealth and study the importance of credit scores for college investment in this environment.

5.2.1 High Limits on Government Student Loans

As evident in Table 10, a more generous government student loan program leads to a five percentage point increase in four-year college participation rates and a 1.5 percentage point

³⁹This increase consisted of unsubsidized student loans, in that the government does not pay for the interest accumulated during college. For simplicity and ease of comparability, we assume that these loans were subsidized. Lucas and Moore (2007) find that there is little difference between subsidized and unsubsidized Stafford loans.

⁴⁰<http://www.finaid.org/loans/historicallimits.phtml>

⁴¹We take a conservative approach in this experiment considering a drop in wealth for 2008, not for the entire period since the peak. For details on changes in financial wealth across U.S. households in the current recession see Heathcote et. al. (2010).

Table 10: Benchmark vs. Experiments

Variables	Benchmark	Higher Govt Limits	Reaction Private Mkt	Drop in Wealth
Enrollment rate	73.0%	74.5%	73.7%	73.4%
4-year college participation rate	65.6%	70.7%	65.3%	65.5%
Participation in govt mkt	51%	53%	53%	60.4%
Participation in private mkt	29%	25%	19.2%	36.4%
Default rate in govt mkt	5.4%	3.7%	2.8%	5.5%
Default rate in private mkt	3.9%	10.1%	3.9%	4.8%
Average govt debt	\$15,028	\$21,270	\$18,677	\$15,500
Average private debt	\$16,022	\$12,690	\$10,194	\$16,330

increase in college enrollment rates. Students use the government student loan program more and the private market less: participation rates in the government student loan program increase by two percentage points, while participation rates in the private market decrease by four percentage points. In addition, students are borrowing much more in levels from the government (42 percent more than in the benchmark) and borrowing less from private markets (21 percent less). Since government student loans are cheaper than private student loans (i.e., the interest rates are lower), students are taking on more total debt to finance college. Hence, a more generous government student loan program leads to more college investment.

Who benefits the most from this policy? As Table 11 illustrates, students with the lowest credit scores experience some of the largest increases in four-year college participation rates (from 51% to 61%). Recall that students with low credit scores get the worst loan conditions in the private market, such that the wedge between interest rates in the private and government market is quite large. As a result, they borrow from the government at very high rates and levels. Also, poor students (those in the lowest tercile of family contributions) experience the largest increases in four-year college participation rates as a result of a more generous government student loan program. Almost all of them (99%) borrow from the government, resulting in four-year college participation rates that are 11 percentage points higher than in the benchmark. Similarly, students with medium and high ability levels increase their investment in four year colleges the most.

This policy leads to a shift in the distribution of borrowers away from the private market to the government market. Notice in Table 11 that students with medium family contributions and medium ability, fall out of the pool of borrowers in the private student loan market. But these students have lower debt levels on average. Since family contribution and ability are positively correlated, students with relatively high levels of ability also leave the private

Table 11: Variation in initial characteristics: Higher government limits

	Enrollment rate	4-year college completion rate	Participation rates in govt market	Participation rates in private market	Average debt (govt/private)
Family contributions (b_0)					for those who borrow
Low	69 (+4)	61.5 (+11.4)	99 (+1.2)	75.9 (-1.5)	\$23,722/\$12,668
Medium	71.5 (+0.2)	69.3 (+3.9)	59.4 (+3.9)	0 (-9.6)	\$17,140/-
High	83 (+0)	81	5.4(+0)	0	\$2,664/-
Ability (a)					
Low	24 (+4)	31.5 (+3.9)	48.6 (+1.6)	36.3 (-1.7)	\$23,660/\$14,097
Medium	95 (+0)	85.2 (+5.4)	67.5 (+1.5)	25.5 (-7.5)	\$38,813/\$11,302
High	99 (+0)	95.1 (+6)	42.9 (+2.9)	14.1 (-1.9)	\$20,431/\$11,551
Credit score (f_0)					
Low	80 (+2)	60.6 (+9.6)	61.2 (+4.4)	21.3 (-2.4)	\$17,761/\$5,775
Medium	72.5 (+2.5)	72.6 (+5.2)	52.5 (+1.2)	29.7 (-3.9)	\$22,108/\$11,122
High	71.5 (+0.5)	78.6 (+0.3)	45.6 (+0.3)	24.9 (-4.8)	\$25,107/\$20,431

Note: Numbers in parenthesis represent percentage changes from the benchmark.

market. But these are students with higher levels of earnings on average. The remaining pool of borrowers in the private market has lower levels of parental funds (high financial needs) and lower levels of ability on average relative to the pool borrowing in the private market in the benchmark economy. Also, they invest more in their college education, and thus borrow more from all sources. Consequently, the remaining students have high debt-to-income ratios relative to the benchmark economy and much larger incentives to default. The pool of students participating in the private student loan market is more risky (relative to the benchmark), whereas the pool of students participating in the government student program is less risky.

This shift in the distribution of borrowers represents the primary cause of the changes in aggregate default rates: default rates on government student loans fall from 5.4% to 4.1%, while default rates in the private market increase to 10.9% (up from from 3.9%). We confirm this fact by conducting the following exercise: we take the distribution of agents derived from the policy experiment, and insert it into the benchmark economy. We then compare the default rates with the benchmark results. We find that most of the increase in the default rate in the private market is due to a shift in the distribution of borrowers, and not from a change in the agents' choices.

Higher default rates in the private market may induce a reduction in the private creditor's profits. However, this is not the case: total profits are higher with a more generous student loan program than in the benchmark. Recall (from section 3.2.2) that the present value of the private creditor's profit includes revenues from wage garnishments collected during default and revenues from repayments less the total value of loans. With this policy, revenues from

wage garnishment increase (since default rises) and repayment revenues fall, but by less than the value of loans. Hence, total profits are higher both in aggregate levels and in per borrower terms with this policy.⁴² This implies that the average interest rate charged on loans increases in default risk (since the cost of loans is constant for the creditor). This result relies on the nondischargeability of loans and the fact that agents find it optimal to repay their loans in full by the end of the repayment period. However, this calculation does not take into account other costs of default that are associated with procedures to collect loans from delinquent borrowers, for example. Thus, the private creditor may find it optimal to react to the government policy. In the next section, we endogenize the reaction from the private market and re-evaluate its effects.

To summarize, the main finding from this experiment is that an increase in government borrowing limits leads to more college investment for almost every type of student. The largest increases occur for the poorest students, who have the most financial need, and for students with low credit scores, who face tight borrowing limits and high interest rates in the private credit market. In addition, college investment increases for medium- and high-ability students, suggesting that a more generous government student loan program is influencing the right type of students to invest in more college. However, the policy induces higher default rates in the private market since the the most risky borrowers remain in the private market.

5.2.2 The Reaction by the Private Market

Given the high risk of the pool of participants in the private market as a result of the government policy, the private creditor may react to the larger government student loan program. We assume the menu of interest rates is the same as in the benchmark, however, the thresholds of credit scores required to participate and to borrow the entire amount needed in the private market are increased such that default rates in the private market return to 3.9 percent (as in the benchmark).

Our approach is motivated by the following. Faced with a more generous government program, the private creditor understands that students with relatively high levels of family contributions are able to borrow from the government. Consequently, students who turn to the private market to finance college are those with high financial need, and thus high debt levels, but who are not good prospects after college (i.e., their ability is low). Private creditors perceive a high risk in the market and use credit scores as a signal for default for a particular borrower. They adjust the loan terms based on this signal. Furthermore, in

⁴²We find that the increase in repayment minus loan value accounts for 88% of the change in profits, while the increase in the wage garnishment accounts for the rest.

our framework, the average interest rate charged by the private creditor already captures the default risk, so there is no need to adjust interest rates through the profit condition. However, the cost associated with collecting loans from delinquent borrowers may be too high, and thus the private creditor may want to minimize this cost. This approach seems to be in line with actual practice in private markets: creditors increase the minimum credit score required to borrow when default risk is high. For example, Sallie Mae recently (in 2009) increased the minimum credit score required to obtain a student loan from 640 to 670.

When the reaction of the private market is taken into account, fewer students borrow from the private market compared to the benchmark (19% versus 29%), and at lower levels (see Table 10). As a result of tighter borrowing terms, the reaction of the private credit market causes college investment rates to fall, offsetting the positive impact on college investment induced by the government policy.

Certainly, some of the reduction in college investment rates comes from students with the lowest credit scores who no longer qualify for private loans. However, other groups of students are affected as well. As illustrated in Table 12, students with average credit scores (in the 690-735 FICO range) experience a large drop in four-year college participation rates (by 6 percentage points), and much of this is due to lower borrowing levels from the private market. They are eligible to borrow from private markets (since their credit score is greater than 670), but more of them face restrictions on borrowing limits in this environment. As a result of the adjustment in private credit markets, the poorest students experience the largest drop in college participation rates (by 12 percentage points). In addition, students of low- and medium-ability levels invest in college at much lower rates.

As suspected, having less access to private credit reduces college investment and total student borrowing, especially for low-income students and students with relatively low levels of ability. Consequently, default rates in the government student loan program 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.

Overall, our findings show that poor students invest less in their college education relative to the benchmark where there is no government intervention; at the same time, students with medium-high levels of ability still invest in college at higher rates relative to the case where there is no government intervention. The reaction of private creditors has severe adverse effects on poor students, changing the overall composition of college students. This behavior has important policy implications. If the purpose of the government policy is to help students with financial need, then the goal was not accomplished. On the other hand, if the policy aims to attract medium- and high-ability students to college, the policy is successful, but the impact is not large when the reaction from the private sector is endogenized. Therefore,

Table 12: Variation in initial characteristics: Reaction in the private market

	Enrollment rate	4-year college rate	Participation in govt market	Participation in pr market	Average debt (govt/private)
Family contributions (b_0)					
Low	67 (-2)	49.8 (-11.8)	99 (-0)	57.6 (-18.3)	20,671/10,194
Medium	71.5 (+0)	69.3(-0)	59.4(-0)	0 (-0)	16,665/-
High	83 (+0)	81(-0)	0(-0)	0(-0)	-/-
Ability a					
Low	21 (-3)	24.6 (-7)	48.6 (-0)	28.8 (-7.5)	20,552/10,371
Medium	95 (+0)	82.2 (-3)	67.5 (-0)	18.6 (-7)	18,823/9,458
High	99 (+0)	93.3 (-2.8)	42.9 (-0)	10.2 (-4)	19,049/12,447
Credit score (f_0)					
Low	79 (-1)	57.9 (-2.7)	61.2(-0)	3.3 (-20.4)	15,673/5,263
Medium	72 (-0.5)	66.3 (-6.3)	52.5 (-0.2)	29.4 (-1.4)	19,058/5,498
High	71 (-0.5)	75.9 (-2.3)	45.6 (-0)	24.9 (-0.3)	23,348/17,549

Note: Numbers in parenthesis represent percentage changes from the benchmark.

taking into account the impact of credit scores on college investment and the interaction between the government and the private market seems to be important when implementing changes in the government student loan program.

5.2.3 Reduction in Financial Wealth of U.S. Households

We next consider a 23 percent reduction in financial wealth which translates into a leftward shift in the distribution of family contributions for college. Our experiment assumes a uniform drop in wealth, which is consistent with evidence in Cagetti and DeNardi (2005) and Favilukis (2008).⁴³As evident from Table 10, the recent drop in financial wealth (and thus family contributions for college) does not induce a decline in college investment rates relative to the benchmark economy; in fact, the model delivers a slight increase in enrollment rates and very little change in four-year college participation rates. However, to maintain these levels of college investment, students borrow more from both the government and the private sector (in rates and levels). Consequently, debt burdens and default rates increase, with the largest effects being in the private market.

However, the composition of students going to college changes, as documented in Table 13. Poor students invest less in their college education (both at the extensive and the intensive margin) relative to the benchmark economy, whereas the opposite is true for wealthier

⁴³These studies show that wealth inequality increased steadily since 1983 and this increase is mostly due to the boom markets of the late 80s and late 90s. Also, past recessions did not induce a big change in wealth inequality, implying that reductions in financial wealth were not significantly different across individuals with different levels of wealth.

Table 13: Variation in initial characteristics: Drop in wealth

	College enrollment rate	4-year college participation rate	Participation in govt market	Participation in pr market	Average debt (govt/private)
Family contributions (b_0)					for those who borrow
Low	58.9 (-6.1)	42.9 (-7.2)	99.9(+2.1)	75 (-2.4)	\$13,260/\$19,769
Medium	77.4 (+6.1)	71.1 (+5.7)	71.1(+15.6)	34.8 (+25.2)	\$20,111/\$8,830
High	83.6 (+0.6)	82.8 (+1.8)	10.2(+4.8)	0	\$6,028/0
Ability of the student (a)					
Low	20.5 (+0.5)	31.5 (+3.9)	59.1(+12.1)	45.3 (+7.3)	\$14,861/\$19,173
Medium	97.5 (+2.5)	81.6 (+1.8)	72.6(+6.6)	42.3 (+9.7)	\$16,409/\$14,785
High	100	83.7 (-5.4)	49.2(+9.2)	22.2 (+6.2)	\$14,930/\$13,335
Credit score (f_0)					
Low	79.7 (+1.7)	46.5 (-4.5)	63.9 (+7.2)	27.6 (+2.9)	\$10,158/\$7,015
Medium	71.1 (+1.1)	68.1 (+0.9)	62.1 (+10.8)	42.9 (+9.3)	\$15,969/\$14,859
High	69.3 (-2.7)	82.2 (+3.9)	55.2 (+9.9)	39.3 (+9.6)	\$21,161/\$24,400

Note: Numbers in parenthesis represent percentage changes from the benchmark.

students. Students with low financial needs are eligible to borrow more from the government relative to the benchmark economy (since wealth is lower) and thus take advantage of relatively cheap loans to invest in their college education. Our results show that students with medium levels of family contributions experience the largest increase in borrowing rates. At the same time, more students from poor backgrounds hit the government loan limit and thus are borrowing constrained. Consequently, they invest less in their college education. Their average private loan is higher compared to the benchmark economy. In addition, fewer high-ability students invest in college and more students with low and medium levels of ability invest in college relative to the benchmark economy. Consequently, borrowers have higher debt levels and lower earnings on average, especially in the private market, which explains the higher default rates.

This experiment enforces our results regarding the importance of credit scores in relaxing borrowing constraints for students who invest in their college education: in this economy, differences in four-year college participation rates vary even more across groups of credit scores. Only 46.5 percent of students with low credit scores invest in four years of college, whereas 82.2 percent of students with high credit scores do. In an environment where more students are borrowing constrained because of a decline in financial wealth, the effect of high credit scores on borrowing for college is quantitatively more significant. As before, this effect is important at the intensive margin rather than at the extensive margin.

A final observation is that the same logic of how high credit scores relax government borrowing limits can be applied to analyze investment choices between different types of four-year colleges (as measured by cost and/or quality). We conjecture that in an extension

of the current model where we allow for college heterogeneity (for those who invest in four years of college), credit scores would produce larger quantitative effects. Holding ability and family contributions constant, the government limit would be more severe in the case where the student wants to invest in a more expensive four-year college compared to a less expensive four-year college. Thus, a high credit score will matter even more for the decision to invest in different types of four-year colleges than the decision of how much college to invest in (as in the current framework). And in the context of the current experiment, a drop in financial wealth will divert students away from investing in high-cost colleges towards investing in low-cost colleges instead.

6 Summary

It is now quite common for undergraduate students to borrow for college from private credit markets. Different from the government student loan program, private creditors set the conditions for student loans based on the credit history of the student and the parent. As a result, credit scores may affect the college investment decision. In this paper, we develop a life-cycle model where students finance college through family contributions, government student loans, and private credit markets. Our main finding is that students with better credit scores invest in more college. We are able to confirm the link between credit scores and college investment using data from the Survey of Consumer Finances, which provides support to our analysis.

Our findings indicate that credit scores are especially important in the college investment decision for certain types of students. For example, low-income students with relatively good credit scores benefit from having access to the private market for student loans. This is the group of students for whom the limits on government student loans bind. Similarly, students with average abilities who have relatively high lifetime earnings use the private market to supplement the government student loan program, leading to more college investment. Overall, good credit scores provide another mechanism to help students fund college via the private market for student loans. Finally, we find that credit scores affect the amount of college investment (i.e., the intensive margin), but do not affect the college enrollment decision (i.e., the extensive margin).

The relationship between credit scores and college investment has important policy implications. With a more generous student loan program, we find that college investment increases, with the largest increases coming from students with low family contributions and credit scores. In this case, students use fewer private student loans and more government student loans. However, a riskier pool of people remain in the private market in this case,

leading to higher default rates in the private market. Consequently, as private markets adjust loan terms to minimize default rates, the positive effect on college investment is more than offset, especially for poor students for whom credit scores matter the most for college investment. The reduction in borrowing from the private market is accompanied by reductions in borrowing from the government, leading to less college investment. Finally, the importance of credit scores for college investment is even more significant in the context of the recent drop in financial wealth experienced by U.S. households. The composition of college-going students change such that students from low income families and with relatively high levels of ability invest less in college.

Taking into account the impact of credit scores on college investment and the interaction between the government and the private market seems useful to shed light on current policy changes in the wake of recent economic events. As of March 2010, the indirect student loan component of the Federal Program, in which private creditors were administering government student loans, will no longer be available. This will create a flow of borrowers into the private market. At the same time, private creditors have already started to impose tighter loan terms in the recent financial crisis. The combination of these effects may have important consequences for college investment rates. Our research helps provide insights into these issues.

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