Credit Status and College Investment: Implications for Student Loan Policies*

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Abstract

The private market for student loans has become an important source of college financing in the United States. Unlike government student loans, the terms on student loans in the private market are based on credit status, which summarizes individual default risk. We quantify the effect of credit status and private student loans for college education in a general equilibrium heterogeneous agent life-cycle economy and find that they play an important role for college enrollment. We argue that accounting for this relationship is crucial when analyzing higher education policies, such as higher limits on government student loans and tuition subsidies..

JEL Codes: D53; E21; I22; I28
Keywords: College Investment; Credit Status; Student Loans; Default

1 Introduction

In recent years, more than half of undergraduate students in the United States borrowed to finance their college education; in 2013, outstanding student debt totaled approximately $1.2 trillion (U.S. Federal Reserve Board of Governors, 2014). The majority of these funds were borrowed through the government student loan program, but there is a limit to how much

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students can borrow from the government. As college costs continue to increase over time, many students have turned to private sources to finance college. In fact, borrowing from the private student loan market has become more prevalent in recent years: based on the most recent data available, the outstanding student loan debt in the private market is estimated at $100 billion, representing approximately 10 percent of total student debt.

Eligibility, interest rates and loan limits in the private market for student loans all depend on credit scores.[1] Thus, unlike government student loans, where credit status is not relevant, there is an important role for credit status in the private market. Increased participation in the private market for student loans suggests that individual credit status may affect college investment. In particular, individuals with good credit may not be constrained in their human capital investment by limits on Federal loans, while those with bad credit might be. In this paper, we study the implications of higher education policy when investment in college may require private loans and where access to such loans depends on credit status. In particular, we quantify the effects of government student loan policies and tuition subsidies in a general equilibrium setting that incorporates both the government and private markets for student loans.

We develop a heterogeneous agents life-cycle model where agents differ with respect to an index of ability (or college preparedness), resources (expected family contributions for college), and credit status which summarizes default risk, all of which are observable. In the model, students can invest in college and use expected family contributions, intra-family transfers and student loans to finance their college education. Students borrow from the government student loan program, where eligibility conditions depend on their expected family contributions and college costs. Depending on their financial need, students may face a binding borrowing limit on Federal student loans. These students can turn to the private credit market to finance the rest of their college costs. Private creditors assess individual default risk based on credit status and offer type-contingent credit terms.

We analyze the 2008 increase in borrowing limits that the U.S. government student loan program implemented. Undergraduate students can now borrow $31,000 over the course of their undergraduate education, up from $23,000. Using our model, we find that this policy induces an increase in college investment, and students borrow more from the government and less from the private market. However, an increase in the borrowing limit by the government induces a change in the riskiness of the pool of borrowers, which adversely affects the private market for student loans and results in higher default rates. Consequently, the

[1] Additional details about the private market for student loans can be found in Section 1.1.

lending terms in the private market become less favorable to compensate for greater default risk. In a partial equilibrium analysis where interest rates and taxes are fixed, the model overstates the (positive) welfare impact of the policy. However, when the interaction between the private and the government sectors are accounted for in general equilibrium (by allowing interest rates and taxes to adjust), the welfare gain induced by the government policy is completely negated so that welfare is lower with high government borrowing limits compared to the benchmark economy. Our results show that the interaction between the private and government markets for student loans is key when considering student loan policies.

Our findings emerge from a model that accounts for differences in default costs and earnings across individuals of different credit status, default penalties, and a positive correlation between credit status and family contributions for college. In addition, interest rates differ across credit status in equilibrium. These features deliver an important role for credit status among poor students: college enrollment rates are 22 percentage points higher for poor students with good credit compared to poor students with bad credit, and this is because poor students actively use the private market for student loans to finance their education.

Next, we show that accounting for default in the two markets for student loans is crucial in evaluating other education policies such as tuition subsidies. We compare the effects of increasing government borrowing limits in the government student loan program to a set of budget-neutral tuition subsidies. We find that tuition subsidies lead to more college investment *and* higher aggregate welfare (compared to higher government borrowing limits) because subsidies minimize the adverse effects on private credit markets. Nevertheless, different types of tuition subsidies affect the selection of students into college and consequently their borrowing and default behavior. For example, merit-based subsidies reduce default risk in both markets since they increase college enrollment rates among high-ability students, while need-based subsidies increase default risk in the government student loan program since low-income students are more likely to invest in college and also borrow to finance it. Consequently, the welfare gain induced by merit-based subsidies is larger than the gain induced by need-based subsidies, even though need-based subsidies have a larger impact on college investment. Our results suggest that if the goal of education policy is to improve aggregate welfare, then merit-based tuition subsidies are preferable to both need-based subsidies and higher government borrowing limits, as merit-based subsidies promote college investment without increasing default rates in the student loan market. However, if the goal is to deliver high college enrollment rates, then need-based subsidies are preferable to merit-based subsidies and higher government borrowing limits, but come at the cost of increasing default rates in the government student loan program. Our results demonstrate the importance of considering borrowing and default behavior for student loans in both government and private markets when studying the effectiveness of tuition subsidies.

1.1 Student Loan Market Overview

Federal student loans are administered through the U.S. Federal Student Loan Program (FSLP), and include Stafford, PLUS, and Perkins Loans. Government student loans come in two forms: (1) direct loans issued by the Federal government, and (2) indirect loans which are administered by private credit institutions but are guaranteed by the U.S. government.[2] 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 to our analysis. First, students and their families can borrow from the U.S. government at partially subsidized fixed interest rates.[3] Second, no credit history is required for the majority of government student loans. Third, Federal student loans are need-based and 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 previously borrow up to $23,000 over the course of their undergraduate career using Stafford loans (U.S. Department of Education).[4] Borrowing from the government is quite common, with approximately half of all 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), and thus may turn to the private market to finance college.

Typically, repayment of government student loans begins six months after college graduation, and can last up to 25 years with most borrowers paying their loans in ten years. If students fail to make a payment on their student loan in 270 days, they are considered to be in default. The average national two-year cohort default rate in the FSLP was 7 percent in 2008

[2]In 2010, indirect loans were eliminated and after June 30, 2010 the only type of Federal loans borrowed are direct loans. However, in the current paper we focus on repayments of student loans disbursed in 2007. Also, in our analysis, we focus on Stafford student loans, which represents 80 percent of the FSLP in recent years.

[3]Interest rates on Federal student loans are set in statute (after the Higher Education Reconciliation Act of 2005 was passed). The interest rate for Federal student loans was set to 6.8 percent in 2006 and it remained at this level for unsubsidized loans. The rate further decreased for new undergraduate subsidized loans after July 1, 2008. Before 2006 the rate was variable, ranging from 2.4 to 8.25 percent. For details, see U.S. Department of Education (2014b).

[4]http://studentaid.ed.gov/PORTALSWebApp/students/english/studentloans.jsp#03

(U.S. Department of Education, 2014a). Students cannot typically discharge their FSLP debt upon default, and penalties on defaulters include garnishment of their wages, seizure of federal tax refunds, possible holds 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 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.[5]

The system for obtaining private student loans is much different than that for Federal student loans. First, most private student loans require certain credit criteria. Second, loan limits in private loans are set by the creditor and do not exceed the cost of college less any financial aid the student receives (from all possible sources). Third, interest rates and fees vary significantly by credit status and hence vary across individuals. In contrast to subsidized Federal student loans, interest accumulates on private student loans while students are in college. Private student loans are not guaranteed by the government.

Estimates of how many students borrow from private markets to finance their education vary, as schools are not required to report these numbers. Based on the 2007-08 National Postsecondary Student Aid Study (NPSAS) data, 19 percent of full-time undergraduates borrow from private markets (Steele and Baum, 2009), while Sallie Mae reports that 14 percent borrow from private sources. 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. Default in the private student loan market is rare; the annualized default rate was 3.3 percent in 2008. Private student loans, like Federal student loans, are also not dischargeable in bankruptcy.

Thus, the key difference in borrowing from the private market to finance college (compared to borrowing from the government) is that eligibility and interest rates depend on the credit status of the student in the private market. In addition, default penalties differ across the two markets. Our study incorporates these features and discusses their implications for borrowing and default behavior in each market and sheds light on the importance of these features for college investment.

1.2 Contribution to the Literature

Our paper adds to the rich literature on the determinants of college investment in several ways: (1) we account for the role of credit status for college investment (alongside the roles

[5]http://www.finaid.org/loans/rehabilitation.phtml

played by family income and college preparedness); (2) we model private student loans as a source of financing college (in addition to family income and government student loans); and (3) we allow for default on both government and private loans and argue that this modeling feature is important when studying higher education policies.

First, 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 Vytlacil (2001) and Cunha et al. (2005). Our analysis contributes to this body of work by showing how credit status affects college investment, in addition to differences in family contributions and ability.

In recent years, the focus in the higher education literature has been on the effectiveness of financial aid in promoting college investment, and specifically on student loans. Papers that study the implications of student loan policies within a quantitative macroeconomic framework include Garriga and Keightley (2007), Schiopu (2008), Ionescu (2009), Johnson (2010), Lochner and Monge-Naranjo (2011), Chatterjee and Ionescu (2012), and Abbott et al. (2013). For example, Chatterjee and Ionescu (2012) examine the value of offering insurance against the risk of taking a student loan and failing to graduate from college. Ionescu (2009) and Schiopu (2008) analyze the effects of alternative student loan policies on human capital investment. Garriga and Keightley (2007), Johnson (2010), and Abbott et al. (2013) 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 contributes to this work by accounting for the role of the private market for student loans in the college investment decision when analyzing the implications of student loan policies. We shed light on the implications of the interaction between the government and the private market for student loans for college investment and, in particular, on the importance of accounting for default risk in equilibrium.

To our knowledge, the only papers that incorporate both the private and government student loan markets are Abbott et al. (2013) and Lochner and Monge-Naranjo (2011). The first paper focuses on the partial and general equilibrium effects of education policies and incorporates an experiment where the private market picks up the excess demand for students loans when the government student loan is removed. However, the focus is on wealth-based and merit-based tuition subsidies. The second paper focuses on the student loan market and considers an environment where credit constraints arise endogenously from a limited commitment problem for borrowers. The framework is used to explain the recent increase in the use of private credit to finance college as a market response to the rising returns of a college degree. Our study adds to this body of work inan important way, namely, we capture default behavior in the student loan market in equilibrium and we account for the individual default risk in both markets. Furthermore, we endogenize interest rates in the private market for student loans to account for individual default risk and incorporate a feedback of default behavior into loan conditions. These modeling features allow us to take into account the interaction between the government and the private market, which proves to be important in providing insights for ongoing policy changes in the government student loan program and for tuition subsidies.

Our paper is related to studies that focus on the role of credit worthiness in unsecured credit markets, and in particular Chatterjee, Corbae and Rios-Rull (2011) and Athreya, Tam and Young (2012). 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. Specifically, Chatterjee et al. (2011) provide a theory where lenders learn about the agent's type from an individual's borrowing and repayment behavior, and credit scores are based on the agent's reputation of default. The second paper develops a theory of unsecured credit and credit scoring consistent with the data and shows that improved information held by unsecured creditors regarding individual default probabilities can account for a significant fraction of the changes seen in unsecured credit markets in past years. Consistent with these theories, we model an observable credit status as a proxy for the probability of default. However, given that our paper focuses on a different question, namely on college investment and higher education policies, we simplify the model in the credit score dimension. In particular, we do not model informational asymmetries. In our model, the credit score is a perfect signal of the individual probability of default.

We also add (in a small but important way) to the large literature that analyzes various types of tuition subsides for college investment in a quantitative macroeconomic framework. For example, Caucutt and Kumar (2003) find that merit-based aid that uses any available signal on ability increases educational efficiency with little decrease in welfare. Akyol and Athreya (2005) find that college subsidies improve outcomes (including aggregate welfare) by reducing college failure risk without affecting mean returns. Consistent with our findings, Johnson (2010) finds that more generous subsidies have a larger impact on educational attainment than relaxing borrowing limits. Furthermore, similar to our results, Abbott et al. (2013) find that the general equilibrium effects of higher government borrowing limits dampen the welfare gains exhibited in partial equilibrium. However, in contrast to this literature, we consider the effects of tuition subsidies and higher government borrowing limits in a model where the private market for student loans and default in the student loan markets are explicitly accounted for.

To this end, what makes our paper novel is that we analyze education policies in a framework that incorporates both the private and government market for student loans with individual default risk in both markets. To our knowledge, no other paper has done this, despite the rising importance of the private market for student loans in financing college and the recent concerns about increased default on student loans.

2 Model Description

We consider a life-cycle economy where agents live for T periods. Time is discrete and indexed by $t = 1, ..., T$ where t represents the time after high school graduation. Agents are heterogeneous in family contributions $b \in B$, ability (i.e., college preparedness) $a \in A$, and credit status $f \in F$, which are jointly drawn from the distributions $G(b, a, f)$ on $X = B \times A \times F$. Agents can borrow from both the government student loan program and the private market for student loans to finance their college education, which last $T_1 < T$ years.[6]

2.1 Credit Status

In our model, credit status represents a signal about the person's probability of repayment and there are no informational asymmetries.[7] Credit status represents a perfect signal about the individual default risk. We assume that individuals of different credit status differ in default costs. In particular, we model two types of individuals: those with bad credit $(f = 0)$ and those with good credit, $(f = 1)$. Those with good credit face high costs of default and those with bad credit find default less costly. Our allowance for heterogeneity in default costs follows Chatterjee et al. (2011) and Narajabad (2012). These costs of default capture pecuniary and non-pecuniary costs associated with default (see Athreya, 2008, and Chatterjee et al., 2007). An important observation is that while this previous work focuses on credit card debt, we model credit status and default cost in the context of the student loan market and this fact has two important implications. First, unlike credit card debt, student loans are not

[6] To keep focus on the importance of initial characteristics and on the interactions between different types of student loans, we model one type of college.

[7] While relaxing this assumption would allow for adverse selection which would deliver interesting policy implications for the government student loan program, this is outside the scope of the current paper and is left for future research.

dischargeable in bankruptcy, and thus default in the student loan market simply means a delay in repayment, which comes with several costs. These costs include wage garnishments, attorney fees, withholding of tax refunds, and the stigma associated with default. Second, for student loans the difference between high and low risk types may be attenuated by the fact that, unlike for credit card debt, the recovery rates for delinquent loans are high.

Heterogeneity in borrowers' income processes may also have implications for heterogeneity in borrowing and default decisions (see White, 1998). We capture this heterogeneity as well, and allow labor income to depend on f, among other characteristics (details are provided in Section 2.3). Consequently, even with the same debt level in the student loan market, default is more costly for some borrowers than for others.[8]

2.2 Student Loans

Each year during college, $t = 1, ..., T_1$, young agents can borrow from the government the amount $d_t^g > 0$ that represents college cost net of grants and education credit, $\overline{d}$, less family contributions, b.[9] Students may borrow from the government up to an exogenous borrowing limit $d_{\max}$. Thus, in the government market, students can borrow up to the borrowing limit each year: $d_t^g = min[max\{\bar{d} - b, 0\}, d_{\max}]$ at a fixed interest rate R^g.

The amount students can borrow from private credit markets each year for college cannot exceed the difference between the cost of college, $\overline{d}$, government loans, d_t^g, and family contributions, b.[10] Thus, the annual borrowing limit in the private market for student loans is given by: $d_t^p = \overline{d} - d_t^g - b$. The interest rate charged in the private market depends on the credit status of the agent, so that $R^p(f)$.

Interest on government student loans does not accumulate during college. At the end of college, total debt owed to the government is $D^g = d_{T_1+1}^g = \sum_{t=1}^{T_1} d_t^g$. This is in contrast to the private market for student loans, where interest accumulates during college. Thus, total debt owed to the private creditor in the first period after college is $D^p = d_{T_1+1}^p = \sum_{t=1}^{T_1} d_t^p \left[R^p(f)\right]^t$.

[8] In reality, a bad credit status may also have negative consequences for the cost of receiving secured debt, insurance costs, and rental costs (Chatterjee et al., 2011). However, as argued in Narajabad (2012), with constant relative risk aversion, all pecuniary default costs could be represented by non-pecuniary costs as long as they are proportional to the defaulter's consumption.

[9] Note that $\overline{d}$, which is exogenous in our model, represents the sum of tuition, room, board and other consumption expenditures less any grants or education credits for a year.

[10] To keep focus on the trade-off between private and government student loan markets, we abstract from modeling other sources of financing college, such as credit card loans or loans from family and friends. Our motivation for this assumption is that these sources of funds are not accounted for in the equation that determines how much students can borrow under the student loan program. At the same time, we recognize that these sources of funds might be important, and so we account for a measure of additional funds used for college, in the form of intra-family transfers (Section 2.5.1).

Students start repaying their loans after college (at $t = T_1 + 1$) and the duration of each loan is set to $T_2 - T_1$ periods. Required payments, denoted by $\underline{p}_t^i$ with $i =\in \{g, p\}$, are calculated every period until the loan is paid in full, $t = T_1 + 1, ..., T_2$, where $i = g$ represents government loans and $i = p$ represents loans in the private market. Default occurs if the borrower does not repay, $p_t^i = 0$. Since student loans are not dischargeable in bankruptcy, agents need to reorganize their debt and repay the student loan in the period after default. Agents may choose to default again in either market once their debt is repaid in full. The total debt of an agent at time $t+1$ depends on the outstanding balance of each type of student loan (d_t^i), his repayment ($p_t^i \in \{\underline{p}_t^i, 0\}$), and the interest rate in each market (R^i). Hence, debts evolve according to:

$$d_{t+1}^g = (d_t^g - p_t^g)R^g \text{ and } d_{t+1}^p = (d_t^p - p_t^p)R^p(f). \tag{1}$$

When agents default on a student loan, they experience a utility loss $\mu^i(f) > 0$. When agents make the required minimum payment on either government or private student loans ($p_t^i = \underline{p}_t^i$), there is no utility loss, $\mu^i(f) = 0$.

Depending on the default/repayment behavior in the private market for student loans, credit status evolves according to the following rules. Define f as the credit status in time t and $f^{'}$ as the status at time $t+1$. The agents' repayment choices determine a transition matrix for f and f', namely $F^* : F \times F \to [0,1]$:

$$F^*(f^{'} = 0) = \begin{cases} 1 & \text{if } p^p = 0 \\ 1 - \alpha & \text{if } p^p = \underline{p}^p \text{ and } f = 0 \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

$$F^*(f^{'} = 1) = \begin{cases} 1 & \text{if } p^p = \underline{p}^p \text{ and } f = 1 \\ \alpha & \text{if } p^p = \underline{p}^p \text{ and } f = 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

When the agent defaults ($p^p = 0$), he will have bad credit in the next period ($f' = 0$) regardless of his current credit status. When the borrower pays the amount that it is required ($p^p = \underline{p}^p$), his credit status changes as follows: if he has good credit ($f = 1$), his credit status does not change. If he has bad credit ($f = 0$), he may obtain good credit status with probability α, or remain with bad credit status with probability $1 - \alpha$. This mechanism captures the feedback between repayment behavior in the private market for student loans and credit status.[11] In this framework, default is penalized (by making agents with good credit have bad credit), whereas good repayment behavior is rewarded (by gaining good credit or maintaining good credit). In our model people care about credit status, since agents incur costs from having bad credit. The borrower is excluded from borrowing in the risk-free market upon default, a penalty which captures the immediate impact of bad repayment behavior on participation in other credit markets.[12]

2.3 Labor Income

Agents are endowed with exogenous labor income that differs across education groups and is intended to mimic the returns to college investment for different types of students as well as the risks faced over the life cycle. We disaggregate endowments into three components: an age-specific mean of log income, persistent shocks, and transitory shocks.[13]

An empirically accurate description of the labor income process, and in particular the income risks that college students face, is central to our approach. First, earnings uncertainty is one of the leading causes of default among young households (Sullivan et al., 2000), and heterogeneity in borrowers' income processes has implications for heterogeneity in default decisions (White, 1998). Second, credit status has an important role in an environment with earnings uncertainty. For students who borrow from the private market, interest rates are higher for someone with bad credit compared to someone with good credit (Sallie Mae, 2008). Thus, the cost of a student loan, especially when financed over ten or more years, can be significantly higher for students with bad credit. Earnings uncertainty (and in particular, the persistent component) amplifies the effects that credit status have on college investment, compared to an environment without earnings uncertainty. Both persistent and transitory income shocks are relevant to mimic the repayment and default decisions related to college investment. In addition, we specify an income process that accurately captures the returns to college investment, and in particular, how these returns vary across individuals with different levels of ability.

We specify log income, $\ln y_t^h$, of an agent at time t with ability a, credit status f and human capital $h = \{h_0, h_2, h_4\}$, which represent the three education groups in the model (no college,

[11]It is important to note that parents may co-sign on student loans in the private market, suggesting that the credit scores of the student and their parents may matter for the college investment decision. In our model, we focus on the credit status of the individual rather than on the credit status of the parent. The relationship between the credit status of the parent and the child's investment in college is an interesting topic, which we leave for future research.

[12]This modeling follows Chatterjee et al. (2007), Livshits et al. (2007), and Athreya et al. (2012), and assumes that an individual with (observable) bad credit is exogenously excluded from borrowing.

[13]A standard specification of this process is in Storesletten et al. (2001).

some college but no bachelor's degree, and four-year college graduates, respectively). The age specific mean depends on education, ability, and credit status, while the persistent and transitory shocks depend only on education. The income process evolves according to:

$$\ln y_t^h = \lambda_a^h \lambda_f^h \ln \mu_t^h + z_t^h + \varepsilon_t^h \tag{4}$$

where λ_a^h and λ_f^h represent fixed effects for ability and credit status on the age-education specific mean μ_t^h. The terms z_t^h and ε_t^h represent the persistent and the transitory shocks to earnings, respectively, where $z_t^h = \rho z_{t-1}^h + \nu_t$, and $\varepsilon_t^h \sim i.i.d.N(0, \sigma_{\varepsilon,h}^2)$ and $\nu_t^h \sim i.i.d.N(0, \sigma_{\nu,h}^2)$ are independent innovation processes.

Agents begin life as unskilled households and receive their initial realization of the persistent shock, z_1^h, from a distribution with a different variance than at all other ages. That is $z_1^h = \xi^h$ where $\ln \xi^h \sim N(0, \sigma_\xi^2)$. This modeling of the income process reflects heterogeneity prior to any direct exposure to labor market risk, i.e., households first draw a realization of the persistent shock z_1^h from the random variable ξ^h with distribution $N(0, \sigma_\xi^2)$. In subsequent periods, the agent's labor income is determined as the sum of the unconditional mean of log income scaled by ability, credit status, and innovations to the persistent and transitory shocks. These shocks depend on human capital to reflect the fact that the risk characteristics of labor earnings appear to differ systematically by education (e.g., Abbott et al., 2013; Hubbard et al., 1994; Storesletten et al., 2001).

2.4 Means-Tested Transfers and Retirement Income

In addition to labor income, agents receive means-tested transfers from the government, τ_t, which depend on age t, income y_t, and net assets s_t. These transfers provide a floor on consumption. Following Hubbard et al. (1994), we specify these transfers as

$$\tau_t(y_t, s_t) = \max\{0, \underline{\tau} - (\max(0, s_t) + y_t)\}. \tag{5}$$

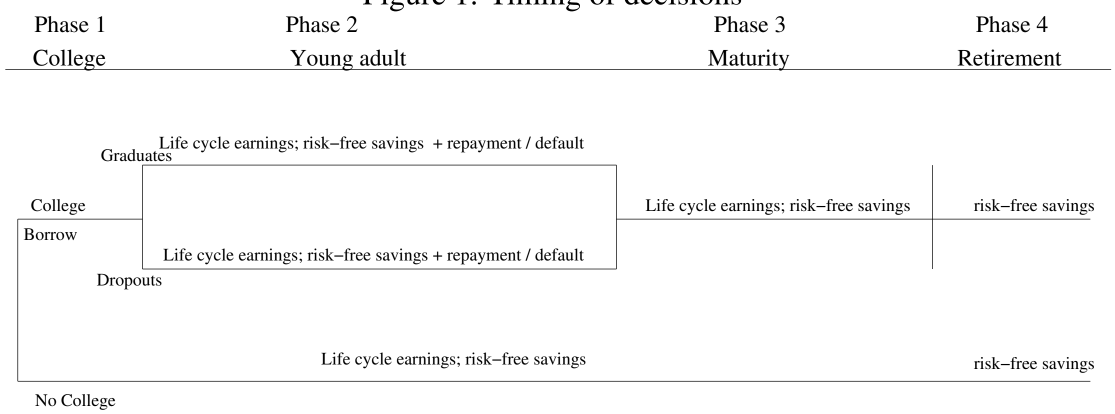
Total pre-transfer resources are given by $\max(0, s_t) + y_t$ and the means-testing restriction is represented by the term $\underline{\tau} - \max((0, s_t) + y_t)$. These resources are deducted to provide a minimal level of income, $\underline{\tau}$. For example, if $s_t + y_t > \underline{\tau}$ and $s_t > 0$, then the agent receives no transfer. By contrast, if $s_t + y_t < \underline{\tau}$ and $s_t > 0$, the agent receives the difference, in which he has $\underline{\tau}$ units of the consumption good at the beginning of the period. Agents do not receive transfers to cover debts, which requires the term $\max(0, s_t)$. Lastly, transfers are required to be nonnegative. After period $t = T_3$ when agents start retirement, agents get a constant fraction of their income in the last period as working adults, ϕy_{T_3}, where $\phi > 0$. They do not receive the means-tested transfers during retirement.

2.5 Household decisions

2.5.1 Overview

Recall that agents are heterogeneous in three dimensions: family contributions (b), ability (a), and credit status (f). Each agent's life is characterized by four phases: college, young adult, maturity, and retirement. Figure 1 illustrates the timing of decisions for a typical agent in the model.

Figure 1: Timing of decisions



In the first period, agents make a one-time decision of enrolling in college or going directly to work as non-college workers, hence $h = h_0$. If they decide to enroll in college, agents finance their consumption and college investment when young by the use of family contributions for college, b, intra-family transfers $Q(b)$, and the use of student loans from the government and the private market. At the end of the college phase, students may complete college and receive a bachelor's degree with probability $\pi(a)$; in this case, $h = h_4$. With probability $1 - \pi(a)$, students fail to receive a bachelor's degree, so that $h = h_2$.[14] We explicitly consider dropouts of four-year colleges since they represent a significant portion of college students (Gladieux and Perna, 2005).[15]

[14] We focus on traditional students in the United States, i.e., students who enroll in college full-time without a delay after high school graduation, and we model college risk at the end of the college years. Our modeling is motivated by empirical evidence that documents that the average completion time is 4.13 years and the average enrollment time for dropouts in college is 3.5 years (see Bound et al., 2009 and Ionescu, 2011). In our environment, the college investment decision is purely a financial decision.

[15] We model college drop-out as a risk of failing to acquire a four-year college degree. In addition, students who do not complete four years of college may simply choose to leave college (see Arcidiacono, 2004; Manski and Wise, 1983; Stange, 2012; and Stinebrickner and Stinebrickner, 2012). As shown in Chatterjee and Ionescu (2012), failing to graduate is quantitatively more important as a reason to drop out than voluntarily leaving college.

Agents in the second phase of their life are working adults who use their labor earnings to consume, pay off their student loans (both public and private), save or borrow in a risk-free market, and pay a lump sum tax which finances the government student loan program. Then, in the third phase (maturity), agents use their labor income to consume, save or borrow, and pay taxes. In the last phase of life, retired agents receive retirement income and earn interest on their savings. We assume that old agents die with certainty at the end of this period. Young agents who do not invest in college start their life cycle as working adults and then retire in the last phase of life.

Lifetime utility consists of the discounted stream of consumption, and is discounted at the rate $\beta \in (0,1)$. The agent's problem is to maximize utility subject to budget constraints (described below).

2.5.2 Dynamic Programming Formulation

We describe the problem in a dynamic programming framework and solve recursively for choices in the model. In any period t, variable x_t is denoted by x and its period $t+1$ value by x'. The value function is defined as $V_j^K(t)$, where $t = T_j$ represents the terminal node of each phase $j = \{1,2,3,4\}$ and $K = \{C,N\}$ represents the college (C) and no-college (N) paths.[16] For the terminal node (the last period of phase 4 when $t = T_4 = T$), we assume that the value function is defined as: $V_4^K(s,T) = u(\phi y_{T_3} + Rs)$ where s represents the stock of savings, R is the risk-free interest rate, and ϕy_{T_3} represents retirement transfers.

College

For individuals who enroll in college, the value functions for the four phases of the life cycle are given below. For the retirement phase ($j = 4$) when $t < T_4$, the agent faces a simple consumption-savings problem, with the value function $V_4^C(s,t) = \max_{s'} u(\phi y_{T_3} + sR - s') + \beta V_4^C(s', t+1)$,where ϕ represents retirement transfers as a fraction of last year's earnings (y_{T_3}). For the maturity phase ($j = 3$), the value function V_3^C is denoted as:

$$\begin{aligned} V_3^C(h,a,f,s,z,\varepsilon,t) &= \max_{s'} u(y(h,a,f,z,\varepsilon) + \tau(y,s) - \Theta + sR - s') \\ &\quad + \beta E_{z',\varepsilon',f'} V_3^C(h,a,f,s',z',\varepsilon',t+1) \end{aligned}$$

with the state space $(h,a,f,s,z,\varepsilon,t)$, representing education, ability, credit status, savings, and income shocks (z,ε), respectively. Credit status does not change during this phase ($f = f'$). During the maturity phase, agents earn labor income $y(h,a,f,z,\varepsilon)$ and the means-tested

[16] T_1 and T_3 also differ across education groups, as we explain below. For ease of exposition, however, we suppress this notation.

transfer $\tau(y,s)$, save or borrow $s^{'}$, pay a lump sum tax Θ, and earn (pay) the risk-free rate on their previous period's savings (borrowings) R. Note that $V_3^C(h,a,f,s,z,\varepsilon,T_3+1) = V_4^C(s,1)$ for any given h,a,f,z,ε.[17]For the young adult ($j=2$), the value function is given by:

$$\begin{aligned} V_2^C(h,a,f,s,d^p,d^g,z,\varepsilon,t) &= \max_{p^g,p^p,s'} u(y(h,a,f,z,\varepsilon)+\tau(y,s)-\Theta+sR-s'-p^g-p^p)- \\ &\quad (\Lambda^g\mu^g(f)+\Lambda^p\mu^p(f))+\beta E_{z',\varepsilon',f'}V_2^C(h,a,f',s',d^{p'},d^{g'},z',\varepsilon',t+1) \end{aligned}$$

with the evolution of debt, $d^{i'}$, as given by equation 1, and the evolution of credit status, f', by equations 2 and 3. As young adults, agents consume, save/borrow s', earn labor income $y(h,a,f,z,\varepsilon)$, receive the transfer $\tau(y,s)$, pay a lump sum tax Θ, earn/pay the risk-free rate on savings/borrowings R, and pay down their student loans, p^i, for $i \in g,p$. Denote $\Lambda^i \in \{0,1\}$ an indicator function for default for loans of type $i \in \{g,p\}$. When agents default on their student loans ($\Lambda^i = 1$), they face a utility loss $\mu^i(f)$. Agents with bad credit are penalized in the credit market, such that $s^{'} \geq 0$.[18]

Recall that in the first year after college $t = T_1+1$, the amount owed to the government at the beginning of this period is given by $d^g_{T_1+1}$ and $d^p_{T_1+1}$, defined above. For period $t = T_1+1,...,T_2$, debt accumulates according to equation 1 above. We require that in period $t = T_2$, agents must pay off all of their student loans during the young adult phase; this requires $p^i_{T_2} = d^i_{T_2}$ for $i = g,p$.

Finally, for the college phase (phase 1 of their life), agents may complete a bachelor's degree with probability $\pi(a)$, which varies by ability. Thus, the value function for the last period in college ($t = T_1$) is given by:

$$\begin{aligned} V_1^C(a,b,f,T_1) &= \max_{d^p,d^g} u\left(b-\bar{d}+d^p(b,f,h)+d^g(b,h)+Q(b)\right)+ \\ &\quad \beta[\pi(a)E_{(z',\varepsilon',f'}V_2^C(h_4,a,f',s',d^{p'},d^{g'},z^{'},\varepsilon^{'},T_1+1)+ \\ &\quad (1-\pi(a))E_{z',\varepsilon',f'}V_2^C(h_2,a,f',s',d^{p'},d^{g'},z^{'},\varepsilon^{'},T_1+1)] \end{aligned}$$

and for any other period in college is:

$$V_1^C(a,b,f,t) = \max_{d^p,d^g} u\left(b-\bar{d}+d^p(b,f)+d^g(b)+Q(b)\right)+\beta V_1^C(a,b,f,t+1)$$

with $V^C(a,b,f,1)$ the value function associated with the college path. The parameter $\bar{d}$ represents the direct cost of college (tuition and fees) per year. During college, agents use

[17]The same methodology is used when defining the other phases of the life cycle.

[18]Note that this constraint is not included in the value function above for ease of exposition. In addition, we assume that this penalty does not extend beyond phase 2 to be consistent with the fact that, in reality, penalties associated with default are not long-lasting (see Musto and Souleles, 2006).

annual family contributions b and intra-family transfers $Q(b)$ to finance college.[19] They may also borrow from the government d_t^g and from the private sector d_t^p during each period in the college phase, $t = 1,2,3,4$. Note that agents do not save or borrow from the risk-free market during college and do not pay the lump sum tax or receive government transfers.

Agents will start their repayment/working phase of the life cycle in $T_1 + 1$ and thus will forgo four years of labor income. We assume that students attend college full-time (if they attend college at all).[20]

No college

Agents who do not go to college (so that $h = h_0$) earn labor income $y(h_0, a, f, z, \varepsilon)$ and solve a consumption-savings problem for the first three phases of their lives. For agents who do not invest in college, we assume that they may allocate family contributions (b) to consumption or savings in the first period. Agents start life in the working phase and remain there until period T_3, after which they retire. There are no student loans and thus no repayment or default behavior. As a result, there is no change in credit status during the young adult phase, and thus the credit status in this value function is the one drawn at the beginning of the cycle. Similar to the college path, agents incur some adverse effects from having bad credit in that they cannot borrow in the risk-free market during phase 2. Agents receive a means-tested transfer $\tau(y,s)$ and face a lump sum tax Θ during their working periods of life. In phase 4, agents retire, receive a fixed retirement income ϕy_{T_3} and consume their savings.

The value functions in the retirement and maturityphases are:

$$\begin{aligned} V_4^N(s,t) &= \max_{s'} u(\phi y_{T_3} + sR - s') + \beta V_4^N(s', t+1), \text{ and} \\ V_3^N(h_0, a, f, s, z, \varepsilon, t) &= \max_{s'} u(y(h_0, a, f, z, \varepsilon) + \tau(y,s) - \Theta + sR - s') + \beta E_{z', \varepsilon', f'} V_3^N(h_0, a, s', z', \varepsilon', t+1), \end{aligned}$$

respectively, and for the young adult, the value function is given by:

$$V_2^N(h_0, a, f, s, z, \varepsilon, t) = \max_{s'} u(y(h_0, a, f, z, \varepsilon) + \tau(y,s) - \Theta + sR - s') + \beta E_{z', \varepsilon', f'} V_2^N(h_0, a, f', s', z', \varepsilon', t+1)$$

In the first phase of life (which lasts only one period), the agent who does not go to college has the value function:

[19] This feature is in accordance with empirical evidence in Johnson (2010) and Kaplan (2012) who show that there is risk-sharing for young adults within a range of networks including families, friends, firms, and unions. We estimate these parameters within the model, as described in the next section.

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

$$V_1^N(a,b,f,z,\varepsilon,1) = \max_{s'} u(b+y(h_0,a,f,z,\varepsilon)-s') + \beta E_{z',\varepsilon',f'} V_2^N(h_0,a,f',s',z',\varepsilon',1)$$

Agents choose between the college and no-college paths and hence solve:

$$\max\{V^C(a,b,f,1), V^N(a,b,f,1)\}. \tag{6}$$

where $V^N(a,b,f,1) = E_{z,\varepsilon} V_1^N(a,b,f,z,\varepsilon,1)$.

2.6 Private creditors

The private market for student loans is assumed to be competitive: the representative private creditor takes prices as given and the private creditor can borrow and lend in the risk-free capital market at interest rate R. Also, as standard in the literature, the lending rate in the private market for student loans covers the transaction cost of intermediation, q, which captures the per-unit cost of servicing accounts (see Athreya, Tam, and Young, 2012, and Li and Sarte, 2006).

Pricing of private student loans in the model arises from the condition that private student loan lenders earn zero profits on any contract type. The private creditor uses the credit status of borrowers to assess their probability of default and supplies loans for all (D^p, f)-type contracts in order to maximize the present discounted value of profits, where f is the initial credit status and D^p represents the accumulated debt at the rate R^p during college, given by:

$$D^p(d_1^p, ..., d_{T_1}^p, R^p) = \sum_{t=1}^{T_1} R^{p(T_1-1)} d_t^p. \tag{7}$$

The lender has perfect information about the agent's probability of default and so loan contracts are perfectly priced. Our problem is consistent with theories of default, as standardized by Chatterjee et al. (2007). In contrast to their paper, only individuals who go to college have access to this market. The private creditor solves his optimization problem at the beginning of the model when borrowing in the private market takes place. In other words, the expected present value of cash-flows is zero, discounting at the risk-free rate.

Let $\Phi_p(D^p, f)$ be the set of all agents of type f who decide to go to college and take out private loans of size D^p for the entire college period, such that:

$$\Phi_p(D^p, f) = \{k \in B \times A \times F \mid V^C(k) \geq V^N(k), D^p(k) = D^p \text{ and } f(k) = f\}.$$

Recall that loan repayments start in the first period after college, $t = T_1 + 1$. The expected present value of profits for each (D^p, f)-type contract is given by:

$$\textstyle\sum_{k \in \Phi_p(d^p, f)} \left\{ \sum_{t=T_1+1}^{T_2} \frac{1}{R^{t-1}} (1-\omega^p(d_1^p, ..., d_{T_1}^p, f, t)) \left[\underline{p_t^p}(d_1^p, ..., d_{T_1}^p, f, R^p) \right] \right\} - (1+q) \sum_{t=1}^{T_1} \frac{d_t^p}{R^{t-1}}. \tag{8}$$

Profits for each type of contract (D^p, f) depend on the expected present value of repayment on student loans less total debt owed to the private creditor. The first term of equation (8) represents the expected present value of total payments made by all agents of type f who borrowed D^p from the private marketfor the entire college period and who do not default on their loans in period t during the repayment phase. Recall that the payment each period after college is given by $p_t^p((d^p, f, R^p) \in \{\underline{p_t^p}((d^p, f, R^p), 0\}$ where $\underline{p_t^p}((d^p, f, R^p)$ represents the fixed payment due each period, which in turn depends on the size of the loan, d^p, the interest rate, R^p (which in turn depends on the credit status f), and the duration of the loan, T_2. There is no payment during the period of default; that is, if default occurs in period t, $p_t^p(k) = 0$. The term $\omega^p(d^p, f, t)$ in Equation 8 represents the probability that an agent of type f with the size of the loan d^p defaults on his loans at time t.[21] Also recall that defaulters enter repayment in the period after default occurs. Therefore, the private creditor 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). The second term of the equation represents the present value of total debt owed to the private creditor in period $T_1 + 1$ and the transaction cost faced by the private creditor, qd^p.

To solve for $R^p(d^p, f)$, we first note that we know how large the payments need to be for the lender to break even and so a simple application of the annuity formula delivers that:

$$D^p(d_1^p, ..., d_{T_1}^p, R^p) = p^p(d_1^p, ..., d_{T_1}^p, f, R^p)(\frac{1 - R^{p(-T_2 - T_1)}}{R^p - 1}). \tag{9}$$

Then, to get from the zero profit condition to the contract-specific interest rate we use Equation 9 and replace D^p determined by Equation 7 and $p^p(\cdot)$ from the zero profit condition. This results in an equation that can be solved for the interest rate R^p and the solution delivers that the interest rate on private student loans depends on the credit status (f) and the size of the loan (d^p). Specifically, optimization implies $R^p(d^p, f) \leq (R + q)(1 - \omega^p(d^p, f))$ with q the transaction cost per unit of loan and $\omega^p(d^p, f)$ the probability that an individual with credit status f defaults on the private student loan of size d^p. This modeling feature captures the fact that different borrowers have different likelihoods of default and the private lender prices the loans accordingly.

[21] This probability of default also depends on the realized shocks to earnings in period t. For ease of exposition, however, we suppress this notation.

2.7 Government

Our policy analysis takes into account the limited size of the government budget. In this economy, the government finances the student loan program through a lump sum tax. We assume that there are two lump sum taxes: one to finance the student loan program (Θ_1) and one to finance the means-tested transfers and retirement benefits (Θ_2). Thus, $\Theta = \Theta_1 + \Theta_2$.

Related to the student loan program, government expenditures consist of the present value of government student loans and the subsidization of interest rates on government student loans during college. The government borrows in the risk-free capital market at the interest rate R. The interest rate on government student loans (set to the data) is greater than the risk-free interest rate. The revenue from the repayment of government student loans is used to cover the costs associated with subsidizing interest during college.

As in practice, the government does not collect any repayment from defaulters during the period when default occurs. Loan collections may not suffice to cover the interest rate subsidization during college. To balance the budget, the government collects taxes to finance the remaining cost. Lump sum taxes are paid by all consumers in the economy during each period in the working phases (phases 2 and 3 in the model).

As before, let $\Phi_g(d^g) \subseteq X$ be the set of all agents who decide to go to college and take out government student loans of size d^g each period during college: $\Phi_g(d^g) = \{k \in A \times B \times F \mid V^C(k) \geq V^N(k)$ and $d^g(k) = d^g\}$. The government budget constraint is given by

$$\sum_{k \in \Phi_g(d^g)} \left(\sum_{t=1}^{T_1} \frac{1}{R^t} d^g \right) = \sum_{k \in \Phi_g(d^g)} \left[(1-\omega^g) \sum_{t=T_1+1}^{T_2} \frac{1}{R^{t-1}} \underline{p^g} \right] + \sum_{k \in X} \left[\sum_{t=T_1+1}^{T_3} \frac{1}{R^{t-1}} \Theta_1 \right]. \quad (10)$$

Equation 10 represents a lifetime government budget constraint. The term in the left hand side represents the present value of loans. The right hand side consists of the present value of revenues, which includes loan payments from individuals who took out government loans and do not default on their loans, and lump sum taxes, Θ_1, collected each period during the working phase from all agents in the economy. Recall that loan repayment starts at period $t = T_1 + 1$ and there is no interest accumulated on government student loans during college. As in the case of private loans, the per period payment is given by $p_t^g(k) = \{\underline{p^g}(d^g), 0\}$ where $\underline{p^g}(d^g)$ represents the fixed payment due each period, which depends on the size of the loan d^g, the duration of the loan, T_2, and the fixed interest rate, R^g. Also, in the case where default occurs in period t, $p_t^g = 0$. The term ω^g in Equation 10 represents the probability of default.Separate from the student loan market, the government collects lump sum taxes

Θ_2 and pays means-tested transfers to all agents during their working phases of life, and issues retirement benefits ϕy_{T_3} during the retirement phase. We assume that the revenues and expenses associated with these government programs must also balance in equilibrium.[22]

2.8 Equilibrium

Our general equilibrium analysis is consistent between individual decisions and decisions made by the government and financial intermediaries in the private market for student loans, such that interest rates in the private market arise from zero-profit conditions in equilibrium and taxes are set so that the government budget constraint balances.[23] This formulation captures the interaction between the private and the government market for student loans alongside the pricing of default risk in equilibrium, both of which are essential for our analysis.

Definition 1. An equilibrium in this economy is a collection of: i) individual choices: education level h, consumption c, savings s'; default and debt payments in the public and private market of student loans, $\{\omega^g, \omega^p, p^g, p^p, d^g, d^p\}$; and credit status f; ii) interest rates $\{R, R^g,$ and $R^p(f)\}$; iii) earnings $y(h,a,z,\varepsilon)$, intra-family transfers $Q(b)$ and the probability of completing four years of college $\pi(a)$, iv) utility losses $\{\mu^g(f), \mu^p(f)\}$, and v) policy parameters $\{\underline{\tau}, d_{\max,} \phi, \Theta_1, \Theta_2\}$ such that:

1. Agents solve their dynamic programming problem (outlined in Section 2.5.2).
2. The government budget constraints hold (equations 10 and **??**).
3. The profits of the private creditors for each (d^p, f)-type contract are zero (equation 8).

The first step of the algorithm supposes that on the college path, the agent $x \in X = B \times A \times F$ maximizes utility by choosing $\{h, c, s', p^g, p^p, d^g, d^p, f\}$, taking interest rates and earnings $\{R, R^g, R^p(f), y(h,a,f,z,\varepsilon)\}$, utility losses $\{\mu^g(f), \mu^p(f)\}$, probability of completing four years of college $\pi(a)$, and policy parameters $\{\underline{\tau}, d_{\max}, \Theta_1, \Theta_2\}$ as given. The set $\{V_4^C(s,t), V_3^C(h,a,s,z,\varepsilon,t), V_2^C(h,a,f,s,d^p,d^g,z,\varepsilon,t), V_1^C(a,b,f,t)\}$ contains the associated value functions. On the no-college path, the agent $x \in X$ maximizes utility by

[22] The budget constraint associated with these programs is given by $\sum_{k\in X}\left[\sum_{t=T_3}^{T_4-1} \frac{1}{R_t}\phi y_{T_3}(k)\right] + \sum_{k\in X}\left[\sum_{t=T_1}^{T_3-1} \frac{1}{R_t}\tau(k)\right] = \sum_{k\in X}\left[\sum_{t=T_1}^{T_3-1} \frac{1}{R^t}\Theta_2\right]$.

[23] Endogenizing labor markets is not crucial for the analysis and will increase the computation intensity given the high dimension of the state space and the number of periods in the repayment phase. Thus, we abstract from delivering wages from a labor market condition in equilibrium.

choosing $\{c, s'\}$ and taking the risk-free interest rate and earnings $\{R, y(h,a,f,z,\varepsilon)\}$ as given. The set $\{V_4^N(s,t), V_3^N(h,a,s,z,\varepsilon,t), V_2^N(h,a,s,z,\varepsilon,t), V_1^N(a,b,f,1)\}$ contains the associated value functions. Lastly, the agent optimally chooses between the college and no-college paths (equation 6). Our model delivers in equilibrium that individuals with bad credit are charged higher interest rates in the private student loan market than individuals with good credit for any size of loan, consistent with evidence for default pricing in the credit card market provided in Musto and Souleles (2006).

3 Calibration

Each model period represents one year, and agents live for 58 years ($T = 58$), which corresponds to 18-76 years of age. On the college path, the first phase (college) lasts four years ($T_1 = 4$). The young adult/repayment phase lasts 10 years ($T_2 = 14$), the maturity phase lasts 24 years ($T_3 = 38$), and the retirement phase lasts 20 years ($T_4 = 58$). On the no-college path, the young adult and maturity stages last 38 years and retirement lasts 20 years. The model parameters capture the behavior of high school graduates who enroll in college in 2003; thus, the model economy is calibrated to 2003. All values are given in 2003 dollars.

There are four sets of parameters that we calibrate: 1) standard parameters, such as the discount factor, the coefficient of risk aversion, and the risk-free interest rate; 2) parameters for the initial distribution of individual characteristics: family contributions for college, credit status and ability; 3) parameters specific to education and student loans such as, college costs, tuition, borrowing limits, default consequences, and interest rates on student loans; 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.

There are several sources of data that we use to calibrate the economy. For earnings profiles, we use the Current Population Survey (CPS) 1968-2002 and National Education Longitudinal Study (NELS:1988). We use the Beginning Postsecondary Student Longitudinal Survey (BPS) 2009 for college completion rates and the NELS:1988 for enrollment rates to test the predictions of the model across different groups of individual characteristics.[24]

[24] More recent data for enrollment rates across expected family contributions and SAT groups are not available. For our purpose, the use of this enrollment dataset is suitable: enrollment behavior for full-time recent high school graduates has not changed significantly between 1992 and 2003. According to NPSAS data, the enrollment rate for recent high school graduates in 2003 is 67 percent; our sample delivers an enrollment rate of 65.6 percent.

We assume constant relative risk aversion in the utility function such that $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ with $\sigma = 2$. We set the risk-free rate (R) at 4 percent. 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 earnings dynamics. Lastly, we explain the estimation strategy for the remaining nine parameters and discuss the fit of the model when matching the targets in the data.

Table 1: Exogenous parameters

Parameter	**Name**	**Value**
$\{T, T_1, T_2, T_3, T_4\}$	Model periods and phase lengths	{58, 4, 14, 38, 58}
σ	Risk aversion	2
R	Risk-free interest rate	4%
μ_a	Mean ability (SAT scores)	1016
σ_a	St dev of ability (SAT scores)	226
μ_f	Percent with good credit scores	0.75
ρ_{bf}	Correlation between income and credit scores	0.30
ρ_{ba}	Correlation between income and ability	0.35
ρ_{af}	Correlation between ability and credit scores	0
$\pi(a)$	Probability of completing college by ability	{0.60, 0.72, 0.845}
$\overline{d}$	Net price for one year of college	$52,140/4
$d_{\max}$	Borrowing limit in government student loans (for four years of college)	$23,000
R^g	Interest rates in the government student loan program	6.8%
q	Transaction cost in the private student loan market	0.05
α	Percent chance that bad credit improves to good credit	0.10

3.1 Initial Distribution of Characteristics

For family contributions for college, we consider a uniform grid, $B = [0, ..., \$28,500]$. For initial credit status, we consider two types: bad and good credit. We measure ability level by SAT scores and consider three groups of SAT scores: $A = \{< 900, 900-1100, 1101-1600\}$ on the 1600-point test.

We estimate a joint distribution of family contributions (b), credit status (f), and ability (a) accounting for correlations between all three characteristics. These characteristics are drawn from a distribution with moments $(\mu_b, \sigma_b, \mu_a, \sigma_a, \mu_f, \rho_{ba}, \rho_{bf}, \rho_{af})$ where μ_i is the mean, σ_i represents the standard deviation for $i = b, a$, μ_f is the probability of having good credit status, and ρ_{ij} the correlation coefficients of b, f, and a. While expected family contributions (EFC) are a good predictor for actual family contributions for college, differences may arise between the two.[25] Rather than using an exogenous distribution for expected fam-

[25]The U.S. Department of Education calculates EFC for students using a need analysis methodology which

ily contributions, we estimate moments of the distribution for family contributions (μ_b, σ_b) to match participation rates in the government and private student loan markets (45 percent and 17.5 percent, respectively). We assume a normal distribution and obtain $\mu_b = \$17,700$ and $\sigma_b = \$6,900$, as explained in Section 3.4.

In our model, ability represents college preparedness, which embodies both innate ability and acquired ability. Thus, we directly consider a measure of ability that reflects college preparedness: for the distribution of ability, $A(a)$, we assume a normal distribution and use the national distribution of SAT scores to set $\mu_a = 1016$ and $\sigma_a = 226$ (College Board, 2007). Our calibration procedure considers all high school graduates who intend to go to college and take the SAT. This allows us to better capture the effects of government and private student loan policies on college investment decisions. At the same time, our procedure recognizes that college preparedness matters for college investment.[26]

To estimate the distribution of credit status $F(f)$, we use the Survey of Consumer Finances (SCF) and the FRBNY Consumer Credit Panel (Equifax) data. In the SCF data, we define individuals with bad credit as 18 to 28 year old respondents who report that they were turned down for credit or did not get as much credit as they applied for based on their credit history (or lack thereof). The 2001 and 2007 SCF data indicate that 75 of young adults have good credit, while 25 percent have bad credit. Thus $\mu_f = 0.75$. This distribution is consistent with the one for the Equifax Risk Score in the 2001 Equifax data, where young individuals with bad credit are subprime borrowers who have an Equifax Risk Score below 560, while those with good credit have an Equifax Risk Score above 560.[27] Our model assumes a positive correlation between all three initial characteristics (b, f, a). Based on Equifax and Census block data, the correlation between credit scores (identified as the Equifax Risk Scores) and income is $\rho_{bf} = 0.3$. In addition, data suggest a strong positive correlation between SAT scores and parental income (College Board, 2009). We therefore assume $\rho_{ba} = 0.45$, which is in the middle of the estimates (Ionescu, 2011). We assume $\rho_{af} = 0$ because there is no data that links ability to credit status.

takes into account dependency status, income, assets, number of siblings in college, and other related factors. The formula is designed to compare the ability-to-pay across families to promote the equitable distribution of available aid.

[26]While other measures of ability such as Armed Forces Qualification Test (AFQT) scores may be used, SAT scores represent a more appropriate measure since we focus on students who intend to go to college.

[27]Credit scores of young individuals are primarily based on the number of accounts and differences in scores for this group are significant, even after controlling for other demographics (Avery, Brevoort, and Canner, 2009). According to the Equifax data young individuals mostly engage in transactions for credit card (60 percent) and auto loans (15 percent). The fractions of individuals with bad and good credit do not change over time in SCF and Equifax data. A full description of Equifax data can be found at www.newyorkfed.org/microeconomics/ccp.html.

3.2 College and Student Loan Parameters

We use 2003 college enrollment data from the BPS to set the probabilities of completing four years of college across ability groups. We consider only students who enroll without delay in a four-year college following high school graduation. Because we do not have part-time enrollment in the model, we consider students who enroll full-time in college. The survey records the fraction of students (by ability) who, six years later, report having earned a bachelor's degree. We use these as proxies for the probability of completing college $\pi(a)$. We obtain college completion rates of $\{0.60, 0.72, 0.845\}$ across the three levels of ability.

To set 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 (2007). The cost is calibrated to academic years 2003-2004 through 2007-2008. The net price of college for these years was \$33,849 for public universities and \$78,570 for private universities. Since college is modeled as a consumption good, 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 were \$98,584 and \$20,925, respectively, using the same College Board data.

To match the actual costs of attending four years of college, we use BPS data on drop-out and completion rates for the cohort of students starting college in 2003-2004 for students who obtained their bachelor degree by 2009. Approximately 55.6 percent of students completed a four-year degree (59.1 percent of these students attended a public institution and 40.9 percent a private institution). Using these weights, the average net price for four years of college is \$52,140. The average direct cost (tuition and fees) using the same weights is \$52,687.

The limits on (Stafford) government student loans for dependent undergraduates is \$23,000 for up to five years of post-secondary education. Dependent students who enroll in college are eligible for \$2,625 in the first year, \$3,500 in the second year of college, and \$5,500 in additional years. Limits in the private market for student loans are set by the creditor and do not exceed the cost of college less any financial aid the student receives, including government student loans. Interest rates in the government student loan program are fixed at 6.8 percent, which is consistent with the 2004-2008 period. Recall that interest rates in the private market are derived in equilibrium such that the creditor earns zero profits across levels of credit status and debt. We consider three levels of debt in the private market for each credit status. The three loan sizes are: below \$5,700, between \$5,700 and \$10,700, and above \$10,700. We assume that the transaction cost in the private student loan market is the same as in the credit card market, and set $q = 0.05$ as in Li and Sarte (2006), close to the cost of servicing credit card accounts of 5.3 percent found in Evans and Schmalensee (1999).

We calibrate the default punishments to match the default behavior in the data, as explained in Section 3.4. In addition, when default occurs in the private market, credit status is penalized: individuals with good credit then have bad credit. In the case of no default, we assume that there is a 10 percent chance that bad credit improves to good credit ($\alpha = 0.1$). This is consistent with estimates in Livshits et al. (2007) and Chatterjee et al. (2011), and mimics the fact that in practice, having bad credit remains on your credit report for a while (e.g., 10 years).

3.3 Earnings

Our earnings estimation consists of the following steps. First, we use 1969-2002 CPS data to estimate age-earnings profiles for different education groups. Second, we use NELS:1988 data to determine the fixed effect of SAT scores on earnings. Third, we use SCF data to determine the fixed effects of credit status on earnings. Lastly, for the stochastic component of income, we follow Hubbard et al. (1994).

First, for the age-earnings profiles by education groups, we generate synthetic cohorts for each year in the CPS by using earnings for 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. People with 16 and 17 years of education are classified as people with four years of college in the model. For individuals with some college in the model, we estimate earnings for people with more than 12 years but less than 16 years of education in the data. For people who do not go to college, we use the earnings of people with 12 years of education.

Second, the calibration of λ_a^h (the ability fixed effect from equation 4) is challenging because of the lack of data needed to distinguish between the independent effects of ability – as measured by SAT scores – and education. We follow Chatterjee and Ionescu (2011) and use the NELS:1988 dataset. We group students into our three education groups and terciles of ability and compute mean earnings for students who are five years out from the year they acquired their highest degree and are employed full-time.[28] The resulting parameters for the three ability levels are: 0.99, 1.01, and 1.01 for high school graduates; 0.99, 1.08, and 0.95 for individuals with some college; and 0.94, 1.02 and 1.11 for college graduates. We then

[28]We did not want earnings of students with very low and very high SAT scores to overly affect the results of their respective groups. We employed a 1 percent Winsorization with respect to SAT scores to reduce the sensitivity of group earnings to outliers.

use these estimates to compute the mean earnings of each ability-education group relative to the mean earnings of its education group.

Our calibration is consistent with empirical evidence showing individuals of higher ability levels experiencing higher returns to their education investment (Rosen and Willis, 1979; Heckman and Vytlacil, 2001; Cuhna et al., 2005). An important question is whether these returns are due to the innate ability of the individual, the quality of the high 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 because we think of ability as college preparedness. Empirical findings show that returns to schooling are mostly driven by the ability of the student rather than the quality of the school (Dale and Krueger, 1999). In addition, 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 implied by our estimation delivers an average return per additional year of college education of roughly 14 percent, which is consistent with estimates in the literature (Willis, 1986; Restuccia and Urrutia, 2004). Furthermore, our estimates suggest that the premium from completing four years of college relative to no college increases in SAT scores, but at a declining rate.

Third, to determine the fixed effects of credit status (λ_f^h in equation 4), we follow the same procedure as the one used in determining ability fixed effects. Specifically, we use SCF data and compute the mean earnings of each of our credit-education groups relative to the mean earnings of its education group. The resulting parameters for the two credit types are $\lambda_f^h = \{0.95, 1.06\}$ for high school graduates and $\lambda_f^h = \{0.8, 1.06\}$ for those with a college education.[29]

Lastly, in the parametrization of the stochastic idiosyncratic labor productivity process, we follow Hubbard et al. (1994) whose estimates use after-tax and transfer income, and also feature a shock-structure for earnings that is now standard. They report the following values for high school graduates: $\rho = 0.95$, $\sigma_\varepsilon^2 = 0.021$, $\sigma_\nu^2 = 0.025$, and $\sigma_\xi^2 = 0.5$; and for college graduates: $\rho = 0.95$, $\sigma_\varepsilon^2 = 0.021$, $\sigma_\nu^2 = 0.014$, and $\sigma_\xi^2 = 0.5$. We use the first set of values for people with no college, h_0, and for those with some college education, $h = h_2$, and the second set of values for individuals who complete a college degree, $h = h_4$. We have approximated these processes as two-state Markov chains, normalizing the average value for the idiosyncratic shock to 1. The resulting supports are the sets $Z^{0/2} = \{0.9285, 1.0715\}$ and $Z^4 = \{0.9314, 1.0686.$

[29]Note that we group college dropouts together with college graduates because of the small number of observations for college dropouts with good credit.

3.4 Parameters estimated within the model

We jointly estimate nine parameters in the model (reported in Tables 2 and 3): the default penalties for government and private loans, the mean and standard deviation from the initial distribution of expected family contributions, the discount factor, and the average amount of transfers across terciles of expected family contributions for college. These parameters are set to match the following targets: the national two-year cohort default rates in both the government and private student loan markets in 2008 (7 percent and 3.3 percent), the ratio of default rates for bad and good credit (12.5:1 ratio), participation rates in the government and private student loan market (45 percent and 17.5 percent, respectively), college enrollment rates across income terciles (Table 3), and the wealth-to-income ratio (3.3).

Table 2: Model Predictions vs. Data

Parameter	**Name**	**Variables Targeted**	**Data**	**Model**
$\mu^g(f_0)$	Default penalty for bad credit - govt	Default rate in govt market	7%	7%
$\mu^p(f_0)$	Default penalty for bad credit - private	Default rate in private market	3.3%	3.1%
$\mu(f_1)$	Default penalty for good credit	Ratio of default rates	12.5	11
μ_b	Mean of family contribution	Participation in govt market	45%	48.2%
σ_b	St. dev. of family contribution	Participation in private market	17.5%	17.8%
β	Discount factor	Wealth-income ratio	3.3	2.95
$Q(b_i)$	Transfers by terciles of family cont	College enrollment rates	see Table 3	

Table 3: College Enrollment Rates by Family Contributions

College enrollment	Data	Model
Low b	52.5%	52.7%
Medium b	65.5%	65.8%
High b	78.5%	78.3%

To estimate these parameters, we start with an initial guess of the nine parameters and implement the following algorithm: 1) we first solve for the decision problems for each education path; 2) we endogenize the college decision as well as the borrowing decisions in the government and the private markets; 3) we iterate until the profit conditions for each contract type and the government budget constraints hold; and 4) we simulate the economy and compute the nine moments targeted in the calibration, averaging the values predicted by the model over 500 economies. We repeat these four steps until the distance between the model and data is minimized and delivers estimates for the nine parameter values as well as the predictions of the model for statistics not targeted in the calibration.[30]

[30] Note that we map the estimated parameters to observable implications of the model. However, there is no one-to-one mapping so parameters are jointly estimated.

We obtain a discount factor of 0.9627 to match the ratio of mean wealth to mean pre-tax income provided in Heathcote et al. (2010).[31]

We allow utility losses $\mu^i(f)$ to differ across the government and private markets for individuals with bad credit and set these costs equal for individuals with good credit, $\mu^p(f_1) = \mu^g(f_1)$. Our estimation strategy is motivated by the fact that there are important differences in the consequences of defaulting on government student loans and defaulting on private student loans. Recall that the consequences for default on government loans include wage garnishments, seizure of federal tax refunds, possible holds on transcripts and ineligibility for future student loans, all consequences that are absent in the private student loan market.[32] In addition, we observe default rates for each market but not across individuals of different credit types, and we observe delinquency rates across individuals of different credit types but for both government and private student loans together (from Equifax data).[33] Therefore, we have three moments to match for default behavior: the average two-year cohort default rate for government student loans in 2008 (7 percent), the two-year default rate for private student loans in 2008 (3.3 percent), and the ratio between the delinquency rate for bad credit and the delinquency rate for good credit in 2008 (12.5:1).[34] We obtain the utility cost for default for individuals with bad credit in the government student loan market $\mu^g(f_0) = 0.00991$ and in the private market $\mu^p(f_0) = 0.00766$. For individuals with good credit, the utility cost is $\mu^g(f_1) = \mu^p(f_1) = 0.013$. Our estimates imply that individuals with good credit have a higher cost associated with default, which is consistent with the literature, and that defaulting on government loans may be more costly than defaulting on private loans (apart from the negative consequences on credit status), which is in line with the default consequences implemented in the two markets.

We estimate moments of the distribution for family contributions (μ_b, σ_b) to match participation rates in the government and private student loan markets. We obtain $\mu_b = \$17,700$ and $\sigma_b = \$6,900$. The participation rate in the government market is consistent with esti-

[31]This estimate is based on trimmed SCF data which is consistent with our use of the CPS in the earnings calibration.

[32]State affiliated private lenders may also garnish wages. However, a court order is needed for this action and wage garnishment for default on private student loans is limited in practice.

[33]We use the measure for 120+ days delinquency for student loans in Equifax, which is the closest measure to the national default rate for student loans (which is based on 270+ days).

[34]We use the default rate for 2008 to be consistent with the calibration of the college phase between 2003-2007. Recall that borrowers need to start repaying their loans six months after they finish college. The 2008 two-year cohort default rate represents the fraction of borrowers who entered repayment in FY2008 and defaulted by the end of FY2009. In the model, this is the sum of default during the first two periods of the repayment phase.

mates from the U.S. Department of Education (2008) and Wei and Skomsvold (2011) who report that between 42 to 45 percent of undergraduates in 2003-04 borrowed from the government student loan program. Estimates for the private market for students loans are more difficult to obtain, as schools are not required to report this information. Steele and Baum (2009) report that, in 2007-08, 19 percent of undergraduates borrowed from nonfederal sources, while the survey from Sallie Mae reports that 14 percent borrow from private sources (for the same years). We choose 17.5 percent as a target.

Finally, we estimate intra-family transfers during college, which is in accordance with research that shows that there is risk-sharing for young adults within a range of networks including families, friends, firms, and unions (Johnson, 2010; Kaplan, 2012). We estimate these transfers to match college enrollment rates across terciles of family contributions, based on NELS:1988 and BPS 2009 data. As evidenced by Table 2, the model does a very good job in matching these moments. The model delivers intra-family transfers that increase by family contributions: \$12,945, \$13,347, and \$13,923. These estimates imply that students from higher income groups have extra funds available, funds which are not captured by expected family contributions.

4 Benchmark Results

In this section, we first analyze the benchmark economy and compare the model's predictions of college investment and borrowing behavior to the data. We study how credit status interacts with other characteristics — family contributions and student ability — to affect the college investment decision. We evaluate the relationship between the government student loan program and the private market for student loans, and study the implications of this relationship for college investment, borrowing, and default behavior across individual characteristics.

In the benchmark economy, the college enrollment rate is 65.6 percent and the four-year college completion rate conditional on enrolling in college is 74.8 percent, both of which are consistent with the data (65.5 and 74.9 percent, respectively). This implies that 49.1 percent of agents in the model have a four-year college degree. In equilibrium, borrowers in the model borrow \$13,227, on average, to finance college: \$8,157 from the government and \$5,070 from the private market.[35] The amount borrowed from the government is close to the estimates of \$8,859 (in 2003 dollars) from Wei and Skomsvold (2011) for 2003-04. About 40 percent of borrowed funds is from the private market for student loans, which is

[35]Recall that 48 percent of students who go to college take out student loans to finance college education.

consistent with data from the College Board (2009). Thus, the private student loan market is an important source of funds for college investment in the model.

Furthermore, interest rates in the private market increase with individual credit status, consistent with the default behavior in the model.[36] Specifically, the model delivers no default in the private market for individuals with good credit, but positive default, which increases in the amount of debt, for individuals with bad credit. Our model yields a 9 percent interest rate for all (d^p, f_1) contracts and the following interest rates for (d^p, f_0) contracts as the size of the loan rises: 10.1 percent, 11.2 percent and 12.1 percent. Our predictions about interest rates are consistent with several key aspects of the data. First, in most cases, interest rates are higher on private loans than in the government student loan program (which are fixed at 6.8 percent). Second, individuals with bad credit face higher rates than individuals with good credit. And third, interest rates increase with the loan size, conditional on having bad credit. An important observation is that the interest rates for private student loans in the model may be a bit lower than those in the data. This discrepancy is because the recovery rate in the model is 100 percent and thus the default risk in the model is small, whereas in reality the recovery rate may be less than 100 percent, although still high given the non-dischargeability of these loans.[37]

The importance of the private market for student loans as a source of financing college together with the relevance of credit status for such loans suggest that credit status may have an important quantitative effect on college investment, in addition to family contributions and ability. Such an effect is exactly what we find, as described below.

4.1 Importance of family income and ability

Table 4 presents the model's predictions regarding college investment, borrowing, and default behavior for students with different levels of expected family contributions,[38] ability, and credit status. Note that we report both college enrollment rates and the percent of agents with a four-year college degree. The latter consists of multiplying the enrollment rates (which are endogenous in the model) by college completion rates (which are exogenous).

The model predicts that poor individuals (in the bottom tercile of family contributions) need to borrow much more than wealthy individuals, a result consistent with the data. Notice

[36]Recall that the solution to the private creditor's problem delivers that $R^p(f, d^p) \leq (R+q)(1-\omega(f, d^p))$ where R is the risk-free interest rate, q is a transaction cost and $\omega(f, d^p)$ represents the probability that an individual with credit status f defaults on the private student loan of size d^p.

[37]Precise data on recovery rates for private student loans are not available.

[38]We use the terms "expected family contributions" and "family income" interchangeably in our discussion since high family income usually results in high family contributions for college.

Table 4: Benchmark Results

	College enrollment rate	Percent with a four-year college degree	Average debt (govt/private)	Default rates (govt/private)
Family contributions (b)			for those who borrow	
Low	52.7%	36.6%	\$9,885/\$6,873	15.7%/1.2%
Medium	65.8%	49.0%	\$10,165/\$1,138	5.4%/7.1%
High	78.3%	61.9%	\$4,401/\$0	0.6%/NA
Ability of the student (a)				
Low	50.3%	30.2%	\$9,161/\$6,403	14%/0.7%
Medium	53.3%	38.4%	\$8,586/\$5,008	6.9%/0.9%
High	93.7%	79.2%	\$7,372/\$3,616	3.5%/8.5%
Credit status (f)				
Bad	53.7%	40.6%	\$8,800/\$5,775	23.9%/11.3%
Good	69.6%	52.0%	\$7,969/\$4,806	2.1%/0%

Note: For family contributions, the low group ranges from \$0-\$14,997, the medium group from \$14,998-\$20,957, and the high group over \$20,958 in 2003 dollars. For ability, the low group has SAT scores that are less than 900, the medium group from 900-1100 SAT scores, and the high group over 1100. Recall that the college completion rates by a are calibrated to the data and the college enrollment rates by b were targeted in the calibration procedure. For credit status, the bad group represents 25 percent and the good group 75 percent.

that students in the top one-third of family contributions do not borrow from the private market and borrow little from the government. However, low- and middle-income students rely on both the government and the private student loan market. Poor individuals take on the most student loan debt (approximately \$16,758 in both markets, on average). These students need to borrow a lot and most likely borrow at high interest rates given the positive correlation between family income and credit status. Ability and income are also positively correlated in our framework, as are earnings and ability. Thus, poor individuals in the model experience relatively low returns to college investment. The combination of high student loan indebtedness and low lifetime earnings leads to high default rates for this group.

We find significant differences in college investment and borrowing behavior across ability types: college enrollment increases with ability, a result consistent with the data.[39] These results are driven by the trade-off between returns to college (which are positively related to ability) and the financial need for loans (which are negatively related to ability). On the one hand, students need to have future earnings that are high enough to warrant college investment; the college premium increases in ability (as reported in Section 3). In addition,

[39] Authors' calculations from the NELS data deliver the following college enrollment rates across the three ability groups: 53 percent, 65.6 percent, and 85.5 percent, respectively. Also, the model is calibrated to match college enrollment by family contributions. Data are not available for college enrollment rates and borrowing behavior by credit status. Complete details of the data are provided in Section 3.

the probability of completing college increases in ability. Both factors induce college enrollment to increase in ability. At the same time, the earnings risk is high for borrowers with high levels of ability.[40] On the other hand, family contributions must be low enough so that individuals qualify for large government student loans. Individuals with high ability also have high levels of family contributions (given the positive correlation between the two) and thus need to borrow less to invest in college education. Not surprisingly, high-ability students borrow less from both markets even though their college investment rates are the highest; they most likely have sufficient family contributions to invest in college.

An interesting result is that default patterns across ability levels are quite different in the government market compared to default patterns in the private market for student loans. As illustrated in Table 4, low-ability individuals have high default rates in the government market and low default rates in the private market for student loans, whereas the opposite is true for high-ability individuals. The economic intuition behind this result is as follows. The disutility of defaulting in the private market is lower than the disutility of defaulting in the government market (an estimation result). This feature alone would induce borrowers to default at higher rates in the private market for student loans. However, default in the private market also triggers exclusion from borrowing in the unsecured credit market. For low-ability borrowers, access to credit markets is quite valuable. For them, the negative impact on credit status resulting from defaulting on private student loans is costly and the difference between the disutility levels from defaulting in the two markets is not large enough to compensate for this negative impact on access to credit. As a result, low-ability individuals would rather default on government loans than private loans. In contrast, for high-ability borrowers, exclusion from credit markets is not too costly, and therefore the difference in disutilities of default in the two markets is sufficiently large to make high-ability borrowers prefer to default on private student loans rather than defaulting on government loans. Overall, we find important quantitative differences in college investment and borrowing and default behavior by ability levels.

4.2 Importance of credit status

In addition to family contributions and ability, we find an important role for credit status in the college investment decision. Table 4 illustrates that college enrollment rates are 53.7 percent for agents with bad credit and 69.6 percent for agents with good credit. What drives this result? Three forces are at play.

[40]This is a direct consequence of having ability as a fixed effect on earnings (it is a multiplicative factor in the earnings equation).

First, there are differences in default costs and earnings across individuals of different credit status. Specifically, borrowers with good credit have higher disutility of default than borrowers with bad credit (this is an estimation result). Higher default costs may discourage college investment for individuals with good credit, although the effect is small. In addition, borrowers with good credit have higher earnings, on average, than individuals with bad credit, and these differences are larger on the college path than on the no-college path (this is a direct implication from the data, as explained in Section 3). Earnings differences encourage college investment for individuals with good credit relative to individuals with bad credit.

Second, there is a positive correlation between initial credit status and family contributions for college. Given that individuals with high family contributions enroll in college at high rates, this positive correlation works towards increasing college investment for individuals with good credit relative to individuals with bad credit.

Third, there are differences dictated by institutional details. Credit status is negatively affected when borrowers default in the private student loan market and individuals with bad credit are penalized in their access to the unsecured credit market. These penalties decrease the incentive to invest in college for individuals with good credit. They have the most to lose from defaulting in the private market: if they default, their credit status will be revised downward and the penalty is long-lasting. At the same time, pricing of private student loans accounts for the individual probability of default in equilibrium, a feature which results in better loan terms for individuals with good credit relative to those with bad credit. As explained earlier, the interest rates faced by individuals with bad credit are significantly higher than the interest rates faced by individuals with good credit. Moreover, the gap in interest rates across credit status increases with the size of the loan. This last prediction is because the default risk increases with the size of the loan, conditional on having bad credit. These differences in loan terms amplify the incentive to invest in college for individuals with good credit and diminish it for those with bad credit.

A natural question arises: How much of the importance of the credit status for college investment is driven by the correlation between initial family income and credit status? And how much is driven by institutional arrangements and differences across individuals with different credit status? To isolate the effects of these channels, we look at college enrollment rates by credit status conditional on initial family income, b (reported in Table 5). Note that there are gaps in enrollment rates by credit status for all terciles of b. More importantly, the gap in college investment between bad and good credit type is larger for the poorest individuals (with low levels of b). The government borrowing limit binds for a significant proportion of college students, and most notably for students with low family contributions. Good credit relaxes the relevance of the government borrowing limit. Students in the bottom tercile of family income are most likely to hit the government borrowing limit and have larger amounts of unmet financial need. They must turn to the private market to finance college. For them, having good credit creates better loan terms in the private student loan market. These findings imply that credit status is quantitatively important for college investment, and in particular for poor students. To conclude, differences in college investment behavior across credit types delivered by the model are mainly driven by differences across individuals with different credit status and by institutional details in the student loan markets.

Table 5: College Enrollment Rates by Credit Status

Family contributions (b)	Low	Medium	High
Credit status (f)			
Bad	38.5%	63.8%	73.4%
Good	60.7%	66.4%	78%

5 Policy Analysis

Our analysis so far shows that the private market for student loans plays a considerable role in college investment. Yet, borrowing in this market has declined significantly in recent years, in part due to the financial crisis and in part due to a recent expansion of the government student loan program. We first focus on the latter channel and analyze the effects of such a policy on college investment, borrowing and default behavior and welfare. We consider both the partial and general equilibrium effects of higher government borrowing limits. We then consider the implications of worsening conditions in the private market for student loans and analyze the equilibrium effects of possible policy responses. Lastly, we compare the effects of increasing the government borrowing limit with a set of budget-neutral tuition subsidies.

5.1 Increase in the government borrowing limit

For the first time since the early 1990's, the U.S. government increased the amount undergraduate students can borrow. Since 2008, undergraduate students can borrow up to \$31,000 total for college (up from \$23,000).[41] We analyze the effects of the expansion of the government student loan program in a general equilibrium (GE) and partial equilibrium (PE)

[41] The increase in 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

framework. In the GE analysis, taxes adjust to guarantee a balanced government budget and interest rates in the private market adjust to deliver zero profits for the private lender. Alternatively, in the PE analysis, taxes and interest rates are fixed to their benchmark levels.

We then study two possible responses to the expansion of the government student loan program: (1) the private creditor charges higher default penalties, and (2) the government provides an injection of liquidity in the private market to compensate for losses associated with higher default rates. Table 6 provides the aggregate results for all of the policy experiments, while Table 7 presents the individual-level results for the GE case.[42]

5.1.1 General equilibrium analysis

We find that college enrollment increases to 75.3 percent (up from 65.6 percent in the benchmark economy) and the fraction of four-year college graduates increases to 55.8 percent (compared to 49 percent). Individuals have increased access to cheaper funds (since they can borrow more from the government at lower interest rates), and, as a result, invest in more college. Participation rates in the government student loan program increase by 7.5 percentage points while participation rates in the private market decrease by eight percentage points. In addition, students are borrowing more (in levels) from the government ($9,589 versus $8,157 in the benchmark) and borrowing less from the private market ($3,998 versus $5,070). Our results suggest that students are treating government and private student loans as substitutes, although increased usage of the government student loan program results in more college investment. However, the government program leads to increased risk in the private market for student loans: the default rate in the private market increases from 3.1 percent in the benchmark economy to 7.8 percent. As a result, interest rates in the private market increase relative to the benchmark to account for the extra default risk. In addition, the cost of the government student loan program requires higher taxes (to $141, up from $68.1 in the benchmark). On the one hand, the increases in college investment and therefore earnings in the economy increase welfare. On the other hand, higher interest rates and taxes reduce welfare. Quantitatively, the latter channel dominates so that the policy induces a small reduction in aggregate welfare relative to the benchmark economy (-0.04 percent). Note that the welfare calculations depend on the welfare function, which is assumed to be an aggregate equally weighted function. In addition, our welfare calculations assume exoge-

year (up from $5,500). Source: www.finaid.org/loans/historicallimits.phtml. Also, this 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.

[42] All of the other results are available from the authors by request.

Table 6: Aggregate Results: Benchmark vs. Policy Experiments

Variables	Benchmark	Higher govt limit: GE	Higher govt limit: PE	Default penalty	Liquidity injection
College enrollment rate	65.6%	75.3%	70.9%	75.5%	75.5%
Percent with a four-year college degree	49.1%	55.8%	52.7%	55.9%	55.9%
Participation in govt mkt	48.2%	55.7%	52.4%	55.8%	55.8%
Participation in private mkt	17.8%	9.8%	9.2%	9.8%	9.8%
Default rate in govt mkt	7%	7.6%	7.7%	8.9%	7.7%
Default rate in private mkt	3.1%	7.8%	9.3%	3.2%	8.5%
Average govt debt	$8,157	$9,589	$9,585	$9,587	$9,590
Average private debt	$5,070	$3,998	$3,978	$4,003	$4,009
Aggregate welfare change	—	-0.04%	+0.12%	-0.047%	-0.045%
Avg rate in the private mkt w/ bad credit	11.2%	11.7%	11.2%	11.3%	11.2%
Avg rate in the private mkt w/ good credit	9%	9%	9%	9%	9%
Per period taxes	$68.1	$141	$68.1	$159	$143

nous earnings and high recovery rates for student loans. Therefore, welfare in our economy ignores the extra feedback into earnings induced by having a higher fraction of educated people in the economy and it assumes a relatively lower risk premium imbedded into interest rates for student loans. Both of these effects may negatively affect welfare.

Who benefits the most from this policy? As Table 7 illustrates, college investment increases for all types of students. Poor individuals (those with low b) experience the largest increases in government student loans (compared to the benchmark results in Table 4), which suggests that looser credit constraints make college more affordable for them. Poor students, however, borrow much less from the private market. Middle-income students also take out slightly more government student debt, but do not borrow from the private market any longer. In fact, the poorest individuals are the only ones who participate in the private market for student loans. Although they borrow less in the private market relative to the benchmark economy, overall they have slightly more total student debt. Poor individuals now experience higher earnings levels (since college investment is higher) and cheaper sources of funds (since interest rates in the government program are lower than in the private market) and therefore benefit from the policy (in welfare terms). At the same time, middle- and high-income students experience welfare losses. For them, the positive effect of higher earnings is not large enough to compensate for the negative effect of higher taxes.

Similarly, students across all ability groups increase college investment with a higher government borrowing limit, with larger increases for low- and medium- ability students.

Table 7: Higher Government Borrowing Limit: General Equilibrium

	College enrollment rate	Percent with a four-year college degree	Avg debt govt/private	Default rates (govt/private)	Welfare change
Family contributions (b)					
Low	65.3% (+12.6)	45.1% (+8.5)	$12,983/$3,998	17.5%/7.6%	+0.1%
Medium	78.1% (+12.3)	57.5% (+8.5)	$10,670/$0	4.2%/NA	-0.1%
High	82.4% (+4.1)	64.8% (+2.9)	$4,480/$0	0.7%/NA	-0.14%
Ability of the student (a)					
Low	63.3% (+13)	38.0% (+7.8)	$11,054/$4,779	16%/0%	-0.05%
Medium	63.4% (+10.1)	46.4% (+8.0)	$10,108/$3,883	4.6%/9.5%	-0.09%
High	99.6% (+5.9)	84.2% (+5.0)	$8,321/$2,460	4.5%/21.1%	+0.01%
Credit status (f)					
Bad	66.6% (+12.9)	49.8% (+9.2)	$10,586/$3,996	17.5%/22.6%	-0.03%
Good	78.2% (+8.6)	57.8% (+5.8)	$9,273/$3,999	4.2%/0%	-0.05%

Note: Numbers in parentheses represent changes from the benchmark.

However, a more generous government student loan program encourages all types of students to substitute away from private loans to government loans to finance their increased college investment. Overall, high-ability students experience a small welfare gain as a result of the policy, whereas students with low and medium levels of ability face welfare losses.

Students with bad and good credit invest in college at higher rates and borrow larger amounts from the government and less from the private sector. However, because students with bad credit receive worse loan conditions in the private market (in equilibrium), they benefit the most from substituting away from private loans to government loans. They borrow from the government at high levels, and this borrowing behavior is more pronounced as the government increases its borrowing limits. As a result, individuals with bad credit experience smaller welfare losses than those with good credit.

Our key result is that while a higher government borrowing limit leads to more college investment, it also leads to a shift in the distribution of borrowers away from the private market towards the government market. The remaining pool of borrowers in the private market has lower levels of family contributions and higher levels of ability, on average, relative to the pool of borrowers in the benchmark economy. Students with low family contributions and students with high ability levels have a large incentive to default in the private market for student loans, as explained in Section 4. Consequently, the pool of students participating in the private student loan market as a result of the policy is comparatively more risky. This shift in the distribution of borrowers is the reason why aggregate default rates in the private market more than double. At the same time, the default rate in the government market increases slightly (by 0.6 percentage points), which is attributable to higher debt-to-income ratios for borrowers in the government market. Recall that low-ability and low-income students borrow more as a result of higher debt limits to finance their college education; however, they experience relatively low returns to their investment.

To conclude, our main finding is that an increase in government borrowing limits leads to more college investment for every type of student, with the largest effects for students with low levels of ability, income and credit status. The policy triggers much higher default rates in the private market, despite lowering average private debt. This is caused by the fact that the remaining pool of borrowers in the private market is relatively risky. Consequently, borrowers with bad credit face even higher interest rates on private loans (11.7 percent on average relative to 11.1 percent in the benchmark, as reported in Table 6). In addition, taxes are higher in this economy. Overall, the distributional effects of the policy suggest that the poorest individuals and those with high levels of ability experience welfare gains whereas other groups of individuals lose out (albeit with small welfare losses).

5.1.2 General equilibrium versus partial equilibrium analysis

As shown in Table 6, there are several important differences between the PE and GE experiments.[43] College enrollment and participation rates in the two markets are lower in PE than in GE (but still higher than in the benchmark), and there is more default in both markets. In the partial equilibrium setting, there is no adjustment in the private market for student loans and therefore no feedback between default behavior and loan terms for private student loans. Consequently, the default rate in the private market is significantly higher (9.3 percent in the PE case compared to 7.8 percent in the GE case) and the interest rates in the private market are relatively low for the most risky borrowers (those with bad credit).

These equilibrium effects have important implications for welfare. In the PE case, the policy delivers a 0.12 percent increase in welfare relative to the benchmark economy, with the poorest individuals and those with high ability experiencing the larger gains in welfare. However, when general equilibrium effects are taken into account, the policy delivers a welfare loss (-0.04 percent) due to higher taxes and interest rates in the private market.[44] Our results show that taking into account the interaction between the private and the government sector is key when analyzing government student loan policies. Given the interaction

[43]There are no major allocational consequences across individual characteristics. For brevity, we do not show all of the quantitative results, but they are available from the authors.

[44]Note that the welfare calculations do not take into account the effects of changing skill premia since wages are exogenous in the model.

between the two sectors, student loan administrators may consider alternative responses to minimize the adverse effects of higher government borrowing limits. We study two such responses: (1) an adjustment in the default penalty in the private market that is designed to reduce the default risk in this market induced by the higher government borrowing limit, and (2) an injection of liquidity from the government to the private sector to cover the extra losses in the private market due to the higher government borrowing limit. Both of these experiments account for the limited size of the government budget and zero profits for the private lender. Details and findings are in the next subsection.

5.1.3 Possible responses to worsening conditions in the private market

During the 2007-2009 financial crisis, the private market for student loans tightened which led to less credit being allocated and higher interest rates.[45] Default rates in both the government and private market for student loans increased.[46] Thus, it is plausible that there was a shift in the initial distribution of credit scores as a result of the financial crisis. However, data from both the Survey of Consumer Finances (SCF) and the FRBNY Consumer Credit Panel (Equifax) suggest the distribution of credit scores was quite stable between 2001-2010.[47] Given the worsening credit conditions but similar distribution of credit scores, it is likely that the same credit score before and after the financial crisis yielded different outcomes in the private market for student loans. In this section, we consider two different responses to the worsening credit conditions: private creditors charge higher interest rates in the student loan market, and alternatively, the government provides liquidity to private creditors as a way to mitigate the adverse effects of tighter credit markets.

Higher default penalties in the private market

It is plausible that if an increase in the government borrowing limit leads to a riskier pool of borrowers in the private market, creditors may respond by increasing the default penalties

[45] The College Board (2014) reports more than a 50 percent reduction in private non-federal students loans between 2007-08 and 2008-09.

[46] Trends in default rates for government student loans can be found here: https://www2.ed.gov/offices/OSFAP/defaultmanagement/defaultrates.html, while data for the private market is here: http://files.consumerfinance.gov/f/201207_cfpb_Reports_Private-Student-Loans.pdf

[47] Using SCF and Equifax data, we estimate the distribution of initial credit status (the percent with good and bad credit in the model). In the SCF data, we define individuals with bad credit as 18 to 28 year old respondents who report that they were turned down for credit or did not get as much credit as they applied for because of their credit score. The 2001 and 2004 SCF data indicate that 75 percent of young adults have good credit, while 25 percent have bad credit. This distribution is consistent with Equifax data, where young individuals with bad credit are subprime borrowers who have a risk score below 560, while those with good credit have a risk score above 560. We checked all years between 2001-2010 and find no sizable change in the distribution of credit scores over time, even in the wake of the financial crisis.

in the private market.[48] Recall that default penalties in both markets are calibrated in the benchmark economy to match default rates for student loans. We study the case where the default penalty for borrowers with bad credit in the private market, $\mu^p(f_0)$, adjusts to deliver the private market default rate from the benchmark economy (the private market default rate increased from 3.1 percent in the benchmark to 7.8 percent in the GE case of higher government loan limits, as displayed in Table 6).[49] As before, this experiment considers the general equilibrium adjustments of taxes and interest rates in the private market. We find that higher default penalties in the private market induce more default on government loans: the default rate in the government market increases to 8.9 percent (up from 7 percent in the benchmark). The high cost of default in the government market, in turn, leads to higher taxes. Even though this experiment delivers similar college investment rates to the experiment with higher government borrowing limits, the increases in the default penalty and taxes reduce welfare more (by 0.047 percent relative to the benchmark). In addition, all types of agents, except for the very poorest, experience slight reductions in welfare as default penalties increase.

Liquidity injection to private creditors

Next, we consider the possibility that the government will compensate private creditors via a liquidity injection. This experiment assumes that *instead of* the interest rate adjustment for private student loans in equilibrium to deliver zero profits, there is a transfer from the government to the private sector to cover the losses incurred by the private creditor due to the higher government borrowing limit. The size of the transfer is determined in equilibrium to guarantee zero profits in the private market for all type of contracts. The results are displayed in the last column of Table 6. Similar to the default penalty, a liquidity injection leads to a slightly larger reduction in welfare relative to the benchmark economy (of 0.045 percent) compared to the GE case of higher government borrowing limits. However, unlike the default penalty, a liquidity injection does not significantly increase the default rate in the government market. Therefore, taxes are lower relative to the previous experiment. In addition, the default rate in the private market is much higher with a liquidity injection compared to the default penalty.

The general equilibrium response to an increase in government borrowing limits is best

[48] In response to the 2007-09 financial crisis, private creditors reacted in other ways to minimize default. For instance, Sallie Mae increased the minimum credit score eligible for private student loans from 640 to 670.

[49] We choose to adjust the utility loss of borrowers with bad credit in this experiment since the default for private student loans in the model comes only from individuals with bad credit.

(in a welfare sense) on its own, without any further reaction from the government or private sector. In all cases, higher government borrowing limits lead to more college enrollment but lower aggregate welfare. Importantly, how the private and government market for student loans interact with one another is central to this result. In particular, when the adjustment of interest rates in the private market is not accounted for in equilibrium, the increase in government limits improves welfare. In the next section, we consider a different type of government policy; instead of increasing the limit on government student loans, the government could implement various types of tuition subsidies.

5.2 Tuition subsidies

We study two budget-neutral subsidy policies: a merit-based subsidy and a need-based subsidy. Our analysis assumes that instead of subsidizing the cost of higher borrowing limits, the government simply reallocates these funds to tuition subsidies. Our analysis delivers the following subsidy amounts each year per enrolled student: a merit-based subsidy of $654 for high-ability students and a need-based subsidy of $702 for low-income students.

Our main finding is that compared to the government policy of raising the borrowing limits on government student loans, both types of tuition subsidies increase college investment *and* improve aggregate welfare, as reported in Table 8. The gains in aggregate welfare are 0.35 percent in the case of a need-based subsidy and 0.45 percent in the case of a merit-based subsidy (compared to -0.04 percent induced by higher government borrowing limits). There are two main factors that contribute to this welfare result. First, the subsidies reduce the cost of college enough to promote college investment without increasing borrowing levels.[50] We find that tuition subsidies have a larger positive effect on college investment compared to higher government borrowing limits, and in particular for need-based subsidies. A key second factor that explains these welfare gains is that unlike an increase in government borrowing limits, neither subsidy increases the default rate in the private market for student loans. Recall that low-income and high-ability students represent high risk for the private market and tuition subsidies lower the net cost of college faced by these high risk individuals. Consequently, they need to borrow less (in levels) in the private market for student loans, although their participation rates increase (because more students in these groups go to college). The two forces offset each other in the model and overall the default rate in the private market remains at its benchmark level. Consequently, the interest rates in the private market for student loans remain at low levels (as in the benchmark economy).

[50]We assume that college costs are not adjusted in response to subsidy policies.

Why do merit-based subsidies induce higher welfare gains relative to the benchmark economy compared to need-based subsidies? This result may seem counterintuitive, especially given the larger impact on college enrollment from the need-based subsidy.[51] The key finding that explains this gap in welfare gains is that the two subsidies have different implications for default in the government market for student loans. Specifically, the need-based subsidy induces a significant increase in the default rate in the government market (10 percent compared to 7 percent in the benchmark economy), whereas the merit-based subsidy decreases the default rate slightly (to 6.7 percent). Recall that low-income students represent high risk for government loans, whereas high-ability students represent low default risk. But with need-based subsidies, low-income students invest in college at higher rates. However, low-income students still need to borrow from the government for the remaining cost (although at lower levels). Note that participation in the government market increases significantly in the case of a need-based subsidy. Unlike in the private market, the increase in the participation rate in the government market coming from low-income borrowers is large, and as a result, the average debt level increases slightly (compared to the benchmark economy). The pool of borrowers in the government market is relatively riskier and therefore default increases. In the case of a merit-based subsidy, however, the pool of borrowers in the government market is relatively less risky, given that high-ability students invest in college at higher rates and have lower default incentives for government student loans. Consistent with this default behavior, taxes are higher in the economy with a need-based subsidy than in the economy with a merit-based subsidy. As a result, welfare gains are lower in the case of a need-based subsidy.

As suspected, the distributional effects from the two different types of subsidy vary significantly (as reported in Table 9). Not surprisingly, individuals with low income and low levels of ability lose with a merit-based subsidy, while individuals with high income and high levels of ability lose in the need-based case.

Our results are comparable to those in Akyol and Athreya (2005) and Abbott et al. (2013), who find that tuition subsidies (in general) are welfare-improving. However, unlike Abbott et al. (2013), we find that the most effective policies (in terms of aggregate welfare) are merit-based subsidies (as opposed to need-based subsidies in their paper). The interaction between subsidy policies and default behavior in student loan markets is key for

[51] Note that the need-based subsidy increases college enrollment by almost 20 percentage points relative to higher government limits, whereas the merit-based subsidy increases enrollment about 11 percentage points. This result is not surprising given that high-ability students already invest in college at high rates in the benchmark economy.

Table 8: Aggregate Results: Tuition Subsidies

Variables	Benchmark	Higher govt limit: GE	Need-based subsidy	Merit-based subsidy
College enrollment rate	65.6%	75.3%	84.9%	76.1%
Percent with a four-year college degree	49.1%	55.8%	62.1%	56.4%
Participation in govt mkt	48.2%	55.7%	63.6%	54.8%
Participation in private mkt	17.8%	9.8%	28.5%	19.5%
Default rate in govt mkt	7.0%	7.6%	10%	6.7%
Default rate in private mkt	3.1%	7.8%	3.0%	2.4%
Average govt debt	$8,157	$9,589	$8,505	$7,993
Average private debt	$5,070	$3,998	$5,073	$4,780
Aggregate welfare change	—	-0.04%	+0.35%	+0.45%
Avg rate in the private mkt w/ bad credit	11.2%	11.7%	11.3%	11.2%
Avg rate in the private mkt w/ good credit	9%	9%	9%	9%
Per period taxes	$68.1	$141	$159	$96

this result. Default rates in the government market are high in the case of need-based subsidies since need-based subsidies encourage more college investment and participation in the government market among the poorest individuals. This fact, in turn, leads to higher taxes when the need-based subsidy is implemented relative to the merit-based subsidy. At the same time, the two subsidies have similar effects on default in the private market for student loans and therefore deliver the same interest rates in equilibrium. These adjustments in equilibrium dampen the welfare effects of the need-based subsidy relative to those of the merit-based subsidy. Our results suggest that if the goal of the policy is to increase college investment, need-based subsidies are desirable, but if the goal is to reduce default rates on student loans, merit-based subsidies may be preferred. Generally speaking, our results demonstrate the importance of considering borrowing and default behavior for student loans in both government and private markets when studying the effectiveness of tuition subsidies.

To this end, by providing tuition subsidies (of any sort), the government is reducing financial need for students, and this fact in turn lowers default incentives in the private market for student loans. As such, interest rates in the private market do not increase with subsidies. This is in contrast to a higher government borrowing limit, which induces more default in the private market for student loans and higher interest rates. Overall, our results imply that tuition subsidies represent good instruments to limit the adverse effects for — and possible reactions from the private market — as opposed to an expansion of the government student loan program.

Table 9: Welfare Effects: Tuition Subsidies

	Need-based subsidy	Merit-based subsidy
Aggregate welfare change	+0.35%	+0.45%
Family contributions (b)		
Low	+1.30%	-0.09%
Medium	-0.11%	-0.07%
High	-0.15%	+1.6%
Ability of the student (a)		
Low	+0.56%	+0.12%
Medium	+0.28%	+0.38%
High	+0.21%	+0.89%
Credit status (f)		
Bad	+0.35%	+0.19%
Good	+0.35%	+0.54%

6 Conclusion

It is quite common for undergraduate students to borrow for college from private credit markets. In contrast to the government student loan program, private creditors set the conditions for student loans based on the credit status of the student. As a result, credit status may affect the college investment decision. We build a life-cycle model where agents are heterogeneous in family income, ability and credit status. Agents use family contributions, government student loans, and the private market for student loans to finance their college expenditures. We find that the role of credit status for college investment and the interaction between the government and the private markets for student loans have important policy implications.

We focus on a recent policy that increased the borrowing limits in the government student loan program. Our model indicates that this policy increases college investment as students borrow more from the government and less from the private market. However, this policy results in a riskier pool of students participating in the private market, which causes higher default rates and negative profits to private creditors. Consequently, both interest rates in the private market and government taxation increase in equilibrium. We show that if these adjustments are ignored in equilibrium, an increase in government borrowing limits is welfare-improving. However, the general equilibrium effects negate the welfare gains from a more generous student loan program, inducing important distributional effects in the economy.

If the private sector adjusts default penalties in equilibrium to neutralize the extra default risk induced by the higher government loan limits, or if the government provides liquidity to the private sector to compensate them for their profit losses, individuals in the economy are worse off relative to an economy with no change in policy, even though college investment increases. Thus, it is critical for policymakers to consider how the private market for student loans may respond to higher default rates. In fact, our analysis shows that tuition subsidies are welfare superior to increasing government borrowing limits because subsidies minimize the adverse effects on private credit markets. Furthermore, we find that merit-based subsidies lower default rates in both the government and the private markets, while need-based subsidies lower default in the private market but increase default risk in the government student loan program. Thus, it is important for policymakers to consider how borrowing and default decisions vary under different tuition subsidy programs.

The private market for student loans is still evolving. Our analysis suggests that the private market is playing an important role for college investment and that the government should consider how the private market for student loans reacts to policy changes. We hope this paper represents a starting point for more analysis of this important source of funding for college students.

References

[1] Abbott, B., Gallipoli, G., Meghir, C., and Violante, G. L. (2013). “Education policy and intergenerational transfers in equilibrium.” National Bureau of Economic Research Working Paper No. w18782.

[2] Akyol, A., and Athreya, K. (2005). “Risky higher education and subsidies.” *Journal of Economic Dynamics and Control*, 29(6), 979-1023.

[3] Arcidiacono, P. (2004). “Ability sorting and the returns to college major,” *Journal of Econometrics*, 121(1-2), 343–375.

[4] Athreya, K. (2008). “Default, insurance, and debt over the life-cycle." *Journal of Monetary Economics,* 55(4): 752-774.

[5] Athreya, K., Tam, X. S., and Young, E. R. (2012). “A quantitative theory of information and unsecured credit.” *American Economic Journal-Macroeconomics*, 4(3), 153.

[6] Avery, R. B., Brevoort, K. P., and Canner, G. B. (2009). ”Credit scoring and its effects on the availability and affordability of credit.” *Journal of Consumer Affairs*, 43(3), 516-537.

[7] Becker, G. (1975). *Human Capital*, 2nd Ed., New York, NY: Columbia University Press.

[8] Belley, P. and Lochner, L. (2007). "The changing role of family income and ability in determining educational achievement." *Journal of Human Capital* 1(1), 37-89.

[9] Berkner, L. (2000). "Trends in undergraduate borrowing: Federal student loans in 1989-90, 1992-93, and 1995-96." Washington, DC: National Center for Education Statistics Report 2000-151.

[10] Bound J., Lovenheim, M. and Turner, S. (2009). "Why have college participation rates declined? An analysis of changing student preparation and collegiate resources," NBER Working Paper No. 15566.

[11] Cameron, S. and Taber, C. (2004). "Estimation of educational borrowing constraints using returns to schooling." *Journal of Political Economy*, 112(1), 132-182.

[12] Carneiro, P. and Heckman, J. (2002). "The evidence on credit constraints in post secondary schooling." *Economic Journal,* 112, 705-734.

[13] Caucutt, E. M. and Kumar, K. B. (2003). "Higher education subsidies and heterogeneity: A dynamic analysis." *Journal of Economic Dynamics and Control*, 27(8), 1459-1502.

[14] Chatterjee, S., Corbae, D., Nakajima, M. and Rios-Rull, J.V. (2007), "A quantitative theory of unsecured consumer loans with a risk of default." *Econometrica,* 75(6), 1525-1589.

[15] Chatterjee, S., Corbae, D. and Rios-Rull, J.V. (2011), "A theory of credit scoring and the competitive pricing of default risk," 2011 Meeting Papers 1115, Society for Economic Dynamics.

[16] Chatterjee, S. and Ionescu, F. (2012). "Insuring student loans against the risk of college failure," *Quantitative Economics*, 3(3), 393-420.

[17] College Board. (2007). "Trends in college pricing." Trends in Higher Education Series, The College Board. http://www.collegeboard.com/trends

[18] College Board (2009). "College-bound seniors: Total group profile report," The College Board. http://professionals.collegeboard.com/profdownload/cbs-2009-national-TOTAL-GROUP.pdf

[19] College Board. (2014). "Trends in student aid." Trends in Higher Education Series, The College Board. http://trends.collegeboard.org/sites/default/files/2014-trends-student-aid-final-web.pdf

[20] Cunha, F., Heckman, J. and Navarro, S. (2005). "Separating uncertainty from heterogeneity in life cycle earnings." *Oxford Economic Papers* 57, 191-261.

[21] Dale, S. and Krueger, A. (1999). "Estimating the payoff to attending a more selective college: An application of selection on observables and unobservables," NBER Working Paper No. 7322.

[22] Digest of Education Statistics. (2007). U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. http://nces.ed.gov/programs/digest/d07/tables/dt07_002.asp?referrer=list

[23] Evans, D. and Schmalensee, R. (1999). *Paying with plastic: the digital revolution in buying and borrowing*. Cambridge, MA: The MIT Press.

[24] Garriga, C. and Keightley, M. (2007). "A general equilibrium theory of college with education subsidies, in-school labor supply, and borrowing constraints." Federal Reserve of St. Louis Working Paper 2007-051A.

[25] Gladieux, L. and Perna, L. (2005). "Borrowers who drop out: A neglected aspect of the college student loan trends." The National Center for Public Policy and Higher Education, National Center Report #05-2, May.

[26] Heathcote, J., Perri, F., and Violante, G. (2010), "Unequal we stand: An empirical analysis of economic inequality in the United States, 1967-2006", *Review of Economic Dynamics*, 131(1), 15-51.

[27] Heckman, J. and Vytlacil, E. (2001). "Identifying the role of cognitive ability in explaining the level of and change in the return to schooling." *Review of Economics and Statistics* 83(1), 1-12.

[28] Hubbard, G., Skinner, J. and Zeldes, S. (1994). “The importance of precautionary motives in explaining individual and aggregate saving,” *Carnegie-Rochester Conference Series on Public Policy*, 40(1), 59-125.

[29] Ionescu, F. (2009). “Federal student loan program: Quantitative implications for college enrollment and default rates.” *Review of Economic Dynamics* 12 (1), 205-31.

[30] Ionescu, F. (2011). “Risky human capital and alternative bankruptcy regimes for student loans.” *Journal of Human Capital*, 5(2), 153-206.

[31] Johnson, M. T. (2010). “Borrowing constraints, college enrollment, and delayed entry.” Mathematica Policy Research, Working Paper.

[32] Kaplan, G. (2012). “Moving back home: Insurance against labor market risk.” *Journal of Political Economy*, 120(3): 446-512.

[33] Keane, M. and Wolpin, K. (2001). “The effect of parental transfers and borrowing constraints on educational attainment.” *International Economic Review* 42, 1051-1103.

[34] Li, W. and Sarte, P. (2006). “U.S. consumer bankruptcy choice: The importance of general equilibrium effects.”, *Journal of Monetary Economics*, 53, (3), 613–631.

[35] Livshits, I., MacGee, J. and Tertilt, M. (2007). "Consumer bankruptcy: A fresh start," *American Economic Review*, 97(1), 402-418.

[36] Lochner, L. and Monge-Naranjo, A. (2011). “The nature of credit constraints and human capital.” *American Economic Review,* 101 (6), 2487-2529.

[37] Lucas, D. and Moore, D. (2007). “The student loan consolidation option.” Congress of the United States, Congressional Budget Office Working Paper 2007-05.

[38] Manski, C. and D. Wise. (1983). *College choice in America*. Harvard University Press.

[39] Musto, D. and N. Souleles. (2006). “A portfolio view of consumer credit,” *Journal of Monetary Economics*, 53(1), 59–84.

[40] Narajabad, B. (2012). “Information technology and the rise of household bankruptcy”, *Review of Economics Dynamics*, 15, 526-550.

[41] Restuccia, D. and Urrutia, C. (2004). “Intergenerational persistence of earnings: The role of early and college education,” *American Economic Review,* 94(5), 1354-1378.

[42] Rosen, S. and Willis, R. (1979). "Education and self-selection," *Journal of Political Economy* 87(5), S7-36.

[43] Sallie Mae. (2008). “ABS East Investor Presentation,” SLM Corporation, October 2008. http://www.sec.gov/Archives/edgar/data/1032033/000095013308000355/w47877fwp.htm

[44] Schiopu, I. (2008). “Macroeconomic effects of higher education funding policies.” Working Paper.

[45] Stange, K. (2012). “An empirical investigation of the option value of college enrollment,” *American Economic Journal: Applied Economics*, 4(1), 49–84.

[46] Steele, P. and Baum, S. (2009). “How much are college students borrowing?” College Board Policy Brief, August.

[47] Stinebrickner, T.R. and Stinebrickner, R. (2007). “The effect of credit constraints on the college drop-out decision: A direct approach using a new panel study,” NBER Working paper No. 13340.

[48] Stinebrickner, T.R. and Stinebrickner, R. (2012). “Learning about academic ability and the college drop-out decision,” *Journal of Labor Economics*, 30(4), 707-748 .

[49] Storesletten, K., Telmer, C.I. and Yaron, A. (2001). “How important are idiosyncratic shocks? Evidence from labor supply,” *American Economic Review,* 91(2), 413-417.

[50] Sullivan, T., Warren, E. and Westbrook, J. (2000). *The Fragile Middle Class*, Yale University Press, New Haven and London.

[51] Titus, M. (2002). “Supplemental table update for trends in undergraduate borrowing: Federal student loans in 1989-90, 1992-93, and 1995-96.” http://nces.ed.gov/pubs2000/2000151update.pdf

[52] U.S. Department of Education. (2004). “Paying for college: Changes between 1990 and 2000 for full-time dependent undergraduates.” Institute of Education Sciences NCES.

[53] U.S. Department of Education. (2008). “Trends in Undergraduate Borrowing II: Federal Student Loans in 1995–96, 1999–2000, and 2003–04.” Institute of Education Sciences, NCES 2008-179rev. http://nces.ed.gov/pubs2008/2008179rev.pdf

[54] U.S. Department of Education. (2014a). “Cohort Default Rates Comparison for FY 2011 2-Year FFEL, FDSLP, and National.” http://www2.ed.gov/offices/OSFAP/defaultmanagement/ffeldl2yrbargraph.pdf

[55] U.S. Department of Education. (2014b). "Student Loans Overview: Fiscal Year 2014 Budget Proposal," http://www2.ed.gov/about/overview/budget/budget14/justifications/s-loansoverview.pdf

[56] U.S. Federal Reserve Board of Governors. (2014). Economic Research & Data, Consumer Credit - G.19 Release. http://www.federalreserve.gov/releases/g19/current/default.htm

[57] Wei., C.C. and Skomsvold, P. (2011). “Borrowing at the Maximum: Undergraduate Stafford Loan Borrowers in 2007–08.” U.S. Department of Education, Stats in Brief, National Center for Education Statistics, NCES 2012-161.

[58] White, M. J., (1998). “Why don’t more households file for bankruptcy”, *Journal of Law, Economics, and Organization,* 14 (2), 205–231.

[59] Willis, R. (1986). “Wage determinants,” *Handbook of Labor Economics*, North Holland, Amsterdam.