Credit Constraints, College Quality Choice, and Tuition Policy *

Irina Shaorshadze†

Department of Economics

University of Wisconsin-Madison

The latest version at http://irinashaorshadze.cloudapp.net

December 18, 2016

Abstract

Understanding barriers to college completion has been at the heart of academic and policy debates. A large literature investigates the importance of credit constraints for college attendance. However, the importance of credit constraints for the intensive margin of college quality choice is not well understood. My paper informs the debate about the importance of credit constraints for college attainment by developing and estimating a dynamic life-cycle model that incorporates the college quality choice. In my model, agents choose a college when they graduate from high school and then proceed to make borrowing, consumption, enrollment, and labor-supply decisions over the life cycle. I account for in-state and out-of-state differences in tuition, government student loan policy, graduation risk, and student employment. I introduce a novel identification strategy that exploits the state-by-state differences in the portfolio of available in-state public colleges where one pays in-state tuition to identify the tightness of credit constraints and the elasticity of college attendance with respect to tuition on the extensive and intensive margin. Using the estimated model, I simulate the effect of counterfactual tuition, financial aid, and student loan policies on the choice of the quality of college attended and quantify the rate of return on college quality.

JEL codes: J24, I21, I23, I24, I26.

*I am thankful to Steven Durlauf, Ananth Seshadri and Chris Taber for guidance, help and encouragement on this project. I also thank Mariacristina De Nardi, Eleanor Dillon, Chao Fu, Jeff Groen, Joel Han, Dennis McWeeny, Peter Meyers, Sabrina Pabilonia, Chuck Pierret, Ann Polivka, Leo Sveikauskas and Matt Wiswall for helpful discussion and feedback. I am indebted to the seminar participants at the University of Wisconsin and staff at the U.S. Bureau of Labor Statistics (BLS) for very useful comments. This research was conducted with restricted access data from BLS. Part of this project was completed during my visit to BLS headquarters in Washington, DC. I thank BLS for their hospitality, resources, and help with the data. The computations in this paper were carried out at the Center for High Throughput Computing maintained by the University of Wisconsin. I am responsible for any remaining errors.

†shaorshadze@wisc.edu

1 Introduction

Understanding the barriers that impede college attainment is a top priority of policy makers and academics alike. A large literature documents an increase in the college earnings premium (earnings of college graduates relative to the earnings of high school graduates) since the 1980s and finds that the trend in college completion did not match the large increase in rewards for doing so. Another strand of literature investigates the importance of credit constraints in college attainment and, with some exceptions, finds that credit constraints are not the main reason for low college completion. Meanwhile, parental income is found to be positively related to college attendance and to college quality.

The literature on credit constraints and educational outcomes has primarily looked at college attainment in terms of college attendance or years of schooling. However, there are large tuition differences between colleges. If colleges are differentiated by their underlying quality, and colleges of higher quality improve future earnings prospects but cost more, then credit constraints are also important at the margin of college choice. The importance of college choice has been increasingly stressed in the literature. However, the role of credit constraints in college choice has not been formally investigated. My paper aims to fill this gap.

I develop a model that incorporates the college choice decision at the time one graduates from high-school as well as borrowing, consumption, and labor supply decisions over the life cycle. I assume colleges are characterized by an underlying one-dimensional measure of quality. Quality differentiates two-year from four-year institutions and four-year colleges from each other. This quality may affect the chances of obtaining a bachelor's degree and future wages. For every individual, I model the choice among (1) in-state four-year public colleges available in the state of residence, (2) two-year community college, and (3) out-of-state or private college. When formulating the choice set, I take into account the portfolio of in-state public colleges available to each individual in his or her state. After deciding where to go to college, individuals make savings, enrollment, and labor supply decisions. I control for unobserved heterogeneity that may affect college choice, enrollment, and labor supply throughout the life cycle.

I take advantage of the geographic variation within the available portfolio of in-state public colleges across states to help identify the tightness of credit constraints and the tuition elasticity of college attendance and college quality choice. Two aspects of the model and the estimation procedure help exploit geographic variation for identification. The first aspect is the formulation of the college choice sets that vary by state. The identifying assumption I use is that conditional on measured ability and parental wealth, the portfolio of public colleges available in one's state can be considered exogenous. The portfolio of colleges in one's state shifts the tuition one needs to pay for a given quality. Conditional on individual ability and family background, this shift is what drives identification of the tuition elasticity. The second aspect I use for identification is that my estimation incorporates the moment conditions that use geographic variation to explain differences in college quality choices and net assets accumulation conditional on college choices.

Having estimated the model, I quantify the effect of several counterfactual policies, some of which are on the policy agenda but have never been implemented. I model the effect of an increase in the borrowing limit on student loans, a reduction or elimination of the tuition at in-state four-year public colleges.

With the caveat that the fit of the model currently needs improvement in terms of sorting to out-of-state colleges, I have simulated policies that involved a modest increase in subsidies of $2,000, both limited for in-state colleges and general subsidies. I also simulated the effect of an increase in the loan limit by $2,000. All these policies increased schooling and resulted in students being resorted among colleges. Tuition subsidies had a larger impact than increase in loans. Finally I simulated more drastic policy changes: free tuition at in-state public colleges and letting individuals borrow up to the full cost of college. Both there policies resulted in students resorting towards higher quality colleges, and increased the graduation rate by 5 and 4 percentage points respectively. Borrowing the full cost of college improved the degree completion for the individuals of the median ability the most. Credit constraints appear to be very important for these individuals.

The rest of the paper proceeds as follows: Section 2 summarizes the related previous literature on credit constraints, college quality, and college choice. Section 3 presents the institutional details of higher education in the United States and provides the motivation for the questions addressed by the paper. Section 4 presents motivational facts for the importance of credit constraints in college quality choice. Section 5 describes the data used and presents descriptive statistics. Section 6 presents the model. Section 7 discusses estimation and identification. Section 8 presents the results, and Section 9 concludes.

2 Related Literature

To my knowledge, this is the first study that uses a structural model to investigate the importance of credit constraints in college quality choice in both four-year and two-year colleges while allowing college quality to affect both degree completion and post-graduation wages. It does this by bringing together several distinct strands of literature. The literature on credit constraints has not considered their effect on college quality choice. Meanwhile, the literature on college quality has abstracted from credit constraints. Papers that document the correlation of family circumstance and college quality or the correlation of college quality and subsequent labor market returns do not investigate if the relationship is causal, or what if any role is played by credit constraints. Because this study is related to three broad strands of literature (credit constraints, college choice, and college quality), I summarize these three strands in turn.

2.1 Literature on Credit Constraints and Student Loans

There is a long-standing debate in the literature on the importance of credit constraints in determining education attainment and the evidence is mixed. Cameron and Taber (2004) use the insight that credit constraints affect direct costs and opportunity costs of going to college differently. Using data from the National Longitudinal Survey of Youth NLSY79, they did not find any evidence that credit constraints were important for college attendance. This conclusion is also corroborated by Keane and Wolpin (2001), who developed a structural life-cycle model that accounts for decisions on college enrollment, work, and borrowing. Using this model, they simulate the effect of alleviating credit constraints. While they find that credit constraints are very tight, they also find that these constraints affect consumption and labor supply while in college but not college attendance itself.

The debate on the importance of credit constraints was rekindled by Belley and Lochner (2007). Using data from NLSY79 and NLSY97, they find that the effect of family income on college attendance increased between these two surveys. They investigated the effect of family income on the type of the postsecondary institution, delayed enrollment, and work decisions during the academic year. They present evidence that family income has a larger effect on the quality of institution attended (as measured by two- versus four-year college) for the cohort in the NLSY97 and that there is a significantly negative effect of family income on working while in college for the cohort from the NLSY97 but not the cohort from the NLSY79. While Belley and Lochner

(2007) find suggestive reduced-form evidence that family income has become more important for determining the quality of the institution attended, they do not investigate the mechanism driving increased importance. Using a stylized model, they note that one needs to account for credit constraints in order to fit the college attendance patterns in the NLSY97.

Subsequent papers have further investigated the importance of credit constraints with varying conclusions. Brown et al. (2012) use the fact that expected family contributions (EFC) are not legally enforceable and are not universally provided. They take advantage of the rules for calculating EFC based on the spacing of children's ages within the family. Using data from the Health and Retirement Study (HRS), they find that credit constraints are in fact important for college attainment. Johnson (2013) builds on the model of Keane and Wolpin (2001) and incorporates a distinction between two-year and four-year colleges. He estimates a model using the NLSY97 and studies the effect of credit constraints on enrollment choice, choice between two-and four-year colleges and delayed entry and finds that credit constraints are not important. Instead, he finds that the correlation between family income and college attendance arises because families that have higher wealth make larger college-contingent transfers. While his paper incorporates a binary notion of college quality (two- versus four-year colleges), it treats all four-year colleges symmetrically (except for tuition, which varies by broadly-defined regions). In a related paper, Liu (2015) extends Johnson (2013) by allowing students to choose among the four-year colleges that she classifies by quartiles of quality at the national level. However, that paper does not investigate the effect of credit constraints nor does it simulate any policy counterfactuals that involve changes in loan limits. In addition, Liu's paper does not incorporate the important institutional details of the U.S. college market, such as in-state/out-of-state public and private colleges. These details are important, because there is a wide variation in the quality of public and private colleges across states, and the state of residence determines the tuition one pays.

In a recent paper, Hai and Heckman (2016) estimate a structural life-cycle model where they endogenize credit constraints by estimating the natural borrowing limit in the private lending market. They find two groups of individuals are credit constrained: individuals with poor initial endowments who acquire little human capital, and very-able individuals who have high human capital and high wage growth but who can not smooth consumption early in life. Unlike in their paper, I do not derive the natural borrowing limit, but I complement their study by incorporating an additional margin in human capital investment choice.

Evidence on the importance of credit constraints in educational attainment is inconclusive. Furthermore, none of the previous studies have investigated the importance of credit constraints on choice of college quality, other than the distinction between two- and four-year colleges. My study fills this gap by incorporating the intensive margin in the decision of college quality.

2.2 Literature on College Quality

While a number of papers have examined the effect of college quality on labor market outcomes, there is no consensus on its importance. Different papers use different proxies for college quality. For reference, Table 1 lists the proxies for college quality used in the literature. Dale and Krueger (2002) and Dale and Krueger (2011) study the effect of quality by first conditioning on the set of colleges to which individuals applied and were admitted. While they generally do not find significant returns to college quality, there is an important exception: they find that there are significant returns to college quality for minorities and for children of less-educated parents. This is precisely the group for which one may think the credit constraints are binding. Using multiple proxies for college quality, Black and Smith (2004) and Black and Smith (2006) find that the returns to college quality are significant. Similarly, Hoxby (2001) finds that there are significant returns to attending selective colleges.

State merit aid programs may also play an important role in college-quality choice. Cohodes and Goodman (2014) study the effect of the Massachusetts Adams Merit Aid program. Under this program, top-scoring high school students from Massachusetts can go to any public college in Massachusetts tuition-free. The authors find that students who take advantage of this offer have lower graduation rates than those who do not, because the scholarship induces some of them to attend lower-quality, in-state public colleges rather than higher-quality private or out-of-state colleges where they would have been more likely to graduate. Meanwhile, Chakrabarti and Roy (2013) find that the Georgia Hope program did not induce students in Georgia to sort into less selective colleges.

It has been stressed in the literature that college quality might increase graduation rates. Higher-quality colleges tend to have higher educational spending. Access to better resources and peer effects may increase the chances of graduation at higher-quality colleges. Kane (2006) and Bound et al. (2011) have stressed the fact that low-quality colleges may lead to lower completion rates as well as longer time to graduation. To connect my paper to this strand of literature, I allow college quality to affect the probability of graduation.

2.3 Literature on College Choice

One of the earliest contributions to the college choice literature was by Manski and Wise (1983). They analyzed different stages of the college choice process (application, admission, attendance, graduation) separately. Their book is based on a number of papers by the authors, and stresses heterogeneity in the college choice experience based on the cohort from the NLS High School Class of 1972. Many of the arguments for the importance of the college choice margin are summarized in Hoxby (2004). The underlying theme of this edited volume is that the relevant margin is no longer whether one goes to college, but which college to attend and how.

Arcidiacono (2005) examines the effect of removing affirmative action on the resorting of students within colleges of varying quality. He allows for the choice of college quality, and also choice of major. He finds that there are large returns to choosing different majors, and college quality influences the major chosen. However, he also finds that the returns to college quality by itself are modest. In a survey of the literature, Arcidiacono and Lovenheim (2016) stress that the low returns to college quality found by Arcidiacono (2005) might be a result of measurement error in college quality, which would attenuate the returns to college quality to zero. The 2005 paper measured college quality using the average SAT score. To minimize the measurement error problem, I measure college quality using the first principal component of a number of proxies.

Fu (2014) and Kapor (2015) develop equilibrium models of college choice that incorporate selectivity, which is one measure of quality. However, they do not allow for the credit constraints, and thus cannot evaluate their importance. Kennan (2015) takes into account the differences in state subsidies, distinguishes colleges by selectivity, and estimates a model of migration where students decide where to go to college, and subsequently where to move for work. While this paper has a notion of differences in quality and tuition and offers a rich description of migration dynamics, it does not investigate the credit constraints or decisions students make while in college.

None of the above papers looks at the effect of the credit constraints on the college quality choice, the margin that I am investigating in this paper.

3 Institutional Details

3.1 Higher Education in the United States

In 2000, there were 3,717 degree-granting institutions in the United States. Figure 1 shows the distribution of these institutions by the type of degree offered and ownership. Public institutions receive most of their funding from public (state) funds and are governed by a publicly-appointed or elected official. Private institutions get most of their support from private donations and endowments, and can operate as either for-profit or nonprofit organizations. Figure 2 shows the distribution of students in these institutions by ownership. There were over 600 for-profit degree-granting institutions in 2000. However, most of these institutions were small, and only about 3% of students were enrolled in theses colleges at that time. Because such a small share of students take the for-profit option, I do not include for-profit colleges in my analysis. Students who attended such institutions were dropped from the dataset.

Public institutions receive funding from the state in which they are located. Different states have chosen to subsidize higher education at different rates for historical, political, and economic reasons. Students who reside in any given state are eligible to pay lower in-state tuition for public institutions in that state. Higher rates are charged to students who attend public colleges outside their states of residence. In practice, a student who is dependent on his or her parents (typically before the age of 21) will have in-state classification in the state in which the parents reside. Private colleges typically do not differentiate between in-state and out-of-state status of students.

Colleges in the United States are also differentiated by the types of degrees they grant. More specifically, after graduating from high school, individuals may choose to attend two-year or four-year colleges. Two-year community colleges do not grant bachelor's degrees. However, they are also cheaper and typically have open enrollment. Slightly less than half of all first-time undergraduate students enter college in two-year community colleges. It is possible for such students to transfer to four-year colleges. In practice, only half of these students go on to attend four-year colleges. Out of these, roughly half obtain a four-year degree.

3.2 Student Loans

While funding for higher education comes primarily from state governments, the federal government is the primary provider of student loans. The approval for government student loans does not depend on the credit status of the individual. Government student loans can be used at all accredited public and private institutions. Tuition, consumption, and other expenses while in college can also be financed through other types of credit, such as credit cards, mortgages, car loans, and private student loans. Credit other than government student loans requires a good credit rating of the borrower or his/her cosigner (typically parents).

The Federal Family Education Loan Program (FFEL) was the government loan program in effect when the NLSY97 respondents were college age. This program lasted from 1965 until 2010 and was replaced by the Federal Direct Loan (DL) program. Compared to FFEL, the DL program has modified options for loan repayment and now offers an income-based repayment plan. Changes were also made in how the program is administered. However, the other program rules for eligibility and loan limits remained similar to those under FFEL. FFEL offered two types of loans: Stafford Loans were given to students, and Plus Loans could be obtained by parents to pay for their child's college education. In 2000, Plus loans represented around 16% of outstanding federal student loans. For the purposes of this paper, I assume that Stafford Student Loans have to be repaid by the student, but Plus Loans are taken by parents and are part of any transfers that the child receives from them. Table 4 lists the yearly and aggregate loan limits of the FFEL program. Table 2 summarizes the types of loans available for higher education.

3.3 Grants and Other Financial Aid

Students can obtain financial aid other than loans through a number of sources. The three main sources of such aid are the federal government, the states, and the institutions themselves. Little merit-based financial aid is given by the federal government. However, low-income students can receive Pell grants. Federal Pell grants effectively serve as vouchers and can be used at any accredited institution, public or private. In 2000, the maximum available Pell grant was $2,300, while the average Pell grant was $1,933. Some states also offer need-based aid for students at in-state institutions. An increasing number of states also offer merit-based aid. For example, the Georgia Hope and Massachusetts Adams scholarships let top-scoring high school students from these states go to any public in-state college for free. In addition, individual colleges may provide both need-based and merit-based aid. [1] Table 3 displays the distribution of sources of grants for higher education in 2000 and 2010.

4 Data

4.1 Restricted Access NLSY79 and NLSY97

The main dataset I use is the restricted-access NLSY97. The NLSY97 surveys a nationally representative sample of individuals who were born between 1980 and 1984. The data collection started in 1997, and the survey was conducted annually before 2011 and biannually since then. The data include identifiers for the specific colleges that the respondents attended and graduated from. These identifiers let me link NLSY97 colleges to the Integrated Postsecondary Education Data System (IPEDS). The restricted version of the NLSY97 also provides zip code and census tract information on the residences of respondents.

Since respondents in the NLSY97 are in their early 30s at the time of estimation, I also use NLSY79 data. The NLSY79 surveys a nationally representative sample of individuals born between 1957 and 1965. I assume that the NLSY97 respondents expect their labor market experience to be similar to that of the NLSY79 cohort. In estimation, I use the wage and asset data from the NLSY79 to match that of the simulated agents.

4.2 IPEDS

I use the IPEDS dataset to get information about the colleges that individuals in the NLSY97 attended. IPEDS is maintained by the National Center for Education Statistics (NCES) and provides information on the universe of post-secondary institutions in the United States. IPEDS contains information on college characteristics such as size of the entering cohort, SAT quartiles, acceptance rates, retention and graduation rates, cohort sizes, as well as instructors' annual salaries.

[1]For the survey of the different sources of financial aid for higher education see Dynarski and Scott-Clayton (2013).

4.3 Sample Selection

In order to obtain a more homogeneous sample, I estimate the model only on white males. I drop observations on individuals for whom there was no Armed Forces Qualification Test (AFQT) information, or no parental education information. I also dropped all individuals who did not graduate from high school (this group includes individuals who received a GED) and who went to colleges that could not be identified in IPEDS.

In order to track the in-state or out-of-state status of individuals, I dropped observations for those individuals who first attended college after the age of 21. Individuals under the age of 21 are assumed to be dependent on their parents; therefore, the in-state or out-of-state classification depends on the state where the individual lived when 17, presumably with their parents. While in principle anybody can establish residence in a state after meeting residency and work requirements, in reality about 85% of individuals who will ever go to college do so by the age of 21, or delay entry by no more than 8 semesters, as demonstrated in Table 8. Table 9 describes this sample selection process.

4.4 Variable Definition and Descriptive Statistics

4.4.1 College Quality

I assume every college is endowed with unidimensional latent quality that affects both graduation rates and subsequent wages. I measure college quality using the first principle component of three indicators reported in IPEDS: (1) the average SAT score, (2) faculty salary, and (3) the retention rate (i.e., the percentage of entering full-time students returning the following fall). I average these indicators for the years 2002-2014 before extracting the principal component based on the averaged indicators. When extracting the first principal component, I weigh college observations using the average size of the entering cohort. I only use observations for the colleges that were never for-profit during the years 2002-2014 and were always degree-granting institutions during this period. Overall, I estimate quality for 2,985 institutions, 1,056 of which are two-year colleges, and 1,929 of which are four-year colleges.

One of the challenges to be confronted while estimating the quality of colleges is missing data. This problem is especially severe for two-year colleges because they typically do not require or report SAT scores. Occasionally, one of the three indicators is also missing for four-year colleges. I deal with the missing data using the following procedure: First, I estimate the principal component using all three indicators based on the colleges that report all three indicators. Second, for each component that is missing, I use the other remaining indicators that are available to regress the estimated principal component on the fully interacted second-order polynomial of the remaining available indicators. Third, I use the predicted values from this regression as an estimate of the quality for the colleges that lack one of the indicators in IPEDS.

I further assume the quality of two-year colleges is homogeneous throughout the country and estimate this to be the average quality of two-year colleges in the data. The average quality of community colleges falls in the bottom quartile of the overall quality distribution.

4.4.2 Residency Status for Tuition Purposes

In the survey, the respondents are not directly asked whether their status at college was in-state or out-of-state. However, in the restricted version of the NLSY97, there is information on the respondent's state of residence at the time of the interview. I take the state of residence when the individual was 17 years old as the state of residence for tuition purposes. At that age, most respondents were attending high school and dependent on their parents. Using the state of residence at a later time may confound the state of legal residence with the state where one attends college. In case the information for the state of residence is not available for age 17, I use earlier years when available.

Figure 3 displays the relationship between tuition and the quality measure. The figure also distinguishes between in-state and out-of-state tuition for public and private colleges. The fitted line is weighted by total freshman enrollment. This figure shows that the public in-state tuition slope with respect to quality is relatively flat. The gradients of public out-of-state and private tuition with respect to quality are much steeper than that for in-state public tuition.

Figures 4a and 4b show the variation in tuition at flagship institutions—a state's college or university with the highest research profile and the most doctoral programs. Figure 4a shows the variation in average SAT score of the entering cohort. The average SAT is not the quality measure I use but it is one of the proxies of the underlying quality measure. Figure 4b shows the variation in terms of the quality measure used in this paper. There is substantial variation in the quality of the flagship institutions among states. I exploit this variation for identifying tightness of credit constraints and tuition elasticity as discussed in section 7.1.

4.4.3 Admissions and College Choice

In order to estimate the admissions cutoff, I take advantage of the special college applications module collected by the NLSY97 in 2003-2005. In that module, respondents who were born in 1983 and 1984 and who had completed either 12th grade or a GED provided information on all colleges they applied to and were accepted by.

Figure 9 shows a histogram of application portfolios in terms of the number of colleges that each individual applied to. The modal action is to apply to one college only. I take this as evidence that for many students there is no uncertainty about being admitted to the place they chose to apply to.

4.4.4 College Attendance

Respondents in NLSY97 attended colleges with different terms — semester, quarter, trimester, or other — and it is necessary to allocate attendance to the appropriate semester. BLS aggregates college attendance information in monthly tables, but these tables do not distinguish among different colleges individuals might have attended. Because I want to keep my aggregates specific to colleges of a given type, I construct each individual's college-specific attendance data from the raw files of the NLSY97. I allocate college attendance term to a semester if that term *began* in that semester. I also assume an individual attended college full-time if he was reported to have attended full time for more than three months in any semester. Figures 5 and 6 show the enrollment in different college types by parental income and AFQT score.

Tables 15 and 16 show the college attendance experience in four- and two-year colleges respectively. Degree attainment was low even for the students who started in four-year colleges. Over 40% of individuals who started in four-year colleges never earned a bachelor's degree. Among the students who did get a degree, over 80% did so at the first institution they attended. For this reason, I focus on the quality of the first institution attended.

Bachelor's degree attainment was even lower for students who began at a two-year college. This is not surprising, because presumably some of these students did not intend to get a bachelor's degree. More than 30% of students who started at a community college were subsequently enrolled at a four-year institution. However, only about a quarter of those who did transfer to four-year colleges ever received a bachelor's degree.

4.4.5 Financial Aid

I construct a financial aid sequence for each college an individual attends by using the raw files of the NLSY97. This allows me to estimate the grant function conditional on college quality. BLS has constructed financial aid aggregates by semester. However, I do not use these aggregates, as they potentially combine information from more than one college. Unfortunately, the data do not indicate the source of the financial aid received. Therefore, I cannot tell if the grant that was received is transferable to other colleges. In estimation, I condition the amount of grant received on the college quality and in-state and out-of-state or private status.

4.4.6 Assets

I construct an estimate of each individual's net assets by aggregating asset and debt information available in the NLSY97. In order to construct the value of the respondent's assets, I take the reported values from the following sections: farm, mobile home, lot, house, land owned, checking and savings accounts, bonds, stocks, life insurance, pensions, car, business, and other property. I account for debt through student loans, business debt and other debt. Table 10 shows asset ownership in NLSY97 by age.

4.4.7 Parental Transfers

I construct the amount of parental transfers received from three different sections of the NLSY97 questionnaire: (1) the annual amount of remittances received from parents or other members of the family, (2) money contributed by parents toward college expenses, and (3) self-reported co-residence.

Some clarification is needed to explain how I monetize co-residence. At the time of the interview, the questionnaire asks respondent's to list members of what he or she considers permanent household. In Johnson (2013) coresidence was defined as a binary variable depending on if the respondent's parents appeared in the current household roster list. Unfortunately it appears that the household roster is a very noisy measure of co-residence. This is not surprising because students who live in a dormitory would consider their parental house as their primary residence. In fact, respondents tend to report that they share a primary dwelling with a parent even if they are enrolled at a college that is thousands of miles away from their primary residence.[2]. For

[2]The NLSY97 on-line topical guide is clear on this: "respondent's household is based on what the respondent

most of the students who live in dormitories, the parental household technically *is* the primary household.

To define the indicator of coresidence, I take advantage of the zip-code information available in the on-site-access-only restricted version of NLSY97. I use the zip codes of the dwelling and the college and construct a measure of physical distance from the individual's home to their college. I treat the response as true co-residence if the respondent claimed to share a dwelling with parents and the distance to college is less than 50 miles. I follow Kaplan (2012) and Johnson (2013) and monetize the value of parental co-residence at $650 per month. This amount comes from an estimate from the American Housing Survey that the median rent for households with incomes between $15,000 and $30,000 is $600 per month. The additional $50 are the estimated utility expenses.

4.4.8 Parental Income and Education

During the first five waves of the survey, parents were asked about their income directly. In subsequent waves, the respondents are asked to report the income of their parents. I construct the parental income variable by adding the incomes of the mother and the father and averaging this total over the years for which income information is available. The parental income variable constructed in this way is an estimate of the parental permanent income.

The respondents are also asked about the educational attainment of their parents. I construct a variable that represents the maximum years of schooling of the mother and father and split it into four categories: no high school degree, only high school degree, some college, and four-year college degree or above.

4.4.9 Employment and Wages

In order to get employment and wage information, I use the monthly aggregates in the NLSY data. I assume individuals who work over 30 hours per week on average during a semester are full-time employees. Individuals who work on average 10 to 30 hours per week are defined as working part-time. If an individual reported being unemployed at least once during the semester and worked less than 10 hours per week in that semester, I classify him as unemployed. If an

considers to be his or her permanent household as reported in the household information section. This is not necessarily the same as where he or she is living at the time of the survey."

individual worked for 10 hours or less on average during the semester but never reported being unemployed, I categorize him as being out of the labor force.

5 Motivating Facts

This section presents the facts that suggest that credit constraints may be important for college choice. I first show that the influence of parental income on the quality of the college one attends varies systematically with the quality of the in-state flagship institution. I also show that net assets of the higher-ability individuals at age 25 are lower if they are from states with lower-quality flagship institutions. I next document the influence of parental income on the quality of the college attended. Finally, I provide descriptive evidence that suggests the quality of the college affects wages in the labor market. The analysis presented in this section is not meant as definitive evidence of the presence of credit constraints. Rather it presents patterns consistent with the presence of credit constraints and motivates the structural analysis that follows.

Does Quality of the In-State Flagship College Mediate the Effect of Family Income on Quality?

The portfolio of public colleges available in a student's state of residence determines the colleges a student may attend by paying the cheaper in-state tuition. A student of high ability may be admitted to a high-quality college; however, if there are no high-quality colleges in his state, credit constraints might prevent him from being able to afford out-of-state or private college tuition. Intuitively, this would imply that family income is more important in determining college quality for high-ability individuals who reside in states where the quality of the flagship institution is relatively low. The relationship between family income and college quality should not depend on the quality of flagship institutions for low-ability individuals since these individuals are unlikely to be admitted to higher-quality institutions.

To see if this prediction holds in the data, I have divided the states found in my NLSY97 sample into those that have higher-than–median- and lower-than-median-quality flagship institutions. To determine the median, I weighted the states by the number of survey respondents in my sample from each state. Therefore, half of the individuals in my data reside in states where the quality of the flagship institution is low by this definition. I ran a regression where the dependent variable is the quality Q of the actual college attended by the time the respondent is 21 years old. I regress the quality of the actual college attended on the parental income Y^F, the AFQT score θ, and an indicator for living in a state with a high-quality flagship institution $\mathbb{1}(QF = 1)$. I also include the interaction of the parental income with the indicator for a high-quality flagship institution, which is the main variable of interest.

$$Q = \alpha_0^Q + \alpha_1^Q \theta + \alpha_2^Q Y^F + \alpha_3^Q \mathbb{1}(QF = 1) + \alpha_4^Q Y^F \cdot \mathbb{1}(QF = 1) \tag{1}$$

Table 18 reports estimates for equation 1. Column 1 estimates this regression for individuals of below-median ability θ as measured by the AFQT score, and column 2 estimates it for individuals of above-median ability. The quality of the institution attended increases in both individual ability and parental income. For the individuals of above-median ability, the impact of parental income on quality is significantly reduced in the states where the quality of the public institutions is high. Meanwhile, the impact of family income does not vary significantly by the quality of the flagship institution for the low-ability individuals. In the regression for the low-ability individuals, the estimate for the interaction coefficient α_4 is statistically insignificant and small in magnitude.

Does the Quality of the In-State Flagship College Affect Net Assets?

Next, I proceed to show the relationship between net assets at age 25 and the quality of the flagship institution. For this purpose, I regress the net assets A_{25} on the ability θ, parental income Y^F, and the quality of the institution attended Q. I also include the interaction of quality of the college attended and the quality of the in-state flagship institution. The estimated regression is summarized in equation 2.

$$A_{25} = \alpha_0^A + \alpha_1^A \theta + \alpha_2^A Y^F + \alpha_3^A Q + \alpha_4^A \mathbb{1}(QF = 1) + \alpha_5^A Q \cdot \mathbb{1}(QF = 1) \tag{2}$$

I estimate this equation separately for individuals of above- and below-median ability. If the presence of high-quality, in-state flagship public institutions allows the high-ability individuals to attend high-quality institutions by borrowing less money, then one expects the interaction coefficient α_5^A to have a positive sign for individuals of higher ability. Results are reported in Table 19 and support this prediction. The coefficient on the interaction is positive and significant for higher-ability individuals, and is insignificant and negative for lower-ability individuals.

Do Individuals with Higher Family Income Attend Higher-Quality Colleges?

In the NLSY97 data, individuals with higher family income attend higher-quality colleges. Figure 7a shows this association by presenting the distribution of initial college attendance by the quartiles of family income and college quality. This figure includes individuals of all abilities. However the association still holds if one looks at only individuals with the AFQT score in the top quartile, as demonstrated by Figure 7b.

To show how the quality of college attended varies with income, I conduct an exercise similar to that in Kinsler and Pavan (2011). I first estimate the probability of choosing a college in a given quality quartile by multinomial logit regression where the college quality quartile chosen is the dependent variable. I regress the college quality quartile on parental income quartiles, the AFQT score quartiles, and the quality of the in-state flagship institution. Next, I predict the probability of attending a top-quartile college and how this probability changes if I move the individual from the first to the fourth quartile of family income.

For purposes of this exercise, I constructed an average individual in each ability quartile by taking the average of all controls other than ability and family income within that ability quartile in the sample. Similarly, I constructed an average individual by taking the average of all controls other than family income in the sample. Results of the multinomial regression are found in Table 20, and the predicted probabilities are found in Table 21. These results are similar to those reported in Tables 6 and 7 in Kinsler and Pavan (2011) even though that paper uses a different sample selection procedure and measures ability using SAT scores rather than the AFQT. The probability of attending a college in the top quality quartile increases by 16 percentage points if we move a high-ability individual from the first quartile of parental income to the top quartile. Meanwhile, such a move would have no effect on attending a top-quality quartile college for an individual of low ability or for an average individual.

Do Graduates of Higher-Quality Colleges Earn More?

I now document that wages increase in college quality even after controlling for measures of ability, schooling, and experience. Figure 8a shows the variation of the raw wages by quality quartile of the first college attended. It shows that there is substantial variation in raw wages across the college quality quartiles. Next, I residualize the log wage by accounting for the years of education e_t, bachelor degree status B_t, current experience E_t, experience squared, the AFQT score θ, part-time status $d_{k,t}$, and school enrollment $d_{e,t}$ as shown in equation 3. In figure 8b, I graph the residual from this regression by the quality quartile of the college attended.

$$logw_t = \alpha_1^w + \alpha_2^w e_t + \alpha_3^w E_t + \alpha_4^w E_t^2 + \alpha_5^w \theta + \alpha_6^w B_t + \alpha_7^w \mathbb{1}(d_{k,t} = 0.5) + \alpha_8^w \mathbb{1}(d_{e,t} > 0) \qquad (3)$$

Figure 8b shows that after age 25, the gap in the log wage remains roughly constant, except for the lowest-quality quartile. This suggests that the college quality is not merely a signal for ability as measured by the AFQT score θ and observed by the econometrician but initially unknown to the employer. If employers were to take college quality as a signal for ability, but eventually learn the true ability, one would expect the quality to affect the wages at the start of the career and later fade in its impact.

The motivating facts presented in this section are not meant as causal evidence. Rather, they suggest that the broad patterns found in the data are consistent with the presence of credit constraints that affect the college quality choice. I now turn to the structural model that investigates the college quality choice within the life-cycle framework.

6 The Model

In this section, I first describe the general features of the model. I then discuss the model features in greater detail.

The model describes behavior of forward-looking rational individuals who make education, borrowing, and labor supply choices over the life cycle. The model starts when individuals graduate from high school and consists of two stages. In the first stage, an individual chooses a college from the portfolio that depends on his state of residence. This dependence is a result of the institutional features of the higher education market in the US. Individuals pay lower in-state tuition at colleges found in their states of residence and states vary in the quality of the public institutions available. This choice set is presented in greater detail in section 6.1.2. In the second stage, the life cycle unfolds, and an individual makes enrollment, saving (or borrowing), and labor supply decisions every period. Figure 16 shows the timeline of the model. I adopt the convention that the age of graduation from high-school is 18 regardless the actual graduation age in the data. In this way, age in the model captures the years from high school graduation.

One period of the model is equal to one semester, and goes from January through June, then July through December. At the beginning of every period, the individual receives the shocks that will affect his choices that period. These shocks are (1) a parental transfer incidence shock, (2) a job offer and wage shock, and (3) preference shocks. Therefore, an individual may delay enrollment or not enroll at all if a series of bad shocks materializes. The individual may enter college until the age of 21. However, if the agent was already enrolled by the age of 21, he may continue enrollment (either continuously or sporadically) until the age of 27. After the individual acquires 3.5 years of full-time college education, he may receive a bachelor's degree. Receipt of a bachelor's degree is stochastic, and depends on human capital acquired as well as the quality of college attended. Wages depend on accumulated years of education and on the quality of the college an individual graduated from. If an individual leaves college before receiving a bachelor's degree, he does not receive returns to the quality of the college attended.

Individuals have full information about their ability, preferences, and the distribution of the shocks. This modeling choice abstracts from potentially important determinants of the college experience, such as learning about match value in a noncollege career, and learning about his own preferences. Modelling these details is left for future work. For reference, Table 7 summarizes the variables used to describe the model. I now present the model in greater detail.

6.1 Stage I - College Choice

6.1.1 Initial Conditions

The initial state Ω_0 at the time of college entrance or at the time of high school graduation for the individuals who never went to college is summarized in equation 4.

$$\Omega_0 = (A_0, s, \tau, \theta, E^F, Y^F, T_0, d_{k,0}, a_0) \tag{4}$$

Here A_0 denotes the initial asset level, s denotes the state of residence, τ denotes the individual's unobserved type, θ denotes ability measured by AFQT, E^F denotes parental education, Y^F denotes average parental income, T_0 denotes the receipt of parental transfers in the initial period, $d_{k,0}$ denotes employment status in the initial period, and a_0 denotes the individual's age. The individual's state of residence determines the portfolio of public college qualities from which he may choose while paying discounted in-state tuition.

6.1.2 Choice Set

For any given individual, each college C is characterized by a tuple (Q, S) that depends on his state of residence.[3] Q represents the quality of the college, and S represents whether the college is an in-state public college ($S = 1$) or ”other” ($S = 0$), where ”other” can be an out-of-state public college or a private college. For ease of exposition, I refer to ”other” colleges as private colleges. However, one should keep in mind that this category includes both private colleges and public out-of-state colleges for a given individual.

For tractability, I need to restrict the set of available portfolio choices. I assume that at the time an individual decides whether or not to attend college, he chooses from (1) the set of in-state public four-year colleges that are willing to admit him, (2) a generic two-year college that has open admissions, and (3) the optimal ”other” college that is willing to admit him (in terms of providing the highest present discounted value of future utility flows [4]). Below I describe the procedure of forming the set of in-state public colleges and the optimal ”other” college.

When forming the individual-specific choice set, I aggregate the in-state public colleges as follows. First, I select the flagship college for each state by using the Carnegie classification. In states that have two flagship colleges according to this classification, I include these two colleges in the same bin. Next, for states that have a range of public college options, such as California and Pennsylvania, I further combine the public in-state colleges into a maximum of five bins by quality. Table 17 shows the college-quality bins constructed for each state.

Within his own state, an individual can choose from a maximum of five four-year public in-state colleges. Within any given state, the choice of public in-state college can be best represented by a discrete choice. However, when considering out-of-state or private colleges, an individual faces the price-quality locus of all four-year institutions in the country that are willing to admit him. Overall, there are 2,985 four-year institutions to choose from in the data. Therefore I assume that when choosing out-of-state/private college, an individual chooses from a continuous distribution of qualities.

[3]For expositional clarity, drop the individual subscript i.

[4]Note that the optimal private college does not imply the highest-quality college to which an individual can be admitted. Depending on the returns to college quality, tuition function, presence of credit constraints, and family circumstances, the optimal private college may be in the interior of the relevant quality-tuition locus. I give details on how I find the optimal private college in section 7.1 when discussing estimation.

The overall choice can be best described as having a nested structure. First, the individual finds the optimal ”other college” from continuous distribution of qualities. He then chooses from the in-state public colleges, two-year colleges, and the optimal “other” college. The later choice is discrete. This mixture of continuous and discrete choices is not meant to represent exactly how the college decision process unfolds, but rather to summarize the salient aspects of this decision. Because of the large tuition discounts available at in-state colleges, the ”other” colleges represent a category of its own. If one decides to go for the out-of-state option, then one might as well optimize in terms of such ”other” colleges first and then choose from his optimal “other” college and what is available in his state. The choice process just described does not capture all aspects of actual college decision. For instance, it does not have a notion of geographic distance. Also, this choice treats private and out-of-state colleges symmetrically. Nevertheless, this choice structure is the richest yet implemented within the dynamic life-cycle model in the literature, and it captures the key relevant institutional aspects of the college market in the United States.

6.1.3 Constraints

I assume admissions are nonstochastic, and high school graduates know the highest possible cutoff value in terms of college quality to which they would be accepted. Therefore, the consideration set of colleges to choose from is to the left of this cutoff. I estimate this cutoff outside the model using the observed admissions patterns from the college applications module of the NLSY97. I calibrate the individual-specific cutoffs so that 15% of applicants are admitted to the flagship colleges, which is equivalent to setting the cutoff to an admissions rate of 65%. Therefore, the choice set depends on the the state of residence and admissions cutoff.

6.1.4 Preferences

I assume preferences for attending a given college depend on three components: (1) the present discounted value of future utility flows $V^J(\Omega_{0_i};\theta)$ from a given college choice J (this component reflects the consumption and earnings sequence conditional on the chosen college path), (2) the intrinsic utility from quality Q, and (3) random shock ϵ (assumed to follow a Type I extreme value distribution). In addition, I include the intercept for choosing a community college and an out-of-state college to capture the mean utility of these choices. I also let the utility of going to a community college or going to out-of-state college depend on the latent discrete type τ that represents persistent heterogeneity. Equation 5 describes the individual's choice.

$$U_i^J(\Omega_{0_i};\theta) = \begin{cases} V^J(\Omega_{0_i};\theta) + \gamma_i^C Q^J + \epsilon_i^J, & \text{if } J \in \{C_{3(i)}...C_{n(i)}\} \\ V^J(\Omega_{0_i};\theta) + \gamma_i^C Q^J + \gamma_3^C + \sum_{k=2}^{K} \gamma_{4,k}^C \mathbb{1}(\tau_i = k) + \epsilon_i^J, & \text{if } J \in \{C_1\} \\ V^J(\Omega_{0_i};\theta) + \gamma_i^C Q^J + \gamma_5^C + \sum_{k=2}^{K} \gamma_{6,k}^C \mathbb{1}(\tau_i = k) + \epsilon_i^J, & \text{if } J \in \{C_2\} \end{cases} \tag{5}$$

Here $\{C_1, C_2, C_{3(i)}...C_{n(i)}\}$ are the colleges that are in the choice set for a given individual. This choice set depends on the quality of colleges in a given state, as well as the admissions cutoff for a given individual. C_1 represents the community college, C_2 represents the optimal out-of-state college, and $C_{3(i)}...C_{n(i)}$ represent in-state four-year colleges. Note that parameter γ_i^C capturing the preference for quality Q is random, and depends on both observable and unobservable characteristics of the individual as summarized by equation 6.

$$\gamma_i^C = \gamma_0^C + \gamma_1^C X_i + \sum_{k=2}^{K} \gamma_{2,k}^C \mathbb{1}(\tau_i = k) \tag{6}$$

In equation 6, X_i is a vector of individual characteristics that consist of the tercile of the AFQT score θ, parental income Y^F, and parental education E^F. Components of X_i are summarized in equation 7.

$$X_i = (\mathbb{1}(\theta_i \in T2^\theta), \mathbb{1}(\theta_i \in T3^\theta), Y^F, \mathbb{1}(12 < E^F < 16), \mathbb{1}(E^F >= 16)) \tag{7}$$

The last component of the random parameter γ_i^C is the latent unobserved type τ. Presence of this unobserved heterogeneity allows for the college choice to be correlated with enrollment and labor supply choices later in life. The latent heterogeneity has two points of support and an individual of type 1 can be thought of as a *high* type, and can be interpreted as representing higher noncognitive skills, such as motivation and focus.

The motivation behind including the observed and unobserved heterogeneity X and τ in college choice is that an individual's family circumstances may affect both the decision of where to go to college and subsequent life choices in a systematic way, above and beyond purely monetary considerations for a college decision. I do not take a stand on what mechanism these additional influences have on college choice. Growing up in a well-educated wealthy family may directly affect the preference for education on both the extensive and intensive margins. If this is the case, the X variables capture the consumption value of education. However, it might be that growing up in a privileged environment gives one more resources to obtain better information about college and financial aid opportunities. In this case, X can be interpreted as conditioning variables that capture these additional influences in a reduced-form way.

The optimal college J is found as a solution to the problem given in equation 8.

$$J = argmax\{U_i^J(\Omega_{0_i};\theta)\} \text{ where } J \in \{C_1, C_2, C_{3(i)}...C_{n(i)}\} \tag{8}$$

6.2 Stage II - Life-cycle post college choice

6.2.1 Choice Set and State Space

Every semester each individual makes three choices: (1) consumption c_t and saving s_t, (2) whether to go to college and, if in college, whether to attend part time or full time $d_{e,t} \in \{0, 0.5, 1\}$, and (3) labor supply (not working, working part time or full time) $d_{k,t} \in \{0, 0.5, 1\}$. I assume that an individual cannot go to school after the age of 27 nor can he start college after the age of 21.

The state Ω_t at time t is captured by the following 15 variables:

$$\Omega_t = (A_t, s, \tau, \theta, E^F, Y^F, T_t, a_t, d_{k,t-1}, d_{e,t-1}, B_t, J, Q_t, E_t, e_t) \tag{9}$$

The first nine state variables were described in the initial conditions section. The remaining components of the state space are the lagged enrollment choice $d_{k,t-1}$, bachelor's degree status B_t, college choice made in the first stage J, quality of the college Q_t, experience E_t, and accumulated years of education e_t.

The time subscript on college quality allows individuals to transfer from community colleges to four-year institutions. I do not model college transfers for students in four-year colleges. However, it is essential to allow for transfer for the individuals who start in two-year colleges. This is handled as follows: I assume community colleges are homogeneous throughout the country and estimate the average quality and average tuition of community colleges. For students who have chosen to continue college after two years in community college, I assume they transfer to the in-state public college that is in the lowest quality bin of the state they live in. Admittedly, this modeling choice is ad hoc. As a robustness check, future iterations of the model will seek to relax this assumption.

6.2.2 Preferences

Individuals derive flow utility from consumption and nonpecuniary enrollment and employment status as summarized in equation 10.

$$U(c_t, d_{e,t}, d_{k,t}; \Omega_t) = \frac{c_t^{(1-\gamma)}}{(1-\gamma)} + u_e(d_{e,t}, \Omega_t) + u_k(d_{k,t}, \Omega_t) + u_{e,k}(d_{e,t}, d_{k,t}, \Omega_t) \tag{10}$$

The first component is of the constant relative risk aversion type. The second component captures the idea that one may derive utility (or disutility) from being enrolled in school as well as from leisure. The nonpecuniary components may change over the life cycle. For instance, college enrollment may be less pleasant as one grows older. Similarly, preferences for full-time versus part-time work may change with age. This may capture the influences such as family formation and career progression over the life cycle that are not explicitly modelled otherwise. For expositional clarity, I split the second component into the utility derived from college enrollment ($u_e(d_{e,t}, \Omega_t)$), the utility or disutility from working ($u_k(d_{e,t}, \Omega_t)$), and the utility from working while in school ($u_e(d_{e,t}, d_{k,t}, \Omega_t)$).

Equation 11 describes the nonpecuniary utility from enrollment.

$$\begin{aligned} u_e(d_{e,t}, \Omega_t) = {} & (\gamma_1^U \mathbb{1}(\theta \in T1^\theta) + \gamma_2^U \mathbb{1}(\theta \in T2^\theta) + \gamma_3^U \mathbb{1}(\theta \in T3^\theta) + \epsilon_t^U) \cdot \\ & (\mathbb{1}(d_{e,t} = 0.5) + \gamma_4^U \mathbb{1}(d_{e,t} = 1)) + \sum_{k=2}^{K} \gamma_{5,k} 1(\tau = k) \cdot 1(d_{e,t} > 0) + \gamma_6^U \cdot a_t \cdot \mathbb{1}(a_t \geq 22) \\ & + \gamma_7^U \cdot 1(d_{e,t} > 0) \cdot \mathbb{1}(d_{e,t-1} > 0) + \gamma_8^U \cdot 1(d_{e,t} > 0) \cdot \mathbb{1}(B_t = 1) + \gamma_9^U \mathbb{1}(d_{e,t} > 0) \cdot \mathbb{1}(e_t \geq 2) \end{aligned} \tag{11}$$

I let this component of flow utility depend on terciles of the AFQT score θ, preference shock ϵ_t^U, and the individual type τ. I let the preferences for enrollment to shift after the age of 22 and depend on age from then on. I also capture persistence in enrollment by introducing the interaction of current and past enrollment states, the interaction of enrollment with bachelor's degree status, and the interaction of enrollment and the indicator of having accumulated two or more years of schooling.

Equation 12 describes the nonpecuniary utility flow (or disutility) from the labor supply. I let this component of utility depend on the individual's type τ and preference shock ϵ_t^W. I also let the preference for part-time and full-time employment depend on age.

$$\begin{aligned} u_k(d_{e,t}, \Omega_t) &= (\gamma_{10}^U + \sum_{k=2}^{K} \gamma_{11,\tau} \mathbb{1}(\tau = k) + \epsilon_t^W) \cdot (\mathbb{1}(d_{k,t} = 0.5) + \gamma_{12}^U \mathbb{1}(d_{k,t} = 1)) \\ &+ \gamma_{13}^U \cdot a_t \cdot \mathbb{1}(d_{k,t} = 1) + \gamma_{14}^U \cdot a_t \cdot \mathbb{1}(d_{k,t} = .5) + \gamma_{15}^U \cdot a_t \cdot \mathbb{1}(d_{k,t} = 1) \cdot \mathbb{1}(a_t < 21) \end{aligned} \tag{12}$$

Finally, equation 13 captures the effect of working while being in school.

$$\begin{aligned} u_e(d_{e,t}, d_{k,t}, \Omega_t) &= \gamma_{16}^U \mathbb{1}(d_{k,t} = 0.5) \cdot \mathbb{1}(d_{e,t} = 1) + \gamma_{17}^U \mathbb{1}(d_{k,t} = 1) \cdot \mathbb{1}(d_{e,t} = 0.5) \\ &+ \gamma_{18}^U \mathbb{1}(d_{k,t} = 0.5) \cdot \mathbb{1}(d_{e,t} = 0.5) \end{aligned} \tag{13}$$

6.2.3 Constraints

Labor Market

Accumulation of human capital ϕ depends on years of education e_t, years of work experience E_t, experience squared, ability θ captured by the AFQT score, and the unobserved latent type τ. I also allow human capital to depend on bachelor's degree status B_t and the interaction of the bachelor's degree with quality Q and quality squared as presented in equation 14.

$$\begin{aligned} log\phi_t = \gamma_1^\phi + \gamma_2^\phi e_t + \gamma_3^\phi E_t + \gamma_4^\phi E_t^2 + \gamma_5^\phi \theta + \gamma_6^\phi B_t + \gamma_7^\phi B_t \cdot Q + \gamma_8^\phi B_t \cdot Q^2 \\ + \sum_{k=2}^{K} \gamma_{9,k}^\phi \mathbb{1}(\tau = k) \end{aligned} \tag{14}$$

I allow the wage w_t to depend on human capital ϕ_t, full- or part-time work status $d_{k,t}$, and college enrollment $d_{e,t}$ as shown in equation 15. Note that the college quality affects wages through accumulated human capital. The quality of the institution attended affects wages only if the individual graduates. The influence of the quality of the institution on wages may capture the network effects in getting superior employment opportunities through alumni associations or career placement services of colleges with better resources. This can be thought of as the sheepskin effect that varies with the quality of the institution. If an individual does not graduate, he will still receive a return on the years spent in college. However, the return to years in college for dropouts does not depend on the quality of the institution. I abstract from any migration decision for labor market purposes. More specifically, I assume there is only one labor market and without any notion of a local labor market or geographic variation in wages.

$$lnw_t = log\phi_t + \gamma_1^w \mathbb{1}(d_{k,t} = 0.5) + \gamma_2^w \mathbb{1}(d_{e,t} > 0) \tag{15}$$

The human capital equation allows for the complementarity between individual ability and college quality. This is because equations for human capital and wages have the dependent variable that enters in *log* terms. In terms of the wage *level*, a high-ability individual will have higher returns to college quality upon graduation. To see this, note that the cross-partial derivative of wages (and human capital) in terms of ability and quality is positive.

At the beginning of every period, an individual may receive a job offer. If the offer does not arrive, he will be unemployed that period. If the offer does arrive, he might decline it ($d_{k,t} = 0$) and be out-of-the labor force. In equation 16, I describe this process in terms of probability of unemployment $Pr(UE)$, which is equivalent to the probability of not receiving a job offer.

$$Pr(UE) = \Phi(\gamma_1^{UE} + \gamma_2^{UE} e_t + \gamma_3^{UE} E_t + \gamma_4^{UE} a_t + \gamma_5^{UE} \cdot \mathbb{1}(d_{k,t-1} = 0)) \tag{16}$$

This probability depends on accumulated years of education e_t, accumulated years of experience E_t, age a_t, and lagged employment status ($d_{k,t-1} = 0$). The dependency of employment on age and experience captures various possible mechanisms that determine the labor market experience, such as sorting to find the best employment and career match, learning by doing, and firm-specific human capital. Meanwhile, the dependence on lagged employment status captures the idea of skill depreciation or loss of firm-specific human capital.

For individuals who are unemployed, I allow for the unemployment benefits UEB to depend on accumulated years of experience E_t as shown in equation 17.

$$UEB = \gamma^{UEB} + \gamma^{UEB} E_t \tag{17}$$

Probability of Graduating with a Bachelor's Degree

Every semester, after accumulating 3.5 years of schooling, an individual receives a bachelor's degree B_t with positive probability. I refer to this event as the probability of graduation. This process is summarized in equation 18. This probability captures aspects not explicitly modeled, such as course credit accumulation and meeting degree requirements. This probability depends on accumulated schooling e_t, ability measured by AFQT score θ, human capital ϕ_t, and school quality Q. Unobserved individual type τ affects bachelor's degree probability through human capital ϕ_t. The probability of receiving a bachelor's degree should not be confused with the chances of failing college. In the model, individuals may take more than four years to obtain a bachelor's degree, drop out before obtaining one, or choose to continue schooling after receiving a bachelor's degree.

$$B_{ij}^{*} = \Phi(\gamma_1^B + \gamma_2^B e_t \cdot \mathbb{1}(e_t > 3.5) + \gamma_3^B e_t \cdot \mathbb{1}(e_t > 4.5) + \gamma_4^B \phi_t + \gamma_5^B \phi_t^2 + \gamma_6^B Q + \gamma_6^B Q^2) \quad (18)$$

The dependence of the graduation probability on quality aims to capture the idea that at higher quality schools students benefit from higher instructional and administrative expenditure and receive more individualized attention and guidance. This increases the chances of obtaining a bachelor's degree for given schooling and given ability. The influence of college quality on graduation probability may also be the result of peer effects at colleges of various qualities, whether through direct peer influence, or through network effects in obtaining more lucrative employment. The model does not take a stand on the exact channel by which this influence operates, and rather captures these influences in a reduced-form fashion.

Terminal Value Function

Following Johnson (2013), I estimate the terminal value as a function V^{TERM} of the present discounted lifetime earnings PDV_{income} and assets at age 41 A_{41} as shown in equation 19. The present discounted value of earnings is calculated assuming that individuals work full time until the age of 65 with no wage uncertainty.

$$V^{TERM} = PDV_{income} + \gamma^{TERM} A_{41} \quad (19)$$

Using terminal value function avoids having the computational burden of solving the model over a long time horizon. The terminal value function does not imply that individuals die at the age of 41 or that the state variables after that age do not matter for decisions. It simply reflects the notion that the marginal effect of other state variables on the terminal value at age 41 is small.

Grants and Financial Aid

Grants are not derived from the college optimization problem. Equation 20 presents the grant function for community colleges. Grants at two-year colleges G_{it}^C depend on family income Y^F, but not on ability or human capital. There is limited merit aid availabile for community college students (Johnson, 2013). However, low-income students do qualify for Pell grants and state need-based grants based on their family income.

$$G_{it}^C = \gamma_1^C + \gamma_2^C Y^F + \gamma_3^C (Y^F)^2 \tag{20}$$

Equation 21 presents grant function for four-year colleges. Four-year college grants G_{it}^U depend on college quality Q, family income Y^F, and the AFQT score θ of the individual. Dependence of the grants on college quality captures the empirical regularity that the higher-quality colleges tend to offer bigger aid packages.

$$G_{it}^U = \gamma_1^U + \gamma_2^U Y^F + \gamma_3^U (Y^F)^2 + \gamma_4^U \theta + \gamma_5^U \theta^2 + \gamma_6^U Q + \gamma_7^U Q^2 + \gamma_8^U e_t \tag{21}$$

Parental Transfers

For simplicity, I do not derive parental transfers from parental utility optimization. Instead, I estimate the probability of receiving parental transfers and the amount of parental transfers when positive. Students receive the parental transfer incidence shock at the beginning of the period. The actual transfer amount is given to him as a rule and is conditional on his enrollment decision that period. Since the transfer from parents is an important way of financing college and will be key in determining which college one can afford, I condition the transfer amount both on the quality of college and its in-state status.

The parental transfers probability Tr_{it} depends on parental income Y^F, lagged enrollment status $d_{e,t-1}$ interacted with the indicator for the years of accumulated schooling, parental income Y^F, individual's age a_t, lagged incidence of transfers Tr_{t-1}, and lagged unemployment status UE_{t-1}. The probability of receiving parental transfers is given in equation 22.

$$
\begin{aligned}
Tr^*_{it} = \Phi(&\gamma^T_1 + \gamma^T r_2 Y^F + \gamma^T r_3 (Y^F)^2 + \gamma^T r_4 \mathbb{1}(d_{e,t-1} > 0) \cdot \mathbb{1}(e_t < 2) + \gamma^T r_5 \mathbb{1}(d_{e,t-1} > 0) \cdot \mathbb{1}(2 \leq e_t < 4) \\
&+ \gamma^T r_6 \mathbb{1}(d_{e,t-1} > 0) \cdot \mathbb{1}(e_t > 4) + \gamma^T r_7 \mathbb{1}(d_{e,t-1} > 0) \cdot Y^F + \gamma^T r_8 \mathbb{1}(d_{e,t-1} > 0) \cdot a_t + \gamma^T r_9 \cdot a_t \\
&+ \gamma^T r_{10} \mathbb{1}(a_t > 23) + \gamma^T r_{11} \mathbb{1}(Tr_{t-1} > 0) + \gamma^T r_{12} \mathbb{1}(UE_t = 1)
\end{aligned}
\tag{22}
$$

The amount of parental transfers is given in equation 23. The amount of parental transfers P_{itJ} depends on parental income Y^F, lagged enrollment status $d_{e,t-1}$ interacted with the indicator for the years of accumulated schooling, parental income Y^F, and individual's age a_t. It also depends on quality Q, indicator if the college is in-state public PUB, as well as on parental education categories E^F. Parental education indicator 3 stands for having a college degree. This indicator enters both directly and interacted with college quality. This is meant to capture the possibility that more-educated parents might value the college quality more and be willing to provide larger transfers conditional on quality.

$$
\begin{aligned}
P_{itJ} = &\gamma^P_1 + \gamma^P_2 Y_F + \gamma^P_3 {Y_F}^2 + \gamma^P_4 \mathbb{1}(d_{e,t-1} > 0) \cdot \mathbb{1}(e_t < 2) + \gamma^P_5 \mathbb{1}(d_{e,t-1} > 0) \cdot \mathbb{1}(2 \leq e_t < 4) \\
&+ \gamma^P_6 \mathbb{1}(d_{e,t-1} > 0) \cdot \mathbb{1}(e_t > 4) + \gamma^P_7 \mathbb{1}(d_{e,t-1} > 0) \cdot Y^F + \gamma^P_8 \mathbb{1}(d_{e,t-1} > 0) \cdot a_t + \gamma^P_9 \cdot a_t \\
&+ \gamma^P_{10} \mathbb{1}(a_t > 23) + \gamma^P_{11} \mathbb{1}(d_{e,t} > 0) \cdot Q + \gamma^P_{12} \mathbb{1}(d_{e,t} > 0) \cdot PUB + \gamma^P_{13} \mathbb{1}(d_{e,t} > 0) \cdot PUB \cdot Y^F \\
&+ \gamma^P_{14} \mathbb{1}(E^F \geq 16) + \gamma^P_{15} \mathbb{1}(E^F \geq 16) \cdot \mathbb{1}(d_{e,t} > 0) \cdot Q
\end{aligned}
\tag{23}
$$

6.2.4 Unobserved Heterogeneity

It is important to account for persistent unobserved heterogeneity that affects college choice, enrollment, and labor market outcomes. I allow for unobserved heterogeneity τ in terms of two discrete types for now. Future versions of the model will include more types to better capture the underlying unobserved heterogeneity. The individual's type depends on his AFQT score, parental income, and parental education. The unobserved heterogeneity represents early childhood and young adulthood influences that stem from family, neighborhood, and school influences, but that are immutable by the time the individual graduates from high school and are not reflected in the AFQT score.

Equation 24 presents the logit probability that determines the individual's type τ. The type depends on the tercile of the AFQT score θ, tercile of parental income Y^F, and parental education E^F.

$$\begin{aligned} Pr(\tau = k) = \Lambda(\gamma^{\tau}_{1,k} + \gamma^{\tau}_{2,k}\mathbb{1}(\theta \in T1^{\theta}) + \gamma^{\tau}_{3,k}\mathbb{1}(\theta \in T2^{\theta}) + \gamma^{\tau}_{4,k}\mathbb{1}(Y^F \in T1^{Y^F}) \\ + \gamma^{\tau}_{5,k}\mathbb{1}(Y^F \in T2^{Y^F}) + \gamma^{\tau}_{6,k}\mathbb{1}(E^F > 16) + \gamma^{\tau}_{7,k}\mathbb{1}(12 < E^F \leq 16)) \end{aligned} \tag{24}$$

Budget Constraint

When in college, students may freely borrow up to the student loan program limit. Any borrowing constraints would bind if the individual wanted to borrow an amount above what is allowed by the student loan program. Following Keane and Wolpin (2001) and Johnson (2013), I estimate the asset lower bound $\underline{\mathrm{A}}_t$ as shown in equation 25. The asset lower bound represents the maximum amount of debt an individual can hold, and captures the borrowing constraints in the model. The asset lower bound depends on human capital ϕ_t and age a_T. Therefore, as individuals accumulate human capital, they may borrow more. This dependence means to capture higher credit score accumulation through higher earning potential.

$$log\underline{\mathrm{A}}_t = \gamma^A_1 + \gamma^A_2\phi_t + \gamma^A_3\phi^2_t + \gamma^A_t a_t + \gamma^U_t \cdot 1(a_t \geq 23) \tag{25}$$

Consumption C_{it} and tuition T_{itJ} are financed through earnings W_{it}, transfers from parents Tr_{it}, assets (loans) A_{it}, and grants G_{it}. I do not keep track of two different assets (student loans and other forms of borrowing). However, I allow interest rates r for borrowing and lending to differ. Also, I allow for interest-free borrowing up to the student loan limits while in school. Equation 26 summarizes the budget constraint.

$$c_{it} + T_{itJ} + A_{it+1} = W_{it} + Tr_{it} + (1+r)A_{it} + G_{it} \tag{26}$$

7 Estimation and Identification

7.1 Estimation

I estimate the model using a two-step procedure. In the first step, I estimate the exogenous elements of the model. These exogenous elements are the parental transfer probabilities and amounts, unemployment probabilities and benefits, and the tuition function. In the second step, I estimate the structural parameters of the model.

Estimation proceeds as follows: I take an initial guess of the parameters and solve the life-cycle problem by backward induction from the terminal age of 41. I integrate over the shocks by drawing a set of 40 random shocks each period for each observation. I approximate the value function in every period using a random draw of the points of the state space and their interactions. Once I have an estimate of the value function, I proceed to simulate the model. Using the initial conditions for agents observed in the data, I simulate five life-cycle paths. With the estimated value function V in the first period, I calculate V^J for all colleges J in the choice set of a particular individual. I also estimate V^J the optimal out-of-state college. I obtain the best out-of-state college by maximizing the value function in terms of the best out-of-state college. I calculate the nonpecuniary component of each of the possible college choices, draw the logit shocks, and choose the option that gives the highest utility. I keep this best chosen alternative when simulating the life cycle.

I estimate the structural parameters using indirect inference. Indirect inference involves specifying an auxiliary model that is evaluated at the actual and simulated data. The estimation procedure searches over the structural parameters until the auxiliary model evaluated at the actual and simulated data are as close as possible. In equation 27, γ denotes the structural parameters, and β denotes the parameters of the auxiliary model. H is the weighting function and L denotes the likelihood function.

$$\hat{\gamma} = argmin \frac{\delta L}{\delta \beta}[y(\gamma); \hat{\beta}] H \frac{\delta L}{\delta \beta}[y(\gamma); \hat{\beta}]' \tag{27}$$

Tables 5 and 6 lists the moments used by the auxiliary model. The moments used include average work status and enrollment status shares by age and college quality quartiles, assets at ages 21 and 25, bachelor's degree status by age, and college quartiles. I also use reduced-form equations for wages. The moments that help identify the college choice stage are an aggregate share of respondents who chose a given college quality bin. I also use Diff-in-Diff equations that use quality of the flagship in-state institutions to explain differences in the college quality chosen by parental income. Overall, I estimate 64 parameters and use 238 moments.

7.2 Identification

Variation in tuition across states as well as variation in tuition between four- and two-year colleges help identify the elasticity of college attendance with respect to tuition. The identifying assumption is that unobservables are uncorrelated with tuition and college quality variation across the states conditional on measured ability and parental wealth. Two aspects of the model and the estimation procedure help exploit geographic variation for identification. These aspects are the formulation of the choice sets that vary by state, and the incorporation of the moment conditions in estimation that exploit geographic variation to explain differences in college choices and net assets conditional on college choices. I now discuss these aspects in greater detail.

The first aspect of the model to help with identification is that the college choice set in the model varies by the state of residence. Conditioning on the family background and ability, the quality–tuition tradeoffs facing an individual across states is assumed to be random. In a reduced-form analogy, one can think of regressing quality Q of college attended on tuition T. The differences in the menus of college quality for given tuitions across the states shift T. This shifting is exogenous for a given individual conditional on his background, and this is what drives identification of the tuition elasticity. To give intuition for this mechanism, Figure 10 shows the shift of tuition for given quality through the example of tuition functions faced by residents of California and Colorado. The national tuition-quality locus is the same for residents of both states. However, residents of each state have access to a different set of in-state public colleges for discounted tuition. Figure 11 shows the variation of the choice of in-state public colleges across the states. This variation drives the identification of price elasticity.

The second aspect that I am exploiting for identification is related to the estimation procedure. Indirect inference used in estimation is generalization of method of moments. Using indirect inference, I can incorporate reduced-form equations into the auxiliary model. Coefficients of these reduced-form regressions are estimated both on the actual and simulated data. Estimation proceeds until the moments from the simulated and actual data are as close as possible, and the reduced-form coefficients are now also part of the moments used. With the judicious choice of moments, I can exploit exogenous geographic variation. The moments that specifically harness the geographic variation are the following: (1) The Diff-in-Diff regressions of college quality choice of individuals of high- and low- family incomes across the states that have high- or low-quality flagship colleges. (2) The Diff-in-Diff regressions of net assets by age 25 for individuals of high- and low- family incomes across the states that have high- or low-quality flagship colleges. (3) The share of individuals choosing given college quality bins across the states. The Diff-In-Diff equations used in the auxiliary model are also presented and discussed in greater detail in Section 5.

The rest of the identification arguments are standard as to the similar dynamic discrete choice models. More detailed identification arguments are given in Johnson (2013) and Hai and Heckman (2016). The identification comes from the combination of the functional forms assumed and the moments used in the auxiliary model. The distribution of unobserved types is identified by observing systematic differences in decisions of individuals with similar observable characteristics.

8 Results

8.1 Components Estimated Outside the Model

I first present the results from the first step of the estimation procedure. In this step, I estimate the parameters that are later used as inputs in the second step of estimation.

Table 22 presents estimates for the admissions probability equation. This equation is estimated in the college application module of NLSY97, and is based on the subset of NLSY97 respondents who were eligible for the extended questionnaire. As expected, the admissions rate increases with higher AFQT score and decreases with higher college quality. When estimating the admissions threshold, I use AFQT scores to project having taken advanced placement classes in high school for those observations where this information is not available.

Table 23 presents estimates for the tuition function for in-state and out-of-state colleges. These are regressions of the log tuition on a 6th-degree polynomial of college quality. These equations are estimated using the IPEDS dataset and are weighted by the size of the freshman cohort. The out-of-state tuition equation was estimated both on private colleges and public out-of-state colleges. Both the slope and the intercept for out-of-state tuition are higher than those for in-state tuition.

Table 24 presents estimates for the probability of parental transfers. Lagged transfer receipt is a strong predictor of receiving transfers in the current period. As expected, higher parental income makes receiving transfers more likely, especially if one is enrolled in college. The relationship between transfers and age is not significant. In fact, respondents of all ages report receiving transfers. However, the incidence of transfers is significantly higher if the respondent is enrolled in school or is unemployed. Once in school, the incidence of transfers does not vary much by year of enrollment. Table 25 reports the estimates for the amount of parental transfers. As with transfer incidence, the transfer amount increases with parental income, especially if the child is enrolled in college. The amount of transfers is larger in the third and fourth years of college and declines with age. Individuals in higher-quality colleges receive larger transfers. However, parental education has only a weak association with transfer amounts.

Tables 27 and 26 show estimates of the probability of unemployment and unemployment benefits. The probability of unemployment is decreasing in years of college education and experience, and increasing in age. The chances of unemployment are also higher if an individual did not work in the previous period. Tables 28 and 29 give estimates for grants at two- and four-year colleges respectively. Grants decrease with parental income. Unfortunately, the relationships between grants and both AFQT score and college quality are imprecisely estimated. As expected, grants are lower at in-state public colleges.

8.2 Model Fit

Figures 18 through 20 show the fit of the simulated model and the life-cycle pattern of enrollment, employment, bachelor's degree receipt, wages, and asset accumulation. The model generally fits the life-cycle patterns well, except for part-time enrollment and part-time employment, both of which are overpredicted during early years and underpredicted in later years.

Figure 21 shows the model fit for college quality choice. The model currently underpredicts out-of-state enrollment and overpredicts enrollment in colleges in the top quartile.

Discussion is in order why the model currently underpredicts the out-of-state college attendance. This underprediction has three reasons. First, currently individuals choose college only one time, when they graduate from high school. They are committed to this choice, in the sense that regardless what shocks the life brings, they can only adjust on enrollment margin, but can not adjust in terms of the college choice. Second, admissions is not stochastic, and is currently rather slack. Third, the model predicts considerable returns if one goes to and graduates from the high quality college. Therefore, in the simulations, individuals pick the out-of-state college at the end of high school. The out-of state colleges they can get into are high quality. However many of these individuals never end up being able to enter these out-of-state colleges or in fact in any college. However they are willing to bear the risk of not being able to enroll by the age 21 in any college because the returns to enrolling in very high quality college are quite high. The next iteration of the model will allow for the college choice sequentially at the time the enrollment decision is actually made as well as introduce stochastic admissions threshholds. That modelling choice would more closely follow how the decisions are made in the real world, and this would improve the fit of the model in terms of the out-of-state enrollment.

Meanwhile, simulations in the current version are still informative because there is a gradient of college tuition and college quality even within in-state-public colleges as seen in figure 3. Both grant and loan limit increases can be salient at the margin of choosing colleges within the state. It is also interesting to analyse the change in enrollment in out-of-state colleges, keeping in mind that the level of enrollment is currently underpredicted.

8.3 Life Cycle

Tables 30 through 31 present the parameters of the estimated model. The model fit and counterfactual simulations are of primary interest; therefore, I will discuss the parameters briefly. Estimates of the wage equation indicate that there is a wage return to having a bachelor's degree, in addition to the return to years spent in college. Also, the return to bachelor's degree increases with college quality. Part-time work and being enrolled in college are associated with a wage penalty. The lower bound of assets increases with both human capital and age. The quality of the college one attends positively affects the probability of receiving a bachelor's degree.

Parameters of the first-stage college choice equation are of particular interest and are presented in table 31. Parameters γ_7 through γ_{13} are related to the college quality choice. Being in the top AFQT tercile also makes one prefer higher-quality colleges, as does parental education. The sign on the parameter for quality by itself is negative and can be interpreted as a utility cost of higher effort.

8.4 Counterfactual Simulations

To begin, I consider a policy of tuition and loan limit change equal to the amount of the Pell grant, which was around $2000 per year in 2000. I simulate five types of policies. The first simulated policy is an across-the-board tuition subsidy equal to $2,000. The second policy is a tuition subsidy of $2,000 for in-state public colleges only. The third policy is an increase in the federal student loan limit by $2,000 per year. The fourth is removing tuition completely from public in-state colleges. Finally, the fifth policy is to allow individuals to borrow the full cost of college.

Table 32 presents the distribution of students in colleges by quality quartiles. Table 33 presents the share of students in out-of-state or private colleges, community colleges and the share not attending college. One needs to keep in mind that the baseline estimates underpredicted the share of students going out-of-state, as in figure 21.

All five policy experiments result in students resorting across college quality. As expected, the subsidy has the largest impact on resorting because this is money that does not have to be repaid. The pattern of resorting observed as a result of the general subsidy is intuitive: more students go to higher- quality colleges and more go out-of-state. Table 34 displays the impact of the simulated policies on bachelor's degree completion. All three policies lead to improvements in these indicators. The unrestricted subsidy of $2000 increases college completion by 3 percentage points. This estimate is on the high end of what is typically found in the literature. A loan limit increase by $2,000 has almost no effect of degree completion. This is not surprising, as 2,000 is a small fraction of the tuition and living expenses, and it is money that needs to be repaid. However letting individuals borrow up to the full college cost increases degree completion for overall by 4.4 percentage points. The increase is highest for the individuals in the middle tercile of the AFQT score. This indicates that the credit constraints are indeed quite salient. These results have to be taken with caution, as they are preliminary and the model fit needs to improve in terms of both enrollment patterns and the distribution of students between in-state and out-of-state colleges. Work on improving the fit is currently under way.

9 Conclusion

In this paper, I investigate the importance of credit constraints on the margin of college choice within the framework of a structural lifecycle model. I exploit variation in the available in-state public colleges across the states to help identify the strength of credit constraints and tuition elasticity of enrollment and college quality choice. I use the institutional feature of the U.S higher education market that residents of any given state pay discounted in-state tuition to attend colleges in their state of residence and the portfolio of in-state colleges differs across the states. I account for this portfolio of available in-state public colleges when formulating individual's choice set according to his state of residence. Individuals can also choose to attend out-of-state colleges or a two-year community college. This is the first paper to study the effects of credit constraints through dynamic lifecycle model while allowing for the college choice of such richness.

I first document the patterns that suggest that family income affects the quality of college one attends, and the quality translates into higher wage outcome after graduation. Furthermore, the effect of family income on college choice varies systematically with the quality of in-state flagship institutions. I then proceed to investigate the mechanisms behind these data patterns through the lifecycle model. My model combines enrollment, employment, and saving decisions over the lifecycle and college choice in the first stage. The estimated model fits the data reasonably well, with the exception of sorting into private and out-of-state colleges, which it currently underpredicts.

With the caveat that the fit of sorting into the out-of-state colleges in the baseline needs to be improved, I have simulated policies that involved a modest increase in subsidies of $2,000, both limited for in-state colleges and general subsidies. I also simulated the effect of an increase in the loan limit by $2,000. All these policies increased schooling and resulted in students being resorted among colleges. Tuition subsidies had a larger impact. Finally, I simulated more drastic policy changes: free tuition at in-state public colleges and letting individuals borrow up to the full cost of college. Both these policies resulted in students resorting towards higher quality colleges, and increased the graduation by 5 and 4 percentage points respectively. Borrowing the full cost of college improved the degree completion for the individuals of the median ability the most. I find that there are wage returns to college quality if one graduates from college. These returns are convex in college quality. I also find that college quality has a positive effect on graduation.

This paper opens several interesting avenues for future research. I assume that individuals have perfect information about returns to different college choices, as well as about admissions and financial aid at different institutions. Evidence suggests that high-ability students from disadvantaged backgrounds do not apply to selective universities, even if the net price for them were lower in such institutions than in non-selective colleges that they actually attend (Hoxby and Avery, 2013). How an individual's family circumstances affect preferences and information on college options is an interesting avenue to explore. This paper does not investigate the effect of college debt on post-college outcomes, such as career and employment choices and family formation. There is evidence that college debt might have influence on these outcomes (Rothstein and Rouse, 2011). Exploring the effect of student debt on later life outcomes would be an interesting avenue for future work. Finally, this paper does not investigate what determines regional variation of government subsidies on higher education or the effects of this variation on the regional labor market. In the future, it would be interesting to explore what determines the quality variation of institutions across the states.

References

Peter Arcidiacono. Affirmative Action in Higher Education: How Do Admission and Financial Aid Rules Affect Future Earnings?. *Econometrica*, 73(5):1477–1524, 09 2005.

Peter Arcidiacono and Michael Lovenheim. Affirmative action and the quality-fit trade-off. *Journal of Economic Literature*, 54(1):3–51, March 2016.

Philippe Belley and Lance Lochner. The changing role of family income and ability in determining educational achievement. *Journal of Human Capital*, 1(1):37–89, 2007.

Dan A Black and Jeffrey A Smith. How robust is the evidence on the effects of college quality? evidence from matching. *Journal of Econometrics*, 121(1):99–124, 2004.

Dan A. Black and Jeffrey A. Smith. Estimating the returns to college quality with multiple proxies for quality. *Journal of Labor Economics*, 24(3):701–728, 2006.

John Bound, Sarah Turner, et al. Dropouts and diplomas. *Handbook of the Economics of Education*, 4:573–613, 2011.

Meta Brown, John Karl Scholz, and Ananth Seshadri. A New Test of Borrowing Constraints for Education. *Review of Economic Studies*, 79(2):511–538, 2012.

Stephen V Cameron and Christopher Taber. Estimation of educational borrowing constraints using returns to schooling. *Journal of political Economy*, 112(1):132–182, 2004.

Rajashri Chakrabarti and Joydeep Roy. Merit aid, student mobility, and teh role of college selectivity. Working paper, New York Fef, 2013.

Sarah R. Cohodes and Joshua S. Goodman. Merit aid, college quality, and college completion: Massachusetts' adams scholarship as an in-kind subsidy. *American Economic Journal: Applied Economics*, 6(4):251–85, October 2014.

Stacy Dale and Alan B. Krueger. Estimating the Return to College Selectivity over the Career Using Administrative Earnings Data. NBER Working Papers 17159, National Bureau of Economic Research, Inc, June 2011.

Stacy Berg Dale and Alan B. Krueger. Estimating the payoff to attending a more selective college: An application of selection on observables and unobservables. *The Quarterly Journal of Economics*, 117(4):1491–1527, 2002.

Susan Dynarski and Judith Scott-Clayton. Financial aid policy: Lessons from research. *The Future of Children*, pages 67–91, 2013.

Chao Fu. Equilibrium tuition, applications, admissions, and enrollment in the college market. *Journal of Political Economy*, 122(2):225–281, 2014.

Rong Hai and James Heckman. Inequality in human capital and ebdogenous credit constraints. Mimeo, University of Chicago, 2016.

Caroline Hoxby and Christopher Avery. The Missing "One-Offs": The Hidden Supply of High-Achieving, Low-Income Students. *Brookings Papers on Economic Activity*, 46(1 (Spring):1–65, 2013.

Caroline M. Hoxby, editor. *College Choices*. Number 9780226355351 in National Bureau of Economic Research Books. University of Chicago Press, September 2004.

Matthew T. Johnson. Borrowing constraints, college enrollment, and delayed entry. *Journal of Labor Economics*, 31(4):pp. 669–725, 2013.

Thomas J Kane. Public intervention in post-secondary education. *Handbook of the Economics of Education*, 2:1369–1401, 2006.

Greg Kaplan. Moving Back Home: Insurance against Labor Market Risk. *Journal of Political Economy*, 120(3):446 – 512, 2012.

Adam Kapor. Distributional Effects of RAce-Blind Affirmative Action. Working paper, Yale University, 2015.

Michael P. Keane and Kenneth I. Wolpin. The effect of parental transfers and borrowing constraints on educational attainment. *International Economic Review*, 42(4):1051–1103, 2001.

John Kennan. Spatial Variation in Higher Education Financing and the Supply of College Graduates. NBER Working Papers 21065, National Bureau of Economic Research, Inc, April 2015.

Josh Kinsler and Ronni Pavan. Family income and higher education choices: The importance of accounting for college quality. *Journal of Human Capital*, 5(4):453–477, 2011.

Junwen Liu. The effects of tuition and student loan policies on college outcomes and lifetime earnings. Mimeo, University of Pennsylvania, 2015.

Charles F Manski and David Wise. College choice in america, 1983.

Jesse Rothstein and Cecilia Elena Rouse. Constrained after college: Student loans and early-career occupational choices. *Journal of Public Economics*, 95(1-2):149–163, February 2011.

Tables

Table 1: Commom Proxies Used for College Quality

Paper	Data	Measure
Black and Smith (2006)	Restricted NLSY79 IPEDS US News and World Report (Only keep 4 year colleges)	1. Faculty/student ratio 2. Rejection rate 3. Freshmen retention rate 4. Mean SAT 5. Mean faculty salaries
Fu (2014)	NLSY97 college choice series US News and World Report	Using USNWR, top 30 universities top 20 LAC, top 30 public, CC
Liu (2015)	NLSY97 IPEDS	Principal factor of (1) Average SAT score and (2) Average faculty salary. Groups them into CC and 4 quality levels of 4YC
Dale and Krueger (2002)	College and Beyond CEEB HERI Barron's Guide	1. Mean SAT 2. Barron's Competitiveness Index
Kinsler and Pavan (2011)	Restricted NLSY79 Restricted NLSY97 IPEDS	Principal factor when using (1) Total SAT score, (2) Freshman retention rate and (3) Faculty salary

Table 2: Loans for Undergraduate Students by Source, 2000-01 and 2010-11

	2000-01	2010-11
Total federal loans	$29.9	70.0
Subsidized Stafford	14.4	28.4
Unsubsidized Stafford	9.7	30.3
PLUS (Parent) loans	4.7	10.4
Other federal loans	1.2	0.8
Nonfederal loans	4.4	6.5

Source: College Board, Trends in Student Aid 2011, Table 1A.

Table 3: Grants for Undergraduate Students by Source, 2000-01 and 2010-11

	2000-01	2010-11
Total federal grants	$13.5	47.8
Pell Grants	10.0	34.8
Veterans	1.9	10.0
Other grants	1.6	3.1
State grant programs:	5.9	9.1
Grants from colleges	15.3	29.7
Private and employer grants	5.1	6.6

Source: College Board, Trends in Student Aid 2011, Table 1A.

Table 4: Parameters Calibrated Outside the Structural Model

Description	Value	Source
Coefficient of Risk Aversion, ρ	2.0	Johnson (2013), Hai and Heckman (2016)
Discount Factor, β	0.97	Johnson (2013)
Interest Rates		
Student loans while in college	0%	Federal Student Aid
Borrowing	5%	Federal Student Aid
Lending	1%	Average real interest rate on 1-yr U.S. government bonds from 2001 to 2007
GSL Annual Borrowing Limit:		Annual Stafford loan limits 1993-2007
Year 1	2625	
Year 2	3500	
Year 3	5500	
Year 4	8500	
GSL Aggregate Limit	23000	Aggregate undergraduate Stafford loan limit 1997-2007

Table 5: Moments Used in Estimation

Target Moments	#
1. College Enrollment	
• Share of individuals in college by age (ages 18-25)	8
• Enrollment by AFQT terciles (ages 18-21)	3
• Not enrolled by AFQT terciles (ages 18-21)	3
• Regression of enrollment on laged enrollment and age (ages 18-21)	3
• BA degree receipt by age (ages 22-25)	4
• BA degree receipt by age and quality quartiles (ages 22-25)	16
• Fulltime enrollment if in college (ages 18-27)	1
• Regression of BA status on AFQT tercile, quality and public-instate (ages 21-25)	6
• Reg. of Q on AFQT, par.income, Flagship FQ, FQ x par.income, for high AFQT	7
• Reg. of Q on AFQT, par.income, Flagship FQ, FQ x par.income, for low AFQT	7
• Share by college quality quartiles by the age 21	4
• Share no college by age 21	1
• Years of fulltime equivalent schooling (age 25)	1
• Enrolled part time by age (ages 18-25)	7
• Not enrolled by age (ages 18-25)	7
• Reg. of enrollment at age 21 on AFQT quartiles, and fam inc quartiles	7
• Reg. of four or more years of college on AFQT quartiles, and fam inc quartiles	7
• Reg. of four or more years of college on Coll Quality quartiles	4
• Reg. of enrollment at age 21 on fam inc quartiles	4
• Reg. of four or more years of college on fam inc quartiles	4
• Reg of BA status on schooling and quality quartiles (at 25)	4
• Reg. of four or more years of college on quality quartiles	4
• Enrolled part time by age and by quality quartiles (ages 18-25)	24
• Not in college by age 21	1
• Share by college quality bins by age 21	5
• Share out-of-state by age 21	1
• Share in two-year colleges by age 21	1
• College quartiles by age 21	4
2. Labor Supply	
• Work status if not in school (Not working, Work PT/FT; ages 18-27)	3
• Work status if in college full-time (ages 18-27)	1
• Work status if in college part-time (Work FT/PT; ages 18-27)	2
• Work full time by age (ages 18-27)	8
• Work part time time by age (ages 18-27)	8
• Not work time by age (ages 18-27)	8
• Work full time by age if enrolled (ages 18-27)	8
• Work part time time by age if enrolled (ages 18-27)	8
• Not work time by age if not enrolled (ages 18-27)	8
• Work full time by age if not enrolled (ages 18-27)	8
• Work part time time by age if not enrolled (ages 18-27)	8
• Not work time by age if enrolled (ages 18-27)	8
• Fraction working full time by age (ages 18-25)	8
• Fraction working part time by age (ages 18-25)	8
• Not working and declined employment by age (ages 18-25)	7

Table 6: Moments Used in Estimation - ctd

Target Moments	#
3. Wages	
• Reg. of *logw* on schooling, BA, *Exp*, Exp^2, AFQT, Wk PT, enrolled, Q x BA	9
• Reg. of *logw* on schooling, BA, *Exp*, Exp^2, AFQT, lagged not working (ages 24-41)	7
• Person specific variance of wage by age (ages 18-25)	8
• Reg. of wages on lagged wages	2
• Wage by age if working (ages 18-25)	8
4. Loan and Asset Accumulation	
• Mean net assets by age (ages 20, 25)	2
• Share with negative networth by age (ages 20, 25)	2
• Mean loan amount if negative assets by age (ages 20, 25)	2
• Reg. of assets at 20 on assets at 18	2
• Reg. of assets at 25 on assets at 20	2
• Mean net assets for those never enrolled by age (ages 20,25)	2
• Mean net assets at 25 by quality quartiles	4
• Mean net assets at ages 38-40	1
Total number of moments	238

Table 7: Variable Definition

Variable	# Description
1. Decision Variables	
• $d_{e,t} \in \{0, 0.5, 1\}$	Enrollment decision
• $d_{k,t} \in \{0, 0.5, 1\}$	Employment decision
• C_t	Consumption
• Q	School quality
2. Outcome variables	
• A_t	Assets
• $\underline{\mathrm{A}}_t$	Assets lower bound
• E_t	Work experience
• e_t	Schooling in fulltime years
• B_t	Bachelor's degree
• w_t	Wages
• UE_t	Unemployment
• UEB_t	Unemployment benefits
• ϕ_t	Human capital
• a_t	Age
• Tr_t	Parental transfer incidence
• P_t	Parental transfer amount
• T_t	Tuition
• G_t^C	Grant in two-year college
• G_t^U	Grant in four-year college
• PDV_{income}	Present Discounted Value of Income
3. Exogenous characteristics	
• θ	AFQT score
• Y^F	Parental family income
• E^F	Parental education
• s	State of residence
• τ	Individual's type
• QF	Quality of the flagship in-state college
• X	Individual controls
4. Functions	
• $T1^z..T3^z$	Tercile of the variable z
• Φ	Normal distribution function
• Λ	Logistic function

Table 8: Cumulative Distribution of Number of Delay Semesters

	N	Share	Cumul
0	3461	61.2	61.2
1	737	13.0	74.2
2	11	0.2	74.4
3	250	4.4	78.8
4	18	0.3	79.2
5	153	2.7	81.9
6	32	0.6	82.4
7	89	1.6	84.0
8	35	0.6	84.6
9	86	1.5	86.1
10	39	0.7	86.8
11	83	1.5	88.3
12	40	0.7	89.0
13	74	1.3	90.3
14	36	0.6	90.9
15	63	1.1	92.1
16	30	0.5	92.6
17	46	0.8	93.4
.	5283	93.4	

Note: Number of semesters of delayed enrollment from high school graduation for those individuals that were ever enrolled by the age of 27 in NLSY97 sample.

Table 9: Sample Selection

	Count				Share		
	No College	Start 2-yr	Start 4-yr	Total	No College	Start 2-yr	Start 4-yr
NLSY97 Sample Size	3315	2735	2910	8960	37.00	30.52	32.48
Sample after dropping:							
Females	1982	1268	1334	4584	43.24	27.66	29.10
Did not graduate fromHS	886	1088	1288	3262	27.16	33.35	39.48
No parental education info	790	1022	1224	3036	26.02	33.66	40.32
Went to Forprofit	790	936	1181	2907	27.18	32.20	40.63
Entered college after 21	789	758	1118	2665	29.61	28.44	41.95
Went to more than 3 cols	789	735	1089	2613	30.20	28.13	41.68
Missing info on first college	789	735	1058	2582	30.56	28.47	40.98
Drop non-white	492	453	762	1707	28.82	26.54	44.64
Drop if no AFQT	391	376	657	1424	27.46	26.40	46.14
Final	391	376	657	1424	27.46	26.40	46.14

Table 10: Asset Statistics by Age

Age	N	Median	Mean	Standard Deviation	Percent Negative
18	1389	2317	5881	10145	5.5
20	1350	2625	5756	11154	13.3
25	670	6513	11066	22505	26.9

Note: N refers to the number of individuals in the estimation sample with available data.
Source: NLSY97

Table 11: Parental Transfers

		Money from Parents		College Transfers		Co-residence[a]	Total Transfers	
Age	N	%	Mean if >0	%	Mean if >0	%	%	Mean if >0
18	2848	39.4	1354	37.3	9300	60.7	89.3	5682
19	2848	33.1	1469	39.2	9086	55.6	84.8	5394
20	2848	29.7	1482	35.5	8731	50.3	80.3	4881
21	2848	26.4	1473	29.9	8982	43.6	72.8	4589
22	2848	23.5	1499	24.4	7482	39.5	66.7	3065
23	2848	21.2	1445	15.7	6919	35.6	58.8	2141
24	2846	19.5	1484	11.7	7067	28.7	51.2	1865
25	2838	21.7	1592	9.9	4956	24.5	49.4	1638
26	2703	30.4	1718	9.3	3476	21.0	53.1	1581
27	2256	38.0	1625	9.0	9664	18.5	56.1	2210
28	1652	43.8	1673	7.7	913	16.6	59.3	1485
29	1085	57.2	2037	7.0	850	12.5	67.7	1585
30	539	77.6	2224	6.7	1000	8.6	82.7	1833

Note: N refers to the number of person-semester observations in the estimation sample with available data.
Source: NLSY97

.

Table 12: Work Status and College Attendance by Age and Semester

			In College			Not in College			
Age	Sem.	N	Full	Part	No	Full	Part	No	Unemp.
18	Fall	1382	4.1	19.0	18.2	26.1	19.2	13.5	6.3
	Spring	1347	4.5	14.4	24.8	26.7	16.7	13.0	10.9
19	Fall	1343	7.5	23.2	12.0	32.9	13.7	10.7	4.8
	Spring	1331	5.6	14.5	20.7	32.6	13.7	12.8	8.6
20	Fall	1325	9.1	19.6	12.9	36.1	10.5	11.8	5.1
	Spring	1325	6.1	15.2	19.7	36.5	10.9	11.6	7.0
21	Fall	1319	9.9	20.0	12.8	38.3	9.5	9.6	2.9
	Spring	1327	8.3	13.9	17.5	38.9	10.0	11.5	8.0
22	Fall	1315	15.8	15.1	9.1	41.5	8.7	9.7	4.1
	Spring	1312	8.8	8.0	8.9	51.0	11.7	11.6	4.9
23	Fall	1300	12.2	8.4	5.2	56.2	7.8	10.3	3.9
	Spring	1288	6.5	5.3	5.0	63.0	9.8	10.4	3.9
24	Fall	1281	8.1	4.5	4.0	65.6	8.7	9.1	2.5
	Spring	1280	5.2	3.6	3.8	65.6	9.8	12.0	4.4
25	Fall	1277	6.0	3.4	3.1	67.8	9.2	10.4	3.6
	Spring	1252	4.6	2.1	4.0	68.1	10.1	11.2	4.8
26	Fall	1229	6.0	2.6	2.3	70.3	9.5	9.3	3.2
	Spring	1128	5.5	1.9	2.8	67.9	9.2	12.7	5.3
27	Fall	1102	6.3	2.1	1.9	69.8	9.5	10.4	3.7
	Spring	833	3.7	1.6	2.8	70.0	9.6	12.4	4.3
28	Fall	814	3.8	1.7	2.7	72.4	8.7	10.7	3.1
	Spring	562	3.2	2.0	2.1	72.8	8.7	11.2	3.1
29	Fall	542	4.4	1.7	1.7	74.0	9.0	9.2	1.5
	Spring	332	4.2	1.2	1.5	74.7	5.7	12.7	4.0
30	Fall	319	3.4	1.3	1.9	73.7	9.7	10.0	2.5
	Spring	103	1.0	2.9	4.9	68.9	8.7	13.6	4.4

Note: N refers to the number of individuals in the estimation sample with available data.
Source: NLSY97

Table 13: College Attendance by Age and Semester (% of Sample)

Age	Semester	N	Full	Part	No School
18	Fall	1394	39.5	1.6	58.9
	Spring	1373	41.3	1.8	56.9
19	Fall	1369	40.9	1.3	57.8
	Spring	1374	38.0	1.8	60.2
20	Fall	1372	38.0	2.3	59.7
	Spring	1381	37.9	1.5	60.5
21	Fall	1377	39.1	1.9	59.0
	Spring	1394	35.2	2.8	62.1
22	Fall	1387	34.3	4.0	61.7
	Spring	1400	18.5	5.6	75.9
23	Fall	1396	18.1	6.2	75.7
	Spring	1396	10.2	5.5	84.3
24	Fall	1397	10.2	5.3	84.5
	Spring	1401	6.1	5.4	88.5
25	Fall	1402	6.3	5.3	88.4
	Spring	1394	4.7	4.9	90.4
26	Fall	1393	4.9	4.9	90.2
	Spring	1264	3.6	5.5	90.8
27	Fall	1260	3.4	5.7	90.9
	Spring	951	1.7	5.5	92.8
28	Fall	951	1.9	5.4	92.7
	Spring	664	2.3	4.1	93.7
29	Fall	665	2.3	4.2	93.5
	Spring	398	1.3	4.5	94.2
30	Fall	397	1.3	4.3	94.5
	Spring	134	1.5	5.2	93.3

Note: N refers to the number of individuals in the estimation sample with available data.
Source: NLSY97

Table 14: Descriptive Statistics by College Type

	Public		Private	
	Instate	Outofstate	Instate	Outofstate
Number of respondents	642	3790	403	490
Coreside with parents	0.56	0.68	0.72	0.78
Flagship	0.16	0.08	0.00	0.00
Avg grant	1847	1101	4713	5546
Receive grant	0.68	0.63	0.82	0.90
Avg grant if >0	2710	1746	5751	6181
Avg transfers	2670	1391	4870	2944
Receive transfers	0.93	0.89	1.00	0.88
Avg transfers if >0	2865	1555	4870	3351
Avg student loans	890	384	1399	1175
Receive student loans	0.58	0.48	0.64	0.66
Avg student loans if >0	1535	796	2190	1770
Avg parental income	89531	85789	93293	83296
Parental education yrs - highest	15	14	15	15
Parent college graduate	0.73	0.64	0.79	0.72
Individual SAT - Math	548	524	564	555
Individual SAT - Verbal	535	528	581	545
Individual SAT - Total	1083	1050	1145	1107
Highschool GPA	3.05	3.04	3.18	3.21
AFQT	175	176	183	180
Took AP classes in HS	0.38	0.37	0.56	0.50
College Average SAT - Math	529	444	567	546
College Average SAT - Verbal	527	456	563	540
College Average SAT - Total	1081	1059	1130	1086
College Quality - PCI	-0.717	-0.737	0.080	-0.300
Instate tuition	2837	2623	22874	21685
Outofstate tuition	6430	6054	22877	21686
Room charges	3118	3142	4872	4581
Board charges	2182	2117	3650	3611

Source: NLSY97

Table 15: Path for Those Starting at 4Yr College

	N	Share	Cumul
Only one college, not graduate	608	21.1	21.1
Degree from first college	1332	46.2	67.3
Degree from second college	223	7.7	75.0
Degree from third or later college	124	4.3	79.3
Transfer colleges but no degree	596	20.7	100.0
.	2883	100.0	

Note: Path of college transfers and graduation for NLSY97 sample.
Source: NLSY97

Table 16: Path for Those Starting at Community College

	N	Share	Cumul
Only one community college	1478	54.6	54.6
One transfer to 4YR, get BA degree	275	10.2	64.8
One transfer to 4YR, but no degree	247	9.1	73.9
Multiple transfers, eventual degree	112	4.1	78.1
Multiple Transfers, but no degree	244	9.0	87.1
One transfer to com. college, no degree	334	12.3	99.4
Other	15	0.6	100.0
.	2705	100.0	

Note: Path of college transfers and graduation for NLSY97 sample.
Source: NLSY97

Table 17: College Quality Bins by State

State	Q1	Q2	Q3	Q4	Q5
AL	0.529	-0.436	-0.815	-1.154	-1.700
AK	-0.400	-0.610	-1.190		
AZ	0.331	-0.410	-0.827	-0.950	-1.005
AR	0.458	-0.804	-1.121	-1.216	-2.044
CA	1.933	1.017	0.159	-0.140	-0.492
CO	0.609	-0.124	-0.884	-1.225	-1.439
CT	1.216	-0.121	-0.219	-0.398	-0.537
DE	1.032	-1.352			
FL	1.437	0.532	-0.008	-0.251	-1.361
GA	1.413	-0.098	-0.548	-0.909	-1.148
HI	0.158	-0.774	-1.442		
ID	0.020	-0.810	-1.454	-1.651	
IL	1.566	0.191	-0.325	-0.640	-1.148
IN	0.804	-0.604	-1.116	-1.210	-1.516
IA	0.864	0.727	0.085		
KS	0.298	0.029	-0.585	-0.975	-2.157
KY	0.337	-0.250	-0.745	-0.878	-2.063
LA	0.555	-0.486	-0.884	-1.064	-1.384
ME	-0.096	-0.485	-0.857	-1.405	-1.780
MD	1.653	0.514	-0.033	-0.955	-2.375
MA	0.802	0.230	-0.182	-0.336	-0.512
MI	1.709	0.635	-0.198	-0.441	-0.915
MN	1.182	-0.047	-0.294	-0.773	-1.149
MS	0.138	-0.488	-0.789	-1.190	-1.429
MO	0.589	-0.203	-0.621	-1.019	-2.043
MT	-0.351	-0.612	-1.191	-1.418	-1.550
NE	0.651	-0.382	-0.964	-1.053	-1.462
NV	0.047	-0.218	-1.418	-1.474	
NH	0.579	-0.302	-0.474	-0.524	-1.984
NJ	1.216	0.569	0.436	0.104	-0.449
NM	-0.073	-0.827	-1.937	-2.017	-2.171
NY	1.253	0.632	0.054	-0.376	-1.091
NC	1.743	0.621	-0.133	-0.667	-1.021
ND	-0.090	-1.068	-1.353	-1.381	-1.741
OH	1.269	-0.001	-0.691	-1.259	-1.803
OK	0.559	-0.430	-1.261	-1.587	-1.902
OR	0.284	-0.228	-0.645	-0.960	-1.164
PA	1.071	0.167	-0.385	-0.630	-0.845
RI	0.152	-0.482			
SC	0.803	0.048	-0.862	-1.056	-1.352
SD	-0.247	-0.531	-1.013	-1.216	-2.616
TN	0.485	-0.288	-0.593	-0.772	-1.077
TX	1.212	-0.116	-0.949	-1.237	-1.619
UT	0.531	-0.532	-1.099	-1.680	-1.777
VT	0.518	-0.925	-0.984	-1.160	-1.428
VA	1.866	0.828	0.243	-0.194	-1.073
WA	1.260	0.210	-0.093	-0.405	-0.467
WV	-0.027	-0.874	-1.222	-1.601	-1.852
WI	1.400	0.056	-0.405	-0.521	-0.842
WY	-0.164				

Note: In-state public colleges are aggregated into maximum of five bins per state. See section 6.1.2 for discussion.
Source: IPEDS

Table 18: Quality of College Attended by Quality of Flagship Institution

VARIABLES	(1) Low AFQT	(2) High AFQT
AFQT	11.7***	39.2***
	(2.3)	(3.6)
Par. income	2.0	5.0***
	(1.3)	(1.0)
High Quality Flagship	169.0	543.1***
	(192.9)	(170.3)
Parinc x High Qual Flagship	0.8	-2.9**
	(1.8)	(1.5)
Constant	-401.0	-5,762.3***
	(391.9)	(722.3)
Observations	271	558
R-squared	0.1	0.2

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 19: Assets at Age 25 by Quality of Flagship Institution

VARIABLES	(1) Low AFQT	(2) High AFQT
AFQT	-47.6	-99.7
	(64.7)	(79.3)
Par. income	37.6	27.2*
	(22.8)	(15.0)
Quality	1.8	0.1
	(2.1)	(1.1)
High Quality Flagship	1,687.3	-9,801.8**
	(5,952.8)	(4,339.2)
Quality x High Qual Flagship	-1.5	3.5**
	(3.0)	(1.5)
Constant	7,515.7	21,465.7
	(10,704.5)	(15,293.3)
Observations	264	561
R-squared	0.0	0.0

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 20: Family Income and Quality of College Attended, Multinomial Logit

VARIABLES	(1) Qual qrtl. 2	(2) Qual qrtl. 3	(3) Qual qrtl. 4
Family Inc. qrtl. 2	-0.216***	0.144*	0.079
	(0.072)	(0.084)	(0.097)
Family Inc. qrtl. 3	-0.081	0.712***	0.111
	(0.073)	(0.083)	(0.096)
Family Inc. qrtl. 4	-0.202***	0.385***	0.771***
	(0.072)	(0.083)	(0.092)
AFQT qrtl. 2	0.504***	1.505***	1.815***
	(0.066)	(0.103)	(0.178)
AFQT qrtl. 3	0.328***	2.070***	3.009***
	(0.067)	(0.102)	(0.171)
AFQT qrtl. 4	0.846***	3.150***	4.857***
	(0.076)	(0.106)	(0.173)
Parent's highest grade	0.060***	0.064***	0.176***
	(0.011)	(0.011)	(0.012)
Flagship Quality	0.000***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)
Constant	-2.140***	-4.062***	-9.897***
	(0.219)	(0.247)	(0.310)
Observations	18,098	18,098	18,098

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 21: Predicted Probability of Attending a Top-Quartile College, Conditional on College Attendance

	Family Income		
	Quartile 1	Quartile 4	Change
AFQT qrtl. 1	0.011	0.026	0.014
	(0.002)	(0.004)	(0.004)
AFQT qrtl. 2	0.041	0.087	0.046
	(0.003)	(0.005)	(0.006)
AFQT qrtl. 3	0.131	0.240	0.108
	(0.008)	(0.008)	(0.011)
AFQT qrtl. 4	0.369	0.530	0.161
	(0.015)	(0.009)	(0.017)
Average Ability	0.012	0.027	0.015
	(0.002)	(0.004)	(0.005)

Note: The average individual in each ability quartile is constructed by taking the average of all controls other than the ability and the family income within that ability quartile in the sample. The average individual is constructed by taking the average of all controls other than the family income in the sample. See section 5 for discussion.

Table 22: Admissions Probability - Logit

VARIABLES	Estimate
College quality - PC1	-1.394***
	(0.100)
Instate public college	0.191
	(0.169)
AFQT	0.014***
	(0.005)
Took advanced placement classes in high school	0.568***
	(0.179)
High school GPA	1.025***
	(0.204)
White	-0.389
	(0.311)
Black	2.652*
	(1.369)
Black x AFQT	-0.020**
	(0.008)
Constant	-3.509***
	(0.919)
Observations	1,839

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10. (c) Applications from all rounds before initial college attendance included. (d) Only four year degree-granting not-for-profit institutions included.

Table 23: Instate and Outofstate Tuition by Quality

VARIABLES	(1) Outofstate	(2) Instate
P1	0.225***	0.142***
	(0.001)	(0.001)
P2	0.020***	0.217***
	(0.001)	(0.001)
P3	0.033***	0.033***
	(0.000)	(0.001)
P4	-0.003***	-0.129***
	(0.000)	(0.001)
P5	-0.004***	-0.004***
	(0.000)	(0.000)
P6	0.000***	0.017***
	(0.000)	(0.000)
Constant	2.786***	1.717***
	(0.000)	(0.000)
Observations	2,287,372	1,559,796
R-squared	0.332	0.212

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 24: Parental Transfer Probability

Parameter	Variable	Estimate
γ_2^T	Parental Income	0.004***
		(0.001)
γ_3^T	Parental Income Sq.	-0.013***
		(0.004)
γ_4^T	Lag Enrolled x $\mathbb{1}$(Year $\leq$ 2)	1.464***
		(0.290)
γ_5^T	Lag Enrolled x $\mathbb{1}$(2<Year$\leq$4)	1.578***
		(0.314)
γ_6^T	Lag Enrolled x $\mathbb{1}$(Year>4)	1.488***
		(0.344)
γ_7^T	Lag Enrolled x Par.Income	0.002***
		(0.000)
γ_8^T	Lag Enrolled x Age	-0.057***
		(0.014)
γ_9^T	Age	-0.009
		(0.008)
γ_{10}^T	Age = 23	-0.013
		(0.044)
γ_{11}^T	Lag Tranfer Receipt	1.867***
		(0.024)
γ_{12}^T	Unemployed	0.176***
		(0.050)
γ_1^T	Constant	-1.403***
		(0.177)
Observations		21,895

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 25: Parental Transfer Amount

Parameter	Variable	Estimate
γ_2^P	Parental Income	0.006***
		(0.001)
γ_3^P	Parental Income Sq.	-0.016***
		(0.006)
γ_4^P	Lag Enrolled x $\mathbb{1}$(Year $\leq$ 2)	0.976***
		(0.297)
γ_5^P	Lag Enrolled x $\mathbb{1}$(2<Year$\leq$4)	1.097***
		(0.307)
γ_6^P	Lag Enrolled x $\mathbb{1}$(Year>4)	0.931***
		(0.303)
γ_7^P	Lag Enrolled x Par.Income	0.007***
		(0.001)
γ_8^P	Lag Enrolled x Age	-0.043***
		(0.013)
γ_9^P	Age	-0.057***
		(0.012)
γ_{10}^P	Age = 23	-0.057
		(0.065)
γ_{11}^P	Enrolled x Quality	0.213***
		(0.021)
γ_{12}^P	Enrolled x $\mathbb{1}$(Instate & Public = 1)	-0.009
		(0.094)
γ_{13}^P	Enrolled x $\mathbb{1}$(Instate & Public = 1) x Par. Income	-0.003***
		(0.001)
γ_{14}^P	$\mathbb{1}$(Par. Education 12-15 Years)	0.076*
		(0.039)
γ_{15}^P	$\mathbb{1}$(Par. Education $\geq$16 Years)	0.060
		(0.057)
γ_{16}^P	$\mathbb{1}$(Par. Education $\geq$16 Years) x Quality x Enrolled	0.023
		(0.022)
γ_1^P	Constant	7.113***
		(0.266)
Observations		6,885
R-squared		0.364

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 26: Unemployment Probability

Parameter	Variable	Estimate
γ_2^{UE}	Years in College	-0.027***
		(0.008)
γ_3^{UE}	Experience	-0.062***
		(0.008)
γ_4^{UE}	Age	0.022***
		(0.008)
γ_5^{UE}	Lag Not Working	0.658***
		(0.031)
γ_1^{UE}	Constant	-2.088***
		(0.150)
Observations		25,828

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 27: Unemployment Benefits

Parameter	Variable	Estimate
γ_2^{UEB}	Experience	2.011
		(5.973)
γ_1^{UEB}	Constant	457.068***
		(39.975)
Observations		120
R-squared		0.001

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 28: Grants in Two-Year Colleges

Parameter	Variable	Estimate
γ_2^C	Parental Income	-9.952***
		(1.594)
γ_2^C	Parental Income Sq.	37.772***
		(7.223)
γ_2^C	Constant	868.669***
		(76.288)
Observations		2,748
R-squared		0.018

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 29: Grants in Four-Year Colleges

Parameter	Variable	Estimate
γ_2^U	AFQT	29.118
		(18.397)
γ_2^U	AFQT Sq.	-77.450
		(58.389)
γ_2^U	Parental Income	-29.413***
		(2.500)
γ_2^U	Parental Income Sq.	67.027***
		(10.360)
γ_2^U	Quality	49.754
		(365.060)
γ_2^U	Quality Sq.	39.357
		(31.908)
γ_2^U	$\mathbb{1}$(Instate Public = 1)	-2,949.562***
		(56.652)
γ_2^U	Quality x AFQT	2.011
		(2.282)
γ_2^U	Constant	1,933.450
		(1,520.212)
Observations		13,161
R-squared		0.232

Note: (a) Standard errors in parenthesis. (b) *** p<0.01, ** p<0.05, * p<0.10.

Table 30: Stage 2 Parameter Estimates

Parameter	Variable	Estimate	(SE)
Utility Function:			
Psychic costs of 4-year college attendance:			
γ_1^U	$AFQT_3$	34.38	(0)
γ_2^U	$AFQT_2$	-2.717	(0)
γ_3^U	$AFQT_1$	-29.25	(0)
γ_4^U	Psychic costs for 4-year college full time shifter	103.6	(0)
Unobserved heterogeneity in psychic schooling costs:			
$\gamma_{5,2}^U$	Type 2	-2.706	(0)
Persistence in college attendance:			
γ_6^U	Attending 4-year college after age 22	3.553	(0)
γ_7^U	Persistence in 4-year college	-14.88	(0)
γ_8^U	Enrollment after completing BA	15.64	(0)
γ_9^U	Enrollment after 2 year	-20.81	(0)
Work preferences:			
γ_{10}^U	Preference for working part-time	174.6	(0)
$\gamma_{11,2}$	Type 2	-117.4	(0)
γ_{12}^U	Preference for working full time shifter	-109.7	(0)
γ_{13}^U	Work full-time interacted with age	19.17	(0)
γ_{14}^U	Work part-time interacted with age	170.1	(0)
γ_{15}^U	Work by age before 21	1.509	(0)
Working while attending college:			
γ_{16}^U	Work while in 4-year college full-time	7.653	(0)
γ_{17}^U	Work full-time 4-year college part-time	-586.1	(0)
γ_{18}^U	Work part-time 4-year college part-time	-89.59	(0)

Table 30: Stage 2 Parameter Estimates - Ctd.

Parameter	Variable	Estimate	(SE)
Human Capital Function:			
γ_1^{ϕ}	Constant	2.062	(0)
γ_2^{ϕ}	Years at 4-year college	.0243	(0)
γ_3^{ϕ}	Years of experience	.0644	(0)
γ_4^{ϕ}	Years of experience squared	-.0019	(0)
γ_5^{ϕ}	$AFQT$	.0016	(0)
$\gamma_{6,2}^{\phi}$	Type 2	-.0423	(0)
Wage Equation Parameters:			
γ_1^{w}	Part-time work	-.0272	(0)
γ_2^{w}	Enrolled in school	-.1217	(0)
γ_3^{w}	BA degree	.0862	(0)
γ_4^{w}	BA degree x Quality	.0211	(0)
γ_5^{w}	BA degree x Quality Sq.	.0257	(0)
Asset Lower Bound:			
γ_1^{A}	Constant	.7214	(0)
γ_2^{A}	Human capital	.1328	(0)
γ_3^{A}	Human capital squared	-9.4e-04	(0)
γ_4^{A}	Age	.2252	(0)
γ_5^{A}	Age 23 or older	.3907	(0)
BA Degree Completion Probabililty:			
γ_1^{B}	Constant	-2.634	(0)
γ_2^{B}	Years at 4-year college if $>$ 4.5	.006	(0)
γ_3^{B}	Years at 4-year college if $>$ 5.5	.1682	(0)
γ_4^{B}	Human capital	.0671	(0)
γ_5^{B}	Human capital squared	-9.8e-06	(0)
γ_6^{B}	Quality	.2424	(0)
γ_7^{B}	Start at Comm. college	-.001	(0)
Type Probability Distribution:			
Type 2:			
$\gamma_{1,2}^{\tau}$	Constant	-.2657	(0)
$\gamma_{2,2}^{\tau}$	$AFQT_1$	-2.969	(0)
$\gamma_{3,2}^{\tau}$	$AFQT_2$	.0238	(0)
$\gamma_{4,2}^{\tau}$	Inc_1	.2114	(0)
$\gamma_{5,2}^{\tau}$	Inc_2	1.078	(0)
$\gamma_{6,2}^{\tau}$	Parent Educ. Years >16	.1	(0)
$\gamma_{7,2}^{\tau}$	Parent Educ. Years 12-16	.3	(0)
Terminal Value Function:			
γ_1^{TERM}	Assets	.0232	(0)
Shock Distribution:			
$\sigma_{d_e}^2$	Preference for 4-year college	499.6	(0)
$\sigma_{d_k}^2$	Preference for work	217.3	(0)
σ_w^2	Wage	.1873	(0)

Table 31: Stage 1 Parameter Estimates - College Choice.

Parameter	Variable	Estimate	(SE)
College Choice:			
γ_1^C	Quality	-10.66	(0)
γ_2^C	Quality x $AFQT_2$	-3.594	(0)
γ_3^C	Quality x $AFQT_3$	5.3	(0)
γ_4^C	Quality x Parental Income	4.947	(0)
γ_5^C	Quality x Parental Education Years 12-16	2.136	(0)
γ_6^C	Quality x Parental Education Years =16	5.233	(0)
γ_7^C	Quality x Parental Education Years >16	5.233	(0)
$\gamma_{8,2}^C$	Quality x Type 2	49.12	(0)
γ_9^C	Intercept Community College	-10.32	(0)
$\gamma_{10,2}^C$	Community College x Type	-10.03	(0)
γ_{11}^C	Intercept Out-of-state	15.42	(0)
$\gamma_{12,2}^C$	Out-of-state x type	-10.22	(0)

Table 32: Simulated Policies: College Choice

Simulation	Q1	Q2	Q3	Q4
Baseline	19.2	24.9	17.3	38.1
General Subsidy $2000Yr	18.7	25.2	16.7	39.4
Instate Subsidy $2000Yr	18.4	23.1	17.1	41.3
Loan Increase $2000Yr	17.8	22.6	19.4	39.3
Free In-state Public college	13.2	15.0	19.6	51.7
Borrow full cost	15.5	21.1	22.3	41.1

Table 33: Simulated Policies: College Choice - ctd

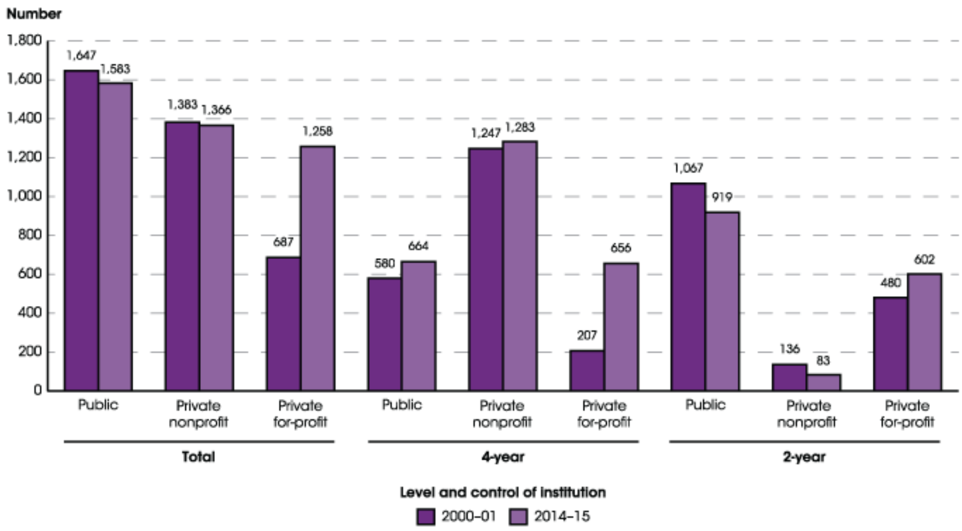
Simulation	OutofState	Com. College	No College
Baseline	10.3	29.1	31.1
Unrestricted $2000Yr Subsidy	11.4	29.8	29.6
Instate $2000Yr Subsidy	10.4	27.6	30.2
Loan Limit Increase $2000Yr	14.2	29.2	29.6
Free in-state public college	10.8	19.1	27.5
Borrow Full Cost	23.1	28.7	17.4

Table 34: Simulated Policies: BA degree and PDV of Income

	$AFQT_1$	$AFQT_2$	$AFQT_3$	Inc_1	Inc_2	Inc_3	All
Baseline	5.31	42.73	66.36	34.97	35.20	42.66	37.61
Unrestricted $2000 subsidy	1.60	11.65	4.81	6.30	7.33	4.30	5.98
Instate $2000 subsidy	1.27	9.68	4.66	5.38	6.25	3.86	5.16
Loan limit increase $2000 per year	0.51	4.56	0.86	2.16	2.75	0.99	1.97
Free instate public colleges	4.08	34.56	6.88	14.41	17.80	13.10	15.09
Borrow Full Cost	1.74	13.39	3.08	6.76	7.97	3.40	6.04
Baseline	487.60	647.31	727.54	599.90	586.53	669.66	618.72
Unrestricted $2000 subsidy	2.67	20.16	4.17	6.39	11.42	9.13	8.96
Instate $2000 subsidy	2.41	16.88	3.16	6.01	9.23	7.14	7.45
Loan limit increase $2000 per year	1.36	10.40	1.41	4.05	5.90	3.18	4.37
Free instate public colleges	6.26	57.02	5.65	14.67	26.49	27.67	22.89
Borrow Full Cost	4.05	23.17	3.21	11.50	12.29	6.54	10.11

Figures

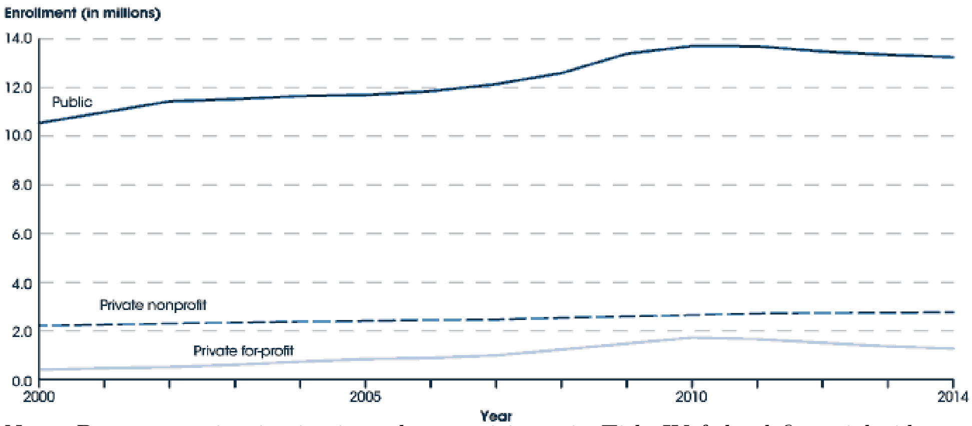
Figure 1: Number of degree-granting institutions with first-year undergraduates, by level and control of institution: Academic years 2000–01 and 2014–15



Note: Degree-granting institutions that participate in Title IV federal financial aid programs. Excludes institutions not enrolling any first-time degree/certificate-seeking undergraduates.

Source: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Fall 2000, Institutional Characteristics component; and Winter 2014–15, Admissions component. See Digest of Education Statistics 2015, table 305.30.

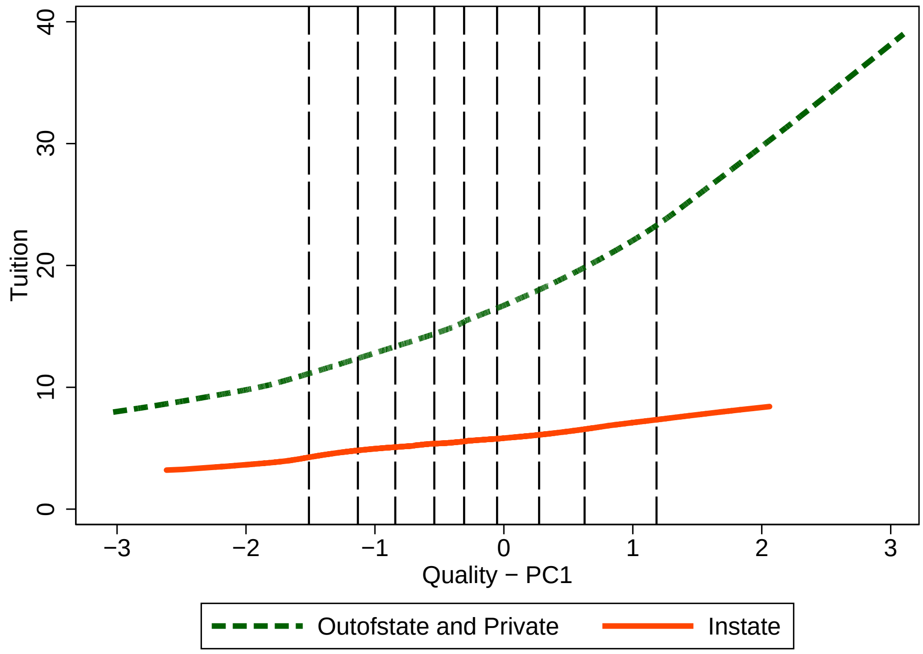
Figure 2: Undergraduate enrollment in degree-granting postsecondary institutions, by control of institution: Fall 2000–2014



Note: Degree-granting institutions that participate in Title IV federal financial aid programs.

Source: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), IPEDS Spring 2001 through Spring 2015, Fall Enrollment component. See Digest of Education Statistics 2015, table 303.70.

Figure 3: In-state and out-of-state tuition, nonparametric fitted graphs

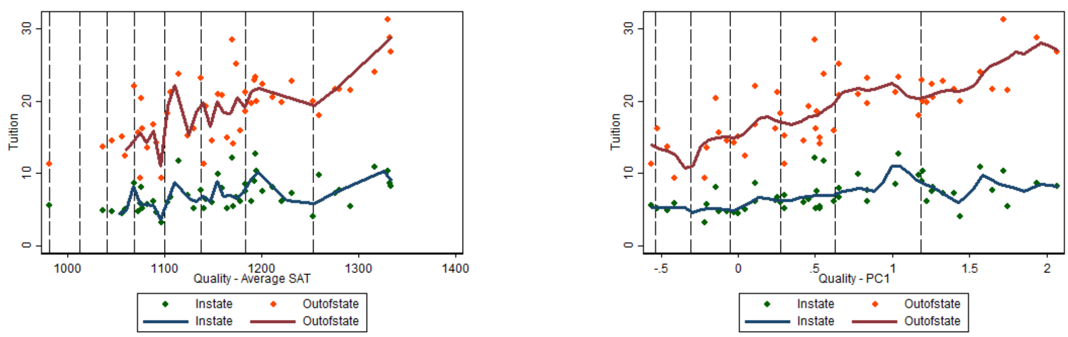


Note: Tuition measured in thousand dollars. Vertical lines denote quality deciles.
Source: IPEDS

Figure 4: In-state and out-of-state tuition, ONLY flagships

(a) Quality measured by average SAT

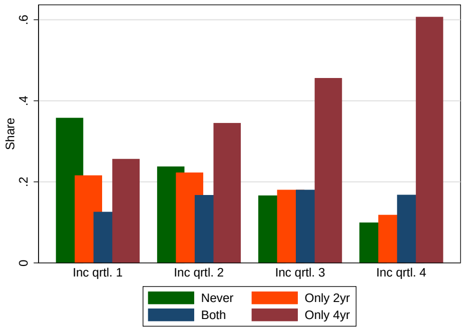
(b) Quality measured by PC1



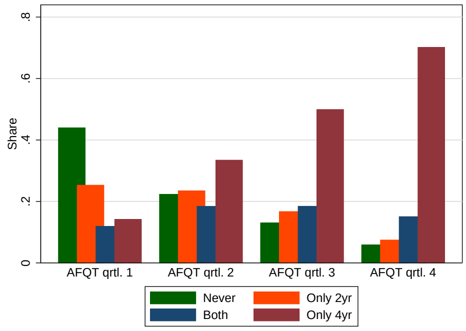
Note: Tuition measured in thousand dollars. Vertical lines denote quality deciles.
Source: IPEDS

Figure 5: College type by parental income and AFQT

(a) College type by parental income qrtl.



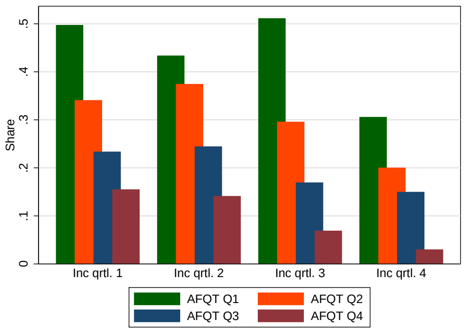
(b) College type by AFQT



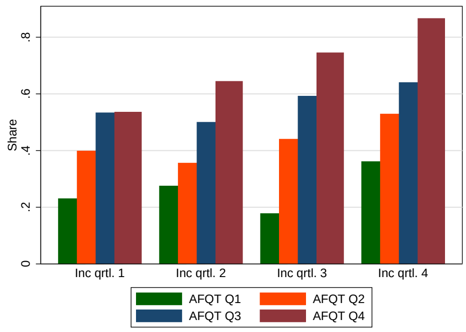
Note: The Figure includes colleges from the initial enrollment only.
Source: NLSY97

Figure 6: Attendance in 2yr and 4yr colleges, by parental income and AFQT

(a) 2YR College by AFQT and parental income qrtl.



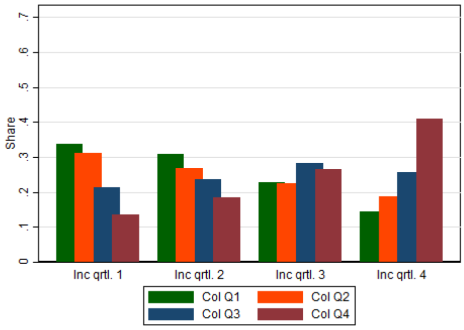
(b) 4YR College by AFQT and parental income qrtl.



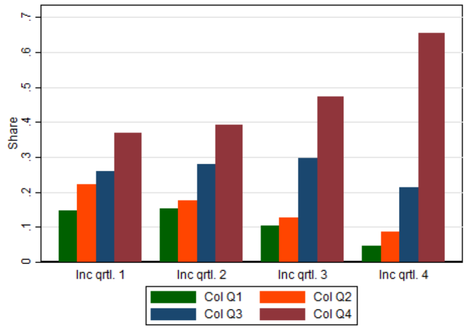
Note: The Figure includes colleges from the initial enrollment only.
Source: NLSY97

Figure 7: College quality quartiles, by parental income and AFQT

(a) College quality quartile by income quartile



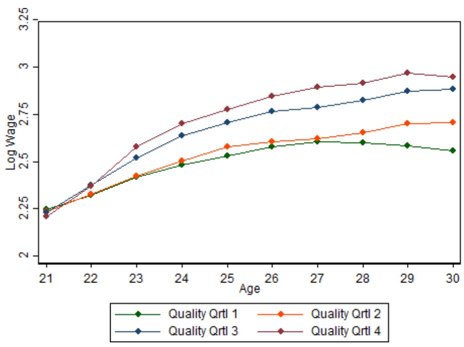
(b) College quartile by income quartile - ONLY AFQT qrtl. 4



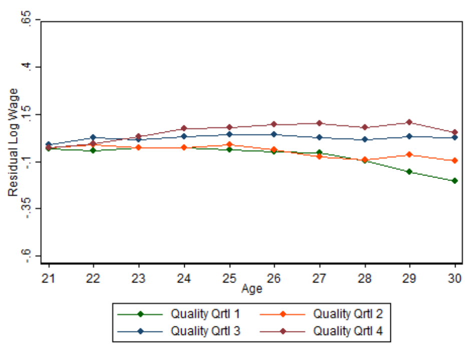
Notes: Figure 7a shows distribution of initial four-year college attendance by college quality and family income. Figure 7b includes only individuals with the AFQT score in the top quartile.
Source: NLSY97

Figure 8: Age wage profile by quality of attended college

(a) Raw wage



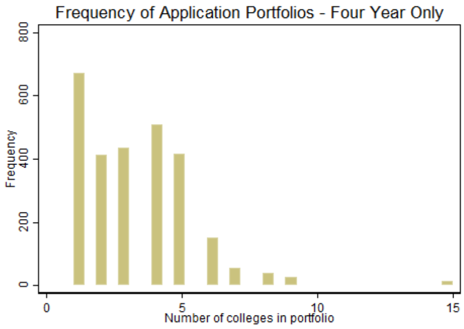
(b) Residual wage



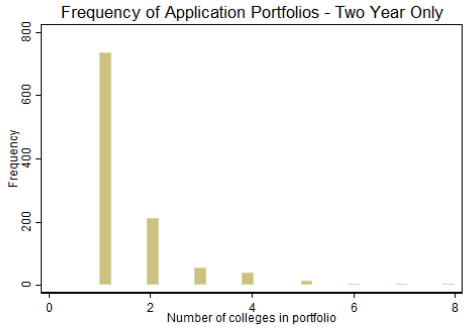
Note: Residual wage is derived by regressing log wage on years of education, bechelor's degree status, current experience, experience squared, AFQT score, part-time employment status and college enrollment. See section 5 for details.
Source: NLSY97

Figure 9: Number of college applications

(a) Applications to 4-yr colleges



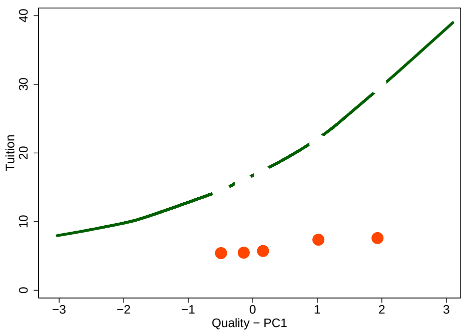
(b) Applications to 2-yr colleges



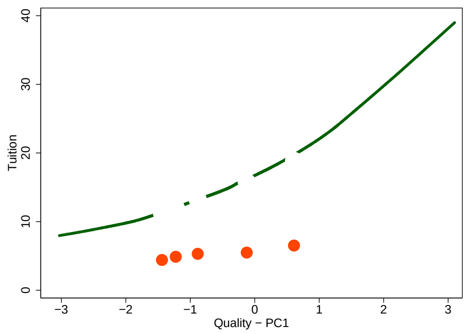
Note: Only undergraduate applications included. Only the applications from the academic year when the applications were first observed are included.
Source: NLSY97

Figure 10: Tuition functions faced by California and Colorado residents

(a) Tuition function faced by California residents

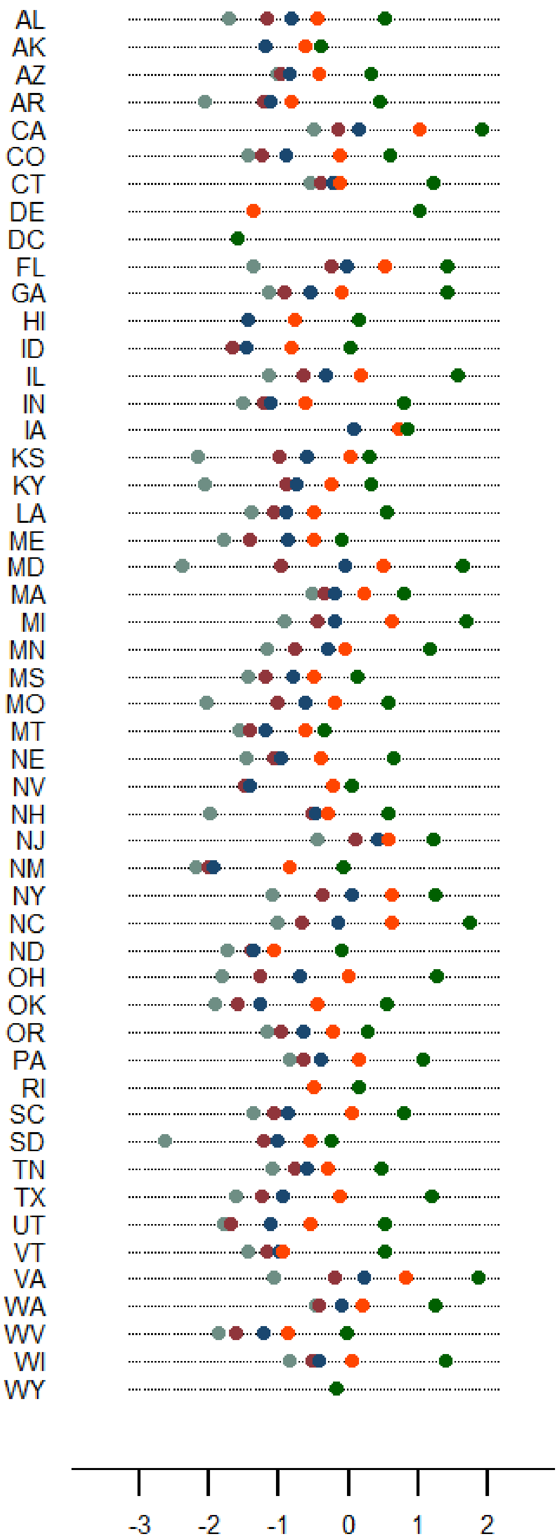


(b) Tuition function faced by Colorado residents



Note: The line gives estimate of out-of-state and private tuition. Tuition is measured in thousand dollars. Dots represent in-state public college bins in each state. See section 6.1.2 for detail.
Source: IPEDS

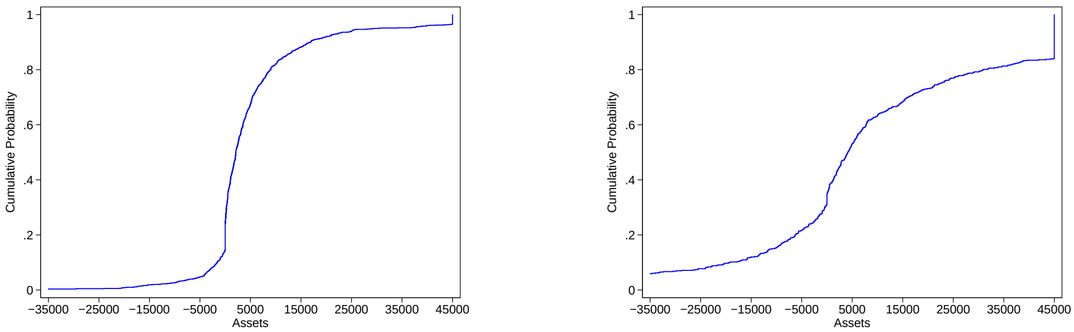
Figure 11: Quality of instate public coleges



Note: X axis measures quality in terms of PC1. See 6.1.2 for details.
Source: IPEDS

Figure 12: CDF of assets at ages 20 and 25

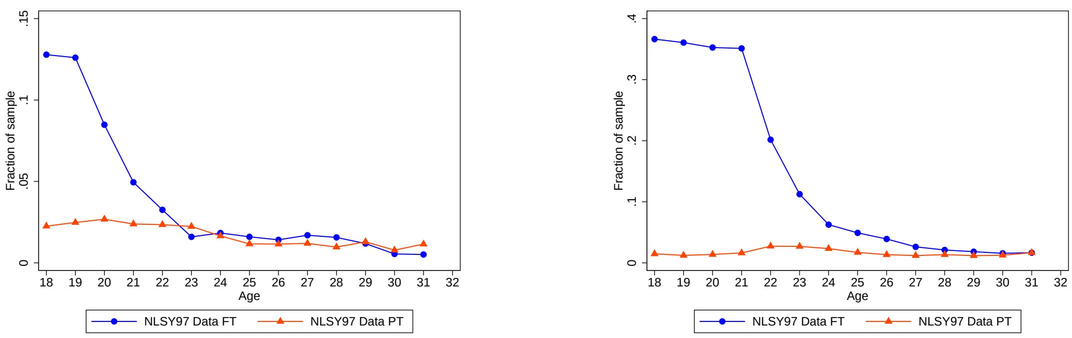
(a) CDF of assets at age 20 (b) CDF of assets at age 25



Note: Assets include reported values for farm, mobile home, lot, house, land owned, checking and saving accounts, bonds, stocks, life insurance, pensions, car, business and other property, student loan debt, business debt and other debt.
Source: NLSY97

Figure 13: Community college and 4yr college enrollment by age

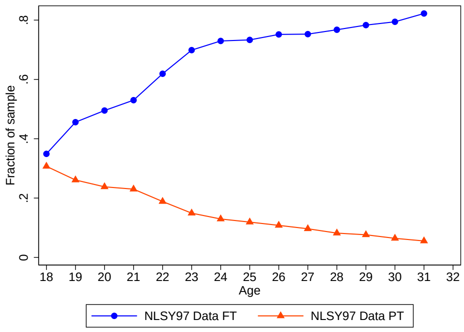
(a) Community college enrolment by age (b) 4-Year college enrollment by age



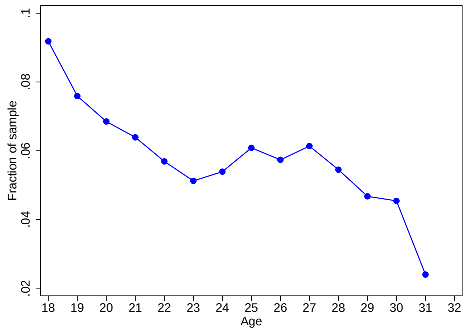
Source: NLSY97

Figure 14: Full- and part-time employment, and unemployment by age

(a) Full- and part-time work by age



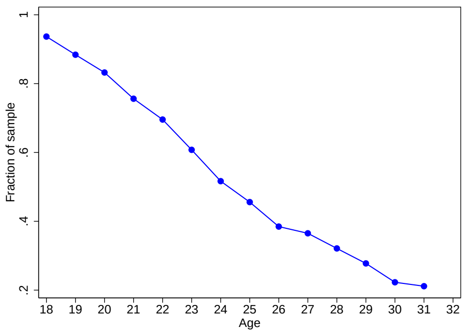
(b) Unemployed by age



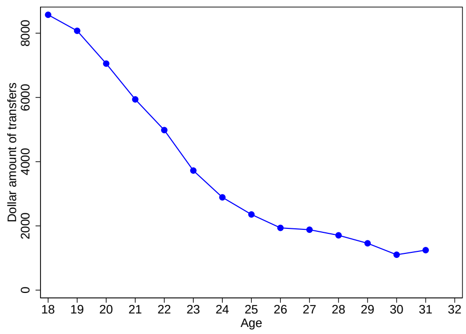
Source: NLSY97

Figure 15: Parental transfers by age

(a) Receipt of parental transfers by age



(b) Parental transfer amount by age



Note: Parental transfers include remittances, money given towards college and monetized coresidence.
Source: NLSY97

Figure 16: Model Timing

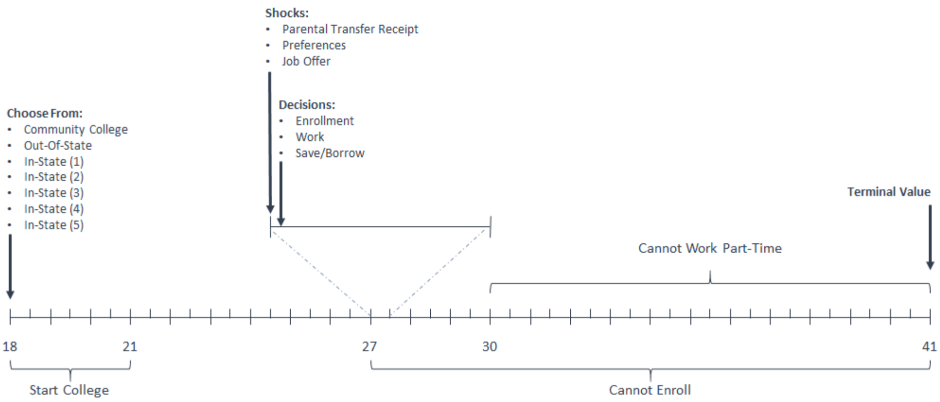


Figure 17: Model fit: Full- and part-time employment and unemployment by age

(a) Full- and part-time work by age

(b) Unemployed by age

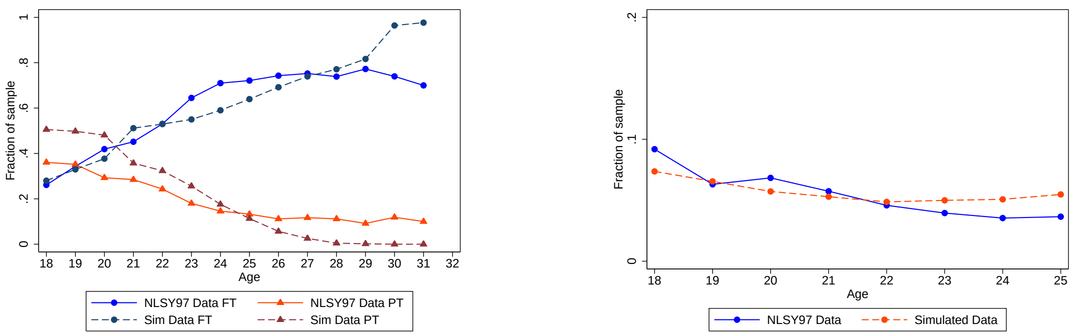
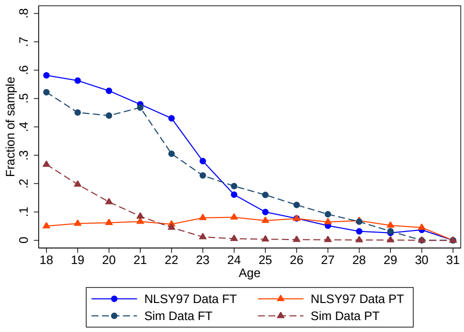


Figure 18: Model Fit: Enrolled in college

(a) Full- and part-time enrollment by age



(b) Enrollment by age

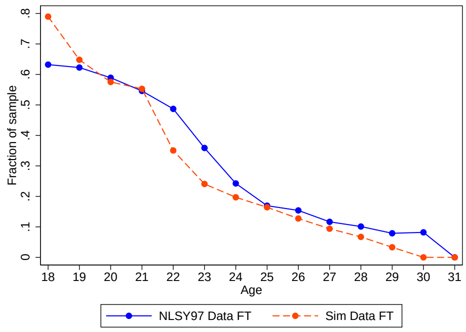
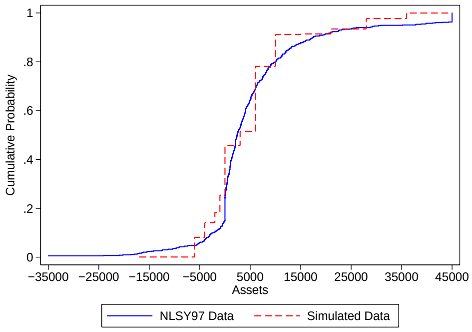


Figure 19: Model Fit: CDF of assets at ages 20 and 25

(a) CDF of assets at age 20



(b) CDF of assets at age 25

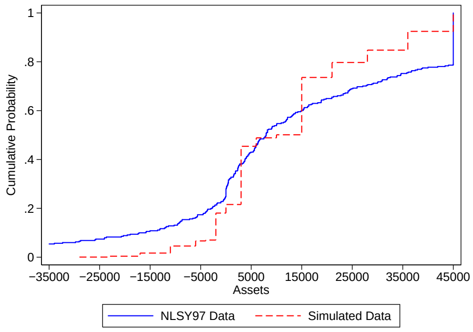
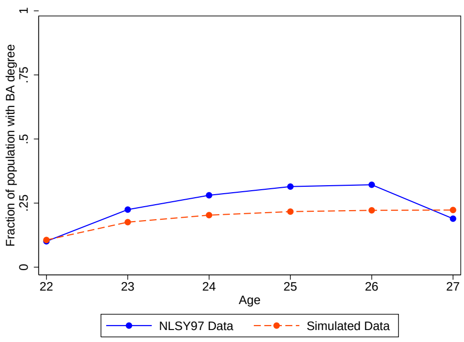


Figure 20: Model Fit: Bachelor's degree and wages by age

(a) Bachelor's Degree by age



(b) Wage by age

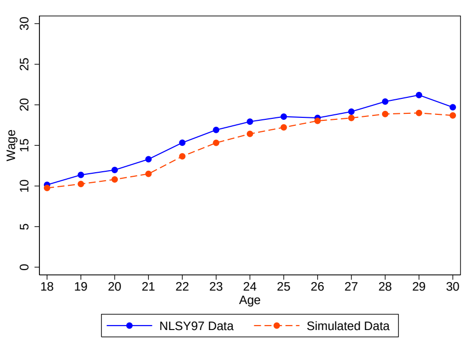


Figure 21: Model Fit: College choice

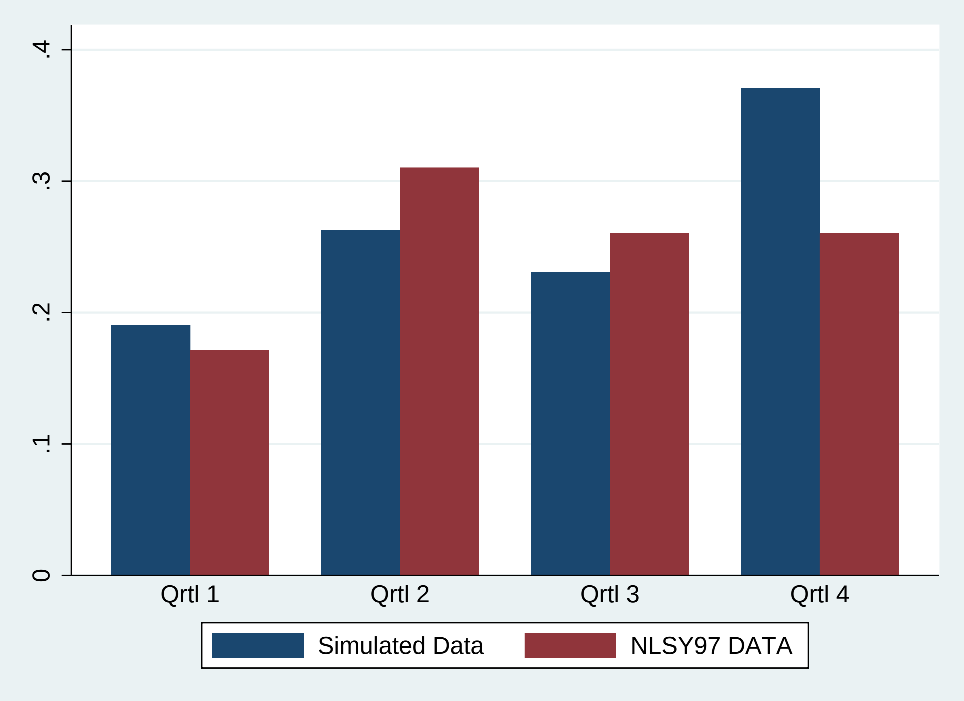


Figure 22: Model Fit: College choice