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ACCOUNTING FOR CHANGES IN COLLEGE ATTENDANCE PROFILE: A QUANTITATIVE LIFE-CYCLE ANALYSIS

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Resumen
El documento analiza los cambios en la distribución de tasas de matrículas universitarias entre los años 1980 y 2000. El propósito no es sólo explicar el 69% de incremento del número de matrículas, sino también cambios en el perfil del estudiante, en términos de su habilidad e ingreso familiar. Las matrículas universitarias aumentaron un 27% menos que el promedio para estudiantes del cuartíl más bajo de la distribución conjunta de habilidad e ingreso familiar; sin embargo, aumentó en 12% más para los del cuartíl más alto. El aumento de matriculas universitarias no fue uniforme, y para explicar dichos cambios se construye un modelo de ciclo de vida con agentes heterogéneos que optan por acumular capital humano o participar en la fuerza laboral. El modelo es calibrado para replicar patrones de matrícula observados en los paneles NLSY de 1979 y 1997. Se modela explícitamente y se cuantifican los efectos de cuatro fuerzas: incremento del premio a la educación, cambios en la distribución de becas, incremento de costos educacionales y cambios en la distribución de habilidad e ingreso familiar. Finalmente se exploran las políticas educacionales y su efecto sobre distintos grupos de individuos.

Abstract
This paper analyzes changes in the distribution of college enrollment rates that occurred between 1980 and 2000. It aims not only to explain the 69% increase in the overall college enrollment, but also changes in the profile of college students in terms of their ability and financial status. College attendance increased by 27% less than average among individuals in the lowest quartile of the joint family income and ability distribution. However, it increased by 12% more than average for individuals in the highest quartile of the distribution. The increase in college enrollment was far from uniform and, to explain these changes, I construct a life-cycle heterogeneous agents model of labor supply and human capital formation. The model is calibrated to match schooling patterns and labor market outcomes for the 1979 and 1997 NLSY cohorts. I explicitly model and quantitatively estimate the effect of four potential driving forces to explain the observed changes: The increase in the college wage gap, the change in the allocation of grants and scholarships, the increase in educational costs, and the changes in the ability and family income distribution. Finally, I explore alternative educational policies and their effect on different population groups.

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1 Introduction

Overall college enrollment increased from 41% in 1980 to 68% in 2000. A number of studies have documented significant changes in schooling patterns (Belley and Lochner 2007, Buera and Kaboski 2007, Chen 2007, Goldin and Katz 2007, Greenwood and Seshadri 2002, Restuccia and Vandenbroucke 2008). In this work I show that this increase was observed across individuals at all levels of cognitive ability and financial status; however the increase was far from uniform and biased toward richer families.[1] For example, data from the National Longitudinal Survey of Youth 1979 and 1997 (hereafter, NLSY79 and NLSY97 respectively) indicate the college participation rate of high school graduates from the lowest quartile of the joint distribution of family income and ability increased, but this increase was 27% less than the estimated increase for the entire population. On the other hand, those from the highest quartile of the family income and ability distribution experienced a 12% increase in enrollment above the average.[2]

The overall rise in college participation rates was accompanied by changes in the incentives to attend college and changes in the distribution of financial status and ability. These changes came in the form of increases in the college wage premium, increased availability of merit-based grants and scholarships, increases in tuition costs, and a shift in the distribution of high school graduates family income and ability. The aim of this paper is to analyze the extent to which each of these factors contributed to the overall increase in the college attendance rate between 1980 and 2000, and more specifically how each of these factors contributed to the changes experienced by students with different financial status and ability levels. The value added of understanding what shapes the distribution of college attendees is that allows to undertaking of policy analysis to understand who in particular benefits from a given policy, rather than an average or simple aggregate results. To do so, I construct a life-cycle model of labor supply and human capital formation and use data from NLSY79 and NLSY97 to analyze the educational and labor market decisions of individuals from the 1980 and 2000 cohorts of high school graduates.

Each of these four factors is expected to have a substantial effect on the college attendance decision. The increase in the college wage premium has been documented by a number of researchers (see Goldin and Katz 2007). The higher return to college education has increased the enrollment rates of high school

[1]Source: National Longitudinal Survey of Youth 1979 and 1997. Family income or financial status is measured as parental income when the individual was 16-17 years old, and cognitive ability is measured from the Armed Forces Qualification Test (hereafter, AFQT). AFQT scores are widely used in the literature as a measure of cognitive achievement, aptitude and intelligence.

[2]These statistics were constructed using a uniform projection of the average decrease in the college non-enrollment rate from 1980 to 2000. See Appendix A for a full description.

graduates from all backgrounds, however the effect is not expected to be uniform across ability and family income groups, since the wage premium varies by ability level. The second factor is the change in the allocation of federal grants and scholarships towards a more merit-based scheme. Educational subsidies are a key determinant of college enrollment (Akyol and Athreya, 2005). Moreover, the modifications in educational aid are likely to have a differential impact on college attendance rates across individuals from different ability groups. Third, there were substantial changes in the cost of education. Previous studies show that tuition is an important factor in the schooling decision (Heckman, Lochner and Taber, 1998; Gallipoli, Meghir and Violante, 2007; and Garriga and Keightley, 2007). The increase in tuition is expected to have a negative impact on enrollment rates, and the largest effect is expected to be on students from low-income families. Finally, the joint distribution of ability and family income changed from 1980 to 2000.[3] Altonji, Bharadwaj and Lange (2008) suggest that the observed shift in ability distribution was driven by changes in parental education. Additionally, Belley and Lochner (2007) show that the effect of the change in the family income distribution became more significant over time. Both ability level and parental income are important channels which affect individual decisions about college participation since they affect the amount of grants awarded, expected wages, and college success.

To quantitatively estimate the extent to which these factors affected the college attendance distribution I build a model of labor market participation, college attendance and college dropout decisions for heterogeneous individuals in a life-cycle setup. The model is calibrated to match key moments from the data in 1980 and 2000. The model allows individuals to choose from three levels of schooling: no college, some college and college education. An individual's life-cycle consists of three stages, and schooling decisions are made in the first and second stages. Foregone earnings and tuition charges are the direct costs of schooling. I incorporate the observed changes in incentives to attend college and shifts in the family income and ability distribution that occurred during these two decades into the analysis to explain the changes in college attendance profile.

The four driving forces considered in the model explain 58% of the increase in college enrollment from 1980 to 2000. Moreover, the model suggests that the increase in the college wage premium is the most important factor affecting the attendance profile (the model predicts that students from the lowest ability level increase their participation rate by 24 percentage points, and students from the highest ability level by 6.5 percentage points). The effect of the higher college wage premium is constant in family income level within each ability group. The effect on enrollment rates is higher for low ability students and the college

[3] Source: NLSY79 and NLSY97 respectively. See Appendix C for details and summary statistics.

wage gap is also lower for this group, but so is their consumption level, implying a higher return to education as measured by marginal utility of consumption. Changes in tuition subsidies toward a more merit-based scheme accounts for 6% of the profile change. The effect is stronger for the high-ability group, an increase of 2 percentage points versus 1 percentage point for those students with low ability level, because of the merit oriented scheme of grants. The effect is uniform across different family income levels, but differs within each ability group. The model predicts that the increased tuition costs reduced college attendance by 3.4% and this change was most detrimental for high ability and low income students who reduce participation rates by 2 percentage points. This occurs because low income families have to allocate a larger fraction of their disposable income for college financing. Finally, the change in the joint probability distribution of ability and family income accounts for less than 1% of the overall change. The effect is positive for students from the center of the ability distribution (about 2 percentage points), but negative for those on the tails (about 3 percentage points for low ability and 1 percentage point for high ability students). Changes in ability and family income levels generate model effects through changes in subsidies and expected wages after graduation. In addition to quantifying how these factors impact the college enrollment distribution, I use the model to perform a set of policy experiments, and show that the most effective way to increase college participation is a tuition subsidy directed towards high-ability students, since these individuals face the lowest dropout rates.

This paper contributes to the ongoing discussion on changes in college participation rates. Compared to the existing literature (Belley and Lochner 2007, Gallipoli, Meghir and Violante 2007, Garriga and Keightley 2007, among others) the value-added of the current analysis is as follows: (i) it offers a more detailed analysis of the college attendance profile, and not just an examination of aggregate trends. Understanding how the four driving forces affect each particular group of students can serve to guide the design of economic and educational policies aiming to increase college participation and allocate resources efficiently; (ii) the dropout decision is explicitly modelled in the current study and adds an important dimension to the analysis.[4]

The remainder of the paper is organized as follows. Section 2 provides empirical evidence of college participation patterns using data from NLSY79 and NLSY97. Section 3 describes the characteristics and assumptions of the model. Section 4 describes the NLSY79 and NLSY97 data, calibration strategy, and estimation procedure. The results are presented in Section 5. Section 6 concludes.

[4]The dropout rate decreased dramatically from 55% in 1980 to 27% in 2000, as seen from NLSY79 and NLSY97.

2 Empirical Evidence

In this section I use data from the NLSY79 and NLSY97 to quantify changes in the educational environment and college enrollment of youths in their late teens during the early 1980s and early 2000s. College participation rates by ability and family income levels show the striking changes in college attendance that occurred during the observed period. A detailed description of the data and sample selection procedures are provided in section 4.

The average college enrollment rate increased by 69% during the 1980 - 2000 period. However, the increase in college participation was not uniform across different ability and family income groups. Using the mean non-enrollment rates in 1980 and 2000 I construct a trend in college attendance.[5] The mean college non-participation rate was 59% in 1980 and 32% in 2000. A uniform change in educational attainment across groups with different ability and family income levels would imply that high school graduates from the lowest quartile of the family income and ability distribution should have had an increase in attendance of 27% more than was observed. On the other hand, for those from the highest quartile of family income and ability distribution we should have observed an increase of 12% less than the actual participation rate. Figure 1 summarizes these findings.

Figure 1 displays college enrollment rates for the first and fourth quartiles of ability and family income distributions for NLSY79 and NLSY97 cohorts.

The overall rise in college participation rates was accompanied by changes in the incentives to attend college and changes in the distribution of financial status and ability. The first of these, an increase in the college wage premium, has been documented by a number of researchers. For example, Goldin and Katz (2007) find that the college premium increased by approximately 22% from 1980 to 2000. This increase is explained by the rapid advance of skill-biased technological change. The higher return to college education has a positive effect on enrollment rates of high school graduates from all backgrounds, however the effect is not expected to be uniform across ability and family income groups since the college wage premium varies by ability.

The second factor is a change in the allocation of federal grants and scholarships towards more merit-based aid. The total amount awarded in federal grants increased as did the number of recipients, while per student aid remained relatively constant around $7,000.[6] During the 1980-2000 period the ratio between the amount

[5]See Appendix A for a full description of trend composition.

[6]Source: College Board. See Appendix B, Figure B.1 for more details.

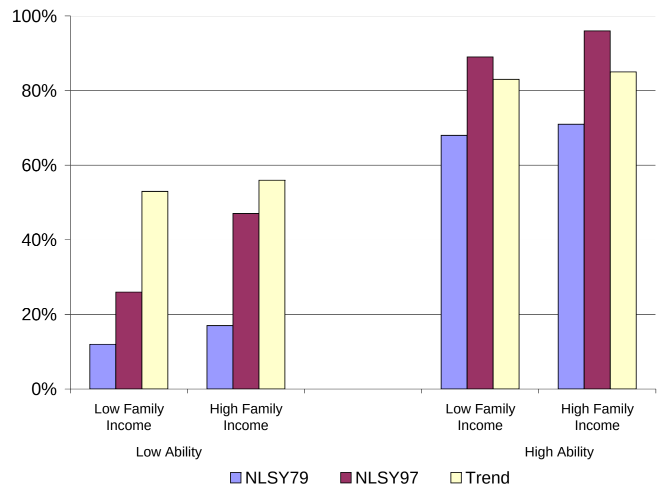

Figure 1: College Enrollment Rates by Ability and Family Income: Data and Deviations from the Trend Prediction for 2000

Note: Source data: NLSY79 and NLSY97. Trend prediction for 2000 corresponds to a constant decrease in non college participation rates. AFQT scores are used as a measure of cognitive ability and parental income as a measure of family income. For a full description of trend composition and enrollment rates for the whole ability and family income distribution see Appendix A.

of grants awarded and cost of education remained fairly constant among students from the low-ability and low-income groups, but the ratio increased by 70% for high ability students with low family income and by 50% for those with high family income and high ability.[7] These modifications in educational aid are likely to have a differential impact on the college attendance rates of individuals from different ability groups. There are a number of studies that show the importance of educational subsidies in access to tertiary education (see for example Akyol and Athreya, 2005).

Third, there were substantial changes in the tuition cost of education. Average tuition increased from $9,000 in 1980 to $23,000 in 2000 (prices are denominated in 2007 dollars).[8] The increase in tuition had a negative impact on enrollment rates and the largest deterring effect was for students from low-income families. The most notable response to this cost increase was greater borrowing, particularly by those with insufficient funds to finance tuition costs. Loans increased by 34% for students from low-income families and

[7]Source: NLSY79 and NLSY97. See Appendix B for details.
[8]Private four-year college. Source: College Board and U.S. Department of Education. See Appendix B, Table B.1 for details.

by 19% for students from high-income families.[9] Previous studies show that tuition cost is an important determinant of the schooling decision. See Heckman, Lochner and Taber (1998), Gallipoli, Meghir and Violante (2007) and Garriga and Keightley (2007).

Finally, the joint distribution of ability and family income changed from 1980 to 2000.[10] The changes in ability-family income patterns had a fundamental impact on borrowing constraints and financial returns to education, and therefore affected schooling patterns. These changes are summarized by three important empirical observations. First, the cross-sectional correlation between ability and family income fell from 0.41 to 0.23. Second, the average ability level and its dispersion increased. Altonji, Bharadwaj and Lange (2008) document this finding and suggest that this change was driven by developments in the distribution of parental education. Additionally, average family income and its dispersion increased.[11] Belley and Lochner (2007) show that the enrollment effect of this distributional change became more significant over time. Both ability level and parental income are important channels which affect individual decisions about college participation, since they affect the amount of grants awarded, expected wages, and college success. Given the shifts in joint distribution of family income and ability, the change in college attendance across individuals with different characteristics is not expected to be uniform.

3 The Model

In this section I describe the model used to explain the changes in the college attendance profile. I develop a three stage life-cycle model with a discrete choice between college enrollment and college dropout. I assume that the economy is populated by a unitary mass of heterogeneous agents that derive instantaneous utility solely from consumption. Schooling decisions are made in the first and second stages and are based on the lifetime utility maximization problem that each agent faces. Individuals may obtain three levels of education: no college, some college and college education. Education and employment are mutually exclusive in each period.

The life-cycle of an agent has three different phases. In the first phase, agents draw their type, a pair $\{x, y\} \equiv \Omega$, that corresponds to ability and family income levels from the joint distribution $H(x, y), x \in [\underline{x}, \overline{x}] \equiv \Phi$, $y \in [\underline{y}, \overline{y}] \equiv \Gamma$ and H: $\Phi \times \Gamma \rightarrow [0, 1]^2$. In this stage agents decide whether to enroll in college. This

[9] Source: NLSY79 and NLSY97, College Board.

[10] Source: NLSY79 and NLSY97 respectively. See Appendix C for details and summary statistics.

[11] See Table C.3 in Appendix C for details.

decision is a function of their type and current wage offer. Agents receive this wage offer from the non-college wage distribution, $w^N \sim F^N(w)$. They simultaneously observe the wage distributions of college graduates and college dropouts. I assume that individuals have perfect foresight about the skill price distributions and that wages depend on ability and are constant over the life-cycle. With the high-school wage offer in hand and observable college-graduate and college-dropout wage distributions, the decision for agent i about whether or not to participate in college at the first stage is based on the following optimization problem: $V(\Omega_i; w_i^N) = max\{V^C(\Omega_i), V^N(\Omega_i; w_i^N)\}$, where $V^C(\Omega_i)$ is the life time-utility of attending college and $V^N(\Omega_i; w_i^N)$ is the life-time utility of not attending college.[12]

Agents who attend college during the first stage derive utility from consumption c, discount future utilities at rate β, and are allowed to borrow at a subsidized interest rate, ρ; they also have to pay a college tuition cost, which equals $\tau(\Omega)$. In order to finance their education, students receive grants and scholarships which are a function of ability and family income, represented by $g(\Omega)$. These agents also receive transfers, $TR_C(\Omega)$. Transfers are treated as a residual in the model since they are not directly measured in the data. However, they have an important interpretation, and are a function of parental transfers, part time earnings, an effort cost of college and the consumption value of schooling. The consumption value of schooling summarizes non-pecuniary benefits of acquiring college education. Agents maximize life-time utility subject to budget and borrowing constraints and the natural borrowing limit is imposed to rule out Ponzi schemes.[13]

The discounted life-time utility of college attendees of type Ω_j is given by the following expression:

$$
\begin{aligned}
V^C(\Omega_j) = \quad & \max_{c,a'} \left\{ u(c) + \beta \int_w \max\{V^{CD}(\Omega_j, a'; w), V^{CS}(\Omega_j, a')\} dF^{CD}(w) \right\} \qquad (1) \\
& s.t. \\
& c + \rho a' I_{(a'<0)} + a' I_{(a'>0)} + \tau(\Omega_j) = g(\Omega_j) + TR_C(\Omega_j) \\
& a' \geqslant -\underline{a}
\end{aligned}
$$

Agents decide whether to continue attending college or to drop outin the second stage of their life-cycle, in each case their discounted life-time utilities are given by $V^{CS}(\Omega_j, a')$ and $V^{CD}(\Omega_j, a'; w)$ respectively.

[12]See Appendix D for a detailed description of the solution method.

[13]The least strict limit, $\underline{a}$, corresponds to the level of debt such that agents can keep consuming a positive amount even in the most unfortunate future states, i.e. if they draw the lowest wage from the corresponding wage distribution. See Aiyagari 1994 for more details.

Equation (1) also describes the trade off faced by high school graduates when making the college enrollment decision. Graduating from college is associated with a higher expected wage, but the costs of financing education may lead to negative asset holdings. Taking into account the college dropout option at the second stage of the life-cycle, makes college enrollment a risky investment decision.[14] Individuals who attend college in the first period but drop out in the second period are likely to receive a lower wage offer and may have accumulated debt when they join the labor force.

Agents who choose not to enroll in college in the first stage of their life-cycle and join the labor force after high school graduation face a consumption-saving decision problem described by:

$$\begin{aligned} V^N(\Omega_j; w_j^N) = \quad & \max_{c,a'} \left\{ u(c) + \beta W\left(a'; w_j^N\right) \right\} \\ & s.t. \\ & c + a' = w_j^N + TR_N(\Omega_j) \\ & a' \geqslant -\underline{a} \end{aligned} \tag{2}$$

Agents who decide to join the labor force consume (c), borrow or save (a'), receive ability-dependent wage compensation and get a transfer ($TR_N(\Omega_j)$). They face the natural borrowing limit and discount at rate β. $W(a; w)$ corresponds to the life-time utility of agents at the working stage. The value of $W(a; w)$ is obtained through a standard consumption-saving utility maximization problem with no uncertainty, where the state variables are the asset/debt level and wage. A complete description of $W(a; w)$ is provided in equation (5).

The life-time utility of individuals without college education increases with wage. On the other hand, receiving a higher wage offer in the first stage of the life-cycle reduces the probability of college enrollment.

In the second phase of their life-cycle, agents who are enrolled in college decide whether to continue education or to drop out. This decision depends on the values of $V^{CS}(\Omega_j, a')$ and $V^{CD}(\Omega_j, a'; w)$. Agents draw a wage w^{CD} from the college dropout wage distribution, $w^{CD} \sim F^{CD}(w)$, and make their decisions based on this wage offer.

If agents decide to continue college, they will continue paying tuition, will receive grants, transfers and will be allowed borrow at the subsidized interest rate in the second stage of their life-cycle. The maximization

[14] See Castex (2010),Chen (2002) and Chatterjee and Ionescu (2009).

problem of a college student in the second stage of the life-cycle takes the following form:

$$\begin{aligned}
V^{CS}(\Omega_j, a) = \quad & \max_{c,a'} \left\{ u(c) + \beta \int_w W(A; w) dF^C(w) \right\} \qquad (3) \\
& s.t. \\
& c + \rho a' I_{(a'<0)} + a' I_{(a'>0)} + \tau(\Omega_j) = g(\Omega_j) + TR_C(\Omega_j) + a(1+r) I_{(a>0)} \\
& a' \geqslant -\underline{a} \\
& a I_{(a<0)} + a' = A \\
& A \geqslant -\underline{a}
\end{aligned}$$

Note that in the maximization problem, the borrowing constraint faced by the agent considers the total accumulated debt, A. Thus it takes into account previous savings.

Agents who decide to drop out after spending the first stage of their life-cycle in college receive transfers for only one period and they have to repay their accumulated debt. In each remaining period of their life-cycle they maximize a consumption-saving problem, $W(a; w)$. Their discounted life-time utility in the second stage is described by:

$$\begin{aligned}
V^{CD}(\Omega_j, a; w) = \quad & \max_{c,a'} \{ u(c) + \beta W(a'; w) \} \qquad (4) \\
& s.t. \\
& c + a' = a(1+r) + w + TR_{CD}(\Omega_j) \\
& a' \geqslant -\underline{a}
\end{aligned}$$

The third stage of the life-cycle is the working stage for those who graduate from college; the working stage arrives earlier for those who decided not to enroll or to drop out of college. For simplicity it is assumed that the dropout decision is made in the middle of the college education process.

Agents who graduate from college draw a wage from the college wage distribution, $w^C \sim F^C(w)$. In the following periods they face a consumption-saving problem, given by $W(a, w)$. The life time utility at the third stage of the life-cycle is a function of acquired education in the earlier periods. It is specified as follows:

$$
\begin{aligned}
W(a,w) = \quad & \max_{c,a'} \{u(c) + \gamma\beta W(a',w)\} \\
& st. \\
& c + a' = a(1+r) + w \\
& a' \geqslant -\underline{a}
\end{aligned} \tag{5}
$$

Equation (5) describes a consumption-saving problem that agents face when they join the labor force. I include the survival probability γ to match the expected duration of labor force participation (and the retirement age). The maximization problem is solved given the budget constraint and natural borrowing limit. Life-time utility at the working stage is increasing in assets and wages. Since wages are ability dependent, the life-time utility is also increasing in ability level.

Equations (1) and (2) provide some insight about the the effects of the four driving forces on education and labor market decisions. First, a larger college wage gap generates more incentive to enroll in college, since a higher expected wage yields a higher college life-time utility. A more merit-oriented distribution of grants leads to higher attendance rates among high ability students, since their effective cost of education decreases. The increase in tuition costs negatively affects all potential students, since they have to allocate a larger fraction of their family income to meet the costs of education, which leads to a decrease in college enrollment rates. Finally, a shift in the joint probability distribution of ability and family income will have several effects on schooling choices: grants distribution is ability and family income dependent, while wages are a function of individual ability as well. These effects requires calibration of the proposed model to quantify their impact on the change of enrollment rates across time.

4 Data and Calibration

4.1 Data

The analysis uses data from the National Longitudinal Survey of Youth 1979 and 1997 cohorts. The former provides a nationally representative sample of young men and women aged 14-22 at the beginning of 1979, and the latter sample youth who were ages 12-16 at the beginning of 1997. For the individuals in the sample, college attendance decisions took place in the early 1980s for the 1979 cohort and in the early 2000s for the 1997 cohort. Youths who are part of the minority and poor white oversamples are excluded, using only the full random samples in the analysis. The data contain detailed information on individuals, including their ability level, family income and other family and personal characteristics.[15]

Both data sources contain comparable measures of ability, AFQT[16] scores, widely used in the literature as a measure of cognitive achievement, aptitude and intelligence. For the NLSY79 cohort I use the AFQT89 variable. For the NLSY97 cohort I use a subset of the Armed Services Vocational Aptitude Battery (ASVAB) scores, specifically the ASVAB MATH VERBAL SCORE PCTP, which provides a summarizing percentile score variable created by the NLS staff using four key sub-tests.[17] This variable is similar to the AFQT score that was used for the NLSY79 cohort.[18]

Another key variable in this analysis is family income. Both NLSY79 and NLSY97 contain measures of family income reported in early survey years. For both cohorts I use average family income when respondents are ages 16-17. [19] I denominate the family income measure in 2007 dollars using the consumer price index for all urban consumers.

I focus on college attendance and dropout decisions, which took place in the early 1980s for the 1979 cohort and in the early 2000s for the 1997 cohort. Since the oldest individuals in the NLSY97 turned age 24 during the most recent 2004 wave of data, I do not have a measure of the wage distribution for the second cohort. Instead, wage distributions are projected for each educational and ability level using data from NLSY79. This procedure is described in detail in the following section. Following Belley and Lochner (2007), an individual is considered to have attended college if their highest grade attended is equal or greater than 13. Similarly, an individual is considered a college dropout if she attends college but does not graduate.

The raw NLSY79 and NLSY97 contain information on 6,111 and 6,748 individuals respectively.[20] Individuals with no information about AFQT scores, family income or schooling were dropped from the sample. The final sample contains 2,477 individuals for the NLSY79 cohort and 3,354 for the NLSY97 cohort. Descriptive statistics for the variables used in the analysis for both cohorts are provided in Appendix C.

[15] See Appendix C for details and summary statistics.

[16] Armed Forces Qualification Test

[17] Tests on Mathematical Knowledge (MK), Arithmetic Reasoning (AR), Word Knowledge (WK), and Paragraph Comprehension (PC).

[18] AFQT89 is not adjusted by age. I thank Lance Lochner for pointing this out. I follow the age-correction procedure suggested by Carneiro, Heckman and Masterov (2005).

[19] When income is available only for age 16 or age 17 and not both, I use the available measure.

[20] Considered only the cross-sectional representative sample.

4.2 Calibration

The proposed model is calibrated to explain the changes observed in college attendance rates between the early 1980s and 2000s for each ability and family income level.

This section discusses the choice of parameters used in the model. The model has a set of 18 parameters. I divide the parameter space into three subsets. The first corresponds to parameters that I impose in the model from pre-existing estimates in previous literature. The second set corresponds to parameters estimated directly from the data. I calibrate the remaining parameters to match some moments in the sample. The model is calibrated for two steady states, 1980s and 2000s.

External parameters: The first subset of parameters and their values are reported in Table 1.

I use a CRRA utility function with coefficient of risk aversion σ. Agents enter the first stage as an 18-year-old high school graduate. The duration of the first and second stages of the life-cycle is two years each; during these periods agents make college enrollment and dropout decisions respectively. The third stage has an infinite horizon; I add a survival probability to the specification to match the retirement age.

Parameter		Value	Target/Source
Coeff. of risk aversion	σ	2	standard
Discount factor	β	0.96	standard
Prob. to survive	γ	0.957	to match 65 yrs.
Interest rate	r	4%	standard
Subsidized int. rate	ρ	0.9246	to set $r_{t=1} = 0$

Table 1: Imposed parameters in the model

The coefficient of risk aversion, the discount factor and the interest rate are chosen following the standard practice in the literature. I use a survival probability in the third stage (working stage) maximization problem to match retirement age of 65 years. Finally, the subsidized interest rate was chosen to create a zero cost for those agents who borrow to finance their education. I use the same set of parameter values for both steady states, 1980 and 2000.

Estimated parameters: The second subset of parameters are estimated from the data set. They include the tuition cost, grants awarded and the ability/family income distribution.

I follow the previous literature and estimate an average tuition (Akyol and Athreya 2005, Caucutt and Kumar 1999, Gallipoli, Meghir and Violante 2007 and Garriga and Keightley 2007). Tuition is reported only in the 1979 dataset and therefore it is only available for the first cohort. The average annual tuition cost is estimated to be \$4,350 (2007 dollars). Since data on tuition for the second cohort is not reported, I project the value of tuition from the NLSY79 cohort according to the trends reported by College Board.[21] During the 1979 - 1997 period, the increase in tuition was around 100% in all higher education institutes.[22]

To estimate grants and scholarships awarded, I follow Gallipoli, Meghir and Violante's (2007) methodology, who suggest a linear specification in ability and family income. Using data from NLSY79 and NLSY97 the following equation for log-grants is estimated:

$$g(\Omega_i) = \alpha_0 + \alpha_1 x_i + \alpha_2 y_i + \theta X_i + \alpha_\lambda \widehat{\lambda}_i + \varepsilon_i, \tag{6}$$

where X_i is a set of controls for individual and family characteristics.

To estimate the above equation requires correction for selection bias: grants are not observed for those high school graduates who do not enroll in college. To correct for this selection, I implemented the conventional two-step selectivity adjustment procedure suggested by Heckman (1979). In the first stage I formulate an econometric model to estimate the probability of attending college, which is used to predict the probability of college enrollment for each individual, $\widehat{\lambda}_i$.[23] In the second stage, I correct for the selection problem by including the predicted individual probability as an additional explanatory variable in the grants specification. See Appendix E for details, parameter values and estimated effects of individual and family characteristics on college attendance. The parameters of interest are reported in the following table:

log grants	*constant*	*ability*	*family income*
NLSY79	11.395	0.231	-0.349
	(1.994)	(0.113)	(0.178)
NLSY97	11.131	0.361	-0.224
	(1.904)	(0.136)	(0.159)

Table 2: Parameters estimated for grant equation

Note: Estimates for log grants as a function of ability (afqt scores) and family income, as described in equation 6. Values in parenthesis correspond to standard errors. Parameters estimated from the selection equation and controls are reported in Appendix E.

Estimation results show that grants increase in ability and decrease in family income for both cohorts. The results also suggest that grants distribution is more merit oriented at the second cohort. Further, the

[21]Trends in College Pricing, 2007. College Board.

[22]See Appendix B for details.

[23]Parental education is used as instrumental variable in the first stage estimation.

penalty for a higher family income is lower at the second cohort.

To solve the model I impose the joint probability distribution of ability and family income observed in NLSY79 and NLSY97. Ability is normalized to have zero mean and standard deviation equal to one. Family income is expressed in natural logs. Figure 2 shows the marginal densities.

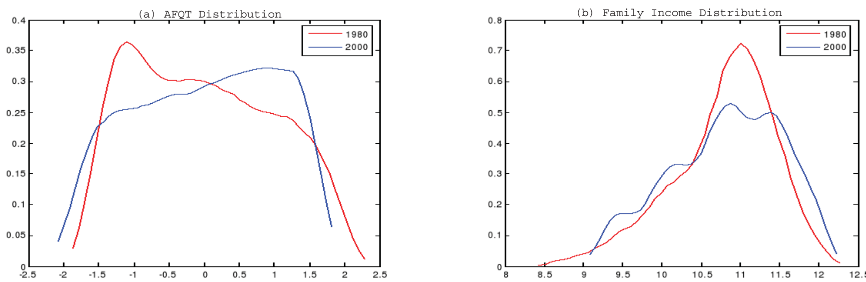

Figure 2: Marginal densities: (a)Ability, (b)Family Income distributions, NLSY79 vs NLSY97

Calibrated parameters: The third subset of parameters is calibrated using simulated method of moments. I calibrate parameters of the wage distributions and transfer functions to match key moments observed in the data.

Wage distributions are calibrated to match means and standard deviations of the life-cycle wages for each ability and educational level. Transfers, which are assumed to have a linear specification in ability and family income, are calibrated to match the profile of college enrollment rates.

I use the NLSY79 data to obtain wage distributions for high school graduates, college graduates and college dropouts. The annual mean wage is $22,549 for high school graduates, $25,399 for those who drop out from college and $29,158 for college graduates.[24] The obtained college premium is consistent with the one reported by Goldin and Katz (2007) who use the 1980 Current Population Survey (CPS).

To generate the wage profile, I estimate the return to ability and experience for different educational levels. These estimates are used to project wage profiles along the life-cycle for different ability and education groups. I use the estimated wage paths to calculate a mean wage for each ability and education level. Parameter estimates are reported in Appendix E.

At each educational level agents receive ability dependent wage offers. I define the wage offer function as

[24]See Appendix E for details. Wages are nominated in 2007 dollars.

follows: $w^{educ} = \varpi_0 + \varpi_1 x_i + \varepsilon_w$. I assume that these wage offers are constant throughout each agent's life and are generated such that the accepted wages for each ability and educational level match mean life-cycle wages estimated in the data.

Wage data for the second cohort are not available because of the short history of the NLSY97 sample. About 6% of the sample are still in college in the last available wave of NLSY97. Therefore, there is not enough information to estimate the return to experience for each educational level and to project the wage profile along the life cycle. To solve the short panel issue, I use an alternative technique to construct a wage distribution. The 1980's wage distribution is shifted to the right up to the point where its average corresponds to the 22.3% increase in college premium documented by Goldin and Katz (2007). Using the CPS 1980 and 2000 data I find that there was an increase in wage dispersion during these 20 years (12% increase in wage volatility for college graduates). These two empirical facts are incorporated to generate a right shift of the wage distribution for college graduates, reaching an average wage of $36,442. The high school wage distribution is kept unchanged and the college dropout wage distribution is proportionally shifted to the right.

Transfers are not measured in the data, and are evaluated as a residual in the model. Transfers are a function of part-time earnings while in college, parental transfers and the consumption value of schooling (non-pecuniary benefit of attending college). I assume that transfers are a linear function of ability and family income, as specified by the following equation.

$$TR(\Omega_i) = \delta_0 + \delta_1 x_i + \delta_2 y_i \tag{7}$$

I calibrate the coefficients of the transfer function in order to reproduce some relevant features observed in the data, in particular, the college attendance rates for each ability and family income level.

Appendix E summarizes the parameters calibrated. Transfers are increasing in ability and in family income. As demonstrated in Figure F.1 in Appendix F, the model without transfers overestimates college participation for low-ability students and underestimates college participation for high-ability students. The average of transfers for those who attend college is estimated around $122,000. I interpret this value as the sum of the consumption value of college, parental transfers and part-time income while in college.

Calibration results: Here I document how the model performs by comparing model generated statistics with those observed in the data.

Grants and scholarships from the model and data are reported in the following table.[25]

Grants	Data	Model
NLSY79	2,128	2,394
	(556)	(819)
NLSY97	6,448	7,209
	(2,296)	(2,497)

Table 3: Annual grants: Model vs. Data

As can be seen from Table 3, in the data average annual grants and scholarships increased by 3 times from 1980 to 2000, while the model slightly overestimates the mean and standard deviations for the two steady states (values are nominated in 2007 dollars).

The following tables show mean log wages by ability quartile and educational levels.

	1980		2000	
Ability quartile	Model	Data	Model	Data
lowest - Q1	10.030	10.049	10.285	10.272
	(0.62)	(0.63)	(0.70)	(0.71)
Q2	10.164	10.196	10.446	10.419
	(0.62)	(0.63)	(0.70)	(0.71)
Q3	10.324	10.360	10.604	10.583
	(0.62)	(0.63)	(0.70)	(0.71)
highest - Q4	10.513	10.517	10.755	10.740
	(0.62)	(0.63)	(0.70)	(0.71)

Table 4: Average log-wage for college graduate

Note: Average log-wage for a college graduate over the life-cycle for different ability levels, measured as AFQT score. Standard deviation in parenthesis. Source is NLSY79 for 1980. A projection according with the increase in college wage premium was performed to generate the wage distribution for 2000. The procedure is described earlier in this section.

Table 4 shows that the model performs well in replicating the wage premium for each ability level. High-ability college graduates (Q4) get a 48% higher wage relative to those of low-ability level (Q1). Consistent with the evidence documented by Goldin and Katz (2007), The model reproduces the 22% increase in wage gap that occurred between 1980 and 2000. The wage structure for high school graduates is reported in Table 5.

As can be seen in Table 5, in the high school wage distribution the ability premium is lower compared to the one for college graduates, and it is approximately 36%.

[25]Note: standard errors reported in parenthesis.

	1980		2000	
Ability quartile	Model	Data	Model	Data
lowest - Q1	9.855	9.828	9.855	9.828
	(0.64)	(0.68)	(0.66)	(0.77)
Q2	9.964	9.952	9.964	9.952
	(0.69)	(0.68)	(0.69)	(0.77)
Q3	10.090	10.091	10.090	10.091
	(0.68)	(0.68)	(0.69)	(0.77)
highest - Q4	10.237	10.224	10.237	10.224
	(0.70)	(0.68)	(0.70)	(0.77)

Table 5: Average log-wage for high school graduates

Note: Average log-wage for a high school graduate over the life-cycle for different ability levels, measured as AFQT score. Standard deviation in parenthesis. Source is NLSY79 for 1980. For the 2000 cohort the wage profile is kept fixed since what drives college participation is the college wage gap. See details in section 3.

5 Results

Using the calibrated parameters I simulate the model and evaluate its ability to reproduce schooling and labor participation patterns observed in the data. To examine the performance of the model I match the detailed college participation profile of the 1980 cohort. Then I proceed to explain the change in the college participation profile that occurred between 1980 and 2000. To do so, I evaluate the effects of each of the four channels on enrollment rates for each ability and family income group: an increase in the college premium, merit-oriented reform in distribution of grants, an increase in tuition costs and changes in the ability-family income distribution. I also analyze the extent to which each of these factors contributed to the changes experienced by students within each subgroup.

The model is calibrated to generate college attendance rates for each ability and family income group using NLSY79 parameters. These simulated outcomes are compared to those observed in the data. The model outcome and data comparison are reported in Figure 3.[26]

The simulated participation rates for 1980 serve as a starting point for the accounting experiments. To test to which extent each driving force can explain the change in the attendance profile between the 1980 and 2000 cohorts, I update the simulation with parameter values relevant to the particular driving force. The marginal effect of each driving force is quantified by ability and family income levels. The transfer function, $TR(\Omega_j) = \delta_0 + \delta_1 x_i + \delta_2 y_i$, is kept fixed using the 1980 parameters in all experiments.

[26]See Appendix F for details.

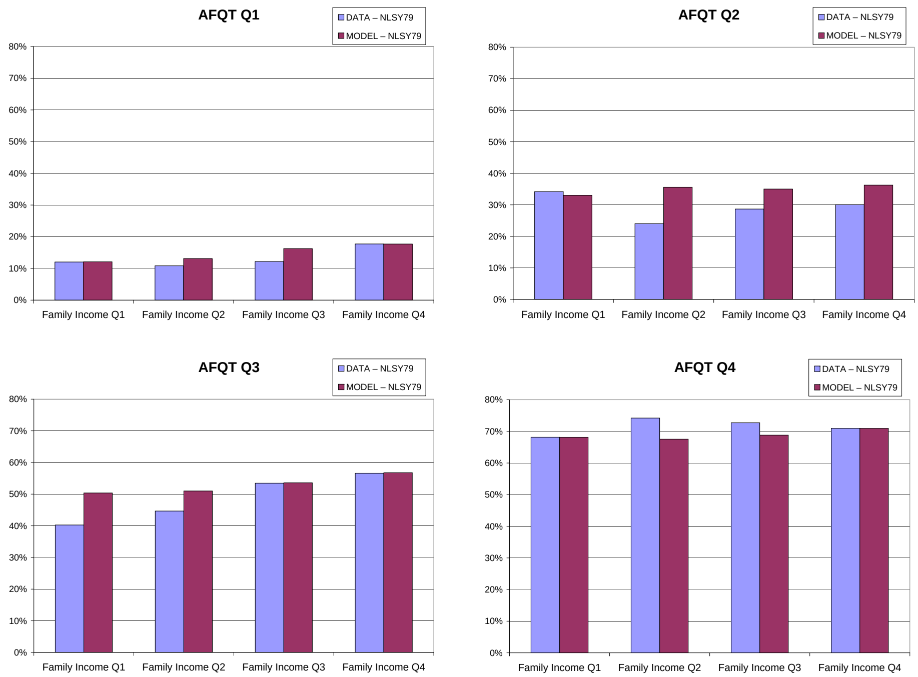

Figure 3: College participation profile NLSY79 -Data vs Model

Note: College participation rates per ability (AFQT) and family income quartiles. Outcome from calibrated model and the data (Source NLSY79).

5.1 Incentives vs. Distribution: College Premium, Redistribution of Grants, Increase in Tuition and Change in Ability/Family Income Distribution

Here I analyze the extent to which the four explicitly modelled forces (increase in college wage premium, merit-oriented redistribution of grants, increase in tuition cost and shift in the joint probability distribution of ability and family income) can explain the observed change in the college attendance profile, for each ability and family income level. I employ the model solution for the NLSY79 cohort, shown in Figure 3, and incorporate one by one each of the four driving forces using calibrated parameters for the NLSY97 cohort. This exercise allows me to evaluate the effects of each channel on specific target groups. Finally, I present results incorporating all changes in incentives and distributions that occurred between 1980 and 2000 to generate a combined effect.

5.1.1 College premium

The first counterfactual experiment is to solve the economy for the NLSY79 cohort but with the wage structures calibrated for the NLSY97 cohort. This experiment quantifies the effect of the increase in the college premium on college enrollment rates, and also allows me to evaluate to what extent this channel explains change in the college attendance profile. The results for the highest and lowest quartiles of the ability and family income distribution are presented in Figure 4.[27] I find that between 1980 and 2000 the overall college participation rate increased from 41% to 68%. Changes in the wage structure explain 61% of the overall change.

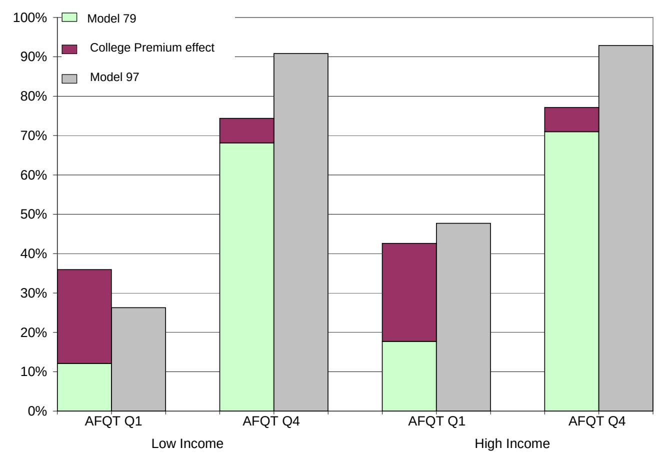

Figure 4: College premium effect on enrollment rates

Note: This figure shows the effect of the increase in the college wage premium on college enrollment rates, for the lowest and highest quartiles of the ability and family income distribution. The effect across the whole distribution is presented in Table G.1 in Appendix G.

Increases in college participation rates are observed across all ability and family income groups; higher returns to college education lead to higher expected wages for potential college graduates and therefore promote enrollment. However, the effect was distinctive across ability groups. Enrollment increases were larger for those students with low ability level; the effect on participation rates is about 24 percentage points, much higher than for high ability students, the effect was 6.5 percentage points. Low ability students face a

[27] See Appendix G for a full description of the wage premium effect on enrollment rates for all ability and family income levels.

lower consumption level along the life cycle and therefore a higher return to education as measured by the marginal utility of consumption. This group of students strongly react to an increase in the college wage premium. Within each group of ability, there is no different effect across family income groups, since wage premium is solely a function of the individual ability.

5.1.2 Redistribution of grants

The second driving force considered in the model is the change toward a more merit-oriented distribution of educational subsidies. I analyze how the change in allocating grants and scholarships from 1980 to 2000 account for the change in enrollment rates observed in the data. I solve the calibrated model for the NLSY79 cohort, while employing the grants distribution estimated using data for the NLSY97 cohort. The redistribution of grants accounts for 6% of the overall increase in college participation. Individuals from all income and ability backgrounds are positively affected by this change.

The figure 5 shows how much of the change in the college attendance profile can be explained by the redistribution of grants.[28]

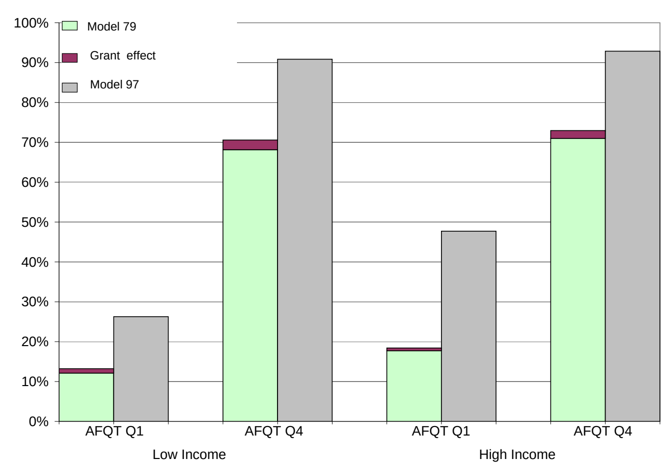

Figure 5: Grants effect on enrollment rates

Note: The figure shows the effect of the change in grants allocation on the college enrollment rates, for the lowest and highest quartiles of the ability and family income distribution. The effect across the whole distribution is presented in Table G.2 in Appendix G.

[28]See Appendix G for a full description of the change in grants effect for all ability and family income levels.

The change in grant structure has a larger positive effect on high-ability students, independently of their family income (2 percentage points increase on enrollment rates for high ability students and 1 percentage point for low ability students), which is consistent with the fact that grants became more merit oriented than before. The extent of this effect is smaller as family income increases, since grants depend negatively on family income.

5.1.3 Increase in tuition

The cost of education directly affects individual decisions about college enrollment. Here I analyze the extent to which the increase in tuition from 1980 to 2000 accounts for the change in the college attendance profile.

The model is solved and calibrated for the NLSY79 cohort, but incorporating estimated tuition costs for the NLSY97 cohort. Figure 6 shows the effect of the increase in tuition on the attendance profile.

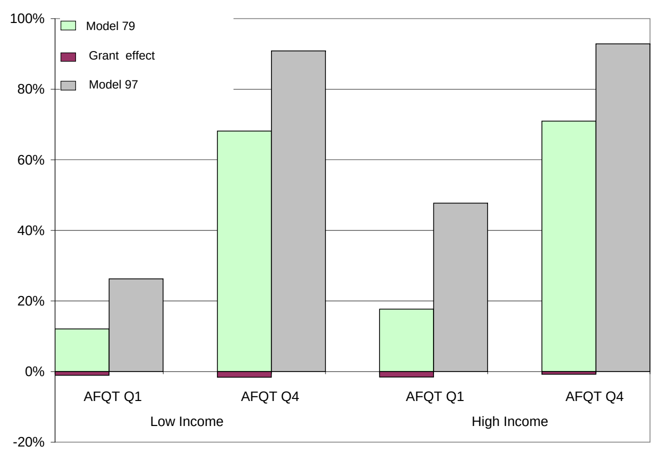

Figure 6: Tuition effect on enrollment rates

Note: The figure shows the effect of the increase in educational cost on the college enrollment rates, for the lowest and highest quartiles of the ability and family income distribution. The effect across the whole distribution is presented in Table G.3 in Appendix G.

Figure 6 shows that an increase in tuition has a negative effect on college enrollment: on average, students reduce their college participation rate by 3%. The effect, as a fraction on enrollment rates, is stronger on low-ability students, because they have to allocate a larger fraction of their disposable income to finance their education (due to the high correlation between ability and family income).

5.1.4 Change in joint probability distribution of ability and family income

Finally, the model is solved and calibrated for the NLSY79 cohort using the joint probability distribution of ability and family income obtained from the NLSY97 cohort. This exercise allows me to evaluate how much of the change in enrollment rates is due to changes in family income levels, changes in students ability and changes in the correlation between ability and family income (Figure 7 summarizes these impacts).

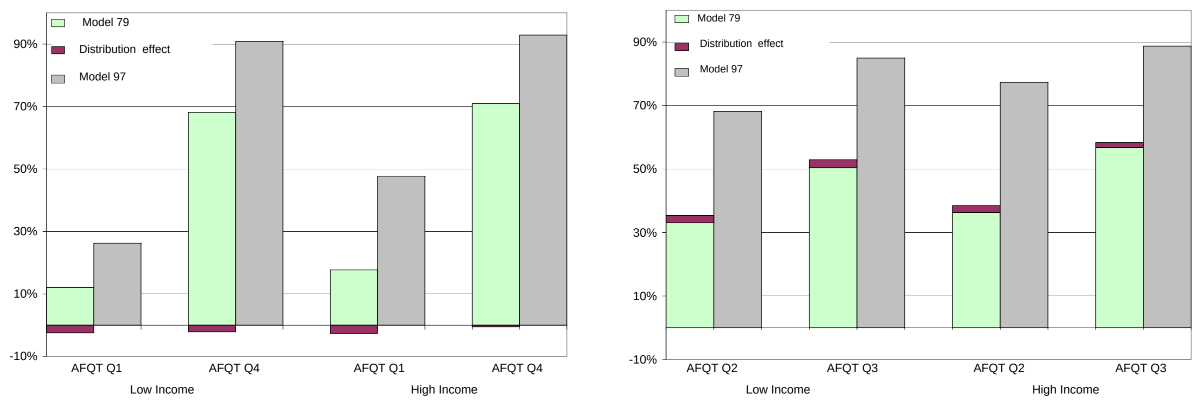

Figure 7: Ability-F.Income distribution effect on enrollment rates. Left panel: highest and lowest ability levels - right panel: middle ability levels.

Note: The figure shows the effect of the change in the ability and family income distribution on the college enrollment rates, for the lowest and highest quartiles of the family income distribution for each quartile of ability. The effect across the whole distribution is presented in Table G.4 in Appendix G.

The lowest and highest ability groups (first and fourth quartiles of the ability distribution, AFQT Q1 and AFQT Q4 respectively, left panel) decreased their ability level from the NLSY79 to NLSY97 cohort. This effect implies fewer grants and lower expected college wages if they graduates and therefore a lower college enrollment rate (3 percentage points for low ability levels and 2 percentage points for high ability levels). On the other hand, middle ability groups (second and third quartiles of the ability distribution, AFQT Q2 and AFQT Q3 respectively, right panel) increased their ability level from the NLSY79 to NLSY97 cohort. This implies more grants and higher expected college wages if they graduate.[29] Therefore, higher college enrollment rates (2 percentage points).

[29] See details of the change of ability-family income distribution from NLSY79 to NLSY97 in Section 4 and Appendix C.

5.1.5 Combined effect

To evaluate the combined effect of all four channels on college attendance profile I solve the model using parameters calibrated for NLSY79, but incorporating NLSY97 estimated parameters for wage distribution, grants and subsidies function, tuition costs and ability/family income distribution. Figure 8 shows to what extent the combined effect can explain changes in college participation profile between both steady states.

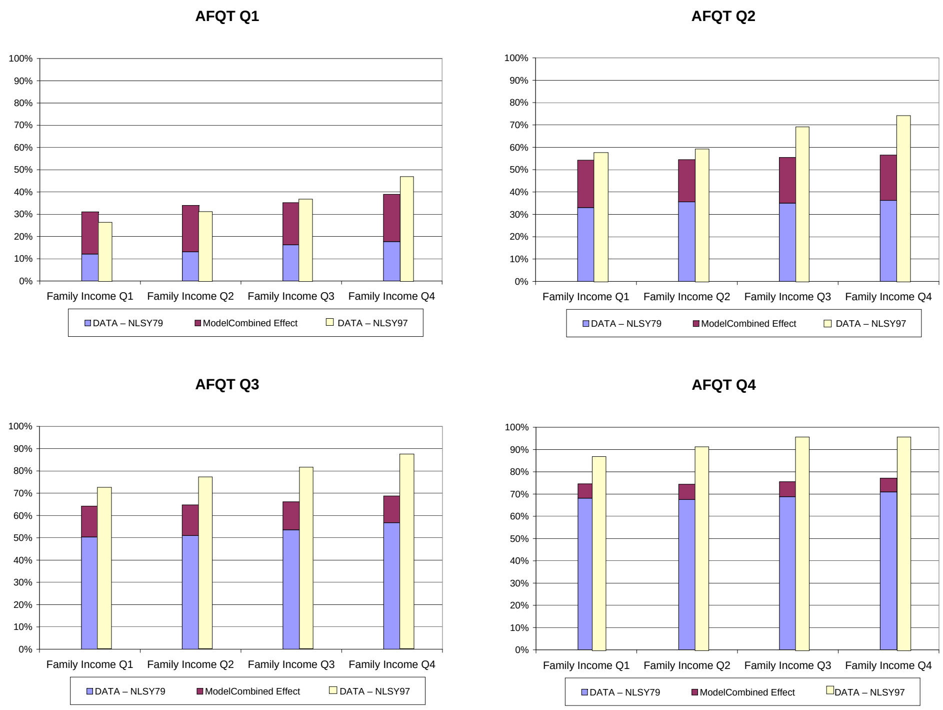

Figure 8: Combined effect on college participation profile

Note: The figure shows the effect of the four driving forces of the model on the college enrollment rates. See details in Table G.5 in Appendix G.

Figure 8 displays college enrollment rates for each level of ability (measured by AFQT score) and family income. The starting point is the enrollment rates calculated using the NLSY79 data. By adding the combined effect to the initial 1980 rate I evaluate the ability of the model to generate enrollment rates observed in 2000. The combined effect of all four channels generates an average increase in college participation rates that explains around 59% of the overall change.

The performance of the model varies across ability and income groups. The combined effect of the four driving forces explains most of the increase in enrollment rates for the low-ability students. Moreover, the rising college wage premium alone can explain most of this change for this subgroup.

Figure 8 also shows that the model explains around 55% of the change in college attendance rates for the middle-ability groups (AFQT Q2 and AFQT Q3). The mean ability level within these groups increased due to shifts in the ability distribution. Given that the allocation of grants became more merit-oriented during the 1980 - 2000 period, the amount of education subsidies awarded to individuals in these quartiles increased substantially, which explains around 4% of the overall rise in college participation rates (This is 20 percentage points for AFQT Q2 and 12 percentage points for AFQT Q3). The shift in the ability distribution also had a positive effect on expected wages upon graduation, which promoted college enrollment as well.

The results presented in Figure 8 show that the effects of changes in the four driving forces have a larger effect on students from low-income families, especially on lower ability ones. High school graduates who choose not to attend college join the labor force. This choice yields lower wages and lower consumption along the life-cycle than could be achieved given a college degree. Since the expected high school graduate wage offer is ability dependent (as shown in Table 5), the response to changes that affect wages and consumption is more pronounced within the lower ability group, which in turn is reflected in changes in enrollment rates. Specifically, changes college premium, cost of education and in incentives to accumulate human capital, have a larger effect on this subgroup of students. In contrast, the effects of these channels on enrollment rates are not as substantial within the high-ability group of students.

The model does not capture the entire change in the college participation profile observed between 1980 and 2000 (the model performs reasonably well to explain changes in participation rates for the low-ability groups, but it should be extended to explain changes in college participation for the high-ability groups. The model explains around 86% of change in college attendance for the low-ability groups and approximately 38% of the change for the high ability groups). The next section provides some possible suggestions for extensions to improve the performance of the model. Those are left for future research.

5.2 Extensions

The model explains almost 60% of the overall change in the college attendance profile between 1980 and 2000. Some channels are not explicitly present in the model, but are accounted for by incorporating the ability and family income dependent transfer function into the budget constraint. This transfer function is kept fixed in all counterfactual experiments. Here I present some plausible examples of what could change this function over time and make some suggestions about which channels the model might be missing.

In the early 1980s there was an important tax reform (progressive tax system has become flatter), as documented by Kaygusuz (2007), Guner, Kaygusuz and Ventura (2008) and others. (These authors show that the progressive tax system suddenly become flatter). These changes in taxation generated more incentives to undertake college education. Individuals with higher wages - high ability students - face lower tax rates compared to those of 20 years ago, which implies an even higher effective return to college education.

Precautionary motives also play an important role in access to education. Individuals who choose to acquire college education face shorter unemployment spells and therefore lower wage volatility along their life-cycles.[30] Risk averse agents will prefer to obtain a college education to avoid this uncertainty. Retirement and social security also play a role in college enrollment decisions. If agents care about their retirement years, they will have a higher incentive to attend college because higher wages, on average, will imply higher benefits after retirement. Finally, as documented by Lee (2005), attending college provides a direct consumption value which is estimated around 70,000 for high ability men, explaining most of the residual in the model.

The transfers, or the residual, in the model are interpreted as a sum of all channels which have no direct representation in the model. If I allow transfers to change over time in the model, the resulting college participation profile is reported in figure 9.

Average enrollment rates are 68% for the NLSY97 cohort, and a greater increase in enrollment rates is computed for students with a high ability level.

5.3 Policy analysis

Previous literature has analyzed the effectiveness of different types of educational policies on enrollment rates.[31] However, the existing studies mostly focus on evaluating the effects of various policies on the average enrollment rate. Results presented in the preceding section suggest that the changes in educational subsidies, educational costs, and labor market conditions distinctively affect schooling decisions of individuals from different ability and family income levels. These outcomes imply that the evaluation of public policies should be performed within each group of interest. This approach to policy analysis is particularly important when resources are scarce and have to be efficiently allocated. For example, ability and family income groups

[30] Dynamics of Economic Well-Being: Spells of Unemployment 2001–2003 - U.S. CENSUS BUREAU.

[31] See for example Akyol and Athreya (2005), Gallipoli, Meghir and Violante (2007), Garriga and Keightley (2007) and Heckman, Lochner and Taber (1998).

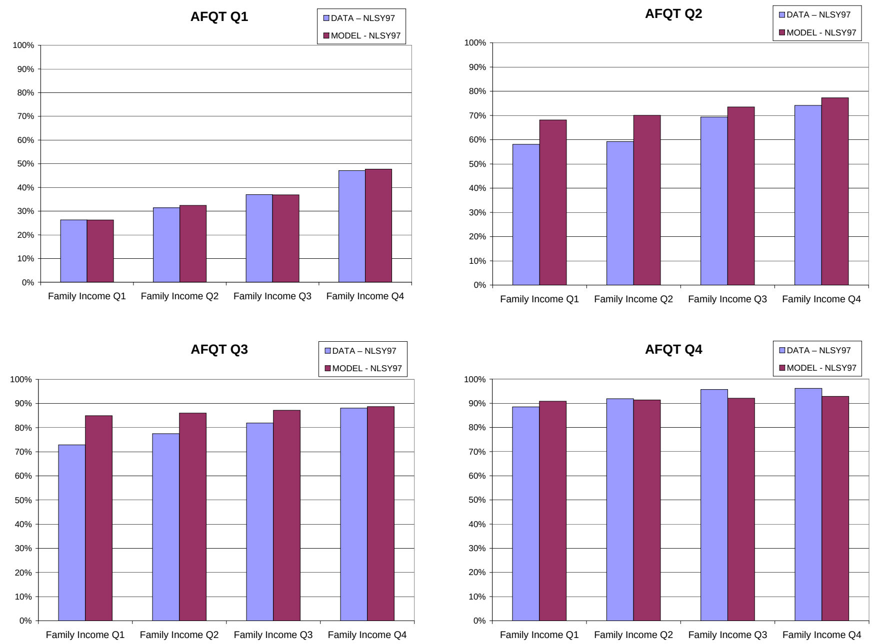

Figure 9: College participation NLSY97 -Data vs Model

Note: College participation rates per ability (AFQT) and family income quartiles. Outcome from calibrated model for 2000 and the data (Source NLSY97).

differ in their college drop out risk; this risk should be taken into account when choosing the optimal policy. I adopt this strategy and perform a series of policy experiments.[32] I analyze how college participation within each ability and income group responds to changes in educational subsidies and in the costs of education.

I first analyze the response of enrollment rates to a 10% decrease in the cost of education. The overall enrollment rate increases by 14%. The effect is stronger for students from high-income families with a low ability level, who increase their participation by 24%. The effect is decreasing as ability level increases. These results are in line with previous analysis in the literature, however it is important to notice that the group who benefits the most are those with low ability a level, who face higher dropout rates.

Second, I analyze alternative grants schemes and their effects on enrollment rates. I consider lump sum, financial need and merit-oriented subsidies. A lump sum subsidy of 10% in grants raises college participation rates by 6%. This effect is increasing with family income and is constant across ability levels. This policy

[32]The model under consideration while analyzing different financing alternatives is the one with no transfer function in the budget constraint. This is done to not alter the saving or borrowing decisions made by the students.

experiment benefits students from a higher income family, while unaffected by the student ability level.

To implement a financial or need based subsidy policy reform I decrease the returns to family income in the grants specification, as defined by equation 6, by 10%. This change leads to a 23% rise in the overall college participation rate. The effect is constant across ability levels and it is increasing in family income. A merit-oriented reallocation of grants is implemented by increasing the returns to ability in the grants equation by 10%. This change leads to an increase in the college participation rate within the high ability group, around 3%. The effect is increasing in family income.

The presented policy analysis shows that the most effective way to promote college participation of high-ability students, who exhibit lower dropout rates, is a merit-oriented grants allocation. Subsidizing education unconditionally or using a financial-need scheme increases enrollment rates as well. However, in this case many entering students have lower ability levels and lower financial status, due to the high positive correlation, and majority of them eventually drop out of college and do not graduate.

6 Conclusion

This paper analyzes changes in college participation rates that occurred between 1980 and 2000. It aims not only to explain the overall increase in college enrollment rates, but also changes in the profile of college students, in terms of their ability and financial status. To serve this objective I develop a discrete choice model with heterogeneous agents and endogenous college dropout. The model is calibrated to match the wage structure, college attendance profile and dropout rates observed in the data for two steady states. I then analyze partial effects of four driving forces on the change of the college attendance distribution between the NLSY79 and NLSY97 cohorts.

The existing literature on college participation mainly analyzes policy experiments using different model environments. The usual approach in these studies is to analyze only the average moments of college participation. The main contribution of this paper is in providing a detailed analysis of college enrollment rates, within each ability and family income level, in an attempt to understand the changes in educational attainment that occurred between 1980s and 2000s.

The model explains 58% of the increase in college enrollment from 1980 to 2000. Moreover, the results suggest that the increase in college wage premium was the most important factor affecting the attendance profile. Students from the lowest ability level increased their participation rate by 24 percentage points, compared 6.5 percentage points for students from the highest ability level. Changes in tuition subsidies toward a more merit-based scheme accounts for 6% of the profile change. The effect is stronger for the high-ability group, an increase of 2 percentage points relative to a 1 percentage point for those students with low ability level, because of the merit oriented change. Finally, the change in the joint probability distribution of ability and family income accounts for less than 1% of the overall change. The effect is positive for students from the center of the ability distribution (about 2 percentage points), but negative for those on the tails (about 3 percentage points for low ability and 1 percentage point for high ability students). Changes in ability and family income levels generate effects through changes in subsidies and expected wages after graduation.

This study offers a detailed analysis of changes in schooling and labor force patterns over the last twenty years. It demonstrates the importance of understanding not only the changes in the overall college participation rates but also the changes in profile of college attendees. Different channels distinctively affect the schooling decisions of individuals from different backgrounds. This result is very suggestive and of practical use when evaluating various public policy alternatives to promote college participation. Several policy experiments are conducted and they demonstrate the importance of incorporating individual background data into the analysis.

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A College Participation Profile: From 1979 to 1997

Table A.1 shows college participation, by ability and family income levels, for the 1979 cohort.

	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	*Average*
Family income Q1	12%	34%	40%	68%	*39%*
Family income Q2	11%	24%	45%	74%	*38%*
Family income Q3	12%	29%	53%	73%	*42%*
Family income Q4	18%	30%	57%	71%	*44%*
Average	*13%*	*29%*	*49%*	*72%*	*41%*

Table A.1: College enrolment rates, NLSY79

Average college participation is measured to be 41% for the NLSY79 cohort. Table B.1 shows that college participation is increasing in ability level, at approximately 13% within the lowest ability quartile and it is 72% within the highest. College participation is also a positive function of family income; the mean participation within the lowest income quartile is 39% and 44% within the highest.

Average college participation increased to 68% in 1997, as measured using the NLSY97 data. The overall change in the college participation rate between 1979 and 1997 is around 69%. Equivalently, the percentage of high school graduates who did not attend college fell from 59% to 32%, which implies a 47% reduction in college non-participation. By uniformly distributing this 47% decrease in non-enrollment rate across all high school students, i.e. ignoring the different changes that occurred within each ability and family income subgroup, I obtain the college participation profile that is given in Table A.2. This allocation is termed the *non-sorting college attendance profile* or *implied trend*:

	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	*Average*
Family income Q1	53%	65%	68%	83%	*67%*
Family income Q2	53%	60%	71%	86%	*67%*
Family income Q3	53%	62%	75%	86%	*69%*
Family income Q4	56%	63%	77%	85%	*70%*
Average	*54%*	*62%*	*73%*	*85%*	*68%*

Table A.2: Projected enrollment rates, 2000

As shown in Table A.2, college participation by level of ability is independent of family income, i.e. there is not much dispersion in college enrollment rates by family income within each quartile of ability. College participation increases in ability from 54% to 85%.

Table A.3 shows the actual college participation profile for the later cohort, NLSY97.

	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	*Average*
Family income Q1	26%	58%	73%	89%	*61%*
Family income Q2	31%	59%	78%	92%	*65%*
Family income Q3	37%	69%	82%	96%	*71%*
Family income Q4	47%	74%	88%	96%	*76%*
Average	*35%*	*65%*	*80%*	*93%*	*68%*

Table A.3: College enrolment rates, NLSY97

As shown in Table A.3, college participation increases in ability and in family income. The increase of college enrollment with ability, (35% participation rate within the lowest ability quartile and 93% within the highest quartile), suggests a movement towards an efficient allocation of college participation. The NLSY97 allocation is suggested to be more efficient than in 1980 since more able students attend college at a higher rate relative to low ability students, and also more independently of their family income. The family income effect is also documented as becoming more efficient, students from low-income families participate less in college, 61%, compared to those from high-income families, 76%. The differences between Table A.1 and Table A.3 correspond to the net income and efficiency effects on college participation, or deviation from the projected trend in college participation

Table A.4 shows the deviations from the implied trend, as measured by the differences between Table A.3 and Table A.2.

	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	*Average*
Family income Q1	-27%	-7%	5%	5%	*-6%*
Family income Q2	-21%	0%	7%	6%	*-2%*
Family income Q3	-16%	7%	7%	10%	*2%*
Family income Q4	-9%	11%	11%	12%	*6%*
Average	*-18%*	*3%*	*7%*	*8%*	*0%*

Table A.4: Deviations in college enrollment rates, implied trend vs. NLSY97

Table A.4 shows that college participation of low-ability students increased by 18% less than the implied trend, the *non-sorting college attendance allocation*. On the other hand, college participation of the high ability students increased 8% more than the *non-sorting college attendance allocation*. These differences in college participation are due to the efficient allocation effect of changes in driving forces.

College participation of the low family income students increased by 6% less than the *implied trend*, as demonstrated in Table A.4. On the other hand, college participation of the high family income students increased by 6% more than the *non-sorting college attendance allocation*. This difference in college participation is due to the family income effect.

B College Attendance Costs, Loans and Subsidies

B.1 Tuition and Fees.

Source: College Board, 1987-88 to 2007-08: data from Annual Survey of Colleges, College Board, New York, NY, weighted by full-time undergraduate enrollment; 1977-78 to 1986-87: data from Integrated Postsecondary Education Data System (IPEDS), U.S. Department of Education, National Center for Education Statistics, weighted by full-time equivalent enrollment.

Academic Year	Private four-year	Public four-year	Public two-year
1977-78	9,172	2,225	1,039
1978-79	9,317	2,167	1,030
1979-80	9,085	2,079	1,000
1980-81	9,027	2,006	975
1981-82	9,264	2,047	977
1982-83	9,871	2,193	1,006
1983-84	10,567	2,381	1,095
1984-85	11,053	2,443	1,161
1985-86	11,782	2,537	1,233
1986-87	12,618	2,679	1,250
1987-88	12,808	2,698	1,342
1988-89	13,983	2,756	1,395
1989-90	14,454	2,829	1,403
1990-91	14,755	3,014	1,431
1991-92	14,933	3,206	1,782
1992-93	15,416	3,443	1,646
1993-94	15,803	3,639	1,787
1994-95	16,351	3,774	1,827
1995-96	16,610	3,822	1,808
1996-97	17,173	3,931	1,936
1997-98	17,822	4,022	2,025
1998-99	18,714	4,131	1,977
1999-00	19,306	4,182	2,051
2000-01	19,336	4,220	1,975
2001-02	20,353	4,410	1,883
2002-03	20,778	4,714	1,925
2003-04	21,341	5,231	2,149
2004-05	21,991	5,623	2,280
2005-06	22,208	5,813	2,309
2006-07	22,745	5,917	2,310
2007-08	23,712	6,185	2,361

Table B.1: Tuition and Fees - Constant (2007) dollars

B.2 Borrowing

Average Amount Borrowed from Federal and Private Sources by Full-Time Dependent Undergraduates by Family Income in Constant (2006) Dollars, 1992-93 to 2003-04.

Sources: College Board, NPSAS: 1993, 1996, 2000, and 2004; U.S. Census Bureau, Current Population

Survey, Annual Social and Economic Supplement, 1992, 1995, 1999, and 2003.

	Total loan amount 1992-1993	Total loan amount 1995-1996	Total loan amount 1999-2000	Total loan amount 2003-2004
Sector				
Public four-year	3,972	4,769	5,078	5,384
Private four-year	5,065	5,549	6,977	7,317
Public two-year	2,374	2,862	3,399	3,179
For-profit	4,707	4,635	5,823	6,751
All Institution Types Combined				
Low Income	4,131	4,838	5,528	5,636
Low-Middle Income	4,410	4,912	5,433	5,879
Middle-High Income	4,676	4,939	5,876	6,088
High Income	5,149	4,975	6,035	6,142

Table B.2: Average educational loans

B.3 Federal Grants

Number of Recipients and Aid per Recipient for Federal Grants, Campus-Based Programs in Constant (2006) Dollars, 1980-81 to 2006-07. Source: College Board of Education.

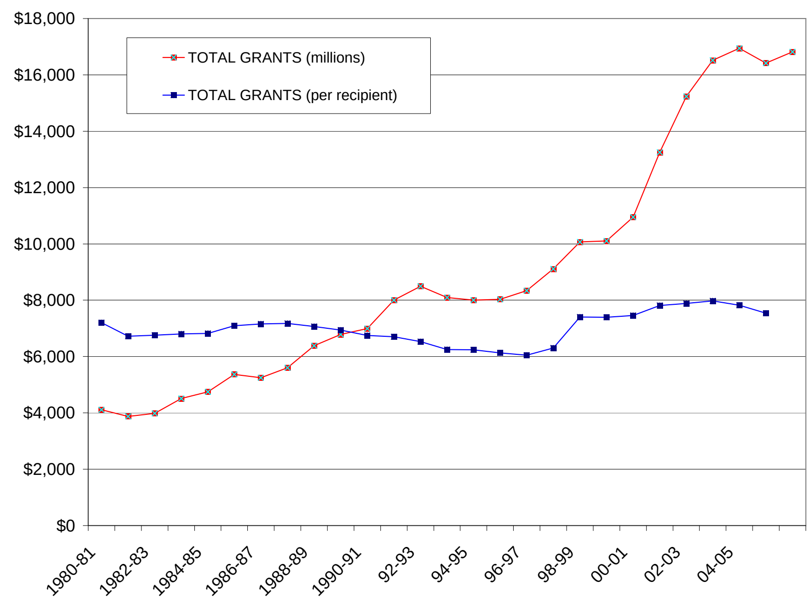

Figure B.1: Aid per recipient for Federal grants and Allocation of Grants

C Summary Statistics

Descriptive statistics

Sample Descriptive Statistics	**NLSY79**	**NLSY97**
Male	49.80%	50.85%
Black	12.53%	14.26%
Hispanic	8.25%	11.22%
Completed high school	75.63%	91.43%
Attended college	40.73%	69.25%
Completed at least one year of college	28.16%	54.92%
Urban residence at age 12	76.05%	72.61%
Number of siblings	2.9	3.7
Mother HS graduate	67.36%	61.95%
Father HS graduate	66.55%	58,87%
Family income ($10,000, 2007 dollars)	5.789	5.973
Sample size	2,477	3,489

Table C.1: Sample summary statistics, NLSY79 and NLSY97

Ability/family income distribution

Correlation	NLSY79	NLSY97
Ability-Family income	0.41	0.23

Table C.2: Ability/ Family income correlation

AFQT was normalized to mean zero and a unitary standard deviation. Altonji et al. documented an increase in the AFQT level of 7.75% and increase in its variance of 1%.

D Solution Method

In this Appendix I propose an analytical solution to the model. Given the nature of the life-cycle environment, the model is solved backwards from the third stage of the agent life-cycle.

The individual's maximization problem at the working stage, $W(a, w)$, has a simple analytical solution since there is no uncertainty in the final stage of the life-cycle. Given the asset level at the beginning of this stage and the wage drawn, the life-time utility is given by the following specification:

	NLSY1979	NLSY1997
AFQT*	0	0
	(1)	(1)
F. income	57,889	59,739
	(33,157)	(43,101)
AFQT Q1	-1.228	-1.333
	(0.202)	(0.286)
AFQT Q2	-0.490	-0.395
	(0.235)	(0.259)
AFQT Q3	0.353	0.468
	(0.259)	(0.237)
AFQT Q4	1.362	1.260
	(0.330)	(0.227)
F. income Q1	20,673	14,319
	(7,310)	(5,898)
F. income Q2	43,805	37,229
	(5,834)	(7,679)
F. income Q3	63,821	65,839
	(6,278)	(10,865)
F. income Q4	103,254	121,621
	(24,363)	(28,128)

Table C.3: Family income and AFQT summary statistics

$$
\begin{aligned}
W(a_o, w) &= \max_{\{c_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t u(c_t) \\
& \quad s.t. \\
c_o + \frac{c_1}{1+r} + ... &= a_0 + w + \frac{w}{1+r} + ...
\end{aligned} \tag{D.1}
$$

Agent's life-time utility at the working stage is increasing in assets and wages. Since wages are ability dependent, the life-time utility is also increasing in ability level.

Equation(D.1) describes the trade off faced by high school graduates when facing the college enrollment decision. Graduating from college is associated with a higher expected wage, but education costs may lead to negative asset holdings. Taking into account the college dropout option at the second stage of the life-cycle, college enrollment is also a risky investment decision.[33] Individuals who attend college in the first period but drop out in the second period are likely to receive a lower wage offer but may have more accumulated debt when they join the labor force.

[33]See Castex (2009), Chen (2002) and Chatterjee and Ionescu (2009).

Equation(D.1) also provides some insight about the the effects of the four driving forces on education and labor market decisions. First, a higher college wage gap generates a higher incentive to enroll in college, since a higher expected wage yields a higher life-time utility. A more merit-oriented distribution of grants leads to higher attendance rates among high ability students, since their effective cost of education decreases. The increase in tuition cost negatively affects all potential students, since they have to allocate a larger fraction of their family income to pay for education, which leads to a decrease in college enrollment rates. Finally, a shift in the joint probability distribution of ability and family income will have several effects on schooling choices: grants distribution is ability and family income dependent, while wages are a function of individual ability as well.

The saving decision of agents who choose not to enroll in college is given by equation (D.2).

$$a_{NC}^{*} = \frac{\left[\beta(1+r)\Psi_1\Psi_2\right]^{\frac{1}{\sigma}}\left(TR_N(\Omega_j)+w\right) - \frac{w(1+r)}{r}\Psi_1}{(1+r)\Psi_1 + \left[\beta(1+r)\Psi_1\Psi_2\right]^{\frac{1}{\sigma}}} \tag{D.2}$$

where $\Psi_1 \equiv \left(\frac{1+r-[\beta(1+r)]^{\frac{1}{\sigma}}}{1+r}\right)$, $\Psi_2 \equiv \left(\frac{1}{1-\beta[\beta(1+r)]^{\frac{1-\sigma}{\sigma}}}\right)$.

Their saving decisions are explained by consumption smoothing. Agents who do not enroll in college in the first period of their life-cycle do not face any uncertainty in future stages and therefore have no precautionary motives affecting their saving decisions. The discounted life-time utility of individuals who join the labor force as high school graduates is given by:

$$\begin{aligned} V^N(\Omega_j, w_j^N) &= u(c^*) + \beta W\left(a^*, w_j^N\right) \\ &= \frac{\left(w_j^N + TR_N(\Omega_j) - a^*\right)^{1-\sigma}}{1-\sigma} + W(a^*, w_j^N) \end{aligned} \tag{D.3}$$

The life-time utility of individuals without college education increases with wage. On the other hand, receiving a higher wage offer in the first stage of the life-cycle reduces the probability of college enrollment.

To evaluate the savings decision of individuals who enroll in college in the initial stage of the life-cycle I numerically solve the following equation.

$$\left(g(\Omega_j) + TR_C(\Omega_j) - \tau - a^* \left[\rho I_{(a^*<0)} + I_{(a^*>0)}\right]\right)^{-\sigma} =$$
$$\beta \int_w \left[\left((a + a^*)(1+r) + w\frac{1+r}{r}\right)\Psi_1\right]^{-\sigma} (1+r)\Psi_1\Psi_2 dF^C(w)$$

The previous equation is obtained from the first order conditions of the college participation problem. The savings of individuals who enroll in college is a decreasing function of their value of college participation, determined by transfers, and also a decreasing function of expected wage following graduation or drop out. Their saving/borrowing decisions are affected by consumption smoothing motives and precautionary motives.

Given the solutions of optimal saving decisions and wage offers, I estimate the life-time utilities at working stage for each ability and family income level. With the set of estimated life-time utilities in hand, I proceed to evaluate college enrollment rates and labor force participation patterns for each ability-family-income group.

E Estimated Effects on College Participation

Estimated effects on college participation (selection equation used to implement the Heckman two-step procedure)

	NLSY79	NLSY97
Highest grade mother	0.0914	0.0173
	(0.08))	(0.02)
Highest grade father	0.0770	0.0387
	(0.01)	(0.02)
Sex	0.2502	0.4055
	(0.07)	(0.06)
Hispanic	0.5270	-0.1702
	(0.15)	(0.11)
Urban	0.1016	0.0712
	(0.08)	(0.06)
Siblings	-0.0323	-0.0351
	(0.03)	(0.02)

Table E.1: Estimated effects on college participation

The parameters estimated for the grant equation, $g(\Omega_i) = \alpha_0 + \alpha_1 x_i + \alpha_2 y_i + \theta X_i + \alpha_\lambda \widehat{\lambda}_i + \varepsilon_i$ are reported in Table 2.

Wage estimation from the data proceeds as follow: First I estimate a wage profile along the life-cycle. I impose rational expectations over the wage structure, i.e., agents can observe the wage profile along the life-cycle for each educational level and ability level. I control for experience and ability and perform estimations for each educational level. The wage equation is estimated for the first cohort using NLSY79 data available for the 1979 - 2006 period. The wage specification is: $w_{it}^{educ} = \lambda_0 + \lambda_1 exp_{it} + \lambda_2 exp_{it}^2 + \lambda_3 x_i + \lambda_4 X_i + \varepsilon_{it}$. The preceding equation represents the log-wage structure for an individual i in period t who has an educational level *educ*. The variables *exp* corresponds to experience and variable x to ability level. X_i is a set of controls for individual and family characteristics. In these estimations I use information on white males only, whose annual wages are between \$3,000 and \$280,000. In the sample I include only individuals who participate in the labor force and are not attending school at that time. Estimates are presented in Table E.2.

	High school	College dropout	College graduate
λ_0	9.046	9.071	9.344
	(0.02)	(0.04)	(0.09)
λ_1	0.123	0.122	0.118
	(0.004)	(0.007)	(0.012)
λ_2	-0.0027	-0.0026	-0.0027
	(0.0001)	(0.0002)	(0.0004)
λ_3	0.157	0.037	0.186
	(0.006)	(0.012)	(0.014)

Table E.2: Estimated parameters for wage equations

Standard errors are in parenthesis. I project a hump shaped wage profile and estimate the average wage along the life-cycle. Average wages are reported in Table E.3. For the second cohort I inflate these mean wages in accordance with the increase in the college premium documented by Goldin and Katz (2007).

	college wage	dropout wage	non-college wage
NLSY79	29,158	25,339	22,549
NLSY97	36,442	28,161	22,549

Table E.3: Average wage per educational level, NLSY79 and NLSY97

The estimated parameters of the transfer function, $TR(\Omega_j) = \widehat{\alpha}_0 + \widehat{\alpha}_1 x_i + \widehat{\alpha}_2 y_i + v_i$, are reported in Table E.4:

	College			Non College			College drop out		
	$\widehat{\alpha}_0$	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$	$\widehat{\alpha}_0$	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$	$\widehat{\alpha}_0$	$\widehat{\alpha}_1$	$\widehat{\alpha}_2$
NLSY79	70,084	24,123	0.61	205,579	-42,874	1.42	153,000	650	0.91

Table E.4: Calibrated parameters for the transfer functions

F Model Predictions

First, I solve the model without transfers. The model generates college attendance rates for each ability and family income group using NLSY79 parameters. These simulated outcomes are then compared to those observed in the data. This exercise allows me to evaluate the performance of the model while only using parameters estimated from the data. Figure F.1 presents the simulated and actual college attendance profiles the NLSY79 cohort.

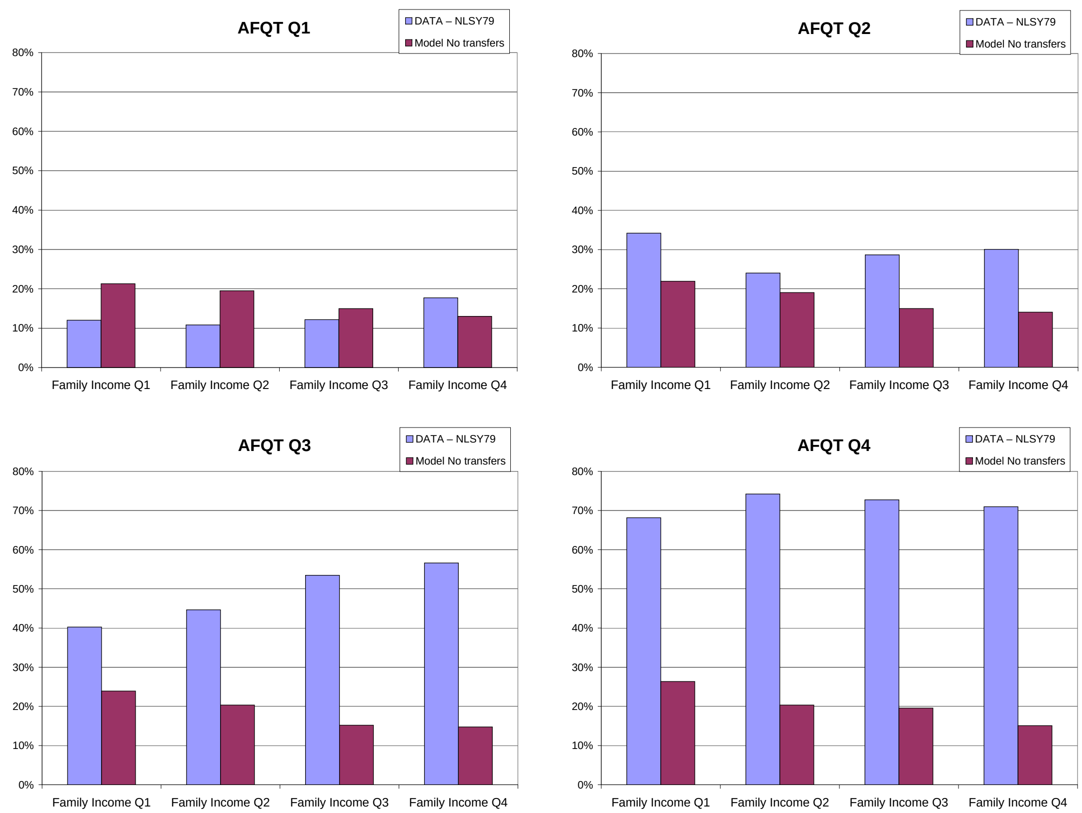

Figure F.1: College participation profile NLSY79-Data vs Model (no transfers)

Adding the transfer function, $TR(\Omega_j) = \delta_0 + \delta_1 x_i + \delta_2 y_i$, to the calibration of the model generates the participation rates provided in Figure 3.

	Data				Model			
	Ability							
Family Income	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Q1	12.09%	34.19%	40.25%	68.15%	12.09%	33.03%	50.37%	68.14%
Q2	10.83%	24.03%	44.65%	74.21%	13.12%	35.58%	51.00%	67.54%
Q3	12.17%	28.66%	53.46%	72.73%	16.26%	35.01%	53.57%	68.81%
Q4	17.72%	30.07%	56.60%	70.97%	17.70%	36.25%	56.77%	70.96%

Table F.1: College participation profile, Model vs Data, NLSY79

	Data				Model			
	Ability							
Family Income	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Q1	26.32%	58.10%	72.86%	88.52%	26.27%	68.16%	84.95%	90.85%
Q2	31.43%	59.24%	77.51%	91.91%	32.42%	70.07%	86.03%	91.38%
Q3	36.97%	69.38%	81.91%	95.71%	36.88%	73.52%	87.19%	92.10%
Q4	47.12%	74.16%	88.10%	96.17%	47.72%	77.30%	88.71%	92.87%

Table F.2: College participation profile, Model vs Data, NLSY97

G Marginal effects on enrollment rates

Here I document in detail the effect of each driving force on the changes of college enrollment rates. Values are reported in percentage points.

The marginal effect of the increase in the wage premium is reported in Table G.1.

College premium effect	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	Average
Family income Q1	23.87%	19.49%	12.60%	6.24%	15.55%
Family income Q2	23.71%	19.03%	12.30%	7.10%	15.54%
Family income Q3	23.78%	19.49%	11.97%	6.26%	15.38%
Family income Q4	24.90%	19.59%	11.04%	6.18%	15.43%
Average	24.07%	19.40%	11.98%	6.45%	15.47%

Table G.1: Marginal college premium effect on enrollment rates

The marginal effect of the the change in grant allocation is reported in Table G.2.

The marginal effect of the increase in the tuition level is reported in Table G.3.

The marginal effect of the change in the ability and family income distribution is reported in Table G.4.

Grant effect	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	Average
Family income Q1	1.12%	0.54%	1.98%	2.44%	1.52%
Family income Q2	1.24%	0.68%	1.78%	2.36%	1.52%
Family income Q3	0.76%	0.68%	2.89%	1.43%	1.44%
Family income Q4	0.71%	1.34%	2.26%	1.99%	1.58%
Average	0.96%	0.81%	2.23%	2.06%	1.51%

Table G.2: Marginal grants effect on enrollment rates

Tuition Effect	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	Average
Family income Q1	-1.08%	-1.48%	-1.31%	-1.63%	-1.38%
Family income Q2	-0.87%	-1.43%	-1.65%	-2.00%	-1.49%
Family income Q3	-1.93%	-0.96%	-1.55%	-1.92%	-1.59%
Family income Q4	-1.59%	-1.45%	-1.82%	-0.80%	-1.42%
Average	-1.37%	-1.33%	-1.58%	-1.59%	-1.47%

Table G.3: Marginal tuition effect on enrollment rates

The combined effect of the 4 driving forces analyzed is reported in Table G.5.

Distribution Effect	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	Average
Family income Q1	-2.47%	2.33%	2.52%	-2.16%	0.06%
Family income Q2	-1.63%	0.38%	2.47%	-1.00%	0.06%
Family income Q3	-3.84%	2.18%	1.07%	-0.15%	-0.19%
Family income Q4	-2.66%	2.18%	1.58%	-0.54%	0.14%
Average	-2.65%	1.77%	1.91%	-0.96%	0.02%

Table G.4: Marginal distribution effect on enrollment rates

Combined Effect	AFQT Q1	AFQT Q2	AFQT Q3	AFQT Q4	Average
Family income Q1	18.96%	21.21%	13.84%	6.45%	15.12%
Family income Q2	20.85%	18.89%	13.77%	6.87%	15.10%
Family income Q3	18.94%	20.44%	12.59%	6.74%	14.68%
Family income Q4	21.26%	20.27%	12.00%	6.17%	14.93%
Average	20.00%	20.20%	13.05%	6.56%	14.95%

Table G.5: Combined effect on enrollment rates

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