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Abstract

This paper uses a game-theoretic model to analyze the disincentive effects of low-tuition policies on student effort. The model of parent and student responses to tuition subsidies is then calibrated using information from the National Longitudinal Survey of Youth 1979 and the High School and Beyond Sophomore Cohort: 1980-92. I find that although subsidizing tuition increases enrollment rates, it reduces student effort. This follows from the fact that a high-subsidy, low-tuition policy causes an increase in the percentage of less able and less highly motivated college graduates. Additionally—and potentially more important—all students, even the more highly motivated ones, respond to lower tuition levels by decreasing their effort levels. This study adds to the literature on the enrollment effects of low-tuition policies by demonstrating how high-subsidy, low-tuition policies have both disincentive effects on students' study time and adverse affects on human capital accumulation.

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1 Introduction

The primary goal of higher education subsidies has been to promote college enrollment by reducing tuition costs. Most studies do, in fact, find that education subsidies make a college education more accessible by increasing families' ability to pay for college.¹ What is less obvious, however, is how subsidizing higher education affects students' academic effort choices. When faced with lower educational costs, parents are likely to have lower expectations about their child's academic success; parents might send their child to college even if the child's expected benefit from college education is not as high; and parents might continue to pay for their child's college education even if a lower educational outcome, (i.e. grade) occurs. Consequently, students might reduce their effort by studying less. This paper studies the potential disincentive effects of higher education subsidies on student effort by analyzing the parents' decision to send their child to college and the child's academic effort choice. The results point out the presence of potentially important disincentive effects that adversely affect human capital accumulation.

In the U.S., higher education subsidies take two basic forms: *means-tested grant and loan programs* and *operating subsidies* to public postsecondary institutions. Operating subsidies, which are primarily funded by the state and local governments, constitute the major part of higher education subsidies. For example, in 1997, the state and local governments provided \$56.4 billion in subsidies to public institutions, which is considerably more than the total amount offered by federal grant and loan programs. Not surprisingly, at the average public four-year institution more than 50% of the educational expenditures are subsidized.² Unlike means-tested grant and loan programs which have certain eligibility criteria, operating subsidies keep tuition low for all students who are admitted to college, thereby decreasing the expenses faced by families from all income groups. The lower tuition caused by the operating subsidies, accordingly, results in an increase in college enrollment. This paper concentrates on analyzing the effects of operating subsidies on parental expectations and student motivation. The focus of operating subsidies was chosen due to the fact that operating subsidies con-

¹See McPherson and Shapiro (1991) and the references therein for a detailed study of the enrollment effects of higher education subsidies.

²See Kane (1999) and McPherson and Shapiro (1997) for a descriptive summary and empirical study of financial aid programs and detailed statistics.

stitute the major part of higher education subsidies, and operating subsidies result in lower tuition for all students which is more likely to create disincentives than the means-tested or merit-based financial aid programs.

The National Longitudinal Survey of Youth 1979 (NLSY79) data set is used to examine the relationship between tuition, family income, ability, and study time of students. The main finding is a positive relationship between the total time spent on academic activities and the tuition paid by a student controlling for ability and family income. Additionally, students in states with higher public tuition do study harder.

A game-theoretic model of the parents' decision to send their child to college and the child's academic effort decision is constructed as follows. As suggested by Becker (1974, 1981) the parents are altruistic, i.e., they care about the well-being of their offspring, and the child is *rotten*, i.e. derives utility only from her own consumption and leisure.³ In addition, parents assign no value to the child's utility from leisure. As in Becker and Tomes (1976, 1979), altruism is the underlying reason for parental investment in the child's human capital. Specifically, parents invest in their child's human capital by paying for her college education. College education increases the human capital of the child and thus college educated workers earn more. Moreover, the return to college education depends both on the ability and the effort of the child. Children differ both in their intellectual ability and motivation. Parents know their child's ability, however, they do not have perfect information about their child's motivation.⁴ This feature along with the assumption that parents and children do not share the same preferences creates a conflict of interest between the parents and the child.

College education is modelled as two periods. At the beginning of the first period, parents decide whether or not to send their child to college. If they decide to do so, they pay for the first period of college and the child chooses an academic effort level, i.e. how much to study. At the end of the first period, parents observe a noisy measure of the child's academic effort, i.e. grades. The parents then update their beliefs about the child's motivation and decide whether or not to keep the child in college. Knowing that staying at college depends on her grades, the child studies harder to influence her parents' decision. However, when parents

³The expression "the rotten kid" is originally from Becker (1974).

⁴Asymmetric information in the context of family has been an ongoing assumption in similar problems. See, for example, Loury (1981), Kotlikoff and Razin (2001), and Villanueva (1999).

pay lower tuition, they tend to keep the child in college even if they observe low grades. Hence, the child is tempted to study less.

The model is then calibrated by using the High School and Beyond (HS&B) Sophomore Cohort: 1980-92 and the NLSY79 data sets. The calibrated model is used to simulate the enrollment and effort choices of students under different tuition policies. The simulation results imply that subsidizing tuition increases enrollment rates and graduation rates (the *enrollment effect* of tuition subsidies). However, subsidizing tuition creates two distinct adverse effects on human capital. First a low-tuition, high-subsidy strategy causes an increase in the ratio of less able and less highly-motivated students among college graduates (the *composition effect* of tuition subsidies). Secondly, all students, even the more highly-motivated ones, respond to lower tuition levels by decreasing their effort levels (the *disincentive effect* of tuition subsidies). Specifically, the simulation results find that the composition effect and disincentive effect of tuition subsidies result in a potential loss of human capital of around 30%. Decomposition of this loss shows that approximately half of the total loss can be attributed to the disincentive effect.

This paper also analyzes how grade inflation can arise in this environment. If students have more information about the difficulty of courses than their parents do, then students can self-select themselves into easier courses. Clearly, this informational asymmetry over the differences in grading practices could result in decreased student effort and grade inflation.

The findings of this paper are complementary to Caucutt and Kumar (2003) and Blankenau and Camera (2001). These studies concentrate on different aspects of education subsidies and address related, yet different issues. Caucutt and Kumar (2003) argue that a policy that aims to maximize the fraction of college-educated labor, by sending as many children as possible to college, results in little or no welfare gain. They show that if the government subsidizes children without making the subsidy contingent on the child's ability (as in the case of operating subsidies), the subsidy can actually decrease educational efficiency. Blankenau and Camera (2001) study the role of education by separating human capital accumulation from the educational investment decision. In their framework, as in the case of this study, student effort is necessary for skill formation during education. They show, by using a search-theoretic model, that lowering educational costs does not necessarily increase skill formation

unless incentives to student effort are provided.

This study is also related to the educational standards literature. The impact of educational standards on students' achievements and earnings has received considerable attention. Costrell (1994) and Betts (1998) are recent examples. Both of these studies analyze how a policy maker chooses the educational standards and how students respond to these standards. The main focus of these studies is on policy makers and parents play no role in setting the standards in either of these studies. Alternatively, this paper considers a framework where students respond to standards that are implicitly set by their parents. Parents, while comparing the cost and the return of a college education, implicitly set a standard for their child to meet.⁵

The framework used in this paper is related to that of Weinberg (2001), which models children as utility maximizing agents whose behavior is affected by their parents' incentive schemes and also assumes that parents and children have different preferences over the child's action (similar to the preferences used in this paper). Weinberg (2001) then emphasizes the role of parental incentives in human capital accumulation and argues that at low incomes parents' ability to provide incentives through reward/punishment schemes is limited.

The rest of this paper is laid out as follows. Section 2 presents the results from the NLSY79 data set. Section 3 describes the game-theoretic model of the parents' decision to send their child to college and the child's academic effort decision. Section 4 addresses the calibration of the model. Section 5 discusses the simulation results. Section 6 presents a model of grade inflation, and Section 7 concludes.

2 Differences in Study Time Across Students

The NLSY79 Time Use Survey is used to examine the relationship between tuition, family income, ability, and study time of students. This survey was conducted in 1981, and it contains responses to a set of questions regarding each respondent's use of time during the

⁵Since parents generally argue that schools set standards below what parents would like and higher education requires considerable parental contribution, this specification seems natural. For instance, National Survey of Student Engagement 2000 Report argues that there is a mismatch between what many postsecondary institutions say they want from students and the level of performance for which they actually hold students accountable.

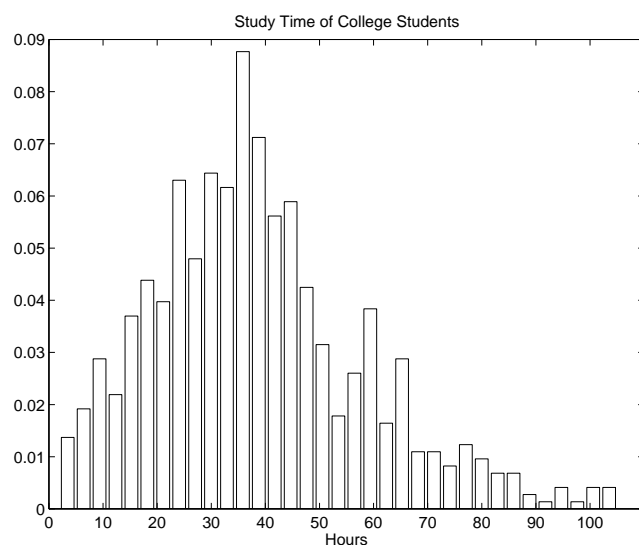


Figure 1: Distribution of the weekly study time for college students from the NLSY79 Time Use Survey in 1981.

past seven days, e.g., how much time was spent on attending school, studying, sleeping, etc. Figure 1 shows the distribution of weekly study time for college students. Study time is defined as the sum of total time spent on studying and time spent at school, at classes, library, etc. As Figure 1 points out, study time varies considerably across students. The average study time is 38.5 hours per week. The average weekly study time for the top third, 60.2 hours, is drastically different from that of the bottom third, 18.7 hours. This observation clearly demonstrates heterogeneity in student motivation.⁶

To examine the relation between the tuition paid, family income, ability, and the study time for students, the family income and the Armed Forces Qualification Test (AFQT) scores for 1476 students who reported attending college in 1981 from the NLSY79 are utilized. The Federal Interagency Committee on Education (FICE) codes of the postsecondary institutions are used to identify the colleges that the respondents attended.⁷ The FICE codes are then

⁶However, the empirical evidence should be evaluated carefully. The time use observations are available only for a certain week of a student's college education. Since a student's study effort can change significantly throughout her college education, part of the variation suggested by Figure 1 might result from the individual variations in study time. Study time averaged over the whole course of college education would be a much better measure of study time. However, data limitations make it impossible to study the variation in this parameter.

⁷For the NLSY79, the FICE codes are available starting from 1984. In 1984 respondents were asked the

	Dependent Variable
Independent Variables	Study Time
Constant	14.20 (9.16)
log(Tuition)	3.64 (0.79)
log(Family Income)	-0.62 (0.90)
AFQT Score	0.056 (0.034)
Number of Obs.	591
R^2	0.05

Table 1: Ordinary least squares estimation. Standard errors are in parentheses.

merged with the Higher Education General Information Survey (HEGIS) data set to obtain the tuition levels of the colleges.

A relationship between academic effort, which is proxied by the total time spent on academic activities, and the variables of interest is estimated by OLS as follows:

$$S_i = X_i\beta + \epsilon_i, \quad (1)$$

where S_i is the study time by student i and X_i represents the variables of interest, such as parental income, AFQT score, and tuition level of the college that the student has attended. As Table 1 shows, there is a positive relationship between the total time spent on academic activities and the tuition level. However, one might argue that this effect is driven by the selection of highly-motivated students to more selective schools. Since tuition levels at public postsecondary institutions vary dramatically across states, a natural strategy for the estimation is to analyze how the study time of college students differs across states.

In order to examine how the study time of students differs across states, the following relationship is estimated by weighted least squares:

$$\bar{S}_j = Z_j\gamma + \epsilon_j. \quad (2)$$

\bar{S}_j is calculated from the NLSY79 Time Use Survey as in Table 1 and the weights reflect name of the most recently attended college. The sample is formed by checking whether the students reported the same school for 1982-1984. This is why the sample size is small.

	Dependent Variable
Independent Variables	Study Time
Constant	168.22 (49.04)
log(State Public Tuition)	4.04 (1.61)
log(Median Family Income)	-17.28 (5.05)
Average SAT Score	0.039 (0.016)
Number of Obs.	48
R^2	0.30

Table 2: Weighted least squares estimation. Standard errors are in parentheses.

the number of observations in each state.⁸ The state-specific regressors are average public tuition, median family income, and average Scholastic Aptitude Test (SAT) score for that state. Average public tuition is formed by using data from the Higher Education Coordinating Board’s Survey on Tuition and Fee Rates. Median family income for four-person families in 1981 for each state is taken from the U.S. Census Bureau. The results given in Table 2 imply a positive relationship between the total time spent on academic activities and public tuition. At the same time, there is a negative and significant relationship between the study time and median family income. The finding that study time is positively related to tuition combined with the wide differences in study time for college students, point to potential disincentive effects of operating subsidies.⁹

⁸The sample has 1476 observations from the NLSY79. The respondents are then grouped by states. Since one does not need to identify the postsecondary institution that the respondent has attended, sample size is larger compared to the regression in Table 1. The District of Columbia and Maine are not included since the data set does not contain observations from these states.

⁹Admittedly, these regressions do not necessarily identify the causal impact on study time. A natural attack would be to ask how students react when tuition policies change. However, the Time Use data set is available only for 1981, making it impossible to analyze how students’ study time changes as tuition policies change. Cross-sectional IV estimation is difficult due to the small sample size and the lack of obvious instruments. For these reasons, I focus attention on a model calibrated as reasonably as possible to micro data.

3 The Model Economy

This section develops the dynamic game-theoretic model of the parents' decision to send their child to college and the child's academic effort decision. In particular, the model focuses on the interaction between parents and their children prior to and during the college education and analyzes how student behavior responds to different tuition policies.¹⁰ Before developing the model, the basic elements and assumptions of the model are presented.

3.1 Student

Every student is assumed to be endowed with a certain level of intellectual ability, a . Ability is fixed and known to both the student and her parents. In addition to differences in ability, an additional source of heterogeneity, *motivation*, is introduced to capture the differences in academic effort. Specifically, there are two types of students: high-motivation students and low-motivation students. The high-motivation type is represented by θ_h and the low-motivation type is represented by θ_l where $\theta_h > \theta_l$. The type of the student is orthogonal to her ability, i.e., there is no correlation between the student's type and her ability. High-type and low-type students differ in their assessment of the utility of leisure. The utility of leisure for a college student is

$$\frac{1}{\theta} \log(1 - e), \quad (3)$$

where e is the academic effort choice. Since $\theta_h > \theta_l$, high-type students assign less weight to the utility of leisure compared to the low-type students.

After a student enters the labor market, she supplies a fixed amount of labor, which is the same for all workers. Let \bar{e} correspond to the effort level required for a full-time job, then the utility of leisure when working is

$$\frac{1}{\theta} \log(1 - \bar{e}). \quad (4)$$

If $e > \bar{e}$, the student's effort is greater while in college than while working and if $e < \bar{e}$, the student enjoys more leisure while in college than while working.

¹⁰Since students, unlike workers, do not make decisions on effort independently but are, instead, influenced by their parents a family analysis is more appropriate for a study of student effort as Owen (1995) argues.

3.2 Earnings

In order to analyze the parents' decision to send their child to college and the child's academic effort decision, it is necessary to model the future return to college education. The literature on return to schooling finds that college graduates on average earn more than less-educated workers.¹¹ However, the return to college education varies considerably across individuals: more able students and more highly motivated students acquire more cognitive and social skills in college.¹² Lounsbury and Garman (1995) show that college performance and ability are important determinants of future wages. Using SAT scores as a proxy for ability and using college grade point average (GPA) and choice of major as proxies for college performance, they find that there are significant positive effects of both effort and ability on future earnings.

In order to incorporate effort and ability in the determination of future earnings, a Mincer type earnings specification is used. The standard Mincer specification predicts a relation of the following form between one's earnings, the years of education and the years of experience:

$$w(s, t) = \exp(\alpha_0 + \mu s + \rho_0 t + \rho_1 t^2 + \xi), \quad (5)$$

where $w(s, t)$ is the wage earnings for an individual with s years of schooling and t years of work experience. The coefficient μ is interpreted as the causal effect of schooling and ξ is the random error term. Following Lounsbury and Garman (1995) and Barron et al. (2003), the return to college is partitioned into two parts: the return to ability and the return to effort.

The college education is assumed to be two periods. Each period corresponds to two years of college education. An individual who only completes the first period of college is a college dropout or equivalently a two-year college graduate. The completion of the two periods (four years) of college education is necessary to be a college graduate.

For all education groups future earnings depend on ability and experience.¹³ In particular, a high-school graduate with ability a and years of experience t earns

$$w(a, t) = \exp(\alpha + a + \rho_0 t + \rho_1 t^2). \quad (6)$$

¹¹See Mincer (1974), Card (1995) and Heckman et al. (2001) for a thorough examination of the Mincer regression and the return to schooling literature.

¹²Peer group effects reinforce this effect. As Epple et al. (2003) argue, there is substantial stratification of students by ability among postsecondary institutions. So a more able and more highly-motivated student is more likely to be surrounded by high-quality peers which will yield higher returns.

¹³It is assumed that ξ is zero, i.e., Mincer specification predicts earnings perfectly.

Similarly, a college dropout's earnings are

$$w(a, e_1, t) = \exp(\alpha + a + \mu_1 a + \eta_1 e_1 + \rho_0 t + \rho_1 t^2), \quad (7)$$

where μ_1 is the return to ability and η_1 is the return to effort for the first period of college education. For a college graduate, earnings take the form of

$$w(a, e_1, e_2, t) = \exp(\alpha + a + \mu_1 a + \eta_1 e_1 + \mu_2 a + \eta_2 e_2 + \rho_0 t + \rho_1 t^2), \quad (8)$$

where μ_2 is the return to ability and η_2 is the return to effort for the second period of college education.

3.3 Parents

In the model, parents are altruistic, i.e. they care about their child's prosperity. However, they do not exactly share their child's preferences. Specifically, it is assumed that parents do not assign any value to their child's leisure. Because of this feature of the model, there is a conflict of interest between the parents and the child.¹⁴ This type of disagreement between parents and children has been discussed in the literature before. In *A Treatise on the Family*, Gary Becker discusses the discrepancies between the utility functions of the parents and their child. In the words of Becker,

“Even altruistic parents do not merely accept the utility functions of young children who are too inexperienced to know what is good for them. Parents may want children to study longer, or be more obedient than the children want to. The conflict with older children is usually less severe, and altruistic parents are more willing to contribute dollars that the children can spend as they wish.”

Pollak (1988) also studies a model where parents and their child might disagree about how the child should allocate her time or use her resources and he labels this type of preferences as “paternalistic” preferences. In this particular situation the child wants more leisure than her parents desire for her. According to Pollak (1988) parents generally try to influence the

¹⁴This is not the only way of modelling the disagreement between parents and their children. Another possibility is to assume that parents and children value the future rewards of education differently and introduce different discount factors. Even though the modelling strategy is different, this assumption will not change the main findings of the paper.

child's decisions by making transfers of particular consumption goods rather than money. For example paying for college is an example of tied transfers.

In the model, as in Becker and Tomes (1976, 1979), parents, motivated by an altruistic concern, invest in their child's human capital. In particular, parents pay for their child's college education. This assumption has considerable empirical support. Even though undergraduate borrowing has become more widespread and borrowing limits have increased for college students, the bulk of the burden is still on the parents.¹⁵

It is assumed that parents have perfect information about their child's ability, a , however they do not have perfect information about their child's motivation, θ . Instead, parents only know the prior distribution of their child's motivation, i.e., $\theta = \theta_h$ with probability λ and $\theta = \theta_l$ with probability $1 - \lambda$. Additionally, both the parents and the child are assumed to have logarithmic utility functions that represent their preferences.

3.4 Cost of College Education and Grades

The total cost of college is $C_1 + C_2$ where C_1 is the cost of the first period and C_2 is the cost of the second period. The cost of college includes education expenditures and living expenses of students. In particular, parents provide a certain level of consumption for their child during college, which is denoted by \bar{c} . Hence, the total cost of a 4-year college is

$$C_1 + C_2 = \sum_{t=1}^4 \frac{Tuition(t) + \bar{c}}{(1+r)^{t-1}}. \quad (9)$$

After the first period of college, parents might discontinue paying for the college education of the child, in this case, the child drops-out and starts working.

Parents cannot observe their child's academic effort perfectly. But they can observe her GPA, which is a noisy measure of her academic effort. Grades are assumed to be a function of ability as well as of effort. This specification is supported by the study of Schuman et al. (1985) which argues that there are strong and monotonic relations between grades and both aptitude measures and class attendance. In particular, average grade, y is assumed to be

$$y = \alpha_1 a + \alpha_2 e + \varepsilon, \quad (10)$$

¹⁵For example in 1997, a dependent student was only allowed to borrow, through subsidized Stafford Loan program, up to \$2,625 in her freshmen year.

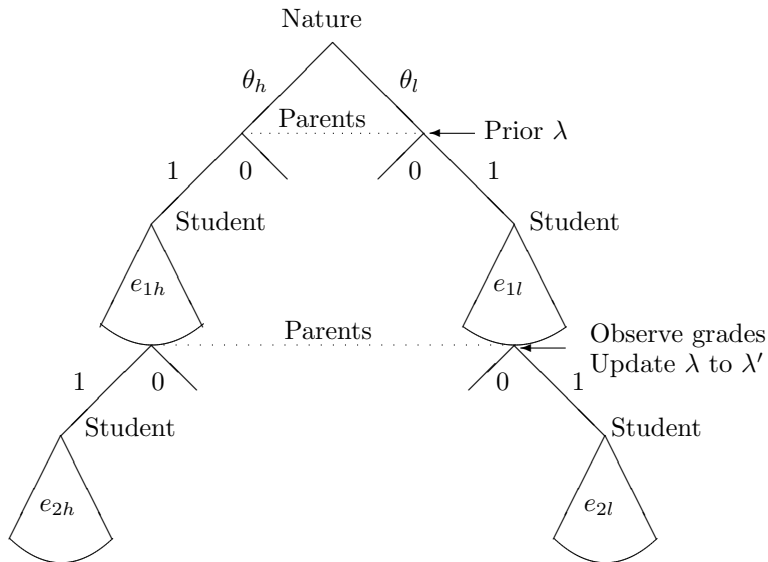


Figure 2: Game tree associated with the model.

where ε is the random error term with distribution function $f_\varepsilon(\varepsilon)$. It is assumed that $f_\varepsilon(\varepsilon)$ satisfies the strict single crossing property.¹⁶

3.5 The Model

At the beginning of the first period, parents make their decision about sending their child to college given the child's ability (a) and the prior distribution of θ ($\theta = \theta_h$ with probability λ and $\theta = \theta_l$ with probability $1 - \lambda$). If parents decide to send their child to college, then the parents pay for all of the child's college costs in the first period. The child then chooses how much time to allocate between leisure and studying given her motivation type and ability level. At the end of the first period, the educational outcome, i.e. the GPA, is observed by the parents and the child. After the outcome is observed, parents update their beliefs about the child's motivation type. Formally, they derive the posterior distribution of θ given the observed outcome (GPA) and the prior distribution. If the observed outcome is higher than the cut-off grade threshold, then the parents keep the child in college, and the child chooses her second-period effort level. If the observed outcome is below the cut-off grade threshold, then the child drops out of college and enters the labor market.

Figure 2 summarizes the timing of the decisions:

¹⁶This condition is frequently used to ensure monotone comparative statistics in similar models. See Mas-Colell, Whinston, and Green (1995).

- In the first period parents decide whether or not to send their child to college; decision $D_1(\cdot)$.
- The child chooses the first period effort level, $e_1(\cdot)$, given the fact that parents will update their beliefs according to the observed outcome (GPA).
- After observing the first period's outcome, the parents update their beliefs about the child's motivation type, and the parents decide whether or not to keep the child in college; decision $D_2(\cdot)$. Equivalently, parents choose a cut-off grade threshold $\bar{y}(\cdot)$ which represents the lowest possible first period GPA for which parents will keep their child in college for the second period.
- The child chooses the second period effort level, $e_2(\cdot)$.

These strategies and beliefs form a Perfect Bayesian Equilibrium iff

1. $\{e_2(\cdot)\}$ is optimal for the child given that the child stays at college for the second period.
2. $\{\bar{y}(\cdot), D_2(\cdot)\}$ is optimal for parents given $e_1(\cdot)$ and the posterior probability λ' .
3. $\{e_1(\cdot)\}$ is optimal for the child given $\bar{y}(\cdot)$ and the fact that the parents' second period decision depends on $\{e_1(\cdot)\}$.
4. $D_1(\cdot)$ is optimal for parents given subsequent strategies.
5. The posterior probability, λ' , is derived from the prior, the child's strategy $\{e_1(\cdot)\}$, and the observed outcome by using Bayes's rule.

First-Period:

At the beginning of the first period, parents decide whether they should send their child to college. To make this decision, parents compare their expected lifetime utilities from both of the possible choices. Thus, the parents' decision problem at the beginning of the first period is

$$\max_{D_1 \in \{0,1\}} \{U_P(w, 0) + \gamma U_{HS}(a, T), pU_P(w, C_1 + C_2) + (1 - p)U_P(w, C_1) + \gamma E(U_{Child})\}, \quad (11)$$

where $0 < \gamma < 1$ is the degree of altruism and $p = Pr(y \geq \bar{y})$ is the probability that the child stays at college. Equation (11) suggests that parents of a high-school graduate child compare the expected utility of sending their child to college with the utility of letting their child enter the labor market as a high-school graduate. The first part of equation (11) is the parents' discounted lifetime utility from having a child who graduates from high-school and enters the labor force. This is calculated as the sum of $U_P(w, 0)$, the parents' discounted lifetime utility from having an income of w and allocating a total amount of 0 for their child's college education, and $\gamma U_{HS}(a, T)$, the degree of altruism times the discounted lifetime utility of consumption for a high-school graduate. (Note that a stands for ability and T is the total worklife of a high-school graduate.) The second part of equation (11) corresponds to the expected utility of sending the child to college. With probability p , the child stays at college and the parents get $U_P(w, C_1 + C_2)$. Likewise, with probability $1 - p$, the child drops out of college and the parents get $U_P(w, C_1)$. In addition to their own discounted expected utility, parents derive utility from their college-attending child which is denoted by $E(U_{Child})$. The expected utility that the parents derive from their college-attending child is

$$E(U_{Child}) = \lambda [(Pr(y \geq \bar{y} | \theta_h) U_{CL}(a, \theta_h, T - 4) + Pr(y < \bar{y} | \theta_h) U_{DO}(a, \theta_h, T - 2))] \\ + (1 - \lambda) [Pr(y \geq \bar{y} | \theta_l) U_{CL}(a, \theta_l, T - 4) + Pr(y < \bar{y} | \theta_l) U_{DO}(a, \theta_l, T - 2)], \quad (12)$$

where $U_{CL}(a, \theta_h, T - 4)$ is the discounted lifetime utility of a college graduate and $U_{DO}(a, \theta, T - 2)$ is the lifetime utility of a college drop-out. (Note that a college graduate works for $T - 4$ years and a college drop-out works for $T - 2$ years.) In order to compute $U_P(w, C)$, $U_{HS}(a, T)$, $U_{CL}(a, \theta, T - 4)$, and $U_{DO}(a, \theta, T - 2)$, it is assumed that both the parents and the child can choose their lifetime consumption optimally by borrowing or saving at the market interest rate, r . The exception to this is the time when the child is at college. The child is not allowed to borrow during her college education and consequently her consumption during college is fixed at \bar{c} . The formulations of $U_P(w, C)$ and $U_{HS}(a, T)$, $U_{CL}(a, \theta, T - 4)$, and $U_{DO}(a, \theta, T - 2)$ are given in Appendix A.

The probability that the child will stay in college, $p = Pr(y \geq \bar{y})$, depends on the prior distribution of θ as well as the ability of the child. Since $y = \alpha_1 a + \alpha_2 e + \varepsilon$ and $\varepsilon \sim f_\varepsilon(\varepsilon)$, the distribution of y , $f_y(y)$, is given by $f_\varepsilon(y - \alpha_1 a - \alpha_2 e)$. Let e_{1h} and e_{1l} be the effort choices of high-type and low-type students for the first period. Then the probability that the student

will complete college is given by

$$\begin{aligned} p = Pr(y \geq \bar{y}) &= Pr(\theta = \theta_h)Pr(y \geq \bar{y} | \theta_h) + Pr(\theta = \theta_l)Pr(y \geq \bar{y} | \theta_l) \\ &= \lambda F_\varepsilon(\alpha_1 a + \alpha_2 e_{1h} - \bar{y}) + (1 - \lambda) F_\varepsilon(\alpha_1 a + \alpha_2 e_{1l} - \bar{y}), \end{aligned} \quad (13)$$

where $F_\varepsilon(\cdot)$ is the cumulative distribution function for ε .

Once the parents have decided to send their child to college, the child chooses an academic effort level by maximizing her expected lifetime utility. Thus, for a given cut-off grade threshold, \bar{y} , a student of type θ chooses her first-period effort level, e_1 , according to

$$\begin{aligned} \max_{e_1} &\left\{ \frac{1 + \beta}{\theta} \log(1 - e_1) + Pr(y < \bar{y} | \theta) \left[\sum_{t=3}^T \frac{\beta^{t-1}}{\theta} \log(1 - \bar{e}) + U_{DO}(a, \theta, T - 2) \right] \right. \\ &\left. + Pr(y \geq \bar{y} | \theta) \left[\frac{(1 + \beta)\beta^2}{\theta} \log(1 - e_2) + \sum_{t=5}^T \frac{\beta^{t-1}}{\theta} \log(1 - \bar{e}) + U_{CL}(a, \theta, T - 4) \right] \right\}. \end{aligned} \quad (14)$$

The first part of equation (14) is the child's utility from leisure in the first period of college. The second and third parts of equation (14) correspond to the child's expected utility conditional on grades. If $y < \bar{y}$, the student drops out of college, supplies \bar{e} units of labor for $T - 2$ years and gets a lifetime utility of $U_{DO}(a, \theta, T - 2)$ from consumption. Likewise if $y \geq \bar{y}$, the student stays at college for the second period and studies for e_2 units of time. After she completes college, the student supplies \bar{e} units of labor for $T - 4$ years and gets a lifetime utility of $U_{CL}(a, \theta, T - 4)$ from consumption.

The first order condition for the student's academic effort choice problem, stated in equation (14), is

$$\begin{aligned} \frac{1 + \beta}{\theta(1 - e_1)} &= \alpha_2 f_\varepsilon(\alpha_1 a + \alpha_2 e_1 - \bar{y}) [U_{CL}(a, \theta, T - 4) - U_{DO}(a, \theta, T - 2)] \\ &+ Pr(y \geq \bar{y} | \theta) U'_{CL}(a, \theta, T - 4) + Pr(y < \bar{y} | \theta) U'_{DO}(a, \theta, T - 2), \end{aligned} \quad (15)$$

where $U'_{CL}(\cdot)$ and $U'_{DO}(\cdot)$ are the first derivatives of the student's lifetime utility with respect to first-period effort. The left hand side of the first order condition is the change in the utility of leisure. The first term on the right hand side is the change in utility due to the increased probability of staying in college and the second term on the right hand side is the direct effect of higher effort on utility. The student simply increases her effort until the disutility of effort exceeds the future reward of effort. Since high-motivation type students value leisure

less than low-motivation students and their return from completing college is higher, they choose to study more than low-motivation type students.¹⁷

Second-Period:

After parents observe the child's grades, y_1 , they decide whether they should keep the child in college for the second period. Parents' second period decision problem is

$$\begin{aligned} \max_{D_2 \in \{0,1\}} \{ & U_P(w, C_1) + \gamma [\lambda' U_{DO}(a, \theta_h, T-2) + (1-\lambda') U_{DO}(a, \theta_l, T-2)], \\ & U_P(w, C_1 + C_2) + \gamma [\lambda' U_{CL}(a, \theta_h, T-4) + (1-\lambda') U_{CL}(a, \theta_l, T-4)] \}, \end{aligned} \quad (16)$$

where λ' , the posterior probability that $\theta = \theta_h$ given that observed grade is y_1 , is

$$\lambda' = Pr(\theta = \theta_h | y = y_1) = \frac{\lambda f_\varepsilon(\alpha_1 a + \alpha_2 e_{1h} - y_1)}{\lambda f_\varepsilon(\alpha_1 a + \alpha_2 e_{1h} - y_1) + (1-\lambda) f_\varepsilon(\alpha_1 a + \alpha_2 e_{1l} - y_1)}. \quad (17)$$

Parents' second-period decision is a binary one: keeping the child in college or not. After parents observe the child's grade they update their beliefs about the child's motivation. Since $f_\varepsilon(\cdot)$ is assumed to satisfy the strict single crossing property, the higher the observed grade, the higher the probability that the child is a high-motivation type. Thus, this binary decision can be summarized in terms of a cut-off grade threshold, \bar{y} . Cut-off grade threshold \bar{y} is the value of grades that makes the parents indifferent between keeping the child at college and not.¹⁸ The cut-off grade threshold depends on the tuition, the degree of altruism, the ability of the child, and the parents' income since all of these parameters affect the future lifetime utility of parents.

The choice of the cut-off grade threshold, \bar{y} , and the first period effort choice, e_1 , are dependent on each other. When choosing her effort level, the student takes into account that her parents will update their beliefs about her type according to her grades. Similarly, parents consider what the effort choices of the student would be for all possible \bar{y} values. Solving equation (14) and equation (16) simultaneously gives the equilibrium values of \bar{y} , e_{1h} , and e_{1l} . Equation (16) shows how parents choose the cut-off grade threshold. This solution is not

¹⁷One can see that in the simulations, however showing this result analytically requires making simplifying assumptions.

¹⁸Note that since $e_{2h} > e_{2l}$, as will be shown next, high-motivation type students gain more from completing college education than low-motivation type students; $U_{CL}(a, \theta_h, T-4) - U_{DO}(a, \theta_h, T-2) > U_{CL}(a, \theta_l, T-4) - U_{DO}(a, \theta_l, T-2)$.

always interior: for low values of tuition, parents would always keep their child in college. Thus, the child will not have an incentive to put forth a high effort. This feature of the model suggests that students are more likely to go to college and stay at college when tuition is low. Similarly, for very wealthy parents, the cut-off grade threshold is likely to be lower. Thus, students from high-income families are more likely to stay at college compared to students from low income families. These predictions are consistent with the empirical findings.

The second period effort levels e_{2h} and e_{2l} are easy to solve. The optimal effort choices for high-type and low-type students are

$$e_{2h}^* = 1 - \frac{1 + \beta}{\beta^2 \eta_2 \theta_h k} \quad e_{2l}^* = 1 - \frac{1 + \beta}{\beta^2 \eta_2 \theta_l k} \quad (18)$$

where $k = \sum_{t=5}^T \beta^{t-1} \frac{w_t}{c_t}$. Since $\theta_h > \theta_l$, $e_{2h} > e_{2l}$.

The equilibrium values of effort choices and parents' optimal decisions can be solved by using backward induction. However, the model does not have a closed form solution. The presence of updating makes the analytical solution of the model very complex. This is why I concentrate on calibrating the model and analyzing the numerical experiments.

4 Calibration

This section explains the choice of each parameter in detail. To calibrate the parameters, the HS&B Sophomore Cohort: 1980-92 and the NLSY79 data sets were used. Since the NLSY79 Time Use Survey was only conducted in 1981, the model is calibrated to the U.S. Economy in 1981.

Average Worklife: The average worklife of a high-school graduate is assumed to be 40 years. It is 38 years for college drop-outs and 36 years for college graduates, respectively. These values are consistent with the values from the U.S. Bureau of Labor Statistics, *Employment and Earnings*, which reports that the remaining expected years of paid work at age 25 for male workers is 33.4 for high-school graduates, 34.5 for workers with some college, and 35.8 for college graduates.

Return to Experience and Labor Supply: Return to experience parameters ρ_0 and ρ_1 are set to 0.05 and -0.0010 following Murphy and Welch (1992). Average weekly hours of full-time paid workers is around 40 hours/week. After sleep, meals, and transportation are

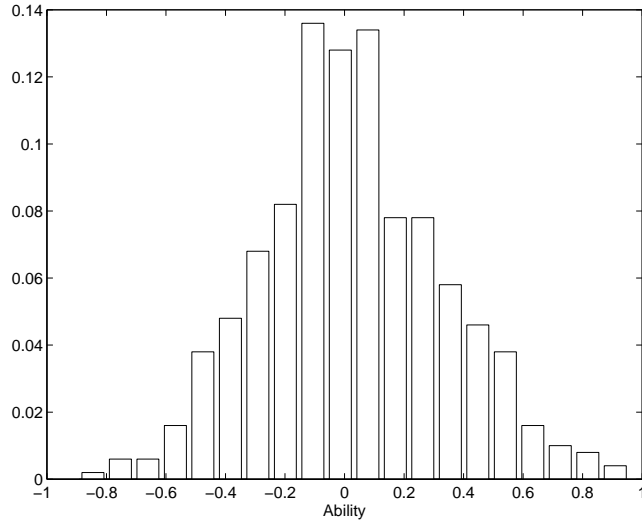


Figure 3: Generated ability distribution.

accounted for, a person has approximately 96 hours to allocate for work. The fraction of time spent on working is $40/96 \approx 0.4$. So \bar{e} is set to 0.4.

Ability: To determine the ability distribution, the wages of 1148 workers from the NLSY79 with 12-16 years of schooling are used. Specifically, a Mincer earnings specification is estimated using this data set and the residual of this Mincer regression is used as the ability distribution. The underlying assumption is that when the average return to schooling and experience are deducted, the remaining wage differences should come from differences in ability. From the Mincer regression, ability is assumed to be normal with mean 0 and standard deviation of 0.35. Figure 3 shows the generated ability distribution.

From the Mincer regression, the annual earnings of a high-school graduate can be computed as

$$w(a, t) = \exp(7.98 + 1.08(1 + a) + \rho_0 t + \rho_1 t^2) \quad (19)$$

where a is the ability and t is the experience of the worker.

Earnings: The estimates for the return to postsecondary education are taken from Kane and Rouse (1995). The return for the first two-years of college for an individual with average intellectual ability \bar{a} and average effort level \bar{e} is set to 0.16 and the total return to college is

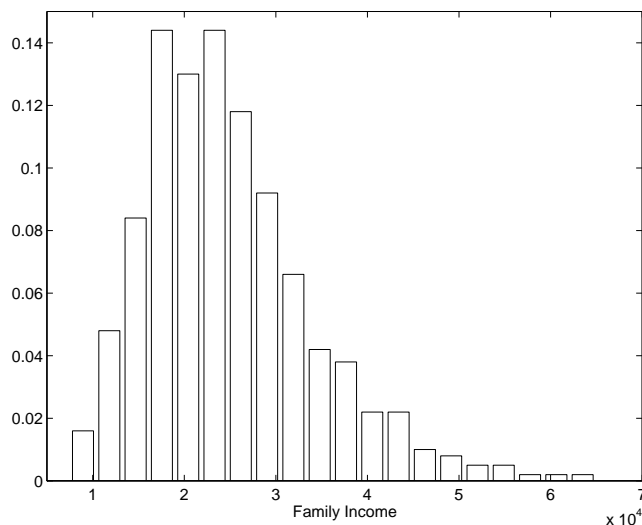


Figure 4: Generated Family Income Distribution.

set to 0.36 following Kane and Rouse (1995). This specification suggests that

$$\mu_1(1 + \bar{a}) + \eta_1\bar{e} = 0.16 \quad \text{and} \quad \mu_2(1 + \bar{a}) + \eta_2\bar{e} = 0.20 \quad (20)$$

where the mean ability, \bar{a} , is 0 and the average study time, \bar{e} , is 0.4.¹⁹ However, this is not enough information to calibrate η_1, η_2, μ_1 , and μ_2 . The relative weights of ability and effort on future earnings are ambiguous. To resolve this problem, it is assumed that a student who chooses to study for 38 hours per week is indifferent between studying for one more additional hour and working. For a college student, the increase in the discounted future earnings provided by one additional hour of studying is the same as the hourly wage earned by working for one hour. According to this calculation

$$\eta_1 = 0.12, \quad \eta_2 = 0.125, \quad \mu_1 = 0.112, \quad \mu_2 = 0.15 \quad (21)$$

which suggests that roughly one third of the total return to college is due to effort and the remaining two thirds is due to intellectual ability.²⁰ The annual earnings of a college drop-out

¹⁹Note that the average ability is 0. In order to ensure that the average return to ability is μ_1 , ability is normalized to $1 + a$.

²⁰Note that this is a conservative estimate for η_2 . Barron et al. (2003) find that the role of effort is higher than the role of ability on future earnings, which implies that more than half of the return to college is associated to effort. The nature of the results of this paper does not change if we use higher η_2 values. Moreover, the disincentive effects become quantitatively more important.

can be computed as

$$w(a, e_1, t) = \exp(7.98 + (1.08 + 0.112)(1 + a) + 0.12e_1 + \rho_0 t + \rho_1 t^2), \quad (22)$$

and the annual earnings of a college graduate are

$$w(a, e_1, e_2, t) = \exp(7.98 + (1.08 + 0.112 + 0.15)(1 + a) + 0.12e_1 + 0.125e_2 + \rho_0 t + \rho_1 t^2). \quad (23)$$

Parental Income: According to the Current Population Report 1981, the median family income was \$23,873 in 1981. The parental income is assumed to have a lognormal distribution. Figure 4 shows the generated family income distribution. Parents from all income groups can finance their child's higher education through borrowing, i.e. there are no borrowing constraints.²¹

Tuition: Tuition costs were taken from the Higher Education General Information System (HEGIS) 1981-1982 files from the National Center for Educational Statistics. Table 3 shows average tuition levels for different types of postsecondary institutions. For the simulations, the tuition paid by the families is assumed to be proportional to the family income. This assumption is empirically supported by the existence of programs that offer different amounts of tuition subsidies to families depending on their incomes. Simply, there is an expected family contribution for each family who apply for financial aid. Even though the calculation is not trivial, the higher the family income, the higher the expected family contribution is. This suggests that families pay tuition costs correlated with their income.²² To capture this, the average cost of college is set to \$4,200, which is approximately one fifth of the median family income. The total cost of college also includes the consumption of the student for four years. The consumption of a college student, \bar{c} , is set to \$3000 per year and it is included in the cost of college.

²¹The influence of borrowing constraints on the education outcomes of children has been widely analyzed by many economists. See Cameron and Taber (2002) for a discussion of the role of borrowing constraints. In this study, borrowing constraints are not considered, and the enrollment rates by income quartile suggested by the model are still consistent with the U.S. data.

²²According to National Postsecondary Student Aid Survey, the net tuition for students attending postsecondary institutions vary considerably by family income. For example for 1992-93 academic year, the net tuition for students attending public institutions was \$360 for low income students, \$2,113 for middle income students, and \$3,112 for high-income students. For private institutions, the net tuition was \$3,619, \$7,704, and \$11,622 for low income, middle income and high-income students, respectively.

	N	In-state Tuition	Out-of-state Tuition	Room	Board
Private 4-year	1,218	\$3,444	\$3,444	\$883	\$1,103
Public 4-year	458	\$842	\$2,076	\$857	\$972
Private 2-year	343	\$2,531	\$2,531	\$924	\$1,032
Public 2-year	878	\$444	\$1,482	\$640	\$979

Table 3: Average tuition levels, HEGIS (1981-1982).

Type (θ): The values of θ_h and θ_l determine the equilibrium effort choices of students. As noted in Figure 1, the average weekly study time for college students was 38.5 hours per week. The average weekly study time for the top third of the distribution was 60.2 hours, and the average weekly study time was 18.7 hours for the bottom third. The values of θ_h and θ_l are chosen so that the equilibrium effort choices would be consistent with the effort values implied by Figure 1. On average, low type students choose an effort level of 0.2 (approximately 20 hours/week) and high-type students choose an effort level of 0.6 (approximately 60 hours/week). To be consistent with these values, θ_h was set to 1.5 and θ_l was set to 0.75.²³

GPA: Recall that the GPA is assumed to be

$$y = \alpha_1 a + \alpha_2 e + \varepsilon, \quad (24)$$

where $\varepsilon \sim f_\varepsilon(\varepsilon)$ is the random error term. To mimic the relative impacts on wages, the relative weight of ability in the GPA function is assumed to be two thirds and the relative weight of effort is set to one third.

It is assumed that ε is normally distributed with a mean value of 0 and a variance of σ_ε .²⁴ The choice of the standard deviation of the random error term, σ_ε , is nontrivial. In order to calibrate the error term, the standard deviations of the first-year GPAs and of the overall GPAs of 2364 college students from the HS&B Sophomore Cohort: 1980-92 were

²³Since, there is a closed form solution for the second period effort choice of students, it is possible to solve for θ_h and θ_l by using equation (20). First, e_{2h} is set to 0.6 and e_{2l} is set to 0.2 in equation (20) and θ_h and θ_l can be solved for. After setting θ_h and θ_l to the implied values, the first period effort choices were computed. Since there is no closed form solution for the first period effort choice in terms of θ_h and θ_l , one needs to repeat the simulations by changing θ_h and θ_l by small steps until the desired equilibrium effort values are obtained.

²⁴For the parameter values that are used, the distribution of ε satisfies the strict single crossing property.

	Observation	GPA	Std. Dev.
First year	2364	2.65/4.00	0.630
Overall	2364	2.80/4.00	0.465

Table 4: GPA of college graduates, HS&B Sophomore Cohort: 1982-1990.

used. Table 4 shows the mean and standard deviation of the GPAs for this sample. Since GPA is a noisy measure of academic effort, the sample mean is expected to have a smaller variance when there are observations in the sample. Thus the difference between the standard deviations in Table 4 can be interpreted as $\sigma_\varepsilon/2$. So, σ_ε is set to 0.33.

Other parameters: The degree of altruism, γ , is set to 0.37. The discount factor, β , is set to 0.98 and the market interest rate is set to 0.03. λ is assumed to be 0.5, i.e., 50% of the students are assumed to be of the low-motivation type.

5 Simulation Results

The simulations primarily focus on the incentive effects of operating subsidies. First, a large number of parents-child pairs are generated. Each child's ability is drawn from the calibrated ability distribution, and the parents' income is drawn from the calibrated income distribution. Then, parents' decision to send their child to college and the child's academic effort choices are numerically computed for the calibrated parameters.

5.1 How Do Students Respond to Different Cut-off Grade Thresholds?

Before moving on to analyze the effects of tuition subsidies, the question of how students choose their academic effort levels when they face different cut-off grade thresholds, \bar{y} , is examined. Note that the cut-off grade threshold, \bar{y} , can also be viewed as an educational standard, and thus this subsection can also be viewed as an analysis of educational standards.

Suppose that students need to satisfy the following educational standard:

$$\begin{aligned} y \geq \bar{y} &\longrightarrow \text{continues college,} \\ y < \bar{y} &\longrightarrow \text{drops out.} \end{aligned} \tag{25}$$

For a given \bar{y} value, the student chooses her academic effort level according to

$$\max_{e_1} \left\{ \frac{1 + \beta}{\theta} \log(1 - e_1) + Pr(y < \bar{y} | \theta) \left[\sum_{t=3}^T \frac{\beta^{t-1}}{\theta} \log(1 - \bar{e}) + U_{DO}(a, \theta, T - 2) \right] \right\}$$

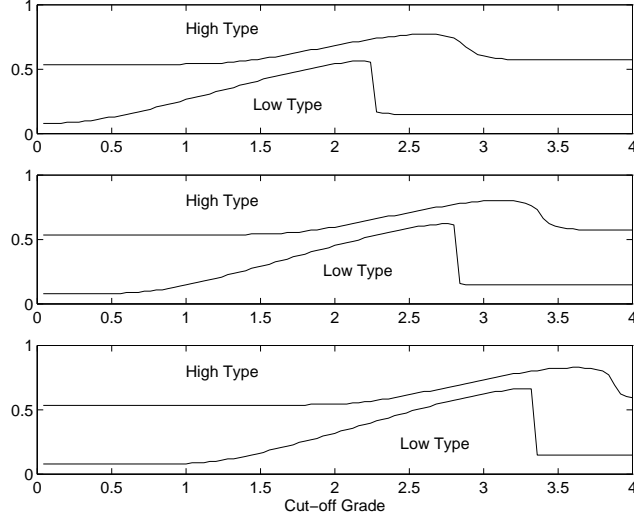


Figure 5: Effort choices of high-motivation type and low-motivation type students with different intellectual ability, $a = -0.35$, $a = 0$ and $a = 0.35$, respectively.

$$+Pr(y \geq \bar{y} | \theta) \left[\frac{(1 + \beta)\beta^2}{\theta} \log(1 - e_2) + \sum_{t=5}^T \frac{\beta^{t-1}}{\theta} \log(1 - \bar{e}) + U_{CL}(a, \theta, T - 4) \right] \}. \quad (26)$$

Figure 5 shows the effort choices of a student for different levels of cut-off grade thresholds, \bar{y} and abilities, a . Recall that ability, a , is normally distributed with a mean value of 0 and a standard deviation of 0.35. Ability is set to three different values to illustrate the behavior of students with different intellectual ability. The first example is for $a = -0.35$, which is one standard deviation below the mean ability. The second example is for $a = 0$, which is the mean ability level, and the third example is for $a = 0.35$, which is one standard deviation above the mean ability level. For low values of \bar{y} , $Pr(y \geq \bar{y} | \theta) = 1$ for both high-motivation and low-motivation types. This implies that the student will stay in college with probability 1. As \bar{y} increases, the student will drop out with a positive probability unless she puts in more academic effort. Consequently, the student tries to meet the higher standards by increasing her effort level. For higher values of \bar{y} , the student no longer tries to meet the standards and sets her academic effort level to maximize the first part of equation (26).

How does this analysis change across the different motivational types? Initially, low-motivation type's effort choice increases as \bar{y} increases. Hence, higher educational standards provide low-motivation type students with an incentive to increase their academic effort levels

up to a certain point. However, since low-motivation type students assign more weight to the utility of leisure, they start lowering their effort levels when confronted with higher standards. Consequently, high-motivation type students match the standards up to a higher threshold than the low-motivation type students.

Figure 5 also shows that for students with different intellectual ability, effort peaks at different values of \bar{y} . Higher ability students continue to meet standards up to higher thresholds than lower ability students.

Figure 5 highlights several implications about educational standards. When educational standards are set too low or too high, they might have adverse effects on student effort. High standards might discourage students, especially low ability and/or low-motivation students. On the other hand, low standards might cause students, especially, high-ability ones, to shirk. Consequently, at colleges where ability is widely dispersed, grading will be a challenging task.

5.2 The Effect of Tuition Subsidies

In Section 5.1 we have seen that students respond to different cut-off grade thresholds (or equivalently different parental expectations) by changing their academic effort choices. Since high tuition subsidies will lower the cost of higher education and decrease the cut-off grade thresholds, tuition subsidies are likely to have disincentive effects on students. This subsection analyzes the effects of tuition subsidies, in particular operating subsidies, on college enrollment and on students' study time. For this analysis, simulations with various ratios of tuition to family income are performed. For the baseline case, the ratio of tuition to family income is 0.18. This ratio is then decreased to 0.16 and to 0.14. When tuition to family income ratio is decreased from 0.18 to 0.14, the average tuition paid decreases by \$1,000.

These simulations mimic the effect of operating subsidies provided to the public postsecondary institutions by the state and local governments. Note that changing the ratio of tuition to family income implies a higher transfer to middle- and high-income students. Interestingly, this is the case for operating subsidies.²⁵ Students from high-income families are more likely to attend four-year public postsecondary institutions. This follows from the fact that admission to these institutions is positively correlated with standardized test scores

²⁵See Kane (1999) for a discussion of this point.

	U.S. Data	$tuition/w = 0.18$	$tuition/w = 0.16$	$tuition/w = 0.14$
Average tuition	\$4,000-\$4,500	\$4,200	\$3,700	\$3,200
Enrollment rate	0.54	0.53	0.62	0.69
Graduation rate	0.57	0.59	0.63	0.67

Table 5: *The enrollment effect*: the effect of tuition on enrollment and college graduation rates; U.S. Data from the Condition of Education, 1981. Note that $tuition/w=0.18$ is the baseline case.

and standardized test scores are positively correlated with family income. Since four-year public postsecondary institutions get higher subsidies from the state and local governments compared to two-year public institutions, students from high-income families collect a higher share of subsidies compared to students from low income families.

Table 5 looks at the *enrollment effect* of tuition subsidies and reports the enrollment rates and graduation rates. The enrollment rate is defined as the fraction of high-school graduates who enroll in college, and the graduation rate is defined as the fraction of college students who graduate from college. The baseline case generates similar statistics with the U.S. Data.²⁶ As Table 5 shows, high operating subsidies encourage college enrollment by decreasing the cost of a college education. Students are more likely to enroll in college and stay at college when the cost of a college education is lower. The simulations suggest that a \$1,000 decrease in the average tuition increases the enrollment rate by 16%. This finding is consistent with the literature on the enrollment effects of tuition subsidies.

	$tuition/w = 0.18$	$tuition/w = 0.16$	$tuition/w = 0.14$
Average tuition	\$4,200	\$3,700	\$3,200
% of students who are low type	0.50	0.50	0.50
% of graduates who are low type	0.26	0.31	0.36
Avg. ability of students	0.22	0.18	0.14
Avg. ability of graduates	0.30	0.27	0.24

Table 6: *The composition effect*: the effect of tuition subsidies on the ability and the type distribution of college students.

Table 5 shows that the decision to enroll in college responds positively to tuition cuts. Another important effect of the operating subsidies is how these subsidies change the ability

²⁶Recall that the model is calibrated to the U.S. Economy in 1981.

	$tuition/w = 0.18$	$tuition/w = 0.16$	$tuition/w = 0.14$
Average tuition	\$4,200	\$3,700	\$3,200
1 st -period effort	0.51	0.46	0.43
2 nd -period effort	0.46	0.44	0.42
Average effort	0.49	0.45	0.43
Average GPA	2.96	2.85	2.76
Cut-off grade level	1.93	1.67	1.46

Table 7: *The disincentive effect*: the effect of tuition subsidies on student effort.

and type composition of college students, i.e. the *composition effect* of tuition subsidies. Table 6 looks at the effect of tuition subsidies on the ability and the type distribution of college students and shows that when tuition levels are lower, the average ability of college students and college graduates decreases. Similarly, a higher fraction of less highly-motivated students graduate from college. Recall that the calibration assumed that student type and ability are not correlated. Due to this orthogonality assumption, the fraction of low-motivation type students who enroll in college does not change. However, a higher fraction of low-motivation type students graduate from college. One might expect high-ability, low-income students to benefit from the tuition cut thereby increasing the average ability of college students. However, this is not the case. Since the financial aid is not conditional on ability, academic success, or family income, the net effect is a decrease in the average ability of college students. Clearly, a financial aid system that depends on student ability and family income would be more successful in encouraging enrollment of high-ability, low-income students.

As mentioned earlier, when tuition rates are lower, college graduation rates are higher. This increase in the graduation rate is partly due to an increase in the ratio of low-motivation type students who complete college. For instance, consider the case where $tuition/w = 0.18$. In this case, the fraction of college students who are low-motivation type is 0.50 and the fraction of college graduates who are low-motivation type is only 0.26. On the other hand, for the $tuition/w = 0.14$ case, the fraction of college graduates that are of the low-motivation type is 0.36. Thus, the average ability of a college graduate decreases as a result of the increase in subsidy.

Table 7 looks at the *disincentive effect* of operating subsidies. The simulations suggest

	$tuition/w = 0.18$	$tuition/w = 0.16$	$tuition/w = 0.14$
Average tuition	\$4,200	\$3,700	\$3,200
1 st -period effort	0.51	0.48	0.46

Table 8: The effort choices of students who would have attended college for all three tuition policies.

that as higher education becomes less costly, the cut-off grade threshold decreases. This follows from the fact that as the cost of a college education decreases, the expected return that makes the parents indifferent between paying and not paying decreases. As Table 7 shows the cut-off grade threshold averaged over all college students decreases as tuition becomes cheaper relative to family income. The first-period academic effort, on average, decreases as a response to the change in parental expectations (decrease in implicit cut-off grade thresholds). Average first-period effort decreases from 0.49 to 0.43, implying, approximately, a 6 hour/week decrease in average study time. The second-period academic effort choice is not affected by the tuition cut (see equation (18)). However due to the increased ratio of low-motivation type college students, second period effort on average decreases as well. To sum up, the model predicts that a 10% decrease in tuition would be accompanied by a 5% decrease in the average study time.²⁷

The simulations show that low-tuition policies change the composition of the college student body. Is this the only effect of low tuition policies? Is the decrease in the average effort coming only from the higher number of low-motivation type students who complete college? To answer these questions, one can look at the academic effort choices of students who would have enrolled in college under all three of the different tuition policies. Table 8 summarizes the first-period academic effort choices of these students. Table 8 shows that when tuition subsidies increase, these students also respond to changes in parental expectations by lowering their effort levels. Thus, the decrease in the average academic effort of students is not completely due to the increase in the ratio of low-motivation type students who graduate from college.

The key findings of the simulations are that low-tuition, high-subsidy policies cause an

²⁷Table 7 shows that as a result of the decrease in average ability and the average effort, GPA decreases implying grade deflation. In section 6, a variant of the model with informational asymmetry, where a decrease in student effort could be accompanied by grade inflation, is considered.

increase in the ratio of less highly-motivated students among the college graduates and that even the highly-motivated ones respond to lower tuition levels by choosing to study less.

5.3 Human Capital

When college enrollment rates and college graduation rates increase, the amount of human capital accumulation is typically expected to increase. However, the human capital acquired during college depends on both the effort and the ability of the students, and when tuition subsidies increase, the average ability of college students and the average amount of study time decrease. In this subsection, the change in the amount of human capital accumulation, when subsidies increase, is examined. In this examination, it is assumed that the human capital accumulation has the same functional form as the earnings equation, as in Bils and Klenow (2000).

Table 9 shows the percentage increase in the amount of total human capital accumulation at college when tuition subsidies increase. If the ability distribution and the effort choices of college students were unaffected by the policy change, then the increase in human capital would have been higher. For example, when the tuition to income ratio is 0.14, the amount of human capital increases by approximately 26% compared to the baseline case. However, if the ability distribution and the effort choices of college students were unchanged, then the amount of human capital would have increased by almost 37%. Table 10 also shows the decomposition of this effect into ability and effort. Almost half of the potential loss in the human capital is due to the decrease in effort.

These experiments show that even though total human capital in the economy increases, the average human capital endowment of a college graduate decreases as a result of the increase in operating subsidies.

6 Grade Inflation

In the U.S., the grades at postsecondary institutions have been increasing for the last 30 years. For example in 1969, 7% of all undergraduate students received grades A- or higher, by 1993, this proportion has risen to 20%. In contrast, grades of C or less moved from 25% to 9% in 1993. This phenomenon is referred to as grade inflation.

	<i>tuition/w</i> = 0.16	<i>tuition/w</i> = 0.14
Average tuition	\$3,700	\$3,200
% Increase in human capital	14.8%	26.4%
% Increase without any effect on ability and effort	19.5%	36.7%
% Increase without any effect on effort	16.7%	31.2%
% of Effort	40.4%	46.4%
% of Ability	58.6%	53.6%

Table 9: The increase in the accumulation of human capital compared to the baseline case where $tuition/w = 0.18$ (Average Tuition=\$4,200).

In this section, grade inflation, in the context of the model presented in this paper, is analyzed. This analysis focuses on how informational asymmetry about the grading process leads to grade inflation and decreased student effort. This is not a complete study of grade inflation, nevertheless it provides some insights into the grade inflation phenomenon.

Generally students have more information about the grading process than their parents do. They can easily avoid taking more demanding courses and choose to take courses that they believe are easier. For example, since grading standards are stricter in the natural sciences than in the social sciences, students generally avoid taking courses in the natural sciences.²⁸ Similarly, students often spend weeks shopping around for the courses and the professors that are the least demanding. As a result, even though the student knows that the grades she is going to get will be upward-biased, parents do not have this knowledge. So when parents evaluate their child's academic success they do not consider it.

Recall that GPA is assumed to be

$$y = \alpha_1 a + \alpha_2 e + \varepsilon, \quad (27)$$

where ε is the random error term. In order to analyze the effect of this informational asymmetry about the grading process, it is assumed that the mean of the error term is 0.3 rather than 0. However, parents do not have access to this information.

Table 10 shows the summary statistics with and without this informational asymmetry. In the first column of Table 10, $\varepsilon \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ and both the parents and the child know that the mean of the error term is 0. For the second column, $\varepsilon \sim \mathcal{N}(0.3, \sigma_\varepsilon^2)$, but only the child knows

²⁸See Sabot and Wakeman-Linn (1991) for a discussion of this observation.

	Mean=0.0	Mean=0.3
Enrollment rate	0.53	0.53
Graduation rate	0.59	0.67
% of college graduates who are low type	0.26	0.32
Average effort	0.49	0.47
Average GPA	2.96	3.21

Table 10: The summary statistics without and with informational asymmetry about the mean value of ε .

that the true mean of the error term is 0.3 rather than 0. As a result of this informational asymmetry, the graduation rate and average GPA increase. However, the average student effort decreases.

These simulations show how an informational asymmetry coupled with the differences in grading policies for different courses or different academic majors could create disincentives for students. Thus, grade inflation could be accompanied by a decrease in student effort. One can identify the lack of consistency in grading standards as one of the reasons for grade inflation in the U.S.

7 Conclusion

Tuition subsidies have a positive impact on enrollment rates, however as this paper has shown, these subsidies also have adverse effects on human capital accumulation. This can be seen in the simulation results, which indicate the existence of two potential adverse effects. First, a low-tuition, high-subsidy policy causes an increase in the ratio of less able and less highly-motivated students among college graduates. Secondly, all students, even the more highly-motivated ones, respond to lower tuition levels by choosing to study less. The simulations of the calibrated game-theoretic model suggest that a 10% decrease in tuition would be accompanied by a 5% decrease in the average study time. Additionally, the potential loss of human capital, caused by the *composition effect* and *disincentive effect* of tuition subsidies, is around 30%. Decomposition of this loss shows that approximately half of the total loss can be attributed to the disincentive effect.

This study also has implications for educational standards. Educational standards that

are set too low or too high might have adverse effects on student effort. For example high standards might discourage students, especially low ability and/or low-motivation students. On the other hand, low standards might cause students, especially high-ability ones, to shirk. Consequently, at colleges with high ability dispersion, grading will be a challenging task.

Grade inflation may also arise in this environment. If students have more information about the difficulty of courses, compared to their parents, then students can self-select themselves into easier courses. Clearly, this informational asymmetry over differences in grading practices could result in grade inflation. Thus, the lack of consistency in grading standards may be one reasons of grade inflation in the U.S.

One might argue that parents can set higher standards for their child and by doing so can make them work harder. Şahin (2002) considered a model like this and looked at the disincentive effects in an environment where parents set the cut-off grade thresholds optimally in the first-period and commit to these standards in the second period. In this case, parents can set the cut-off grade threshold, \bar{y} , at the level which will make the child choose a higher effort level. The simulation results show that if parents can actually commit to higher standards, disincentive effect on students' study time is negligibly small. However, the commitment assumption is crucial and hard to justify in the context of family.²⁹ Parents most of the time have difficulty in implementing the reward/punishment scheme that they offer to their child.

This paper mainly focused on analyzing the effect of operating subsidies that are directly offered to higher education institutions. An interesting research question would be to analyze the effect of different financial aid programs and try to design the *optimal financial aid* system. As a first step, Şahin (2002) has studied the effects of a different type of subsidy: a subsidy that lowers the tuition by the same amount for all students regardless of their family income. Hope Scholarship credit, which was created in 1997, is very similar to that kind of subsidy. This program provides a tax credit of 100% of tuition expenses for up to \$1,000. Since tuition expenses are almost always higher than \$1,000, the tax credit lowers tuition by \$1,000 for almost all students. These experiments suggest that a subsidy that is provided directly to students is more effective in encouraging human capital accumulation

²⁹See Laitner (1997) for a discussion of commitment in the context of family.

compared to the operating subsidies provided to postsecondary institutions. This finding is not surprising. Operating subsidies provide higher amount of subsidy to students from middle and high-income families since students from high-income families are more likely to attend four-year public postsecondary institutions. On the other hand, low-income students who attend two-year colleges get a lower share of the subsidies since operating subsidies to these schools are lower. So a direct subsidy to a low-income student could be more effective by decreasing the cost more than the operating subsidy would.

This study raises some interesting questions for future research. First of all, the model can easily be extended to include a government which levies taxes on parents to finance the higher education subsidies. This extension would be useful in the analysis of welfare implications of tuition subsidies. Secondly, the disincentive effects of tuition subsidies can be analyzed in a general equilibrium framework which will make it possible to consider the general equilibrium effects on skill prices.

Appendix A

The discounted lifetime utility of consumption, $U_{HS}(a, T)$, can be computed by solving the straightforward optimal consumption problem

$$U_{HS}(a, T) = \max_{s_{t+1}, c_t} \sum_{t=1}^T \beta^{t-1} u_c(c_t), \quad (28)$$

$$\begin{aligned} & s.t. \\ & s_{T+1} = 0, s_1 = 0, \\ & s_{t+1} = (1+r)s_t + w_t - c_t, \end{aligned} \quad (29)$$

where $w_t = w(a, t)$ is the earnings, $u_c(\cdot)$ is the utility function of the child, s_t is the savings, c_t is the consumption, r is the market interest rate, and β is the discount factor.

The expected lifetime utility of consumption for a college graduate is

$$\begin{aligned} U_{CL}(a, \theta, T-4) &= (1 + \beta + \beta^2 + \beta^3) u_c(\bar{c}) + \max_{s_{t+1}, c_t} \sum_{t=5}^T \beta^{t-1} u_c(c_t), \\ & s.t. \quad s_{T+1} = 0, s_5 = 0, \\ & \quad s_{t+1} = (1+r)s_t + w_t - c_t. \end{aligned} \quad (30)$$

Note that $w_t = w(a, e_1, e_2, t) = \exp(\alpha + a + \mu_1 a + \eta_1 e_1 + \mu_2 a + \eta_2 e_2 + \rho_0 t + \rho_1 t^2)$ and \bar{c} is the amount of consumption that parents provide for their child during the college education.

Similarly, for a college dropout, the expected lifetime utility of consumption is

$$\begin{aligned} U_{DO}(a, \theta, T-2) &= (1 + \beta) u_c(\bar{c}) + \max_{s_{t+1}, c_t} \sum_{t=3}^T \beta^{t-1} u_c(c_t), \\ & s.t. \quad s_{T+1} = 0, s_3 = 0, \\ & \quad s_{t+1} = (1+r)s_t + w_t - c_t. \end{aligned} \quad (31)$$

Note that $w_t = w(a, e_1, t) = \exp(\alpha + a + \mu_1 a + \eta_1 e_1 + \rho_0 t + \rho_1 t^2)$ and \bar{c} is the amount of consumption that parents provide for their child during the college education.

The discounted lifetime utility of parents with annual earnings w , $U_p(w, C)$, is

$$U_p(w, C) = \max_{s_{t+1}, c_t} \sum_{t=1}^T \beta^{t-1} u_c(c_t), \quad (32)$$

$$\begin{aligned} & s.t. \quad s_{T+1} = 0, s_1 = -C, \\ & \quad s_{t+1} = (1+r)s_t + w_t - c_t, \end{aligned} \quad (33)$$

where w_t is the earnings, $u_c(\cdot)$ is the utility function of the parents, and C is total amount used for education of the child. Note that all debts must be repaid in full at the time of death.

Appendix B

NLSY79: The National Longitudinal Survey of Youth 1979 (NLSY79) consists of data on respondents' labor force participation, labor market attachment, and investments in education and training. In 1981, the National Institute of Education sponsored a set of time-use questions. This survey contains responses to the special set of questions, asked in the 1981 survey, about each respondent's use of time during the past seven days, e.g., how much time was spent on working, commuting, attending school, studying, sleeping, etc. The total study time variable in the regressions was formed from the data in this survey. The NLSY79 also collected information about the Federal Interagency Committee on Education (FICE) codes of the postsecondary institutions that the respondents have attended starting from 1984. I have used the FICE codes to identify the institutions attended by the respondents.

HS&B: The High School and Beyond (HS&B) survey began in 1980, and the data were collected on over 58,000 high-school seniors and sophomores. In this study, the Sophomore Cohort: 1980:1992 data set is used. The follow-up surveys were conducted in 1982, 1986 and 1992. The supplement for the Postsecondary Education Transcript Study (PETS) of the HS&B Sophomore Cohort was used to get estimates of the grade point averages of college students. These grade point averages were then used in the calibration of the model.

Tuition and Fee Rates: The Washington State Higher Education Coordinating Board surveys state institutions and prepares a report of tuition and fee rates at public institutions in the 50 states. The data used in this study contains an average for each state from a number of 4-year comprehensive universities for 1981.

HEGIS: The Higher Education General Information Survey (HEGIS) includes information about postsecondary institutions in the United States such as revenues and expenditures, enrollment statistics including number of students by residence status, basic characteristics of educational institutions, numbers of full and part-time employees, and faculty compensation. The FICE codes were merged with the NLSY79 data and the tuition levels of the schools that respondents have attended were obtained.

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