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Default Risk and Private Student Loans: Implications for Higher Education Policies

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Abstract

In recent years, the proportion of students facing a binding constraint on government student loans has grown. This has led to substantially increased use of private loans as a supplementary source of finance for households' higher education investment. A critical aspect of the private market for student loans is that loan terms must reflect students' risk of default. College investment will therefore differ from a world in which government student loans, whose terms are not sensitive to credit risk, are expanded to no longer bind. Moreover, beyond simply crowding out private lending, expansions of the government student loan program will feed back into default risk on private loans. The goal of this paper is to provide a quantitative assessment of the likely effects of the private market for student loans on college enrollment. We build a model of college investment that reflects uninsured idiosyncratic risk and a well-defined life-cycle that is consistent with observed borrowing and default behavior across family income and college preparedness. We find that higher government borrowing limits increase college investment but lead to more default in the private market for student loans, while tuition subsides increase college investment and reduce default rates in the private market. Consequently, higher limits on government student loans have small negative welfare effects, while tuition subsidies increase aggregate welfare.

JEL Codes: D53; E21; I22; I28

Keywords: College Investment; Credit Risk; Student Loans; Default

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1 Introduction

More than half of undergraduate students in the United States borrow to finance their college education and an increasing number of students borrow the maximum available in the government student loan program (Berkner, 2000). This has led to substantially increased use of private loans as a supplementary source of finance for households' higher education investment. In fact, undergraduate borrowing from nonfederal sources peaked at 25 percent in 2007-08 (College Board, 2014). This is important to policy makers because as more funds are borrowed for student loans (from all sources), the repayment process becomes complex, especially in light of recent policy changes in both the government and private student loan markets.[1] In fact, default rates on all forms of student loans have increased in the past decade (refer to Figure 2 in the Appendix). The goal of this paper is to provide a quantitative assessment of the likely effects of the private market for student loans on college enrollment in order to better assess the effectiveness of higher education policies.

A critical aspect of the private market for student loans is that, unlike in the government student loan market, loan terms must reflect students' risk of default. Eligibility, interest rates and loan limits in the private market, all depend on credit scores. In addition, default in the private market affects credit risk and in turn, results in worse loan conditions. The rise of student loans originating in private credit markets suggests that individual credit risk may affect college investment. In particular, individuals with good credit may not be constrained in their college investment by limits on Federal student loans since they can access the private market, whereas the opposite may be true for those with bad credit. Moreover, beyond simply crowding out private lending, expansions of the government student loan program will feed back into default risk on private loans. More generally, higher education policies may affect the distribution of borrowers, and as a result, may have different implications for default behavior, credit risk, and consequently welfare.

This discussion raises the following question: What are the implications of the private market for student loans in the presence of public funding for student loans? In answering this question, we shed light on two additional issues: How important are credit risk and the private student loan market for college investment? How do borrowing and default behavior in both the government and private markets for student loans vary across individual characteristics? To our knowledge, this is the first paper to quantify these effects in a model that is able to replicate observed patterns in borrowing and default behavior in student loans. We demonstrate the importance of accounting for the interaction between government and

[1] Section 1.2 includes a discussion about recent policy changes in the government and private market for student loans.

private student loan markets when studying higher education policies.

We develop a general equilibrium 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 risk type which summarizes the likelihood of default, all of which are observable. We assume that ability, credit type, and family income are positively correlated and that the returns to college increase in ability (consistent with the data). 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 type and offer type-contingent credit terms.

In order to provide a credible laboratory for our policy counterfactuals, we ensure that our benchmark economy is consistent with borrowing and default behavior in the data. First, students from high-income families invest more in their college education, but borrow less than those from low-income families. In addition, default rates among rich students are lower than those of poor students. The same holds true for students with more college preparedness (or innate ability): high ability students have higher college enrollment rates, lower borrowing levels and lower aggregate default rates than those with low ability. As for credit type, we are the first to document that college investment is higher for students with good credit compared to those with bad credit.

We study the policy implications of the importance of credit risk for college investment and the interaction between the government and private student loan markets. Specifically, 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 by almost 10 percent, and students borrow more from the government and less from the private market. At the same time, 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 (7.8 percent compared to 3.1 percent in benchmark). Consequently, the lending terms in the private market become less favorable to compensate for greater default risk in equilibrium and the cost of default is transferred to borrowers via higher interest rates. We find that these effects have important welfare implications. In particular, in a partial equilibrium analysis where interest rates do not adjust with an increase in default risk, the model overstates the (positive) welfare impact of the policy (+0.12 percent). However, when the interaction between the private and the government sectors are accounted for in general equilibrium, 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, albeit the loss is small (-0.04 percent).

We then compare the effects of increasing government borrowing limits in the government student loan program to a set of budget-neutral tuition subsidies (equal, need-based and merit-based subsidies). Our main results are two-fold. First, we find that tuition subsidies lead to more college investment *and* higher aggregate welfare compared to higher government borrowing limits. This result hinges on the fact that, unlike higher government borrowing limits, subsidies increase college investment without increasing the default risk in the private market for student loans. Therefore, interest rates in the private market are lower under a tuition subsidy compared to an environment with higher government borrowing limits. Our second result is that merit-based tuition subsides lead to larger welfare gains than need-based subsidies, even though need-based subsidies encourage more college investment. Compared to the higher government limits policy, merit-based subsidies reduce default risk in both the government and private markets since they increase college enrollment rates among high-ability students. Need-based subsidies, on the other hand, induce a smaller decline in default risk in the private market and an increase in default risk in the government student loan program. In this case, low-income students are more likely to invest in college and borrow relatively more to finance their college education. Consequently, the welfare gain induced by merit-based subsidies is 0.45 percent compared to 0.35 percent with need-based subsidies.

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 higher default rates on student loans.

The richness of our model allows us to explore other dimensions of student loan markets that are currently not well understood because of the lack of a comprehensive dataset of credit risk, borrowing levels and default. Specifically, we find that low-income students benefit from having access to the private market for student loans. They are most likely to hit the government borrowing limit since they have large amounts of unmet financial need. In addition, low-income borrowers have higher incentives to default in the government market than in the private market, and especially those with good credit. For them, having good credit creates better loan conditions in the private market (for the entire life of the loan), encouraging college investment. Indeed, our results show that low-income students with good credit have college enrollment rates that are 22 percent higher than those with bad credit (compared to only 4 percent higher for high-income students).

Our analysis also delivers an interesting pattern of default behavior across borrowers with different ability levels. In the model, the disutility of defaulting in the private market is lower than the disutility of defaulting in the government market. This feature induces borrowers to default at higher rates in the private market for student loans. However, default in the private market results in exclusion from unsecured credit and this penalty is quite costly for individuals with low ability levels (and hence low earnings) and more than offsets the disutility effect. Consequently, low-ability agents have higher default rates in the government loan market, while high-ability agents have higher default rates in the private market. At the same time, the model delivers declining default rates in income and credit type for both government and private student loans. This type of interaction between the government and private market for student loans is very difficult to uncover in existing datasets and points to the importance of using a rich general equilibrium heterogeneous agent model to begin to understand these complexities.

1.1 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 risk in college investment (alongside the roles 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 in both government and private loans and argue that this 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 risk 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 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 interaction between the government and the private market for student loans 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 absorbs the excess demand for student loans when the government student loan is removed. However, the focus is on wealth-based and merit-based tuition subsidies and their implications for inequality. 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 in an 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. 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.

Our paper is related to studies that focus on the role of credit worthiness in unsecured credit markets, and in particular Chatterjee et al. (2011) and Athreya et al. (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. Athreya et al. (2012) 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 many of the changes seen in unsecured credit markets. Consistent with these theories, we model an observable credit risk as a proxy for the probability of default. However, given that our paper focuses on college investment and higher education policies, we simplify the model in terms of credit scores by not modelling informational asymmetries. Instead, credit risk 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 quantitative macroeconomic frameworks. 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 and Abbott et al. (2013) find that general equilibrium effects are important when analyzing education policies. 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. Different from the papers mentioned above, we find that merit-based subsidies induce larger welfare gains than need-based subsidies, even though need-based subsidies have a larger impact on college investment. Our paper is closely related to Garriga and Keightley (2007) who arrive at similar conclusions, albeit through a different mechanism. Specifically, Garriga and Keightley (2007) focus on the role of in-school labor supply and show that need-based subsidies increase college enrollment by attracting students from the lower end of the ability distribution (many of these students eventually drop-out or take longer than average to complete college). In the same vein, we find that need-based subsidies encourage college enrollment for low-income students.

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 recent concerns about increased default on student loans and calls for more transparency in lending practices.

1.2 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. Specifically, interest rates on Federal student loans are set in statute, following the Higher Education Reconciliation Act of 2005. In 2006, the interest rate for Federal student loans was set at 6.8 percent and it remained at this level for both subsidized and unsubsidized loans for several years.[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. There is a limit to how much students can borrow from the government. Prior to 2008, dependent students could 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 (Steele and Baum, 2009). Of those who borrow from the government, approx-

[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 represent 80 percent of the FSLP in recent years.

[3]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. Currently, interest rates on new Federal student loans made on or after July 1, 2013 are based on the 10-year Treasury rate, plus a fixed margin, but they are still fixed for the life of the loan. For details, see U.S. Department of Education (2014b) and https://www.edvisors.com/college-loans/federal/stafford/interest-rates/#sthash.NFFt7mdv.dpuf

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

imately 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. In reality, most borrowers pay 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 (U.S. Department of Education, 2014a) and has since increased, as Figure 2 in the Appendix shows. 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. 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 risk and hence vary across individuals and during the life of the loan. 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 Federal 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 somewhat rare; the annualized default rate was 3.3 percent in 2008. Private student loans, like Federal student loans, are 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 type of the student. In addition, default penalties differ across the two markets. Our study incorporates these features and discusses their implications for borrowing and default

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

behavior and points to the importance of these features for college investment and in evaluating policy.

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 risk $f \in F$, 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.

2.1 Credit Risk

In our model, credit risk f represents a signal about the agent's probability of repayment. We refer to f as credit risk type (in short, credit type) and assume it represents a perfect signal about individual default risk. There are no informational asymmetries in our model.[6] We assume that individuals of different credit types differ in default costs. In particular, we model two types of individuals: those with bad credit $(f = 0)$ and those with good credit $(f = 1)$. 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 this previous work focuses on credit card debt, while we model credit risk and default cost in the context of the student loan market. This fact has two important implications. First, unlike credit card debt, student loans are not 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 credit 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 by allowing 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,

[6] 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.

default is more costly for some borrowers than for others.[7]

2.2 Student Loans

Our model captures key features of the student loan program. Specifically, 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.[8] 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 interest rate on Federal student loans does not change during the life of the loan.

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.[9] 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 type of the agent, so that $R^p(f)$. Therefore, the interest rate on private loans may change during the life of the loan depending on the evolution of the borrower's credit type.

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 $D^p = d_{T_1+1}^p = \sum_{t=1}^{T_1} d_t^p \left[R^p(f)\right]^t$.

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,

[7] In reality, bad credit may also have negative consequences for the cost of receiving secured debt, insurance costs, and rental costs (Chatterjee et al., 2011). We therefore take a conservative approach in modeling the impact of credit risk on college investment. 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.

[8] 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.

[9] 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 when the government decides 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).

agents need to reorganize their debt and repay the student loan in the period after default. The interruption of default penalties provides sufficient incentives for borrowers to do so, as we explain below. 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 type evolves according to the following rules. Define f as the credit type in time t and $f^{'}$ as the type 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 type. When the borrower pays the amount that it is required ($p^p = \underline{p}^p$), his credit type changes as follows: if he has good credit ($f = 1$), his credit type does not change. If he has bad credit ($f = 0$), he may become a good credit type with probability α, or remain a bad type with probability $1-\alpha$. This mechanism captures the feedback between repayment behavior in the private market for student loans and credit risk. Also, we assume no default in other asset markets so we can isolate the relationship between the repayment behavior for private student loans and the credit risk of young borrowers.[10]

[10]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 risk of the individual rather than on the credit risk of the parent. The relationship between the credit risk of the parent and the child's investment in college is an interesting topic, which we leave for future research. At the same time, even though young agents have short credit history, their credit scores differ

To summarize, in our framework, default on student loans in both markets is penalized in two ways during the period when default occurs: through a utility cost and by not having the option to borrow in the risk-free market. Avoiding the continuation of these penalties gives defaulters an incentive to start repaying their defaulted loans. In addition, default in the private market for student loans 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 as shown in equations 2 and 3). In our model, people care about credit type since borrowers with bad credit are excluded from borrowing in the risk-free market, and face a penalty which captures the immediate impact of bad repayment behavior on participation in other credit markets.[11] This feature gives defaulters in the private market an additional incentive to start repaying their loans.

2.3 Labor Income

Agents are endowed with exogenous labor income that differs across education groups which 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.[12]

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 type 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 type has on college investment, compared to an environment without earnings uncertainty. Both persistent and transitory income shocks are relevant to replicate 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

significantly and are primarily based on the number of credit accounts (Avery et al., 2009).

[11]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.

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

levels of ability. Lastly, we link credit type to earnings in order to capture the fact that credit scores are a signal about the probability of default conditional on observables (such as wealth and income).

We specify log income, $\ln y_t^h$, of an agent at time t with ability a, credit type f and human capital $h = \{h_0, h_2, h_4\}$, which represent the three education groups in the model (no college, some college but no bachelor's degree, and four-year college graduates, respectively). The age-specific mean depends on education, ability, and credit type, 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 type on the age-education specific mean μ_t^h.[13] 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 (at $t = 1$) 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 type, 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

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

[13] Ideally, we would allow the riskiness of the income processes to depend on credit type. However, given data limitations for the estimation process, we instead capture earnings differences by credit type in the same manner that we capture ability differences in earnings. Explanations on the estimation procedure are provided in Section 5.

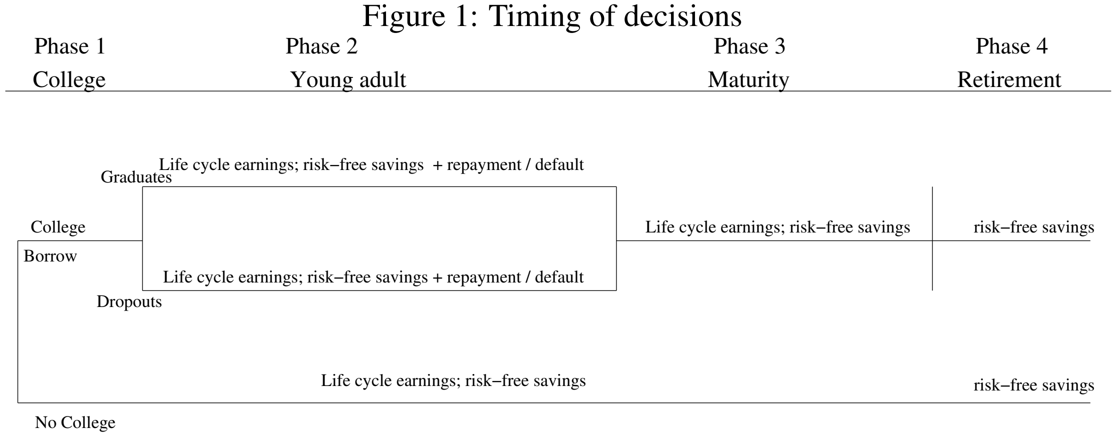
Total pre-transfer resources are given by $\max(0, s_t) + y_t$ and the means-testing restriction is represented by the term $\underline{\tau} - \max((0, s_t) + y_t)$. These resources are deducted to provide a minimal level of income, $\underline{\tau}$. For example, if $s_t + y_t > \underline{\tau}$ 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, they receive 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 type (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 $h = h_0$. In our environment, the college investment decision is purely a financial decision. If they decide to enroll in college, agents finance their consumption and college investment when young by using family contributions for college, b, intra-family transfers $Q(b)$, and student loans from the government and the private market. We assume there is no choice in college quality and hence consider only one type of college in the model. This assumption may be a bit restrictive given that drop-out rates, job outcomes, and default rates on student loans vary across different types of colleges, such as public, private and for-profit institutions (see Cellini and Darolia, 2015; Looney and Yannelis, 2015). However, this research shows that students who enroll at for-profit colleges are of lower ability, on average, and come from poorer backgrounds. These are precisely the type of individuals in our model who are more likely to get lower returns on their college investment and to default on their student loans (recall that our earnings function depends on the ability of the individual, following Abbott et al., 2013). 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). Even though our model does not fully capture heterogeneity in behavior by individuals enrolled in different types of colleges, to the extent that we account for heterogeneity in drop-out rates and job outcomes across ability levels, our model has implications (albeit in general terms) for the observed heterogeneity in borrowing and default behavior by school types.[14]

We assume that 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 $h = h_2$. In this way, our model captures drop-outs from four-year colleges, which represent a significant portion of college students (Gladieux and Perna, 2005). However, there are several assumptions that we make concerning drop-outs. First, the probability of dropping out depends on the ability of the individual. This is motivated by the fact that students' college preparedness is a strong signal for college success (Chatterjee and Ionescu, 2012). Second, we assume that college risk is realized at the end of college since the majority of drop-outs intend to complete a four-year degree (rather than dropping out early in their college career).[15] Third, we model dropping out as a pure risk of failing to acquire a four-year college degree, whereas in reality, students who do not complete four years of college may simply choose to leave college (see Arcidiacono, 2004; Manski and Wise, 1983; Stange, 2012; Stinebrickner and Stinebrickner, 2012). However, as shown in Chatterjee and Ionescu (2012), failing to graduate from college is quantitatively more important as a reason to drop-out than voluntarily leaving college.[16]

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

[14] We believe that accounting for heterogeneity in school quality could be a natural extension of the current study.

[15] Our modeling is motivated by empirical evidence that documents an average enrollment time of 3.5 years for drop-outs (Bound et al., 2009; Ionescu, 2011).

[16] In fact, Chatterjee and Ionescu (2012) also show that the fraction of college students who drop-out early is small using BPS data. Therefore, we believe our assumptions about drop-out behavior are not restrictive. Our model could be extended in the spirit of this previous work to account for different reasons and times for dropping out.

market, and pay a lump sum tax which finances the government student loan program. The key decisions that individuals make in this phase are repayment/default decisions on student loans in the two markets. 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 their 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.[17] 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, where ϕ represents retirement transfers as a fraction of last period's earnings (y_{T_3}).

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

$$V_4^C(s,t) = \max_{s'} u(\phi y_{T_3} + sR - s') + \beta V_4^C(s',t+1).$$

For the maturity phase ($j = 3$), the value function V_3^C is denoted as:

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

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

with the state space $(h,a,f,s,z,\varepsilon,t)$, representing education, h, ability, a, credit type, f, savings, s, and income shocks (z,ε), respectively. Credit type does not change during this phase since agents no longer make repayment/default decisions on their private student loans. During the maturity phase, agents earn labor income $y(h,a,f,z,\varepsilon)$ and the means-tested transfer $\tau(y,s)$, save or borrow $s^{'}$, pay a lump sum tax Θ, and earn (pay) the risk-free rate R on their previous period's saving/borrowing. 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.[18] 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 type, 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 repay or default on 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 (as a result of defaulting in the previous period) are penalized in the credit market, such that $s^{'} \geq 0$.[19]

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 in equation 1. 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 $i = g,p$. This assumption is consistent with the fact that in reality the majority of borrowers pay off their loans within 10 years after entering repayment.[20]

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, in which they begin phase two with education level h_4. In the case they do not acquire a college degree, however, agents start phase two as college drop-outs with education level, h_2. Thus, the value function for the last

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

[19] 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).

[20] Relaxing this assumption is a natural extension, in particular with the prevalence of income driven repayment plans, which extend the life of the loan up to 25 years. This will simply result in lower per period payments without changing the nature of our analysis, given that these repayment plans are available for both government and private student loans.

period in college ($t = T_1$) is given by:

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

For any other period in college the value function is given by:

$$V_1^C(a,b,f,t) = \max_{d^p,d^g} u\left(b - \bar{d} + d^p(b,f) + d^g(b) + Q(b)\right) + \beta V_1^C(a,b,f,t+1) \quad (6)$$

with $V^C(a,b,f,1)$ being 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 expected annual family contributions b and intra-family transfers $Q(b)$ to finance college.[21] 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, $t = 1,2,3,4$. We assume 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. We also assume that college students forgo four years of labor income and attend college full-time (if they attend college at all).[22]

No college

Agents who do not go to college $h = h_0$ 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 type during the young adult phase, and thus the credit type 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

[21] Our modeling recognizes the fact that while expected family contributions are important for eligibility for student loans, actual family contributions during college may be different. In our model, $Q(b)$ captures the difference. This feature is also 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.

[22] 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.

credit in that they cannot borrow in the risk-free market during phase two.[23] 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 maturity phases are:

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

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

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

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

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

At the beginning of life, agents choose between the college and no-college paths and hence solve:

$$\max\{V^C(a,b,f,1), V^N(a,b,f,1)\}. \tag{7}$$

where $V^N(a,b,f,1) = E_{z,\varepsilon} V_1^N(a,b,f,z,\varepsilon,1)$ and $V^C(a,b,f,1)$ as defined in equation 6.

2.6 Private creditors

The private market for student loans is competitive: the representative private creditor takes prices as given and the creditor can borrow and lend in the risk-free capital market at interest rate R. 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 et al., 2012; Li and Sarte, 2006).

Pricing of private student loans in the model arises from the condition that private student lenders earn zero profits on any contract type. The private creditor uses the credit type of borrowers to assess the 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 type and D^p represents the accumulated debt at the rate R^p during college, given by:

[23]Both these assumptions are made so that the college and the no college paths are symmetric regarding the role of credit risk.

$$D^p(d_1^p,...,d_{T_1}^p,R^p) = \sum_{t=1}^{T_1} R^{p(T_1-1)} d_t^p. \tag{8}$$

The lender has perfect information about the agent's probability of default and so loan contracts are actuarially fair. Our problem is consistent with theories of default, as standardized by Chatterjee et al. (2007). In contrast to their paper, we have features specific to the private market for student loans requiring that our pricing mechanism be slightly different from those representing credit card markets. For example, only individuals who go to college have access to this market and they make borrowing decisions during college. Recall that this is one-time decision and individuals do not go back to college later in life. Therefore, the creditor in the private student loan market 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:

$$\sum_{k \in \Phi_p(d^p,f)} \left\{ \sum_{t=T_1+1}^{T_2} \frac{1}{R^{t-1}} (1-\omega^p(d_1^p,...,d_{T_1}^p,f,t)) \left[\underline{p_t^p}(d_1^p,...,d_{T_1}^p,f,R^p) \right] \right\} - (1+q) \sum_{t=1}^{T_1} \frac{d_t^p}{R^{t-1}}. \tag{9}$$

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 (9) represents the expected present value of total payments made by all agents of type f who borrowed D^p from the private market for the entire college period and who do not default on their loans in period t during the repayment phase. Recall that the per period payment 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 type 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 9 represents the probability that an agent of type f with the size of the loan d^p defaults on his loans at time t.[24] Also recall that defaulters enter repayment in the period after default occurs. Therefore, the private creditor

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

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:

$$D^p(d_1^p, ..., d_{T_1}^p, R^p) = p^p(d_1^p, ..., d_{T_1}^p, f, R^p)(\frac{1 - R^{p(-T_2 - T_1)}}{R^p - 1}). \tag{10}$$

Then, to get from the zero profit condition to the contract-specific interest rate we use equation 10 and replace D^p determined by equation 8 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 type (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 being the transaction cost per unit of loan. This modeling feature captures the fact that different borrowers have different likelihoods of default and the private lender prices the loans accordingly. Also recall that credit type may change over time depending on the individual repayment and default behavior. Therefore, the interest rate on private student loans may change over time.

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: $\Phi_g(d^g) = \{k \in A \times B \times F \mid V^C(k) \geq V^N(k) \text{ and } d^g(k) = d^g\}$. The government budget constraint is given by

$$\sum_{k \in \Phi_g(d^g)} \left(\sum_{t=1}^{T_1} \frac{1}{R^t} d^g \right) = \sum_{k \in \Phi_g(d^g)} \left[(1-\omega^g) \sum_{t=T_1+1}^{T_2} \frac{1}{R^{t-1}} \underline{p^g} \right] + \sum_{k \in X} \left[\sum_{t=T_1+1}^{T_3} \frac{1}{R^{t-1}} \Theta_1 \right]. \quad (11)$$

Equation 11 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 11 represents the probability of default in the government program. 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.[25]

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. This formulation captures the interaction between the private and the government market for student loans

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

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, $\{\omega^g, \omega^p, p^g, p^p, d^g, d^p\}$; ii) credit type f; and interest rates in the private market for student loans $\{R^p(f)\}$; given earnings $y(h,a,z,\varepsilon)$, intra-family transfers $Q(b)$, the risk-free rate and the government student loan rate $\{R, R^g\}$, and 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 (equation 11).
3. The profits of the private creditors for each (d^p, f)-type contract are zero (equation 9).

There are two important comments worth mentioning here. First, we follow Athreya (2008) and keep the risk-free interest rate exogenous. Second, we abstract from delivering wages from a labor market condition in equilibrium. 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.[26]

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 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 7). 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).

[26]Our model therefore has limited scope for the analysis of the relationship between default behavior and labor market conditions. However, this is an interesting avenue to pursue in light of the trends in default rates during and after the financial crisis when borrowers faced worse job outcomes (see Figure 2 in the Appendix).

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 the year 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 type 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 also use the NELS:1988 for enrollment rates.[27] In addition, we use several other data sources to test the predictions of the model across different groups of individual characteristics, namely the Beginning Postsecondary Student Longitudinal Survey (BPS) 2004/2009, the Credit Panel Equifax data, and the Survey of Consumer Finances data. A detailed description of all these data sets, the samples used and the computed moments are included in the Appendix (Section 7.1).

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

[27]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.

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 type, 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 expected family contributions (b), credit type (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, and ρ_{ij} the correlation coefficients of b, f, and a.

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.[28]

To estimate the distribution of credit type $F(f)$, 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 20 to 30 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 Equifax Risk Score in 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.

Expected family contributions (EFC) are a good predictor for actual family contributions for college, but EFC estimates vary across various surveys and differences may arise between EFC and actual family distributions.[29] Therefore, we take the following approach in calibrating EFC and accounting for actual contributions during college. Given the importance of EFC for receiving student loans in both markets, we estimate moments of the distribution for expected family contributions (μ_b, σ_b) such that our model matches participation rates in the government and private student loan markets (45 percent and 17.5 percent, respectively) rather than assuming an exogenous distribution. In addition, we recognize that differences between EFC and actual family contributions may arise and allow for intra-family transfers during college, $Q(b)$, in addition to EFC and we jointly estimate these transfers to match college enrollment rates by family contributions for college. Details on the estimates are provided in Section 3.4.

We set the correlations between all three initial characteristics (b, f, a) as follows. 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 type.

[28]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.

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

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.

We calibrate the cost of college to academic years 2003-2004 through 2007-2008. The net price of college for these years, which is total student charges (tuition, fees, room, and board) net of grants and education credits was \$33,849 for public universities and \$78,570 for private universities, as reported by the College Board (2007). 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 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 type and debt. We consider three levels of debt in the private market for each credit type. 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 type is penalized: individuals will have bad credit following default. 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 type 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.[30] 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 use these estimates to compute the mean earnings of each ability-education group relative to

[30]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.

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 type (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.[31]

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 $Z^4 = \{0.9314, 1.0686\}$.

[31] Note that we group college drop-outs together with college graduates because of the small number of observations for college drop-outs 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.[32]

[32]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).[33] 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, $\mu^p(1) = \mu^g(1)$. 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.[34] One challenge in the calibration of default costs to match default behavior is that we observe aggregate default rates for each market (from the U.S. Department of Education releases and Sallie Mae surveys) but not across individuals of different credit types. In addition, we observe various measures of delinquency rates across individuals of different credit types but for both government and private student loans together (from Equifax data). To overcome these issues, we construct our own measure of the default rate (in Equifax data) as follows: we use the measure for 120+ days delinquency for student loans and further restrict it to individuals who report being delinquent for at least two quarters in a year. This measure is the closest one to the national two-year cohort default rate for student loans (which is based on 270+ days). As illustrated in Figure 2 in the Appendix, the two measures match up quite well. Using these measures, 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).[35] We obtain the utility cost for default for individuals with bad credit in the government student loan market $\mu^g 0) = 0.00991$ and in the private market $\mu^p(0) = 0.00766$. For individuals with good credit, the utility cost is $\mu^g(1) = \mu^p(1) = 0.013$. 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

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

[34]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.

[35]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.

type), 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 estimates 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 expected family contributions, based on NELS:1988 data. As evidenced by Table 2, the model does a 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.

As shown in Tables 2 and 3, the model does well in matching the targeted moments. In addition, we compare and discuss our model predictions to the data on a variety of non-targeted moments in Section 4.3.

4 Benchmark Results

In this section, we analyze the benchmark economy and study how credit risk interacts with other characteristics — namely, 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. We then assess the performance of our model by comparing our results to observed patterns in the data.

Before presenting the quantitative predictions of the model, we describe the economic intuition behind college enrollment, borrowing, and repayment decisions in our economy. The structure of our model is such that individuals who enroll in college will first use their own assets to finance college, then government loans (that are based on initial assets b) and, if there are still college costs to cover, they will borrow private loans (based on both b and credit type f). At the same time, ability, credit type, and returns to college are positively correlated. Given the logic of our model, individuals will self-select into college and then decide how to finance their college education. For instance, individuals with low ability will not go to college if they have few assets and/or their credit type is bad. Individuals with enough assets and high ability will chose to attend to college. Those with high ability and median assets will use both their own resources and government loans to finance college. Finally, individuals with high ability and low assets will use all three sources of funds, regardless of their credit type. Thus, credit type and the private student loan market are relevant for the first and last set of agents.

Turning to the quantitative predictions, our economy delivers results that are consistent with the data. First, the college enrollment rate is 65.6 percent and the four-year college completion rate conditional on enrolling in college is 74.8 percent (compared to 65.5 and 74.9 percent in the data, respectively). This implies that 49.1 percent of agents in the model have a four-year college degree. Second, individuals in the model borrow \$13,227 on average to finance college: \$8,157 from the government and \$5,070 from the private market.[36] 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 consistent with the College Board (2009).

Furthermore, interest rates in the private market decrease with individual credit type, which depends on default behavior. Specifically, the model delivers no default in the private market for individuals with good credit, but positive default that increases in the amount of debt for individuals with bad credit. Our model yields a 9 percent interest rate for all debt contracts with good credit and interest rates between 10.1 and 12.1 percent for debt contracts with bad credit; notice that for the latter, interest rates increase with the size of the loan. Our predictions about interest rates are consistent with several key facts. First, 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 interest 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 interest rates in the private market 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 default risk is relatively small, whereas in reality the recovery rate may

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

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 suggests that credit type 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 we describe 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, ability, and credit type. We report college enrollment rates, the percent of agents with a four-year college degree,[38] debt levels and default rates in both student loan markets.

The model predicts that poor individuals (in the bottom tercile of family contributions) need to borrow much more than wealthy individuals. Notice 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). Recall that these individuals experience relatively low returns to college investment given a positive correlation between ability and income, and between ability and earnings. The combination of high student loan indebtedness and low lifetime earnings leads to high default rates for this group, as Table 4 shows.

We also find significant differences in college investment and borrowing behavior across ability types. The positive correlation with ability and college enrollment, as observed in the data, is driven by the trade-off between the returns to college (which are positively related to ability) and the financial need for loans (which is negatively related to ability).[39] An interesting result is that default patterns across ability levels are quite different in the government market compared to 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 (which is

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

[38]The latter consists of multiplying the enrollment rates (which are endogenous in the model) by college completion rates (which are exogenous).

[39]Table 6 in Section 4.3 delivers all of the data counterparts for the model.

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)				
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 type (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 type, the bad group represents 25 percent and the good group 75 percent.

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 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 risk 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 less 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 government loans.[40] Our results regarding borrowing and default behavior in the two markets for student loans across groups of family income and ability are novel and provide insights for policy design, which we explore in Section 5.

4.2 Importance of credit type

In addition to family contributions and ability, we find an important role for credit type in the college investment decision. Table 4 illustrates that college enrollment rates are 53.7 percent

[40] These trade-offs do not exclude the possibility that borrowers may also borrow in the risk-free market to repay their student loans.

for agents with bad credit and 69.6 percent for agents with good credit. What drives this result? We believe there are three forces at play.

First, we document differences in default costs and earnings across individuals of different credit types. Specifically, borrowers with good credit have a higher disutility of default than borrowers with bad credit. 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 of the data, as explained in Section 3.3). 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 type 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 those with bad credit.

Third, there are differences dictated by institutional details. Credit type 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. (Note that our quantitative results are lower bounds since we do not incorporate all of the mechanisms in credit markets that could affect interest rates.) 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 type will be revised downward and the penalty is long-lasting. At the same time, the 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 type increases with the size of the loan as default risk increases, 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 type for college investment is driven by the correlation between initial family income and credit type? And how much is driven by institutional arrangements and differences across individuals with different credit type? To isolate the effects of these channels, we look at college enrollment rates by credit type conditional on initial family income, b (reported in Table 5).

Table 5: College Enrollment Rates by Credit Type

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

Note that there are gaps in enrollment rates by credit type 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 nearly half 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 risk is quantitatively important for college investment, and in particular for poor students. This set of results contributes to the literature in showing that credit type is an important dimension to consider when analyzing college investment decisions, in addition to those traditionally studied in the literature (e.g., ability and family income).

4.3 Model Implications and Data Counterparts

Before exploring the policy implications of our research, we compare our model to the data and asses how well the model does in capturing the observed behavior along the three dimensions of heterogeneity in our framework (most of which are not targeted in the calibration). In addition, we analyze borrowing and default behavior for different levels of college attainment in the model and the data. Before presenting our findings from the data, it is important to note that there is not a single data source that contains information on family contributions/income, ability, credit type, educational attainment, borrowing and default behavior. We therefore use four different datasets: Beginning Postsecondary Student Longitudinal Survey (BPS 04/09), National Education Longitudinal Study (NELS:1988), Survey of Consumer Finances (SCF) and FRBNY Consumer Credit Panel (Equifax), all of which are described in detail in the Appendix. There are two important points to make: (1) we target only college enrollment rates across different levels of family contributions using NELS data and default rates across credit types from Equifax, a, and (2) none of the data sources fully distinguish between private and public student loans, so at best we can compare our model and its implications to the government student loan market or to aggregate measures of student loans to those in the data. All of the other moments are not targeted. The findings from the data are reported in Table 6.[41]

Table 6: Data Counterpart

	College enrollment rate	Percent with a four-year college degree	Average debt (total)	Default rates (govt only unless noted)
Family contributions (b)				
Low	52.5%	24.6%	\$13,565	11.5%
Medium	65.5%	43%	\$14,734	3.9%
High	78.5%	56.5%	\$11,586	1.5%
Ability of the student (a)				
Low	53%	30%	\$14,391	6%
Medium	65.6%	50.4%	\$14,269	3.1%
High	85.5%	68.7%	\$13,190	1.3%
Credit type (f)			SCF/Equifax	Default for govt + private
Bad	54%	37%	\$17,312/\$15,048	30%
Good	57%	50%	\$11,237/\$20,718	1.4%

Our findings are broadly consistent with the data in terms of educational attainment, debt levels and default rates across various characteristics (compare Table 6 with Table 4). College enrollment and college completion increase in family contributions, ability and credit type in the data, which is what we find in our model. Quantitatively, we do very well in replicating enrollment and completion rates, especially by family contributions and ability. We nearly match college completion rates for individuals with bad and good credit with the data. SCF data suggest that college enrollment rates, however, are not that different for individuals with different credit types (a 3 percentage point different), whereas our model suggests a much higher enrollment rate for those with good credit (a 16 percentage point difference). Much of this is due to differences between the SCF data and the structure of the model (such as the timing of credit status and educational attainment, which are described in the Appendix). In the model, individuals know they face different interest rates, which are based on credit type, whereas in reality students may not fully understand their loan terms at the time they enroll in college. Still, we are satisfied that our model is delivering important features of the data in a variety of dimensions.

In the third column of Table 6, we report average (total) student loan debt. Similar to our model predictions, total student loan debt generally falls in family contributions and

[41]Please refer to Table 10 in the Appendix for a detailed list of sources used to produce Table 6.

ability (the one exception is that debt is slightly higher for middle-income students than low-income students in the data). As for debt levels by credit type, the evidence is mixed. Debt levels are lower for individuals with good credit, whereas in Equifax data the reverse is true: students with good credit have higher debt levels than those with bad credit. This is primarily driven by the fact that the debt levels in SCF represent outstanding college debt, while in Equifax they represent outstanding balances at the time when the data was collected (which coincides with when credit scores are reported).[42] Therefore, it is likely there are some other interactions between repayment/delinquent behavior, the credit score, and the outstanding balance in Equifax data. In our model, however, debt represents the amount students walk away from college with and is in line with SCF data. In fact, our model predictions are consistent with the findings from the SCF.

The last column of Table 6 reports default rates in the government market using BPS data. Importantly, default rates are lower in BPS data than in both the model and Equifax data given the differences in measurements. In particular, given the short time span after entering repayment on student loans, we expect the measure of default in the BPS data to be lower than the measure in Equifax and the overall aggregate number.[43] Still, at least qualitatively, default rates on government student loans fall in income and ability, consistent with our findings (recall that default rates by credit type are targeted in the calibration).

Next, we take a close look at constrained borrowers in both the model and the data. Specifically, using BPS data, we compute the percent of student borrowers who borrow the maximum amount from the government; we find that the percent who hit the borrowing limit increases in both ability and family contributions. For example, for individuals in the lowest tercile of income, 36 percent hit the government borrowing limit, while for the richest students, 52.5 percent borrow the maximum amount. However, in our model, rich students do not hit the government borrowing limit since they are borrowing very little. The discrepancy between the model versus the data is because there is no choice regarding college quality in our model. Given that all agents in our model face the same college costs, our model does not capture the fact that the richest students are attending more expensive colleges and hence need to borrow more to finance their college education. Certainly, future work could allow for a college choice mechanism that could exploit variation in college quality.

In addition, we compare the model predictions with the data in terms of college graduates

[42] Debt levels in general are higher in Equifax than in SCF, as documented by Brown et al. (2014).

[43] The default question in the BPS is asked in 2009, right after students are out of college with or without a degree (and it is available only for Federal student loans). This measure is not the exact counterpart of our model, which represents a two-year cohort default rate, in line with the official release from the U.S. Department of Education and our measure from Equifax data (as explained in Section 3).

versus college drop-outs given that college drop-outs are an important part of the story when thinking about the population of student loan defaulters. In our model, college drop-outs are those who do not complete a four-year degree by the end of T_1; thus, they include those with a two-year degree. This is consistent with how we define college drop-outs in the BPS data, namely the fraction of students who report not having earned a bachelor's degree by 2009 and are no longer enrolled in college. We find that the model does a good job in predicting the observed borrowing and default behavior for college drop-outs and college graduates. Specifically, in both the model and the data, college graduates are more likely to participate in the government student loan program than drop-outs (90 percent versus 22 percent in the model and 82 percent versus 18 percent in BPS data); in addition, college graduates have higher average (total) debt levels and more often hit the government borrowing limit than college drop-outs, again consistent with the data. The default rates of college graduates (in the government market) are much lower then those of college drop-outs (3.8 percent versus 45 percent in the model and 0.2 percent versus 6.75 percent in the data).[44] This points to the importance of the debt-to-income ratios in default behavior: with high returns to college, college graduates experience higher income levels which reduces the likelihood that they will default, even though their borrowing levels are higher.

Our analysis across individuals with different default status also confirms this fact: we find that defaulters have higher debt-to-income ratios relative to non-defaulters. For instance, the ratio of Federal student loans to annual income in 2009 in the BPS is 66.8 percent for defaulters versus 56.1 percent for non-defaulters.[45] Our model is consistent with this fact: we find that defaulters have lower EFC and ability levels, on average. But this in turn implies both higher student debt levels and lower returns to college. Indeed, we find that, on average, defaulters have higher debt levels than non-defaulters. The differences between defaulters and non-defaulters are not as large, however, compared to the differences in debt-to-income ratios. Defaulters experience much lower income levels, on average, which drives up their debt-to-income ratios relative to non-defaulters.

To conclude, our model is able to explain observed behavior regarding college investment, borrowing and default across key individual characteristics, and in particular by credit type. There is currently very little known about the role of credit type in the college invest-

[44]The differences in default rates is mostly due to differences in measurement, as we discuss in Section 7.2.

[45]BPS data provides this ratio for cumulative Federal loans relative to reported annual income in 2009. The data is top-coded so that those with cumulative Federal loans over 100 percent of income were set to 100. Also, recall that there is no income information in Equifax and that the measurement of outstanding debt in Equifax is not the exact counterpart of our model. Therefore, we compare our model predictions with these moments in the BPS data.

ment decision and the implications of credit type on borrowing and default behavior in the student loan market. Our model matches important features of the data in this dimension along with other individual characteristics, namely ability and family contributions. We now turn to exploring the policy implications of our model.

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 since 2007, in part due to the financial crisis and in part due to a recent expansion of the government student loan program. We 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 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. Beginning in 2008, undergraduate students can borrow up to \$31,000 total for college (up from \$23,000).[46] We analyze the effects of the expansion of the government student loan program in a general equilibrium (GE) and in a partial equilibrium (PE) framework. A general equilibrium is defined in definition 1 in Section 2.8, while a partial equilibrium does not require equations 9 and 11 to hold. Intuitively, the feedback between the public and private student loan markets is shut down in the PE framework because interest rates in the private market do not adjust to deliver zero profits for the private lender. Table 7 provides the aggregate results for all of the policy experiments.

5.1.1 General equilibrium analysis

With a higher borrowing limit, 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

[46]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 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.

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.

The expanded 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. 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 high ability 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. As a result, interest rates in the private market increase relative to the benchmark to account for the extra default risk. 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. 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. Consequently, the higher cost of the government student loan program requires taxes to increase since wage garnishments are fixed.

The equilibrium adjustments have important welfare implications. 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 equally-weighted aggregate function. Our

Table 7: Aggregate Results: Benchmark vs. Policy Experiments

Variables	Benchmark	Higher govt limit: GE	Higher govt limit: PE
College enrollment rate	65.6%	75.3%	70.9%
Percent with a four-year college degree	49.1%	55.8%	52.7%
Participation in govt mkt	48.2%	55.7%	52.4%
Participation in private mkt	17.8%	9.8%	9.2%
Default rate in govt mkt	7%	7.6%	7.7%
Default rate in private mkt	3.1%	7.8%	9.3%
Average govt debt	$8,157	$9,589	$9,585
Average private debt	$5,070	$3,998	$3,978
Aggregate welfare change	—	-0.04%	+0.12%
Avg rate in the private mkt w/ bad credit	11.2%	11.7%	11.2%
Avg rate in the private mkt w/ good credit	9%	9%	9%

welfare calculations assume exogenous earnings and high recovery rates for student loans.[47]

5.1.2 General equilibrium versus partial equilibrium analysis

As shown in Table 7, there are several important differences between the PE and GE cases. 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 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. Unlike in the GE analysis, the policy in the PE case 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. The negative effects of higher interest rates and taxes are absent in the PE setting.

[47] Welfare in our economy ignores the changing skill premia 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.

Table 8: 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 type (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.

5.1.3 Allocational consequences

Who benefits the most from this policy? As Table 8 illustrates, college investment increases for all types of students.[48] 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. However, a more generous government student loan program encourages all types of students to substitute away from private loans towards government loans to finance their increased

[48]For brevity, we show the quantitative results for the GE case, but all of the other results are available from the authors.

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. Unlike the former, students with low and medium levels of ability experience lower returns to education and even though they have higher educational attainment relative to the benchmark economy, the positive impact of higher earnings for them is not enough to compensate for more expensive private student loans and higher taxes.

Students with bad and good credit invest in college at higher rates with a higher government borrowing limit: they 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.

To summarize, 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 type. 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 7). 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). Our findings point to the importance of understanding the characteristics of students who borrow from both the government and student loan market as student loan policies evolve over time. In fact, there is a national conversation taking place right now that calls for increasing transparency in the borrowing and repayment process for student loans. In addition, borrowers are participating at higher rates in income-driven repayment (IDR) plans, especially in the government student loan program. While these plans are more generous in that they reduce financial distress, especially for students with high debt-to-income levels and allow for partial dischargeability, IDR's entail multiple eligibility criteria and repayment rules, especially in the private market, and thus introduce more complexity into the process. This suggests that expansions in the government borrowing limits and, in general, a more generous student loan program, should consider the consequences on borrowing and default behavior in student loan markets.

5.2 Tuition subsidies

We study three budget-neutral subsidy policies: an equally distributed tuition subsidy, 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: an equally distributed subsidy of $255, a merit-based subsidy of $654 for high-ability students and a need-based subsidy of $702 for low-income students.[49]

Our main finding is that compared to the government policy of raising the borrowing limits on government student loans, all three types of tuition subsidies increase college investment *and* improve aggregate welfare, as reported in Table 9. The gains in aggregate welfare are 0.38 percent with an equal tuition subsidy, 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 in GE). There are two main factors that contribute to these welfare results. First, tuition subsidies reduce the cost of college enough to promote college investment without increasing borrowing levels. We find that tuition subsidies have a larger positive effect on college investment compared to higher government borrowing limits. A key second factor that explains these welfare gains is that unlike an increase in government borrowing limits, subsidies do not increase default rates in the private market for student loans. Recall that low-income and high-ability students are risky borrowers in 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, although their participation rates increase (because more students go to college). The two forces offset each other so the default rate in the private market remains close to its benchmark level for need-based and equal subsidies and a bit lower in the case of merit-based subsidies. Consequently, the interest rates in the private market for student loans remain at low levels (as in the benchmark economy).

Why do merit-based subsidies induce higher welfare gains relative to the benchmark economy compared to need-based subsidies? This result may seem counter-intuitive, espe-

[49]We acknowledge several caveats of our model regarding tuition subsidies. First, we assume that college costs are not adjusted in response to subsidy policies. Second, agents cannot choose to improve college preparedness (or ability) in response to merit-based subsidies or cannot adjust family contributions for college in response to need-based subsidies.

cially given the larger increase in college enrollment with the need-based subsidy.[50] Importantly, the two types of 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 exhibit high default risk for government loans, whereas high-ability students have low default risk. With need-based subsidies, low-income students invest in college at higher rates. However, low-income students still need to borrow from the government. 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, 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. At the same time, the default rate in the private market declines a bit more in the case of merit-based subsidy and the interest rate for private student loans is lower. As a result, welfare gains are higher in the case of a merit-based subsidy compared to the need-based subsidy.

Our results are comparable to those in Akyol and Athreya (2005), Garriga and Keightley (2007), and Abbott et al. (2013), who find that tuition subsidies (in general) are welfare-improving. We contribute to this literature in two important ways. First, we analyze the effects of different tuition subsidies across students who differ in their credit type. As evident in Table 9, students with good credit benefit relatively more from merit-based and equal subsidies (compared to those with bad credit). This contrasts to the case of need-based subsidies where welfare gains are exactly the same across credit types. Individuals with bad credit receive higher subsidies given the correlation between income and credit type. They also face slightly higher interest rates in the private market (relative to other types of subsidies). The need-based subsidy makes college more attractive for low-income students who

[50]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 9: Aggregate Results: Tuition Subsidies

Variables	Benchmark	Higher govt limit: GE	Equal subsidy	Need-based subsidy	Merit-based subsidy
College enrollment rate	65.6%	75.3%	83.8%	84.9%	76.1%
Percent with a four-year college degree	49.1%	55.8%	61.6%	62.1%	56.4%
Participation in govt mkt	48.2%	55.7%	62%	63.6%	54.8%
Participation in private mkt	17.8%	9.8%	23.5%	28.5%	19.5%
Default rate in govt mkt	7.0%	7.6%	9.2%	10%	6.7%
Default rate in private mkt	3.1%	7.8%	2.75%	3.1%	2.4%
Average govt debt	$8,157	$9,589	$8,279	$8,505	$7,993
Average private debt	$5,070	$3,998	$5,065	$5,073	$4,780
Aggregate welfare change	—	-0.04%	+0.38%	+0.35%	+0.45%
Avg rate in the private mkt w/ bad credit	11.2%	11.7%	11.2%	11.3%	11%
Avg rate in the private mkt w/ good credit	9%	9%	9%	9%	9%

borrow more in the private market and have relatively high default risk. We find that the most effective policies (in terms of aggregate welfare) are merit-based subsidies; this contrasts to Abbott et al. (2013), for instance, who find that need-based subsidies lead to larger welfare gains. Default rates in the government market are high in the case of need-based subsidies. This 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 comparable interest rates in equilibrium. The equilibrium adjustments dampen the welfare effects of the need-based subsidy relative to those of the merit-based subsidy. However, our findings are similar in spirit to those in Garriga and Keightley (2007) who show that, although merit based subsidies have small enrollment responses, they counteract adverse selection problems that need-based subsidies create.

To summarize, by providing tuition subsidies (of any sort), the government is reducing financial need for students, and this lowers default incentives in the private market for student loans. 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 encourage college investment, as opposed to an expansion of the government student loan program. More generally, while student loan default provides some insurance and repayment relief to some borrowers, the negative consequences of default can be significant. Tuition subsidies minimize the negative effects of defaulting on student loans and prove to be superior in terms of aggregate welfare.

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 type of the student. As a result, credit type may affect the college investment decision which in turn affects borrowing and default behavior. Due to limitations in the data, little is currently understood about how different types of college students use the combination of government and private student loans to finance their college expenditures. We build a life-cycle model where agents are heterogeneous in family income, ability and credit type and document important differences in borrowing and default behavior across different individual characteristics.

We find that credit type plays a role for college investment and that there are significant interactions in borrowing and default behavior between the government and the private markets for student loans, which have important policy implications. Specifically, our results reveal that a recent policy that increased the borrowing limits in the government student loan program increases college investment as students borrow more from the government and less from the private market. However, we find that 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, while inducing important distributional effects in the economy.

Furthermore, our analysis shows that tuition subsidies are welfare superior to increasing government borrowing limits because subsidies minimize the adverse effects on private credit markets. 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 for student loans 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.

7 Appendix

7.1 Description of data sets and samples

We present the datasets we use to study observed patterns of college enrollment and attainment, borrowing and default behavior across various individual characteristics. It is important to note that there is not a single data source that contains information on family contribution, ability, credit type, educational attainment, borrowing and default behavior. Therefore, we use four data sets: Beginning Postsecondary Student Longitudinal Survey (BPS 04/09), National Education Longitudinal Study (NELS:1988), Survey of Consumer Finances (SCF) and FRBNY Consumer Credit Panel (Equifax). Specifically, the Equifax dataset contains detailed credit-related information (e.g., repayment and various measures of delinquencies), but does not provide demographic characteristics (with the exception of age). Most notably, it lacks any information about income or educational attainment/enrollment. Contrast this with data from the U.S. Department of Education (namely, the BPS and NELS), which provide detailed information about enrollment, educational attainment, sources of financing, and demographic characteristics. U.S. Department of Education data also contain some information about default behavior, but does not provide any information on credit type. The Survey of Consumer Finances (SCF), on the other hand, provides self-reported information about credit type (as discussed in Section 3.1 of the paper) and educational attainment, but it does not provide information about student loan default behavior. We next provide a detailed description of each data set and sample used in the analysis.

Beginning Postsecondary Student Longitudinal Survey (BPS 04/09)

The Beginning Postsecondary Student Longitudinal Survey (BPS 04/09) is one of several National Center for Education Statistics (NCES)-sponsored studies that is a nationally representative dataset with a focus on post-secondary education indicators. BPS cohorts include beginners in post-secondary schools who are surveyed at three points in time: in their first year in the National Postsecondary Student Aid Study (NPSAS), and then three and six years after first starting their post-secondary education in follow-up surveys. BPS collects data on a variety of topics, including student demographics, school experiences, persistence, borrowing/repayment of student loans, and degree attainment six years after enrollment.

Our sample consists of students aged 20-30 who enroll in a four-year college following high school graduation. For demographic characteristics, we use SAT (and converted ACT) scores as the measure of ability (or college preparation) and expected family contribution

(EFC), a measure which we check with reported family income. The survey records the fraction of students who, six years later, report having earned a bachelor's degree. We exclude students who continue with graduate studies since they are not part of our model. We divide the population into terciles of ability and family contribution and compute our model counterparts, including the fraction with a four-year degree, the amount of debt owed at the end of college (total student loan debt in the BPS includes both Federal and private student loans but it does not include Parent Plus loans), and default rates. It is important to note that the information on default status is limited. The question is asked in 2009, right after students are out of college (with or without a degree) and it is available only for Federal student loans. Therefore this measure is not the exact counterpart of our model, which represents a two-year cohort default rate, in line with the official release from the U.S. Department of Education and our measure from Equifax data (as explained in Section 3). In particular, we would expect the measure of default in the BPS data to be lower than the measure in Equifax and the overall aggregate number.

In addition, we use the BPS data to compute the fraction of borrowers who are constrained (e.g., hit the maximum government borrowing limit) across different terciles of EFC and SAT scores. We also use the BPS data for college drop-outs, defined as individuals who do not have a bachelor's degree by 2009 and are no longer enrolled in college.

National Education Longitudinal Study (NELS:1988)

The National Education Longitudinal Study (NELS:1988) is a nationally representative sample of eighth-graders who were first surveyed in the spring of 1988. A sample of these respondents were then resurveyed through four follow-up surveys in 1990, 1992, 1994, and 2000. We use the third follow-up survey when most respondents completed high school and report their post-secondary access and choice. As in the BPS, demographic information, including SAT scores and EFC, are available. We use this data set to compute college enrollment rates by ability and family contributions. Our sample consists of recent high school graduates aged 20-30 who have taken the SAT (or ACT).

Survey of Consumer Finances (SCF)

We use the 2007 SCF data to produce estimates across households with good and bad credit. Importantly, unlike Equifax, which is individual data, the SCF surveys households. Therefore, the variables about bad credit are based on the household's credit history. We define households with bad credit as those who report being turned down for credit or did not get as much credit as they applied for based on their credit history (or lack thereof). The SCF includes the highest educational attainment of the household head so it is the best source for linking credit type and educational attainment (but does not contain SAT scores or EFC). The SCF data report a composite amount owed from all sources of student loans, but it does not contain any details about default on student loans. To be consistent with the BPS and NELS samples, our SCF sample consists of household heads who have at least a high school degree and are between the ages of 20 and 30. We use the SCF to compute enrollment rates, the percent with a four-year college degree and (total) student loan debt across households with different credit types (note that 25 percent of our sample has bad credit).

FRBNY Consumer Credit Panel (Equifax)

The FRBNY Consumer Credit Panel/Equifax data is a nationally representative five percent sample of all credit files and has a rich set of variables on consumers' credit behavior, including risk scores, various measures of delinquency and outstanding balances for all types of loans, including student loans. It is a longitudinal database and collects information derived from consumer credit reports to track individuals' and households' access to and use of credit at a quarterly frequency. There is no distinction, however, between Federal and private student loans and there are no demographic characteristics except for age. Consistent with samples in the other data sets we employ, our Equifax sample consists of young individuals (20-30 year-olds) who have positive student loan balances.[51] We use this data for default behavior and loan amounts by credit type. Consistent with our definition in the SCF, we define those with bad credit as in the bottom quartile, which translates into Equifax risk scores below 560; those with good credit have a risk score at or above 560. To construct default rates, we use the measure for 120+ days delinquency for student loans and further restrict it to individuals who are 120+ days delinquent for at least two quarters in a year. This measure is the closest one to the national two-year cohort default rate for student loans (which is based on 270+ days). We discuss the compatibility between the two measures of default in Section 7.2.

As we discuss in Section 4.3, debt levels and credit scores in Equifax are captured (quarterly) at the time of data collection. Therefore, it is likely there are some other interactions between repayment/delinquent behavior, the credit score, and the outstanding balance in Equifax data. This contrasts to SCF data which captures (household) outstanding debt and

[51] Since there is no education information in Equifax, we use this sample assumption to insure that everyone has at least some college education to be consistent with our BPS sample.

credit type for the previous year.

To recap, we report the various sources of data for each component of our model in Table 10.

Table 10: Data Sources

	College enrollment rate	Percent with a four-year college degree	Average debt (total = govt+pvt)	Default rates* (govt student loans only)
Family contributions (b)	NELS**	BPS	BPS	BPS
Ability of the student (a)	NELS	BPS	BPS	BPS
Credit type (f)	SCF	SCF	Equifax & SCF	Equifax**

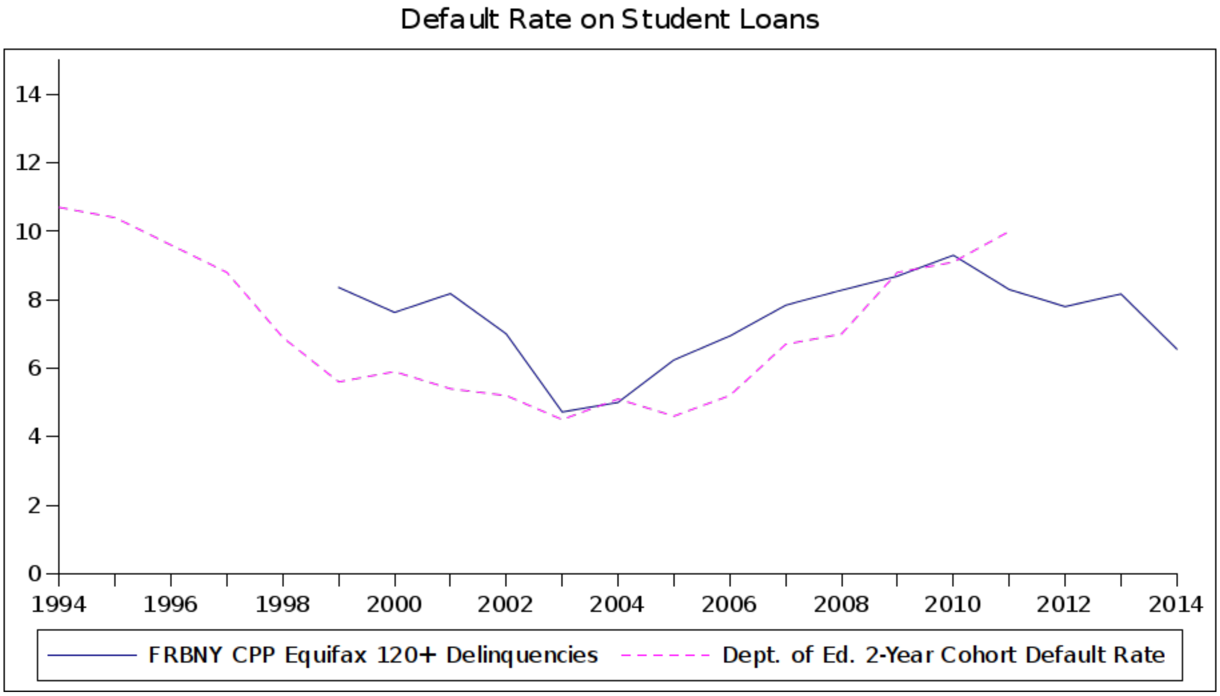
Note: *Cohort default rates are reported differently across the BPS and Equifax. **These moments are targeted in the calibration procedure.

7.2 Default rates on student loans

The official national default rate on student loans is released by the U.S. Department of Education and it represents a two-year cohort default rate, that is, the fraction of borrowers who enter repayment in a particular fiscal year and default by the end of the next fiscal year. Recall that borrowers who have not repaid on their student loans for 270+ days are considered to be in default. We also compute a measure of the default rate from Equifax, as explained before. The purpose of this exercise is two-fold: to validate our measure of the default rate in Equifax and to fill in the gaps for trends in default rates for the periods when data from the U.S. Department of Education are not available. (In 2011, the U.S. Department of Education stopped releasing the two-year cohort default rate and instead released a three year-cohort default rate - this measure is available for fiscal years 2010, 2011 and 2012). Figure 2 shows the two series of default rates for the past two decades (with the first year available in Equifax being 1999).

There are two important observations. First, the two measures of default match up quite well for the entire period and in particular, during the peaks and troughs. Note that the Equifax default rate is greater or equal to the default rate released by the U.S. Department of Education for most of the period. This is expected since the former includes default in both government and private student loan markets, whereas the latter represents default only for Federal student loans. Thus, we are confident to use this measure of default for borrowers characteristics (namely, credit type), which is not available in the U.S. Department of Education data or surveys from the private market. Second, both measures of default indicate a constant decline between 1999 and 2007, but then an increase after 2007. While the two-year cohort default rate seems to suggest a further increase after 2011, the three-

Figure 2: Trends in Default Rates



year cohort default rate (not shown) presents a decline starting in 2010. This decline is also present in Equifax data. Furthermore, Equifax data suggest that this declining trend continues in the most recent years (similar findings are presented in research by staff at the St Louis Fed using a 30-day delinquency measure on student loans; Sánchez and Zhu, 2015). We are confident in our calibration, which is based on both the aggregate default rate from the U.S. Department of Education and default rates by credit type from Equifax data.

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