THE EFFECTS OF TUITION AND STUDENT LOAN POLICIES ON COLLEGE OUTCOMES AND LIFETIME EARNINGS

Junwen Liu

A DISSERTATION

in

Economics

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2016

Supervisor of Dissertation

Hanming Fang, Class of 1965 Term Professor of Economics

Graduate Group Chairperson

Jesús Fernández-Villaverde, Professor of Economics

Dissertation Committee:

Kenneth I. Wolpin, Distinguished Research Professor and Lay Family Professor of Economics

Petra E. Todd, Alfred L. Cass Term Professor of Economics

THE EFFECTS OF TUITION AND STUDENT LOAN POLICIES ON COLLEGE OUTCOMES AND LIFETIME EARNINGS

To my beloved family and friends

Acknowledgments

I am deeply indebted to my advisor, Professor Hanming Fang, for his invaluable guidance and support throughout my entire PhD program. Professor Fang is a great mind who has given me directions and provided insights in every stage of my graduate studies. I am very grateful to him for sharing life wisdom and helping me grow stronger and more confident both as a researcher and as a person. Professor Fang's passion and dedication to research is exceptional and truly inspiring.

I would like to express my most sincere thanks to my dissertation committee members, Professor Kenneth I. Wolpin and Professor Petra E. Todd. I have benefited greatly from numerous fruitful discussions with Professor Wolpin and I am extremely thankful to Professor Wolpin for his patience and continous help and encouragement. I am also immensely grateful to Professor Todd for her thoughtful feedback, for giving me confidence, and being incredibly supportive of me.

I thank all the faculty members at Penn. I especially owe gratitude to Professors Cecilia Fieler, Andrew Shephard, and Holger Sieg for their comments and suggestions to my dissertation and their assistance during the job market process.

I would also like to thank my peers and friends at Penn. Together we shared the pains and joy, and the intellectual exchanges with them helped me complete my dissertation. In particular, I want to thank Gloria Allione, Diego Amador, Salome Baslandze, Yumi Koh, Eun-young Shim, Vesa-Heikki Soini, Fan Wang, and YinYin Yu. Their friendship has made my life at the graduate school so much more rewarding and memorable.

Last but not least, I would like to express my heartfelt gratitude to my family. I want to give special thanks to my parents, Nanyuan Liu and Xiaoli Zhang; my grandparents,

Minghua Liu and Zexian Guo; and my cousin Yuanqin Shen's family. They have filled my life with so much love and hope, and they have always supported me to follow my dreams. Without them, I could not have become who I am today and it is because of them what I have and will ever achieve is meaningful. Finally, I want to thank Nils Mattis Gornemann, the love of my life, who has stood by me in difficult times and always believed in me. I feel blessed that I have found Mattis and with him I am looking forward to starting my new life chapters.

Thank you, everyone.

ABSTRACT

THE EFFECTS OF TUITION AND STUDENT LOAN POLICIES ON COLLEGE OUTCOMES AND LIFETIME EARNINGS

Junwen Liu

Hanming Fang

To increase college access and reduce the burden of student loan debt, the US government has developed several new tuition and student loan policies. These include the newly proposed free community college plan and the recently enacted Pay As You Earn plan that makes student loan repayments contingent on earnings. I develop and estimate a dynamic life-cycle model of the decisions individuals make with regard to schooling, work, savings and student loan borrowing. The model is estimated with micro-level US data and is used to evaluate the effects of these educational policies on education outcomes, lifetime earnings and welfare. My results show that the free community college plan benefits individuals from lower-income families the most, increasing their community college enrollment rate by 17 percentage points from 41 percent to 58 percent. However, it reduces the population proportion of individuals who achieve a bachelor's degree by 9 percent. The Pay As You Earn plan reduces labor supply in college, lowers the time it takes to complete a bachelor's degree, and enables individuals to attend higher-quality colleges. The overall education level is improved with the percent of individuals holding a bachelor's degree increasing from 31 to 33 percent. I also evaluate the effects of a hypothetical loan forgiveness plan for college dropouts, which is found to increase college enrollment but reduce college completion. Of the three policies, the Pay As You Earn plan achieves the highest welfare gain and reduces lifetime earnings inequality.

Contents

List of Tables

List of Figures

1 Introduction

How can the government increase college access and reduce the student loan debt burden? This question has become a major focus of US educational policy for a couple of reasons. First, the total outstanding student loan debt in the US quadrupled between 2004 and 2015, increasing from 263 billion dollars in 2004 to 1.19 trillion dollars in 2015 (Federal Reserve Bank of New York (Q2,2015)). Second, despite existing need-based student grant and loan programs, there remains a wide college attainment gap with respect to family income levels. In 2013, 77 percent of individuals from the highest family income quartile obtained a bachelor's degree by age 24 but only 9 percent of those from the bottom family income quartile did the same (Cahalan and Perna (2015)). Moreover, among individuals who enroll in college, students from lower-income families are more likely to attend colleges with a quality level that is below what their SAT score qualifies them for (Bowen, Chingos, and McPherson (2009), Smith, Pender, and Howell (2013)).

To tackle these problems, the Obama administration has developed many initiatives, such as the recently proposed free community college plan that would make two years of community college education free for all students. To improve federal student loan offerings, the government has implemented a new repayment plan called Pay As You Earn (PAYE) in 2012.[1]

These policies are expected to be costly, and the outcomes are not immediately available for assessment. However, it is possible to evaluate the effects of these policies ex ante using a behavioral model. In this paper, I develop and estimate a dynamic life-

[1]The PAYE plan has three new features. First, it caps the repayment amount at 10% of annual income. Second, it extends the maximum repayment time from 10 years to 20 years. Third, it forgives the loan balance after 20 years of repayment. I discuss this reform in more details below.

cycle model of the decisions that individuals make with regard to college choice, years of schooling, work, savings and student loan borrowing. I use the estimated model to answer two questions. First, how effective are the new tuition and student loan policies in improving college outcomes and lifetime earnings? Second, what are the fiscal costs of the policies and are the policies welfare-improving after accounting for fiscal costs?

The existing literature studying credit constraints has mainly focused on an individual's binary choice of whether or not to attend college when quantifying the effect of credit constraints. However, the effect of credit constraints extends beyond this margin. This paper builds in two additional channels through which a lack of financial resources can affect college outcomes. First, colleges in my model are heterogeneous in qualities and costs. Specifically, I allow for five types of colleges: community colleges and four types of four-year colleges, each distinguished by a particular quality of education.[2] Having different college quality levels captures the trade-off between college quality and cost. As the quality level of a college may influence the chance of college completion and labor market returns, it is crucial to understand the extent to which an individual's financial concerns influence his college quality choice. Second, I model the schooling accumulation process during college. In particular, working while attending college may affect an individual's rate of progression in college, which can result in a lower completion rate or a longer time to complete a degree. Since the labor income a student earns during college and his student loan debt are two major financial resources apart from family transfers and other financial aids, it is important to consider the interaction between working in college and college outcomes when we assess the impact of student

[2]Following a similar approach as Black, Smith, and Daniel (2005), I construct the quality index using two measures: average SAT score and average faculty salary. Based on this index, I categorize four-year colleges into four quality levels.

loan policies.

To evaluate the effect of reforms on federal student loan repayment structure, I explicitly model the federal student loan program. In the model, risk-averse individuals face uncertainty about both schooling accumulation and labor income. These risks suggest that the student loan debt repayment structure potentially affects their schooling and subsequent labor supply decisions. Under the standard repayment plan that existed prior to the 2012 Pay As You Earn plan, individuals are required to repay a fixed amount of student loan debt regardless of their labor market income. This repayment structure implies low levels of consumption during periods when individuals suffer bad income shocks and the expectation of this will affect college choices. The Pay As You Earn plan makes student loan repayments co-move with income, reducing the risk of low consumption. Individuals in the model are heterogeneous in family income and SAT scores. I also allow for unobserved permanent heterogeneity in risk aversion, in preferences for schooling and labor supply, in admissions and schooling accumulation probabilities, in family transfers, and in the initial human capital. Explicitly accounting for unobserved heterogeneity allows for potential selection on unobservables into schooling types.

I estimate the model using two micro-level data sets: the National Longitudinal Survey of Youth 1997 (NLSY97) and the Integrated Postsecondary Education Data System (IPEDS). The NLSY97 surveys a nationally representative sample. It contains rich information about college choices, employment, asset, and student loan debt, and from this I identify model parameters. IPEDS is a school-level data set that includes a range of information on US colleges, such as institutional characteristics, admissions and test scores, and student charges. My estimation, carried out using simulated method of moments, matches key data moments along various dimensions, including enrollment patterns in each college type, college outcomes, the labor supply and average wages series, savings, and student loan debt levels.

My estimation results show that the college completion rate is influenced by both working while attending school and college quality levels. Working has a negative effect on completion, whereas attending a higher quality college tends to increase the chance of completion. I simulate the model to understand how the gap in the college completion rate across family income quartiles is affected by these two channels. I find that working while attending school is a key factor that influences college completion for students from lower family income quartiles. When I turn off the effect of working on schooling accumulation, there is a larger increase in the completion rate among students from lower-income families, thus reducing the college completion gap across family income levels. When there is no effect of college quality on schooling accumulation, college completion is on average lower for students in all family income quartiles. There is a larger reduction in the completion rate among students from lower-income families than there is for those from richer families.

With the estimated model, I conduct three policy experiments. First, I study the impact of the proposed free community college plan by simulating the model with zero tuition for community colleges. Second, I evaluate the newly implemented Pay As You Earn repayment plan. Third, I study a hypothetical loan forgiveness program for college dropouts. This plan is motivated by the low college completion rate, and the sizable student loan debt college dropouts have on average upon exiting college.

I find that under the free community college plan, community college enrollment increases significantly among individuals from lower-income families. For individuals whose family income is below the median, the community college enrollment rate increases by 17.30 percentage points from 41.00% to 58.30%. The associate degree completion rate also rises considerably. The fraction of individuals in the population who have an associate degree increases from 9.20% to 16.35%. However, the plan has a negative effect on both the four-year college enrollment and completion rate: there is a 9.00% reduction, from 31.10% to 28.30%, in the fraction of individuals who attain a bachelor's degree. The gap in lifetime earnings between the 50th and 10th percentile is reduced, indicating a decrease in earnings inequality among lower-earning individuals.

The Pay As You Earn plan increases the rate of enrollment in both the community and four-year colleges primarily for individuals from lower-income families. The plan also enables students to attend higher quality colleges. For students whose family income is lower than the median, the fraction of students enrolled in the top two college quality levels goes up by 2.40%, from 41.30% to 42.30%. Under this plan, more students take out student loan debt, yet they spend less time working in college. The average years worked by four-year college graduation falls by 5.60%, from 2.33 years to 2.20 years. Among students enrolled in four-year colleges, the college completion rate increases from 70.79% to 72.00%. At the same time, the time it takes to receive a bachelor's degree declines slightly. The overall education level in the population improves as the fraction of individuals who have a bachelor's degree increases from 31.10% to 32.78%. The ratio between the 90th and 50th percentile of the lifetime earnings is lower, which suggests there is a reduction in earnings inequality in the upper half of the distribution.

The loan forgiveness plan for college dropouts encourages college enrollment, and the most significant increase occurs among individuals from lower-income families. However, the plan discourages students from completing the degree. The fraction of individuals who earn an associate degree falls by 28.30%, from 9.20% to 6.60%, while the fraction who earn a bachelor's degree falls by 8.68%, from 31.10% to 28.40%. The reduction in the number of individuals who hold a college degree reduces average lifetime earnings.

In terms of fiscal costs, the Pay As You Earn plan costs the least while the loan forgiveness plan is the most expensive. All three polices are welfare-improving for a utilitarian government that maintains a neutral budget.[3] The Pay As You Earn plan leads to the highest welfare gain, and the free community college plan ranks second among the three policies. The Pay As You Earn plan produces the largest improvement in the quality of the college attended and in the four-year college completion rate. The free community college plan is the most effective in terms of improving college outcomes for lower-income students. The two policies are complementary.

The paper is organized as follows. Section 2 discusses the related literature. Section 3 describes the data and summarizes the results from statistical analysis applied to the data. Section 4 presents the model. Section 5 discusses the identification and estimation strategy for the model. Section 6 provides the estimates of the model parameters and the model fit. Section 7 presents results from counterfactual experiments using the estimated model. Section 8 concludes the paper.

[3] To make welfare comparisons, I adjust the labor tax rate to maintain a neutral government budget by re-solving the model and simulating it under the new tax rate. To measure welfare I compute the lump-sum annual transfer to all individuals that would make a utilitarian government indifferent between the baseline and the new policy. Note that the effects of all polices on college outcomes and lifetime earnings presented here derive from simulations that do not impose the cost of the policy on individuals. These results are qualitatively and largely quantitatively unaffected when the costs are imposed through tax changes.

2 Related Literature

This paper is related to several strands of literature. First, there is a large literature on credit constraints and college enrollment. One important empirical motivation for research in this area is the well-established positive correlation between family income and college enrollment found in US data. The general agreement of the papers that study cohorts born around the 1960s is that credit constraints have little power in explaining college attendance behaviors in the early 1980s (e.g., Cameron and Heckman (1998), Cameron and Heckman (2001), Carneiro and Heckman (2002), Keane and Wolpin (2001), Cameron and Taber (2004)). The collection of newer data sets, such as the NLSY97, which follows a cohort born in the 1980s, has renewed the research interest in credit constraints and college attendance. Belley and Lochner (2007) document a dramatic increase in the importance of family income for college attendance from the NLSY79 cohort to the NLSY97 cohort. They argue that today young people are more borrowing constrained than they were in the early 1980s.[4]

My paper uses the NLSY97 cohort. Among the recent papers that use this data set, such as Lochner and Monge-Naranjo (2011b), Johnson (2013), Abbott, Gallipoli, Meghir, and Violante (2013), my paper is most closely related to Johnson (2013). There are three main differences. First, Johnson (2013) does not separate student loan debt from other assets while I distinguish student loan debt from risk-free assets, enabling me to evaluate reforms to the federal student loan program. Second, I allow for the trade-off between college quality and cost of four-year colleges, a feature that is not present in Johnson (2013). Third, I incorporate the effect of working in school on schooling

[4] See Lochner and Monge-Naranjo (2011a) for an extensive review of the literature.

accumulation and I show that it is an important factor for college outcomes.

My study also relates to a growing literature that examines student loan program design.[5] In several papers, Felicia Ionescu (Ionescu (2008, 2009, 2011)) evaluates how different student loan policies impact college attainment and student loan default. Compared to Ionescu's framework, my model provides a more detailed characterization of the college enrollment stage. For example, my model allows colleges to be heterogeneous in their quality and costs. This enables me to evaluate how student loan policies affect the lifetime earnings and welfare through the trade-off between quality and cost when an individual makes college decisions. There are other significant differences as well. Her model only allows individuals to make college enrollment decisions at the beginning of life, and all students are enrolled for four years without the option to drop out. Whether a student becomes a college graduate realizes with certain probabilities at the end of the fourth year and students are not allowed to enroll for more than four years. In contrast, in my model individuals decide whether to enroll in college every period sequentially until a certain age, and they can choose to drop out at any period. This enables the model to fit the intertemporal enrollment patterns in the data well. Moreover, since I model the schooling accumulation process, I can assess the impact of student loan policies on time-to-degree, which also has important implication for lifetime earnings.

Third, my paper contributes to the literature that studies the link between college quality and labor market returns. Dan Black and Jeffrey Smith (Black and Smith (2004, 2006), Black, Smith, and Daniel (2005)) document the substantial returns that come from attending a high quality school after controlling for individual characteristics, such as ability. Hoekstra (2009) and Kinsler and Pavan (2011) find similar results.

[5] Lochner and Monge-Naranjo (2015) summarizes this literature.

Scholars continue to debate, however, the issue of whether the higher labor market returns for graduates from elite colleges can be attributed to self-selection based on ability, especially unobserved ability, or to institutional characteristics. For example, in an effort to identify unobserved ability, Dale and Krueger (2002) do not find an earnings differential when they compare the earnings for students who attended more selective colleges to those who were accepted and rejected by comparable schools but attended less selective schools. They conclude that the payoff to attending an elite college is greater for students from more disadvantaged family backgrounds. My framework explicitly addresses the selection problem by accounting for unobserved heterogeneity. Therefore, the model estimates can also shed light on the extent to which we can attribute the higher college returns to elite colleges to institutional features. To my knowledge, my paper is the first to account for college quality in the context of a structural model.

My model also accounts for the differences between community colleges and four-year colleges. The former are an important alternative to four-year colleges; they are much cheaper and they provide a more flexible course schedule that accommodates working students' schedules. Most papers do not distinguish between community colleges and four-year colleges. To my knowledge only two structural papers—Johnson (2013) and Russo (2011)—make this distinction. Johnson (2013) does not model schooling accumulation or degree completion in community colleges, nor does he evaluate policies targeted at community colleges. In Russo (2011)'s framework, individuals are risk-neutral and there is no constraint on consumption or borrowing, which makes it hard to quantify effects of a tuition subsidy on individuals with different financial resources.

The fourth line of literature to which my paper relates studies college behaviors such as college dropout and working while in school. Several papers recognize college investment is risky and model the college dropout risk (e.g., Akyol and Athreya (2005), Garriga and Keightley (2007), Johnson (2013), Hendricks and Leukhina (2014), among others). Stinebrickner and Stinebrickner (2008) find that credit constraints can explain part of the attrition, but they caution that this is not the main impetus for dropout behaviors. At the same time, many papers incorporate in-school labor supply as an important component of students' financial resources. For example, Keane and Wolpin (2001) find that when borrowing constraints are relaxed, individuals tend to work less in school and enjoy higher consumption. Similarly, Garriga and Keightley (2007) conclude that tightening the borrowing limit only has a considerable effect when the option to work is removed. Many other recent structural papers (e.g., Johnson (2013), Abbott, Gallipoli, Meghir, and Violante (2013)) also allow for working in school. However, few papers have examined how working affects college completion.[6] As I show in the data section, poor students work much more in school than less-poor students, and they are more likely to drop out. Moreover, among those who complete a bachelor's degree, the time-to-degree is positively correlated with the amount of labor supply during the period when the student was enrolled in school. My paper incorporates the interaction between in-school labor supply and college completion, because it is an important channel through which financial constraints affect college outcomes.

[6]See Russo (2011), Garriga and Keightley (2007), Joensen and Mattana (2014).

3 Data

I obtain most of the data used in my analysis from the National Longitudinal Survey of Youth 1997 (NLSY97). In this data set, a nationally representative sample of individuals who were born between 1980 and 1984 in the US were interviewed. The process of data collection started in 1997 and respondents were reinterviewed on an annual basis thereafter. I use all the waves from 1997 to the most recent one (1997 to 2011). The data set contains rich information on college choices, employment, asset and student loan debt, which allows for identification of model parameters. I focus on white males in the cross-sectional sub-sample who have at least some high school education. I exclude individuals in the military because military service often results in a very different career path that I do not aim to capture in my model.

I complement the NLSY97 with the Integrated Postsecondary Education Data System (IPEDS). IPEDS contains information on every college in the US, such as institutional characteristics, admissions, test scores, and student charges, etc. I use this information to calculate the net cost of attendance for each college enrollee and to construct a college quality index.

3.1 Main Data Variables

3.1.1 College Quality

Following a similar approach to that employed by Black, Smith, and Daniel (2005), I use the principal factor of two measures, average SAT score and average faculty salary, to construct the quality index.[7] I categorize four-year colleges into four quality levels

[7] Both measures are demeaned and normalized by their standard deviation. Black, Smith, and Daniel (2005) use a third measure for constructing the quality index which is the freshmen retention rate. I do

based on the college's quartile in the distribution of the college quality index.

3.1.2 Family Transfers and Family Income

Family income is measured as the total income of both parents from all sources including wages and salaries, commissions, tips, business income, pension income, etc. The NLSY97 collects such information in Round 1 to Round 5 (1997-2001). I use the average family income over these five years as the family income for each individual in the model. When I present the descriptive statistics, I categorize the family income into four quartiles, Quartile 1: less than \$43,000, Quartile 2: between \$43,000 and \$66,400, Quartile 3: between \$66,400 and \$98,400, Quartile 4: above \$98,400.[8] I construct family transfers using two variables in the data. One is the money parents/other family members give to the individual, including any gifts in the form of cash or a check. The other is the amount of money from parents/other family members to help pay for attendance in colleges. The NLSY97 has information on family transfers in each survey year.

3.1.3 Net Cost of Attendance

The gross cost of attendance is defined as the sum of the tuition, room and board expenses and other educational expenses. I use the college identifiers in the NLSY97 and link them to the IPEDS data to calculate the gross cost of attendance for the college(s) that the individual attended. At the same time, the NLSY97 records the total financial aids received by an individual in the form of grants, tuition or fee waivers or reductions, fellowships and scholarships. For each college an individual attended, I

not include this measure because staying in college will be an endogenous choice of individuals in my model.

[8] All dollar values in 2006 constant dollars.

construct the net cost of attendance by subtracting the financial aid from the gross cost of attendance.

3.1.4 College Application and Admissions

The NLSY97 has college application and admissions records for all individuals in the sample who were born between 1983 and 1984. It collects information on all the colleges to which an individual applied and was admitted. Linking college identifiers in the NLSY97 to the IPEDS data, I get the name of each of the colleges an individual applied to and identify the quality level of the college. I then calculate the admissions probabilities for a college of a given quality level conditional on students' observable conditions (family income and SAT score).

3.1.5 College Enrollment and Schooling Accumulation

I use the monthly enrollment records in the NLSY97 to construct the enrollment (or attendance) status for each period. An individual is assigned to be enrolled in a type of college in an academic year if he is observed to have enrolled for more than 5 months in that academic year. If in an academic year an individual is recorded to have attempted both 4-year college and 2-year college, I assign him to the type of college he is enrolled in for longer part of that year. To determine whether an individual has completed a year of schooling, I use the annual records on the highest grade the individual achieved. Combined with the attendance records, I use these observations to estimate the schooling accumulation probability in the model.

3.1.6 Degree Completion and Time to Degree

In the NLSY97 data, an individual reports in each survey year the highest degree completed and when he attained the degree. Together with the enrollment data, time to degree is calculated as the number of years between the initial enrollment and the year the degree is completed. I distinguish an associate degree from a bachelor's degree as these two types of degrees have different labor market returns.[9]

3.1.7 Employment

I categorize the work status into three broad types: nonemployment, part-time and full-time. I make use of the weekly hours worked records in the NLSY97 to calculate the total number of hours worked in an academic year. If an individual works less than 500 hours in a given academic year, he is assigned to be nonemployed. If an individual works in a year between 500 and 1500 hours, he is classified as a part-time worker. A full-time worker is an individual that supplies labor for more than 1500 hours in an academic year.

3.1.8 Student Loans and Assets

I follow the definition of assets in Keane and Wolpin (2001). I construct the net asset value from (i) housing and property values; (ii) savings and checking accounts, money market funds, retirement accounts, stocks, bonds, life insurance; (iii) farm operation and business wealth; (iv) student loan debt; (v) other assets and other debt. The NLSY97 collects the asset information when an individual turns 18, 20, 25 and 30 years old.

[9] In the model students can still attend graduate schools after college but I do not explicitly model the returns to different types of advanced degrees.

While the asset questions are not frequently asked, the NLSY97 collects the amount of student loans a student borrows in every survey year. The survey question asks, "Other than assistance you received from relatives and friends, how much did you borrow in government-subsidized loans or other types of loans while you attended this school/institution this term?". Together with the records on school terms, I construct the total amount of student loans taken out in a given academic year. Unfortunately, there is no information on repayment available in the data. I assume the repayment schedule follows a standard repayment scheme as most students use this scheme. I use the information on remaining student loan debt collected at the same time as the asset information as a way to check the validity of this assumption.

3.2 Empirical Analysis

There are two broad types of colleges in the US post-secondary education system, 4-year colleges and 2-year colleges. Figure 1 shows the distribution over no enrollment, enrollment in 2-year colleges only, enrollment in 4-year colleges only and enrollment in two types of colleges in accordance with family income quartiles and SAT groups. A student is classified as having enrolled into both types of college if I observe his enrollment in 2-year college and 4-year college at any point in the sample period.

Two interesting patterns can be observed in Figure 1. First, the enrollment rate of 4-year colleges goes up as family income increases for all SAT levels. For the lowest SAT group (SAT$\leq$800), only 13% of those from the poorest family group enrolled in 4-year colleges while 41% from the highest family income quartile enrolled. This substantial gap in 4-year college enrollment rates across family income quartiles is slightly reduced for higher SAT levels but still remains high with a differential of 19% between the highest and lowest family income quartile for individuals with SAT>1200. Second, students from the lower middle income families (Quartile 2) are more likely to transfer between 2-year colleges and 4-year colleges. For example, among those in the second SAT group (800<SAT≤1200) who once enrolled in 4-year colleges, 32% of students from family income quartile 2 also went to 2-year colleges while only 20% students in the highest family income quartile did so. A similar pattern holds for the highest SAT group, with 30% of those in family income quartile 2 transferred between the two types of colleges and only 10% from the richest group transferred. Overall, there is a declining enrollment rate into 2-year colleges by family income quartile, although it is not always monotonic.

As 4-year colleges differ a lot in their quality of education, which has different implication on labor market returns, it is important to understand the enrollment pattern in 4-year colleges in terms of the college quality. Figure 2 presents a plot of the choice distribution over no enrollment in 4-year colleges and enrollment in each college quality quartile for every combination of the family income quartile and the SAT level. An interesting pattern in this figure is that, for any SAT level, there tends to be more enrollment in higher quality when family income is higher. This pattern is particularly salient for the enrollment in colleges of the highest quality level. For example, we can see that although the overall enrollment rate for the smartest students (SAT>1200) is high across family income, there is significant variation in the quality levels of the colleges. 29% of the high school graduates from the lowest income quartile enroll in the best colleges compared to 47% of those from the highest family income quartile. Overall, this suggests that family income plays an important role for college quality choices.

I focus on three important aspects regarding college outcomes: (i) the fraction of

Figure 1: Two- or Four-Year College Distribution by Family Income and SAT

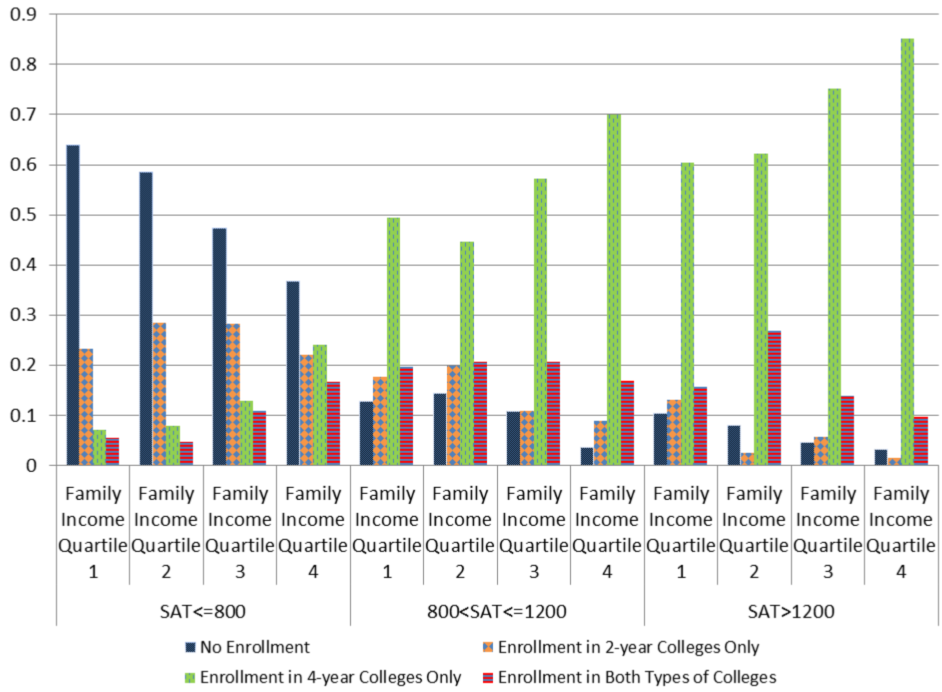
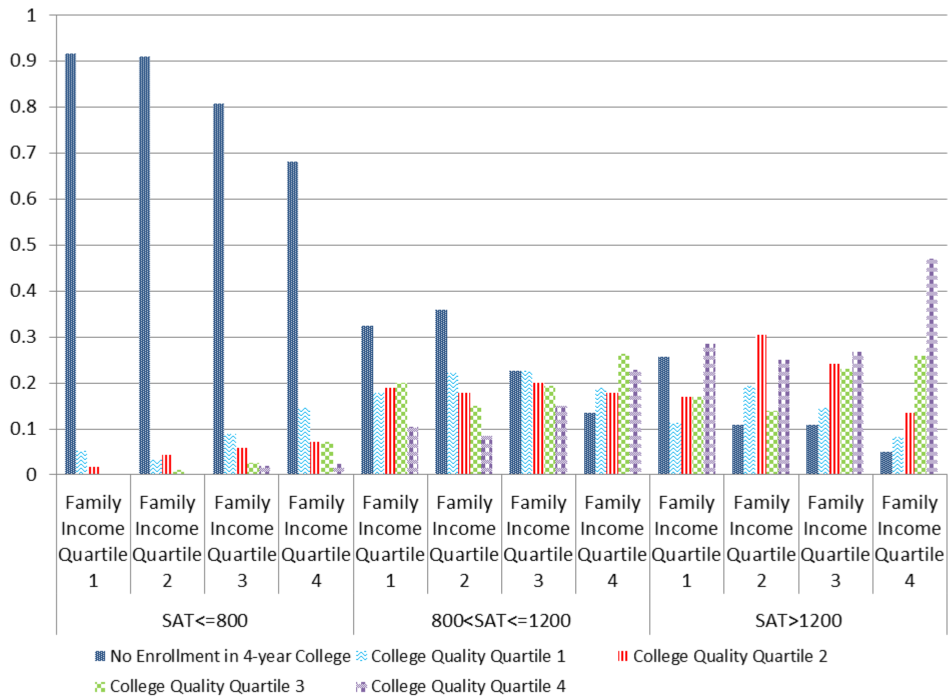


Figure 2: College Quality Distribution by Family Income and SAT



college students who manage to complete a degree; (ii) the number of years it takes to receive a bachelor's degree; (iii) how much students work in school. The statistics are summarized in Table 1. Note that the fraction of individuals with a college degree, either Associate degree or Bachelor's degree, is calculated conditional on having enrolled in college. For example, 31% of high school graduates in family income quartile 1 enrolled in 2-year college. Among them, 34% managed to complete their education in 2-year colleges and attain an Associate degree. While there does not seem to be much difference across family income levels for 2-year colleges, the college outcomes for 4-year colleges vary according to family income. Specifically, we see that students from rich families are more likely to complete a bachelor's degree and they take less time to finish the degree. At the same time, the amount of time spent working while enrolled in 4-year colleges decreases with family income. To look at the correlation between the time to complete the bachelor's degree and individual characteristics and choices, I regress the time to bachelor's degree on the college quality, SAT level, family income and total years worked in school in the first panel of Table 2. The college quality is negatively correlated with the time to bachelor's degree. Students from the highest college quality quartile on average take 0.32 years less to graduate. On the other hand, the time to degree goes up with the total years worked in school. The coefficient on the total years worked in school implies that working full-time in school for a year extends the graduation time by 0.27 years. The coefficients on both the SAT and family income are statistically insignificant. I exclude the total years worked in school in the second specification of Table 2 and I find that the R^2 declines from 0.24 to 0.07, suggesting a high explanatory power of in-school labor supply on the time needed to graduate.

Table 1: College Outcomes by Family Income

	Family Income Quartile			
	1	2	3	4
%Enrolled in 2-year college	31	36	32	25
	[46]	[48]	[47]	[43]
%with AA	34	34	33	30
	[47]	[47]	[47]	[46]
%Enrolled in 4-year college	38	41	59	79
	[49]	[49]	[49]	[41]
%with BA	58	62	66	76
	[50]	[49]	[47]	[43]
Time to BA	4.93	4.87	4.75	4.72
	[1.42]	[1.23]	[1.07]	[1.08]
Avg Yrs Worked by BA Graduation	2.91	2.88	2.49	1.97
	[2.23]	[1.92]	[1.79]	[1.47]

AA: Associate Degree, BA: Bachelor's Degree. College completion rate is calculated as the fraction of college students who completed the degree. Standard deviation is in the bracket.

Table 2: Regression of Time to BA Degree Regression

	(1)	(2)
College Quality Q2	-0.0417	-0.062
	[0.123]	[0.135]
College Quality Q3	-0.0937	-0.207
	[0.119]	[0.129]
College Quality Q4	-0.325***	-0.562***
	[0.115]	[0.122]
$800 \leq$SAT≤ 1200	0.171	0.062
	[0.173]	[0.187]
SAT>1200	0.149	0.019
	[0.178]	[0.194]
Family Income (In Thousands)	0.0007	9.45e-5
	[0.0005]	[0.0005]
Total Years Worked by BA Graduation	0.270***	
	[0.033]	
Constant	3.992***	4.830 ***
	[0.211]	[0.198]
R^2	0.240	0.069
Observations	409	409

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Standard errors are in the bracket.

Table 3: Student Loan Debt by Family Income Among BA Graduates

	% With Positive Debt	Avg Amount Borrowed (cond. on borrowing)
Family Income Quartile 1	79[41]	$17480[13071]
Family Income Quartile 2	81[40]	$16014[10726]
Family Income Quartile 3	67[47]	$19059[12490]
Family Income Quartile 4	42[49]	$18260[13163]

The standard deviation is in the bracket.

Next, I summarize statistics on student loan debt. In order to control for the effects of different education levels, I focus on the 4-year college graduates. Table 3 shows the fraction of graduates who borrow student loan debt conditional on the family income quartile and SAT levels. We see that the fraction of students who borrow tends to go down as the family income quartile increases. About 80% of students in the bottom two family income quartiles borrow while only 42% of those in the highest family income quartile take out student loan debt. To look at the correlation between post-graduation wages and student loan debt, I run a log wage regression controlling for college quality, SAT, family income, experience, occupation and industry. Table 4 shows that the coefficient on the student loan debt is -0.003. If an individual has an average amount of student loan debt, which is $18,000, this coefficient implies a 5.4 percentage point lower hourly wages.

To summarize, we see that there is a difference across family income levels in college enrollment, college completion and subsequent labor market performance. In terms of college enrollment, family income is correlated not only with the binary choice of whether to go to college, but also where to attend colleges. Both the 4-year college enrollment rate and the enrollment rate in higher-quality colleges tend to increase with family income. Apart from the enrollment decision, college outcomes also differ in accordance

Table 4: Regression of Log Hourly Wage Among BA Graduates

Student Debt (in thousands)	-0.003^{*}
	[0.001]
College Quality Q2	0.078
	[0.062]
College Quality Q3	0.186^{***}
	[0.054]
College Quality Q4	0.303^{***}
	[0.058]
Family Income (in thousands)	0.004^{***}
	[0.0009]
Family Income Sq (in thousands)	-1e-5 ***
	[2.82e-6]
Experience by BA Graduation	0.031
	[0.015]
Experience (Post Graduation)	0.079^{***}
	[0.019]
Experience Sq (Post Graduation)	-0.002
	[0.004]
Constant	3.702^{***}
	[0.356]
R^2	0.27
Observations	1845

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Occupations and industries are included. Standard errors are in the bracket.

with family income. Students from lower-income families are more likely to take out student loan debt and work more in school. These lower-income students have a lower college completion rate compared to students from richer families. The data also shows that the time to degree is positively correlated with the amount of work in school and it is declining over the family income.

The discrepancy in college completion rate and the quality of the college degree across family income levels could potentially explain the persistent lifetime earnings differences between individuals from poor and rich families. It is therefore important to understand to what degree these correlations are driven by financial restrictions and what kind of policies can improve the current situation.

The model I build and estimate in this paper is designed to replicate the data patterns derived above and to distinguish the channels through which such trends arise. The estimated model is used to evaluate whether policies that aim to subsidize 2-year colleges and reform the student loan debt structure could improve education outcomes for the less wealthy and alleviate the income inequality problem. I will now progress to describe the model in more details.

4 Model

4.1 Basic Structure

In this section I lay out my model by describing all the elements of the decision problem of an individual. A model period corresponds to one year. All individuals start out as high school students and make decisions for 45 periods until age 61. Individuals are initially heterogeneous in their family income (y_f), SAT score (SAT), and the unobserved type (k). The unobserved types allow for permanent heterogeneity in preferences for schooling and labor supply, admissions and schooling accumulation probabilities, family transfers, and initial human capital.

4.1.1 Choice Sets

In the first period, a high school student chooses whether to finish high school ($s^{\text{hs}} = 1$), or drop out ($s^{\text{hs}} = 0$). If he chooses to finish, he will get a high school diploma by the end of the period. If he drops out, he can work right away but will never be able to enroll in school again.

At the beginning of the second period, each high school graduate decides on whether to apply to college. Individuals can apply to a set of types of colleges. Specifically, there are five types of schools, four types of 4-year colleges, each distinguished by a particular quality of education ($Q \in \{1, 2, 3, 4\}$), and 2-year colleges. For ease of notation, I denote the quality level of community colleges by $Q = 5$. The admissions rules will be discussed later. After the set of admitted colleges realizes, an individual makes schooling, labor supply, student loan debt, and savings decisions and continue to make these decisions in each following period. An individual can choose to enroll in a 4-year college that admits him, a 2-year college, or not to enroll in college. I use an indicator for 4-year and 2-year college enrollment denoted by s_t^u and s_t^c respectively. An individual is not allowed to enroll in any college after age 30. At a given period t, there are three labor supply intensities (h_t): no work ($h_t = 0$), part-time work ($h_t = 0.5$), and full-time work ($h_t = 1$). When an individual is enrolled in college, he chooses the amount of student loans to borrow ($d_t \geq 0$). In each period, he also decides on the amount of savings ($x_t \geq 0$) to hold.

4.1.2 State Space

The state vector (Ω_t) contains the initial conditions: family income (y_f), SAT and the unobserved type (k). In addition, it contains the following variables: COA_Q denotes the net cost of attendance for a college type Q. x_t is the amount of savings in the standard risk free bond. D_t is the total amount of student loan debt and Td_t is the number of periods left on repayment of student loan debt in period t. s_{t-1} denotes the enrollment status in period $t-1$. S_t^u, S_t^c, S_t^g measure the years of completed schooling in 4-year college, 2-year college and graduate school, respectively. There are two states related to the labor market. ep_t is the years of experience accumulated and z_{t-1} denotes the state of the persistent wage shock in period $t-1$. In total Ω_t looks as follows

$$\Omega_t = \left(y_f, SAT, k, \text{COA}_Q, x_t, D_t, \text{Td}_t, s_{t-1}, S_t^u, S_t^c, S_t^g, ep_t, z_{t-1}\right). \tag{1}$$

4.1.3 Preferences

At the beginning of period t, individuals observe the preference shocks to both schooling and working summarized by ϵ_t. The period utility function is an augmented CRRA utility given by

$$U_t = \delta_s \frac{c_t^{1-\alpha_k}}{1-\alpha_k} + g(s_{t-1}^u, s_{t-1}^c, s_t^u, s_t^c, Q, h_t, k, SAT, \epsilon_t, t), \tag{2}$$

where α_k is the constant relative risk aversion parameter, and it can differ by the unobserved type k. Note that the marginal utility of consumption is shifted by δ_s, which is a function of the college enrollment status. This is to capture the potential difference in the preference for consumption between students and those who are not enrolled. $g(\cdot)$ contains utility values from schooling and working. Specifically, at the college application stage, it includes preferences toward different types of colleges. When students are enrolled in college, they incur psychic costs, which are a function of both the previous and current enrollments status, the unobserved type k, and their SAT scores. When an individual works in period t, they pay the utility costs associated with working which vary by the enrollment status and the work intensity. The exact functional form of U_t is given in Appendix A.

4.1.4 Application and Admissions

Individuals choose a portfolio of colleges to apply to at the beginning of the second period. They pay the application cost which is a function of the number of types of schools applied (N), $C_{\text{App}}(N,k) = c^{1,k}_{\text{App}} N - c^{2,k}_{\text{App}} \max\{0, N-1\}$. The application cost is paid in terms of foregone utility.

An individual is admitted to college quality quartile Q if $I^{Q}_{\text{Adm}} = 1$. His admissions probability into college quality quartile Q is a function of his SAT and the unobserved type. I categorize the SAT score of each individual into three groups. Group 1 contains SAT scores below 800, group 2 SAT scores between 800 and 1200, and group 3 SAT scores above 1200. Here and in the following $I(\cdot)$ denotes the indicator function of the set described in $(\cdot)$.

$$Pr(I^{Q}_{\text{Adm}} = 1) = \sum_{k=1}^{2} I(\text{type} = k)\Big(g^{0,k}_{\text{Adm,Q}} + g^{1}_{\text{Adm,Q}} I(\text{SAT} = 2) + g^{2}_{\text{Adm,Q}} I(\text{SAT} = 3)\Big) \tag{3}$$

4.1.5 Net Cost of Attendance

The net cost of attendance is defined as the total cost of attendance net of grants and aids. An individual draws this cost only once, before making his application decisions from the distribution of the net cost of attendance for community colleges and each quality level of the four-year colleges. The distribution for each type of colleges is assumed to be log-normal:

$$\log(\mathrm{COA}_Q) \sim N(\mu_Q(y_f, \mathrm{SAT}), \sigma_Q^2) \tag{4}$$

$$\mu_Q(y_f, \mathrm{SAT}) = \sum_{m=1}^{3} \mu_Q^{1,m} I(\mathrm{SAT} = m) + \mu_Q^2 y_f \tag{5}$$

4.1.6 Schooling Accumulation

An individual who enrolls in college in a given period completes a year of schooling with a probability which is a function of the unobserved type, the labor supply and the 4-year college quality quartile.

$$\begin{aligned} Pr(I_{\mathrm{Sch}^i} = 1) =& \Phi\Big(\sum_{k=1}^{2} g^{0,k}_{\mathrm{Sch,i}} I(\mathrm{type} = k) - g^{1}_{\mathrm{Sch,i}} I(h_t = 0.5) - g^{2}_{\mathrm{Sch,i}} I(h_t = 1) \\ & + \sum_{q=2}^{4} g^{3,q}_{\mathrm{Sch,u}} I(Q = q)\Big), \end{aligned} \tag{6}$$

where $i \in \{u, c\}$. I_{Sch^u} and I_{Sch^c} is an indicator for completing a year of schooling in 4-year college and 2-year college, respectively. I assume that an individual obtains a bachelor's degree when he completes four years of schooling in four-year colleges and he obtains an associate degree with two years of completed schooling in 2-year colleges. Individuals can go to graduate school after the bachelor's degree.[10]

4.1.7 Wage Process

The wage process is given by

$$w_t = \exp(H_t + z_t + \epsilon_t), \tag{7}$$

where H_t is the amount of human capital accumulated at time t. u_k is the initial human capital of an individual of unobserved type k, and ep_t is the total experience at time t. Individuals gain human capital from the number of years of completed schooling in 4-year colleges (S_t^u), community colleges (S_t^c), and graduate school (S_t^g). The human capital is also increased from earning an education degree (HD). There are four education levels: high school dropouts, high school graduates, associate degree and bachelor's degree, denoted by $HD = 0, 1, 2, 3$, respectively. The labor market return to a bachelor's degree can differ according to the college quality Q. κ_H^k allows the unobserved type to affect the labor market return to an education degree. I normalize κ_H^1 to 1. $\epsilon_t \sim N(0, \sigma_\epsilon^2)$ is an i.i.d productivity shock. z_t is a persistent wage shock, which I discretize into two states $(\underline{z}, \bar{z})$. z_t evolves according to a Markov process and the transition probability (z_p) is the same for all individuals.

[10] Individuals can continue to enroll in college after completing the bachelor's degree. I do not explicitly model the return to various professional degrees or other advanced degrees.

$$H_t = \sum_{k=1}^{2} I(\text{type} = k)u_k + \phi_1 ep_t + \phi_2 ep_t^2 + \phi_3 I(\text{HD} = 1) + \phi_4 S_t^u + \phi_5 S_t^c + \phi_6 S_t^g$$
$$+ \sum_{k=1}^{2} I(\text{type} = k)\kappa_H^k \Big(\phi_m^5 I(\text{HD} = 2) + \big(\phi_m^1 + \sum_{q=2}^{4} \phi_m^q I(Q = q)\big) I(\text{HD} = 3)\Big). \quad (8)$$

The accumulation of experience is given by:

$$\text{ep}_{t+1} = \text{ep}_t + m_{\text{ep}}, \quad (9)$$

$$m_{\text{ep}} = \Big(\sum_{i=0,1,2,3} \chi_{\text{HD}}^i I(\text{HD} = i)\Big)\Big(I(h_t = 1) + 0.5 I(h_t = 0.5)\Big) I(s_t = 0)$$
$$+ \sum_{i=u,c} \Big(\chi_s^i I(h_t = 1) + 0.5\chi_s^i I(h_t = 0.5)\Big) I(s_t^i = 1). \quad (10)$$

where I normalize χ_{HD}^3 to 1. The accumulation of experience can differ according to education levels and the enrollment status. This captures the heterogeneity in the wage growth patterns across people with different education degrees and enrollment status observed in the data.

4.1.8 Family Transfers

In the initial period, the family transfer is a function of the high school enrollment status (s^{hs}), the family income (y_f), the savings of the individual (x_t), and the unobserved type (k).

$$tr_t = \max\{\gamma_1 I(s^{hs}=1) + \gamma_2 y_f I(s^{hs}=1) + \gamma_7 y_f + \gamma_8 x_t + \sum_{k=1}^{2} \gamma_9^k I(\text{type}=k) + \epsilon_{\text{tr}}, 0\} \tag{11}$$

From the second period on, the family transfer function is given by

$$\begin{aligned} tr_t = &\max\Big\{\gamma_3 I(s_t^u=1) + \sum_{q=1}^{4} \gamma_4^q y_f I(s_t^u=1, Q=q) + \gamma_5 I(s_t^c=1) + \gamma_6 y_f I(s_t^c=1) \\ &+ \gamma_7 y_f + \gamma_8 x_t + \sum_{k=1}^{2} \gamma_9^k I(\text{type}=k) + \gamma_{10} t + \epsilon_{\text{tr}}, 0\Big\}, \end{aligned} \tag{12}$$

where the amount of family transfer is a function of the college enrollment status (s_t^u, s_t^c), the family income (y_f), the savings of the individual (x_t), and the unobserved type (k). There is also a shock to the family transfer ($\epsilon_{\text{tr}} \sim N(0, \sigma_{\text{tr}}^2)$) to capture fluctuations in the family income and other unexpected events that affect the family transfers.

4.1.9 Borrowing and Savings

There are two types of assets: student loan debt and the risk-free asset. In any given period, an individual can save in the risk-free asset at a rate R_s. When an individual is enrolled in college, he can take out student loan debt. I incorporate the key elements of the federal student loan program in the US. The repayment schedule of the student loan debt in the model features the standard fixed repayment plan in the US. There are three main features. First, an individual cannot borrow more than the net cost of attendance and there is a fixed maximum limit on the total amount of student loan debt ($\bar{D}$). Second, an individual does not repay any student loan debt while enrolled in school but interests accrue during this period at a rate R_e.[11] Third, when an individual is not enrolled in school, he has in total 10 years to completely pay off his debt. The repayment amount is fixed and the same over the whole repayment period. It is a constant amount such that the total amount of student loan debt owed and its accrued interest at a rate R_d are fully repaid by the end of the 10th year after leaving school.

4.1.10 Budget Constraint

If an individual is not enrolled in school, his budget constraint is given by

$$c_t + x_{t+1} = T(w_t h_t) + tr_t - \mathrm{pp}_t + R_s x_t, \tag{13}$$

where savings $x_{t+1} \geq 0$. pp_t is amount of student loan debt repayment at period t, and is calculated as $\mathrm{pp}_t = \frac{D_t}{\sum_{t=0}^{\mathrm{Td}_t - 1} \frac{1}{(R_d)^t}}$. Td_t is the number of repayment periods at period t. After the repayment the total amount of student loan debt is $D_{t+1} = (D_t - \mathrm{pp}_t) R_d$. $T(\cdot)$ denotes the after-tax labor income. I include the progressive labor income taxation schedule. The after-tax labor income follows the specification in Aizawa and Fang (2013) and Kaplan (2012), and they approximate the U.S. tax code by

$$T(y) = \tau_0 + \tau_1 \frac{y^{1+\tau_2}}{1+\tau_2}, \tag{14}$$

[11] For the subsidized federal student loan debt students do not need to pay the interests accumulated during school. Since the data does not distinguish subsidized and unsubsidized student loans, I assume all loans are unsubsidized.

where $\tau_0 > 0$, $\tau_1 > 0$ and $\tau_2 < 0$.

If an individual is enrolled in school, his budget constraint is given by

$$c_t + x_{t+1} = T(w_t h_t) + d_t + tr_t - \sum_{q=1}^{5} \text{COA}_Q I(Q = q) + R_s x_t, \tag{15}$$

where $x_{t+1} \geq 0$, d_t is the amount of student loan debt taken out in period t and is capped by the net cost of attendance, $d_t \leq \text{COA}_Q$. The total amount of student loan debt D_{t+1} evolves as $D_{t+1} = (D_t + d_t)R_e$ and is bounded by the fixed maximum limit $\bar{D}$. When an individual is not employed, he will get unemployment benefit, y_b.

4.1.11 Unobserved Type Distribution

There are two unobserved types. The type distribution is a function of two initial conditions, the family income (y_f) and the SAT level. The probability of being a type 2 agent is given by

$$\Pr(\text{type} = 2) = \frac{\exp(\pi_0 + \pi_1 y_f + \pi_2 I(\text{SAT} = 2) + \pi_3 I(\text{SAT} = 3))}{1 + \exp(\pi_0 + \pi_1 y_f + \pi_2 I(\text{SAT} = 2) + \pi_3 I(\text{SAT} = 3))}. \tag{16}$$

4.2 Optimization Problem Over the Life Cycle

At period t, an individual maximizes the sum of his flow utility and the expected utility for the remaining lifetime given the state space Ω_t:

$$V_t(\Omega_t) = \max_{j \in C_t^J} U_t(j) + \beta E[V_{t+1}(\Omega_{t+1} | j, \Omega_t)], \tag{17}$$

where the expectation is taken with respect to the distribution of preference shocks and wage shocks, and the probability of schooling accumulation. j is the combination of choices over schooling, work, student loan debt, and savings which are within the choice set at time t, denoted by C_t^J. β is the discount factor.

At the college application stage, an individual chooses an application portfolio (m) from the set of available combination of colleges (M^J) to solve the following maximization problem:

$$V_t(\Omega_t) = \max_{m \subseteq M^J} \sum_{o \subseteq m} Pr(o|\Omega_t) E[V_t(o, \Omega_t)] - C_{\text{App}}(m|\Omega_t), \tag{18}$$

where $Pr(o|\Omega_t) = \prod_{j \in o} Pr(I_{\text{Adm}}^j = 1|\Omega_t) \prod_{l \in m \setminus o} (1 - Pr(I_{\text{Adm}}^l = 1|\Omega_t))$ is the probability that the set of colleges $o \subseteq m$ admits an individual with state space Ω_t. $C_{\text{App}}(m|\Omega_t)$ is the application cost of the portfolio m.

4.3 Solution Method

I solve the model by backward recursion. At any period, to solve for the expected continuation value (V_{t+1}) at a given state space point, which I refer to as Emax, I approximate the integral using Monte Carlo integration. Specifically, I randomly take A draws of the set of shocks from their respective distributions. Conditional on each draw, I solve V_{t+1} in equation (4.17). I then average over the A draws to calculate the value of the Emax at time t. Since the state space is very big, it is computationally infeasible to solve Emax at any given state space point. I follow the approximation method in Keane and Wolpin (2001). First, I randomly draw a set of state space points and I solve for Emax at these points. Second, I regress the Emax values on these state space points on a set of linear and quadratic terms of the state variables. Using the coefficients obtained from the regression, I approximate the Emax on all the other state space points that are not drawn.

5 Estimation

In this section, I first discuss the intuition for the identification of the model parameters. Then, I describe the estimation strategy.

5.1 Identification

The utility function characterizes the value an individual attaches to work and school. Although the terms of the utility function cannot be observed from the data, they govern the choices individuals make, which allows us to infer these parameters. The disutility of working and the shocks to it can be identified from the level of labor supply and its variation over time. The psychic cost of schooling for a given SAT level is mainly determined by the level of enrollment in each broad type of colleges by SAT level in the data. The change in the enrollment behavior between periods identifies the variance of shocks to the psychic costs of schooling. The fraction of individuals who drop out and re-enroll pins down the cost of interrupted enrollment. The fraction of individuals transfer from 2-year college to 4-year college implies the disutility of such type of transfer. The preference for college quality at the application stage is pinned down by the difference in the application behaviors.

Unobserved types mainly capture the permanent heterogeneity across individuals. For example, if there are two individuals with the same observed initial conditions but who consistently make different choices, then they have different unobserved types. Since an individual's type directly affects all the decisions it makes, the distribution of types is mainly identified through the overall fit of the model to the data. Similarly, risk aversion is also not easy to identify since it affects individual's college choices, both the enrollment and drop out behavior, and their willingness to borrow. It requires the joint fit of the moments on college decisions and borrowing behavior.

Apart from the utility function, unobserved types and risk aversions, almost all other parameters can be directly identified from the data. The college admissions function for each college type is pinned down using the application data and the admissions results observed in the subsample of the NLSY97 data. Similarly, net cost of attendance and the family transfer function have data counterparts that can identify the level of each component. For the schooling accumulation probability, I have both the enrollment data and the grade completion records to determine the function. The wage process is identified using the annual individual wage records. The difference in the accumulation of experience across education attainment is pinned down by the difference in the wage growth observed in groups with different education attainment.

5.2 Estimation Strategy

The model parameters are estimated using the simulated method of moments. The parameter estimates are found by minimizing a weighted distance measure between a set of aggregate moments constructed from the data and their model counterparts. The weights are given by the inverse of the estimated variances of the data moments.

Some parameters (summarized in Table 5) are calibrated before the estimation procedure. I set the discount factor at 0.99. The interest rate for savings in a riskless asset is

1.01. The interest rates for the student loans are calculated as the average real interest rates of the federal student loans over the sample period. I use the parameters for the progressive tax schedule in Aizawa and Fang (2013) and Kaplan (2012) who approximate the US tax code by $T(y) = \tau_0 + \tau_1 \frac{y^{1+\tau_2}}{1+\tau_2}$ and determine the parameters from the National Bureau of Economic Research's TAXSIM program.

	Description	Value
β	Discount Factor	0.99
Interest Rate		
R_s	Riskless Asset,Savings	1.01
R_d	Student Loan (in Repayment)	1.03
R_e	Student Loan (in School)	1.024
Tax Schedule		
τ_0		0.0056
τ_1		0.6377
τ_2		-0.1362

Table 5: Calibrated Parameters

In total I match 494 moments. The following is a list of moments employed in the estimation:

1. College Enrollment

 - Enrollment rate in 4-year colleges over time, and by family income quartiles
 - Enrollment rate in 2-year colleges over time, and by family income quartiles
 - Enrollment rate in 4-year and 2-year colleges by family income quartiles and SAT
 - Enrollment rate in 4-year college quality quartiles by family income quartiles and SAT
 - Admissions rate by 4-year college quality quartiles
 - Persistence rate in enrollment in 2-year and 4-year college

- Fraction of stop-outs re-enrolled in 2-year and 4-year college

2. College Outcomes

- Average years of schooling in 2-year colleges by family income quartiles
- Average years of schooling in 4-year colleges by family income quartiles
- Fraction graduated with Associate Degree by family income quartiles
- Fraction graduated with Bachelor's Degree by family income quartiles
- Fraction graduated with Bachelor's Degree by college quality quartiles
- Time to Bachelor's Degree by family income quartiles
- Time to Bachelor's Degree by college quality quartiles
- Fraction completed a year of schooling in 2-year and 4-year college

3. Labor Supply

- Fraction worked part-time over time, by education levels
- Fraction worked full-time over time, by education levels

4. Wages

- Average log hourly wages over time, by education levels
- Average log hourly wages of 4-year college graduates over time, by college quality quartiles

5. Cost of Attendance, Student Loan and Family Transfers

- Average cost of attendance for 4-year colleges (by college quality quartiles) and 2-year colleges

- Fraction of 4-year enrollees who borrowed student loans by family income quartiles
- Fraction of 2-year enrollees who borrowed student loans by family income quartiles
- Fraction of 4-year graduates who borrowed student loans by family income quartiles
- Fraction of 2-year graduates who borrowed student loans by family income quartiles
- Average debt size of 2-year graduates by family income quartiles
- Average debt size of 4-year graduates by family income quartiles
- Average family transfers by family income quartiles
- Average savings by family income quartiles[12]

6 Estimation Results

In this section, I analyze the key parameter estimates. Next, I show the model fit. After that, I discuss how the college completion rate is affected by working in school and college quality.

6.1 Parameter Estimates

The parameter estimates of primary interests are summarized in Table 6 to Table 9. The rest of the parameters can be found in Appendix B.

[12] When I calculate the average savings level in the data, I also include the savings of individuals with negative savings.

6.1.1 Preferences

Table 6 shows the estimates of key utility parameters. First, the risk aversion differs between types. Type 1 has a risk aversion of 1.3 while Type 2's risk aversion is 2.2, suggesting that Type 2 agents are much more risk averse than Type 1 agents. The preference for 2-year colleges is normalized to 0 for both types. Students' preferences for different college quality levels are different both across types and within the types. These preference parameters capture the individual's taste/expectation when he makes decision about which college quality to apply to. For each type of agent, the psychic cost of schooling in 4-year colleges tend to be lower for higher SAT groups as higher ability makes it easier for students to keep up with the courses. Compared to the psychic costs of 4-year colleges, the psychic cost of schooling is lower for 2-year colleges, which is not surprising as courses are usually harder in 4-year college. The utility parameter estimates of working in school, both full-time and part-time, are not positive. For both types of agents the utility cost of working is higher for 4-year colleges than for 2-year colleges. This implies that it is less costly in terms of utilities to work in 2-year colleges. This cost could capture the lost time working student could have used to participate in school events and join student clubs. Compared to 4-year colleges, 2-year colleges do not offer much a campus life, which is likely to reduce the cost of spending time working. Moreover, community colleges tend to offer a more flexible course schedule such as more evening classes to accommodate students who work.

Table 6: Key Utility Parameter Estimates

	Description	Estimate	S.E.
Risk Aversion			
α_1	Risk aversion (k=1)	1.300	0.00002
α_2	Risk aversion (k=2)	2.200	0.00007
Preference for College Quality			
$\mu_{\text{cq}}^{1,1}$	Preference for 4-year college Q^1 (k=1)	0.150	0.00077
$\mu_{\text{cq}}^{1,2}$	Preference for 4-year college Q^2 (k=1)	-0.174	0.00264
$\mu_{\text{cq}}^{1,3}$	Preference for 4-year college Q^3 (k=1)	-0.521	0.0024
$\mu_{\text{cq}}^{1,4}$	Preference for 4-year college Q^4 (k=1)	-1.000	0.0046
$\mu_{\text{cq}}^{2,1}$	Preference for 4-year college Q^1 (k=2)	0.015	0.00003
$\mu_{\text{cq}}^{2,2}$	Preference for 4-year college Q^2 (k=2)	0.015	0.00002
$\mu_{\text{cq}}^{2,3}$	Preference for 4-year college Q^3 (k=2)	0.000	0.000003
$\mu_{\text{cq}}^{2,4}$	Preference for 4-year college Q^4 (k=2)	0.000	0.00004
Psychic Cost of Schooling			
4-year College:			
$\mu_{\text{ec}}^{u,1,1}$	Cost for k=1	-0.65	0.00032
$\mu_{\text{ec}}^{u,1,2}$	Change in cost for k=1, 800<SAT≤1200	0.150	0.00020
$\mu_{\text{ec}}^{u,1,3}$	Change in cost for k=1, SAT>1200	0.180	0.00045
$\mu_{\text{ec}}^{u,2,1}$	Cost for k=2	-0.027	0.000003
$\mu_{\text{ec}}^{u,2,2}$	Change in cost for k=2, 800<SAT≤1200	0.008	0.000004
$\mu_{\text{ec}}^{u,2,3}$	Change in cost for k=2, SAT>1200	0.011	0.000005
2-year College:			
$\mu_{\text{ec}}^{c,1}$	Cost for k=1	-0.450	0.00069
$\mu_{\text{ec}}^{c,2}$	Cost for k=2	-0.040	0.000002
Disutility of Working in School			
4-year College:			
λ_1^1	Cost of part-time work,k=1	-0.200	0.00067
λ_2^1	Cost of full-time work,k=1	-0.250	0.00052
λ_1^2	Cost of part-time work,k=2	-0.003	0.000002
λ_2^2	Cost of full-time work,k=2	-0.000	0.000016
2-year College:			
λ_3^1	Cost of part-time work,k=1	-0.030	0.0007
λ_4^1	Cost of full-time work,k=1	-0.100	0.0014
λ_3^2	Cost of part-time work,k=2	-0.000	0.000069
λ_4^2	Cost of full-time work,k=2	-0.000	0.00005

Table 7: Schooling Accumulation

	Description	Estimate	S.E.
4-year College:			
$g^{0,1}_{\text{Sch,u}}$	Constant,k=1	1.000	0.00158
$g^{0,2}_{\text{Sch,u}}$	Constant,k=2	0.900	0.00065
$g^{1}_{\text{Sch,u}}$	Coefficient on part-time work	0.180	0.0003
$g^{2}_{\text{Sch,u}}$	Coefficient on full-time work	0.600	0.00046
$g^{3,2}_{\text{Sch,u}}$	Coefficient on college quality Q2	0.160	0.00116
$g^{3,3}_{\text{Sch,u}}$	Coefficient on college quality Q3	0.100	0.0006
$g^{3,4}_{\text{Sch,u}}$	Coefficient on college quality Q4	0.400	0.00175
2-year College:			
$g^{0,1}_{\text{Sch,c}}$	Constant,k=1	0.350	0.00347
$g^{0,2}_{\text{Sch,c}}$	Constant,k=2	0.350	0.00294
$g^{1}_{\text{Sch,c}}$	Coefficient on part-time work	0.000	0.00195
$g^{2}_{\text{Sch,c}}$	Coefficient on full-time work	0.050	0.00178

6.1.2 Schooling Accumulation

Table 7 shows the schooling accumulation function for both 4-year colleges and 2-year colleges. A student in 4-year college who does not work has a higher probability of completing a year of schooling if he is of type 1. Working in 4-year colleges reduces the likelihood of advancing a grade. Full-time work has a much larger negative effect on schooling accumulation than part-time work. A better college quality tends to make it easier to progress in college. This captures the idea that colleges of higher quality tend to have better institutional resources which facilitate students to advance further. In 2-year colleges, the probability of progressing a year in 2-year colleges is much lower compared to 4-year colleges. Working in in 2-year colleges is much less costly compared to 4-year colleges.

Table 8: Wage Process

	Description	Estimate	S.E.
u_1	Constant,k=1	2.558	0.00089
u_2	Constant,k=2	2.350	0.001
ϕ_1	Coefficient on experience	0.075	0.000002
ϕ_2	Coefficient on experience square	-0.002	$7.93E^{-9}$
ϕ_3	Coefficient on high school diploma	0.025	0.00032
ϕ_4	Coefficient on 4-year schooling	0.015	0.000003
ϕ_5	Coefficient on 2-year schooling	0.010	0.000016
ϕ_6	Coefficient on graduate school schooling	0.015	0.01
ϕ_m^1	Return to college quality Q1 graduate	0.040	0.00006
ϕ_m^2	Change in return to college quality Q2 (compared to Q1)	0.079	0.00016
ϕ_m^3	Change in return to college quality Q3 (compared to Q1)	0.160	0.000146
ϕ_m^4	Change in return to college quality Q4 (compared to Q1)	0.206	0.00019
ϕ_m^5	Coefficient on Associate Degree	0.027	0.000086
κ_H^2	Type shifter	0.900	0.00073

6.1.3 Wage Progress

Table 8 shows the parameter estimates for the wage equation. Type 1 individuals have higher initial human capital. There is 1.5% return to a high school diploma and 2.7% return to an associate degree. Each year of completed schooling is also rewarding. There is 1.5% and 1% return for each year of completed schooling in 4-year colleges and 2-year colleges, respectively. There are very heterogeneous labor market returns to different college qualities. For Type 1 individuals, the labor market return to college quality quartile 1 is 10% while 26% for quality quartile 4. Compared to Type 1 individuals, the degree premium for Type 2 individuals is 10 percent lower.

6.1.4 Type Distribution by Family Income and SAT

Table 9 shows the type distribution. Since my model has two types, I directly show the fraction of type 1 individuals in each family income quartile and SAT level group. The table suggests that an individual is more likely to be of type 1 if he is from a richer family. Higher SAT level also tends to increase the likelihood to be of type 1. For example, the fraction of type 1 individuals in family income quartile 4 and with a SAT higher than 1200 points is 90% while it is only 13% in the lowest family income quartile and lowest SAT level group.

Table 9: Estimated Type 1 Proportion by Family Income and SAT

	SAT$\leq$800	800<SAT$\leq$ 1200	SAT>1200
Family Income Quartile 1	0.13	0.20	0.18
Family Income Quartile 2	0.26	0.36	0.33
Family Income Quartile 3	0.44	0.55	0.52
Family Income Quartile 4	0.86	0.91	0.90

Combined with the parameter estimates in the previous tables, we find that individuals from richer families tend to have a higher SAT and higher permanent ability (unobserved ability) level. These individuals are less risk averse and gain more in terms of labor market returns from attending the same type of college.

6.2 Model Fit

Next, I present tables and figures on the model fit to show that the model can fit the most salient features of the data.

Figure 3 to Figure 5 shows the model fit of the distribution of college enrollment in 2-year and 4-year colleges by family income given a SAT level. The model matches quite well the increasing enrollment in 4-year colleges and declining enrollment in '2-year colleges only' with family income. The model also captures the higher transfer rate between 2-year colleges and 4-year colleges in the middle-income groups.

Figure 6 to Figure 8 shows the college quality distribution by family income for each level of SAT scores. The data shows that the fraction of individuals in higher quality

Figure 3: Two- or Four-Year College Distribution by Family Income, SAT≤800

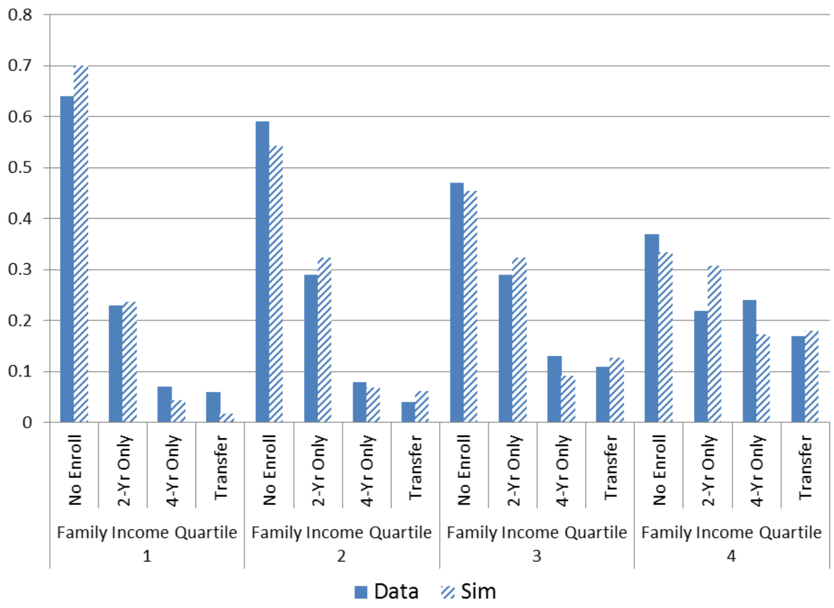
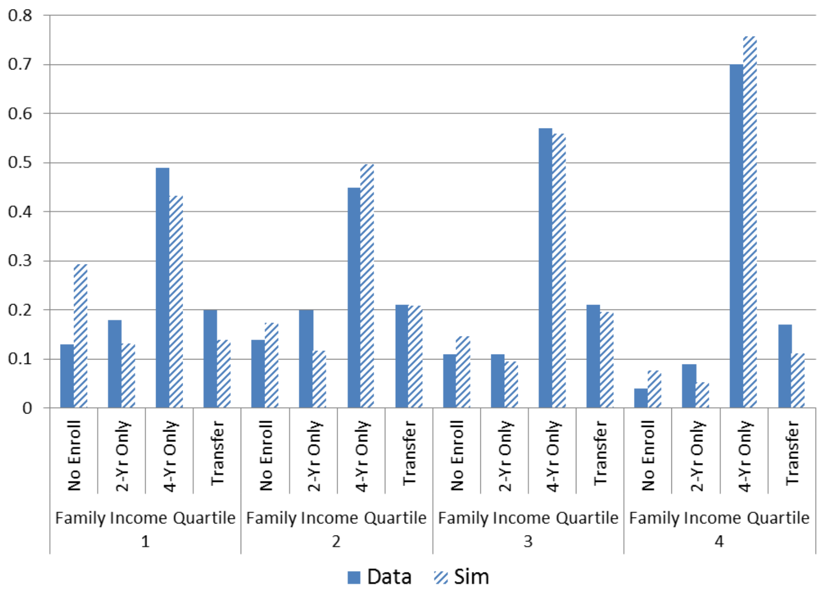


Figure 4: Two- or Four-Year College Distribution by Family Income, 800<SAT≤1200



colleges increases with the family income and the pattern is particularly obvious for the highest college quality quartile. The model is able to fit this data pattern reasonably well.

Figure 5: Two- or Four-Year College Distribution by Family Income, SAT>1200

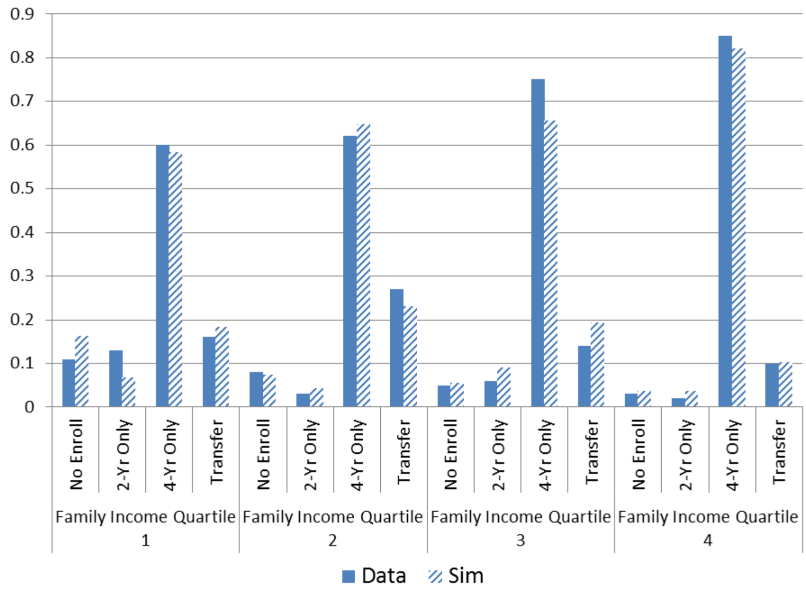


Figure 6: College Quality Distribution by Family Income, SAT≤800

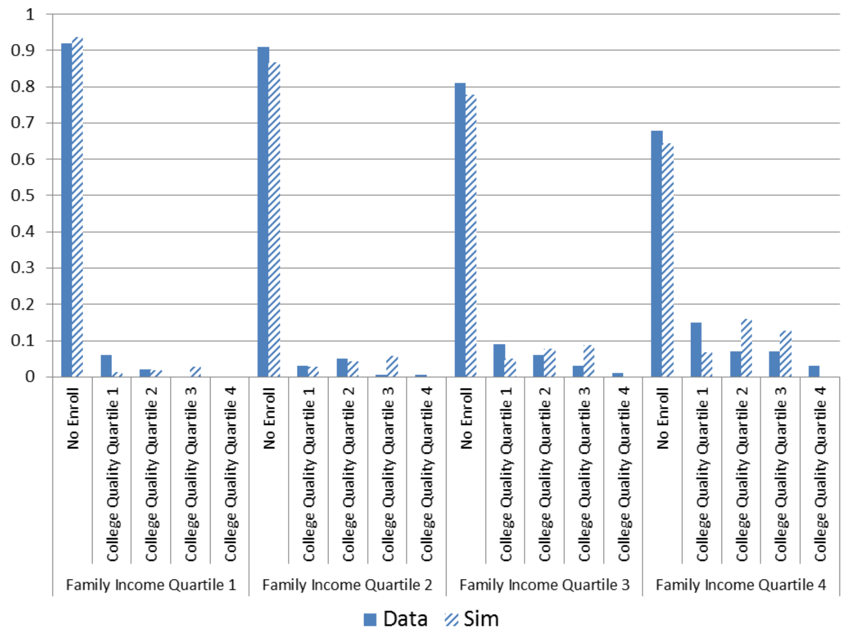


Figure 9 and Figure 10 show the match of the enrollment patterns in 4-year and 2-year college over time. For 4-year college, the model can capture the stable enrollment rate in the first 4 years and the steep drop in the fifth year. However, it underpredicts

Figure 7: College Quality Distribution by Family Income, 800<SAT≤1200

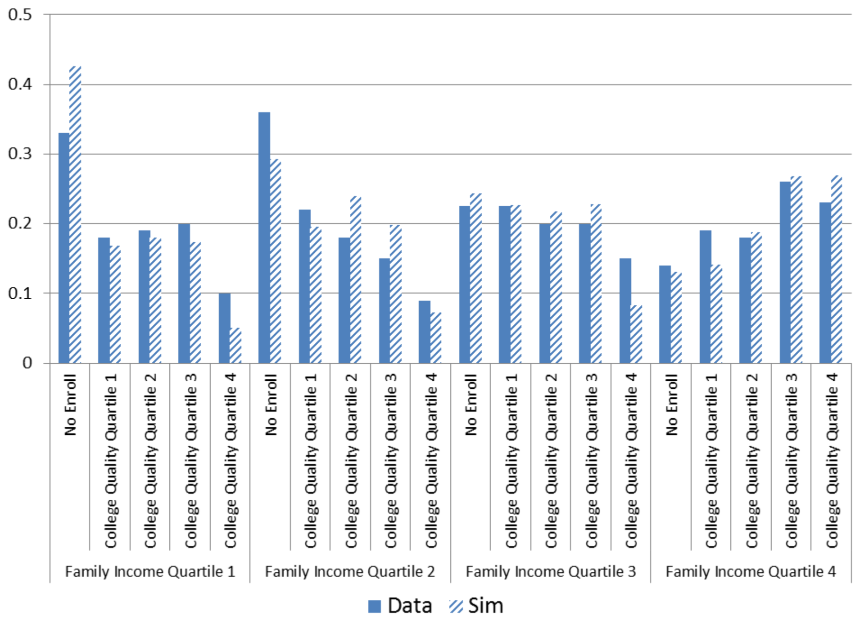
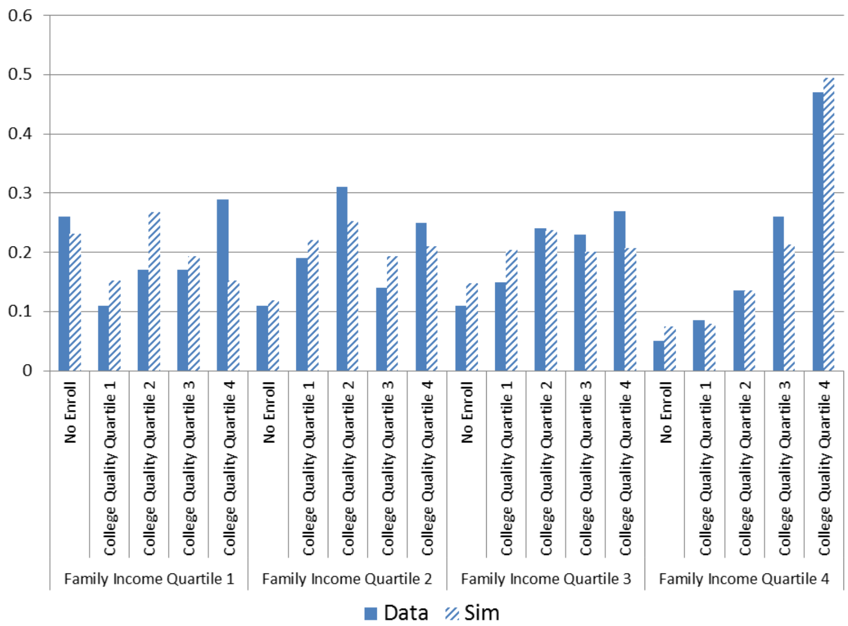


Figure 8: College Quality Distribution by Family Income, SAT>1200



the enrollment in later years. For 2-year colleges the model can replicate the declining pattern in the data but it overpredicts the enrollment in the first year and generates a lower level in later-year enrollment than the data. The reason why model estimates could not easily adjust to generate higher 2-year college enrollment in later periods is because the model already overpredicts the fraction of individuals with an associate degree in the population, as shown in Table 10.

Figure 9: Enrollment in 4-Year Colleges Over Time

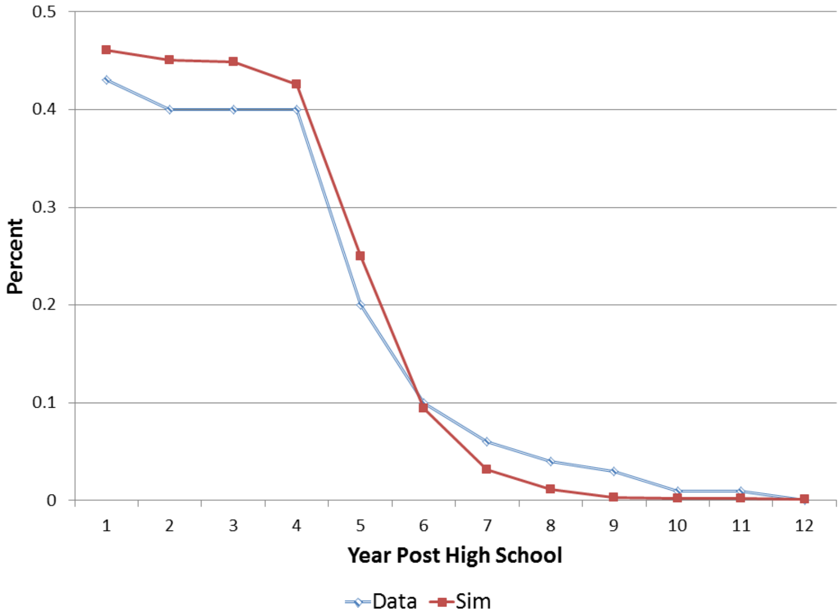


Figure 10: Enrollment in 2-Year Colleges Over Time

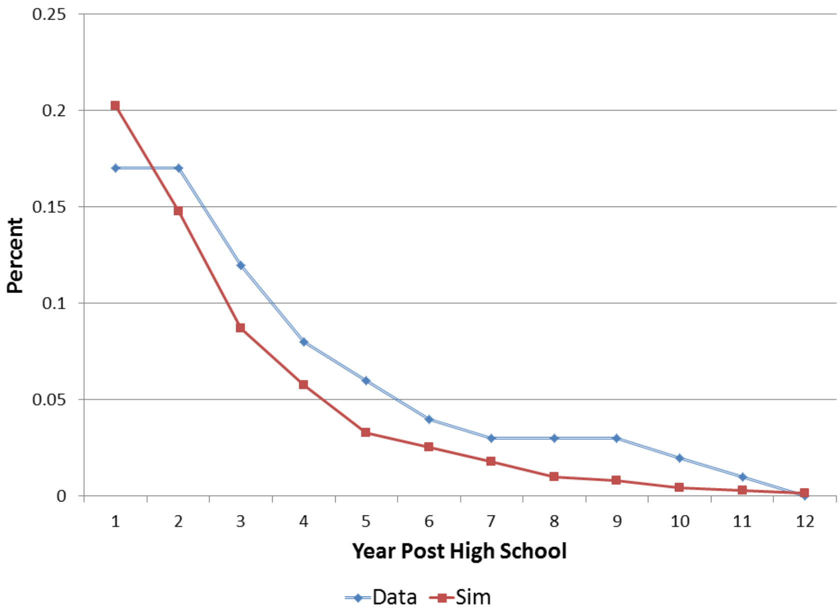


Table 10: Distribution of Education Attainment

	Data	Sim
High School Dropouts	0.16	0.16
High School Graduates	0.45	0.44
Associate Degree	0.07	0.09
Bachelor's Degree	0.32	0.31

I show in Table 11 the 4-year college completion rate by family income, and by college quality levels. The fraction of students who obtained a Bachelor's Degree increases with the family income quartile. Among those who enrolled in 4-year colleges, the graduation rate is also increasing with college quality level. The model is able to capture these patterns. However, the model underpredicts the graduation rate at the lowest college quality quartile but overpredicts the rate for the highest college quality quartile.

Table 11: Fraction with Bachelor's Degree

	Data %	Sim %
Family Income		
Quartile 1	58	50
Quartile 2	62	60
Quartile 3	66	68
Quartile 4	76	84
College Quality		
Quartile 1	56	43
Quartile 2	69	66
Quartile 3	78	82
Quartile 4	81	91

In the data, the amount of time taken to finish a bachelor's degree is declining with family income and with the college quality level. The model can capture this pattern although it overestimates the time needed to graduate from the highest college quality (Table 12). In Table 13 I show that the model matches the decreasing trend in labor market experience in school by family income among the 4-year college graduates.

Table 12: Time to BA Degree (Years)

	Data	Sim
Family Income Quartile 1	4.93	4.79
Family Income Quartile 2	4.87	5.00
Family Income Quartile 3	4.75	4.80
Family Income Quartile 4	4.72	4.78
College Quality Quartile 1	5.00	4.95
College Quality Quartile 2	4.92	4.88
College Quality Quartile 3	4.83	4.89
College Quality Quartile 4	4.42	4.58

Table 13: Average Years Worked by BA Graduation

	Data	Sim
Family Income Quartile 1	2.91	2.89
Family Income Quartile 2	2.88	2.89
Family Income Quartile 3	2.49	2.53
Family Income Quartile 4	1.97	1.99

The model matches the average cost of attendance by college types reasonably well. Table 15 shows the model also matches well the fraction that borrows student loan debt among 4-year college graduates.

Table 14: Mean Cost of Attendance by College Types

	Data	Sim
College Quality Quartile 1	$14,310	$14,260
College Quality Quartile 2	$15,060	$15,010
College Quality Quartile 3	$17,300	$18,000
College Quality Quartile 4	$20,800	$20,800
2-Year Colleges	$12,200	$11,800

The values are in 2006 constant dollars.

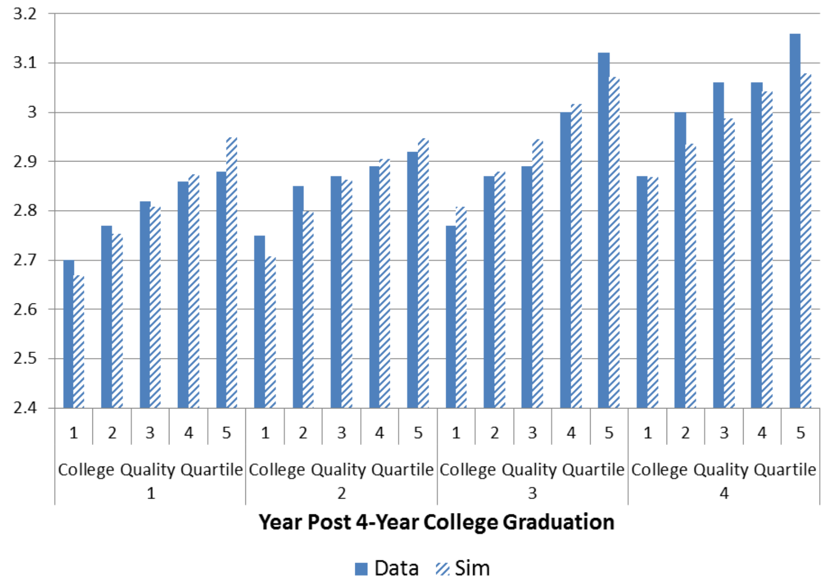
The last three figures in this section show the model fit of the wage patterns and overall labor supply. In Figure 11, the most important feature is that for any given year, the log hourly wages increases with college quality levels. The model can capture

Table 15: Fraction Borrowed by Family Income (BA Graduates)

	Data %	Sim %
Family Income Quartile 1	79	81
Family Income Quartile 2	81	79
Family Income Quartile 3	67	66
Family Income Quartile 4	42	44

this pattern. Figure 12 shows the log hourly wage is increasing in education levels, and the model matches the wage levels quite well. In the data, the fraction of individuals working full time is increasing while the part time workers get less over time. Figure 13 shows that the model can generate this feature.

Figure 11: Log Hourly Wages By College Quality Post 4-Year College Graduation



6.3 Understanding College Completion

The estimation results show that working negatively affects college completion rate while attending a college of better quality tends to lead to a higher completion rate. To

Figure 12: Log Hourly Wages By Education

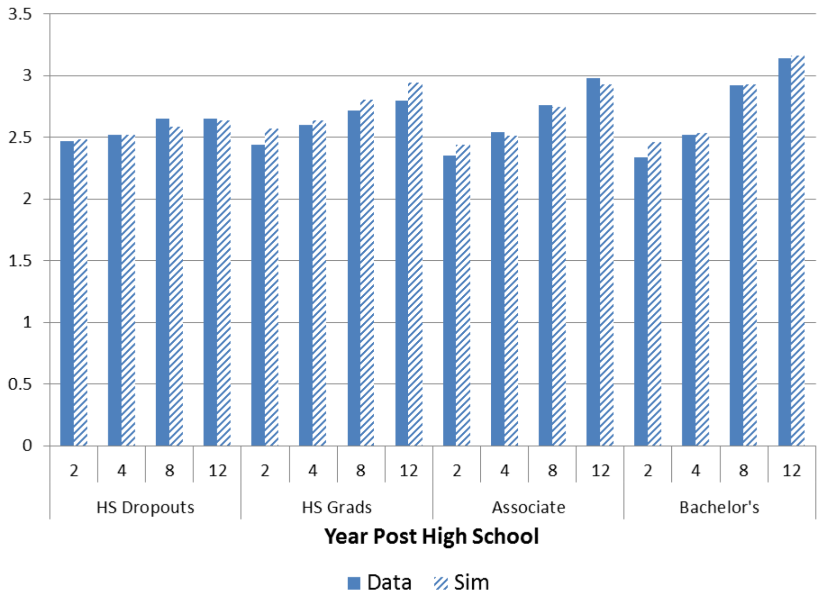
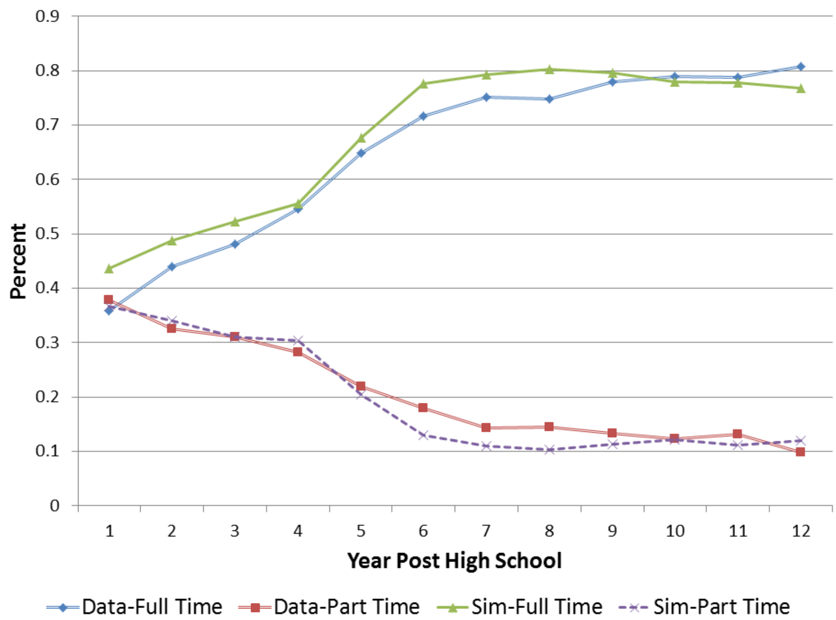


Figure 13: Part- and Full-time Employment Over time



understand how the gap in the college completion rate between the lowest and highest family income quartile is affected by these two channels, I turn off each channel at a time and re-solve the model. The results are shown in Table 16. The first column shows that in the baseline the gap is 34.0 percentage points between family income quartile 1 and quartile 4. When working in school does not affect schooling accumulation, the college completion rate goes up by 22.8 percentage points for students from family income quartile 1 while it only rises by 8.4 percentage points for students in quartile 4. It therefore reduces the difference in college completion rate between students from the lowest and highest family income quartile. On the other hand, when there is no effect of college quality on schooling accumulation probabilities, the gap in college completion rate widens as shown in the third column of Table 16. Students from family income quartile 1 are more likely to drop out whereas students in quartile 4 are not too responsive to changes in the schooling accumulation rate. The results indicate that there are two important ways to bring down the discrepancy in the college completion rate across family income levels. One way is to reduce the amount of time students from low-income families spend working while in college. The other way is to encourage low-income students to attend better quality colleges as their dropout decisions are more sensitive to the schooling accumulation probabilities.

Table 16: Bachelor's Degree Completion Rate

	Baseline	No Effect of Working	No Effect of College Quality
	(1)	(2)	(3)
Family Income Q1	50.0	72.8	38.4
Family Income Q4	84.0	92.4	76.5
Gap between Q1 and Q4	34.0	19.6	38.1

7 Counterfactual Analysis

Using the estimated model, I conduct counterfactual experiments to study the implications of different policies. First, I look at a free community college plan. Second, I examine the Pay As You Earn repayment plan that was recently implemented in the US. Third, I analyze a hypothetical loan forgiveness plan. In this section I first describe these policy measures and their implementations in the model. Then I present the effects of each policy change on educational outcomes and labor supply behavior. After that, I discuss how each policy affects lifetime earnings and its fiscal cost. Finally, I evaluate the welfare implications of these policies.

7.1 The Policy Plans

7.1.1 Free Community College Plan

The free community college plan was proposed by President Obama in the 2015 State of the Union Address. The goal of the government is to increase the total number of college graduates and reduce the amount of student loan debt students have to borrow to finance their education. I implement this plan in the model by setting the tuition for community college to zero.

7.1.2 Pay As You Earn Repayment Plan (PAYE)

PAYE is a new repayment option which was signed into law in the US at the end of 2012. There are three major differences between the standard repayment plan in the baseline and the Pay As You Earn Plan. First, in the standard repayment plan, an individual pays a fixed amount each year. In the PAYE plan, the repayment amount is linked to the annual income in that year. Specifically, the amount of repayment is 10% of the discretionary income, which is defined as the amount of the annual gross income above 150% of the poverty line. I calibrate the poverty line to the single household poverty threshold in the 2000s, which is $\$10,000$ in 2006 constant dollars. Moreover, the period repayment is capped by what they would have paid in the standard repayment plan. Second, the repayment period is 10 years for the standard repayment plan. In the new plan, the maximum repayment period is extended to 20 years. Third, under the standard repayment plan, everyone has to repay the full amount they owe. In contrast, the new repayment plan forgives the remaining debt at the end of the 20th repayment period. The new repayment plan effectively makes student loan debt cheaper by insuring individuals against bad income shocks and partially forgiving the debt balance.

7.1.3 Loan Forgiveness Plan

The loan forgiveness plan is not a policy implemented in reality so far. It is motivated by the fact that the college completion rate is low and college dropouts are burdened with a sizable amount of debt without enjoying the degree premium. When individuals take into account the possibility that they may not finish college, some of them will not even attempt to enroll. In other words, the student loan debt is most costly for college dropouts and consequently individuals may be discouraged to try out the college experience. In this experiment, if an individual does not have a bachelor's degree or associate degree by age 30, his debt is forgiven at that time.[13] For an individual who successfully completes a degree, the student loan debt is repaid according to the standard repayment plan.

[13] In the model no agent can go to school after age 30, so by this age the policy maker is sure if an individual is a dropout or finished college.

7.2 Education Outcomes and Labor Supply

7.2.1 Free Community College

The results of this policy are presented in Table 17. Under this policy, the enrollment rate into 2-year colleges substantially increases for all family income groups, with the strongest rise occurring in the lowest two family income quartiles. There are two major reasons why the 2-year college enrollment is so responsive to the policy. The first reason is that individuals do not have to pay tuition when they enroll in 2-year college. This is particularly appealing to individuals from low-income families who were unwilling to enroll in any college before. Second, compared to 4-year colleges, the psychic cost of 2-year college is significantly lower and the utility cost of working in 2-year college is also lower. Therefore, even the tuition for 2-year colleges is already low before the policy is implemented, only around \$3,000 per year, waiving the tuition goes a long way in getting individuals into 2-year colleges.

However, this plan negatively affects the enrollment in 4-year colleges. Table 17 shows that the enrollment rate into 4-year colleges uniformly declines under the reform. As 2-year colleges become even cheaper compared to 4-year colleges, individuals who are financially constrained are more likely to move away from 4-year colleges to 2-year colleges. For lower income students, the fraction of those enrolled in the top two college quality levels are higher than before. This indicates that most of the substitution from 4-year colleges to 2-year colleges occurs for students originally enrolled in low quality 4-year colleges in the baseline.

Overall, the average education level is higher after the reform, with the fraction of people receiving an associate degree going from 9.2% to 16.4%. This substantial increase in the number of associate degree holders comes from two main sources. First, there are more people enrolled in 2-year colleges. Second, conditional on being a student at a 2-year college, an individual is less likely to drop out when he fails to complete a year of schooling. Since there is no tuition at 2-year colleges, students have a higher tendency to enroll until they finish their degree. Another related reason is that, students tend to work less in 2-year colleges as they have less financial needs to fulfill. As a result, students can spend more time studying which gives them a higher chance of passing the classes.

In contrast to the surge in the number of individuals with an associate degree, there are fewer individuals that get a bachelor's degree. The fraction of the population with this degree falls from 31.1% to 28.3%, a result of both a lower enrollment rate into 4-year colleges and a lower degree completion rate conditional on enrollment. The reduction in the degree completion mainly occurs for students in the bottom family income quartiles.

7.2.2 Pay As You Earn

Table 18 summarizes the effects of this policy on education outcomes and labor supply. In terms of college enrollment, Table 18 shows that this plan mainly affects the enrollment of individuals in the bottom two family income quartiles. For them, both the 4-year and 2-year enrollment rates go up. Compared to the low-income students, the enrollment rate into either 4-year of 2-year colleges for individuals from the highest family income quartile barely changes. The reason why individuals from less wealthy families show a stronger response in enrollment is that they are more reliant on student loan debt to finance their college attendance. As a result, a reduction in the cost of student loans is more beneficial to these agents. If we compare the change in the enroll-

Table 17: Effect of Free Community College Plan on Education Outcomes and Labor Supply

	Baseline	Reform	Percentage Change
Fraction Enrolled in 2-Year Colleges			
Family Income Quartile 1	0.380	0.550	44.7%
Family Income Quartile 2	0.433	0.604	39.5%
Family Income Quartile 3	0.387	0.533	37.7%
Family Income Quartile 4	0.249	0.340	36.5%
Fraction Enrolled in 4-Year Colleges			
Family Income Quartile 1	0.311	0.280	-10.0%
Family Income Quartile 2	0.409	0.383	-6.4%
Family Income Quartile 3	0.539	0.506	-6.1%
Family Income Quartile 4	0.742	0.709	-4.4%
Fraction In Top 2 College Quality Levels			
Family Income Quartile 1	0.400	0.420	5.0%
Family Income Quartile 2	0.420	0.425	1.2%
Family Income Quartile 3	0.398	0.389	-2.2%
Family Income Quartile 4	0.596	0.595	-0.2%
Fraction Completed Bachelor's Degree			
Family Income Quartile 1	0.502	0.464	-7.6%
Family Income Quartile 2	0.600	0.539	-10.2%
Family Income Quartile 3	0.678	0.639	-5.8%
Family Income Quartile 4	0.837	0.837	-0.0%
Fraction Completed Associate Degree			
Family Income Quartile 1	0.238	0.294	23.5%
Family Income Quartile 2	0.280	0.344	22.9%
Family Income Quartile 3	0.350	0.431	23.1%
Family Income Quartile 4	0.409	0.509	24.4%
Distribution of Education Degree			
High School Dropouts	0.158	0.152	-3.8%
High School Graduates	0.439	0.401	-8.7%
Associate Degree	0.092	0.164	78.3%
Bachelor's Degree	0.311	0.283	-9.0%

ment rate in 4-year colleges and in 2-year colleges, we see that the plan is more effective in getting more individuals into 4-year colleges. This is mainly because 4-year colleges are more expensive than 2-year colleges. When student loans become cheaper, students are more likely to take this opportunity to enroll in 4-year colleges.

Besides encouraging more students to enroll in college, the plan also enables students to attend higher quality colleges. For students in the bottom family income quartile, the fraction of them who enrolls in top two college quality levels rises by 3.5%. The college outcomes are also improved. When student loan debt becomes effectively cheaper, students are more willing to borrow student loan debt. Consequently, they work less in school to fulfill their consumption needs. As students are more likely to enroll in higher quality colleges which tend to increase the college completion rate and students invest more time to study, the overall college completion rate in the population goes up. The time it takes to complete a bachelor's degree also mildly declines.

7.2.3 Loan Forgiveness

Table 19 presents the results of this plan. Under this plan, the enrollment rate into both 4-year colleges and 2-year colleges uniformly increases across all family income groups with most of the increase concentrated in the lower family income quartiles. The fraction of students enrolled in top two college quality levels falls because there are more students enrolled compared to the baseline and these individuals are more likely to go to lower quality schools.

Although more individuals are enrolled in college, the degree completion rate in both 4-year colleges and 2-year colleges plummets. The completion rate of the bachelor's degree goes down and the lower the family income the larger the drop in the completion

Table 18: Effect of Pay As You Earn Plan on Education Outcomes and Labor Supply

	Baseline	Reform	Percentage Change
Fraction Enrolled in 2-Year Colleges			
Family Income Quartile 1	0.380	0.401	5.5%
Family Income Quartile 2	0.433	0.449	3.7%
Family Income Quartile 3	0.387	0.392	1.3%
Family Income Quartile 4	0.249	0.249	0.0%
Fraction Enrolled in 4-Year Colleges			
Family Income Quartile 1	0.311	0.337	8.4%
Family Income Quartile 2	0.409	0.435	6.4%
Family Income Quartile 3	0.539	0.554	2.8%
Family Income Quartile 4	0.742	0.751	1.2%
Fraction In Top 2 College Quality Levels			
Family Income Quartile 1	0.400	0.414	3.5%
Family Income Quartile 2	0.420	0.428	1.9%
Family Income Quartile 3	0.398	0.400	0.5%
Family Income Quartile 4	0.596	0.603	1.2%
Fraction Completed Bachelor's Degree			
Family Income Quartile 1	0.502	0.531	5.8%
Family Income Quartile 2	0.600	0.606	1.0%
Family Income Quartile 3	0.678	0.698	2.9%
Family Income Quartile 4	0.837	0.847	1.2%
Fraction Completed Associate Degree			
Family Income Quartile 1	0.238	0.256	7.6%
Family Income Quartile 2	0.280	0.290	3.6%
Family Income Quartile 3	0.350	0.354	1.1%
Family Income Quartile 4	0.409	0.413	1.0%
Distribution of Education Degree			
High School Dropouts	0.158	0.156	-1.3%
High School Graduates	0.439	0.417	-5.0%
Associate Degree	0.092	0.099	7.6%
Bachelor's Degree	0.311	0.328	5.5%
Time to Bachelor's Degree			
Family Income Quartile 1	4.789	4.735	-1.1%
Family Income Quartile 2	5.004	4.990	-0.3%
Family Income Quartile 3	4.803	4.791	-0.2%
Family Income Quartile 4	4.782	4.770	-0.2%
Fraction Borrowed Student Loans by BA Graduation			
Family Income Quartile 1	0.814	0.923	13.4%
Family Income Quartile 2	0.791	0.869	9.9%
Family Income Quartile 3	0.660	0.775	17.4%
Family Income Quartile 4	0.440	0.521	18.4%
Average Years Worked by BA Graduation			
Family Income Quartile 1	2.892	2.733	-5.5%
Family Income Quartile 2	2.895	2.695	-6.9%
Family Income Quartile 3	2.531	2.376	-6.1%
Family Income Quartile 4	1.989	1.926	-3.2%

rate. There are two main reasons. One is that more students are enrolled in lower quality schools which make students less likely to graduate. The other reason is that all the student loan debt is forgiven if a student does not graduate which reduces the willingness to finish the degree if an agent already has a lot of debt. Compared to the change in the completion rate for the bachelor's degree, the completion rate for the associate degree declines even more. Since the degree premium is lower for the associate degree, a student with a sizable amount of debt has a smaller incentive to finish community college.

The disincentive to complete college outweighs the expansion of college students. As a result, the total number of college graduates falls under this policy. The plan, however, has two positive effects on other education outcomes. One is that it reduces the number of high school dropouts by 5.1%. The other one is that when an individual is enrolled in college, he spends less time working and takes less time to receive a bachelor's degree.

7.3 Lifetime Earnings

Income inequality is a serious issue in the US. In particular, the gap in income between the college educated and those without a college degree has been growing wider. Having college education has become the prerequisite for joining the middle class. The three counterfactual experiments all aim at making college more accessible, increase the number of people with college education and bring down income inequality. It is therefore important to assess how the distribution of lifetime earnings change under each policy.

Lifetime earnings are calculated as the present value of an individual's realized annual income in each period of the simulation. Annual income is the hourly wage times total hours worked. An individual who is not employed in a period has an annual income of zero.

Table 19: Effect of Loan Forgiveness Plan on Education Outcomes and Labor Supply

	Baseline	Reform	Percentage Change
Fraction Enrolled in 2-Year Colleges			
Family Income Quartile 1	0.380	0.507	33.4%
Family Income Quartile 2	0.433	0.522	20.5%
Family Income Quartile 3	0.387	0.427	10.3%
Family Income Quartile 4	0.249	0.261	4.8%
Fraction Enrolled in 4-Year Colleges			
Family Income Quartile 1	0.311	0.363	16.7%
Family Income Quartile 2	0.409	0.471	15.2%
Family Income Quartile 3	0.539	0.591	9.6%
Family Income Quartile 4	0.742	0.764	3.0%
Fraction In Top 2 College Quality Levels			
Family Income Quartile 1	0.400	0.388	-3.0%
Family Income Quartile 2	0.420	0.397	-5.5%
Family Income Quartile 3	0.398	0.374	-6.0%
Family Income Quartile 4	0.596	0.570	-4.4%
Fraction Completed Bachelor's Degree			
Family Income Quartile 1	0.502	0.344	-31.5%
Family Income Quartile 2	0.600	0.418	-30.3%
Family Income Quartile 3	0.678	0.548	-19.2%
Family Income Quartile 4	0.837	0.789	-5.7%
Fraction Completed Associate Degree			
Family Income Quartile 1	0.238	0.107	-55.0%
Family Income Quartile 2	0.280	0.161	-42.5%
Family Income Quartile 3	0.350	0.200	-42.9%
Family Income Quartile 4	0.409	0.317	-22.5%
Distribution of Education Degree			
High School Dropouts	0.158	0.150	-5.1%
High School Graduates	0.439	0.500	13.9%
Associate Degree	0.092	0.066	-28.3%
Bachelor's Degree	0.311	0.284	-8.7%
Time to Bachelor's Degree			
Family Income Quartile 1	4.789	4.620	-3.5%
Family Income Quartile 2	5.004	4.854	-3.0%
Family Income Quartile 3	4.803	4.658	-3.0%
Family Income Quartile 4	4.782	4.738	-0.9%
Fraction Borrowed Student Loans by BA Graduation			
Family Income Quartile 1	0.814	0.948	16.5%
Family Income Quartile 2	0.791	0.881	11.4%
Family Income Quartile 3	0.660	0.784	18.8%
Family Income Quartile 4	0.440	0.494	12.3%
Average Years Worked by BA Graduation			
Family Income Quartile 1	2.892	2.635	-8.9%
Family Income Quartile 2	2.895	2.632	-9.1%
Family Income Quartile 3	2.531	2.283	-9.8%
Family Income Quartile 4	1.989	1.908	-4.1%

Table 20 summarizes the distribution of lifetime earnings under the baseline as well as each policy experiment. Both the free community college and the Pay As You Earn plan increase the average lifetime earnings. This is due to the improved college outcomes as shown in the previous subsection. The median lifetime earnings under the free community college plan is lower compared to the baseline as some individuals substitute away from 4-year colleges. These individuals were mostly switching from lower quality 4-year colleges which has more effect on the median level than on the right tail of the distribution. The loan forgiveness plan reduces the mean lifetime earnings mainly because it gives individuals incentive not to finish their degree as in this case he does not need to repay his debt. Since less people get the degree premium, overall lifetime earnings decline.

I also compute three income ratios to measure the income inequality. 90-10 ratio refers to the ratio between the 90th percentile and the 10th percentile of the lifetime earnings. 50-10 ratio calculates the ratio between the 50th percentile and the 10th percentile and the 90-50 ratio divides the 90th and 50th percentile of the lifetime earnings. 50-10 ratio indicates the income inequality in the lower half of the distribution whereas 90-50 ratio measures the inequality in the upper half of the distribution. Comparing the three policies we see that the free community college plan achieves the lowest 50-10 ratio while the Pay As You Earn plan brings down 90-50 ratio the most. This suggests that free community college plan is more effective in reducing the income inequality for lower earning individuals. The Pay As You Earn plan, on the other hand, can be used to lower the income inequality for individuals on the higher end of the distribution.

Table 20: Distribution of Lifetime Earnings, in Thousands of Dollars

	Baseline (1)	Free Community College (2)	PAYE (3)	Loan Forgiveness (4)
Percentile				
1	443.1	443.3	443.3	443.0
5	530.2	531.5	531.4	531.3
10	629.0	630.5	632.1	630.4
50	1045.2	1037.8	1054.2	1041.3
90	2035.2	2041.3	2042.4	2027.2
Mean	1245.7	1246.8	1251.7	1240.5
Standard Deviation	556.7	560.3	557.3	559.1
90-10 ratio	3.24	3.24	3.23	3.22
50-10 ratio	1.66	1.64	1.67	1.65
90-50 ratio	1.95	1.97	1.93	1.95

7.4 The Fiscal Cost of the Policies

The total fiscal cost of the free community college plan is calculated as the present value of the total years enrolled in community colleges multiplied by the annual tuition. The total cost of the Pay As You Earn policy is the present value of the loan balance forgiven at the end of the 20th repayment period. For the loan forgiveness plan, the total cost is the present value of the loan amount forgiven for those without any degree (Associate or Bachelor's Degree). I show the fiscal cost of each policy as the annual cost per capita paid over the lifetime in Table 21. The PAYE plan is the cheapest among the three policies which would cost each individual only 17 dollars each year. The free community college plan is more expensive compared to the PAYE plan. Compared to the other two plans, the loan forgiveness is much more costly.

Table 21: Annual Cost Per Capita

Free Community College	\$62.7
Pay As You Earn	\$17.0
Loan Forgiveness	\$153.2

7.5 Welfare

While the change in lifetime earnings is one measure of the effectiveness of the policy, ultimately individuals make all their decisions to maximize their utility. Therefore we should look at the welfare effects of each policy to understand their desirability. To make all policies comparable in terms of welfare, the tax rate is adjusted under each policy to ensure a neutral government budget.[14] I use an aggregate welfare measure where each individual is equally weighted. The welfare gain is calculated as the annual lump-sum transfer to individuals in the baseline such that the utilitarian government would be indifferent between the new policy and the baseline.[15]

Table 22 summarizes the welfare effect of the three policies. We can see that all three policies improve welfare when the fiscal cost is accounted for. Among the policies, the Pay As You Earn plan leads to the highest welfare gain. There are three factors contributing to this. The first factor is that, as discussed earlier, this plan achieves the largest improvement over all college outcomes by increasing college enrollment in 4-year colleges, allowing students to attend better quality colleges, increasing college completion rate and reducing the time it takes to receive the degree. The second factor is that this plan is the least costly to the government. Finally, as the education level is higher, the total tax revenue generated under this policy is higher than that in the baseline.

[14]Note that the effects of all polices on college outcomes and lifetime earnings presented here derive from simulations that do not impose the cost of the policy on individuals. These results are qualitatively and largely quantitatively unaffected when the costs are imposed through tax changes.

[15]It is important to note that the timing of the transfer may affect the magnitude of the welfare gains. This is due to two main reasons. First, individuals are risk averse and their risk aversion differs across types. Second, in the model capital markets are incomplete and there are borrowing constraints. Therefore, poor and more risk averse individuals will, for example, gain relatively more from shifting to an initial one-time lump-sum transfer instead of the transfer given each period. In addition, the same factors also influence how much an agent values a given transfer.

The free community college plan gives rise to the second highest welfare gain. There are several reasons why the welfare gain is lower than that generated from the Pay As You Earn plan. Despite the fact that many more low-income individuals are now able to obtain community college education, the number of individuals with a bachelor's degree is lower. Moreover, the fiscal cost of this policy is higher as shown before compared to the Pay As You Earn plan. To finance the fiscal cost, the tax rate needs to be raised. Since the model features a progressive income taxation schedule, rich individuals bear more of the tax burden while not benefiting much from the policy as they are mostly enrolled in 4-year colleges. The loan forgiveness plan only mildly increases the welfare because it is the most expensive policy to finance and there is little improvement in education outcomes.

Table 22: Welfare Gains Per Year, in Dollars

Free Community College	\$12.5
Pay As You Earn	\$37.3
Loan Forgiveness	\$2.2

8 Conclusions

The US is falling behind in the college completion rate, ranking 19th out of the 28 OECD countries (OECD (2014)). There is a wide gap in the college enrollment rate and in the quality of colleges attended across family income levels. The majority of college students rely on student loan debt to finance college and the real dollar value of student loan debt is soaring. As a college degree has become a prerequisite to join the middle class, enhancing education outcomes for individuals, especially those from lower-income families, is a crucial way to reduce income inequality and raise average earnings in the US.

Motivated by these concerns, the Obama government has developed many policy initiatives. The goal of my paper is to understand the implications of various proposed or enacted tuition and student loan policies. I build and estimate a structural dynamic life-cycle model incorporating novel features that are necessary for policy evaluation. The estimated model addresses two concerns. First, I evaluate the effectiveness of the policies in improving college outcomes and lifetime earnings. Second, I estimate the fiscal costs of each policy and assess whether these policies are welfare-improving.

In terms of college outcomes, I find that the free community college plan leads to a significant increase in the community college enrollment rate for individuals from lower-income families. The plan, however, has a negative effect on both the four-year college enrollment and on the completion rate. The Pay As You Earn plan not only increases college enrollment but also enables students to attend higher quality colleges. The overall education level in the population increases as the fraction of individuals with a college degree goes up. The loan forgiveness plan for college dropouts encourages college enrollment but also discourages students from completing the degree.

All three polices are welfare-improving for a utilitarian government that maintains a neutral government budget. The Pay As you Earn plan generates the highest welfare gain and the free community college plan ranks the second. The Pay As You Earn plan leads to the largest improvement in the quality of the college attended and four-year college completion rate. It brings down earnings inequality among higher-earning individuals.[16] The free community college plan is the most effective in terms of improving

[16]Here, earnings inequality refers to the ratio between the 90th and 50th percentile of the lifetime

college outcomes for lower-income students and reducing earnings inequality in the lower half of the lifetime earnings distribution.[17] The two policies are complementary and combining elements from each of them could yield an even higher social welfare.

The focus of my paper is on understanding the effects of policies that aim to reduce the financial cost of attending college, either by providing upfront subsidies, or by reducing the cost of student loan debt repayment after university. Therefore, I abstract from channels that might be important for analyzing other aspects of government intervention in the higher education market. To pick a particular case, recent papers have found that an important reason as to why low-income and high-achieving individuals do not apply to higher quality colleges is a lack of information about the available financial aids. For example, Hoxby, Turner, et al. (2013) find that low-cost government interventions that provide students with more information lead low-income and high-achieving students to apply and be admitted to more higher-quality colleges. In my model, the lack of information for certain groups of individuals is captured by stochastic variations in preferences. While this is not a first-order concern for the type of reforms I am studying in the current paper, a comprehensive bundle of educational reforms should also address the issues linked to information frictions or potential behavioral biases. Studying the design and effects of such policies in a structural framework is left for future work.

earnings.

[17]Earnings inequality here refers to the ratio between the 50th and 10th percentile of the lifetime earnings.

9 Appendix

9.1 Utility Function

$$
\begin{aligned}
U_t = & \delta_s \frac{c_t^{1-\sum_{k=1}^{2}\alpha_k I(\text{type}=k)}}{1-\sum_{k=1}^{2}\alpha_k I(\text{type}=k)} \\
& + \underbrace{\sum_{k=1}^{2} I(\text{type}=k)\Big(\mu_w^k\big(I(h_t=0.5)+\kappa_w^k I(h_t=1)\big)+\epsilon_{w^1}^k I(h_t=0.5)+\epsilon_{w^2}^k I(h_t=1)\Big)}_{\text{Disutility of Working } (<0)} \\
& + \underbrace{\sum_{k=1}^{2} I(\text{type}=k)\Big(\lambda_6^k t I(h_t=0.5)+\lambda_7^k t I(h_t=1)\Big)}_{\text{Disutility of Working } (<0)} \\
& + \underbrace{\sum_{k=1}^{2} I(\text{type}=k)\Big(\big(\lambda_1^k I(h_t=0.5)+\lambda_2^k I(h_t=1)\big) I(s_t^u=1)\Big)}_{\text{Disutility of Working in 4-Year College } (<0)} \\
& + \underbrace{\sum_{k=1}^{2} I(\text{type}=k)\Big(\big(\lambda_3^k I(h_t=0.5)+\lambda_4^k I(h_t=1)\big) I(s_t^c=1)\Big)}_{\text{Disutility of Working in 2-Year College } (<0)} \\
& + \underbrace{(\sum_{k=1}^{2} I(\text{type}=k)\Big(\mu_{\text{hs}}^k+\epsilon_{\text{hs}}^k\Big) I(s^{\text{hs}}=1) I(t=1)}_{\text{Preference for High School}} \\
& + \underbrace{\sum_{k=1,q=1}^{2,4} (\mu_{\text{cq}}^{k,q}+\epsilon_{\text{cq}}^k) I(\text{type}=k,\text{Q}=q)}_{\text{Preference for College Quality}} \\
& + \underbrace{\sum_{k=1}^{2} I(\text{type}=k)\Big((\mu_{\text{ec}}^{u,k,1}+\sum_{m=2}^{3}\mu_{\text{ec}}^{u,k,m} I(\text{SAT}=m)+\epsilon_{\text{ec}}^{u,k})+\lambda_8^k t I(t>6)\Big) I(s_t^u=1)}_{\text{Psychic Cost of Schooling } (<0)} \\
& + \underbrace{\sum_{k=1}^{2} I(\text{type}=k)\Big(\mu_{\text{ec}}^{c,k}+\epsilon_{\text{ec}}^{c,k}+\lambda_9^k t I(t>3)\Big) I(s_t^c=1)}_{\text{Psychic Cost of Schooling } (<0)} \\
& + \underbrace{\sum_{k=1,i=u,c}^{2} I(\text{type}=k)\Big(\mu_{\text{mv}}^{i,k} I(s_{t-1}^i \neq 1, s_t^i=1, t>2)\Big)}_{\text{Psychic Cost of Schooling } (<0)} \\
& + \underbrace{\sum_{k=1}^{2} I(\text{type}=k)\Big(\mu_{\text{tran}}^k I(s_{t-1}^c=1, s_t^u=1, t>2)\Big)}_{\text{Psychic Cost of Schooling } (<0)}
\end{aligned}
$$

where $\delta_s = 1$ if an individual is not enrolled in college, $\delta_s = \delta_{s_1}$ if $s_t^u = 1$, and $\delta_s = \delta_{s_2}$ if $s_t^c = 1$. α_k is the constant relative risk aversion parameter which differs by the unobserved type. Including the unobserved type in the utility function allows for permanent unobserved heterogeneity in preferences for work and college choices. All the shocks are assumed to follow a normal distribution: (i) $\epsilon^k_{\text{hs}} \sim N(0,(\sigma^k_{\text{hs}})^2), k = \{1,2\}$, (ii) $\epsilon^k_{\text{cq}} \sim N(0,(\sigma^k_{\text{cq}})^2), k = \{1,2\}$, (iii) $\epsilon^{i,k}_{\text{ec}} \sim N(0,(\sigma^{i,k}_{\text{ec}})^2), i = \{u,c\}, k = \{1,2\}$, (iv) $\epsilon^k_{w^i} \sim N(0,(\sigma^k_{w^i})^2), i = \{1,2\}, k = \{1,2\}$.

9.2 Parameter Estimates

Table 23: Parameter Estimates

Utility							
μ_w^1	κ_w^1	λ_6^1	λ_7^1	μ_w^2	κ_w^2	λ_6^2	λ_7^2
-0.0800	3.0000	0.0100	0.0100	-0.0126	2.8096	0.0000	5.97E-6
(0.00005)	(0.0203)	(0.0003)	(0.0010)	(2.07E-7)	(0.0021)	(4.31E-6)	(6.47E-7)
$\mu_{\text{mv}}^{u,1}$	$\mu_{\text{mv}}^{c,1}$	μ_{tran}^1	λ_8^1	λ_9^1	$\mu_{\text{mv}}^{u,2}$	$\mu_{\text{mv}}^{c,2}$	μ_{tran}^2
-0.3380	-0.1921	-0.2500	-0.0300	-0.0200	-0.0400	-0.0005	-0.0000
(0.0012)	(0.0026)	(0.0015)	(8.55E-5)	(0.0001)	(0.0002)	(3.15E-5)	(1.52E-5)
λ_8^2	λ_9^2	δ_{s_1}	δ_{s_2}	$c_{\text{App}}^{1,1}$	$c_{\text{App}}^{2,1}$	$c_{\text{App}}^{1,1}$	$c_{\text{App}}^{2,1}$
-0.0009	-0.0005	0.60000	0.8000	0.0622	0.0058	0.0025	0.0015
(3.50E-6)	(7.95E-6)	(9.93E-5)	(0.0002)	(0.0007)	(2.23E-5)	(0.0011)	(3.23E-5)
μ_{hs}^1	μ_{hs}^2						
-0.9700	0.4643						
(0.0126)	(0.0042)						
Family Transfer							
γ_1	γ_2	γ_3	γ_4^1	γ_4^2	γ_4^3	γ_4^4	γ_5
1.0510	0.0164	1.0000	0.0750	0.0750	0.1000	0.1300	0.5000
(0.0104)	(3.69E-6)	(0.0030)	(5.73E-5)	(5.63E-5)	(5.10E-5)	(4.76E-5)	(0.0062)
γ_6	γ_7	γ_8	γ_9^1	γ_9^2	γ_{10}		
0.0300	0.0150	-0.0120	0.8500	0.5000	-0.1300		
(7.5E-5)	(0.0005)	(0.0030)	(0.0050)	(0.0030)	(0.0020)		
Net Cost of Attendance							
$\mu_{Q_1}^{1,1}$	$\mu_{Q_2}^{1,1}$	$\mu_{Q_3}^{1,1}$	$\mu_{Q_4}^{1,1}$	$\mu_{Q_1}^{1,2}$	$\mu_{Q_2}^{1,2}$	$\mu_{Q_3}^{1,2}$	$\mu_{Q_4}^{1,2}$
2.6188	2.7700	2.8500	3.1211	-0.0000	-0.0266	-0.0902	-0.0000
(0.0021)	(0.0024)	(0.0009)	(0.0023)	(0.0011)	(0.0012)	(0.0021)	(0.0020)
$\mu_{Q_1}^{1,3}$	$\mu_{Q_2}^{1,3}$	$\mu_{Q_3}^{1,3}$	$\mu_{Q_4}^{1,3}$	$\mu_{Q_5}^{1,1}$	$\mu_{Q_1}^2$	$\mu_{Q_2}^2$	$\mu_{Q_3}^2$
-0.0266	-0.1000	-0.2000	-0.3000	2.5147	0.0006	0.0000	0.0010
(0.0086)	(0.0029)	(0.0038)	(0.0010)	(6.07E-5)	(4.45E-7)	(3.41E-7)	(3.67E-7)
$\mu_{Q_4}^2$							
0.0005							
(3.32E-7)							
Admissions Probabilities							
$g_{\text{Adm},1}^{0,1}$	$g_{\text{Adm},2}^{0,1}$	$g_{\text{Adm},3}^{0,1}$	$g_{\text{Adm},4}^{0,1}$	$g_{\text{Adm},1}^{0,2}$	$g_{\text{Adm},2}^{0,2}$	$g_{\text{Adm},3}^{0,2}$	$g_{\text{Adm},4}^{0,2}$
0.9803	1.0000	0.8200	-1.6203	0.8000	0.4355	0.7000	-2.2000
(0.0438)	(0.0282)	(0.0379)	(0.0219)	(0.0064)	(0.0104)	(0.0178)	(0.0142)
$g_{\text{Adm},1}^{1}$	$g_{\text{Adm},2}^{1}$	$g_{\text{Adm},3}^{1}$	$g_{\text{Adm},4}^{1}$	$g_{\text{Adm},1}^{2}$	$g_{\text{Adm},2}^{2}$	$g_{\text{Adm},3}^{2}$	$g_{\text{Adm},4}^{2}$
0.4000	0.4000	0.2012	2.1944	0.4000	0.7000	0.4668	3.0000
(0.0151)	(0.0147)	(0.0278)	(0.0707)	(0.0463)	(0.0177)	(0.0279)	(0.0246)
Accumulation of Experience							
χ_{HD}^0	χ_{HD}^1	χ_{HD}^2	χ_s^u	χ_s^c			
0.3000	0.7000	0.8000	0.5000	0.7000			
(0.0004)	(8.52E-5)	(0.0005)	(0.0007)	(0.0014)			

Table 24: Parameter Estimates, Continued

Type Distribution							
π_0	π_1	π_2	π_3				
1.6000	-0.0178	-0.3000	-0.2000				
(0.0030)	(3.53E-6)	(0.0050)	(0.0114)				
Shocks							
σ^1_{hs}	σ^2_{hs}	σ^1_{cq}	σ^2_{cq}	$\sigma^1_{w^1}$	$\sigma^1_{w^2}$	$\sigma^2_{w^1}$	$\sigma^2_{w^2}$
0.0232	0.0148	0.2500	0.0300	0.1800	0.1736	0.0030	0.0007
(0.0230)	(0.0029)	(0.0013)	(3.68E-5)	(0.0010)	(0.0004)	(1.05E-5)	(4.40E-6)
$\sigma^{u,1}_{\mathrm{ec}}$	$\sigma^{c,1}_{\mathrm{ec}}$	$\sigma^{u,2}_{\mathrm{ec}}$	$\sigma^{c,2}_{\mathrm{ec}}$	σ_ϵ	$\underline{z}$	$\bar{z}$	z_p
0.2500	0.1250	0.0125	0.0180	0.2000	0.7989	1.1989	0.9500
(0.0003)	(0.0004)	(3.30E-6)	(3.03E-6)	(0.0003)	(0.0003)	(0.0006)	(0.0001)
σ_{Q_1}	σ_{Q_2}	σ_{Q_3}	σ_{Q_4}	σ_{Q_5}	σ_{tr}		
0.0314	0.1000	0.1000	0.1000	0.1000	2.0000		
(0.0008)	(0.0007)	(0.0007)	(0.0010)	(0.0008)	(0.0025)		

Bibliography

Abbott, B., G. Gallipoli, C. Meghir, and G. L. Violante (2013): "Education policy and intergenerational transfers in equilibrium," Working paper, National Bureau of Economic Research.

Aizawa, N., and H. Fang (2013): "Equilibrium labor market search and health insurance reform," Working paper, National Bureau of Economic Research.

Akyol, A., and K. Athreya (2005): "Risky higher education and subsidies," *Journal of Economic Dynamics and Control*, 29(6), 979–1023.

Belley, P., and L. Lochner (2007): "The Changing Role of Family Income and Ability in Determining Educational Achievement," *Journal of Human Capital*, 1(1), 37–89.

Black, D., J. Smith, and K. Daniel (2005): "College quality and wages in the United States," *German Economic Review*, 6(3), 415–443.

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

——— (2006): "Estimating the returns to college quality with multiple proxies for quality," *Journal of Labor Economics*, 24(3), 701–728.

Bowen, W. G., M. M. Chingos, and M. S. McPherson (2009): "Crossing the finish line," *Chapter*, 8, 149–165.

Cahalan, M., and L. Perna (2015): "Indicators of higher education equity in the United States," *Pell Institute for the Study of Opportunity in Higher Education*.

Cameron, S. V., and J. J. Heckman (1998): "Life Cycle Schooling and Dynamic Selection Bias: Models and Evidence for Five Cohorts of American Males," *Journal of Political Economy*, 106(2), 262–333.

——— (2001): "The dynamics of educational attainment for black, hispanic, and white males," *Journal of political Economy*, 109(3), 455–499.

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

Carneiro, P., and J. J. Heckman (2002): "The Evidence on Credit Constraints in Post-Secondary Schooling," *The Economic Journal*, 112(482), 705–734.

Dale, S. B., and A. B. Krueger (2002): "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.

Federal Reserve Bank of New York (Q2,2015): "Quarterly Report on Household Debt and Credit," .

Garriga, C., and M. P. Keightley (2007): "A General Equilibrium Theory of College with Education Subsidies, In-School Labor Supply, and Borrowing Constraints," *Federal Reserve Bank of St. Louis Working Paper Series*, (2007-051).

Hendricks, L., and O. Leukhina (2014): "The Return to College: Selection Bias and Dropout Risk," *CFS Working Paper*.

Hoekstra, M. (2009): "The effect of attending the flagship state university on earnings: A discontinuity-based approach," *The Review of Economics and Statistics*, 91(4), 717–724.

Hoxby, C., S. Turner, et al. (2013): "Expanding college opportunities for high-achieving, low income students," *Stanford Institute for Economic Policy Research Discussion Paper*, (12-014).

Ionescu, F. (2009): "The federal student loan program: Quantitative implications for college enrollment and default rates," *Review of Economic Dynamics*, 12(1), 205–231.

——— (2011): "Risky human capital and alternative bankruptcy regimes for student loans," *Journal of Human Capital*, 5(2), 153–206.

Ionescu, F. A. (2008): "Consolidation of student loan repayments and default incentives," *The BE Journal of Macroeconomics*, 8(1).

Joensen, J., and E. Mattana (2014): "Student aid, academic achievement, and labor market behavior: grants or loans?," in *2014 Meeting Papers*, no. 707. Society for Economic Dynamics.

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

Kaplan, G. (2012): "Inequality and the life cycle," *Quantitative Economics*, 3(3), 471–525.

Keane, M. P., and K. I. Wolpin (2001): "The effect of parental transfers and borrowing constraints on educational attainment," *International Economic Review*, pp. 1051–1103.

Kinsler, J., and R. Pavan (2011): "Family income and higher education choices: The importance of accounting for college quality," *Journal of human capital*, 5(4), 453–477.

Lochner, L., and A. Monge-Naranjo (2011a): "Credit constraints in education," Working paper, National Bureau of Economic Research.

——— (2015): "Student Loans and Repayment: Theory, Evidence and Policy," Working paper, National Bureau of Economic Research.

Lochner, L. J., and A. Monge-Naranjo (2011b): "The Nature of Credit Constraints and Human Capital," *The American Economic Review*, pp. 2487–2529.

OECD (2014): "Education at a Glance 2014: OECD Indicators," *OECD Publishing*.

Russo, D. M. (2011): "Two-year college enrollment and educational attainment," Working paper.

Smith, J., M. Pender, and J. Howell (2013): "The full extent of student-college academic undermatch," *Economics of Education Review*, 32, 247–261.

Stinebrickner, R., and T. Stinebrickner (2008): "The Effect of Credit Constraints on the College Drop-Out Decision: A Direct Approach Using a New Panel Study," *American Economic Review*, 98(5), 2163–84.