College Choice, Credit Constraints and Educational Attainment*

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July 15, 2021

Abstract

This paper examines the influence of credit constraints and government policy on college choice and educational attainment. We propose a discrete dynamic programming model of human capital accumulation where agents make schooling, borrowing, saving, and work decisions. Within this model agents choose between colleges of differing quality, and accumulate human capital through college attendance and labour force participation. Structural parameters of the model are estimated using from the 1997 cohort of the National Longitudinal Survey of Youth (NLSY97) and Generalized Method of Moments (GMM).

JEL Classification: I20, I23, I28, J24
Keywords: College choice, college quality, human capital, structural estimation.

*This version is preliminary and incomplete. The current version is available at `https://ferrall.github.io/QC/`. We are grateful to Marco Cozzi and Susumu Imai for valuable help. Computations are carried out in niqlow (`https://ferrall.github.io/niqlow/`).

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1 Introduction

This papers develops a lifecycle model of post-secondary attendance, borrowing, savings, earnings and consumption. The model parameters are estimated using GMM from moments derived from the Geocode version of the National Longitudinal Survey of Youth (NLSY97). The estimates are used to study the role of ability, college quality, credit markets, and student loan policies.

The literature on education, family background and credit market constraints often assumes quality and tuition costs do not vary systematically across colleges. In many countries these assumptions are fairly realistic. For example, although earnings differ across Canadian universities that are correlated with quality measures(Betts et al) nearly all are public and tuition rates are similar, and within provinces are often identical across universities. However, these simplifications mask the large heterogeneity in U.S. colleges and universities. U.S. universities differ greatly in acceptance standards, nominal costs, net cost differences between students, and observed earnings power of graduates (cite).

The correlation across these observable differences imply that students and their parents face complex tradeoffs when choosing which school to attend. When success in school and later in the job market is uncertain, different choices at age 18 can result is very different outcomes decades later. On the one hand, an elite education may lead to greater earnings to rationale its enormous cost difference compared to an in-state public education. On the other hand, lack of success can result in loan default and lifelong credit issues.

This paper adds to existing empirical estimates of these tradeoffs by capturing the tradeoffs between cost, benefit and risk of college choice in the U.S. [Discuss similarities and differences with other work.]

High school graduates face a choice between 4 school types to accept and keep an option value to attend. The choice among the school types is constrained by which school types accept them based on ability. Students finance their education through family transfers, grants, loans and work. They earn credits toward graduation and possibly a (four-year) degree.

In the model, if a student does not attend school for two consecutive years (or continues sporadic attendance for 13 years) they effectively "grow up" and forgo the option to attend again. This transition from youth to adulthood is structural in the sense that choice sets, active state variables and even the utility function shift in the adult phase. College credits are mapped into labour market skill, reducing redundancies in the state space. Skills evolve through learning-by-doing accumulation and forgetting-by-not-doing in post-schooling jobs.

Former students pay off student loans according to a schedule that mimics actual repayments schemes. Adults can also save to smooth consumption because they have a concave utility. They did not do this as students because young people have linear utility. Students paying off loans face earnings shocks and other risks that can force them into missing a payment and defaulting on their student loan debt. The credit market penalizes this outcome by reducing the interest they earn on savings.

After 25 non-stationary periods of decision making all agents transition to a simplified stationary environment of work and consumption that closes out the model and as the ”penalty” phase of default.

The presence of credit constraints on college quality would mean that by ignoring the quality margin, the extent of borrowing constraints has been underestimated. Furthermore, youth from low income families will most likely be affected by credit constraints as college tuition is higher for higher quality institutions. With evidence that college quality has important impacts on future earnings, understanding the role of credit constraints in shaping college choice will improve our understanding of the intergenerational persistence of earnings.[1] There are also significant implications for educational policy. In particular, those who are constrained along the quality margin are likely different than individuals constrained on the attendance margin. This model allows counter factual policy experiments to understand how people at both margins are effected by policies related to borrowing limits and tuition levels.

There are a number of mechanisms in which credit constraints may influence behaviour. Constrained individuals may: (1) forgo college completely, (2) attend a college of lower quality or tuition, (3) drop out before completing their desired level of schooling, or (4) alter consumption and employment while enrolled in college.

2 The Literature

Lochner and Naranjo (2011) review the credit constraint literature spanning direct, reduced form, and structural methods in identifying credit constrained individuals and the impact of these credit constraints on education decisions. They summarize the evidence as indicating that college constraints have played a more important role in recent years and that borrowing c 1onstraints influence both employment and consumption levels during college. They note some evidence that credit constraints influence quality of college attended.

Keane and Wolpin (2001) estimate a life-cycle model of schooling, work and borrowing decisions using the 1979 wave of the NLSY. They find that parental transfers and labour force participation are important in allowing individuals to attend college. Keane and Wolpin conclude that while borrowing limits may be tight, increasing available credit impacts work decisions and consumption during school, rather than school attendance.

Cameron and Taber (2004) propose a life-cycle model of schooling decisions to test whether alternative schooling options have differing discount rates. They find discount rates are consistent with optimal schooling decisions. Johnson (2013) estimates a discrete choice model of schooling decisions using the NLSY97 wave, and focuses on delayed entry and credit constraints. In an extension of Keane and Wolpin, he allows agents to attend both 2 or 4-year colleges. He finds that tuition subsidies significantly impact credit constraints, but that loosening borrowing limits has

[1] Dale and Krueger (2002) find that the effect of college quality is heterogeneous. In particular, those from low-income families see a greater benefit in attending high quality colleges than their high-income counterparts. Black and Smith (2004) use the 1979 wave of the NLSY and their results indicate that standard estimates may understate the effects of college quality on labour market outcomes.

only a small impact on college completion.

Fu (2014) estimates an equilibrium model of the college market. She aggregates colleges into four groups (elite private, elite public, private, and public) which we follow in this model. Fu models where students apply, how college decide to admit them, and which college type students enrol in Results indicate significant heterogeneity in preference for college, and that tuition and college capacity does not impede college options.

Kinsler and Pavan (2011) examine the relationship between college quality and family income in both the 1979 and 1997 waves of the NLSY. They find that the impact of family income on college quality is significant in both waves, but that impact of family income on college quality has weakened.

The model in this paper expands the existing literature in a number of ways: (1) the college attendance decision is more complex, allowing individuals to choose between colleges that are heterogeneous in quality. Aggregating colleges by quality provides new insights into how credit constraints influence college choice and educational attainment. (2) As in Eckstein and Wolpin (1999), progress is measured by credits earned rather than years attended, and credit is not deterministic.

This provides a more accurate measure of how many individuals are close to the margin in terms of graduation, and allows the model to pick up important differences in credits earned and graduation rates between colleges. (3) Student loan repayments are treated separately from other sources of borrowing and saving. With current estimates that outstanding college loans are over \$1 trillion and 11.5% of loans are 90+ days delinquent or in default, policies relating to student debt are of considerable policy interest.[2]

3 The Model

3.1 Overview

The lifecycle is modeled as an infinite horizon discrete dynamic program of the form:

$$V(\alpha;\theta;\gamma) \quad = \quad \int_{\zeta} \left[\max_{\alpha \in A(\theta)} U(\alpha;\epsilon,\theta,\gamma) + \zeta_{\alpha} + \delta_k E_{\alpha,\theta,\gamma} V(\theta';\gamma) \right] f(\zeta) d\zeta.$$

$U()$ is the utility of the action α chosen in the current year. The feasible set of choices is denoted $A(\theta)$ and depends on the state vector θ which also helps determine utility and expected future outcomes. Although the horizon is infinite, agents first progress through non-stationary phases corresponding to youth and adulthood until approximately 40 years of age.

The scalar ν_{α} is an IID extreme-value shock for the action contained in the vector ζ. The value function $V()$ integrates over ζ to smooth choice probabilities with a logistic kernel in the value of actions.

The state variable ϵ is an IID wage shock that follows a discretized normal distribution. The vector γ contains fixed values for the agent. Their symbols, short descriptions, and number of

[2] Quarterly Report on Household Debt and Credit, New York Federal Reserve, `http://www.newyorkfed.org/householdcredit/2013-Q4/HHDC_2013Q4.pdf`

values are:

$$\gamma = \begin{pmatrix} k & \text{Ability} & 3 \\ AFQT & \text{Test Score} & 2 \\ PI & \text{Parent Income} & 2 \end{pmatrix}$$

The first is an unobserved ability endowment k which is a discretized normal variable. The test score indicator (AFQT) is whether the student scored in the top quartile or not. The same is true for parental income (PI): a value of one indicates the household is in the top quartile of the income distribution.

Following the literature (e.g. Keane and Wolpin 1997 and Ferrall 1997) the distribution of ability k depends on the observed characteristics AFQT and PI. That is, ability is correlated with test scores but not identified directly with them. Parental income also correlates with ability through parental inputs and inherited traits. Endowed ability enters several aspects of the environment including the discount factor δ_k appearing in ???.

The action vector α contains 6 choice variables. Their symbols, descriptions, and potential number of options are:

$$\alpha = \begin{pmatrix} q & \text{College Quality} & 5 \\ a & \text{Attend} & 2 \\ b & \text{Borrow} & 3 \\ w & \text{Work} & 3 \\ m & \text{Miss Payment} & 2 \\ s & \text{Save} & 3 \end{pmatrix}$$

The ordering reflects the lifecycle pattern which is illustrated in Figure 1

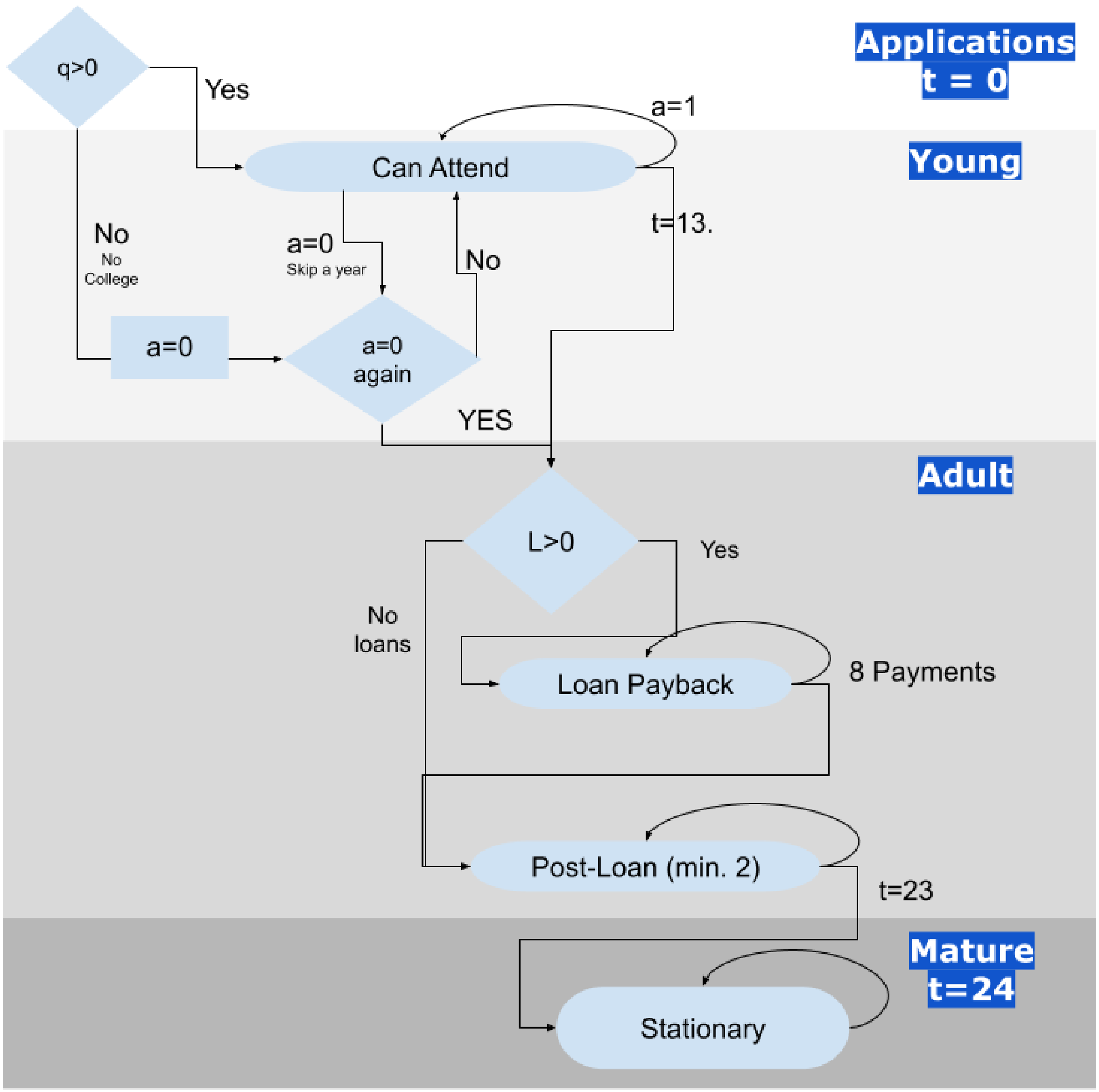
At $t = 0$ there is one decision which is once-and-for-all: which school type to attend (if any), q. Note this choice is to retain the option of attending in the future not a commitment. If post-secondary schooling is chosen the student chooses to attend ($a = 1$) or not in subsequent years, and they may borrow ($b > 0$) if attending. They can also choose to not work ($w > 0$) or not.

If a student skips two consecutive years of schooling or reaches $t = 13$ they transit to a post-schooling environment. At this point options to attend and borrow disappear from $A(\theta)$. Now all agents decide whether to work (w) and how much to save (s). Those with student loans must pay them back according to a schedule. If they miss a payment ($m = 1$) they person go into default, explained later. Otherwise, the payback period continues until completed.

At $t = 24$ all agents enter a final stationary phase. At this point work and savings are the only choices.

The time-varying (and non-IID) state vector θ contains the following variables:

Figure 1: Flowchart for the Lifecycle Model



$$\theta = \begin{pmatrix} t & \text{Time/Age} & 25 \\ p & \text{Phase} & 2 \\ \breve{q} & \text{Alma Mater} & 5 \\ \breve{a} & \text{Attended Last Year} & 2 \\ L & \text{Total Loans} & 3 \\ C & \text{Credits} & 5 \\ D & \text{Degree Earned} & 2 \\ K & \text{Skill} & 10 \\ \breve{m} & \text{Missed Payment} & 2 \\ \breve{s} & \text{Savings} & 3 \end{pmatrix}$$

State variables marked by ˘ are completely determined by a choice variable made in the past with the corresponding letter.

Time is tracked by t which corresponds to the decision period until the stationary infinite horizon phase is reached. The point of the lifecycle is tracked by p. Agents start out as youth $p = 0$ and become adults ($p = 1$) once they have not attended school two consecutive years or reach age $t = 13$. The phase must be tracked separately from t because agents grow up at different ages depending on their choices (namely q and a). Only two phases are required because the other situations illustrated in Figure 1 are determined by t, total loans (L) and payment status ($\breve{m}$).

Accumulated post-secondary credits are tracked while young in C. When it reaches 4 the person has earned a degree $D = 1$. Credits are forgotten once an adult. However, as explained below, credits are converted in initial labor market skill K at the youth-to-adult transi7tion. Degree status persists forever and interacts with school type ($\breve{q}$) in earnings. This allows for "sheepskin" effects to influence student choices separate from the human capital investment of earning college credits.

Last year's attendance is tracked by $\breve{a}$ to determine if this is the transition period. Once a mature person has missed a payment then $\breve{m}$ becomes 1 from then on. Finally, the amount saved last period is tracked in $\breve{s}$.

3.2 Choosing School Quality Type

At $t = 0$ a student chose q. No other variables in α are chosen at $t = 0$. School quality determines tuition, intrinsic utility of attendance, the rate at which earned credits translate into post-school skill and the value of an earned degree. School type is a one-time permanent choice to reduce the dimensions of the choice vector to focus on attendance and credit accumulation. Transfers between schools of the same type are consistent with a one-time choice. Only transfers to a new school in a different class would violate the assumption. These are rare, in part because we classify community college as Public. Thus, students transferring to a university after earning some junior college credits is consistent with a one-time permanent choice of alma mater type.

Students can only choose from school types that they are "accepted" by. We allow for three hidden choice sets that occur with probabilities depending on ability k.[3]First,

$$Q_0(k) = \{0,1\} \equiv \{\text{None}, \text{Public}\} \text{with prob. } \Phi(\nu_0 - k).$$

That is, all high school graduates have the option to enroll in a public university (or not). The probability that this is their choice set depends on their ability k and an estimated cut-off ν_0. This allows for college admissions to be based on a noisy signal on ability because the choice sets are in the form of an ordered probit. The next choice set is

$$Q_1(k) = Q_0(k) \cup \{2,3\} \equiv \{\text{ElitePublic}, \text{Private}\} \text{ with prob. } \Phi(\nu_1 - k) - \Phi(\nu_0 - k).$$

Finally, some students are admitted to all types of schools:

$$Q_2(k) = Q_1(k) \cup \{4\} \equiv \{\text{ElitePrivate}\} \text{ with prob. } 1 - \Phi(\nu - 1 - k).$$

3.3 Attending, Working and Borrowing

At $t = 1$ students who chose a school type other than none at $t = 0$ begin to chose to attend school that year, how much to borrow for school and whether to work or not. In addition they get government grants and scholarships if attending and conditional transfers from their parents. Grants and transfers follow deterministic rules:

If a student attends then they have the chance of earning a year of credit C which depends on

The choice variable w is the amount of time to work. It takes on the values of not to work(0), part-time (0.5), and full-time (1). Individuals make this choice each period after $t = 0$. They also receive a discrete IID wage offer shock ϵ which enters their wage along with other state variables. Working while attending school affects the probability of earning a credit (and thus indirectly skill levels upon transiting out of the schooling phase). In the post-schooling phase work affects the accumulation of skills through learning-by-doing.

The next choice, a, is whether to attend school in year t. This is a binary choice to attend (1) or not (0). Credits accumulate (stochastically) based on attendance. Credits next period are

$$C' = \begin{cases} C+1 & \text{with prob.} a(I_{m=0} + (1 - I_{m>0}))\Lambda(\theta_m + \theta_k k) \\ C & \text{otherwise.} \end{cases}$$

Working while going to school reduces the chance that credits are earned. Ability affects credits as well.

Borrowing b is allowed when $a = 1$. Feasible values are 0, 1, 2 translating into \$0, \$2500, and \$5000 amounts, respectively. The amount borrowed is added to total loans L to pay back once the schooling phase ends.

[3] See Fu (2014) for a structural estimation of application and admission decisions using the College Choice Wave of the NLSY97. This data tracks colleges that are applied to, are accepted by, and attended for individual's born in 1983 and 1984.

3.4 Transition to Adulthood

Attendance also has intrinsic utility, affects parental transfers of income and allows the student to borrow money for schooling.

If not attending two years in a row the person exits the schooling phase permanently and enters the adult labour market. This restriction reflects the pattern that very few people are observed to return to school after prolonged absences.

The first four elements of α are all active during the schooling phase. Once the student leaves school permanently the last two variables become active and only the work choice w stays active. The choice m is whether to miss (1) a payment on school loans or not (0). If the person did not borrow then this is not a choice. And at one level this is not an ordinary choice. If the person has enough income to make the payment they will do so. If not then they do not and go into default. To enforce this, the utility of not missing the payment is set to $-\infty$ if full payment cannot be made. The post-schooling phase begins in the loan repayment phase if the person borrowed money during the schooling phase. How payments are determined and the implications of default are discussed below.

When schooling ends credits and innate ability are converted to labour market skill, K. K takes on 10 values, $0, \ldots, 11$. Innate ability and college credits combine to determine initial labour market skill after schooling. Work then also affects a probabilistic accumulation of additional skill via learning-by-doing.

Details about state variables and transitions are discussed after discussing components of utility that depend on actions and states.

3.5 Consumption and Its Components

Several aspects of the model include exponential and logistic transformations written as

$$\begin{aligned} \exp(x) \quad &\equiv e^x \\ Logit(x) \quad &\equiv \tfrac{\exp(x)}{1+\exp(x)}. \end{aligned}$$

Earnings take the form:

$$Earn = wW \exp\{\sigma_p \epsilon\}$$

where w is the trivariate choice of not working (0), part-time (0.5), or full-time (1). W equals the component of full-time equivalent annual earnings that depends on endogenous states and endowed ability. The complete form of wages is defined below. The iid shock ϵ is discretized standard normal. The variance of shocks depending on the phase through the parameter σ_p. The variance of offers can differ for youth ($p = 0$) versus adults ($p = 1$). Arguments for Earn and other income sources are suppressed to simplify the notation.

Consumption while in the schooling phase depends on earnings, transfers and school related net expenditure. In particular, while young:

$$\text{Consumption} = \text{Earn} + a\left[\text{Grant} - \text{Tuition} + B\right] + \text{Trans}.$$

Grant equals government student grants. Tuition is tuition charged by schools of type $\check{q}$. Transfer equals parental transfers which that depend on age and attendance. B is the dollar value of student loan borrowing b defined above.

Although, in reality, student grants from the government depend on a number of factors, we make them deterministic functions of parent income:

$$\text{Grant} = \exp\left(\tau_0^g + \tau_i^g PI\right)$$

However, grants can be received only if the person attends school in the year. Transfers from parents are also deterministic and take the form

$$\text{Trans} = \exp\left(\tau_0^T + \tau_k^T k - \tau_t^T t + \tau_a^T a + \tau_i^T PI\right)$$

This form allows transfers from parents to vary with age, attendance and endowed ability along with parental income. As discussed below, mean of ability is allowed to vary with parental income the coefficient τ_i^T is only a partial effect conditional on ability.

Three exogenous interest rates enter the problem. First, subsidized student loans charge r_0. There is a lifetime cap of $\bar{L} = \$23,000$ on subsidized loans. If more than that is borrowed the interest rate increases to a market rate r_1, which also equals the interest on savings for adults not in default. Otherwise, people who have defaulted on student loans earn $r_2 < r_1$ on savings.

Loan repayments do not start until the transition to adulthood occurs. At that point L does not change and is frozen. The outstanding principal on the loan is not tracked. Instead a payment schedule $M(\check{m})$ is determined from L. The amortization factor for loans of type i (student or market) is: $h_i = r_i/(1-(1+r_i)^{-T_l}$ for $i \in \{0,1\}$. Re-payment period for loans is set to $T_l = 8$ years. Payment due depends on being current ($\check{m} = 0$) or in default ($\check{m} = 1$):

$$M(\check{m}) \quad = \quad (1 + .1\check{m})\left[h_0 \min\left\{\, L\,,\ \bar{L}\,\right\} + h_1 \max\left\{\, L - \bar{L}\,,\ 0\,\right\}\right]$$

The schedule amortizes the two types of loans if no payments are missed. Once a payment is missed a 10% penalty is added to the loan (regardless of how much of the payment was missed).

While $M(\check{m})$ equals *scheduled* loan re-payments, *actual* payments depend on whether the person is able to make the payment or not. First, define gross income (GI) before loan repayment as earnings plus savings income at the start of the year:

$$\text{GI} = \text{Earn} + (1 + r_{1+\check{m}})\check{s}.$$

The maximum amount the person must pay equals 90% of gross income. If this is less than $M(0)$ the person consumes 10% of their income and enters the permanent state of default ($\check{m} = 1$). This increases scheduled payments, and now up to 50% of earnings can be garnished. Thus, actual payments on student loan debt (during the payback period) equals:

$$\text{Payment} \quad = \quad (1-\breve{m})\min\{\,M(0)\,,\,0.9\times \text{GI}\,\} + \breve{m}\min\{\,M(1)\,,\,0.5\times Earn\,\}$$

Now define consumption as gross income minus the realized payment and any positive amount saved this year:

$$\text{Consumption} = \text{GI} - \text{Payment} - s.$$

Once the loan payback period is over, payments are zero and consumption equals gross income minus savings this period. GI still remembers default status through a lower interest rate on savings, so the penalty for default carries on after payments for the rest of the defaulter's life.

3.6 Utility

When issues of borrowing, loan repayment and credit market constraints are studied it is important to account for risk preferences. This in turn requires separating income with consumption, which is difficult when looking at decisions of teenagers and young adults. Although the NLSY97 collects information on the income sources that enter the model, the data are likely noisy. And it is difficult to value such things as living at home or the non-pecuniary joys of college life. At the same time, college students are paying very large and disparate amounts in tuition that dwarf their earnings power.

Eventually former students begin living independently, paying off loans, saving from their own earnings, and facing risk of default. A single concave utility applied to both these phases would require adjustments to account for changes in risk-sharing and consumption patterns between the young/student and adult phases. For example, it is common to include a consumption floor in models with risk and concave utility in order to avoid negative infinities and undefined values. In this environment, elite college tuition rates are likely to invoke any preset floor in many states of the problem. This in turn could make behavior insensitive to various changes to model and policy parameters as an artifact of the floor.

Our approach is to assume youth make decisions using linear utility. For them current risk is not relevant and negative consumption is not problematic. The disparity in net tuition remains relevant and marginal changes will affect behavior because no floor is imposed.

In particular, while young utility takes the form:

$$U_Y = u_0 + u_1\text{Consumption} + \gamma_q a + I_{w=0.5}(\gamma_p + \gamma_{??}a) + I_{w=1}(\gamma_f + \gamma_{??}a)$$

Adult utility, on the other hand, is assumed to be CRRA with an estimated parameter $\rho < -1$. Because earnings shocks and skill accumulation are random, an adult can still face negative consumption, especially during loan pay back. A floor of 0 is placed on consumption that requires the person to sell-off assets (that is, $s = 0$) if activated. Adult utility is then of the form

$$U_A = \frac{max\{\,\text{Consumption}\,,\,0\,\}^{\rho}}{\rho} + \gamma_p I_{w=0.5} + \gamma_f I_{w=1}.$$

The shift in utility between U_Y and U_A is endogenous to attendance choices (recall that two consecutive periods of setting $a = 0$ triggers the transition before the hard shift at $t = 13$.)

If U_Y and U_A were not related to each other then schooling behavior could become decoupled from future outcomes as an artifact of the utility shift. To avoid this, the terms u_0 and u_1 that appear in U_Y depend on U_A and are re-computed as parameters change. The values of u_0 and u_1 are set so that the level and slope of youth utility equals mature utility at an exogenous consumption level of $10,000. That is,

$$u_1 = U_A'(10) = (10)^{rho-1} u_0 = (1/\rho - 1) * 10^r ho$$

Figure **??** illustrates this seam. Thus, while young consumption may be very low but marginal utility does not explode as it would under U_A, forcing either a floor or other adjustments to generate attendance despite the disutility of low consumption. All else constant, agents will prefer to stay young but the framework limits this effect by the need to attend school and pay tuition and the lack of skill accumulation when working while young. All agents transit to adulthood by $t = 13$ and now make decisions with risk aversion. Thus, they have an incentive to save and avoid default to simply avoid payments.

At $t = 0$ the high school graduate is simply choosing the school type option q within their feasible set. Unless there is a cost to choosing a school type there is no reason to set $q = 0$ and give up the option of attendance, even if unlikely to occur. An additive parameter $\gamma_?$ is included to offset the option value to help match the observed school type ratios: $U_0 = -\gamma_? I_{q>0}$

3.7 Credits, Skill and Wages

College credits accumulate stochastically while attending school:

$$Prob\left(C' = C + 1\right) = Logit\left(\theta_0 + \theta_q(k \times q) + \theta_p \text{Parttime} + \theta_f \text{Fulltime}\right).$$

The degree indicator state variable is permanently set to 1 if credits accumulated entering this year equal four:

$$D = I\{C = 4\}.$$

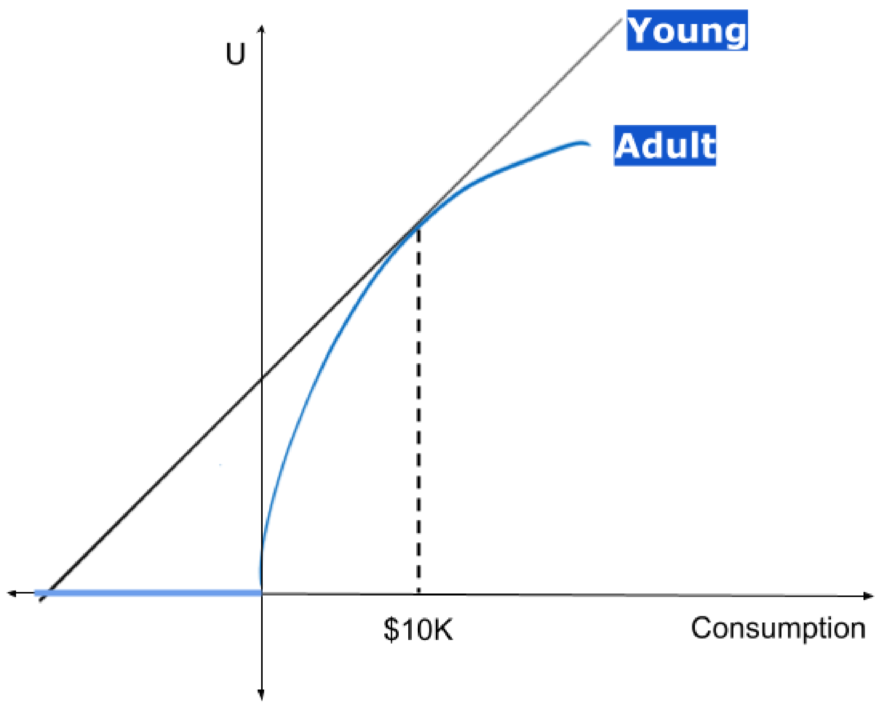
Recall that K denotes labour market skill. It is undefined while young. When transiting to the adult phase its initial value is randomly distributed on support on $[0, 1, 2, 3, 4]$. The full support of K goes up to 8, meaning that college credit is set to at most halfway towards the highest possible skill value. Subsequent experience can increase it and the estimate rate of accumulation determines

Just as attendance does not automatically earn credits, credits do not automatically translate into marketable skills. The distribution over the support is based on the beta distribution. Define

$$P_i = Beta(i/5, \phi_q^y C, 1), \text{ for } i = 0, 1, \ldots, 5.$$

The amount credits shift the a parameter of the beta is determined by ϕ_q^y. Then the initial

Figure 2: Lifecycle Utility



distribution of labour market skill is

$$Prob(K' = i) = P_{i+1} - P_i \text{ for } i = 0, 1, \dots, 4.$$

Greater value of the estimated parameter ϕ_q^y means that the same number credits from that college category translate into greater expected skills. Note that endowed skill k affects the initial distribution of K through its affect on earning credits. However, as defined below, k enters wages directly.

Work while young does not contribute to skill, because otherwise K would have to be tracked at the same time as credits C, expanding the state space greatly. Instead, jobs held during this phase are assumed not to include any human capital investment. Once the person has left school permanently and K is initialized, adult jobs impart skill through learning-by-doing. One more unit of skill is acquired next year with probability

$$Prob\left(K' = K + 1\right) = I_{w>0} Logit\left(\phi_0^o + \phi_a^o a + \phi_w^o w\right).$$

Recall that full-time equivalent wages equal $W \exp(\sigma_p \epsilon)$. The persistent component of wages, W, depends on whether the person is young or not, reflecting again the assumption that students work in a different labour market than those who have completed their education. While young,

$$W = \exp\left(\beta_0 + \beta_k k + \beta_q D_q\right).$$

The school-type specific degree effect β_q allows wages to be higher for degree holders during the two-year transition to adulthood even though labor market skill has not yet been set. Thus, degree holders experience an immediate shift in wage offers but those leaving school. Once adult, full-time equivalent earnings now depend on labor market skill in a standard quadratic form:

$$W = \exp\left(\beta_1 + \beta_k k + \beta_q D_q + \beta_K K + \beta_{K2} K^2\right).$$

The skills learned in school are not realized until after two years after last attendance. This artifact occurs because leaving school is inferred from attendance decisions in the data and, hence, in the model of the labor market.

3.8 Estimated Parameters and Model Specification

3.9 Ability

Ability k is a discretized normal random variable treated as permanent and unobserved (a random effect). The mean of the distribution is allowed to depend on observable characteristics of the student at the time of the initial college quality choice. In particular, the mean of ability is specified as

$$\mu = \mu_A AFQT + \mu_I PI + \mu_x AFQT \times PI$$

AFQT and PI are both binary[4], so there are four possible combinations. This specification allows for 3 free conditional means and one mean, for AFQT=PI=0, to be zero.

Following ?? and Ferrall (1997) the discount factor is allowed to depend on ability within the range $(0.9, .99)$:

$$\delta = 0.9 + 0.09 Logit(d_0 + d_1 k).$$

ΣWage Offer Distn. $= (s_Y s_A)$

ΓNon-pecuniary Utility $= Application g_a Attend g_q (q = 1, .., 4) Work g_w (w = 1, 2) g_{FA}$ ΘCredit Accumulation $= t_w (w = 1, 2) t_k$

ΦSkill Acummulation $= p_Y p_A p_k p_w$

ΩWages $= o_Y o_A o_k o_q (q = 1, ..., 4) o_K o_{K^2}$ BTransfers $= Intercept, k, t, a$ ρUtility $= -1.3$ TGrants MMean Ability $= u_{AFQT} u_{PI}$ ΔDiscount Factor $d_0 d_k$ NAdmissions $n_0 n_1$

4 Data and Moments Matched

Individual level data is provided by the Geocode version of the 1997 representative sample of the National Longitudinal Survey of Youth (NLSY97). The NLSY97 contains a sample of 8984 individuals who were 12-16 years old as of December 31, 1996. Information supplied by individuals and their parents from the initial 1997 interview up to and including 2010 is used in the sample. The NLSY97 contains comprehensive information on individual employment and schooling histories as well as family background. The sample used in estimation is composed of male high school graduates (excluding GEDs) who did not serve in the military.

The Geocode version includes the college attended. Following Fu (2014), colleges are aggregated into four distinct types: Elite Private, Elite Public, Private and Public based on the *US News Rankings of the best US Colleges*.[5] Elite colleges are those that ranked in the top 25 on average between 2003-2007.

Results from the allocation among college types at the age of 18 are outlined in Table 1. Only a small portion of the total sample are predicted to be attending elite private (2.64%) and elite public (10.39%) institutions. The majority of the sample report enrolling in non-elite institutions, with over four-times as many in the public non-elite than private non-elite. Approximately 17.5% of the sample do not enroll in a college of any type.

4.1 Educational Data

Data on credits earned, degree status, grants received, and student loans are used to summarize the college experiences. Individuals who enrol in college more than two months for that year are defined as attending. Semester start dates are used to form yearly attendance, tuition, credits earned and amount borrowed. Table 2 and Table 3 summarize the schooling data. Over 65% of the sample report attending college at age 18, and this rate declines to 5.5% by the age of 29. Only 10% of the sample attend school by the age of 26. College attendance by age and college type is

[4]We classify AFQT as 1 if an individuals AFQT score is in the top quartile, 0 otherwise while we classify parental income (PI) as 1 if if parental income is in the top tercile, 0 otherwise.

[5]https://www.usnews.com/best-colleges

summarized in. Consistent with the overall enrolment rate, college attendance is declining in age for each college type with a large attendance drop off between the ages 22 and 23. The majority of those who attend elite private and public schools enrol at 18, and complete their schooling by the age of 23.

College loans and grants are constructed using responses to questions on amounts owed on government educational loans and total scholarships received for each term. As seen in Table 2, average outstanding college loans rises from just over $4,000 at age 18 to nearly $7,000 at age 29.[6] grants received by students is relatively constant over age, with small declines after the age of 24. Students who attend private elite colleges are the least likely to have student loan debt. These students also receive on average considerably less in grants than those enrolled in non-elite private colleges. This could be partially driven by the fact that over 50% of those enrolled in elite private institutions in our sample have family income in the top tercile of the distribution. These students would be least likely to receive any need-based aid.

The NLSY collects information on the fraction of credits a student attempted and passed towards both associate's and bachelor's degree as well as degree status. The fraction of credits earned towards a bachelors degree are converted to credit totals between 0 and 4.[7] Credits earned towards an associates degree are treated as bachelor's credits. The average number of credits increases significantly over the first four years of college eligibility. This increase coincides with large increases in the number of individuals with a bachelors degree between the ages of 21 and 23. After the age of 22 the mean number of credits and percentage with a bachelor's degree slowly rise, consistent with the smaller fraction of the sample being enrolled. Table 4 shows a significantly higher percentage of those who enrol in elite institutions earn a bachelor's degree.[8]

4.2 Background Variables

The NLSY97 provides numerous variables relating to family background including family income and race. Table 4 displays the distribution of family income terciles, race and ability quartiles by college type. At elite private institutions the majority of attendees have parents in the top terciles of family income. Approximately 50% of individuals that do not attend any college report family income and wealth being in the bottom tercile of the sample.

The NLSY97 also contains information on the Armed Services Vocational Aptitude Battery (ASVAB). The ASVAB is comprised of 12 separate tests, but the ASVAB variable in the NLSY97 is comprised of verbal/math scores which is meant to mimic the Armed Forces Qualifying Test (AFQT) used here as a proxy for ability.[9] ASVAB scores are converted into quartiles for this analysis. Table 4 shows the average ability percentile at each college type.

[6] This is substantially lower than the average student loan debt seen in the United States. In 2005, the national average total student debt level for all ages was $18,600, College Board (2014).

[7] Partial credits are rounded to the nearest integer.

[8] This reflects aggregate data which shows graduation rates vary substantially along quality. For the 2004 cohort, six-year graduation rates vary from 28.8% at colleges with open admissions to 87.2% for colleges that accept less than 25% of their applicants, IPEDS (2013).

[9] For a complete list of the tests see: http://www.bls.gov/nls/handbook/2005/nlshc2.pdf

In the sample, those enrolled in elite private institutions have the highest median ASVAB percentile (75%), followed by elite public (69.3%). Those enrolled at non-elite public and private institutions have percentiles significantly lower than their elite counterparts. Individuals who do not attend a college of any type have an average ASVAB percentile that is over 25 percentage points lower than those attending non-elite institutions.

There are significant differences in educational outcomes across parental income terciles. By the age of 26 individuals from the highest tercile of family income have on average 11.2 credits, those from the middle tercile average 8.4 credits, while those from the lowest tercile have 5.9 credits, leading to significant differences in graduation rates. Nearly 50% of agents in the top third of family income have completed their degree. This is substantially higher than the 34% of youth from the middle tercile and 22% from the lower tercile that report having earned a degree.

4.3 Labour Market Experience

Labour market variables included in the NLSY97 include hours worked, wages and assets. Employment intensity is calculated by totaling the number of hours worked between September and August, and dividing by the number of weeks in the period. To correspond to the model, those who work on average less than 10 hours a week are assumed to not work during that year, those who work between 10 and 30 hours a week are labeled as part-time workers, and individuals who work more than 30 hours a week are said to work full-time.

Individuals appear to shift from part-time to full-time work over the sample period. It is clear from Table 5 that a significant proportion of those enrolled at school report working. At least 70% of those attending college work on at least a part-time basis from the ages of 18 to 25. The proportion of the sample attending college who also work full-time increases from just over 20% at age 18 to nearly 60% at age 28.[10]

Table 6 displays labour market statistics by college type. Those who enrol in elite institutions are slightly more likely to be working part-time while enrolled, but significantly less likely to work full time while attending school.[11] Given these patterns in work intensity, it is not surprising that those attending elite institutions make less than their peers at non-elite colleges. However, by the age of 26 those attending elite private institutions make significantly more than others, with private and elite public students making approximately the same amount. Those who do not attend college experience relatively higher earnings than those attending college at ages 18 and 20, but earn significantly less than college-goers by age 29.

[10]This could be partly driven by a larger proportion of students attending college part-time. Johnson (2013) finds that those who enrol part-time are more likely to work full-time while in school.

[11]It is important to not that we do not directly model part-time enrolment, and those enrolled at non-elite institutions are more likely to be enrolled part-time.

5 Estimation

Multinomial Results

As an initial step to understanding the relationship between family income and college choice in the model, we perform a reduced form analysis where colleges are divided into elite (combined private and public elite from above), non-elite public, non-elite private and non elite public college. Table 7 reports coefficients from a multinomial logit model where agents choose between these three college types. In this analysis of the effect of family income on college choice, we control for four quartiles of ability, gender, race, urban and number of siblings as well as using a heteroskedastic-robust estimator for the variance. The results in Table 7 indicate that both ability and family income have a significant effect on college choice.

To help interpret these results, as well as understand how the effect of family income on attendance varies over the distribution of ability, predicted probabilities are provided in Table 8. The first column indicates the probability of attending an elite college conditional on family income being in the first quartile and the second column conditions on family income being the fourth quartile. For individuals in the lowest ability quartile, the probability of attending an elite college changes from 1% to 1.6% as family income changes from the first to the fourth quartile. For respondents in the highest ability quartile, the probability of attending an elite college approximately doubles from 6.1% for individuals from the lowest family income quartile to 12.3% for those from the highest family income quartile, a difference which is statistically different.[12]

While these results indicate a positive relationship between college choice and family income, it is not clear what is driving this result. As mentioned above, two possible explanations are that individuals from low income households face credit constraints when choosing between colleges, or that family income is correlated with other unobservable attributes, such as preference for college type. In order to understand the mechanism behind this relationship, the model is structurally estimated, and counterfactual experiments are explored to understand the importance of preferences as well as credit constraints on college choice.

GMM Estimation Strategy

The vector of parameters to be estimated is denoted ζ and in total there are 39 parameters to be estimated from the data. Moments predicted by the model are matched to their observed values in the data, conditional on the four combinations of parental income and AFQT that influence the initial unobserved skill, as well as time. There are 4 combinations of the background variables and 13 time periods of data. This vector of conditional variables is denoted $\tilde{B}$, and the expected observation given $\tilde{B}$ as $E[Y|\tilde{B}, \zeta]$.

The moments used to estimate the model are displayed in Table **??**. In each period of the model, averages are taken over earnings, earnings squared, college loans, credits, degree status, attendance, grants and labour force participation. There are also interactions between work intensity and

[12]A Wald Test indicates the difference is significant at the 1% level.

attendance, as well as degree status and earnings. There are a total of 152 moments matched for each combination of parental income and AFQT, meaning a total of 608 moments are used to estimate the model. These observed conditional moments are denoted as $\hat{E}[Y|\tilde{B}]$, where Y represents a vector of measurements.

The model predicts moments for each combination of the variables contained in $\tilde{B}$ given the value of the parameters. These moments are represented by $E[Y|\tilde{B}, \hat{\zeta}]$. The difference between the empirical moments in the data and the moments predicted by the model can then written as:

$$\Delta\hat{m} = \hat{E}[Y|\tilde{B}] - E[Y|\tilde{B}, \hat{\zeta}]$$

Parameters are chosen to minimize the weighted distance between moments predicted by the model and those observed in the data:

$$\hat{\hat{\zeta}} =$$

argmin

$$\Delta\hat{m}' W \Delta\hat{m}$$

where W is a positive semi-definite weighting matrix. As the main interest is fitting college choice decisions and educational attainment more weight is placed on matching predicting moments on college choice, and attendance. Additionally, weighting is dependent on the number of observations used to calculate each moment.

Table 2.10 outlines the fixed parameters and their sources. Tuition levels at Elite Private and Elite Public colleges are \$27,009 and \$14,425 respectively, while Private and Public are assumed to charge \$17,201 and \$10,215. Interest rates applied to student loans are set to 6.13% for subsidized loans after graduation, and 6.8% for unsubsidized loans. These values reflect the average interest rates between 2006-2010 on government loans.[13]Asset levels for individuals at ages 18, 20 and 25 are used from Johnson (2013). Data on assets is collected infrequently by the NLSY.

5.1 Structural Estimation Results

Table 10 reports the current parameter estimates as a snapshot of the estimation procedure. Moments are weighted by inverse standard deviations of observed moments with some adjustments to add weight to key parameters. Final estimates will be based on simulated efficient weighting matrices based on first stage estimates. Because the first stage procedure has not yet converged the values of the estimates will not be discussed in this draft. Instead, the current fit for key variables will be displayed and discussed.

Table 11 compares predicted and actual college choice over the four fixed groups. For the most part the snapshot estimates over-predict the no college ($q = 0$) and elite private ($q = 4$) options. It is encouraging that the specification with just three mass points of unobserved ability is able to produce a wide range of predicted choices. It is also difficult to control the weight moments receive in the GMM objective in this first stage. The importance of q relative of other moments can be

[13]Interest rates prior to July 1st, 2006 are variable, https://studentaid.ed.gov/types/loans/interest-rates

increased to pin down these values before moving to the second stage.

Figures 3, 4 and 5 display predicted and observed attendance, credit accumulation, and degree status by AFQT and parent income group. These figures average over the school quality types and would compare to previous work that treated college quality as homogeneous.

Figure 8 displays the percentage of each group working full-time, again averaging over college quality choice (including no college).

Figures 9 to 11 show earnings for three of the five college streams: none ($q = 0$), public ($q = 1$) and elite private ($q = 4$). Figures 6 and 7 show student borrowing for the latter two college types. Since these values are interacted with school type the gap between predicted and observed values combine differences in quality choice and the outcome variable. What is shown instead in these figures are conditional averages: observed earnings are divided by the fraction observed in the college type and predicted earnings are divided by the predicted fraction. The reasonably close match shows that the model captures the earnings profiles. Subsequent work must focuses on improved fit in college choices and borrowing behavior.

6 Conclusions

Much of the research into credit constraints has focused on the relationship between family income and college attendance. However, this research has ignored important heterogeneity in the college market along both quality- and tuition-dimensions. The correlation between college quality and family income can be explained by credit market constraints affecting college quality choice as well as by other characteristics correlated with family income that favor high quality college. Selection by colleges based on ability also affects the patterns and makes observed returns to college quality a combination of selection, true learning differences, and sheepskin effects of degrees. Accounting for earnings risk and student-loan default is a further complication. Without all these elements, an attempt to distinguish credit market constraints from other explanations remains contingent on strong maintained assumptions. Implications for policy changes related to student loan payment and forgiveness, tuition subsidies, and entrance requirements are clearly affected by the relative importance of credit market constraints.

The current snapshot of the estimated parameters suggests a parsimonious model can account for the observed patterns, although some dimensions of the data remain poorly fit. The model is parsimonious because only 37 parameters are varied to match over 3000 moments related to college performance and earnings.

7 Tables

Table 1: Allocation over College Type

	E.Pri	E. Pub	Private	Public	None	Total
N	15	59	306	99	325	568
% of Sample	2.64	10.39	12.32	57.22	17.43	100

Table 2: Selected College Statistics by Age

Age	% Enrolled	Loans	Credits[1]	Grants[1]	BA Degree[2]
18	63.3	$3,434	0	$4,532	0.0
19	53.4	$4,131	1.11	$4,184	0.0
20	46.8	$4,645	1.75	$4,767	0.0
21	42.1	$4,878	2.37	$4,128	0.4
22	37.2	$5,455	2.89	$5,210	7.23
23	26.6	$5,437	3.20	$3,762	16.9
24	16.4	$5,488	3.35	$3,149	23.1
25	11.7	$5,573	3.30	$4,149	26.2
26	10.5	$5,716	3.26	$3,251	28.3
27	8.5	$6,131	3.14	$3,650	30.0
28	6.6	$6,165	2.89	$3,838	31.2
29	5.5	$5,826	2.87	$400	31.2
30	4.8	$6,061	2.71	$5,000	29.7

Loans and grants are measured in 2004 dollars.

[1] if > 0

[2] percentage of sample

Table 3: College Attendance by Age and College Type (Percent of Sample)

Age	N	Private Elite	Public Elite	Private	Public	None
18	568	2.46	9.33	9.86	41.73	36.6
19	998	2.00	7.92	8.22	35.27	46.59
20	1066	1.97	7.04	7.32	30.49	53.18
21	1080	1.94	6.67	6.85	26.67	57.8
22	1092	1.47	5.31	6.50	23.9	62.82
23	1098	0.82	3.28	4.46	18.03	73.41
24	1099	0.01	1.27	2.27	12.74	83.62
25	1101	0.01	0.82	1.54	9.26	88.28
26	1103	0	0.63	1.09	8.79	89.48
27	558	0	0.82	0.58	7.11	91.49
28	604	0	0.83	0.50	5.3	93.38
29	393	0	0.25	1.02	4.32	94.40
30	165	0	0	1.82	3.03	95.15

Table 4: Selected Statistics by College Type

Variable		Elite Private	Elite Public	Private	Public	None
% Complete BA[1]		95.45	63.04	53.54	28.40	.
% College Loans		33.04	39.69	37.98	24.55	.
Avg. College Loans/year[2]		\$3,632	\$5,849	\$7,481	\$4,608	
Avg. College Grants/year[2]		\$10,260	\$5,332	\$6,120	\$3,026	.
Median Ability Pct.		75.0	69.3	60.1	60.2	33.4
% Black/Hispanic		13.33	13.56	18.57	22.46	40.15
	1st Tercile	19.05	17.58	31.7	30.05	43.84
Familiy Income	2nd Tercile	19.05	23.08	38.2	34.09	38.08
	3rd Tercile	61.90	59.34	30.1	35.86	18.08

Annual amounts, in 2004 dollars.

[1] by the age of 26.

[2] by the age of 26.

Table 5: Employment by Age (Percent of sample)

	Enrolled		Not Enrolled	
Age	Pt. Work	Ft. Work	Pt. Work	Ft. Work
18	48.89	19.16	29.81	47.12
19	43.90	25.14	24.73	52.04
20	43.89	30.26	21.526	54.15
21	42.86	31.21	20.00	56.96
22	38.42	42.61	15.60	65.16
23	27.74	51.71	16.63	68.11
24	20.56	56.67	16.98	68.55
25	25.58	51.94	13.48	70.89
26	27.59	48.28	15.60	68.49
27	19.18	53.42	14.65	68.28
28	15.00	60.00	13.83	68.97
29	9.09	72.27	15.09	67.12
30	62.50	25.00	15.92	63.057

Pt = part-time, Ft = full-time.

Table 6: Employment Statistics by College Type

Variable	Pri Elite	Pub. Elite	Private	Public	None
Wages (age 18)	\$3,262	\$2,853	\$3,864	\$4,349	\$5,853
Wages (age 20)	\$4,052	\$4,290	\$7,649	\$8,633	\$10,822
Wages (age 26)	\$39,839	\$35,554	\$31,358	\$27,893	\$25,890
Wages (age 29)	\$52,741	\$49,281	\$49,429	\$35,271	\$28,153
% PT Work & Enrolled[1]	43.69	42.07	39.04	37.02	.
% FT Work & Enrolled[1]	21.36	19.95	36.33	40.05	.

Annual wages measured in 2004 dollars.

[1] percentage of sample, average over all years enrolled.

Table 7: Family Income and College Choice, Multinomial Logit

Variable		Elite	Non-elite Private
Family Income	2nd Quartile	.302	.167
		(.105)	(.155)
	3rd Quartile	.314	.0212
		(.199)	(.160)
	4th Quartile	.484***	.197
		(.104)	(.157)
Ability	2nd Quartile	.642*	-.492***
		(.332)	(.183)
	3rd Quartile	.822**	-.378**
		(.323)	(.176)
	4th Quartile	1.142***	-.275
		(.321)	(.174)
Additional Controls		Y	
Observations		1846	

Robust standard errors in parenthesis.

Additional controls include: gender, race, urban, number of siblings.

$^{*}p < .1, ^{**} < .05, ^{***} p < .01$

Table 8: Predicted Probabilities, Elite Colleges

		Family Income	
		Quartile 1	Quartile 4
Ability	1st Quartile	.012*	.0161*
		(.007)	(.009)
	4th Quartile	0.061***	0.123***
		(.015)	(.0190)

Predicted probabilities from coefficients in Table 8.

Additional controls at their mean value.

$^{*}p < .1,^{**} < .05,^{***}\, p < .01$

Table 9: Moments Matched for GMM Estimates

Interactions						School		Other				Work			
t	q	q	qXAtt		Borr.	Cred	Grant	Trns	Sav.	PT	FT	Earn	Earn2	Deg	ExDeg
0	0			X											
	1			X											
	2			X											
	3			X											
	4			X											
1-13		0						X	X	X	X	X	X	X	X
		1			X			X	X	X	X	X	X	X	X
		2			X			X	X	X	X	X	X	X	X
		3			X			X	X	X	X	X	X	X	X
		4			X			X	X	X	X	X	X	X	X
			1	X		X	X			X	X				
			2	X		X	X			X	X				
			3	X		X	X			X	X				
			4	X		X	X			X	X				

X indicates the moment is matched. Also crossed with fixed Test Score and Parent Income combinations.
Total Moments Matched = 4(5 + 64*13) = 4(837) = 3228, less missing savings observations

Table 10: Parameter Estimates

Vector	Description	Sub-Category	Variable	Estimate
Σ	Wage St.Dev.		Young	4.0389
			Adult	0.9407
Γ	Non-pecuniary	Application	Intercept	8.6484
		Attend	Public	0.0242
			Private	0.0210
			Elite Public	-0.2966
			Elite Private	0.0284
		Work	None	0.0000
			Partime	-5.1156
			Fulltime	0.5360
			Attend X FullTime	4.8898
Θ	Credits		None	0.0000
			Partime	-0.0053
			Fulltime	0.0044
			Ability	0.0755
Φ	Skill Accum.	Young	Intercept	1.8712
		Adult	Intercept	0.8595
			Ability	-0.4430
			Work (fraction)	-0.0199
Ω	Wages	Intercepts	Young	-0.0282
			Adult	0.6313
		Ability		0.0223
		Degree	Public	-0.0007
			Private	0.1576
			Elite Public	0.3766
			Elite Private	0.0694
		Skill	Linear	1.7392
			Quadratic	0.3750
B	Transfers		Intercept	0.0692
			Ability	0.0799
			Age (t)	1.2011
			Attend	0.0489
ρ	Utility		Intercept	-13.3381
T	Grants		Intercept	-0.6266
M	Mean Ability		AFQT	1.6350
			Parent Income	0.0413
	Ability St.Dev			1.0000
Δ	Disc. Factor		Intercept	8.5842
			Ability	0.9465
N	Admission	Cutoffs	Elite Public	1.3099
			Elite Private	2.2685

Table 11: College Quality Choice (q)

				Ordinary		Elite	
AFQT	Par. Inc	Type	None	Public	Private	Public	Private
0	0	Predicted	0.445	0.476	0.047	0.027	0.005
		Observed	0.290	0.568	0.108	0.035	0.000
		%Δ	*57%*	*-20%*	*-47%*	*-8%*	*14%*
1	0	Predicted	0.098	0.452	0.213	0.165	0.072
		Observed	0.066	0.625	0.112	0.158	0.039
		%Δ	*12%*	*-37%*	*77%*	*7%*	*84%*
0	1	Predicted	0.434	0.481	0.049	0.029	0.006
		Observed	0.154	0.646	0.139	0.062	0.000
		%Δ	*107%*	*-36%*	*-67%*	*-33%*	*15%*
1	1	Predicted	0.091	0.447	0.217	0.169	0.076
		Observed	0.043	0.446	0.174	0.239	0.098
		%Δ	*105%*	*1%*	*40%*	*-83%*	*-59%*

%Δ = (P-O) / ((P+O)/2)

Figure 3: Attendance

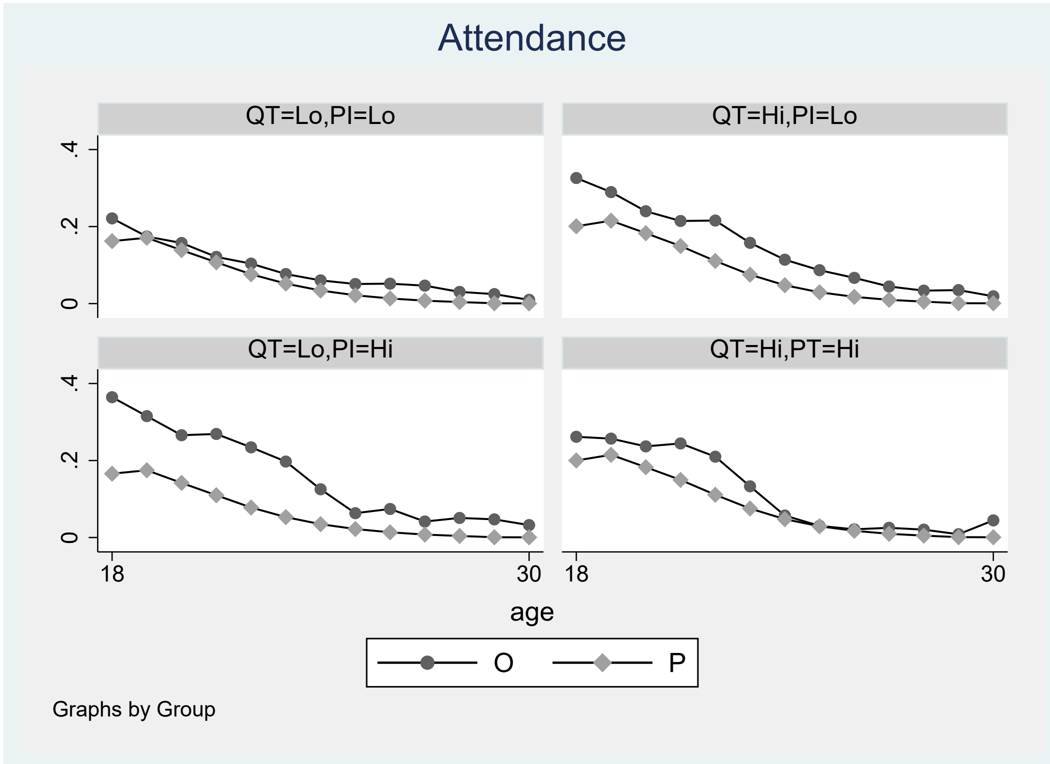


Figure 4: College Credits (Years)

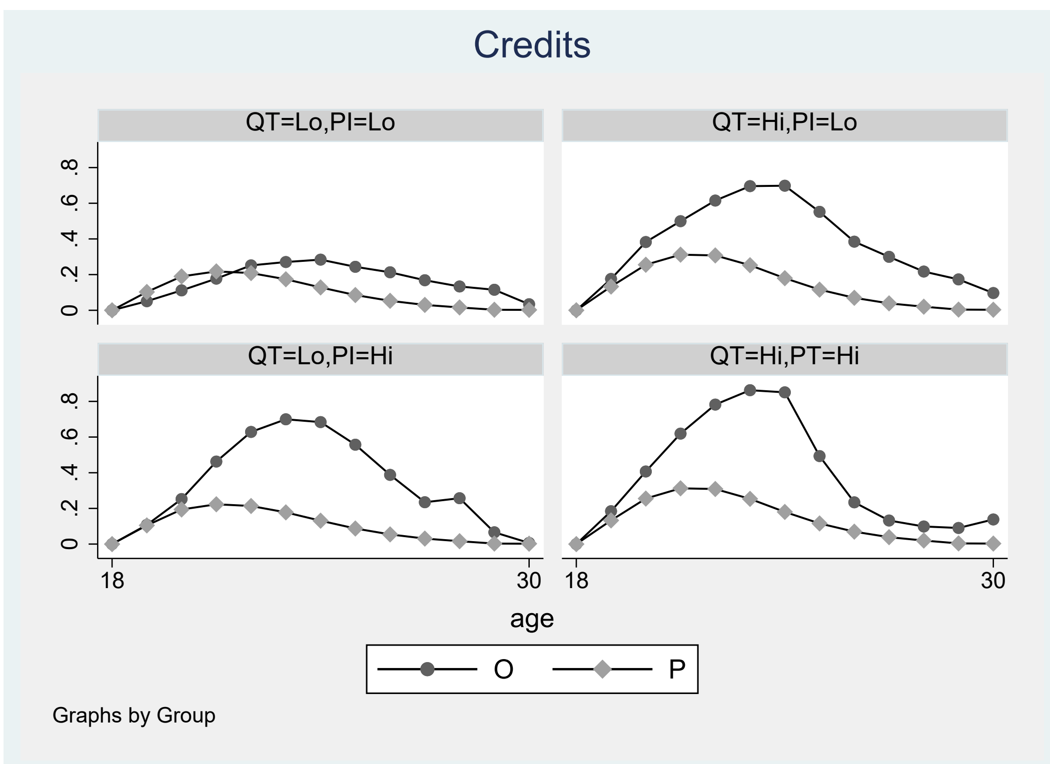


Figure 5: Degree Earned (any type)

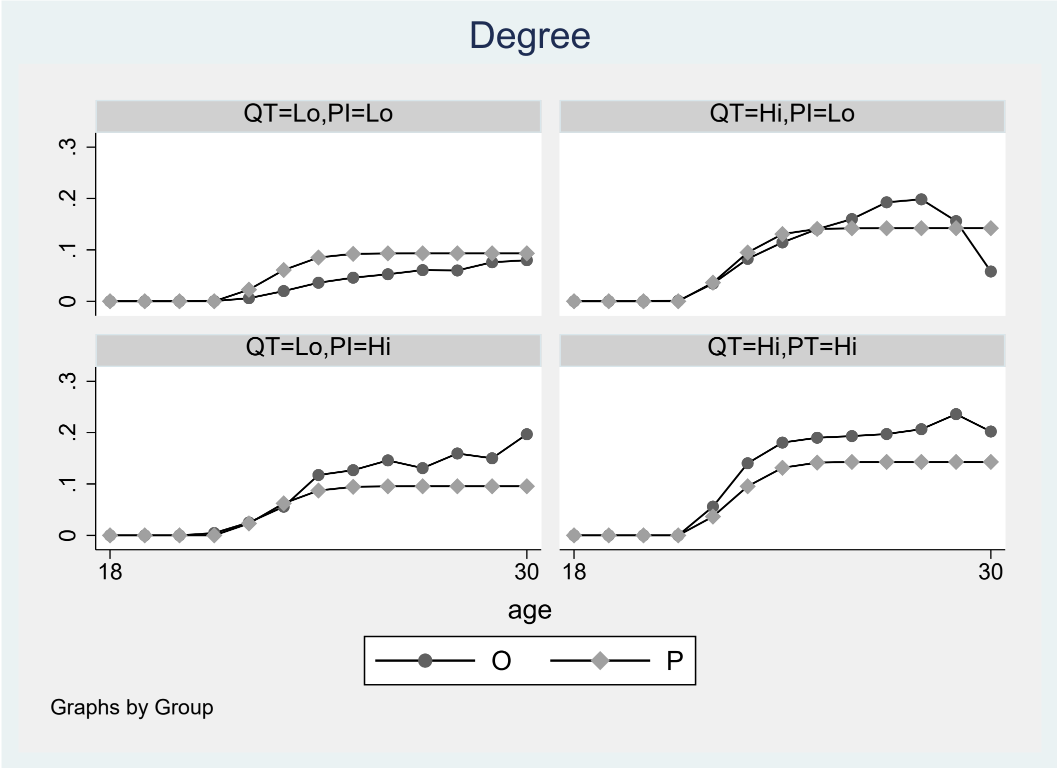


Figure 6: Student Borrowing - Public

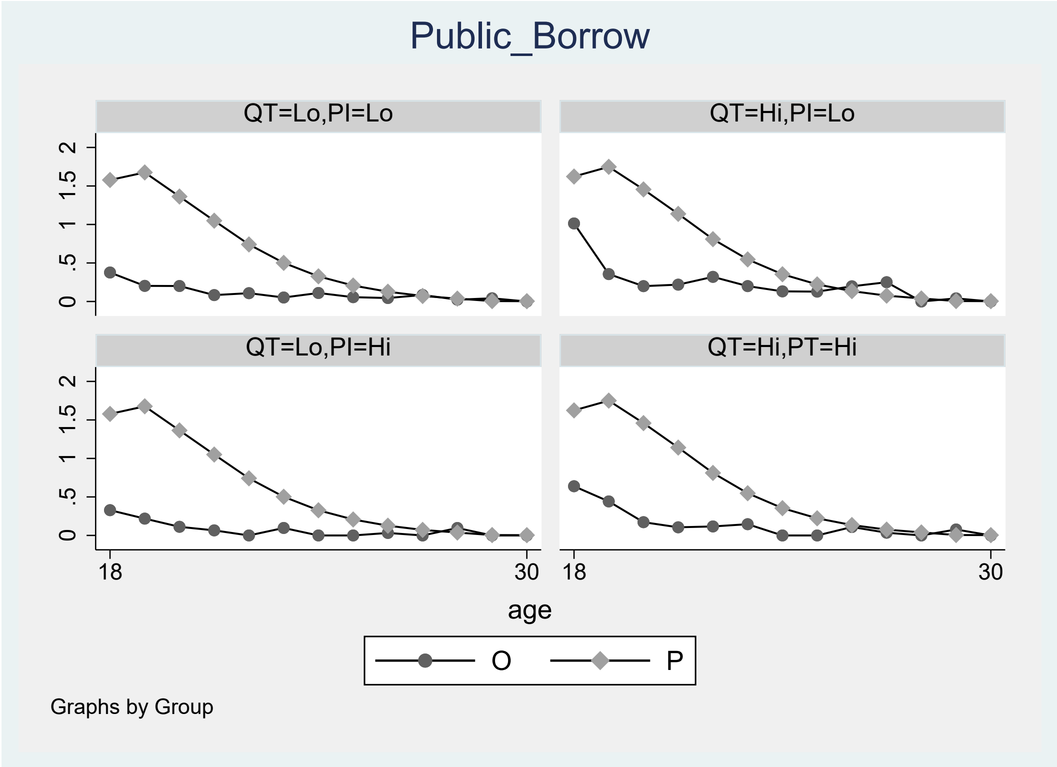


Figure 7: Student Borrowing - Elite Private

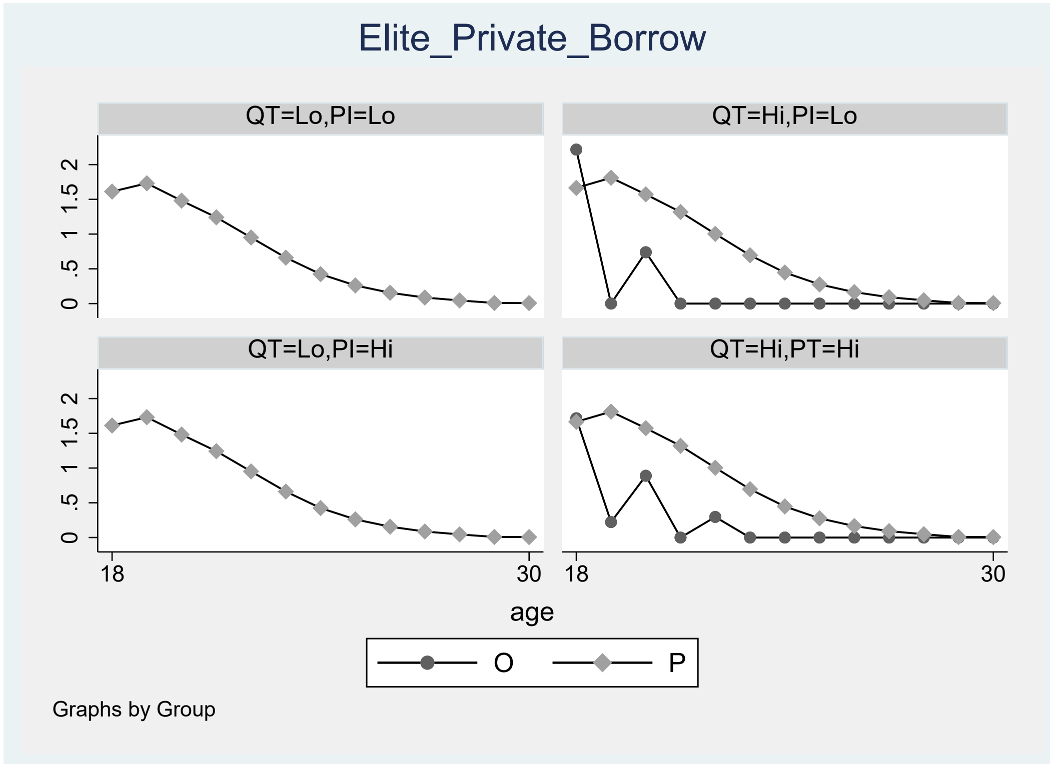


Figure 8: Work Full Time

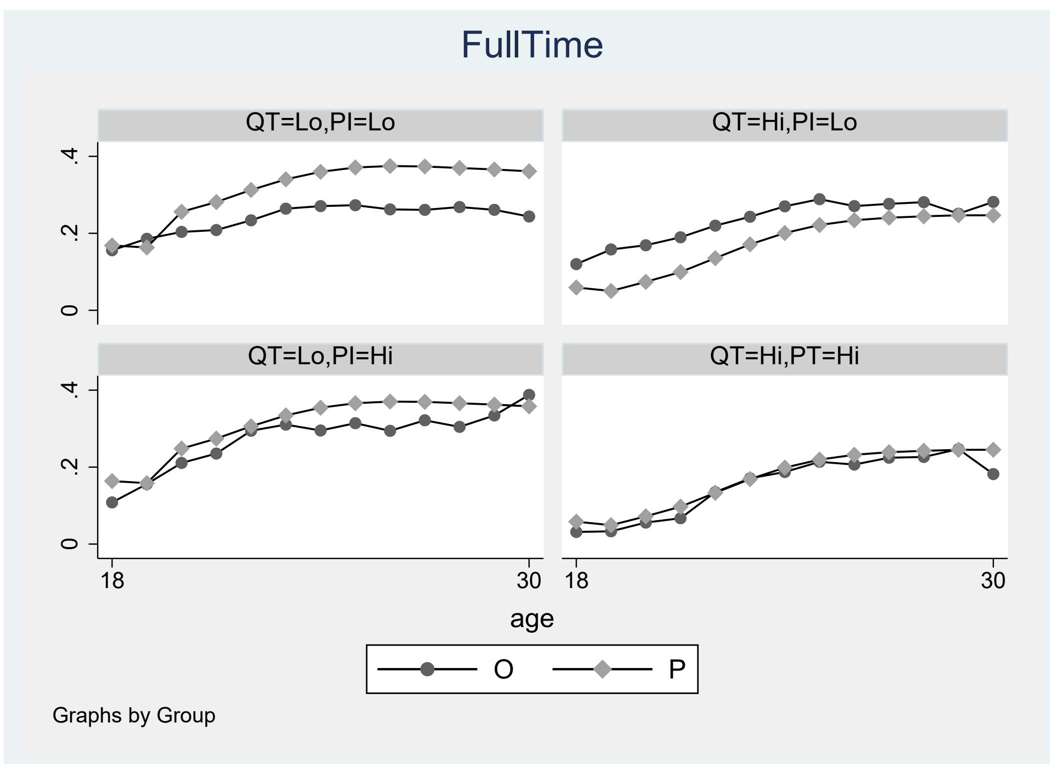


Figure 9: Earnings No College ($q = 0$)

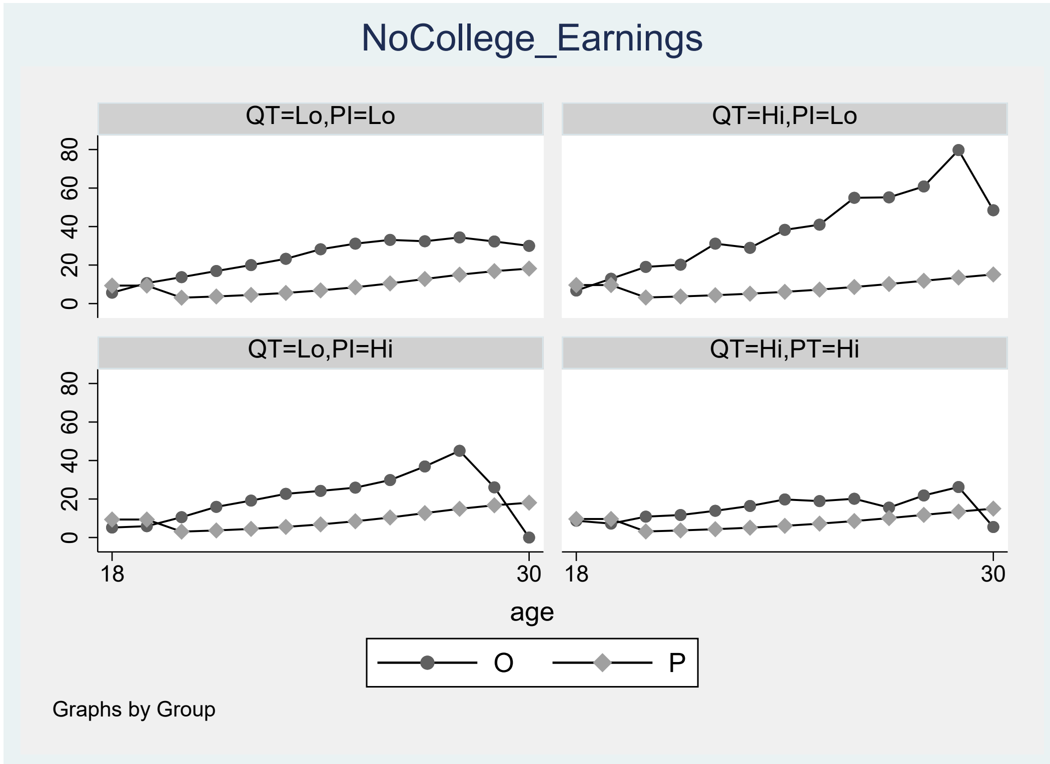


Figure 10: Earnings Public College ($q = 1$)

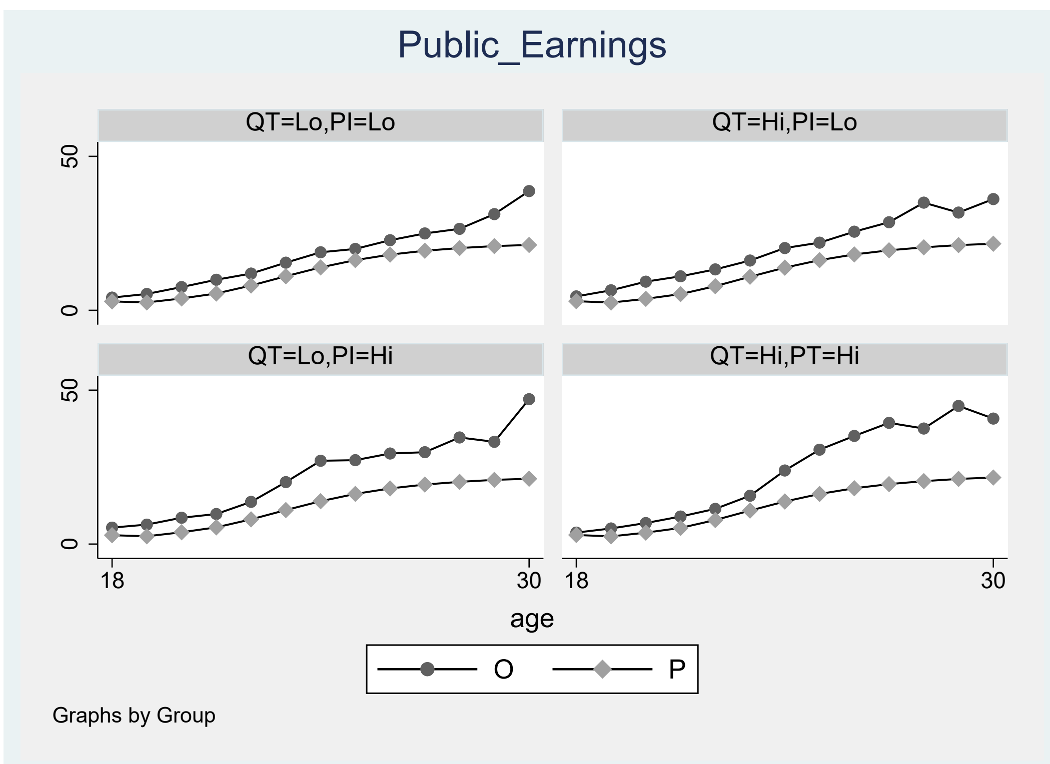
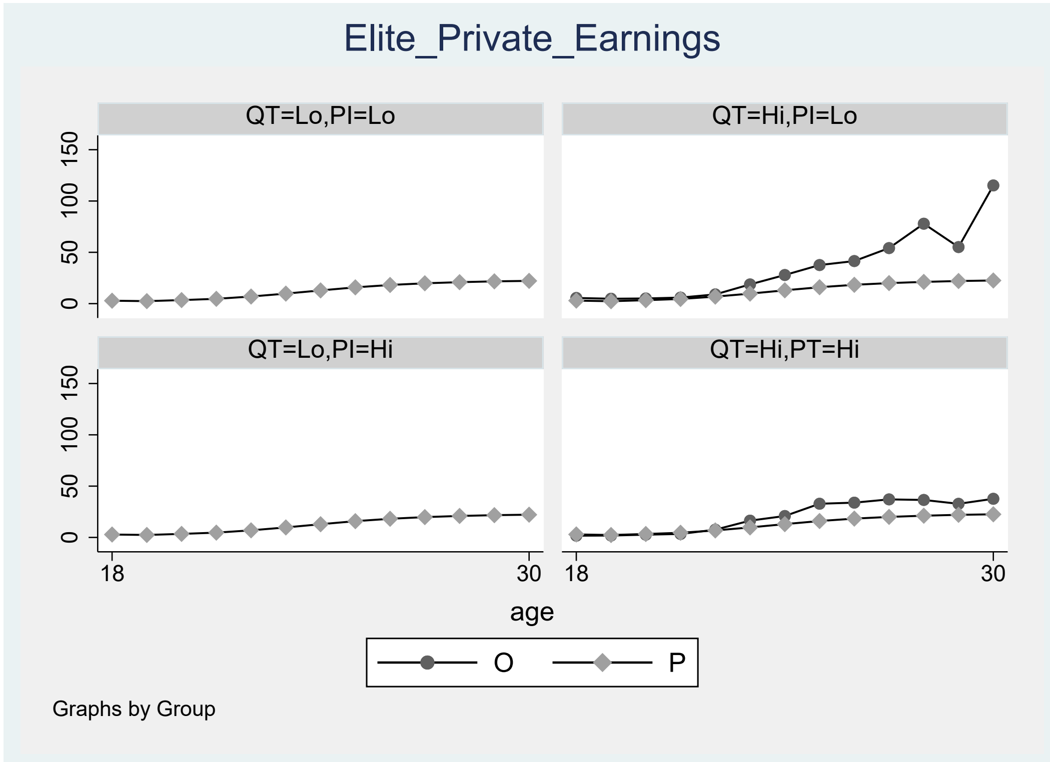


Figure 11: Earnings Elite Private ($q = 4$)



References

Arcidiacono, P. (2005). Affirmative action in higher education: How do admission and financial aid rules affect future earnings? *Econometrica 73*(5), 1477–1524.

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. 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.

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.

Chatterjee, S. and F. Ionescu (2012). Insuring student loans against the financial risk of failing to complete college. *Quantitative Economics 3*(3), 393–420.

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.

Dale, S. B. and A. B. Krueger (2014). Estimating the effects of college characteristics over the career using administrative earnings data. *Journal of Human Resources 49*(2), 323–358.

Eckstein, Z. and K. I. Wolpin (1999). Why youths drop out of high school: The impact of preferences, opportunities, and abilities. *Econometrica 67*(6), 1295–1339.

Epple, D., R. Romano, and H. Sieg (2003). Peer effects, financial aid and selection of students into colleges and universities: an empirical analysis. *Journal of Applied Econometrics 18*(5), 501–525.

Epple, D., R. Romano, and H. Sieg (2006). Admission, tuition, and financial aid policies in the market for higher education. *Econometrica 74*(4), 885–928.

Epple, D. and R. E. Romano (1998). Competition between private and public schools, vouchers, and peer-group effects. *American Economic Review*, 33–62.

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

Hanushek, E. A., C. K. Y. Leung, and K. Yilmaz (2014). Borrowing constraints, college aid, and intergenerational mobility. *Journal of Human Capital 8*(1), 1–41.

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

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

Keane, M. P. and K. I. Wolpin (1997). The career decisions of young men. *Journal of political Economy 105*(3), 473–522.

Keane, M. P. and K. I. Wolpin (2001). The effect of parental transfers and borrowing constraints on educational attainment. *International Economic Review 42*(4), 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 (2012). Credit constraints in education. *Annu. Rev. Econ. 4*(1), 225–256.

Lochner, L. J. and A. Monge-Naranjo (2011). The nature of credit constraints and human capital. *The American Economic Review 101*(6), 2487–2529.

Lovenheim, M. F. and C. L. Reynolds (2011). Changes in postsecondary choices by ability and income: Evidence from the national longitudinal surveys of youth. *Journal of Human Capital 5*(1), 70–109.

Restuccia, D. and C. Urrutia (2004). Intergenerational persistence of earnings: The role of early and college education. *The American Economic Review 94*(5), 1354–1378.

Stinebrickner, R. and T. Stinebrickner (2008). The effect of credit constraints on the college dropout decision: A direct approach using a new panel study. *American Economic Review 98*(5), 2163–84.