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Borrowing Constraints, College Enrollment, and Delayed Entry

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Borrowing Constraints, College Enrollment, and Delayed Entry*

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Abstract

In this paper I propose and estimate a dynamic model of education, borrowing, and work decisions of high school graduates. I examine the effect of relaxing borrowing constraints on educational attainment by simulating increases in the amount students are permitted to borrow from government sponsored loan programs. My results indicate that borrowing constraints have a small impact on attainment: the removal of education related borrowing constraints raises bachelor's degree completion by 2.4 percentage points. Tuition subsidies are necessary to obtain larger increases: I find that higher subsidies for average ability students are the most cost effective targeted tuition subsidies.

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1 Introduction

The large increase in the college wage premium that has taken place since the 1980s has been accompanied by a relatively modest increase in college completion.[1] One possible explanation for this disparity is the fact that in real terms the price of college has approximately doubled while the availability of student loans through government sponsored loan programs has declined.[2] In this paper I propose a dynamic model of college enrollment and completion, labor force participation, and saving to ascertain whether increasing the amount students are able to borrow during college would raise the fraction of the population earning a bachelor's degree.

First, with the objective of understanding the role of borrowing constraints, the model incorporates the details of Federal Family Education Loan Program (henceforth FFEL) and the various grants available to college students. This allows me to examine the extent to which borrowing constraints bind for youths and affect decisions about college completion. Second, with the objective of exploring the importance of heterogeneity, the model recognizes that students differ in observed and unobserved ability, parental income and transfers, asset holdings at age 18, and in the tuition costs they face. It is important to account for the substantial heterogeneity among students considering entry to college since it will determine how many students are near the margin of college completion and who is affected by changes in higher education policy. Third, the model incorporates uncertainty about degree completion and labor market opportunities because uncertainty may importantly affect the responsiveness of risk averse individuals to changes in the price of college and availability of loans. The model is estimated on individual-level longitudinal data from the NLSY97 which pertain to a cohort aged 18 in 1999-2003. The estimated model is then used to evaluate the effects on enrollment and degree completion of increasing the maximum students may borrow from the FFEL program, increasing tuition subsidies, and changing the dependence of loans and tuition subsidies on parental income.

How might borrowing constraints affect educational decisions? Outside of loans the main avenues available for students to finance their college education are transfers from their parents, grants, and labor earnings. For many students these three sources of income are not enough to pay for the costs of college, which leads them to take out loans. If insufficient loans are available to a student attending college he may not be able to smooth consumption between college years and the future as much he desires. Lack of loans could also cause a student close to the margin of enrollment to delay entry to college while he works and accumulates savings. Indeed, a large fraction of students who eventually enroll in college do so after delaying by a semester or more despite the fact that delayed entry to college causes losses in lifetime income and is associated with less favorable educational outcomes. This paper will test borrowing constraints as a possible explanation for delayed entry to college.

My results show that borrowing constraints have a small impact on college enrollment, degree completion, and delayed entry. When I run simulations of the model where students are allowed to borrow up to the full cost of college through government sponsored loan programs degree completion increases by only 2.4 percentage points. It is interesting to note that even though I find borrowing constraints to be tight, removing them has only a small impact on educational attainment. I note that a precautionary savings motive (Carroll (1997)) is consistent with the reluctance of youths to borrow against higher future incomes because they are concerned about building a buffer stock of savings to insure against

[1] The college wage premium increased from 43% in 1980 to 81% in 2005 (Goldin and Katz (2008)). During this time period the percentage of the population between ages 25 and 29 with a bachelor's degree increased from 23% to 29% (Aud et al. (2012)). Throughout this paper "college completion" will refer to attainment of a bachelor's degree.

[2] In real terms the average cost of tuition, room, and board at 4-year colleges increased from $8,000 in 1980 to $17,000 in 2005 (Snyder and Dillow (2012)) while the amount dependent first year undergraduate students can borrow through the Stafford loan program shrunk from $5,700 in 1980 (Wolanin (2003)) to $2,500 in 2005 (Wei and Berkner (2008)). All dollar amounts in this paper are expressed in 2004 dollars.

potential unemployment and low wage shocks.

In addition to explaining the role played by borrowing constraints in the education decisions of students, my model has important implications for higher education policies. Currently the federal government makes available approximately $170 billion worth of grants and loans each year to promote higher education.[3] With such large amounts of money at stake, it is important for the government to know which programs are the most cost effective at increasing the educational attainment of college students. This is a very difficult empirical question to answer since it depends on which students are close to the margin of college enrollment and how they respond to different incentives. Since my model incorporates multiple sources of heterogeneity among students, I can answer this question by simulating changes in loan limits and tuition subsidies. I hold constant the cost of a policy change and evaluate the magnitude of the effects of relaxing borrowing constraints and of targeting tuition subsidies toward various groups. I find that to implement small increases in degree completion, relaxing borrowing constraints is the most cost-effective policy for the government. Tuition subsidies are necessary to cause larger increases in educational attainment. I show that tuition subsidies targeted toward students in the middle third of the ability distribution are the most cost-effective method of obtaining large increases in degree completion.

The final issue explored in this paper is the link between parental income and educational attainment. Even after controlling for ability and family background, parental income is positively correlated with college outcomes. Some recent papers such as Belley and Lochner (2007) and Lochner and Monge-Naranjo (2011) have suggested that the fact that this correlation is much stronger today than it was in the 1980s suggests that borrowing constraints are affecting the educational decisions of youths from low income households. This interpretation conflicts with the findings of this paper that borrowing constraints have a relatively small impact on degree completion. I reconcile these two findings by showing that a large fraction of the disparity in educational attainment between students from high and low income households can be explained by the fact that students from high income households receive larger transfers from their parents while they are enrolled in college.

This paper is organized as follows. Section 2 discusses the relevant literature. The model is presented in Section 3. The data and descriptive statistics are shown in Section 4. The solution and estimation methods are discussed in Sections 5 and 6. Identification issues are discussed in Section 7. The fit of the model is displayed in Section 8 and the results are contained in Section 9. Section 10 concludes.

2 Related Literature

A large literature exists related to borrowing constraints and educational attainment (see Lochner and Monge-Naranjo (2012) for a review).[4] With reference to the NLSY79 cohort Keane and Wolpin (2001), Carneiro and Heckman (2002), and Cameron and Taber (2004) do not find evidence that borrowing constraints affect the educational attainment of youths attending college in the early 1980s. Keane and Wolpin (2001) estimate a structural model and show that relaxing borrowing constraints has no effect on the average highest grade completed. Carneiro and Heckman (2002) examine whether, after controlling for ability and family background, the parental income of the NLSY79 youths matters for outcomes along various dimensions of college enrollment and educational attainment. They argue that youths with parents in the highest income quartile are not credit constrained. Thus, given ability, a significant differ-

[3]See p.383 of the appendix to the fiscal year 2011 federal budget for a detailed description of the funding allocation.

[4]The vast majority of the related literature studies higher education in the United States. Nielsen, Sørensen, and Taber (2010) is a recent exception in which the authors study a reform that relaxed borrowing constraints for students in Denmark. The authors find that borrowing constraints have a very small impact on college enrollment, although they note that this may be due to the fact that students in Denmark were provided with large subsidies even before the reform.

ence in educational attainment across parental income quartiles would be evidence of credit constraints. However, they find that after controlling for ability there is little difference in educational outcomes across parental income quartiles. Cameron and Taber (2004) use an instrumental variables approach to test whether the estimated returns to schooling change when an instrument that should differentially affect students who are and are not credit constrained is compared to an instrument that should affect all students equally. They find no evidence that borrowing constraints affect educational attainment.

In recent years there has been renewed interest in whether borrowing constraints have an impact on educational attainment.[5] Belley and Lochner (2007) use the methods in Carneiro and Heckman (2002) and compare results across the NLSY79 and NLSY97. They find that, conditional on ability and family background, parental income matters much more for educational attainment during recent years.[6] Lochner and Monge-Naranjo (2011) build a 3-period model of human capital formation and show that the empirical findings of Belley and Lochner (2007) are consistent with the importance of borrowing constraints in determining educational attainment. However, they do not model labor market uncertainty, the labor supply decision while enrolled in school, or the choice between college types, which makes it difficult to accurately assess the magnitude of the effect of borrowing constraints on educational attainment.

Rothstein and Rouse (2011) suggest that graduates from elite universities may be credit constrained early in the life cycle. Brown, Scholz, and Seshardi (2012) use the rules of federal student aid programs combined with information on the spacing of children within a family to show that increased financial aid has a significant positive impact on the educational attainment of children who are less likely to receive money from their parents to help pay for college. The data the authors use, however, do not allow them to determine whether the effect of increased financial aid on educational attainment comes through grants or loans. Navarro (2011) estimates a structural model of college attendance and finds borrowing constraints to be important in the context of consumption smoothing during college and uncertainty about future earnings. Navarro (2011) does not distinguish between enrollment at 2-year and 4-year colleges or directly model the borrowing opportunities available to students, making it difficult to precisely measure the impact of increased loan availability. Ionescu (2009) extends a Ben-Porath type model to include borrowing constraints in human capital accumulation and analyzes the effect of the design of the FFEL program on default incentives for students. Ionescu (2011) extends this model to include risk in degree completion and labor market outcomes. These two papers, however, have a relatively coarse measure of educational attainment (the only measure is the amount of human capital) and do not use individual level data to evaluate the decisions and outcomes of agents.[7]

Stinebrickner and Stinebrickner (2008) adopt a more direct approach to examine the effects of borrowing constraints on the decisions of youths; they ask a group of low income students at Berea college if they are constrained in their borrowing decisions. They question students if they would take up a loan offered to them at the market interest rate. The authors find that the vast majority of students

[5]There are a number of papers that examine changes in college completion and educational attainment over the last three decades. See for example Bound, Lovenheim, and Turner (2010) for an analysis of why more students are entering college but a smaller fraction are completing a degree. Goldin, Katz, and Kuzimeko (2006) and Becker, Hubbard, and Murphy (2010) examine the changing patterns of educational attainment by women over this time period. In this paper I will focus more narrowly on the question of whether the availability of student loans has been affecting educational attainment for students in recent years.

[6]Ellwood and Kane (1997) also present evidence of a strengthening relationship between parental income and educational attainment for a cohort of high school graduates in the early 1990s.

[7]There are also a number of papers that use general equilibrium models and address borrowing constraints and educational attainment. Some examples include Akyol and Athreya (2005), Gallipoli, Meghir, and Violante (2010), Garriga and Keightley (2007), Wang (2011), and Winter (2011). These models account for the changes in relative prices which occur as a result of large adjustments to the structure of higher education. For smaller changes in loan limits or tuition subsidies, a model like the one in this paper provides a more accurate assessment of the effects because I can model student decisions at a finer level and include more sources of heterogeneity.

would not take up the loan and that borrowing constraints do not explain most of the drop-out decisions. However, approximately half of all Berea college students drop out of school and 67% of these students cite not having enough money as part of the reason for dropping out. It is puzzling that these students with upward sloping income profiles are so reluctant to borrow against future earnings even though their current marginal utility of income seems to be quite high.

In this paper I also find that borrowing constraints have a small effect on educational attainment and that students are reluctant to borrow. I note that the precautionary savings motive explored in Carroll (1997) and Carroll, Dynan, and Krane (2003) is a possible explanation for this behavior. Students may be reluctant to borrow during college because they are uncertain about whether or not they will complete a bachelor's degree and about future labor market outcomes such as unemployment and negative wage shocks.[8] Therefore even though the amount students are able to borrow while in school may be small relative to the costs of college, relaxing borrowing constraints could have little impact on educational attainment because the amount students desire to borrow is also small.

Delayed entry to college is potentially closely related to borrowing constraints. However, there are very few papers that address delay and those that do find conflicting evidence about the role credit constraints may play in the timing of college entry. Both Carneiro and Heckman (2002) and Belley and Lochner (2007) find only a small correlation between parental income and delayed entry to college after controlling for ability, indicating that borrowing constraints may not affect college timing decisions. However, Kane (1996) finds that delayed entry to college is more common in states with higher average tuitions, especially among low income students. This is suggestive evidence that borrowing constraints may affect the timing of college entry.

In terms of the model in this paper, my approach builds on Keane and Wolpin (2001) (hereafter KW). I propose a number of important extensions of their model. First, I explicitly model the choice between 2-year and 4-year colleges as well as degree completion. College choice and degree completion are important to model since borrowing constraints can potentially alter these outcomes and changes in them can have large impacts on future wages. Only years of completed schooling enter the KW model, however, and there is no variable which measures degree completion. Second, I incorporate a richer model of grants and loans and I use the rules of the FFEL program when I model the borrowing constraints students face. This extension is important because the FFEL program is the one most often altered when the government implements policies to relax borrowing constraints. Third, I explicitly look at delayed entry to college.[9] Finally, I enrich their model of labor market uncertainty by including a probability of unemployment. In the KW model agents receive a random wage draw each period but always have the option to work. It is important to model employment opportunities because when an agent is unemployed the opportunity cost of schooling is lower and there can be important interactions with delayed entry. Also, future labor market uncertainty affects how much agents will choose to borrow while enrolled in college and how much precautionary savings agents accumulate.[10]

[8] Chatterjee and Ionescu (Forthcoming) find that offering insurance against the risk of dropping out of college in the form of loan forgiveness would increase the fraction of the population enrolling in college and completing a bachelor's degree.

[9] Agents are allowed to delay entry to college in the KW model, but they do not examine this phenomenon or look at how policy changes could affect delayed entry.

[10] Because I include a number of state and choice variables that KW do not include in their model I must make sacrifices along other dimensions. I only model the behavior of students after they graduate from high school, whereas KW start their decision period at age 16 and model high school completion. I also choose to exclude marriage from my model. Less than 5% of people in my sample are married by the age of 20 so marriage will likely only have a small impact on schooling decisions, which are the main focus of my paper.

3 Model

The model presented in this section is designed to capture important features of the postsecondary education system that are necessary for understanding the relationship between borrowing constraints and educational attainment. The model allows for a rich set of choices to be made by students and incorporates multiple sources of heterogeneity in ability, family resources, and parental transfers.

The decision period begins when an individual graduates from high school. Each year consists of three decision periods: a fall, spring, and summer semester. The lengths of the fall and spring semesters are five months and the length of the summer semester is two months.

3.1 Choice Set

Each period the agent chooses a vector of variables from the choice set Θ:

$$\Theta = \left\{ (h_t, s_t^C, s_t^U, a_{t+1}) : h_t \in \{0, .5, 1\}, s_t^C \in \{0, .5, 1\}, s_t^U \in \{0, .5, 1\}, a_{t+1} \geq \underline{a} \right\} \tag{1}$$

The work decision of the agent, h_t, is discretized into three possible choices: full-time ($h_t = 1$), part-time ($h_t = .5$), and not at all ($h_t = 0$). s_t^C and s_t^U indicate enrollment in 2-year colleges (community colleges) and 4-year colleges (universities), respectively. The agent may choose to enroll not at all, part-time, or full-time at either college type. Transfer between college types across periods is allowed, but the agent may attend at most one college type in any given period.

As will be discussed in more detail in Section 4, a large fraction of students enroll in 2-year colleges, work while enrolled, and attend school only part-time. These are important margins along which students may adjust when faced with borrowing constraints or changes in the price of college.

The agent also chooses a_{t+1}, the amount of savings for the following period.[11] Assets may not fall below the (potentially negative) amount $\underline{a}$. The variable $\underline{a}$ captures the borrowing constraint faced by agents, which is discussed in detail in Section 3.8.

3.2 Initial Conditions

The agent begins the first period with seven initial conditions which capture heterogeneity across agents that existed before high school graduation. When the model begins the agent is potentially receiving parental transfers, which is denoted by the indicator variable P_0. The income of the agent's parents is denoted by Inc and the agent is endowed with an initial level of assets a_0. The agent's ability is denoted by $AFQT$ in light of the ability measure commonly used in studies involving NLSY data. Permanent unobserved heterogeneity in the population is captured by the agent's *type*. The final initial conditions are the *race* of the agent and the *state* in which the agent lives.

3.3 State Space

In addition to the initial conditions, the following variables are elements of the state space. S_t^C and S_t^U measure years of schooling completed at 2-year and 4-year colleges. BA_t is an indicator variable which takes on the value one if the agent has completed a bachelor's degree. Cumulative weeks of work experience is given by H_t. Lagged choices and the current level of assets also enter the state space. The

[11] In the model the asset choice is treated as a discrete approximation to a continuous saving decision. See Web Appendix E.3 for details.

vector of state variables Ω_t is given by:

$$\Omega_t = (a_t, Inc, AFQT, type, race, state, h_{t-1}, H_t, s^C_{t-1}, S^C_t, s^U_{t-1}, S^U_t, P_t, BA_t, age_t) \quad (2)$$

3.4 Preferences

The agent receives utility each period from consumption, school enrollment, and leisure. The utility function is given by:

$$u_t = \frac{c_t^{1-\rho}}{1-\rho} + g^u(s^C_t, s^U_t, h_t; \Omega_t, \epsilon_t) \quad (3)$$

Utility is constant relative risk aversion (CRRA) in consumption with risk aversion parameter ρ. CRRA utility plays an important role in the model because it captures the consumption smoothing and precautionary savings motives facing youths.

The exact functional forms for the g functions that appear in this section are contained in Appendix A. The function g^u allows for psychic costs of schooling and work which depend on the current state variables. In particular, the psychic costs of college attendance are allowed to depend on ability, which is an important mechanism through which heterogeneity in initial conditions leads to different educational outcomes among youths. The agent also receives a shock to preferences for 2-year college attendance, 4-year college attendance, and the desire to work each period which are contained in the vector $\epsilon_t = (\epsilon^C_t, \epsilon^U_t, \epsilon^h_t)$. The shocks are potentially correlated with each other but independent across time.

3.5 Budget Constraint

The expenses the agent incurs equal the income the agent receives every semester. The expenses are the agent's consumption c_t, the costs of schooling κ^j_{state} at school type j in the state of residence of the agent (if the agent enrolls in school), and the amount the agent saves which is given by a_{t+1}. An agent receives income from work $w_t h_t$, parental transfers tr_t, grants received for schooling costs from the government and from other sources, and interest income on assets carried over from the previous period. The model allows for the lending interest rate to differ from the borrowing interest rate (see Web Appendix E.3 for details).

The budget constraint binds each semester and is given by the following equation:

$$c_t + \kappa^C_{state} s^C_t + \kappa^U_{state} s^U_t + a_{t+1} = w_t h_t + tr_t P_t + grant_t + (1+r)a_t \quad (4)$$

3.6 Wages and Employment Opportunities

The agent's human capital function is of the form:

$$\Psi_t = g^{\Psi}(H_t, S^C_t, S^U_t, BA_t, AFQT, type) \quad (5)$$

This function captures the fact that the productivity of an agent is increasing in experience, education, and ability. Each period the agent receives a job offer with probability p^J_t:

$$p^J(J_t = 1) = g^J(\Psi_t, h_{t-1}, race) \quad (6)$$

If the agent receives a job offer he also receives a draw from the wage distribution with variance σ^2_w. The wages of an agent depend on the agent's human capital, race, and on the agent's school enrollment and work status.[12] This dependence is meant to capture the fact that part-time jobs or jobs held while enrolled in school may pay different wages than those paid when an agent is fully attached to the labor market. The formula that determines the wage of the agent is:

$$w_t = g^w(\Psi_t, h_t, race, s_t^C, s_t^U; \sigma_w^2) \tag{7}$$

If the agent does not receive a job offer and is not enrolled in school he receives w^{MIN} in social assistance programs. w^{MIN} is modeled as a function of the experience of the agent and includes money received from Unemployment Insurance, Food Stamps, and Supplemental Security Income.

3.7 Grants

The grant function is of the form:

$$grant_t = g^{grant}(Inc, s_t^C, s_t^U, AFQT, type, race) \tag{8}$$

The dependencies in this function are intended to capture four important facts about grants for post-secondary education. First, grants are decreasing in parental income since programs such as the Pell Grant are need-based scholarships. Second, grants are increasing in ability due to the prevalence of merit based scholarships. Third, only students that are enrolled in school are eligible to receive grants. Fourth, there are many scholarships available that are targeted toward minority students. As will be discussed in more detail in Section 4.5, grants are important in helping students finance their education and there is substantial variation in the amount of grants students receive.

3.8 Borrowing Constraints

The maximum the agent is allowed to borrow each period is given by $\underline{a}$:

$$\underline{a}_t = \underline{a}_t^s + \underline{a}_t^o \tag{9}$$

Here $\underline{a}_t^s$ is the maximum the agent is allowed to borrow for school-related expenses and $\underline{a}_t^o$ is the most the agent can borrow for other expenses. $\underline{a}_t^s$ is only available to students enrolled in school and is set using the rules of the FFEL program. $\underline{a}_t^s$ is specific to individual students and depends upon the costs of college and the year of enrollment. The interest rate charged to students is also individual specific and varies with family resources. See Web Appendix E.3 for the institutional details of the FFEL program and how they are captured in the model.[13] The function for $\underline{a}_t^o$ is:

$$\underline{a}_t^o = g^{\underline{a}^o}(age_t, \Psi_t) \tag{10}$$

This dependence reflects that the amount the agent is allowed to borrow for other expenses increases with the agent's credit score which is approximated by a function of age and human capital.[14]

[12] The model is silent about why wages and employment opportunities may differ by race. One potential explanation is labor market discrimination.

[13] The FFEL program has been gradually phased out and was fully replaced by the Federal Direct Loan (DL) program on July 1, 2010. From the perspective of the student borrower the DL program is similar to the FFEL program in terms of interest rates and the types of loans available. The DL program includes some additional repayment options such as the Income Based Repayment plan that were unavailable to college students during the years that I study. Detailed modeling of the various repayment plans would be an interesting area for future research but are beyond the scope of this paper.

[14] A person's credit score is determined by a number of factors including past repayment history and length of credit history (see The Board of Governors of the Federal Reserve System (2007) for a detailed analysis of the determinants of

3.9 Degree Completion[15]

If the agent has not completed a bachelor's degree and is currently enrolled in a 4-year college, a degree is awarded with the following probability:

$$\Pr(BA_t = 1) = g^{BA}(S_t^C, S_t^U, age_t, \Psi_t) \tag{11}$$

This function is intended to capture the uncertainty from the point of view of the agent about the completion of a bachelor's degree. Approximately half of students who enroll in college never complete a BA. There is also a wide range of years of 2-year and 4-year college completed before a degree is received. The probability of earning a bachelor's degree increases as the student completes additional years of college, but even in the final semester there is likely some uncertainty on the part of the student about if he will pass enough classes to be able to graduate and earn a degree.[16]

3.10 Parental Transfers

Parental transfers are given to the agent with the following probability:

$$\Pr(P_t = 1) = g^p(age_t, Inc, P_{t-1}, s_{t-1}^C, s_{t-1}^U, race, J_t, \Psi_t) \tag{12}$$

The amount of parental transfers is given by:

$$tr_t = g^{tr}(age_t, Inc, s_t^C, s_t^U, race, J_t, \Psi_t) \tag{13}$$

The agent takes the parental transfers function as given but actual transfer amounts are endogenous in the sense that his school enrollment and human capital accumulation decisions affect the transfers.[17] Parental transfers play a very important role in the financing of a youth's college education.[18] In the data (discussed in Section 4.3) one can see that youths receiving parental transfers at age 18 are given approximately $9,000 per year in terms of income and room and board while living at home. The probability of receipt and the amount of money youths receive are higher if the youth is from a higher

credit scores). Since details on repayment history are unavailable in the data I use, I approximate past repayment with human capital under the assumption that agents with higher human capital will have higher income and be more likely to repay their debts. The age of the agent serves as a proxy for the length of the agent's credit history. See Section 7 for details on how $\underline{a}_t^o$ is identified.

[15] Completion of an associate's degree is not modeled for simplicity and because there is some debate in the literature about whether associate's degrees are valued in labor market. Kane and Rouse (1995) find no effects of associate's degrees on wages for the males in their sample while Jaeger and Page (1996) find positive effects. In the model it will be assumed that the return to completing two years of community college and completing two years of community college plus an associate's degree are the same.

[16] Due to the computational difficulties of adding state variables necessary to keep track of graduate school attendance and degree completion and the relatively small numbers of graduate school attendees (only 1% of the students in my sample have received a graduate degree as of the 2007 wave of the survey), graduate school is not explicitly modeled in the paper. To account for the fact that some students do attend graduate school, students in the model are allowed to continue to attend 4-year colleges after they complete a bachelor's degree. These students will see additional wage returns to this increased schooling since years of schooling enter into the wage equation. This modeling choice does, however, result in the return to schooling at 4-year colleges being slightly overstated for students that do not attend graduate school.

[17] Parents and youths could be playing a non-cooperative repeated game as modeled in Kaplan (2012). It is not computationally feasible for me to model the preferences of parents explicitly, however. Incorporating the fact that the youth realizes his actions affect the amount of parental transfer he receives should account for the most important features of parental transfers from the point of view of the youth.

[18] It is possible that parents would alter their contributions towards their child's education in response to changes in grants and loans available from the government. This would be an interesting area for future research but is beyond the scope of this paper. I am also unaware of any major shifts in government aid and loans during this time period that one could use to identify the magnitude of parental transfer responses.

income household and if the youth is attending school.[19] The probability also depends on whether the youth was receiving parental transfers in the previous period to capture persistence in receipt of transfers. The amount of parental transfers is allowed to differ by race and depends on age to capture the fact that transfers tend to decline as the youth gets older. The probably of receipt and amount also depend on human capital and on whether or not the agent has received a job offer.[20]

4 Data and Summary Statistics

In this section I will provide information on how model equivalent constructs are created from the data and present a series of facts and summary statistics that are important for the model to account for. The data I use come from the National Longitudinal Survey of Youth 1997-2007 (NLSY97). The NLSY97 surveys 8,984 youths aged 12-16 as of December 31, 1996. The NLSY97 is divided into two subsamples, a nationally representative sample of 6,748 youths and an oversample of 2,236 minorities. The first survey was conducted in 1997 and follow-up surveys were conducted annually.

My estimation sample uses non-Hispanic white, black, and Hispanic males from the nationally representative NLSY97 sample. The data I use are unweighted. I exclude women from the analysis because I do not model marriage or fertility.[21] I include only youths that completed a high school degree between the ages of 16 and 19. I exclude GED recipients, youths who never complete a high school degree, and those who serve in the military.[22] I do not analyze these youths because they are not in the same position as the other youths in my sample when it comes to making decisions about entering college. It would also be very complicated to add GED completion or military service to the model. After excluding youths for whom I have missing data on initial conditions and semesters for which I have missing data on all relevant state variables I am left with a sample of 1,492 youths and 28,435 person-semester observations. See Web Appendix C.1 for details on sample selection and summary statistics that compare my sample to the nationally representative NLSY97 sample.

4.1 School Attendance (s_t^C,s_t^U) and Degree Completion (BA_t)

During each survey the youths respond to questions about the beginning and end dates of all part-time and full-time enrollment spells at 2-year and 4-year colleges. These data are used to construct a monthly history of part-time and full-time college enrollment. A youth is defined to be attending either a 2-year or a 4-year college during the spring semester if he reports enrollment during the months of February, March, and April. Fall semester attendance is defined to be equivalent to enrollment during the months of October, November, and December.[23] Due to the data collection methods of the NLSY97, I am not able to determine if the youth is attending college during the summer semester and so exclude summer

[19]The probability of receipt of transfers depends on prior period school enrollment rather than current enrollment because the timing of the model is such that all uncertainty is resolved for the agent before he makes decisions each period.

[20]Parental transfers can provide youths with an important insurance mechanism against poor labor market outcomes. Kaplan (2012) shows that youths are more likely to move back in with their parents if they become unemployed.

[21]Marriage and fertility likely have stronger impacts on women's schooling and labor force participation decisions relative to those of men. Currently it would be too computationally burdensome to add these choices to the model to accurately capture the decisions of women. Simplifying this model along some dimensions and adding in marriage and fertility would be an interesting avenue for future research.

[22]28.3% of male youths fail to graduate from high school between ages 16 and 19. Only 12.2% of these youths attend college at any point during the sample and less than 1% have a completed a bachelor's degree as of the 2007 wave of the survey. 10.6% of the youths who graduate from high school between ages 16 and 19 serve in the military at some point during the survey.

[23]If the youth reports attending different types of colleges within the same semester, the April college type is assigned for the spring semester and the October college type is assigned for the fall semester.

attendance as a choice in my model.[24] Given the short length of the summer semester and the small fraction of youths that likely attended college during the summer, this omission will not miss much completed schooling.

Table 1 shows the fraction of the sample attending each college type by age and semester. From the first row of the table we can see that 53% of youths in the sample are enrolled in college during the fall semester when they are 18 years old.[25] This fraction decreases with age although the fraction attending 4-year colleges is relatively constant from ages 18-21, as is the fraction attending 2-year colleges from ages 18-19. Six percent of youths are still attending school during the spring semester at age 26.

Table 1: College Attendence by Age and Semester (Percent of Sample)

			4-Year College		2-Year College		
Age	Semester	N	Full	Part	Full	Part	No School
18	Fall	1488	36.4	1.5	12.8	2.4	47.0
	Spring	1475	37.2	1.5	12.6	2.3	46.4
19	Fall	1469	36.9	1.0	13.1	2.0	47.0
	Spring	1454	35.9	1.3	12.0	3.0	47.8
20	Fall	1444	35.9	1.3	9.1	2.6	51.0
	Spring	1430	35.5	1.4	7.6	2.7	52.8
21	Fall	1419	36.5	1.0	5.3	1.9	55.3
	Spring	1396	34.6	2.4	4.9	3.0	55.1
22	Fall	1271	23.1	2.8	3.9	2.1	68.1
	Spring	1218	18.4	3.7	2.8	2.6	72.5
23	Fall	968	13.0	2.8	1.9	2.3	80.1
	Spring	864	8.8	3.2	2.0	2.3	83.7
24	Fall	653	6.9	2.5	2.0	1.7	87.0
	Spring	570	6.1	1.4	1.1	1.8	89.6
25	Fall	397	6.0	1.5	1.3	1.5	89.7
	Spring	317	5.4	1.6	1.6	0.9	90.5
26	Fall	170	4.7	1.2	1.2	1.8	91.2
	Spring	112	1.8	3.6	0.0	0.9	93.8

NOTE.–The rows of this table add up to 100%. Sample size varies due to missing data for respondents in some semesters, attrition, and the age structure of the NLSY97.

Part-time enrollment in school is more common at older ages. Seven percent of youths enrolled in school at age 18 enroll part time, whereas 49% of students at age 26 are enrolled part time. Youths enrolled in college part-time may be more likely to be constrained in their borrowing decisions. They may be enrolling part-time so that they do not have to pay the higher cost of enrolling full-time or so that they have more time to spend working.

Table 2 displays various summary statistics categorized by type of college and whether or not students delay entry to college. Students who transfer between 2-year and 4-year colleges (denoted "Both Types" in Table 2) appear similar to those who enroll in only 4-year colleges along some dimensions of educational attainment. The average highest grade completed is very similar between these two groups. One large difference between them is the fraction of students completing a bachelor's degree. This is suggestive evidence that while transferring from a 2-year college to a 4-year college may be a less expensive path

[24] The NLSY97 only collects data on college *enrollment* and does not ask about *attendance*. Almost all students enrolled in consecutive spring and fall semesters report that they were enrolled in the intermediate summer semester. Actual attendance rates during summer are much lower, however. KW report using NLSY79 data that less than 5% of white males attend school during the summer that they are age 18, and that number falls to 2% or below for all ages 19 and higher.

[25] For ease of exposition and simplification of the model estimation I set all agents age to 18 when they graduate from high school. For the remainder of this paper "age" will refer to this created age. For the majority of youths the created age will only differ by a few months. For the purposes of my model the time since graduation from high school is a more relevant statistic than the actual age.

for higher education, it comes at the cost of a lower probability of bachelor's degree completion. It is also interesting to note how much uncertainty there is surrounding degree completion. Only 63.1% of students who enroll solely in 4-year colleges complete a bachelor's degree by age 25.[26]

Table 2: Selected Statistics by Type of College Attended and Delayed Entry

	Only 4-Year	Both Types	Only 2-Year	Never	No Delay	Delay
Sample Size	592	184	271	445	788	259
Parental Income and Transfers:						
Ave. Parental Income[a]	102	90	72	62	98	77
Percent with Par. Trans. at 18	96.2	95.5	93.8	89.3	96.4	92.7
Ave. Par. Trans. at 18 if >0	10848	8740	7837	7688	10293	7886
Percent with Par. Trans. at 20	90.7	86.9	85.2	69.8	89.5	86.3
Ave. Par. Trans. at 20 if >0	9918	7898	7687	6687	9507	7547
College Loans and Grants:						
Percent with College Loans	57.9	62.0	29.5	.	54.2	42.5
Ave. College Loans if >0	9360	8516	5726	.	9128	6746
Ave. Loans/Year if >0	2630	2456	4637	.	2608	3994
Ave. Grants/Year	2800	1711	849	.	2360	1324
College Enrollment and Completion:						
Percent of Sems at 2-year	0.0	48.3	100.0	.	26.6	57.9
Enrolled Part-Time[b]	7.6	15.6	31.7	.	10.6	29.1
Completed BA[c]	62.6	33.3	0.0	0.0	56.2	13.1
Highest Grade Completed[c]	15.8	15.9	13.7	12.0	16.0	14.1
Ability and Race:						
Ave. AFQT Score[d]	189	181	165	155	185	170
Percent Black[e]	9.5	9.2	15.1	16.2	8.6	17.8
Percent Hispanic	6.4	7.1	11.4	8.8	6.7	11.2
Labor Market Outcomes:						
Ave. Hourly Wage at 18	9.9	9.5	11.2	11.6	10.6	9.5
Ave. Hourly Wage at 20	11.3	11.3	11.8	12.4	11.3	11.7
Ave. Hourly Wage at 22	13.6	15.7	13.5	15.4	14.3	13.1
Ave. Hourly Wage at 25	18.5	18.2	17.1	16.5	18.5	17.2
Work PT While Enrolled[b]	30.6	34.3	27.1	.	32.0	25.2
Work FT While Enrolled[b]	27.8	34.9	51.3	.	31.1	47.3
Unemployed Before Enrolled	6.4	7.1	7.4	.	6.2	8.7

[a] Measured in thousands of dollars.
[b] Average over all semesters enrolled.
[c] By age 25.
[d] See Section 4.9 for details on construction of this variable. The mean AFQT score in the sample is 173.4 and the standard deviation is 30.0.
[e] The distribution of race in the sample is: 79.4% white, 12.5% black, and 8.1% Hispanic.

4.2 Work Status (h_t) and Unemployment (J_t)

Youth work status is determined using the weekly history contained in the NLSY97 of number of hours worked. A youth is defined to be not working if he works less than 10 hours per week on average during the semester, working part-time if he works at least 10 hours per week but less than 30 hours per week, and working full-time if he works at least 30 hours per week.

Unemployment is treated as distinct from the choice of not working in the model. In addition to weekly hours data the NLSY97 also collects a weekly history of labor force participation. I exploit the fact that questions distinguish between being employed, unemployed, and out of the labor force. In terms of model equivalents, I define semesters of unemployment to be semesters during which the youth works

[26]The youths who are not yet 25 are excluded from this calculation.

less than 10 hours (so he is classified as not working) and the youth reports that he was unemployed during at least one of the weeks during the semester.

Table 3 displays descriptive statistics about labor force participation. A larger fraction of 2-year college students work while attending college than 4-year college students. Two-year college students are also more likely to work full-time while attending college. As students age they are more likely to work while enrolled. The lower unemployment rate during the summer semester for ages 18-21 is likely caused by students being out of the labor force during the summer. The unemployment rate decreases overall as the youths become older, as does the fraction of youths not working or working part-time.

Overall Table 3 shows that a large fraction of youths work while enrolled in college and that a much larger fraction of those enrolled part-time are working while in school. It is important to model both full and part-time work while in and out of school since this is a margin that students may adjust on when faced with borrowing constraints.

Table 3: Work Status and College Attendance by Age and Semester (Percent of Sample)

			4-Year College			2-Year College			No School			
Age	Sem.	N	Full	Part	No	Full	Part	No	Full	Part	No	Unemp.
18	Sum	1462	.	.	.	.	.	.	38.0	32.6	29.3	6.7
	Fall	1470	2.8	8.8	26.3	4.1	6.8	4.2	23.2	13.5	10.3	9.7
	Spring	1464	5.0	13.3	20.4	5.7	5.9	3.3	25.8	11.1	9.5	11.5
19	Sum	1463	.	.	.	.	.	.	52.4	26.3	21.3	5.9
	Fall	1453	4.8	10.3	22.8	4.9	6.5	3.6	29.5	9.6	8.0	8.2
	Spring	1441	7.0	12.8	17.6	6.5	5.1	3.4	31.4	7.8	8.4	8.8
20	Sum	1440	.	.	.	.	.	.	55.8	22.0	22.2	5.3
	Fall	1432	5.6	12.1	19.6	5.3	3.8	2.7	33.4	9.6	7.9	6.9
	Spring	1424	7.1	13.4	16.5	4.8	3.5	2.0	36.1	7.3	9.2	8.4
21	Sum	1423	.	.	.	.	.	.	57.3	21.2	21.5	4.4
	Fall	1405	7.3	13.3	17.2	3.6	2.6	1.1	37.9	9.5	7.6	5.8
	Spring	1388	9.0	12.9	15.1	4.2	2.6	1.2	39.4	7.9	7.7	8.9
22	Sum	1387	.	.	.	.	.	.	62.0	18.5	19.5	5.6
	Fall	1232	5.9	9.0	10.9	3.7	1.7	0.7	48.9	10.8	8.4	5.2
	Spring	1208	7.0	7.4	7.8	3.3	1.2	0.7	54.6	9.5	8.4	6.1
23	Sum	1210	.	.	.	.	.	.	69.8	14.0	16.2	5.0
	Fall	902	6.4	4.9	4.0	2.9	0.7	0.6	60.8	10.5	9.3	5.3
	Spring	854	5.0	4.0	3.2	2.9	0.7	0.7	65.7	9.6	8.2	4.4
24	Sum	854	.	.	.	.	.	.	75.3	12.8	11.9	4.4
	Fall	590	3.9	3.2	1.5	2.4	1.0	0.2	68.5	11.7	7.6	3.6
	Spring	564	3.4	2.5	1.6	2.0	0.5	0.4	71.5	8.2	10.1	4.6
25	Sum	564	.	.	.	.	.	.	74.8	12.4	12.8	3.4
	Fall	348	3.7	2.6	1.4	1.4	0.9	0.0	71.3	10.1	8.6	3.4
	Spring	312	2.9	2.6	1.6	1.6	0.6	0.3	72.4	8.3	9.6	4.8
26	Sum	313	.	.	.	.	.	.	78.9	9.3	11.8	3.2
	Fall	127	0.8	3.1	0.8	1.6	0.0	0.0	78.0	7.9	7.9	3.9
	Spring	106	2.8	0.9	1.9	0.9	0.0	0.0	81.1	6.6	5.7	2.8

NOTE.–The rows of this table (excluding the Unemployment column) add up to 100%. Sample size varies due to missing data for respondents in some semesters, attrition, and the age structure of the NLSY97. "Full", "Part", and "No" indicate the work status of agents in each schooling option.

4.3 Parental Transfers (P_t, tr_t) and Parental Income (Inc)

Data on receipt of and the amount of parental transfers are only available at the date of interview. The amount of parental transfers is constructed from three sections of NLSY97 questions: the amount of money parents give to the youth, the amount of money the family gives for college related expenses, and whether or not the youth is living at home.[27] It is necessary to assign a monetary benefit (in terms of rent, utilities, etc.) that the youth receives while living at home. I follow Kaplan (2012) and use the 2001 American Housing Survey to construct a monetary value of living at home. The American Housing Survey documents that the median rent for households with incomes between $15,000 and $30,000 is approximately $600 per month. Adding $50 for utilities brings the estimated monetary value of living at home to $650 per month.

Table 4 displays descriptive statistics about the amount of parental transfers in each category, and for the total parental transfers variable. The fraction of youths receiving parental transfers and the amount of parental transfers conditional upon receipt both decline with age. At the age of 18, 93.6% of youths are receiving transfers from their parents. This percentage declines to 36.3% by the age of 26. The average amount received declines from $9,154 at age 18 to $5,290 at age 26. The co-residence category makes up the largest fraction of total parental transfer with youths receiving an estimated $7,800 per year if they live with their parents. The college transfers category is the next largest with most youths receiving between $4,000 and $5,000 while they are enrolled in college between the ages of 18 and 22. The fraction of youths receiving college transfers is higher at age 19 than at age 18. This reflects the fact that a number of youths were interviewed at age 18 in the summer before they started college and would not yet be receiving college transfers from their parents. The money from parents category makes up the smallest fraction of parental transfers. The amount of this transfer is relatively stable between $900 and $1,600 though the fraction of youths receiving money from their parents declines with age.

Parental income is constructed in each year by summing the incomes of the father and mother of the youth.[28] The parental income variable Inc used in the model is intended to be a measure of permanent income, so I average of all available parental income observations to construct this variable. Parental income is top coded at $300,000. As is displayed in Table 2, higher parental income is associated with more favorable educational outcomes. I show in Section 9.4 that higher transfers given by parents with higher income are responsible for a large part of this correlation.

Table 4: Parental Transfer Categories

		Money from Parents		College Transfers		Co-residence[a]	Total Transfers	
Age	N	%	Mean if >0	%	Mean if >0	%	%	Mean if >0
18	1447	54.0	1183	28.5	4820	85.3	93.6	9154
19	1404	49.5	1513	39.0	4508	73.9	88.4	9145
20	1350	39.3	1406	36.4	4495	64.1	83.3	8490
21	1324	36.6	1490	32.6	4087	53.0	75.8	7850
22	1191	33.2	1327	27.4	3943	45.8	70.0	7217
23	905	28.6	1383	13.6	2963	36.0	58.9	6126
24	599	24.9	1111	5.5	1928	30.1	49.1	5555
25	364	20.9	983	3.0	1335	21.4	39.8	4812
26	157	20.4	1351	1.3	459	21.0	36.3	5290

NOTE.–In each category "%" indicates the percent of the sample receiving positive amounts of the transfer type and "Mean if >0" is the average value of the transfer if a positive amount is reported. All categories are top coded at $25,000 and represent the annual amount of transfers received.

[a] Each youth that reports living with his parents is assumed to receive a monetary benefit of $650*12 months=$7,800.

[27] Money received from other family members is counted as part of the parental transfers.

[28] For the first five waves of the survey parents are asked directly about their income if the youth is living at home. In all waves youths who are fourteen years or older are asked questions about the income of their parents.

4.4 Assets (a_t)

The NLSY97 collects asset data when a youth reaches the age of 18, 20, and 25. The categories I use to construct the net asset variable used in the model consist of housing and property values, automobiles, checking and saving accounts, bonds, stocks, life insurance, pension value, business wealth, student loan debt, and categories for other assets and debts.[29] To prevent the skewness of the asset distributions having a large effect on the estimated means, asset values are top coded at \$45,000 and bottom coded at -\$35,000.

Cumulative distributions of the asset holdings are displayed in Figure 1 and descriptive statistics are displayed in Table 5.[30] At age 18 there is already a fair amount of dispersion in the asset distribution. Fifteen percent of youths have net worths of \$10,000 or more (presumably these are savings from high school jobs or money given to them by their parents) while less than 7% are in debt. At age 20, 14.8% of youths have negative net worth. By Age 25 the asset distribution is very skewed with 6% of youths borrowing \$35,000 or more and 15.8% saving \$45,000 or more. The standard deviation also increases from \$9,658 at age 18 to \$22,239 at age 25.

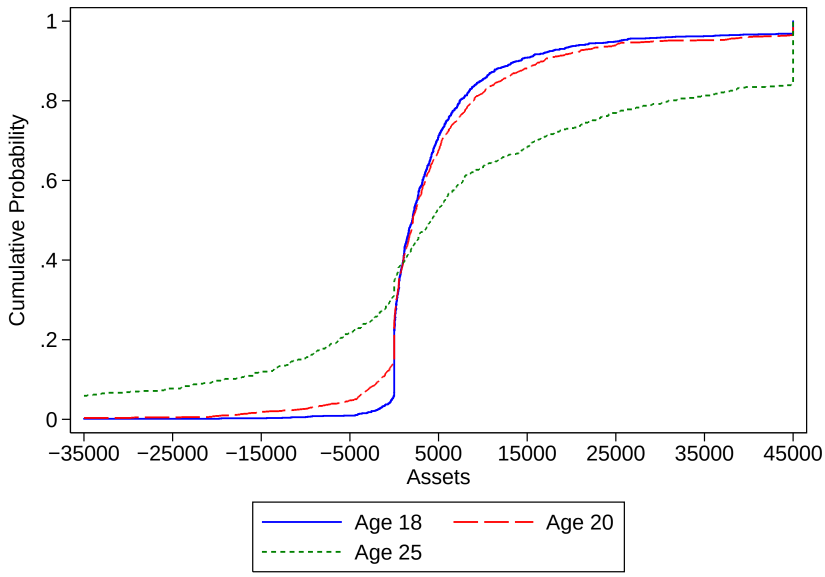

Figure 1: CDF of Net Asset Holdings by Age

Table 5: Asset Statistics by Age

Age	N	Median	Mean	Standard Deviation	Percent Negative
18	1492	2039	5184	9658	6.8
20	1422	2100	5253	11250	14.8
25	659	4145	8458	22239	32.0

[29] I do not include spousal assets in the net asset variable because marriage is not modeled. I also do not include the household furnishing variable in my calculations. I omit the household furnishing variable because it is a categorical variable with large bins so including it would increase the measurement error in the net asset variable. Also, data on household furnishing is not collected in most surveys with asset data and is rarely used in the literature.

[30] Due to the timing of the NLSY97 surveys and the convention of assigning all agents to be 18 years old upon high school graduation some of the asset data are collected a year before or after the ages 18, 20, and 25. This data are assigned to the age category closest to the actual collection time.

4.5 College Loans and Grants ($grant_t$)

The NLSY97 collects data on grants and loans students receive to help finance their college education. The grant variable is constructed from the total grants and scholarship questions asked about each college and term attended. College loans are constructed from the questions about total government subsidized and other loans taken out during each college term.[31] While only net worth is included as a variable in the model, it is interesting to look at loans taken out specifically for college education. Summary statistics are displayed in Table 2.

Students who attend only 2 year colleges are less likely to take out loans to finance college and those who do take out fewer loans overall than students attending 4-year colleges. This is partly because students enrolled in only 2-year colleges spend less time in college and so have less time to accumulate loans. For those who take out loans, the average value of the loans per year of college is actually $2,000 higher for 2-year college students. Students who transfer between 2-year and 4-year colleges appear very similar along the loan dimension to students who attend only 4-year colleges. These students differ when it comes to grants, however. Students who attend only 4-year colleges receive more aid through grants than transfer students, while 2-year college students receive the least amount of grants overall.

4.6 Wages (w_t)

Each semester wage data for the NLSY97 respondents are constructed from the hourly rate of pay variables for each job held. I use the stop and start dates for each job to generate the hourly wage for each semester during which the youth was working.[32]

Average wages by college type are displayed in Table 2. At age 18 the wages of those who never enroll in college are higher than those who enroll in the various college types. This reflects the fact that many students work at part-time jobs while enrolled in school while most youths who are not attending school are working full-time. This disparity in wage is still present at ages 20 and 22. By age 25 when most youths have completed their schooling the wages of those who attended 4-year colleges are higher than for those who attended 2-year colleges or never enrolled.

4.7 Delayed Entry

A student is designated as delaying entry to college if he at some point attends college but does not enroll during the first available semester after he graduates from high school.[33] Twenty-five percent of youths in my sample who eventually enroll in college delay by a semester or more, 16% delay by a year or more, and 8% delay by 2 or more years. In Web Appendix D I show that, holding all else constant, delaying entry to college by one year costs a student more than $9,000 in lifetime income. It is therefore puzzling that such a large fraction of students delay entry to college.

Summary statistics for students who delay entry to college are displayed in Table 2. Students who delay come from lower income households, are more likely to be black or Hispanic, are less likely to receive parental transfers, and receive less money from their parents conditional on receipt. Students that delay entry to college are less likely to receive grants and receive less money conditional on receipt. This is because a much higher fraction of those who delay enroll in 2-year colleges and also because they

[31] The NLSY97 also collects data on total loans received from family members to help pay for college. These loans are not included in the summary statistics since it is not clear if or when they would need to be payed back and if interest is paid to the family members.

[32] If more than one job was held during a given semester, the wages are averaged across jobs. Wages are top coded at $200 per hour and bottom coded at $3 per hour.

[33] Almost all of the youths in my sample graduate from high school during the spring. The first available semester for these youths is the fall semester after the model begins.

are of lower ability and therefore likely earn fewer merit based scholarships. Students that delay are less likely to receive loans for college, but take out more loans per year conditional upon receipt. Those who delay are also more likely to enroll part time and work while enrolled in school. These patterns are consistent with the conjecture that many students who delay entry to college are doing so because they are constrained in their borrowing decisions.

Another factor that could contribute to delayed entry to college are changes in the opportunity cost of enrollment. The last row of the Table 2 shows the unemployment rate of each group averaged over the semester of first enrollment and semester prior to first enrollment. The unemployment rate for all 18-20 year olds in the sample is 7.9%. The higher rate of unemployment for those who delay entry to college is suggestive evidence that some youths enroll in college when the opportunity cost of enrollment is low due to lack of a job offer.

4.8 Labor Market Opportunities in Adult Life

In order to solve the model presented in this paper I need to make assumptions about agents' expectations of future labor market outcomes. The approach commonly used in the literature is to use actual data on future labor market outcomes and assume rational expectations on the part of the agents. Since the respondents in my sample are only between ages 22 and 27 during the last interview, I have very little data on labor market outcomes after the age of 25. I therefore assume that to form expectations about future labor market outcomes the NLSY97 respondents look to the experiences of older people currently in the labor force with similar characteristics to their own.[34] A natural source for such data is the NLSY79. I use moments from the NLSY79 data for respondents aged 25 and older to help identify the parameters of the wage and unemployment probability equations. I use the same sample selection criteria for the NLSY79 data as is done for the NLSY97 data. I additionally exclude observations where a respondent is below the age of 25 or that take place before the year 1990. I exclude the 1980s to avoid potential bias in the parameter estimates induced by the increasing college wage premium.[35] See Web Appendix C.2 for details about the use of the NLSY79 data.

4.9 Ability ($AFQT$)

Ability is measured by the AFQT score. This is an important measure in the model both for documenting the effects of observed ability on college attendance and for controlling for ability in the wage equation evaluated on NLSY79 data and used as future labor market expectations. This section provides details about the construction of the AFQT variable that is comparable across the NLSY79 and NLSY97 surveys.

The Armed Services Vocational Aptitude Battery (ASVAB) was administered to NSLY79 and NLSY97 respondents. The AFQT score used in this paper is the created from the scores on 4 sections of the ASVAB. The AFQT score is equal to the sum of scores on Arithmetic Reasoning, Word Knowledge, Paragraph Comprehension, and half of the score from Numerical Operations. The AFQT scores are not directly comparable across the NLSY79 and NLSY97 because the NLSY97 respondents took a different version of the ASVAB. The NLSY97 respondents took the ASVAB through a computer administered test (CAT) whereas the NLSY79 respondents took a pencil and paper (P&P) version of the test. In addition, the respondents took the test at different ages in the two surveys. I follow the methods used in Altonji, Bharadwaj, and Lange (2012) to make the AFQT scores comparable across the surveys. They use a mapping from the P&P version to the CAT version of the test created in Segall (1997) to make

[34] Dominitz and Manski (1996) show that college students are able to accurately estimate the median of the earnings distribution for college graduates.

[35] After 1990 the college wage premium leveled off; see Fortin (2006) for documentation of the trend in the wage premium.

the raw AFQT scores equivalent. The scores are then age adjusted using an equipercentile procedure. First each respondent is assigned a percentile score within their age. Then the mapping between age 16 percentiles and age 16 scores are used to translate percentiles into scores for all other ages (age 16 is the age of greatest overlap of the number of tests taken in the NLSY79 and NLSY97).[36]

Average AFQT score by college type is displayed in Table 2. Students with higher AFQT scores tend to enroll in 4-year colleges more than 2-year colleges, suggesting that students with higher AFQT scores receive a higher return from 4-year colleges and that the psychic costs of 4-year college attendance may be lower for these students.

4.10 Race

Summary statistics about ability, parental transfers, and schooling by race are displayed in Table 6. Blacks and Hispanics have lower AFQT scores than whites. Blacks and Hispanics on average come from households with lower parental incomes, but are equally likely to be receiving parental transfers at age 18. They receive approximately $1,000 less per year in parental transfers, however. Blacks are less likely to enroll in college than whites and Hispanics. Blacks and Hispanics are more likely to spend time in 2-year colleges and enroll only part time. They are slightly less likely to take out loans for college but take out similar amounts of loans per year on average. Blacks and Hispanic receive higher average grants per year on average as compared to whites. They complete fewer years of schooling on average and are less likely to complete a bachelor's degree.

Table 6: Selected Statistics by Race

	White	Black	Hispanic
Sample Size	1185	186	121
Ave. AFQT Score	178	152	164
Ave. Parental Income[a]	90	51	68
Percent with Par. Trans. at 18	93.8	92.8	94.1
Ave. Par. Trans. at 18 if >0	9382	8330	8199
Percent Enrolling in College	71.8	61.3	67.8
Percent of Sems at 2-year	32.1	43.5	44.9
Enrolled Part-Time[b]	13.7	22.3	20.6
Percent with College Loans	37.0	33.9	31.4
Ave. Loans/Year if >0	2837	3190	3027
Ave. Grants/Year	1974	2876	2375
Completed BA[c]	34.8	25.3	21.4
Highest Grade Completed[c]	14.6	14.3	14.3

[a] Measured in thousands of dollars.
[b] Average over all semesters enrolled.
[c] By age 25.

5 Solution Method

The model is solved numerically through backward recursion on a Bellman equation by assuming a terminal value function when the agent reaches age 40. The agents choose a vector θ_t from the set given by Equation (1) each period to solve the following maximization problem:

$$V_t(\Omega_t) = \max_{\theta_t \in \Theta_t} u_t(\theta_t|\Omega_t) + \delta E(V_{t+1}(\Omega_{t+1})|\theta_t, \Omega_t) \tag{14}$$

[36]See http://www.econ.yale.edu/ ~fl88/ for the data and methods used in Altonji, Bharadwaj, and Lange (2012).

The expectations operator E in Equation (14) is taken with respect to the distribution of preference shocks ϵ_t, the probability of receiving parental transfers, the probability of bachelor's degree completion, the wage draw, and the unemployment probability. This quantity is referred to in the literature as "Emax" and represents the future value that is expected to be attained given that the agent will make the optimal choice in each of the future periods.

The state space in my model is too large to evaluate the Emax functions at every possible point. I therefore follow the method used in KW and evaluate the Emax values at a subset of the points in the state space each period. I then approximate the Emax functions as polynomial functions of the state variables. The integrals needed to evaluate the Emax functions are approximated through Monte Carlo integration. See Web Appendix E.1 for further details.

6 Estimation

The likelihood function for this model is very complex due to the size of the model. In addition there are a number of missing state variables because of the timing of collection of data on parental transfers and assets. Estimation via maximum likelihood is therefore infeasible because it would require that I integrate out the distribution of the unobserved state variables. I use Indirect Inference to estimate the model (see Smith (1993) and Gouriéroux, Monfort, and Renault (1993)).[37]

The idea behind Indirect Inference is to specify a set of easy to estimate auxiliary models that are to be evaluated at both the actual and simulated data. The estimation algorithm searches over structural parameters so that the estimated parameters of the auxiliary model evaluated on the actual and simulated data are as close as possible. This is achieved by minimizing the weighted sum of squared scores of the auxiliary models evaluated at the simulated data. More formally, let η be the vector of structural parameters and L be the likelihood functions of the auxiliary models with parameters β. The estimator $\hat{\eta}$ solves the equation:

$$\hat{\eta} = \arg\min_{\eta} \frac{\delta L}{\delta \beta}(y(\eta); \hat{\beta}) \Lambda \frac{\delta L}{\delta \beta}(y(\eta); \hat{\beta})' \tag{15}$$

$y(\eta)$ is the simulated data, $\hat{\beta}$ is the maximum likelihood estimate of β obtained using the actual data, and Λ is a weighting matrix. By construction $\frac{\delta L}{\delta \beta}$ evaluated at the actual data will be zero. Therefore the structural parameters η are chosen so that right-hand side of Equation (15) is as close to zero as possible. $\hat{\eta}$ is consistent and asymptotically normally distributed when the number of simulated and actual observations are proportional and the number of actual observations goes to infinity (see Gouriéroux and Monfort (1996) for a proof of this claim). See Web Appendix E.2 for details about the weighting matrix Λ.

The auxiliary models I use consist of a series of linear regressions and moments designed to provide a complete enough statistical description of the data to identify the structural parameters.[38] I present some of the auxiliary models below to give examples of the equations used and which parameters they help identify:

- A regression of log wage on years of schooling at each college type, BA degree completion, experience, experience squared, AFQT, race, part-time work, and school attendance helps to identify the parameters of the wage equation.

[37]There have been a number of recent studies which use Indirect Inference. For other implementations see Altonji, Smith, and Vidangos (2009), Guvenen and Smith (2010), van der Klaauw and Wolpin (2008), Nagypál (2007), and Tartari (2007).

[38]See Section 7 for a further discussion of identification.

- A regression of unemployment on experience, experience squared, AFQT, race, and not working in the previous semester helps identify the parameters of the job offer function.
- A regression of BA degree completion on years of 2-year college completed, years of 4-year college completed, and AFQT tercile helps identify the parameters of the degree completion function.
- Regressions of an indicator for enrollment in each college type on AFQT tercile help identify the parameters of the utility function pertaining to the psychic costs of schooling.

See Web Appendix F.2 for a full list of the auxiliary models.

7 Identification

Due to the size and complexity of the model, I am unable to provide a rigorous proof of identification of the parameters. I am, however, able show some simulation evidence and provide intuitive arguments for how the parameters are identified. I focus first on $\underline{a}_t^o$, the lower bound of assets for non-school related expenses. It is important to show identification for this parameter, since the main focus of this paper is determining the extent to which borrowing constraints bind. I then provide a brief discussion describing the identification of the remainder of the parameters in the model.

To isolate the factors identifying $\underline{a}_t^o$ in the simulation, I simplify the model drastically by making the following assumptions: There is no schooling and no psychic costs of working so all agents enter the labor market at age 18 and work full-time. All agents start with 0 assets and the interest rate is set to 0%. I assume a constant probability of unemployment of 5% each semester. There is no wage wage growth; earnings are constant at \$10,000 per semester except during semesters when the agent is unemployed when earnings drops to \$1,000.[39] Agents in this model save for purely precautionary reasons, desiring to smooth consumption between employed and unemployed states. I examine how average asset accumulation at age 25 varies with $\underline{a}_t^o$. The results are displayed in Figure 2.

As $\underline{a}_t^o$ increases from -\$23,000 to 0 the average asset accumulation at age 25 in the simulated population increases from -\$4,000 to \$6,000. $\underline{a}_t^o$ is therefore identified by the assumption of CRRA utility with a precautionary savings motive (positive third derivative) and the asset accumulation patterns of youths in the data.

The remaining parameters of the model are arguments of the g functions in Section 3 that relate observable variables to observable outcomes.[40] The NLSY97 provides data on all the outcomes to be estimated, so the identification comes from the functional forms I assume for the g functions (see Appendix A for the exact functional forms) and the auxiliary models I specify for the Indirect Inference estimation method. As described in Section 6, the auxiliary models are linear regressions which closely approximate the g functions, so the g parameters are identified by the estimation algorithm which attempts to make the simulated data as close as possible to the actual data in terms of the parameters of the auxiliary models.

The utility function, however, is unobserved to the econometrician so it is impossible to supply auxiliary models which approximate the utility function itself. But the outcome of the utility function is a set of choices of asset accumulation, school enrollment, and work each period. Therefore specification of auxiliary models that relate the choices of agents to the arguments of the utility function identify the parameters of g^u.

[39] Here and in the remainder of the paper the dollar amount of income does not decrease during the summer semester. The shorter length of the summer is accounted for by adjusting the discount factor in the utility function.

[40] It is possible to provide simulation of the identification of these parameters similar to the one shown for the asset lower bound. These will be omitted for brevity, however, and only the intuition behind identification will be presented.

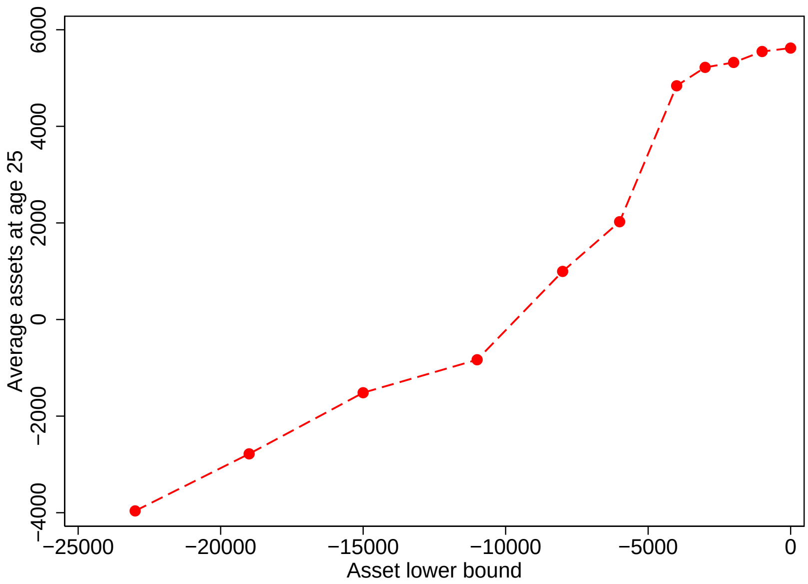

Figure 2: Average Asset Holdings by Borrowing Limit

The *type* distribution and coefficients on the *type* variables in the g functions are identified by examining the choices of agents each period.[41] The idea is to allow for agents to differ in permanent ways unobserved to the econometrician and estimate the distribution of types to fit the persistence of various choices and outcomes of the agents. When two agents that are equivalent in their observable characteristics persistently make different choices, this indicates that they are likely to differ in unobservable characteristics. Of course if the number of types were allowed to approach the number of observations and allowed to vary over time then the data could be fit perfectly. (This is similar to a linear regression with n observations and n parameters fitting the data perfectly). Discipline is imposed by fixing a small number of types and requiring the unobserved heterogeneity to be permanent.

Note that I am using data from both the NLSY79 and NLSY97 to identify the parameters of the wage and unemployment probability equations. I am therefore implicitly assuming that the unobservables affect the estimated parameters of the wage and unemployment auxiliary regressions using NLSY79 data in the same way as they affect the estimated parameters of the auxiliary regressions estimated using NLSY97 data. In the context of my model this is equivalent to assuming that the type distribution is the same in the NLSY79 and NLSY97 data.

8 Parameter Estimates and Model Fit

The parameter estimates and standard errors are reported in Table B2 in Appendix B.2. Overall the parameter estimates are reasonable. The model allows for three types of agents which can be thought of as high ability (type 1), average ability (type 2), and low ability (type 3). The probability that an agent is of a more able type is increasing in *AFQT* and parental income. The estimated distribution of types in the population is: 14% type 1, 41% type 2, and 45% type 3.

Psychic costs of schooling are lowest for high ability agents. The costs are higher for 4-year college attendees, older students, and those who work while enrolled. Psychic costs of schooling are lower for blacks and Hispanics relative to whites at 2-year colleges but higher at 4-year colleges. Wages increase

[41] See Heckman and Singer (1984) for a proof of identification of unobserved heterogeneity related to duration models.

with each year of completed schooling and the highest returns come from completion of a bachelor's degree. A student who completes four years of school at a 4-year college and earns a bachelor's degree has wages that are approximately 29% higher than an otherwise equivalent high school graduate. Wages are lower for blacks than for whites and Hispanics.

The probability of receiving a job offer is increasing in the human capital of the agent but is much lower if the agent is not working in the previous semester. Blacks and Hispanics are on average less likely to receive a job offer than whites.

At 4-year colleges grants are increasing in ability, decreasing in family income, and higher for blacks and Hispanics. The lower bound on assets for other expenses, $\underline{a}_t^o$, is larger (more negative) as human capital and age increase.[42] Parental transfers increase with family income and are higher for youths attending college. There is substantial persistence in the receipt of parental transfers although the probability of receipt declines with age.

For each person in my sample the simulated data consist of 5 agents that have initial conditions that are exactly the same as those of the actual person. Simulated data are generated for these agents from age 18 to age 40. Overall the model fits the patterns of educational attainment very well. The simulated data and actual data on 4-year college enrollment, 2-year college enrollment, and degree completion are contrasted in Figures 3, 4, and 5. The model fits 4-year college enrollment better than 2-year college enrollment, mainly because a smaller fraction of the population is enrolled in 2-year colleges and there is less persistence in 2-year college enrollment. The pattern of decreasing enrollment with age is matched for both college types. The simulated data matches the fraction of the population completing a bachelor's degree quite closely.

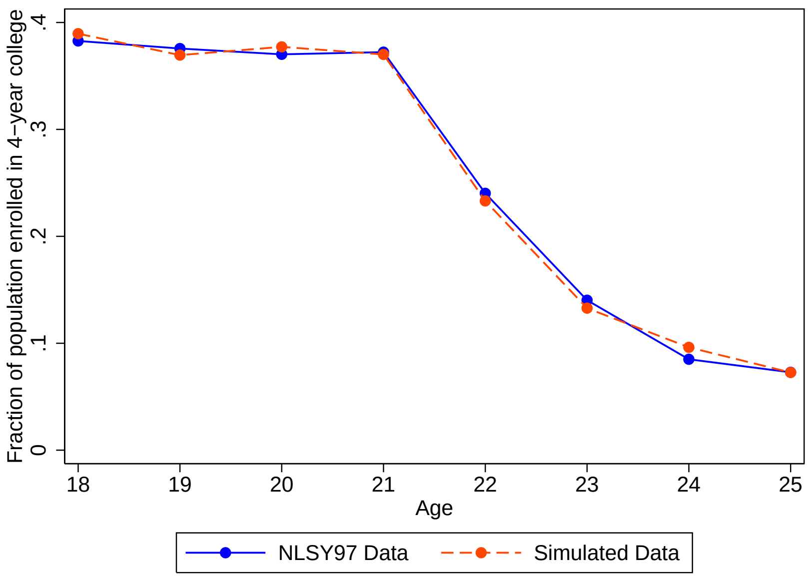

Figure 3: University Enrollment by Age

Statistics from the actual and simulated asset holdings are displayed in Table 7. The simulated data matches the mean and median asset holdings and the fraction of the population with negative net worth well. However, the model has difficulty matching the skewness of the asset distribution and underestimates the standard deviation, particularly at age 25.

[42]See Table E1 in Appendix E.3 for estimates of $\underline{a}_t^o$ categorized by age and ability.

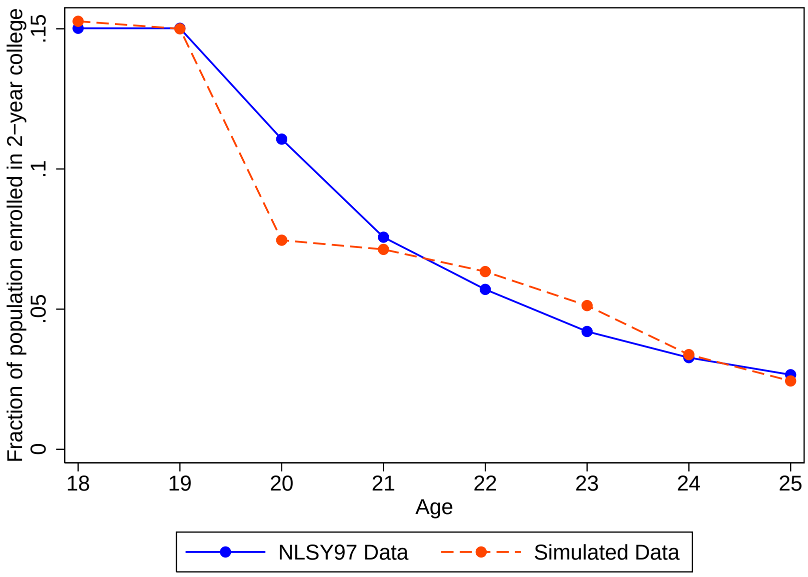

Figure 4: Community College Enrollment by Age

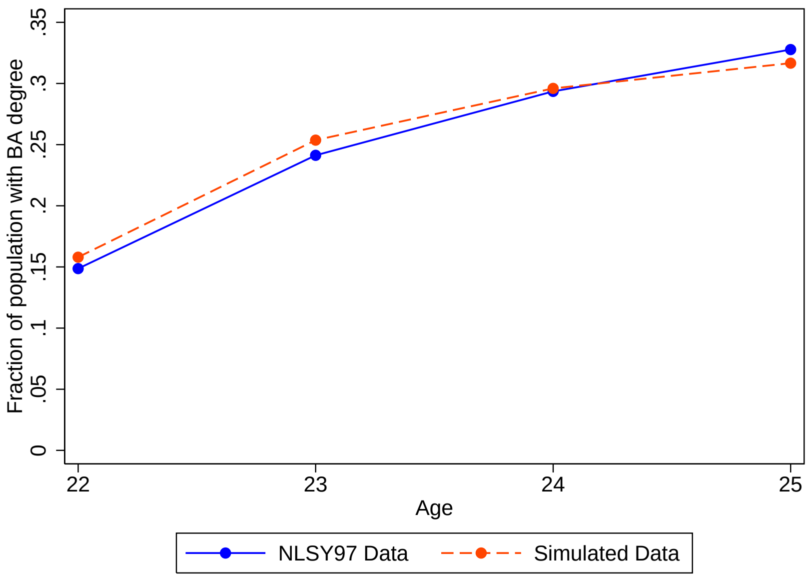

Figure 5: Bachelor's Degree Completion by Age

Table 7: Asset Statistics by Age

Age	Data	Median	Mean	Standard Deviation	Percent Negative
20	Actual	2100	5253	11250	14.8
20	Simulated	3000	5910	8287	16.1
25	Actual	4145	8458	22239	32.0
25	Simulated	6000	6362	9799	28.8

Table 8 shows the percent of students delaying entry to college by number of years of delay along with the percent of students never enrolling in college. The model matches delay patterns well, but slightly overestimates the fraction of students delaying by two or more years.

Table 8: Percentage of Students Delaying Entry to College

Years after HS graduation	0	.5+	1+	2+	3+	Never
Data	75.3	24.7	16.3	7.9	5.0	29.8
Simulation	77.6	22.4	15.1	9.8	7.5	31.6

NOTE.–In this table "0" indicates that a student enrolled in college in the semester after graduating from high school, ".5+" indicates that a student delayed entry to college by a semester or more, "1+" by a year or more and so on. The "Never" column displays the fraction of the sample that does not enroll in college.

The previous dimensions of model fit discussed are all moments that are explicitly targeted by the auxiliary models. The model also fits well along other dimensions. Table 9 shows how well the model fits the various statistics reported in Table 2 broken down by type of college attended and delay status. The model fits the patterns of the data: parental income and transfers, college grants, college enrollment and completion, and ability tend to decrease as college quality decreases and with delayed entry to college. Additional evidence of model fit is displayed in Web Appendix F.1.

9 Results of Policy Experiments

I first evaluate the effects of borrowing constraints by simulating increases in the loan limits of the FFEL program. I compare the changes in educational outcomes to those produced by increasing tuition subsidies. I then determine which policy is most cost effective at promoting higher education by simulating tuition subsidies targeted toward different groups of students. I also examine the effect of relaxing borrowing constraints and increasing tuition subsidies on the fraction of students delaying entry to college. Finally, I discuss the relationship between parental income and educational attainment and show that a large portion of the correlation is due to the transfers parents give their children.

9.1 Borrowing Constraints and Tuition Subsidies

How much do borrowing constraints matter? How effective is relaxing borrowing constraints at increasing educational attainment relative to tuition subsidies? I explore these questions by considering a $1,500 decrease in the cost of tuition at 2-year and 4-year colleges and a $1,500 increase in the maximum students are allowed to borrow each year from the FFEL program.[43] I also increase the cumulative maximum students are allowed to borrow through the FFEL program from $23,000 to $29,000. The results are displayed in Figures 6, 7, and 8. The relaxation of borrowing constraints causes a small increase in 4-year college enrollment which is due in part to a small substitution from 2-year to 4-year colleges. The increase in loan limits causes an increase in bachelor's degree completion at age 25 of 1.4 percentage points.

A tuition subsidy equal in dollar terms to the loan limit increase is much more effective at increasing enrollment and degree completion. The tuition subsidy causes a large increase in enrollment at 4-year colleges and a small increase in enrollment at 2-year colleges.[44] Overall college enrollment increases on average 6.4 percentage points for ages 18-21 in response to a $1,500 decrease in tuition at both college

[43]Note that in general tuition subsidies are much more expensive for the government to implement as compared to increases in loan limits. The end of this section contains details on the costs of financial aid to the government.

[44]As noted previously in Section 3.10, simulated responses in student behavior will not account for changes in parental transfers that may arise as a result of shifts in government subsidies.

Table 9: Selected Statistics by Type of College Attended and Delayed Entry

		4-Year	Both	2-Year	Never	No Delay	Delay
Sample Size	D	592	184	271	445	788	259
	S	2906	815	1386	2353	3958	1149
Parental Income and Transfers:							
Ave. Parental Income[a]	D	102	90	72	62	98	77
	S	102	88	69	67	95	75
Percent with Par. Trans. at 18	D	96.2	95.5	93.8	89.3	96.4	92.7
	S	95.2	92.6	91.6	87.6	94.7	90.6
Ave. Par. Trans. at 18 if >0	D	10848	8740	7837	7688	10293	7886
	S	11103	9756	8703	8373	10659	8815
Percent with Par. Trans. at 20	D	90.7	86.9	85.2	69.8	89.5	86.3
	S	90.7	90.2	84.1	77.0	89.9	85.1
Ave. Par. Trans. at 20 if >0	D	9918	7898	7687	6687	9507	7547
	S	9792	8446	6953	6707	9197	7553
College Grants:							
Ave. Grants/Year	D	2800	1711	849	.	2360	1324
	S	2598	1712	819	.	2137	1628
College Enrollment and Completion:							
Percent of Sems at 2-year	D	0.0	48.3	100.0	.	26.6	57.9
	S	0.0	42.7	100.0	.	27.7	55.4
Enrolled Part-Time[b]	D	7.6	15.6	31.7	.	10.6	29.1
	S	5.1	9.1	8.3	.	6.4	7.2
Completed BA[c]	D	62.6	33.3	0.0	0.0	56.2	13.1
	S	72.0	30.3	0.0	0.0	55.5	12.5
Highest Grade Completed[c]	D	15.8	15.9	13.7	12.0	16.0	14.1
	S	16.3	16.2	13.9	12.0	16.2	13.8
Ability and Race:							
Ave. AFQT Score	D	189	181	165	155	185	170
	S	192	179	163	155	184	172
Percent Black	D	9.5	9.2	15.1	16.2	8.6	17.8
	S	5.1	9.6	24.8	15.3	10.1	15.0
Percent Hispanic	D	6.4	7.1	11.4	8.8	6.7	11.2
	S	0.8	4.4	23.2	9.6	6.2	11.6
Labor Market Outcomes:							
Ave. Hourly Wage at 18	D	9.9	9.5	11.2	11.6	10.6	9.5
	S	10.3	10.5	10.4	10.5	10.1	11.3
Ave. Hourly Wage at 20	D	11.3	11.3	11.8	12.4	11.3	11.7
	S	11.7	12.4	11.9	11.7	11.8	12.0
Ave. Hourly Wage at 22	D	13.6	15.7	13.5	15.4	14.3	13.1
	S	14.1	13.6	12.5	12.5	13.8	12.9
Ave. Hourly Wage at 25	D	18.5	18.2	17.1	16.5	18.5	17.2
	S	18.4	16.9	14.2	13.6	17.6	15.1
Work PT While Enrolled[a]	D	30.6	34.3	27.1	.	32.0	25.2
	S	29.5	20.7	27.4	.	28.8	23.2
Work FT While Enrolled[a]	D	27.8	34.9	51.3	.	31.1	47.3
	S	38.9	46.5	35.8	.	40.3	35.8
Unemployed Before Enrolled	D	6.4	7.1	7.4	.	6.2	8.7
	S	7.6	5.6	7.6	.	7.4	6.8

NOTE.–"D" represents the statistics from the actual data and "S" denotes the simulated data.

[a] Measured in thousands of dollars.

[b] Average over all semesters enrolled.

[c] By age 25.

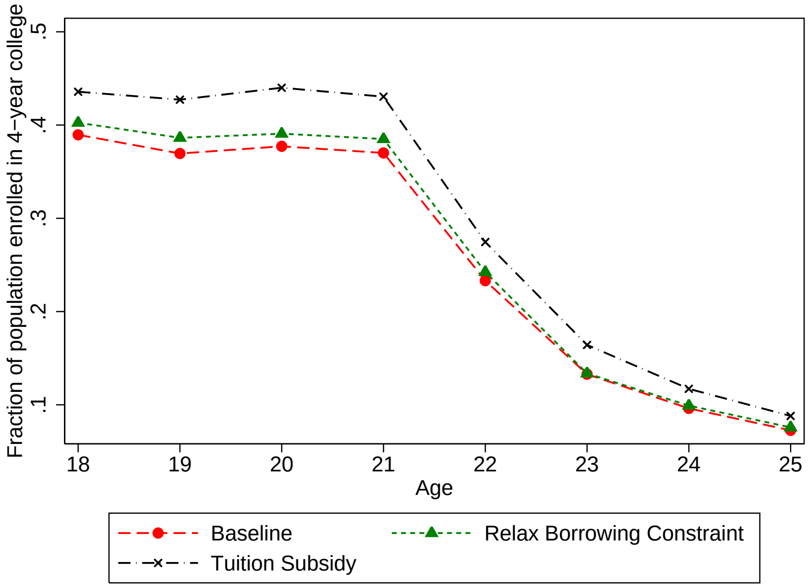

Figure 6: University Enrollment by Age

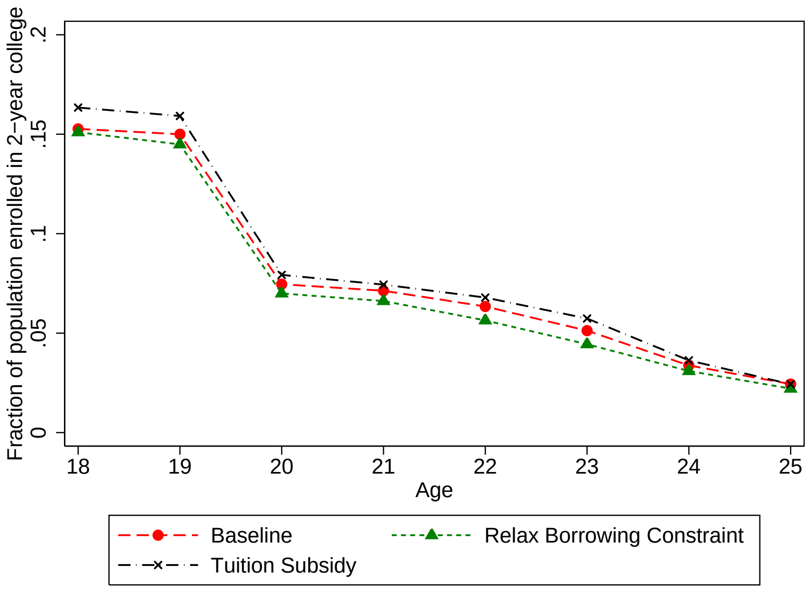

Figure 7: Community College Enrollment by Age

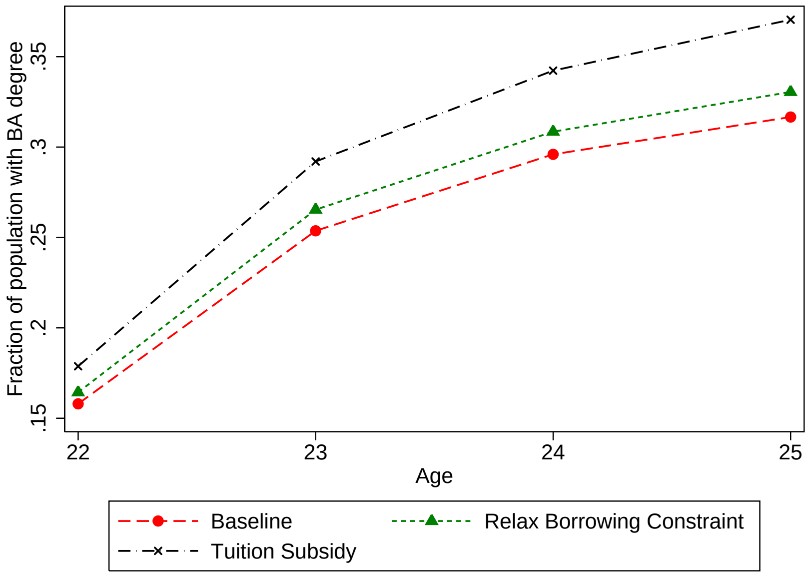

Figure 8: Bachelor's Degree Completion by Age

types. This estimate is in line with estimates in other papers of the effect of changes in the cost of college on enrollment. Kane (2006) surveys the literature on the effects of tuition changes on enrollment and shows that most studies find that a change of $1,000 in 1990 dollars (this is equivalent to $1,445 in 2004 dollars) is associated with a change in enrollment of between 3 and 6 percentage points.[45] Under the tuition subsidy simulation bachelor's degree completion increases by 5.3 percentage points.

Why is a dollar of tuition subsidies more effective at increasing enrollment and degree completion than a dollar of increased loan limits? In part this is because students do not have to repay tuition subsidies. If a youth is currently choosing not to attend school but is close to the margin when he weighs the return to education against the opportunity cost and psychic costs of schooling, then allowing him to borrow more money is unlikely to change his decision and cause him to attend school. Giving him $1,500 each year he attends school is much more likely to influence his decision. The only cases in which relaxing borrowing constraints would change a youth's decision is when he is unable to smooth consumption because he can not borrow enough during school and therefore chooses to work instead. Recall from Table 2 that only about half of students that enroll in college take out loans for school. The reluctance of students to borrow to finance college may be related to the precautionary savings motive explored Carroll (1997) in Carroll, Dynan, and Krane (2003) and could be one of the reasons that there is a small response to the simulated increase in loan limits.[46]

Even though borrowing constraints are tight,[47] few youths are affected by the increase in loan limits. When I run a simulation of the model where the education related borrowing constraint is completely removed and students are allowed to borrow up to the full cost of college each year they are enrolled, the fraction of the population completing a bachelor's degree increases by only 2.4 percentage points (see

[45] For other papers that examine the effects of the changes in the costs of college on enrollment see for example Dynarski (2003) and various papers contained in Hoxby (2004).

[46] It is important to note that the response of youths to the increase in student loan limits is affected by multiple factors including the psychic costs of school, the monetary returns to education, and uncertainty surrounding degree completion and future labor market outcomes. Disentangling the magnitude of these factors would be an interesting exercise but is beyond the scope of this paper.

[47] The average youth attending school can only borrow $3,381 at age 18; he can borrow $756 from other sources and $2,625 from the FFEL program (see Table E1 and Web Appendix E.3). The cost of tuition, room, and board at an average 4-year college is $15,049 (see Table B1).

Table 10 for details).

Increases in loan limits in the FFEL program are much less expensive for the government to implement than tuition subsidies. Ignoring administrative costs to the government the costs of the student loan program are the amount of interest the government pays on subsidized loans while students are enrolled in school and the amount that the government must pay to lenders if students default on the loans. In contrast, the government must pay each dollar of tuition subsidy to all students enrolling in college (unless the subsidies are targeted; targeted subsidies are considered in section 9.2). The added cost to the government of completely removing education related borrowing constraints is approximately $275 per youth in my sample. This number is calculated by simulating a version of the model in which students are allowed to borrow up to the full cost of schooling (tuition, room, and board) each period from the FFEL program. The added cost to the government from implementing these changes is the increase in loans taken out by students multiplied by the default rate on student loans multiplied by the fraction of the loan the government must repay to the lender.[48] To this total I add the subsidized interest the government pays while students are enrolled in school. The default rate in these calculations is assumed to be 6.9% which is the average cohort default rate during 2006-2009, the four years after most of the NLSY97 youths graduate from college.[49] The government repays 97% of the value of a loan to lenders if a student defaults.

The largest increase in degree completion the government can achieve through increasing limits on student loans is 2.4 percentage points, however, indicating that tuition subsidies are needed to implement larger increases in enrollment and degree completion. Given that tuition subsidies are more expensive, it is important to know which subsidies are the most cost-effective. Various designs of tuition subsidies are considered in the next section.

9.2 Tuition Subsidy Design

The tuition subsidy considered in the previous section subsidized tuition at 2-year and 4-year colleges for all students. Given the high labor market returns to bachelor's degree completion and that completion requires attendance at a 4-year college, it is likely to be more cost-effective to increase tuition subsidies at 4-year colleges only. Tuition subsidies targeted at certain groups of students may also be more cost effective than a subsidy that reduces tuition for all students.

Many government aid programs are currently targeted towards low income households. For example, only students who have parents with low incomes are eligible to receive Pell grants and subsidized Stafford loans. If the policy goal of the government is to reduce inequality, then programs targeted toward low income households are the most effective. The government may, however, desire to pursue other policy objectives such as increasing the average productivity of the workforce or increasing bachelor's degree completion. Since success in college is heavily influenced by the ability level of students, the government may wish to consider targeting subsidies based on students' ability levels rather than their family income levels. In the case of a targeted tuition subsidy it is unclear what the most cost-effective subsidy would

[48]The actual payment the government makes to lenders is more complicated. The government guarantees that the lenders will earn an interest rate equal to the three-month commercial paper rate plus a fixed premium. See Delisle (2008) for details. The government also pays small amounts of money to loan guaranty agencies. For simplicity these factors are ignored in the calculations of the cost to the government of increasing loan limits.

[49]Cohort default rates are obtained from the US Department of Education Office of Student Financial Assistance Programs. Note that default on student loans is abstracted from in the model since in general borrowers are required repay student loans even if they declare bankruptcy. The default rate is only used in this exercise to calculate the cost to the government of the policy change and (assuming the cohort default rate remains constant) likely provides an upper bound on the costs. This is because the default rate includes students that may be in default on their loans only temporarily and will later enter repayment either voluntarily or involuntary through wage garnishments. See Web Appendix E.3 for more details on the rules regarding defaults on student loans.

be; it depends on how many people in each section of the family income or ability distributions are close to the margin of college completion. Holding the cost of a subsidy constant, the government can offer higher subsidy levels to lower income and lower ability students since fewer of these youths attend college. However, these youths may be farther from the margin of completion which means that very large subsidies would be necessary to induce them to earn a college degree. The optimal tuition subsidy design is therefore very difficult to determine analytically. My model, however, is well suited to answer this question by simulating various levels of tuition subsidies targeted towards youths who come from different sections of the parental income and ability distributions.

I simulate increases in tuition subsidies at 4-year colleges targeted toward students in each third (tercile) of the parental income and ability distributions and compare them to a decrease in tuition for all students. To keep the costs of these subsides comparable to the cost of allowing students to borrow up to the full costs of college, all of the subsidy schemes considered in this section cost the government approximately $275 per capita for my sample. Lower subsidy amounts are given to higher family income and higher ability students, since these groups contain more inframarginal students which make subsidies more expensive for the government to implement.[50] The results of the experiments are displayed in Table 10 where the effects are broken down by ability and family income tercile. The tuition subsidies are also compared to the effects of completely removing education related borrowing constraints.

Table 10: Changes in Youth Outcomes Under Various Policies

	$AFQT_1$	$AFQT_2$	$AFQT_3$	Inc_1	Inc_2	Inc_3	All
Percent Completing Bachelor's Degree:							
Baseline	6.79	27.89	60.27	14.08	35.27	45.57	31.37
Borrow Full Cost of College	1.09	3.83	2.30	1.88	3.12	2.22	2.40
Untargeted Tuition Subsidy	0.13	1.08	0.70	0.53	0.58	0.80	0.63
Low Income Subsidy	0.33	0.98	0.85	2.10	0.00	0.00	0.72
Middle Income Subsidy	0.08	0.93	0.68	0.00	1.70	0.00	0.56
High Income Subsidy	0.08	1.14	0.46	0.00	0.00	1.73	0.56
Low Ability Subsidy	2.61	0.00	0.00	0.74	0.98	0.92	0.88
Middle Ability Subsidy	0.00	3.37	0.00	0.69	1.36	1.36	1.13
High Ability Subsidy	0.00	0.00	1.78	0.48	0.75	0.51	0.58
Present Discounted Value of Income:[a]							
Baseline	506.21	584.64	635.44	523.72	589.17	613.91	574.81
Borrow Full Cost of College	1.20	5.07	2.07	2.63	3.23	2.49	2.78
Untargeted Tuition Subsidy	0.21	1.22	0.55	0.52	0.60	0.87	0.66
Low Income Subsidy	0.32	1.38	0.78	2.41	0.00	0.00	0.83
Middle Income Subsidy	0.13	1.01	0.39	0.00	1.54	0.00	0.51
High Income Subsidy	0.21	1.23	0.42	0.00	0.00	1.90	0.62
Low Ability Subsidy	3.21	0.00	0.00	1.03	1.34	0.88	1.08
Middle Ability Subsidy	0.00	4.05	0.00	1.02	1.64	1.44	1.36
High Ability Subsidy	0.00	0.00	1.62	0.51	0.56	0.51	0.53

NOTE.–The columns $AFQT_1$ and Inc_1 contain the average outcomes for youths in the lowest third of the ability and family income distributions, respectively. Changes in the outcome relative to the baseline are displayed in each category.

[a] Measured in thousands of dollars.

The effects of the relaxation of borrowing constraints and the untargeted tuition subsidy on bachelor's

[50]The simulations decrease annual tuition at 4-year colleges by the following amounts for each group: the untargeted subsidy decreases tuition by $130, the low income subsidy by $660, the subsidy targeted toward the second income tercile by $340, the high income subsidy by $270, the low ability subsidy by $1190, the middle ability subsidy by $380, and the high ability subsidy by $210. See Web Appendix E.1 for details about how the targeted subsidy calculations are affected by the Emax approximation used to solve the model.

degree completion are concentrated in the top two AFQT and family income terciles. This indicates that students in the middle and top of the ability and family income distributions are most likely to be close to the margin of degree completion. To implement small increases in educational attainment, allowing students to borrow more is the least expensive policy for the government. Since 2.4 percentage points is the upper bound on the effectiveness of this policy, the government needs to use tuition subsidies if it wishes to further increase degree completion. Tuition subsidies targeted toward households in the middle third of the ability distribution turn out to be the most cost effective at increasing educational attainment, raising the fraction of the population completing a bachelor's degree by 1.13 percentage points.[51]

The intuition behind this result is that most high ability youths already attend college and complete a bachelor's degree, so increasing their subsidies will be very costly because the government will need to pay for a large number of inframarginal students. On the other end of the distribution, low ability youths are far enough from the margin of degree completion that very large subsidies are required to induce them to earn a degree. Youths in the middle of the ability distribution are close to the margin of degree completion and there are relatively few inframarginal students, making them the most cost effective group for targeted subsidies. In the subsidies targeted towards various parts of the family income distribution middle ability youths are always the most responsive, but the income based subsides require the government to pay for a number of inframarginal high ability youths which causes them to be less cost effective than the middle ability subsidy.

To evaluate the return the government receives (in terms of increased productivity of the work force) from the increased tuition subsidies I examine the changes in the present discounted value of lifetime income youths experience under the various policies. The return in terms of income outweighs the costs for all the tuition subsidy programs. The total cost per person for each subsidy is $275 whereas the average increase in lifetime income in each case is more than $275. The removal of education related borrowing constraints and the tuition subsidy targeted toward middle ability households have the largest payoffs, increasing average lifetime income by $2,780 and $1,360, respectively.[52]

9.3 Delayed Entry

Table 11 shows the effect that the removal of the education related borrowing constraint and the $1,500 tuition subsidy considered in Section 9.1 have on delayed entry to college. Both of these policies slightly decrease the fraction of students delaying entry to college by a semester or more.[53] The small magnitude of these effects, however, indicate that borrowing constraints and the price of college are not the main reasons behind the large number of students delaying entry to college. Other candidate explanations within the model for delayed entry to college are shocks to preferences for schooling and changes in the opportunity cost of schooling caused by unemployment or negative wage shocks. My results indicate that shocks to preferences are the largest contributor to delayed entry to college. When shocks to 2-year and 4-year college enrollment are removed, the fraction of students delaying entry to college by a year or more drops to zero (results not shown), indicating that the shocks to preference explain almost all the delayed entry to college. The shocks to preferences are a black box, however, since I do not model where the

[51] The differences in effectiveness between the various subsidy designs is small in this example because the subsidy amount is small in order to keep the cost the same as in the simulation where education related borrowing constraints are removed. When larger dollar amounts are are considered the middle ability subsidy is significantly more effective than all other subsidies at the 5% level.

[52] These calculations do not incorporate the dead-weight loss that could arise through an increase in taxes to pay for the tuition subsidy programs.

[53] This can be seen by noting the slight increase in the fraction of students in the "0" column that enroll in college the semester after graduating from high school.

shocks come from. Future research needs to be done to determine exactly what drives such large shocks to preferences for college enrollment. A model that incorporates learning about ability and preferences for high school level jobs might be able to explain the changes in tastes that agents experience.

Table 11: Percentage of Students Delaying Entry to College

Years after HS graduation	0	.5+	1+	2+	3+	Never
Baseline	77.6	22.4	15.1	9.8	7.5	31.6
Borrow Full Cost of College	78.5	21.5	13.7	8.7	6.7	30.2
$1,500 Tuition Subsidy	79.5	20.5	13.7	8.9	6.9	26.2

NOTE.–In this table "0" indicates that a student enrolled in college in the semester after graduating from high school, ".5+" indicates that a student delayed entry to college by a semester or more, "1+" by a year or more and so on. The "Never" column displays the fraction of the sample that does not enroll in college.

9.4 Link Between Parental Income and Educational Outcomes

Parental resources affect the educational attainment of their children through investments made when the children are young and through financial support provided during college years. Early childhood investment by parents enter in this model through the AFQT score and through unobserved heterogeneity. Investments made by parents during college years enter directly through parental transfers. Table 12 replicates and extends the results in Belley and Lochner (2007) to examine the relationship between parental income and educational attainment.

Belley and Lochner (2007) regress various indicators for educational attainment on AFQT, parental income, and other controls for family background. Table 12 uses this methodology to asses the effect of parental income and ability on whether a youth has completed four or more years of college by age 23. The first two columns display the results of the regression run on actual and simulated data. The results in the first column match the patterns found in Belley and Lochner (2007) that family income is significantly positively related to educational attainment even after controlling for ability. The fact that coefficients from the regression run on the simulated data are very similar the coefficients estimated using the actual data provides some additional evidence of how well the model fits the data. The third column of the table adds controls for the unobserved heterogeneity types. When these controls are added, the effect of parental income on educational attainment is diminished, indicating that some of the correlation between parental income and educational outcome is due to the correlation between parental income and unobserved ability of youths. However, parental income still has a direct effect on the educational attainment of youths after controlling for observed and unobserved ability. Youths from households in the highest income quartile are 8.6% more likely to have completed four or more years by age 23 than youths from households in the lowest family income quartile.

According to Belley and Lochner (2007) the fact that, conditional on ability and family background characteristics, parental income predicts college outcomes more strongly in recent years than in the 1980s may indicate that borrowing constraints are currently binding and affecting education outcomes. The results in this paper show, however, that educational borrowing constraints currently have a small impact on educational attainment. Consistent with an observation made by Kane (2006) that direct transfers from parents during college years can explain a large fraction of the gap in educational attainment between youths from low and high income households, my results indicate that the strong correlation between parental income and educational attainment may be driven by higher income parents giving more money to their children while they are enrolled in college.[54] The direct effect of parental income

[54]The model does not, however, explain why the relationship between parental income and educational attainment has

Table 12: Regression of Indicator for 4+ Years of College by Age 23

	Data	Simulation	Simulation
AFQT Q2	0.120**	0.078**	-0.113**
	(0.043)	(0.014)	(0.012)
AFQT Q3	0.282**	0.261**	0.005
	(0.045)	(0.015)	(0.013)
AFQT Q4	0.467**	0.457**	0.253**
	(0.045)	(0.015)	(0.013)
Parental Income Q2	0.021	0.080**	0.018
	(0.042)	(0.014)	(0.012)
Parental Income Q3	0.094*	0.132**	0.016
	(0.043)	(0.015)	(0.012)
Parental Income Q4	0.192**	0.229**	0.086**
	(0.045)	(0.015)	(0.012)
Black	0.029	0.013	0.025
	(0.047)	(0.016)	(0.013)
Hispanic	-0.098	-0.105**	-0.082**
	(0.059)	(0.019)	(0.015)
Type 2			-0.310**
			(0.013)
Type 3			-0.761**
			(0.013)
Constant	0.056	0.071**	0.778**
	(0.041)	(0.014)	(0.017)
R-squared	0.189	0.204	0.477
Sample Size	864	7460	7460

NOTE.–Standard errors appear in parentheses below coefficients.
** $p<0.01$
* $p<0.05$

on educational outcomes is explored further in Table 13.

Table 13: Counterfactual Changes in Youth Outcomes

	$AFQT_1$	$AFQT_2$	$AFQT_3$	Inc_1	Inc_2	Inc_3	All
Percent Completing 4+ Years by Age 23:							
Baseline	13.60	32.26	65.08	18.90	41.13	50.91	36.11
Grants Independent of Income	-0.32	-0.12	1.93	-2.07	0.36	3.29	1.08
Equalize Parental Transfers	-0.64	-7.54	-5.41	3.91	1.21	-19.22	-3.92

NOTE.–The columns $AFQT_1$ and Inc_1 contain the average outcomes for youths in the lowest third of the ability and family income distributions, respectively. Changes in the outcome relative to the baseline are displayed in each category.

Parental income directly affects educational outcomes through two main channels in the model: through government higher education subsidies and parental transfers. The design of government programs to sponsor higher education favors lower income households. Youths from high income households are not eligible to receive Pell grants or subsidized loans. The first counterfactual experiment in Table 13 makes grant receipt independent of income by treating each youth as if he had the average family income in the sample for the purposes of Equation (8). This counter-factual also changes the Stafford loan eligibility rules so that all students are eligible for subsidized loans. Students from the highest income tercile benefit from these changes with a 3.29 percentage point increase in the fraction completing four or more years of college by age 23. Students from the lowest income tercile are hurt the most with a 2.07 percentage point decrease in fraction completing four or more years by age 23.

The direct effect of parental transfers is explored by inserting the average parental income in the sample for all youths into Equations (12) and (13). These changes have large effects on educational attainment across income terciles. Educational attainment increases by 3.91 percentage points for youths from the lowest family income terciles and decreases by 19.22 percentage points for youths from the highest family income tercile. The effects across AFQT terciles are strongest in the top two thirds of the ability distribution. This counterfactual exercise provides evidence that a substantial fraction of the correlation between parental income and educational attainment is due to the direct effect of the parental transfers youths receive while in college.

10 Conclusion

In this paper I solved and estimated a dynamic structural model of the education, work, and asset accumulation decisions of students after they graduate from high school. The model allows for heterogeneity in both observed and unobserved ability, family income, and parental transfers. I explicitly modeled the uncertainty students face about degree completion and about future labor market outcomes. I estimated the model using Indirect Inference and used the estimates to perform various policy and counter-factual experiments.

I showed that borrowing constraints have a small impact on overall educational attainment. Simulated increases in the availability of loans through government sponsored student loan programs raise bachelor's degree completion by at most 2.4 percentage points. Increases in tuition subsidies are necessary to achieve larger impacts on educational attainment. Tuition subsidies targeted towards middle ability households are shown to be the most cost-effective method for the government to increase the average level of degree completion and earnings in the population.

strengthened in recent years. It is possible that in response to the rising costs of college higher income parents currently give relatively more money to their children then they did in the 1980s. Unfortunately the NLSY79 does not contain data on the amounts of parental transfers, and I am not aware of other data from the 1980s that could be used to test this theory.

Recent papers have proposed borrowing constraints as a possible explanation for why parental income matters for educational outcomes after conditioning on ability. I have shown that borrowing constraints are not the main reason behind the effect of parental income and that the transfers youths receive from their parents while in college can explain a large portion of the correlation between parental income and educational attainment.

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Appendix A Exact Functional Forms

Appendix A.1 Utility Function (g^u)[55]

$$u_t = \frac{c_t^{1-\rho}}{1-\rho} + [\gamma_1 AFQT_3 + \gamma_2 AFQT_2 + \gamma_3 AFQT_1 \tag{16}$$

$$+\gamma_4 black + \gamma_5 Hispanic + \epsilon_t^U][I(s_t^U = .5) + \gamma_6 I(s_t^U = 1)]$$

$$+[\gamma_7 AFQT_3 + \gamma_8 AFQT_2 + \gamma_9 AFQT_1 + \gamma_{10} black + \gamma_{11} Hispanic + \epsilon_t^C][I(s_t^C = .5) + \gamma_{12} I(s_t^C = 1)]$$

[55] $AFQT_i$ and Inc_i indicate that the youth's ability and parental income fall in tercile i. sem indicates the semester; 1=Summer, 2=Fall, and 3=Spring. The first term in the utility function is multiplied by 10^6 to avoid dealing with very small coefficients in the remainder of the utility function.

$$+\gamma_{13}age_t s_t^U I(age_t \geq 22) + \gamma_{14}age_t s_t^C I(age_t \geq 20) + \gamma_{15}I(s_t^U > 0)I(s_{t-1}^U > 0)$$

$$+\gamma_{16}I(s_t^C > 0)I(s_{t-1}^C > 0) + \gamma_{17}I(s_t^U > 0)I(s_{t-1}^U > 0)I(sem = 1)$$

$$+\gamma_{18}I(s_t^C > 0)I(s_{t-1}^C > 0)I(sem = 1) + \gamma_{19}I(s_t^U + s_t^C > 0)I(BA_t = 1)$$

$$+[\gamma_{20} + \sum_{k=2}^{K}\gamma_{21,k}I(type = k) + \gamma_{22}black + \gamma_{23}Hispanic + \epsilon_t^w][I(h_t = .5) + \gamma_{24}I(h_t = 1)]$$

$$+\gamma_{25}I(h_t = 1)age_t + \gamma_{26}I(h_t = 1)age_t + \gamma_{27}I(h_t = 1)I(age \geq 23)$$

$$+\gamma_{28}I(h_t = 1)I(s_t^U = 1) + \gamma_{29}I(h_t = .5)I(s_t^U = 1)$$

$$+\gamma_{30}I(h_t = 1)I(s_t^C = 1) + \gamma_{31}I(h_t = .5)I(s_t^C = 1) + \gamma_{32}I(h_t = 1)I(s_t^U = .5) + \gamma_{33}I(h_t = .5)I(s_t^U = .5)$$

$$+\gamma_{34}I(h_t = 1)I(s_t^C = .5) + \gamma_{35}I(h_t = .5)I(s_t^C = .5) + [\gamma_{36}I(s_t^U > 0)AFQT_3$$

$$+\gamma_{37}I(s_t^U > 0)AFQT_2 + \gamma_{38}I(s_t^U > 0)AFQT_1 + \gamma_{39}I(s_t^C > 0)AFQT_3 + \gamma_{40}I(s_t^C > 0)AFQT_2$$

$$+\gamma_{41}I(s_t^C > 0)AFQT_1]I(age_t = 18)I(semester = 2) + \gamma_{42}I(s_t^U > 0)I(S_t^U > 2.5)$$

$$+\gamma_{43}I(s_t^U > 0)I(age \geq 24) + \sum_{k=2}^{K}\gamma_{44,k}I(type = k)I(s_t^C + s_t^U > 0)$$

Appendix A.2 Human Capital Function (g^Ψ)

$$\Psi_t = \exp\{\phi_0 + \phi_1 S_t^U + \phi_2 S_t^C + \phi_3 BA_t + \phi_4 H_t + \phi_5 H_t^2 + \phi_6 AFQT + \sum_{k=2}^{K}\phi_{7,k}I(type = k)\} \tag{17}$$

Appendix A.3 Wage Function (g^w)

$$w_t = \Psi_t \exp\{\alpha_1 I(h_t = .5) + \alpha_2 I(s_t^C + s_t^U > 0) + \alpha_3 black + \alpha_4 Hispanic + \epsilon_t^w\} \tag{18}$$

Appendix A.4 Unemployment Probability (J_t)[56]

$$\Pr(J_t = 1) = \Phi[\xi_0 + \xi_1\Psi_t + \xi_2 I(h_{t-1} = 0) + \xi_3 black + \xi_4 Hispanic] \tag{19}$$

Appendix A.5 Grant Functions (g^{grant})

Appendix A.5.1 Grants at 4-year college

$$grant_t = \zeta_0^U + \zeta_1^U AFQT + \zeta_2^U \frac{AFQT^2}{1000} + \zeta_3^U Inc + \zeta_4^U \frac{Inc^2}{1000} \tag{20}$$

$$+ \sum_{k=2}^{K}\zeta_{5,k}I(type = k) + \zeta_6^U black + \zeta_7^U Hispanic$$

Appendix A.5.2 Grants at 2-year college[57]

$$grant_t = \zeta_0^C + \zeta_1^C Inc + \zeta_2^C \frac{Inc^2}{1000} + \zeta_3^C black + \zeta_4^C Hispanic \tag{21}$$

[56] Φ indicates the normal cumulative distribution function.

[57] In the data grants at 2-year colleges do not appear to depend on AFQT. This indicates that most merit based scholarships are awarded at 4-year colleges and that the Pell grant program is responsible for most of the grants at 2-year colleges.

Appendix A.6 Asset Lower Bound ($g^{\underline{a}^o}$)

$$\underline{a}^o = -exp\{\mu_0 + \mu_1 \Psi_t + \mu_2 \Psi_t^2 + \mu_3 age_t + \mu_4 I(age_t \geq 23)\} \tag{22}$$

Appendix A.7 Degree Completion (BA_t)

$$\Pr(BA_t = 1|Eligible) = \Phi[\nu_0 + \nu_1 S_t^U I(S_t^U > 4.5) + \nu_2 S_t^U I(S_t^U > 5.5) \tag{23}$$
$$+\nu_3 \Psi_t + \nu_4 \Psi_t^2]$$

Appendix A.8 Parental Transfers Probability (P_t)

$$\Pr(P_t = 1) = \Phi[\lambda_0 + \lambda_1 Inc + \lambda_2 \frac{Inc^2}{1000} + \lambda_3 I(s_{t-1}^C + s_{t-1}^U > 0) \tag{24}$$
$$+\lambda_4 I(s_{t-1}^C + s_{t-1}^U > 0) Inc + \lambda_5 I(P_{t-1} = 1) + \lambda_6 age_t$$
$$+\lambda_7 \Psi_t + \lambda_8 I(age_t > 23) + \lambda_9 black + \lambda_{10} Hispanic + \lambda_{11} I(J_t = 0)]$$

Appendix A.9 Amount of Parental Transfers (tr_t)

$$tr_t = \exp\{\chi_0 + \chi_1 I(s_t^U > 0) + \chi_2 I(s_t^U > 0) Inc + \chi_3 (S_t^U + S_t^C + 12) \tag{25}$$
$$+\chi_4 age_t + \chi_5 Inc + \chi_6 \frac{Inc^2}{1000} + \chi_7 \Psi_t + \chi_8 black + \chi_9 Hispanic + \chi_{10} I(J_t = 0)\}$$

Appendix A.10 Type Probability Distribution[58]

$$\Pr(type = k) = \tag{26}$$
$$\frac{\exp\{\pi_{0,k} + \pi_{1,k} AFQT_1 + \pi_{2,k} AFQT_2 + \pi_{3,k} Inc_1 + \pi_{4,k} Inc_2 + \pi_{5,k} black + \pi_{6,k} Hispanic\}}{1 + \sum_{m=2}^{K} \exp\{\pi_{0,m} + \pi_{1,m} AFQT_1 + \pi_{2,m} AFQT_2 + \pi_{3,m} Inc_1 + \pi_{4,m} Inc_2 + \pi_{5,m} black + \pi_{6,m} Hispanic\}}$$

Appendix A.11 Minimum Earnings[59]

$$w^{MIN} = \omega_0 + \omega_1 H_t \tag{27}$$

Appendix A.12 Terminal Value Function (V^{TERM})[60]

$$V^{TERM} = PDV + \upsilon_1 a_t \tag{28}$$

Appendix A.13 Distribution of Shocks[61]

$$\begin{pmatrix} \epsilon_t^C \\ \epsilon_t^U \\ \epsilon_t^h \\ \epsilon_t^w \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_C^2 & & & \\ \sigma_{CU}^2 & \sigma_U^2 & & \\ \sigma_{Ch}^2 & \sigma_{Uh}^2 & \sigma_h^2 & \\ \sigma_{Cw}^2 & \sigma_{Uw}^2 & \sigma_{hw}^2 & \sigma_w^2 \end{pmatrix} \right]$$

[58] Coefficients for type 1 are all normalized to 0.
[59] Amount of monthly welfare benefits received if unemployed and not enrolled in school.
[60] See Web Appendix E.1 for details about PDV, the present discounted value of future wages.
[61] For computational tractability all covariances between shocks are set to zero.

Appendix B Parameter Values

Appendix B.1 Calibrated Parameter Values

Table B1: Calibrated Parameter Values

Description	Symbol	Value	Source
Annual college tuition by state category[a]			IPEDS data on statewide enrollment weighted average tuition from 2001/02-2004/05
	κ_1^U	5,214	
	κ_2^U	7,499	
	κ_3^U	8,607	
	κ_4^U	12,748	
	κ_1^C	1,507	
	κ_2^C	989	
	κ_3^C	2,192	
	κ_4^C	2,520	
Cost of room and board at 2-year college[b]	.	4,539	IPEDS data on room and board at 2-year colleges from 2001/02-2004/05
Cost of room and board at 4-year college	.	6,532	IPEDS data on room and board at 4-year colleges from 2001/02-2004/05
Risk aversion parameter	ρ	2	Standard value from the literature
Annual discount rate	δ	.97	Standard value from the literature

[a] The average tuition in the second group for 2-year colleges is lower in the first group due to the fact that some states have relatively low average tuition at 2-year colleges and relatively high average tuition at 4-year colleges. See Appendix E.4 for details on the construction of the tuition categories.

[b] In principle average costs of room and board could be broken down into the different categories above. The variation in room and board prices across states is relatively small, however, so I use national averages for simplicity.

Appendix B.2 Estimated Parameter Values[62]

Table B2: Estimated Parameters

Description	Symbol	Estimate (SE)
Utility Function:		
Psychic costs of 4-year college attendance:		
$AFQT_3$	γ_1	-20.18 (8.22)
$AFQT_2$	γ_2	-64.7 (6.48)
$AFQT_1$	γ_3	-38.29 (8.6)
Black	γ_4	-29.3 (7.92)
Hispanic	γ_5	-95.85 (21.1)
Psychic costs for 4-year college full time shifter	γ_6	1.082 (.116)
Psychic costs of 2-year college attendance:		
$AFQT_3$	γ_7	-42.98 (9.03)
$AFQT_2$	γ_8	-53.85 (12.9)
$AFQT_1$	γ_9	-30.04 (8.32)
Black	γ_{10}	22.83 (6.92)
Hispanic	γ_{11}	27.88 (15.1)
Psychic costs for 2-year college full time shifter	γ_{12}	1.117 (.016)
Attending 4-year college after age 22	γ_{13}	-1.164 (.165)
Attending 2-year college after age 20	γ_{14}	-2.299 (.326)
Persistence in college attendance:		
4-year college	γ_{15}	130.3 (4.28)
2-year college	γ_{16}	111.4 (3.35)
Fall to spring in 4-year college	γ_{17}	45.64 (12.9)
Fall to spring in 2-year college	γ_{18}	57.39 (13)
Attending school after completing BA	γ_{19}	-127.4 (12.9)
Work preferences:		
Preference for working part-time	γ_{20}	-17.04 (1.93)
Type 2	$\gamma_{21,2}$	-1.667 (.924)
Type 3	$\gamma_{21,3}$	-1.714 (.937)
Black	γ_{22}	-43.44 (6.9)
Hispanic	γ_{23}	-44.25 (8.89)
Preference for working full time shifter	γ_{24}	4.964 (.266)

Continued on next page...

[62] Standard errors are calculated using the formula on page S92 of Gouriéroux, Monfort, and Renault (1993).

Description	Symbol	Estimate (SE)
Work full-time interacted with age	γ_{25}	2.201 (.285)
Work part-time interacted with age	γ_{26}	-.7711 (.12)
Work full-time after age 23	γ_{27}	44.92 (2.31)
Working while attending college:		
Work full-time 4-year college full-time	γ_{28}	-83 (3.22)
Work part-time 4-year college full-time	γ_{29}	-1.83 (1.87)
Work full-time 2-year college full-time	γ_{30}	-8.222 (3.74)
Work part-time 2-year college full-time	γ_{31}	-.1431 (.992)
Work full-time 4-year college part-time	γ_{32}	-65.28 (8.41)
Work part-time 4-year college part-time	γ_{33}	-24.39 (10.7)
Work full-time 2-year college part-time	γ_{34}	-10.9 (5.76)
Work part-time 2-year college part-time	γ_{35}	-6.191 (4.45)
Starting 4-year college semester after high school:		
$AFQT_3$	γ_{36}	44.21 (25.6)
$AFQT_2$	γ_{37}	34.28 (14.8)
$AFQT_1$	γ_{38}	25.2 (42.7)
Starting 2-year college semester after high school:		
$AFQT_3$	γ_{39}	14.3 (20.7)
$AFQT_2$	γ_{40}	37.21 (15.8)
$AFQT_1$	γ_{41}	46.33 (17.8)
Cont. in 4-year college after completing 3 years	γ_{42}	63.94 (5.79)
Attending 4-year college after age 24	γ_{43}	28.16 (5.85)
Unobserved heterogeneity in psycic schooling costs:		
Type 2	$\gamma_{44,2}$	-47.69 (8.91)
Type 3	$\gamma_{44,3}$	-157.5 (16.5)
Human Capital Function:		
Constant	ϕ_0	2.493 ($9.0e-03$)
Years at 4-year college	ϕ_1	.0168 ($2.0e-03$)
Years at 2-year college	ϕ_2	.0159 ($2.3e-03$)
BA degree completion	ϕ_3	.1877 (.015)
Years of experience	ϕ_4	.0688 ($1.6e-03$)
Years of experience squared	ϕ_5	-.0035 ($8.7e-05$)

Continued on next page...

Description	Symbol	Estimate (SE)
AFQT	ϕ_6	2.2e-04 ($6.3e-05$)
Type 2	$\phi_{7,2}$	-.0973 (.016)
Type 3	$\phi_{7,3}$	-.2055 ($7.5e-03$)
Wage Equation Parameters:		
Part-time work	α_1	-.011 ($8.9e-03$)
Enrolled in school	α_2	-.3408 (.016)
Black	α_3	-.1632 (.015)
Hispanic	α_4	-.0359 (.014)
Job Offer Probability Parameters:		
Constant	ξ_0	1.437 (.046)
Human capital	ξ_1	.0479 ($2.9e-03$)
Not working in previous semester	ξ_2	-1.094 (.013)
Black	ξ_3	-.378 (.024)
Hispanic	ξ_4	-.1152 (.043)
Grants at 4-year college:		
Constant	ζ_0^U	6369 ($1.0e+03$)
AFQT	ζ_1^U	-58.79 (6.54)
$AFQT^2/1000$	ζ_2^U	261.5 (23.2)
Family income	ζ_3^U	-30.14 (4.92)
$Inc^2/1000$	ζ_4^U	71.81 (12.9)
Type 2	$\zeta_{5,2}^U$	-147.5 (211)
Type 3	$\zeta_{5,3}^U$	-259.9 (382)
Black	ζ_6^U	974.9 (799)
Hispanic	ζ_7^U	564.1 (525)
Grants at 2-year college:		
Constant	ζ_0^C	1805 (666)
Family income	ζ_1^C	-23.86 (8.01)
$Inc^2/1000$	ζ_2^C	55.93 (30.9)
Black	ζ_3^C	547.5 (516)

Continued on next page...

Description	Symbol	Estimate (SE)
Hispanic	ζ_4^C	49.36 (152)
Asset Lower Bound:		
Constant	μ_0	.7727 (.105)
Human capital	μ_1	.1224 (.014)
Human capital squared	μ_2	-9.4e-04 $(3.2e-04)$
Age	μ_3	.2508 $(5.9e-03)$
Age 23 or older	μ_4	.1517 (.052)
Degree Completion Probabililty:		
Constant	ν_0	-3.216 (.047)
Years at 4-year college if > 4.5	ν_1	-6.0e-04 $(9.9e-04)$
Years at 4-year college if > 5.5	ν_2	.0598 (.022)
Human capital	ν_3	.1615 $(8.0e-03)$
Human capital squared	ν_4	6.2e-05 $(6.1e-05)$
Parental Transfers Probabililty:		
Constant	λ_0	1.897 (.158)
Family income	λ_1	9.4e-04 $(2.0e-04)$
$Inc^2/1000$	λ_2	-.0017 $(5.0e-04)$
Attend college previous semester	λ_3	.0335 (.026)
Attend previous interacted with family income	λ_4	.0025 $(5.8e-04)$
Parental transfers previous semester	λ_5	2.388 (.12)
Age	λ_6	-.195 $(9.6e-04)$
Human capital	λ_7	.0861 $(7.4e-03)$
Age>21	λ_8	-.0292 (.014)
Black	λ_9	.1978 (.076)
Hispanic	λ_{10}	.0809 (.035)
Unemployed	λ_{11}	2.175 (.482)
Amount of Parental Transfers:		
Constant	χ_0	10.73 (.025)
4-year college attendance	χ_1	.0691 (.032)

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Description	Symbol	Estimate (SE)
4-year attendance interacted with family income	χ_2	.002 ($3.9e-04$)
Years of schooling	χ_3	.0011 ($1.4e-03$)
Age	χ_4	-.1198 ($1.7e-03$)
Family income	χ_5	.0027 ($2.4e-04$)
$Inc^2/1000$	χ_6	-.0037 ($6.1e-04$)
Human capital	χ_7	.0251 ($3.8e-03$)
Black	χ_8	.0675 (.04)
Hispanic	χ_9	-.0553 (.03)
Unemployed	χ_{10}	.5374 (.105)
Type Probability Distribution:		
Type 2:		
Constant	$\pi_{0,2}$	-.477 (.389)
$AFQT_1$	$\pi_{1,2}$	.4819 (.61)
$AFQT_2$	$\pi_{2,2}$	3.061 (1.17)
Inc_1	$\pi_{3,2}$	.2226 (.602)
Inc_2	$\pi_{4,2}$	.7373 (.684)
Black	$\pi_{5,2}$	-.1362 (1.02)
Hispanic	$\pi_{6,2}$	.103 (.369)
Type 3:		
Constant	$\pi_{0,3}$	-.1754 (.186)
$AFQT_1$	$\pi_{1,3}$	1.89 (.388)
$AFQT_2$	$\pi_{2,3}$	.277 (.425)
Inc_1	$\pi_{3,3}$	1.392 (.506)
Inc_2	$\pi_{4,3}$	.3138 (.233)
Black	$\pi_{5,3}$	.0816 (1.08)
Hispanic	$\pi_{6,3}$	.2309 (.525)
Minimum Earnings:		
Constant	ω_0	317.5 (136)
Experience	ω_1	45.83 (37.4)
Terminal Value Function:		

Continued on next page...

Description	Symbol	Estimate (SE)
Assets	υ_1	.0229 ($5.1e-03$)
Shock Distribution		
Preference for 2-year college	σ_C^2	4254 (482)
Preference for 4-year college	σ_U^2	1174 (312)
Preference for work	σ_h^2	216.9 (39.1)
Wage	σ_w^2	.0564 ($1.7e-03$)

Appendix C Data and Sample Selection

Appendix C.1 NLSY97 Data

There are 3,459 males respondents in the nationally representative NLSY97 survey. Restricting the sample to white, black, and Hispanic respondents that graduate high school between the ages of 16 and 19 and never serve in the military leaves a sample size 1861. My analysis sample includes all respondents from this subset that have non-missing data on key variables such as AFQT, parental income, or initial asset holdings. Table C1 displays summary statistics that compare my analysis sample to the nationally representative NLSY97 survey.

Table C1: Included and Excluded from Sample

	Full NLSY97	Restrictions	Restrictions + Missing Data
Sample Size	3459	1861	1492
Ave. AFQT Score	165.8	173.2	173.4
	(32.5)	(30.1)	(30.0)
Ave. Parental Income[a]	74.1	83.2	83.2
	(55.7)	(54.6)	(53.1)
Percent with Par. Trans. at 18	91.1	93.6	93.6
	(28.5)	(24.5)	(24.5)
Ave. Par. Trans. at 18 if >0	8626	9134	9154
	(3721)	(4212)	(4266)
Average Assets at 18	3894	4831	5184
	(8773)	(9235)	(9658)
Ave. Hourly Wage at 18	10.7	10.7	10.6
	(15.3)	(14.6)	(14.2)
Highest Grade Completed[b]	12.7	14.5	14.5
	(2.9)	(2.1)	(2.1)
Percent Completed BA[c]	28.4	31.3	32.2
	(45.1)	(46.4)	(46.7)
Percent White	66.0	78.0	79.4
	(47.4)	(41.4)	(40.4)
Percent Black	15.5	13.5	12.5
	(36.2)	(34.2)	(33.0)
Percent Hispanic	13.6	8.4	8.1
	(34.2)	(27.8)	(27.3)

NOTE.–This table displays summary statistics for the nationally representative sample of males from the NLSY97, the observations that remain after imposing sample restrictions, and the final analysis sample that includes only respondents with non-missing data. Standard deviations are displayed in parentheses.

[a] Measured in thousands of dollars.

[b] For high school graduates this variable is defined as twelve plus the number of semesters of college completed.

[c] Degree completion status as of age 25.

It is important to note that, due mainly to the fact that I analyze only traditional high school graduates, imposing the sample restrictions leaves respondents that have higher average AFQT scores, come from higher income households, receive more transfers from their parents, and have higher levels of assets at age 18 as compared to the nationally representative NLSY97 sample. The remaining respondents also receive more education on average and are less likely to be black or Hispanic. The statistics calculated using final analysis sample are displayed in the third column. Overall the analysis sample looks very similar to the sample before excluding respondents based on missing data, though the analysis sample has slightly fewer minorities and respondents are slightly more likely to complete a bachelor's degree. The similarity of the statistics reported in second and third columns indicates that the results are unlikely to be biased due to the exclusion of respondents with missing data.

Appendix C.2 NLSY79 Data

I use data from the NLSY 1979-2004. The NLSY79 surveyed 12,686 youths aged 14-22 in 1979. I use the same sample selection criteria as I do for the NLSY97, namely I use only white, black, and Hispanic males from the nationally representative sample. I include only youths that complete a high school degree between the ages 16 and 19 and exclude GED recipients and youths that ever serve in the military. I additionally exclude youths who received a high school degree before the first survey in 1979 because the NLSY79 did not collect detailed retrospective college attendance histories before the first survey date. I need this data to construct the years of schooling variables at 2-year and 4-year colleges to be consistent with the NLSY97 data. After imposing the additional restriction that youths need to be aged 25 or older and surveyed in year 1990 or later I am left with a sample size of 936 youths and 35,450 person-semester cells of valid data. The data are transformed into model equivalents the same way as the NLSY97 data. College attendance history is constructed using the monthly enrollment history variables in the NLSY79. Work status and unemployment are constructed using the weekly employment history variables.

The wage and unemployment probability equations estimated on NLSY79 data are used as auxiliary models to help identify the structural parameters of the wage and unemployment functions by providing data at ages higher than 25. The parameters of the wage equation are reported in Table C2. The coefficients are consistent with what one would expect to find in a standard Mincer earnings equation. One cannot reject the null hypothesis that the returns to years of schooling at 2-year and 4-year colleges are the same. This is consistent with the findings of Kane and Rouse (1995) about the similar return to credits at 2-year and 4-year colleges. The largest returns to schooling, however, come from completion of a bachelor's degree.

The parameters of the unemployment probability equation are reported in Table C3. The probability of unemployment is higher for blacks and lower for those with a bachelor's degree. The probability of unemployment in a given semester is much larger for someone who did not work in the previous semester.

Appendix D Delayed Entry

Table D1 illustrates the life cycle income profile of the same agent under two possible scenarios. In the first scenario the agent enters college directly after high school and in the second the agent delays entry by one year and works during that year. A number of simplifying assumptions are made to make the comparison easy to interpret. I assume that the agent does not work while enrolled in college, that he completes college in 4 years, and that he retires at age 60. The earnings at the high school level job, W^H, are assumed to be \$17,000. The earnings at the college level job, W^C, initially start at \$23,000 and grow at rate $g = 2\%$ per year. Future income is discounted at an annual rate of $r = 5\%$.

Under these assumptions the agent loses \$9,037 in the present discounted value of lifetime income by delaying entry to college by one year. Some papers indicate that delaying entry to college itself might cause earnings to decrease. This could arise if older students do not benefit as much from college education or if employers statistically discriminate against students who delay entry to college because they believe that delayed entry is correlated with unobservable traits that decrease productivity. Taniguchi (2005) finds that students who earn bachelor's degrees at ages 25 and older earn lower premiums than students who earn the degrees at traditional ages. Light (1995) also shows that students who interrupt their schooling between high school and college earn lower wage premiums. Under the assumption that post

Table C2: NLSY79 Log Wage Regression

Years at University	0.0440**
	(0.0124)
Years at Community College	0.0292*
	(0.0145)
Bachelor's Degree	0.147**
	(0.0529)
Years of Experience	0.0695**
	(0.00583)
Experience Squared	-0.00148**
	(0.000182)
AFQT	0.00479**
	(0.000552)
Black	-0.0828
	(0.0448)
Hispanic	0.0109
	(0.0679)
Part Time Work	-0.0540
	(0.0560)
Enrolled in School	-0.276**
	(0.0431)
Constant	1.316**
	(0.103)
Observations	30,248
R-squared	0.243

NOTE.–Standard errors appear in parentheses below coefficients and are clustered at the person level.
** $p<0.01$
* $p<0.05$

Table C3: NLSY79 Unemployment Probit

Years at University	0.000261
	(0.000578)
Years at Community College	-0.00158
	(0.000910)
Bachelor's Degree	-0.00565**
	(0.00204)
Years of Experience	-0.000783
	(0.000610)
Experience Squared	3.66e-06
	(1.93e-05)
AFQT	-4.39e-06
	(3.52e-05)
Black	0.0108*
	(0.00455)
Hispanic	0.00266
	(0.00388)
Not Working Previous Semester	0.123**
	(0.0144)
Observations	35,422

NOTE.–Marginal effects coefficients reported. Standard errors appear in parentheses below coefficients and are clustered at the person level.
** p<0.01
* p<0.05

Table D1: Life Cycle Income Profile by Timing of College Entry

Age	19	20	21	22	23	24	25	26
No Delay	0	0	0	0	$\frac{W^C}{(1+r)^4}$	$\frac{(1+g)W^C}{(1+r)^5}$	$\frac{(1+g)^2W^C}{(1+r)^6}$	...
Delay By 1 Year	W^H	0	0	0	0	$\frac{W^C}{(1+r)^5}$	$\frac{(1+g)W^C}{(1+r)^6}$	...

school earnings for those who delay entry to college are reduced by 10% each year for 4 years after graduation (near the middle of the range found by Light (1995)) the present discounted value of the loss in lifetime income in the previous example becomes $15,775.

The exercise performed in this section provides a useful benchmark for thinking about the costs of delayed entry to college. It is important to note, however, that the assumptions made in this section do not hold for many students. As shown in Table 2 students who delay entry to college are more likely to enroll in 2-year colleges and less likely to complete a bachelor's degree.

Appendix E Additional Model Details

Appendix E.1 Model Solution

The model is solved through backward recursion starting from the terminal value function V^{TERM} at age 40 (see Appendix A.12). V^{TERM} consists of $\upsilon_1 a_t$, the value of assets at age 40, and PDV which denotes the present discounted consumption value of wages between ages 41 and 65. The $\upsilon_1 a_t$ term is designed to partially capture retirement savings incentives and is also in place to prevent agents from wanting to borrow the maximum amount in the terminal period. υ_1 is identified by adding the average asset holdings of respondents in my NLSY79 sample between ages 38-40 as an auxiliary model. PDV is calculated by assuming that the state variables of the agent remain constant after age 40 and that the agent always works full-time (unemployment is abstracted from after age 40).

In the model youths are allowed to enroll in school until they reach age 30 after which enrollment is prohibited for computational simplicity. Each youth starts the model with 0 years of completed schooling at 2-year and 4-year colleges when he graduates from high school.[63] When a student attends college for a semester his years of schooling variable at the corresponding college type increases by .5 if he attends full-time and .25 if he attends part-time.

During each period prior to the last the Emax functions are approximated using linear regressions. Each period variables in the state space are used as independent variables in the regression approximations. In the approximations there are indicator variables for each asset grid point and indicator variables for each type. Each of the following variables also enters the regression, along with interactions between it and the level of assets: years completed at each college type, bachelor's degree completion, experience, AFQT, indicator for not working in the previous period, parental income, and lagged receipt of parental transfers. There are also interactions between the type indicators and the level of assets, experience, years completed at each college type, bachelor's degree completion, lagged enrollment at each college type, and lagged work status. The remaining variables are the square of AFQT, the square of parental income, lagged school enrollment, lagged school enrollment interacted with the years completed at each college type, lagged school enrollment interacted with AFQT, AFQT tercile indicators interacted with years of school at each college type, parental income interacted with lagged parental transfers, race indicators interacted with assets and parental income, and state of residence indicators interacted with assets and parental income.

In total there are 83 independent variables used each period in the Emax approximation regressions. The Emax values are evaluated at 600 randomly drawn state vectors each period and these points are used as data for the approximation regressions. This provides a very good approximation to the true Emax values; the R-squared of the approximation regressions is 0.99 or higher for each period. Some approximation errors still occur, however, which become evident when targeted subsidies are considered

[63]A small fraction of youths report having attended some college before they graduate from high school. This schooling is ignored for the purposes of the model to simplify the initial conditions.

in Section 9.2. For example, when I simulate a subsidy targeted toward middle ability households a small fraction of high ability households respond to the subsidy even though their choice set remains unchanged. To estimate the impacts of the targeted subsidies as accurately as possible, I only count the changes in education choices made by the targeted groups relative to the baseline condition when calculating the results in Table 10. The multivariate integrals necessary to take expectations with respect to the vector of shocks each period are approximated using Monte Carlo integration. Forty draws from the joint distribution of shocks are taken for each integral approximation. I use a simplex method similar to the one implemented in Lee and Wiswall (2007) to minimize the function in Equation (15).

Appendix E.2 Auxiliary Models

The auxiliary models consist of regressions and moments evaluated on the actual and simulated data and are designed to give a rich enough statistical description of the data to identify the structural parameters. In total there are 260 auxiliary parameters (there are 132 structural parameters being estimated).[64] Recall from Equation (15) that the estimated structural parameters $\hat{\eta}$ are chosen to minimize the weighted sum of squared scores of the auxiliary models evaluated at the simulated data. The β parameters in this equation are the coefficients of the linear regressions. The weighting matrix Λ for each regression is the inverse of the Hessian matrix. Λ gives higher weight to the more precisely estimated β coefficients in each regression. The likelihood contributions of each regression model are summed to generate the likelihood function in Equation (15). The likelihood contributions of the auxiliary models are weighted in the final sum to generate the likelihood function. I give greater weight to the models that describe the more important features of the data such as school enrollment and degree completion.[65] See Web Appendix F.2 for a list of auxiliary models used in the estimation.

Appendix E.3 Borrowing Constraint and Interest Rate Details

Recall from Equation (9) that the lower bound on assets is the sum of the lower bound on schooling related borrowing $\underline{a}_t^s$ and the lower bound on other assets $\underline{a}_t^o$. $\underline{a}_t^o$ evolves according to Equation (22). $\underline{a}_t^s$ is set according to the rules of the FFEL program.[66] From 1993-2007 the loan limits for the Stafford loan program students were constant in nominal terms and set according to the following rules: Dependent undergraduates were allowed to borrow \$2,625 during the first year of enrollment, \$3,500 during the second year of enrollment, and \$5,500 during subsequent years up to a cumulative maximum of \$23,000. Independent undergraduates were allowed to borrow \$6,625 during the first year of enrollment, \$7,500 during the second year of enrollment, and \$10,500 during subsequent years up to a cumulative maximum of \$46,600.[67] Under the Stafford loan program students are allowed to borrow up to the full cost of schooling related expenses (tuition, room, and board) until the yearly maximum is reached. Students

[64] Estimates of the auxiliary model parameters are available upon request.

[65] Weighting the auxiliary models is a more parsimonious, but approximately equivalent, way of adding auxiliary models that describe similar important correlations in the data.

[66] The FFEL program is made up of two main components: the Stafford loan program and the Parent Loan for Undergraduate Students (PLUS) program. The PLUS program is not modeled since loans parents take out are assumed to be part of parental transfers. Students can also borrow money from private lenders and through the Perkins loan program. Private education loans are assumed to be part of the other borrowing limit. Only 5% of students took out loans from private lenders for education in 2003-04 (The Project on Student Debt (2009)). The Perkins loan program is also not modeled for simplicity; the formula for determining Perkins loan eligibility is very complicated and since these loans are distributed at the school level, award amounts vary with funding available at each school. In addition, the Perkins loans is relatively small, accounting for less than 4% of total federal loans granted to students during the 2003-04 school year (College Board (2010)). Modeling private education loans and Perkins loans explicitly would likely strengthen the results that education related borrowing constraints have small impacts on student decisions, as including them would relax the borrowing constraint for some students.

[67] See Wei and Berkner (2008) for a details on Stafford loan limits.

that have a cost of schooling greater then their expected family contribution (EFC) are eligible for subsidized loans. When a loan is subsidized the government pays interest on the loan while the student is enrolled in school. The EFC is a calculated from the parental income and assets, student income and assets, and the number of other children from the family attending college. Since parental assets and number of siblings attending college are outside my model I am unable to calculate the EFC for each student. For simplicity I assume that students from households with incomes below the median income in my sample are eligible for subsidized loans since Wei and Berkner (2008) show that subsidized loans make up the majority of loans for students from households with below median income.

Student loans in general cannot be discharged through bankruptcy.[68] Borrowers are considered to be in default on their student loans if they have not made a payment on the loan for 270 days, but they are still held responsible for the debt. If the borrower does not repay voluntarily the government can garnish the wages of the borrower until the debt is repaid. It is too computationally burdensome to model various repayment plans available to borrowers (whether voluntary or involuntary) but the model assumes that the debt will remain with the borrower until it is repaid.

The borrowing constraint is enforced in model in the following way: Each youth is able to borrow up to his $\underline{a}_t$ each period (subject to the discretization of assets).[69] If the agent is in debt and $\underline{a}_{t+1}$ is closer to zero than his current debt level he is not forced to repay the debt during that period and $\underline{a}_{t+1}$ remains at the level it was during the previous period. This is designed to capture the fact that students are not forced to repay their debts immediately. If the agent leaves school and is not borrowing then the asset lower bound returns to the level of $\underline{a}_t^o$. Table E1 displays the estimates of $\underline{a}_t^o$ categorized by age and ability. The asset lower bound increases with ability and age and increases more quickly as age increases.

Table E1: Estimates of $\underline{a}_t^o$ by Ability and Type

Age	$AFQT_1$	$AFQT_2$	$AFQT_3$	Type 1	Type 2	Type 3	All
18	-711	-778	-781	-886	-784	-692	-756
19	-962	-1059	-1066	-1215	-1067	-936	-1029
20	-1300	-1439	-1455	-1663	-1452	-1265	-1397
21	-1751	-1946	-1979	-2271	-1967	-1705	-1891
22	-2379	-2721	-2945	-3479	-2817	-2308	-2679
23	-3749	-4411	-4999	-6014	-4656	-3627	-4380
24	-5056	-6052	-6993	-8477	-6458	-4875	-6024
25	-6761	-8229	-9579	-11692	-8829	-6501	-8176

The interest rate in the model is intended to capture the real interest rate earned on savings and paid on debts.[70] The interest paid on debt while in school (if the loan is not subsidized) is set to 2.2%, which is the average real interest rate paid on Stafford loans between 2001 and 2005. If the agent is borrowing and is no longer enrolled in school the interest rate is set to 5.9% which is the average prime rate between 2001-2007 minus inflation plus a two percentage point risk premium. If the agent is saving the interest rate is set to 0.9% which is the average real interest rate on one year US government bonds from 2001-2007.

[68] See Ionescu (2009) for a detailed description of the rules surrounding student loan default.

[69] There are 19 asset grid points located at -$35,000, -$29,000, -$23,000, -$17,000, -$11,000, -$6,000,-$4,000,-$2,000,-$1,000, $0, $1,000, $3,000, $6,000, $10,000, $15,000, $21,000, $28,000, $36,000, and $45,000. The grid points are clustered near $0 on the negative side to better capture the effects of the borrowing constraint. The actual lower bound is rounded down to the nearest grid point each period.

[70] Recall that all dollar amounts in the paper are in constant 2004 dollars.

Appendix E.4 Tuition Cost Details

In the model tuition varies by state of residence of the agent. For simplicity in the estimation the state tuitions are collapsed into four categories based on the level of the tuition at 2-year and 4-year colleges in each state. To construct the categories I use data from IPEDS on average public and private tuition by state between 2001 and 2005. I sort the states based on average tuition weighted by enrollment in each college type. With this sorted list I divide the states in to four categories such that each category has approximately the same total population. I then generate the average tuition at 2-year and 4-year colleges within these categories, weighting by state population. The amount of tuition in each category is displayed in Table B1. I use geocode data from the NLSY97 on state of residence at age 16.[71] I abstract from migration across states and assume that the agent goes to school in a state in the same tuition category as the state of residence at age 16.[72]

Appendix F Supplementary Materials

Appendix F.1 Model Fit Graphs

Some additional evidence of how well the model fits the data are presented in this section. Full-time and part-time enrollment at 4-year and 2-year colleges are displayed in Figures F1 and F2. The model fits the broad patterns of part-time and full-time enrollment well, although it tends to under-predict part-time enrollment at 2-year colleges.

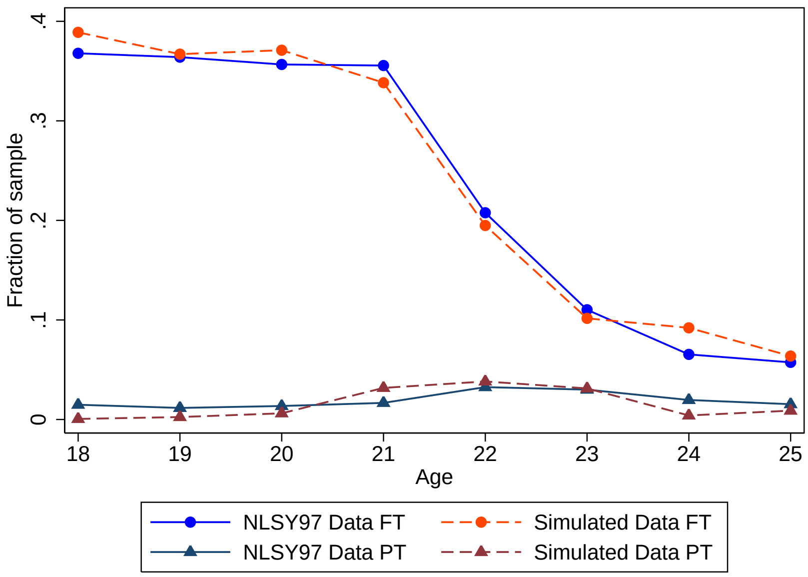

Figure F1: Part-Time and Full-Time 4-Year Enrollment by Age

The model also matches the labor market outcomes of the sample youths. Graphs of the wage and unemployment rates of the youths by age are displayed in Figures F3 and F4. The model slightly under predicts the wages of youths at older ages. This is due to the fact that the model needs to fit wage data from both the NLSY97 and the NLSY79; conversely the model slightly over predicts wages at ages

[71] Age 15 or 14 state or residence is used if the data is missing at age 16.

[72] Eighty-three percent of students in my sample go to school in the same state they were residing in at age 16. Eighty-nine percent of students go to college in a state in the same tuition category as their age 16 state of residence.

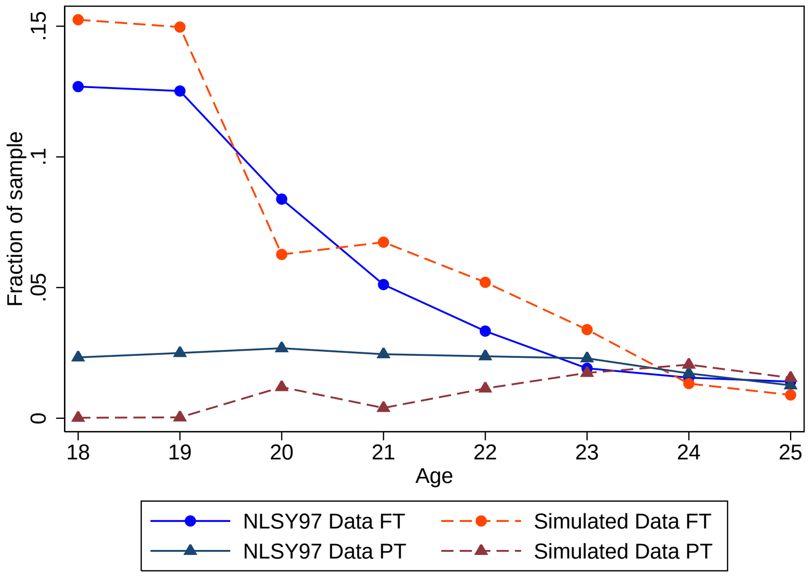

Figure F2: Part-Time and Full-Time 2-Year Enrollment by Age

higher than 25 as compared to the data from the NLSY79 (results not displayed). The unemployment rate declines with age at a similar rate in the actual and simulated data. The fraction of the population working full-time and part-time by age is displayed in Figure F5. The model fits these patterns, although it over-estimates full-time work at ages 18 and 19.

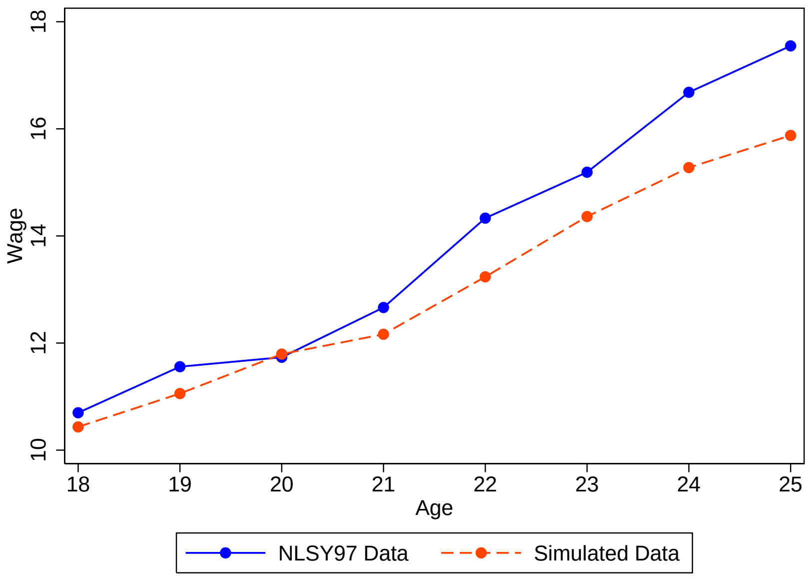

Figure F3: Average Wage by Age

The fraction of the population receiving parental transfers is displayed in Figure F6 and the average amount received is displayed in Figure F7. The parental transfers received by the simulated agents are quite close to those received by the actual agents.

Actual and simulated asset cumulative distribution functions at ages 20 and 25 are displayed in

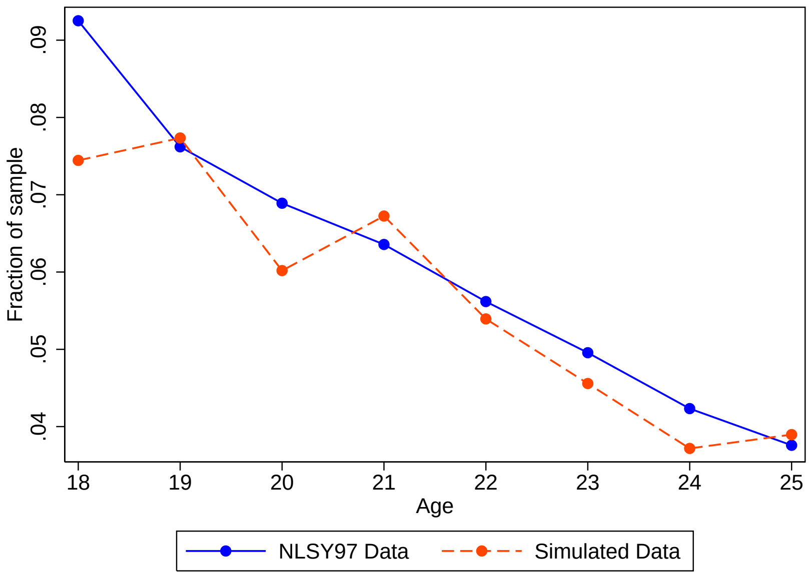

Figure F4: Fraction Unemployed by Age

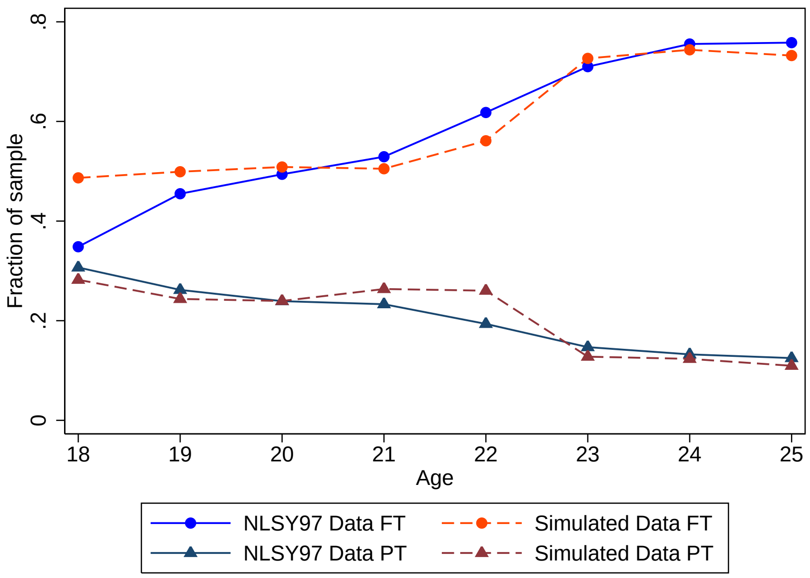

Figure F5: Work Status by Age

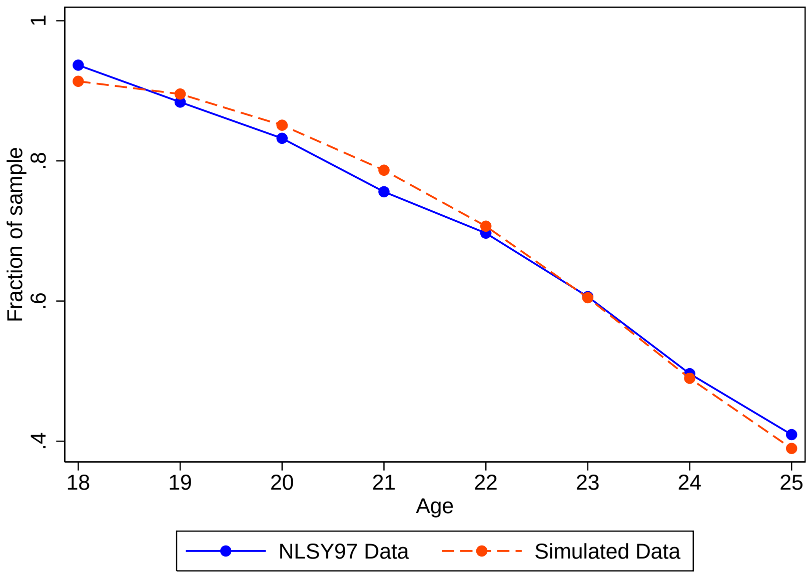

Figure F6: Fraction Receiving Parental Transfers by Age

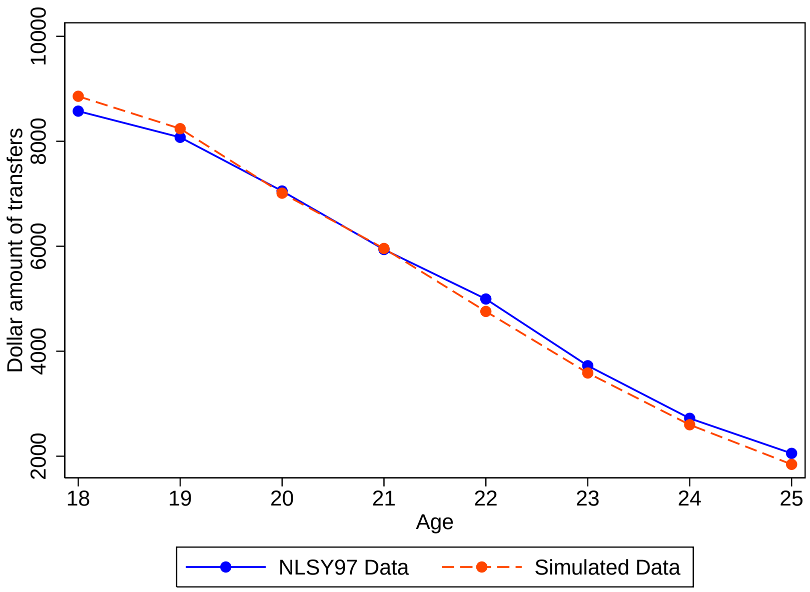

Figure F7: Average Parental Transfers by Age

Figures F8 and F9.[73] It is difficult for the model to match the skewness of the asset distribution, especially at age 25. The fact that the actual and simulated cdfs meet near zero indicates that the model matches the fraction of the population borrowing well.

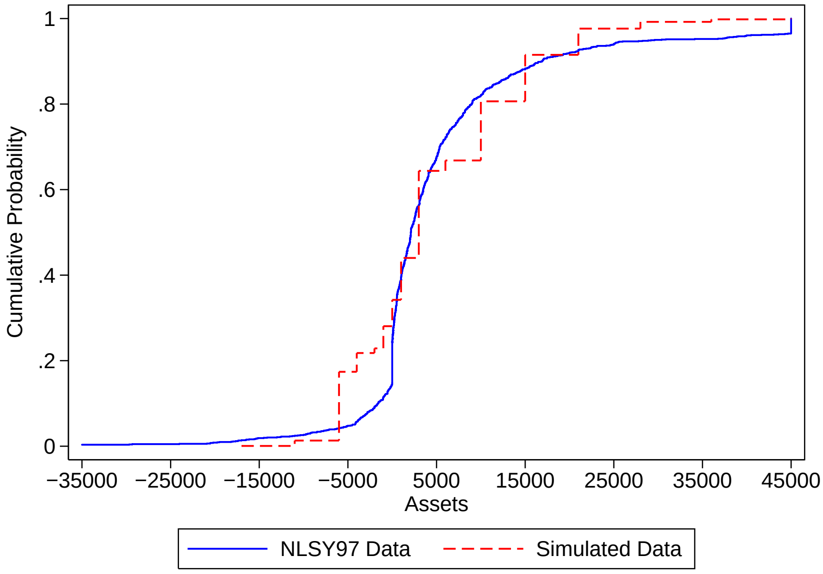

Figure F8: CDF of Asset Holdings at Age 20

Appendix F.2 Auxiliary Models

The auxiliary models used are listed below (with the weight given to each model in the likelihood function listed in parentheses).

1. Regressions

   - Log wage on years of schooling at each college type, BA degree completion, experience, experience squared, AFQT, race, part-time work, and school attendance. Separate equations estimated for ages 25 and below (NLSY97 data) and 26 and higher (NLSY79 data) (1)
   - Enrolled in college by age 21 on AFQT quartile, family income quartile, and race (2)
   - Enrolled in college by age 21 on AFQT on family income quartile (1)
   - Completed 4 or more years of college by age 23 on AFQT quartile, family income quartile, and race (2)
   - Completed 4 or more years of college by age 23 on family income quartile (1)
   - Assets at 25 on assets at 20, and assets at 20 on assets at 18 (1)
   - Unemployed on years of schooling at each college type, BA degree completion, experience, experience squared, AFQT, race, and indicator for not working in previous period. Separate equations estimated for ages 25 and below (NLSY97 data) and 26 and higher (NLSY79 data) (1)

[73] The cdf of the simulated assets jumps discretely at each asset grid point.

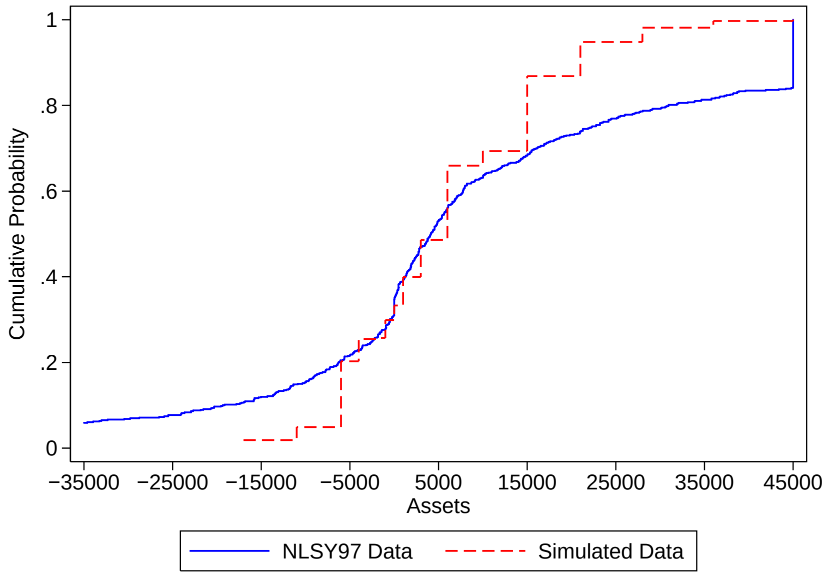

Figure F9: CDF of Asset Holdings at Age 25

- Receipt of parental transfers on family income, family income squared, age, race, previous semester school attendance, previous school attendance interacted with family income, indicator for receipt of parental transfers during previous year, and indicator for being unemployed in the previous year[74] (.01)
- Amount of parental transfers received if positive on family income, family income squared, years of school completed, age, race, enrollment in 4-year college, enrollment in 4-year college interacted with family income, and indicator for being unemployed in the previous year (.01)
- Average 2-year grant amount on family income, family income squared, and race (5)
- Average 4-year grant amount on AFQT, AFQT squared, family income, family income squared, and race (5)
- Three equations of enrollment in 4-year college, enrollment in 2-year college, and not enrolling in college on AFQT tercile for ages 18-21 (1)
- Two equations of enrollment in 4-year college and 2-year college on previous period enrollment in each college type and age (1)
- BA degree completion on years of 2-year college completed, years of 4-year college completed, AFQT tercile, and race (1)
- Log wage on previous period log wage (1)
- Indicator for not working and not in school on race indicators (3)
- Average monthly unemployment benefits on experience (1)

2. Moments

- Fraction of sample completing a bachelor's degree at each age for ages 22-25 (25)

[74]Since there is no error term in the equation for the receipt of parental transfers a low weight is given to prevent this equation contributing too much to the likelihood function.

- Fraction of sample enrolled in each college type at each age[75] (20)
- Fraction unemployed at each age and average wage if working at each age (15)
- Fraction working part-time and full-time at each age (10)
- Fraction receiving parental transfers at each age, average amount of transfers received if positive at each age (2)
- Fraction of population in debt at ages 20 and 25 (10)
- Average asset holdings at ages 20 and 25 (5)
- Average asset holdings if borrowing at ages 20 and 25 (1)
- Fraction of population in debt, average asset holdings, and average asset holdings if borrowing at ages 20 and 25 for those who have not enrolled in school (1)
- Fraction of population never enrolling in college, enrolling directly from high school, delaying by a semester or more, by a year or more, by two years or more, and by 3 or more years (1)
- Fraction of sample enrolled part-time in each college type at each age (1)
- Average highest grade completed at age 25 (1)
- Fraction of sample working full-time, part-time, and not working while enrolled in 2-year and 4-year colleges full-time and part-time (1)
- Fraction of sample working full-time, part-time, and not working while not enrolled in school (1)
- Person specific variance of wages at each age (1)
- Average asset holdings between ages 38 and 40 in the NLSY79 (1)

[75] "Each age" hereafter refers to the ages for which I have enough NLSY97 data for inference, namely 18-25.