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Student Financial Aid and the College Enrollment Decision: the Effects of Public and Private Grants and Interest Subsidies

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Abstract — A multi-period household utility maximization model is the basis for the estimation of a binomial logit model to investigate the effects of four types of student financial aid on the college enrollment decision of high school seniors from the class of 1980. Publicly provided grants are seen to have a significant and positive effect on the decision and tend to increase college enrollments of individuals from lower income households. Other types of student financial aid, including privately funded scholarships and the interest subsidy from public and private source student loans, are found to have no measurable effect on the enrollment decision.

INTRODUCTION

DURING the sixties and seventies the support for equal opportunity of access to higher education through the provision of student financial aid grew substantially. Considerable structural change in amounts and types of financial aid available for this purpose warrants an examination of its current effectiveness. Student aid, in the form of publicly and privately funded grants and interest payments on student loans, is a subsidy that intentionally distorts the prices that households pay and, as such, is expected to contribute to a greater opportunity of access to college. Since past empirical research has consistently shown that college attendance is positively related to parental income,[1] it is expected that student financial aid directed to lower income households, to the extent that the impact is similar to that of an increase in income, results in increased college enrollment rates by these groups.

Up to now, researchers of the effects of student financial aid on the college enrollment decision have not had access to representative data for high school seniors who had available the current menu (and high levels) of financial aid. Recent studies by Fuller *et al.* (1982) and Manski and Wise (1983), for example, rely on 1972 survey data to form out-of-sample predictions of the 1979 college enrollment effects from publicly funded grants which were not actually available to the 1972 sample. Past studies have also been limited to the enrollment effect of non-repayable grants or scholarships, and have not considered the effect of the interest subsidy from low-interest student loans. The present study overcomes these limitations by using a new data set, the High School and Beyond (HSB) survey of the 1980 senior high school class, sponsored by the U.S. Department of Education. The data enable an analysis of the effectiveness of four types of student financial aid to induce college enrollment in 1980, and yield important policy implications concerning future aid.

Previous studies of college attendance either model the individual's behavior as utility maximization in the immediate period following high school graduation (Miller and Radner, 1970; Kohn *et al.*,

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1976; Bishop, 1977; Fuller *et al.*, 1982) or as wealth maximization over the lifetime of the individual (Willis and Rosen, 1979; Abowd, 1980). The model developed in this study is adapted from the well-established multi-period utility maximization model[2] to describe individual college enrollment behavior as a household utility maximizing decision over the lifetime of the high school graduate. The model extends the previous 'single-period' utility model to capture the future utility from investments in human capital by including the present value of the lifetime benefits and costs of college, variables which are traditionally used in the wealth maximization model.

The model yields a demand function from which is derived a reduced-form binomial logit equation of college enrollment. Several empirical results which previously have not been shown in the literature are obtained from estimation of the model. Coefficient estimates indicate the relative influence on enrollment of future economic costs and benefits. Estimates are also obtained of the effect of public source grants, private source grants, and the interest subsidy from public and private source student loans on the probability of college enrollment. In addition, parameter estimates are used to separate the direct and indirect effects of parental income on individual college enrollment, and later through its influence on the level and composition of student financial aid.

The remainder of the paper is divided into four sections. In the next section the theoretical model of the household's choice of whether to enroll an individual in college is presented and discussed. The second section contains a description of the data and empirical model. The empirical results are presented in the third section, and the policy implications of the results are discussed in the final section.

THEORETICAL MODEL

Virtually all the previous college attendance models assume that the individual independently chooses between college and some non-college alternative; however, the individual is not an independent agent in the college enrollment decision. It is expected that the enrollment decision is influenced by the parent's ability to pay and by the parent's ability to attract student financial aid. In addition, utility from college may be gained by both the child and the parents in the form of pecuniary and non-pecuniary benefits in the short-run consumption period, and in the long-run period of investment return. Students may receive consumption utility from the learning experience and extracurricular activities, and parents may receive satisfaction from having a dependent in college. Investment utility to the student may occur from higher future wages and non-pecuniary rewards on the job and in consumption and, in turn, the child may be a future source of higher pecuniary and non-pecuniary returns to the parents.

The household, then, comprised of parents and a graduating high school senior, is defined here as the decision unit for the college enrollment decision. The household is assumed to arrive at a mutually agreeable decision concerning whether the individual will attend college, and will choose college enrollment if, over the lifetime of the individual, it expects to receive greater utility from college attendance than it expects from the best non-college alternative.[3]

The college enrollment decision is assumed to be made final at the end of the student's senior year in high school and to have effects which extend indefinitely into the future, with associated monetary and non-monetary benefits and costs. For the sake of simplicity, college attendance is taken to be full-time enrollment at a 4-year public or private university and the household is assumed to choose between consumption of 4 years of college and labor force participation thereafter, or full-time labor force participation immediately following high school graduation.[4] The choice for the household, then, is modeled in a discrete manner, much the same as the choice between ownership or non-ownership of a durable good.[5]

The time horizon specified for the model is T yearly periods, from the time that the individual graduates from high school until the retirement date.[6] Households are assumed to make the post-secondary activity decision based on the information available to them at the time that the individual graduates from high school. While the household may not know future values with certainty, it is assumed to form single-valued expectations at the start of the initial period for all variables which occur in the future.[7] Expectations are formed for the future income stream of the individual for the college and non-college alternatives, the direct costs of attending college, and the amount and types of student financial aid that the household may receive, whether the college alternative is chosen or not.

The household's valuation of future benefits and costs is, by nature, based on imperfect information and uncertainty, and expectations may or may not be realized. Theoretically, the model does not prohibit households from collecting new information and adapting their expectations and much of their behavior in subsequent periods; however, the relevant period for the college enrollment choice is taken to be the initial period beyond high school graduation.

The discrete household choice is between two utility maxima indicating non-college, u_0, or college, u_1, where the household chooses the alternative which yields the highest utility level, u:

$$\max u = \max (u_0, u_1). \quad (1)$$

Let each alternative be written as a multi-period household utility maximization problem subject to a household wealth constraint:

$$\max u_0 = f(x_1, \ldots, x_T; z)$$

subject to

$$W^0 - \sum_{t=1}^{T} \rho_t p_t x_t = 0 \quad (2)$$

$$\max u_1 = f(x_1, \ldots, x_T, c; z)$$

subject to

$$W^1 - \sum_{t=1}^{T} \rho_t p_t x_t - (TC - G - L)c_t = 0, \quad (3)$$

where $t = 1, \ldots, T$ time periods, x_t is a vector of non-college goods in each period with an associated vector of prices, p_t, c is a discrete variable representing college attendance, W is multi-period household wealth, ρ is the discount factor, TC is direct costs of college, G is non-repayable grants, L is the interest subsidy from student loans and z is a vector of socioeconomic variables to control for tastes and preferences.

Multi-period household wealth, W, is different for each discrete alternative due to the difference in the future earning streams for the individual as either non-college, y^0, or college, y^1. Household wealth at $t = 0$ is the sum of the discounted present value of parental income, y^p, individual income, y^0 or y^1, and household assets, A. Parental income, as a determinant of college enrollment, is assumed to be relevant only during the college-going period, and so is restricted to the first four periods of the model. The present value of household wealth for the non-college alternative is given by:

$$W^0 = \sum_{t=1}^{4} \rho_t y_t^p + \sum_{t=1}^{T} \rho_t y_t^0 + A_0 (1 + i_1) \quad (4)$$

and, similarly, for the college alternative:

$$W^1 = \sum_{t=1}^{4} \rho_t y_t^p + \sum_{t=1}^{T} \rho_t y_t^1 + A_0 (1 + i_1) \quad (5)$$

where the discount factor, ρ, is defined as:

$$\rho_t = 1/((1+i_t)(1+i_{t-1}) \ldots (1+i_2)), \text{ where } \rho_1 = 1. \quad (6)$$

Annual time periods are linked by a financial asset, A, measured at the end of each period, available in positive or negative amounts, and which pays an interest rate at the beginning of each period. The rate of interest, i, applies to both borrowing or lending, and may vary from period to period so that $i_t A_{t-1}$ is paid at the start of each period, t.

The direct price of college to each household consists of payments on tuition, materials and fees, TC_t, less any private and public source grants and low-interest loan subsidies that may be received. Private and public source grants or scholarships, G_t, are non-repayable and so reduce the direct costs of college attendance in each period by their full amount. The discounted present value of direct costs and non-repayable grants is given by:

$$TC = \sum_{t=1}^{4} \rho_t TC_t \text{ and } G = \sum_{t=1}^{4} \rho_t G_t. \quad (7)$$

The household may be able to borrow funds, B_t, to purchase college at a constant, below-market interest rate, r, where $r < i_t$, and is required to repay the loan over a 10-year period following college graduation. The government subsidizes the loans by granting the low interest rate and by making interest payments while the individual is attending college. The net discounted present value of government loan subsidies to the household from low-interest student loans, L, is equal to the difference between the present value of the principal of the loan, B, and the present value of the payments, PA:[8]

$$L = \sum_{t=1}^{4} \rho_t B_t - \sum_{t=5}^{14} \rho_t PA_t. \quad (8)$$

According to the maximization problem given by equations (1), (2) and (3), the household will choose to purchase college for the individual when $u_1 > u_0$ and will choose not to purchase college when $u_0 > u_1$. The household selects its optimal consumption bundle of non-college and college goods based on the alternative which yields the highest utility level. If it is assumed that all households face a common set of prices for the non-college consumption goods, x_t, and interest rates, i_t and r, then the demand function for the discrete college choice can be written as a function of the present value of alternative household wealth, direct costs of college, grants, interest subsidies and the vector of household socioeconomic variables:

$$C = \delta\,(W^1, TC, G, L; Z). \quad (9)$$

It is important to note three differences between this formulation of the demand function and those derived in the previous 'single-period' utility maximization models. The most obvious difference is that the money-valued variables extend over the working lifetime of the individual. As such, this utility maximization model incorporates the present value of the costs and benefits of college that are the basis of the investment return calculation used frequently in the human capital literature, and so embodies the wealth maximization hypothesis in the demand function. Household wealth varies between the college and non-college choices due to this investment return to human capital.[9]

Second, the former utility models include single-period indirect costs of college attendance as a separate component in the demand function. Here the opportunity cost of income foregone during the college-going years is captured by the present value of the individual's future income stream for the non-college alternative. Assuming a positive return to college, the effect is to moderate the difference in household wealth between the college and non-college alternatives.[10]

Third, the model introduces two additional sources of variation in income and cost that are not included in the single-period models. Since the investment return from college is likely to vary across individuals, household wealth across households has additional variation and, perhaps more importantly for the purposes of this study, the net direct cost of college to the household contains additional variation since each household may receive different amounts of grants and interest subsidies.

These differences result from extending the previous utility models of college-going behavior to encompass the household's future costs and benefits from choices made in the immediate period following high school graduation. By treating the lifetime of the individual as the time horizon for the model, a more complete expression of the economic costs and benefits which influence the household's college enrollment decision is obtained for empirical estimation.

EMPIRICAL MODEL AND DATA

The empirical model used to estimate the effects of student financial aid on college enrollment closely follows the demand function, equation (9), derived from the choice model. Before the data and model are described, there are two procedural issues that need to be addressed.

In order to test the hypothesis that student financial aid induces college enrollment, the college choice for the household is defined as its least expensive alternative. The least-cost college for the household is taken to be the nearest 4-year public higher education institution in the household's home state. Although the realized college may be any 4-year public or private university, the threshold expenditure necessary to purchase college in the absence of student financial aid, and therefore the relevant price for this analysis, is the direct cost at this assumed least-cost alternative. Households which, in fact, choose a more expensive college pay a premium over and above the minimum price necessary to obtain a 4-year college degree.[11] The problem associated with modeling a household's choice of a particular college — the endogeneity of academic credentials, applications and the choice set of colleges and tuition prices — is well documented in the literature and need not be re-examined here.[12] The procedure used in this study circumvents the endogeneity problem and allows the formation of a relatively homogeneous collection of higher education institutions.[13]

The second procedural issue concerns the estimation of the four student financial aid variables. Since college costs are an important determinant of financial aid and because the home-state university is defined as the relevant college, the HSB observations used in the estimation of financial aid are limited to those households who chose to enroll the student in a home-state 4-year public university. An instrumental variable approach using the Tobit procedure was chosen because many observations on student financial aid are concentrated at a lower limiting value of zero.[14] Public and private grants and interest subsidies are each estimated, and their fitted values for each HSB observation are entered in the estimation of college enrollment.[15] The results of these estimations are given in Appendix Table 1.

Data

The primary source of data for the empirical model is the 1980 HSB survey of 28,240 high school seniors, contained in the data tapes available from the National Center for Education Statistics. The survey is nationally and regionally representative of both high schools and students.[16]

A second data source is required for the estimation of the future monetary return to college. An instrumental variable is estimated by ordinary least squares on a human capital earnings function and its fitted value then computed for the HSB observations, governed by the individual's characteristics. The information contained in the March 1980 Current Population Survey data tapes from the Census Bureau provides the data necessary to proxy the household's expectation of the future monetary return to college and non-college alternatives and coincides with the time of the HSB survey. Estimation results for the future return variable are given in Appendix Table 2.

The HSB survey is a superior data set to test the effects of student financial aid on the college enrollment decision. The survey was taken at a time when student financial aid programs were well established and proposals to alter financial aid programs occurred nearly 1 year after the senior cohort had been sampled. Thus the sample contains households who were expecting student financial aid programs to continue at 1980 levels, and whose expectations were not affected by recent changes in funding.

In addition, the survey was taken in the spring of the student's senior year in high school, a time when it can be safely assumed that the decision had been made as to whether the student would enroll in college in the following academic year. Economic factors which influence the enrollment decision were known to the households at this time with a high degree of certainty.[17] Unexpected events which changed the decision during the summer months preceding college enrollment are not included, and are not relevant to the *ex ante* household decision being examined by the model. *Ex post* data on realized college enrollment used in previous studies is an imperfect proxy for the enrollment decision because unanticipated events may modify the outcome, but are exogeneous to the household decision modeled here.

Of the original senior class cohort, 11,500 observations have complete information for the variables used in the estimation.[18] Each household in the HSB data set is categorized as making either a non-college or college choice on the basis of responses to questions indicating post-secondary plans. To qualify for college enrollment status the individual indicated plans to attend a 4-year public or private college or university as a full-time student. All other individuals were classified as non-college.

Empirical Model

As noted above, pre-estimation is required for the student financial aid and future return instruments. Data on all other variables are provided directly by the HSB survey. The Logit technique was chosen to estimate the probability of college enrollment, primarily due to the binary nature of the dependent variable. The application of ordinary least squares (OLS) in the case of a qualitative dependent variable is inappropriate.[19] The Logit specification was chosen over a Probit model because the cumulative logistic function is very similar to the cumulative normal function and is computationally less costly.

The following reduced-form binomial Logit equation is fitted to the college enrollment decision of the 11,500 HSB households:[20]

$$\ln[p_i/(1 - p_i)] = \beta_0 + \beta_1 Y_i^{\mathrm{P}} + \beta_2 \hat{Y}_i^{\mathrm{T}} + \beta_3 TC_i + \beta_4 \hat{G}_i^{\mathrm{pb}} + \beta_5 \hat{G}_i^{\mathrm{pr}} + \beta_6 \hat{L}_i^{\mathrm{pb}} + \beta_7 \hat{L}_i^{\mathrm{pr}} + \beta_8 Z_i + \epsilon_i, \tag{10}$$

where p_i is the probability that the ith household chooses college for the high school senior and ϵ_i is the disturbance term. The independent variables in the college enrollment equation (10) are defined in Table 1. Variable means and standard deviations are given in the Appendix.

RESULTS AND IMPLICATIONS

The Logit coefficient estimates for the college enrollment equation are given in Table 2. In general, for the variables which are analogous to those used in past studies, the regression results for this sample of 1980 high school seniors are consistent with previous empirical findings. Factors which in the past consistently have been shown to have a statistically significant effect on the college enrollment behavior of individuals produce the same result here.[21] In addition, a statistically strong and positive result is found for public grants, a factor previously either not considered or found insignificant.[22] This result suggests that public grants are important determinants of college enrollment, and that policies related to their provision will affect college enrollment behavior.

The estimated coefficient on the parental income variable (Y^{P}) is positive and statistically significant. The positive coefficient indicates that individuals from higher income households have a higher probability of attending college than do those from lower income households. The result indicates that college enrollment behavior is not wealth neutral, a result repeatedly found in earlier studies.

Each of the financial aid variables was expected to have a positive effect on the probability that an individual would attend college, but only the one already mentioned, public grants ($\hat{G}^{\mathrm{pb}}$), was found to have a statistically significant effect on college-going behavior. The other three financial aid variables, private grants ($\hat{G}^{\mathrm{pr}}$), public loan subsidies ($\hat{L}^{\mathrm{pb}}$) and private loan subsidies ($\hat{L}^{\mathrm{pr}}$), were found to have no statistically significant effect on the college enrollment decision.

Public grants are largely determined by parental income, with lower income households receiving larger public grants, all else equal. The significant positive coefficient for the public grants variable suggests that the indirect (and inversely related) effect of parental income on the probability of college enrollment through public grants for low-income individuals is positive. That is, lower income households are eligible for higher levels of public grants, and these grants are estimated to increase the probability of college enrollment. However, the independent direct effect of parental income on college enrollment is also significant and positive, indicating that lower income individuals have a lower probability of going to college, when grant levels are controlled. Thus the direct and indirect effects of parental income are countervailing forces in the estimation. Both direct parental income and public grants are found to strongly and independently encourage college enrollment.

With respect to private grants, the statistically insignificant coefficient suggests that the offer of a private grant does not independently increase the probability that an individual will attend college. The result implies that private source scholarships or grants, awarded to individuals who do attend college, may in effect be regarded as gifts to individuals who would have attended college even without the award.[23] The direct effect of academic achievement on the probability of college enrollment is highly significant and positive. While private grants are often largely determined by academic achievement, the direct effect of achievement in the college enrollment estimation appears statistically to outweigh the indirect effects of achievement acting through private source grants. Other variables which are included in the estimation, and which in part determine the level of private grants, also tend to diminish the direct effects of private grants. All these variables are controlled for to the point that private grants *per se* are not a statistically significant factor of college enrollment. The type of student who tends to receive private grants would be expected to attend college with equal likelihood with or without the grant because the characteristics which lead to the receipt of private grants also lead heavily and independently to college enrollment.[24]

Neither the public nor private loan subsidy variables ($\hat{L}^{\mathrm{pb}}$, $\hat{L}^{\mathrm{pr}}$), the variables which measure the interest subsidies from low-interest student loans, are shown to have a significant influence on the probability of college enrollment.[25] That is, interest subsidies on loans available to households to purchase college are not systematically related to the probability that the individual will attend college.

Table 1. Independent variables in the college enrollment equation

Parental income (Y^p)	present value of parental income over the four years of the college period, in thousands of dollars. Demand theory suggests a positive sign
Future return ($\hat{Y}^r$)	present value of the difference between the estimated college and non-college future income streams, in thousands of dollars. Human capital theory supports an expected positive sign. See Appendix for estimation details
Direct costs (TC)	present value of tuition, materials and fees at the public 4-year college or university in the household's home state, in hundreds of dollars. Demand theory suggests a negative sign
Public grants ($\hat{G}^{pb}$)	present value of estimated non-repayable grants from public sources, in hundreds of dollars. Demand theory suggests a positive sign. See Appendix for estimation details
Private grants ($\hat{G}^{pr}$)	present value of estimated non-repayable grants from private sources, in hundreds of dollars. Demand theory suggests a positive sign. See Appendix for estimation details
Public loan subsidy ($\hat{L}^{pb}$)	present value of estimated student loans from public funds less loan repayment, i.e. the interest subsidy, in hundreds of dollars. Demand theory suggests a positive sign. See Appendix for estimation details
Private loan subsidy ($\hat{L}^{pr}$)	present value of estimated student loans from private sources less loan repayment, i.e. the interest subsidy, in hundreds of dollars. Demand theory suggests a positive sign. See Appendix for estimation details
Academic achievement (Z)	a composite index of SAT-type achievement test scores, high school course grades and high school curriculum.* The variable may proxy for consumption utility of college as well as expectations of future utility from college. Previous research suggests a positive sign
Parental education (Z)	the simple average of the parent(s) education level. May proxy for preferences and expected utility. Previous research suggests a positive sign (less than high school = 2, advanced degree = 10)
Distance (Z)	the distance, in miles, to the nearest public 4-year college or university. The variable is a proxy for commuting costs or additional living costs if the student is forced to live away from home. Demand theory suggests a negative sign
Sex (Z)	sex of the individual may capture tastes, preferences, and sociological differences in the demand for college (male = 0, female = 1)
Race (Z)	race of the individual may capture tastes, preferences and sociological differences in the demand for college (white = 0, non-white = 1)
Race × sex (Z)	interaction term representing non-white female, may capture tastes, preferences and sociological differences (other = 0, non-white female = 1)
Region (Z)	eight dummy variables representing the nine standard census regions, Pacific Region omitted. The region variable may proxy cost or attitude difference (example: other region = 0, New England region = 1)

* Details for the method used to construct the academic achievement index are contained in Schwartz (1982).

Table 2. Logit coefficient estimates of college enrollment

Independent variable	Coefficient estimate	Asymptotic t ratio
Constant	−10.4381*	−10.715
Parental income (Y^P)	0.0052*	6.500
Future return ($\hat{Y}^r$)	0.0003	0.056
Direct costs (TC)	−0.0031*	−7.750
Public grants ($\hat{G}^{pb}$)	0.0075*	2.642
Private grants ($\hat{G}^{pr}$)	−0.0033	−0.375
Public loan subsidy ($\hat{L}^{pb}$)	0.0325	0.235
Private loan subsidy ($\hat{L}^{pr}$)	−0.6878	−0.435
Academic achievement	0.1762*	42.951
Parental education	0.1676*	13.462
Distance	−0.0030*	−2.727
Sex (male = 0, female = 1)	0.0198	0.278
Race (white = 0, non-white = 1)	0.8917*	5.837
Race × sex (other = 0, non-white female = 1)	−0.0434	−0.059
New England	0.5986*	4.128
Middle Atlantic	0.5678**	1.808
South Atlantic	0.4211**	1.708
East South Central	0.7338*	5.742
East North Central	0.6971*	7.628
West South Central	0.7061*	3.604
West North Central	0.6255*	5.666
Mountain	0.5306*	2.638
−2 log likelihood ratio	4641.949***	
Estimated R^2	0.2857	
Sample size	11,500	

*Significant at the 0.01 level.
**Significant at the 0.10 level.
***All coefficients in the equation are jointly significant at the 0.01 level.

The results suggest that public funds used for the payment of these interest subsidies are essentially transfers of income to those individuals who attend college and who would have attended even in the absence of these interest subsidies.

A probable cause for the results found for the loan subsidies is that the estimated instrumental variables have relatively limited variation across all households.[26] There are two justifiable reasons for this limited dispersion. First, a majority of students at public institutions in the 1980 sample were not awarded public or private loans (76.8 and 86.6%, respectively), which results in a high concentration of individuals predicted to receive no loan subsidy from either source. Second, two of the statistically significant determinants of the estimated amount of borrowed funds, parental income and the indirect costs of college attendance, have opposite signs and are sufficiently offsetting to cause little variation in the estimated public and private loan awards, and therefore little variation in the interest subsidies from these loans (see Appendix Table 1). While both of these variables entered separately have a direct significant effect on the probability of college attendance, they do not appear to have a significant indirect effect through the loan subsidies since they tend to be offsetting factors in determining the levels of loan awards.

The price variable (TC), which includes tuition, materials and fees of attending college, is found, as expected, to have a negative and significant influence on the probability of college enrollment; higher direct costs tend to decrease college enrollment, all else constant. In addition, distance, which proxies for the additional costs associated with living a long distance from college, is also estimated to have a significant and negative effect on the dependent variable. Both of these price variables conform to the pre-estimation expectation of the direction of influence on the probability of college enrollment.

The future return to college ($\hat{Y}^T$) is found to have no significant influence on the probability of college enrollment. This estimated difference between the present value of the college and high school alternative income streams is positive for all individuals, indicating that a positive return for college attendance is available for all individuals who choose to go to college. In addition, the variable is relatively well dispersed across individuals (see Appendix Table 3) and is not highly correlated with any other variable in the estimation. The result suggests that, given positive future incomes for all students who choose a college education as opposed to only high school, the magnitude of the difference between high school and college earning streams does not affect the likelihood that an individual will choose to attend college. As such, the estimation does not support the hypothesis that individuals go to college in order to maximize lifecycle income.[27] One plausible explanation would be that the functional relationship is more in the form of satisficing than maximizing. The rationale would suggest that students desire to earn at college degree-related levels but, above some threshold, additions to earnings seem to matter little.

As expected, the education level of the parents is shown to have a positive and significant impact on the probability that the individual will attend college.[28] The implication is that parents who have attained higher levels of education view college as worthwhile and encourage their children to enroll. The result is also consistent with the hypothesis that higher educated parents may expect to receive non-pecuniary consumption and investment utility from sending a child to college.

Of the three dummy variables which account for the sex and race of the individual, only the race variable is found to be statistically significant. Being male or female, or a non-white female, does not alter the probability of college enrollment. For this sample in which all individuals are high school graduates, non-whites as a group are shown to have a higher probability of attending college than whites, all else equal. Being a non-white has a strong positive influence on public grants and independently on the probability of college enrollment. Both the indirect effect (through public grants) and the direct effect of race are seen to positively influence the probability of college enrollment.

Finally, six of the geographic regions are found to be significant factors in the estimation. Location in the Middle Atlantic or South Atlantic region can be said to have a significant effect only if a lower level of significance is accepted.

Marginal Effects

It is useful to examine the relative marginal effects of per-unit changes in independent variables on the predicted probability of college enrollment. Table 3 lists the marginal effects of the statistically significant independent variables, except for the geographic region variables, which are evaluated for an individual of sample mean characteristics.[29]

Table 3. Marginal effect of changes to selected variables on the probability of college enrollment, evaluated at $\bar{X}$

Independent variable	Marginal effects
Parental income (Y^P)*	+0.0013
Direct costs (TC)†	−0.0008
Public grants ($\hat{G}^{pb}$)†	+0.0019
Academic achievement	+0.0441
Parental education	+0.0419
Distance (miles)	+0.0008
Race (white 0, non-white = 1)	+0.2223

*Measured in thousands.
†Measured in hundreds.

As shown, the effect of a \$100 increase in public grants has a larger positive effect than a general \$1000 increase in parental income, at the margin. The result is intuitively appealing since, theoretically, specific grants tied to the purchase of a particular good yield a higher consumption rate of the good than do general grants.[30] A similar and consistent result is that a decrease in the direct costs of college by \$100 nearly offsets the effects of a \$1000 decrease in parental income.

Another implication of the relative marginal effects is that an increase in public grants results in a larger increase in the probability of enrollment than does a decrease in direct costs of like amount. The comparison between these two marginal effects should be made with caution, however. The marginal effects are evaluated at the mean values of all variables in the estimation and higher income groups, those with incomes above the mean value of parental income, are estimated to receive no public grants.[31] Thus the comparison between the marginal effects of a tuition change, where tuition is relatively constant over income groups, and public grants, which vary substantially over parental income groups, is not completely appropriate.[32]

It is difficult to make comparisons of the marginal effects of academic achievement, parental education, distance and race with any other independent variable because of differences in units of measurement. A comparison between distance to college and direct costs, however, indicates that changes in the enrollment probability will be equal and offsetting for a simultaneous increase (decrease) of 1 mile and a decrease (increase) in direct costs of \$100. The implication is that, if a student averages 4–5 trips a week for 30–34 weeks a year, then the average household in making the college enrollment decision expects a marginal cost of about \$0.30–0.40 per mile to cover additional commuting costs, including the value of the individual's time.

The relatively large marginal effect of the dummy variable, race, indicates that non-whites have a higher probability of college enrollment than whites who are similar in other characteristics. The predicted probability of enrollment for whites is 0.4710 compared to 0.6842 for non-whites, all else equal. Note, however, that this result assumes that the mean values of all other variables in the sample apply equally to each group. When evaluated at the mean values for each group, the estimated probability of college enrollment is 0.4985 for whites and 0.5277 for non-whites. The result suggests that non-white high school graduates (14.6% of the sample) have about a 3% higher probability of enrolling in college than their white counterparts, on average.

SUMMARY AND POLICY IMPLICATIONS

A multi-period household utility maximization model is developed to explain college enrollment behavior and is the basis for the estimation of a reduced-form binomial logit equation. The model extends previous utility models to include the present value of lifetime benefits and costs of college, and is primarily used to investigate the effectiveness of four types of student financial aid to induce college enrollment in 1980. Coefficient estimates and marginal effects of the determinants of college enrollment are presented and discussed.

The results lead to useful insights into the relationships between the important determinants of student financial aid and college enrollment. Both the direct effect of public grants and the indirect effect of parental income acting through public grants are found to increase the probability of college enrollment. Since public grants are inversely related to parental income, enrollment in college by lower income individuals may be increased by the provision of these grants.

Equally important are the implications of results for factors which are found to have no significant effect on the probability of college enrollment. Private grants and the interest subsidy from public and private student loans may be ineffective means of inducing college enrollment and seem, therefore, to constitute transfer payments to individuals who would enroll in college anyway. Grants from the private sector, although inversely related to parental income, seem not to be substitutes for public grants. Increases in such grants alone cannot be expected to increase the college enrollment of students from lower income households, unless the award criteria match the largely need-based criterion of the public grant programs. As for student loans, the policy implication is that market interest rates could be administered with possibly no significant changes occurring in college enrollments.

Finally, the size of the future monetary reward from college does not appear to increase significantly the probability of enrollment. It appears that other monetary and non-monetary costs and benefits may be more important considerations in the college enrollment decision. The decline in the earnings of recent college graduates relative to other workers[33] may be responsible for the low importance attached to the monetary reward incentive to enroll in college. Since individuals do not expect significantly higher earnings from college, the reward does not appear to matter as much as other factors. Perhaps the size of the monetary reward would be found to affect the choice of academic major among those who do enroll.

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NOTES

1. See, for example, Campbell and Siegal (1967), Galper and Dunn (1969), Miller and Radner (1970), Christensen *et al.* (1975), Bishop (1977), Hoenack and Weiler (1979) and Fuller *et al.* (1982). It should be noted that in the Christensen *et al.* (1975) study, family income was found positively related to college attendance, but was the least highly correlated variable.
2. See Henderson and Quandt (1971, pp. 297–309) for a full exposition.
3. The assumption that the household arrives at a mutually agreeable decision allows household characteristics to be entered explicitly in the model to capture pecuniary and non-pecuniary rewards of college to both the parents and the individual. Previous models of college attendance enter household characteristics as *ad hoc* control variables.
4. While it may be the case that the individual chooses to attend a 2-year junior college, technical or trade school, join the military, etc., the model is restricted to the binary case of full-time college or full-time work after graduation from high school. An alternative approach would be to specify a multinomial choice model to include all other possible alternatives, but such a model is analytically and empirically difficult to manipulate in a multi-period framework. For example, if a 2-year college choice was included then another decision point is met, and requires further modeling or assumptions for whether the individual would complete a 4-year degree, enter the labor force or choose some other activity. A multi-period multinomial choice model requires a large additional cost in terms of complexity, but yields a small marginal benefit in terms of answering the questions posed here.
5. See Deaton and Muellbauer (1980, pp. 366–372) for a description of the durable good model.
6. The retirement date is a convenient termination point for the model since the potential for higher earned incomes for the college educated is ended. Taste and preference control variables are included to capture non-pecuniary returns experienced before and after retirement.
7. Note that this assumption is significantly different from that used in the wealth maximization model by Willis and Rosen (1979), where *ex post* earnings data are used for the individuals who are assumed to know their future lifetime earnings with certainty at the time of the education investment decision.
8. The interest subsidy is capitalized into a present value benefit that reduces the cost of college. Note that the amount of interest subsidy varies directly with the principal of the loan. Thus the measure serves as a good proxy for the loan principal if households (mis)perceive the loan largely as a gift. Note also that the present value of loans and loan repayments are related by the condition that the principal on the loan must be repaid by the end of the 10-year period. The amount of principal repaid in year t is:

$$PR_t = PA_t - r\left(\sum_{\tau=1}^{4} B\tau - \sum_{\tau=5}^{t-1} PR\tau\right), \text{ where } \sum_{\tau=5}^{14} PR\tau = \sum_{\tau=1}^{4} B\tau.$$

9. In previous models, Bishop (1977) included a proxy variable, the difference between annual mean earnings in college and non-college occupations, and Fuller *et al.* (1982) formed a variable based on academic ability for the credential value of college. Neither of these point-in-time proxy variables for the future utility from college fully model the economic costs and benefits over the lifetime of the individual.
10. The earnings variable that measures the opportunity cost of time in college may be biased upward to the extent that students work part-time while in college or in summers. It is not clear, however, that wage rates for part-time or temporary student jobs are as high as full-time wage rates earned by their non-college counterparts. Part-time work for full-time college students is considered here to be time taken away from leisure, much in the same fashion as full-time workers have the option of overtime or a second job.
11. Some households, of course, may in fact face a lower net price from a more expensive institution if offered a sufficient amount of financial aid to drive the direct cost below the net price at the assumed least-cost college. The results should not be seriously affected since the situation is likely to be rare.
12. See Bishop (1977) and Fuller *et al.* (1982) for thorough discussions of the problem.
13. Bishop (1977) uses a similar cost-minimization procedure. The assumption used here introduces a bias to the extent that some individuals may not meet the minimum admissions requirements at the defined university. Manski and Wise (1983) found, however, that most high school students who do not apply would have a high probability of admission even to a college of average quality, where quality is measured by the mean value of SATs of the entering freshmen over all colleges. The potential bias is further diminished in states which charge a relatively uniform tuition price across the public university system, a common case. The bias is expected to be small and should not seriously compromise the final results.

14. If ordinary least squares were to be applied, unbiased estimates of the regression coefficients would be obtained. However, these parameter estimates would be inefficient and inconsistent, because the disturbance terms would be heteroskedastic for observations at the limit of the dependent variable. A description of the Tobit model is given in Tobin (1958).
15. Some may argue that a selection bias is present in the data since only those individuals who enroll in college can be observed to receive student financial aid. However, correction of the bias is impossible in this model. A simultaneity problem exists since the censoring adjustment equation would require an estimation of the probability of college enrollment (the cause of the censoring bias) and this is precisely the variable which is to be ultimately estimated by the model. An equation-by-equation correction procedure is clearly inappropriate. The problem is further complicated by financial aid variables that each require a Tobit estimation, which makes systems estimation to correct both the simultaneity and selection bias problems not feasible.
16. The survey selected students through a two-stage probability sample, with schools as the first stage units and students within schools as the second stage units. A detailed description of the HSB survey is contained in the NCES Codebook (1980).
17. Until recently, colleges informed the household of the admission decision and the source, type and amount of financial aid award by early spring of the senior year in high school. Only since 1981 have financial aid awards been postponed pending the outcomes of various proposed changes in the aid programs.
18. An analysis indicated that the deleted observations did not differ significantly from those in the original sample for the mean values of any of the variables used in the study. See Schwartz (1982).
19. A clear discussion of the problems associated with the application of ordinary least squares estimation of qualitative dependent variables can be found in Kmenta (1972, pp. 425–428).
20. The model is a reduced form of a structural model of both the household's decision and college admission, where admission is assumed to be independent of the error term.
21. The direction of influence is also the same. The variables referred to are: parental income, direct costs, academic achievement, parental education, distance, race, and geographic location. See Note 1 for references.
22. Manski and Wise (1983) provide the only known evidence to date. In out-of-sample simulations based on 1972 data, they predicted that 1979 BEOG awards had no effect on college enrollments in 4-year colleges, for any income group. Note that the public grants variable used here includes funds from all public programs and sources at the state and federal levels, and that the estimation includes three other financial aid variables.
23. Note that although there may be a lower incidence and lower levels of private grant awards at public institutions than at private institutions, this does not cause a bias in the estimation of private grants available at public institutions or in the estimation of the effects of private grants on the college enrollment decision. The correct measure of private grants in the context of the model is the individual's expected private grant award at the assumed least-cost college.
24. Private scholarships, the only financial aid variable in the Fuller *et al.* (1982) study, were found to be statistically significant for the 1972 high school class that did not receive the publicly provided BEOG awards. The insignificant coefficient result found here suggests that a structural change may have occurred in private scholarship awards after large public grants became available. The estimation of public and private grant awards given in Appendix Table 1 indicate that private grants favor the academically gifted relative to public grants, which are heavily influenced by financial need.
25. The interest subsidy for student loans is defined as the difference between the interest cost of comparable non-student loans and the interest cost of the low-interest student loans. The non-student loans are assumed to have a 10% interest rate, the rate on long-term Treasury Bills at the time of the survey. In 1980 student loans which used public funds for the principal had an interest rate of 4% with a deferred payment schedule. Principals drawn from private sources and guaranteed by federal or state governments had a 7% interest rate and deferred payment schedule. In addition to the results presented here, public and private interest subsidies were combined and entered as a single variable in a separate regression, and the variable was found to be statistically insignificant.
26. The estimated instrumental variables for the public and private loan subsidies have the following characteristics, in hundreds of dollars:

	$\bar{X}$	σ	Min	Max	Observed > 0	Estimated > 0
L^{pb}	0.019	0.237	0	11.22	23.2%	22.3%
L^{pr}	0.003	0.175	0	3.62	13.4%	12.8%

27. The result should be taken with some degree of caution. The estimated future return variable is an imperfect measure of the individual's expectation of future earnings. The variables used in the earnings estimation are limited to those which are contained in the Current Population Survey that can be mapped into the HSB sample (see Appendix Table 2).
28. Christensen *et al.* (1975) found a similar strong result when the father's and mother's education were entered separately in the estimation of college attendance.
29. Note that the marginal effects are presented here for comparison purposes only. Prediction at $\bar{X}$ systematically overstates the change in enrollment probability. The marginal effects are computed for the independent variables, x_j: $d\hat{p}/dx_j = \hat{p}(1-\hat{p})\beta_j$.
30. A discussion of this effect is given in Musgrave and Musgrave (1980).
31. The truncation point for public grants was determined from the results of the Tobit estimation of public grants shown in the Appendix. Individuals from households with incomes greater than $23,735 are estimated to receive no public grant aid.
32. Separate regressions of the full model with interaction control variables for public grants and tuition, and for public grants and parental income, were performed. The interaction terms were found to be insignificant in all cases and subsequently dropped. See Schwartz (1982).
33. A recent study by Berger (1983) gives evidence of this relative decline in earnings.

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APPENDIX

Student Financial Aid

Tobit regression results for the four student financial aid variables are given in Appendix Table 1. The data for the estimations are drawn from the HSB survey and are restricted to observations on those individuals who chose to attend a 4-year college in their home state. Public grants include all non-repayable funds from federal and state sources. All other non-repayable grants or scholarships are assumed to be private grants. Public loans are funds provided directly from federal and state revenues. Loans drawn from other sources, primarily banks and other lending institutions, made available by a government guarantee of repayment are classified as private loans. Wages from the college work-study program are not considered a form of student financial aid since no subsidy is given to the student who works *quid pro quo*.

Appendix Table 1. Tobit parameter estimates of student financial aid (asymptotic t ratios)

Variable	Public grants	Private grants	Public loans	Private loans
Constant	1.6744***	−14.9483*	−20.2641*	−18.1274*
	(1.728)	(−8.807)	(−5.289)	(−5.207)
Parental income	−0.5911*	−0.2259*	−0.2384*	−0.1335*
	(−22.706)	(−12.206)	(−5.794)	(−3.554)
Direct costs	0.1115*	0.0427*	0.1903*	0.1272*
	(5.368)	(2.774)	(5.622)	(4.184)
Academic achievement	0.1061*	0.2551*	−0.0423	−0.1247**
	(2.820)	(9.218)	(−0.677)	(−2.197)
Dependent siblings	0.8579*	0.4953*	1.1241*	0.7640*
	(4.975)	(3.910)	(3.965)	(2.987)
College siblings	0.1413	0.1744	−0.8353	−0.3685
	(0.252)	(0.423)	(−0.898)	(−0.436)
Sex (M = 0)	−3.0334*	−0.8710***	−1.8433***	−1.2067
	(−4.978)	(−1.826)	(−1.856)	(−1.332)
Race (W = 0)	8.4922*	6.2335*	3.0394***	2.4964
	(8.222)	(8.208)	(1.751)	(1.626)
Race × sex	0.3637	−1.0311	−0.1592	−1.2968
	(0.275)	(−1.059)	(−0.071)	(−0.651)
New England	2.7902***	2.5738**	14.0731*	10.0885*
	(1.744)	(2.216)	(5.577)	(4.480)
Middle Atlantic	3.5473*	0.4381	12.3505*	8.8303*
	(3.241)	(0.536)	(6.721)	(5.229)
South Atlantic	0.6630	0.3566	2.3356	4.1495**
	(0.603)	(0.442)	(1.208)	(2.367)
East South Central	2.9295**	1.2053	2.0708	3.0698
	(2.205)	(1.217)	(0.874)	(1.437)
East North Central	2.7760*	2.0291*	9.0240*	4.9683*
	(2.808)	(2.809)	(5.311)	(3.117)
West South Central	3.2662*	2.4133*	2.8530	3.9245**
	(3.004)	(3.023)	(1.467)	(2.219)
West North Central	2.9241*	2.7973*	7.6155*	4.1063**
	(2.474)	(3.253)	(3.798)	(2.165)
Mountain	4.4796*	4.5827*	2.1089	4.0512***
	(3.224)	(4.572)	(0.843)	(1.830)
Sample size	4145	4145	4145	4145
Limit observations	2105	2557	3182	3588
Non-limit observations	2040	1588	963	557
−2 log likelihood ratio	940.06	393.48	217.10	122.52

*Significant at $\alpha = 0.01$.
**Significant at $\alpha = 0.05$.
***Significant at $\alpha = 0.10$.

Future Return

The future return variable ($\hat{Y}^r$) is estimated by constructing artificial age cohorts from the March 1980 Current Population Survey data tapes. An ordinary least squares regression of the log of earnings on the usual set of independent variables provides parameter estimates of age–earnings profiles for non-college and college graduates. Fitted values for each HSB individual are determined from each set of parameter estimates and the difference in the present value of the non-college and college income streams is calculated. The OLS parameter estimates are given in Appendix Table 2.

Descriptive Statistics

The mean and standard deviation of the college enrollment variables are given in Appendix Table 3.

Appendix Table 2. OLS parameter estimates for age–earnings profiles (t statistics)

Variable	Non-college cohort	College cohort
Constant	8.3081*	8.2014*
	(211.040)	(93.343)
Age	0.0615*	0.0712*
	(29.335)	(16.334)
Age squared	−0.0006*	−0.0007*
	(−25.878)	(−13.577)
Sex (M = 0)	−0.2689*	−0.2120*
	(−20.191)	(−9.362)
Race (W = 0)	−0.1667*	−0.1059*
	(−10.066)	(−3.557)
Marital status (NM = 0)	0.2372*	0.1902*
	(20.741)	(10.606)
Marital status × sex	−0.1397*	−0.2936*
	(−19.932)	(−10.669)
Race × sex	0.1413*	0.1351*
	(5.929)	(3.106)
New England	−0.1694*	−0.1067*
	(−10.399)	(−4.434)
Middle Atlantic	−0.0617*	−0.0273
	(−4.291)	(−1.201)
South Atlantic	−0.1555*	−0.0537*
	(−11.204)	(−2.518)
East South Atlantic	−0.1844*	−0.1495*
	(−9.839)	(−4.837)
East North Central	−0.1356	−0.0099
	(−1.933)	(−0.442)
West South Central	−0.1716*	−0.0810*
	(−10.767)	(−3.167)
West North Central	−0.2328*	−0.1844*
	(−15.668)	(−7.522)
Mountain	−0.1356*	−0.1421*
	(−9.413)	(−6.380)
Degress of freedom	28433	10566
F ratio	496.40	167.63
R^2	0.2075	0.1922

*Significant at $\alpha = 0.01$.

Appendix Table 3. Mean and standard deviation of college enrollment variables

Variable	$\bar{X}$	σ
Parental income (Y^{P})	94.940	45.791
Future return ($\hat{Y}^{r}$)	202.234	47.502
Direct costs (TC)	110.669	57.954
Public grants ($\hat{G}^{pb}$)	12.174	18.331
Private grants ($\hat{G}^{pr}$)	1.611	4.930
Public loan subsidy ($\hat{L}^{pb}$)	.019	.237
Private loan subsidy ($\hat{L}^{pr}$)	.003	.175
Academic achievement	50.000	8.050
Parental education	4.639	2.189
Distance	18.182	23.230
Sex (M = 0)	.532	.499
Race (W = 0)	.146	353
Race × sex	.080	.271
New England	.050	.218
Middle Atlantic	.145	.352
South Atlantic	.140	.347
East South Central	.061	.239
East North Central	.224	.417
West South Central	.102	.302
West North Central	.099	.299
Mountain	.051	.220