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ABSTRACT

The conventional human capital model of the decision to attend college is modified to account for capital market imperfections and then used to specify variables and functional form of an estimating equation. A binomial logit model is fitted by maximum likelihood to the behavior of 27,046 male, high-school juniors in 1960, divided into 20 strata defined by student ability and family income. Tuition, high admissions standards, travel costs, and room and board costs all have significant negative effects on attendance.

The effects of higher foregone earnings are significantly less negative than tuition and this suggests that capital market imperfections were an important impediment to college attendance in the early sixties. Cross section measures on the expected payoff to college have negligible effects on attendance. The powerful impacts of public policy measures and draft pressure suggest that enrollment growth in the fifties and sixties may be largely due to the liberalization of admissions policies, the establishment of new community colleges and public four-year colleges in cities and states that had none before, and the Vietnam war.

INCOME, ABILITY, AND THE DEMAND FOR HIGHER EDUCATION

Despite the fact that equality of access to higher education has been an objective of public policy for over a decade, little is known about the effectiveness of alternative means of achieving this goal. Econometric work has established that college attendance is positively associated with parental education, family income, and student ability, and negatively related to tuition [Campbell and Siegel, 1967; Hopkins, 1974]. It has been suggested that youth from low-income backgrounds have higher elasticities of demand, and a number of studies have obtained results that are consistent with this hypothesis [Corazzini et al., 1972; Hoenack, 1971; Radner and Miller, 1970; Kohn et al., 1974]. Little is known, however, about the impact of admissions policy, college location or curriculum, draft pressure, or the economic environment on college entrance decisions. Nothing is known about the relative effectiveness of alternative policy measures on different ability groups.

This paper will attempt to fill these holes in the literature by estimating a model of college entrance that focuses on the influences of public policy and the economic environment, and their interaction with student ability and parental income. The policy instruments examined are tuition, admissions requirements, college location, breadth of curriculum, draft deferments, and social class integration of neighborhoods. The aspects of the economic environment not under government control that are examined are the opportunity cost of the student's study time and the size of the anticipated earnings payoff to college graduation.

The conventional human capital decision model is modified to account for capital market imperfections by the naive but simple device of adding a cash flow constraint. The binomial logit model that is derived from this theoretical perspective is fitted by maximum likelihood to the behavior of 27,046 male high-school juniors in 1960, stratified by ability quartiles and by five family-income categories.

For estimating response to price, the Project Talent data used here are better than any previously available. The study is longitudinal; we do not depend upon memory for measures of student ability or of high school location or character, and the dependent variable is actual attendance rather than plans to attend. Its large size allows the estimation of separate models for different income/ability groups. It is national and thus has variation in that most critical variable, tuition. Even its age is an advantage. Only limited amounts of scholarship aid were available at public institutions in 1961, when our sample was graduating from high school, so the impossibility of satisfactorily modeling the scholarship awarding process does not create serious problems.

Tuition, high admissions standards, travel costs, and room and board costs are found to have significant negative effects on attendance. The effects of higher forgone earnings are significantly less negative than tuition, suggesting that capital market imperfections were an important impediment to college attendance in the early sixties. Cross-sectional measures of the expected payoff to college have a negligible relationship with attendance. The powerful impacts of public policy measures and draft pressure suggest that the rise in college attendance rates in the fifties and sixties was partly due to the liberalization of admissions policies, the establishment of new community colleges and public four-year colleges in cities and states that had had none before, and the Vietnam War. Low-income and low-ability students are found to have substantially higher elasticities of demand. Consequently, by the

Baumol-Bradford second best theorem, optimal pricing of higher education involves charging low-income and low-ability students lower prices.

Section I presents the theoretical underpinnings of the estimating equations, and section II describes their empirical implementation. Section III presents the results and develops some of their policy implications. Section IV uses the cross-sectional results to interpret recent trends in college enrollment and to question projections of substantial declines in enrollment rates. Using the Baumol-Bradford quasi-optimality condition, section V shows that both efficiency and equity call for financial aid based on need. Directions for future research are suggested in section VI.

I. College Attendance with Imperfect Capital Markets

An individual will enter college if the expected utility from any of the feasible college alternatives is greater than the utility of the best noncollege alternative. If unlimited borrowing were possible at a given interest rate and there were no debt aversion, lifetime utility maximization would imply college attendance when, discounted at this interest rate, the present value of benefits (both pecuniary and nonpecuniary) exceeds the pecuniary and nonpecuniary costs of attendance. Without government intervention, however, capital markets are bound to be imperfect. In 1961, when the students in the sample were considering college, little or no action had been taken to improve the working of the loan market. Only a few states had guaranteed loan programs, and the National Direct Student Loan program was new and generally awarded loans on the basis of financial need.

The imperfection of 1961 capital markets requires two modifications of the conventional human capital decision model. First, the inability to borrow forces a rearrangement of the timing of consumption, which in turn causes a rise in the implicit discount rate by which the individual trades off present for future benefits. This discount rate is no longer observable. The second modification is the addition of a cash flow or financing constraint (F_j). The sum of resources available--savings, summer and part-time earnings, gifts, and loans--must be greater than the total out-of-pocket costs of attending college--tuition, travel, and all living costs. Written in terms of annualized observable variables, the "desire" conditions and the financing conditions for college attendance by the j^{th} individual are respectively

$$(1)\quad B_j = B_j^m + u_j = -T_j - R_j - W^m\bar{X}^s + d^*\Delta Y^m + \alpha_1 Z_j + u_j > 0 \ ;$$

$$(2)\quad F_j = F_j^m + v_j = -T_j - R_j + GW^m\bar{X}^w + \alpha_2 Z_j + \lambda B_j + v_j \geq 0 \ .$$

Tuition (T_j) and travel, room, and board costs (R_j) enter both conditions negatively. Future benefits (ΔY^m) appear only in the desire condition and are discounted and made comparable to annualized costs by d^*.[1] The benefit, cost, and resources elements of B_j^m and F_j^m that are not directly measurable in dollar terms are captured by a vector of proxies (Z_j). Included in Z_j are family income, family socioeconomic status, number of siblings, an index of the recentness and frequency of school changes, an index of draft pressure, and the median real family income of the neighborhood surrounding the high school. B_j enters the finance constraint with an expected positive coefficient because the expected size of the net benefits influences the parents' willingness to contribute to the costs of college and the students' willingness to sacrifice current consumption in order to go to college. The only nonpecuniary benefits that enter the finance condition are those that can be expressed in cold cash--the parents' maximum willingness to pay for the psychic benefits they receive.

The local wage rate for high-school graduates (W^m) enters both the desire condition and the financing condition, though in contrasting fashions. In the desire or benefit calculation, it enters negatively and is multiplied by the time required by the student to study and attend classes ($\bar{X}^s$). In this benefit calculation, higher local wage rates discourage college attendance by raising the opportunity cost of the student's time. In the finance condition, the local wage rate enters positively and is multiplied by the amount of time a student has available for work ($\bar{X}^w$) adjusted for the savings possible from working during high school (G).[2] Here higher local wage rates facilitate attendance by improving the student's ability to self-finance the costs of college.

The errors in measuring B_j and F_j (u_j and v_j) are assumed to be uncorrelated with Z_j, T_j, E_j, and W_j but not necessarily uncorrelated with each other. They are assumed to be unimodally distributed according to the logistic frequency distribution. The conditional probability that the j^{th} individual will attend college, given B_j^m and F_j^m, is the probability that B_j and F_j are jointly greater than zero. We approximate this by a logistic function that is linear in B_j^m and F_j^m:

$$(3)\quad P_j = P(B_j, F_j > 0 \mid B_j^m, F_j^m) = \int_0^\infty \int_0^\infty f(B_j, F_j \mid B_j^m, F_j^m)\ \alpha B_j \alpha F_j \sim \frac{1}{1+e^{-[\theta+\beta B_j^m+\gamma F_j^m+\varepsilon]}} \quad ;$$

$$(4)\quad \log \frac{P_j}{1-P_j} = \theta + \beta B_j^m + \gamma F_j^m + \varepsilon \quad ;$$

$$(5)\quad \log \frac{P_j}{1-P_j} = \theta + (\beta\alpha_1+\lambda\gamma\alpha_1+\gamma d_2)Z-(\beta+\lambda\gamma+\gamma)(T_j+R_j)-W^m[(\beta+\lambda\gamma)\bar{X}^s-\gamma G\bar{X}^w]$$

$$+ (\beta+\lambda\gamma)d^*\Delta Y^m + \varepsilon \;;$$

$$(6)\quad \log \frac{P_j}{1-P_j} = \theta + \underline{\theta}_1 Z_j + \theta_2 T_j + \theta_3 R_j + \theta_4 \bar{X}^s w^m + \theta_5 \Delta Y^m + \varepsilon \;.$$

The θ's are the coefficients that we estimate.

II. Empirical Implementation

A youth attends college if, relative to the best noncollege alternative, there is at least one college that is simultaneously preferred ($B_{ij} > 0$) and possible to finance ($F_{ij} \geq 0$). Only one college meeting these requirements is necessary. It is not, therefore, the average tuition, selectivity, and proximity of the colleges in some jurisdiction that should enter our model, but rather the characteristics of the "most attractive" college. Determining which college is most attractive, however, is no easy matter. While for each individual it is possible to rank colleges unambiguously on any one criterion, both preferences and colleges are multifaceted and it is not clear what relative weight should be given each facet. Measures of many important facets--quality, climate, religious orientation--are not available.

Our solution to this problem was to first characterize the college availability environment in a multidimensional manner and then use the cost of attendance--tuition, travel, plus incremental room and board costs, if any--as the primary criterion for choosing which college's attributes are used. This approach resulted in the primary determinants of the cost of each individual's minimum-cost means of college attendance being his state's in-state tuition level, whether he lived in a political jurisdiction (county, town, or city) with access to a low-tuition junior college,[3] and the distance from his home to the nearest public institution (see Appendix for details).

Finding the minimum-cost college involved comparing modes of attendance--commuting versus living on campus--as well as colleges. The marginal cost of commuting was the sum of the out-of-pocket transportation costs (3-1/3¢ per one-way mile, or $9.60 per mile per year) plus time costs(which fluctuate with the local wage level around a mean of $7.20 per mile per year).[4] The cost of living on campus was defined as room and board charges plus $205 for travel and laundry minus an estimate of savings of costs at home (which fluctuated around a mean of $285 according to local variations in the price of food). Valued this way, commuting was always cheaper when a public college was within twenty miles. In states with high room and board charges the cutoff point often went as high as thirty-five miles. The premiums for out-of-state tuition and the rise of travel cost with greater distance meant that the minimum-cost college was typically a public college in the student's home state, and more often than not a local one. The tuition charged by this college was identical in almost all cases to the charges at other public colleges in that state.

Implications of the Planned Nature of College

Since college requires financial and academic preparation, most families make general college plans many years in advance of high school graduation. When asked about whether and when they were going to college, only 12 percent of ninth-grade boys in 1960 answered "I may go to college sometime in the future, but my plans are not definite" [Flanagan, The American High School Student, p. E-13].

Advance planning affected the empirical specification of our model of college attendance. The family's financial capacity should be measured by permanent income, not current income, and college availability variables should reflect the environment prior to as well as at the time of high school graduation. Public policies such as tuition level and admissions selectivity influence decisions made early in high school: whether an academic curriculum is chosen, how much time is devoted to study, and how much parents encourage college as a goal. These decisions, in turn, affect the student's grades in high school and performance on achievement tests and, thus, admissibility to various types of colleges. Regressions run on this data to predict grades, test scores, and the academic orientation of courses support these hypotheses. Consequently, part of the influence of low tuition on college attendance is mediated by (operates through) test scores and grades, and using these variables as controls would bias downward our estimate of the total effect of tuition. Our stratification on and control for ability is, therefore, based on an academic aptitude composite purged as much as possible of subtests that reflect a college preparatory curriculum.[5]

The endogeneity of a student's high-school credentials has further implications. The set of prices for college that a student faces upon graduation depends partly upon his performance in high school. Better credentials mean a student can get into more schools and is more likely to be awarded scholarships. Consequently, the price (the cost of the cheapest method of attending a college of given quality) is lowered. However, since performance in high school is influenced by expected college availability, making the set of relevant colleges a function of the student's credentials would result in tuition simultaneously being a cause and a consequence of college plans. We chose to finesse this problem.[6] Each student's set of feasible colleges was not made a function of his ability, and no attempt was made to measure scholarship availability. The effect of admissions standards on college entrance was picked up by our measure of the proportion of the state's high school graduates admissible at the minimum-cost college.

We were estimating, therefore, a reduced-form model that encompassed both the student's behavior--choice of curriculum, effort in high school, applications to and choice of colleges--and the college's admissions decision.[7]

III. Results and Their Policy Implications

The logit model specified by (6) was fitted separately to data for twenty groups of high-school juniors, each group defined by ability and family income. The dependent variable was college entrance the September or January following high-school graduation. The elements of the B_j and F_j conditions that could be measured in dollar terms were T_j, R_j, $\overline{X}^s w^m$, ΔY^m, and the additional cost of attendance at a four-year institution. The Z vector included the following: an academic aptitude test score, the Project Talent socioeconomic status scale, number of siblings, an index of frequency and recentness of school changes, median real family income of the neighborhood, draft pressure, the proportion of a state's high school graduating class admissible at the minimum-cost college (MCCA), and a dummy when the MCCA is a two-year extension campus with no vocational program. All variables measured in dollars were deflated by a local cost-of-living index.

This rather parsimonious logit model proved quite successful in explaining college entrance behavior. For within-strata models, R^2 ranged between .38 and .067 and entropy reductions ranged between .211 and .034.[8] For predicting a zero-one variable in populations stratified on the two most important variables, this range is quite good. The entropy of the distribution before stratification was .6687. The average conditional entropy of our models is .4737. Thus the combined effect of stratification and the separate logit models is to reduce the uncertainty of a particular individual's choice by almost a third. The four background control variables were almost always highly significant. Policy variables generally had the sign predicted a priori and were statistically significant in about half the strata.

Table 1 presents a simple means of translating logit coefficients into more familiar elasticities and impacts on probability. The elasticity is given by $\theta_i \overline{X}_i (1-\hat{P})$. The left-hand side of Table 1 tabulates the expectation of 1-P, the probability of not entering college, for each income/ability group. Note that, for a given logit coefficient, elasticities are larger when the group is less likely to attend. The change in probability per unit of change of X_i, $\frac{\partial P}{\partial X}$, is given by $\theta_i \hat{P}_j (1-\hat{P}_j)$. The expectation of $\hat{P}_j (1-\hat{P}_j)$ in each income/ability group is tabulated on the right-hand side of Table 1. Note that the probability multiplier is largest for groups with approximately one-half attending college.

Higher Education Policies

Tuition at the minimum-cost college had a major effect on college entrance, as indicated by the logit coefficients and elasticities presented

Table 1

Multipliers for Interpreting Logit Coefficients

Family Income[c]	Probability of Not Entering College by Income and Ability[a]					Multiplier for Determining the Effect on Probability of a Unit Change of an Independent Variable[b]			
	Ability Percentile				All Abilities	Ability Quartile			
	100–73	72–49	48–27	26–0		Top	Upper Mid	Lower Mid	Bottom
High	.158	.394	.595	.626	.376	.113	.199	.212	.147
High middle	.248	.563	.643	.708	.502	.145	.202	.179	.151
Middle	.258	.577	.782	.806	.587	.175	.218	.147	.120
Low mid	.336	.681	.832	.865	.701	.176	.193	.126	.109
Poverty	.439	.751	.882	.907	.809	.202	.162	.093	.073
All incomes	.251	.582	.761	.809	.601				

[a]The multiplier for determining elasticity. The elasticity of college attendance with respect to any right-hand-side variable is obtained by multiplying its mean by the product of its logit coefficient and the probability of not entering college.

[b]The impact of a unit change in an independent variable on the proportion of the sample attending college is the product of the multiplier listed above and its logit coefficient. The multiplier is $\Sigma \hat{P}_j(1-\hat{P}_j)wt_j/\Sigma wt_j$, the weighted average of $\hat{P}_j(1-\hat{P}_j)$ of each sample observation, where $\hat{P}_j$ is the model's predicted probability of attendance for the j^{th} individual.

[c]The income groups are not of equal size. They correspond to the bottom 11 percent, the twelfth through the thirty-sixth percentiles, the middle 30 percent, the sixty-sixth through the eighty-first percentiles, and the top 18 percent of the distribution of permanent income of the families of high-school juniors.

in Table 2. For the middle-income, upper-middle-ability group, for instance, the log odds of college entrance fall .211 for every $100 rise in tuition. With the probability multiplier tabulated for this group in Table 1 (.218), this translates into a reduction in probability of .046. The effect on aggregate attendance of a simultaneous change in the tuition faced by all potential students is a weighted average of the individual stratum's probability effects. The .0286 per $100 effect obtained is similar in magnitude to the .0243 obtained by Hopkins [1974] for 1963 enrollment rates.

In sixteen of the twenty strata tuition showed the predicted negative effect on college attendance (Table 2). In fourteen of the strata this negative effect was statistically significant at the .05 level by a one-tail test. There appears to be an important nonlinear interaction between student ability and responsiveness in tuition, for the extremes of the ability distribution were the least responsive to the level of tuition. Three of the four positive tuition coefficients occurred in the bottom ability quartile. No doubt many of these students believed themselves to be irreconcilably ineligible for admission to the minimum-cost college. For them the cost at this college was irrelevant. This explanation is supported by the very powerful effect that admissions policy had on the college attendance of students in the three low-ability strata with positive tuition coefficients.

The impact of tuition on college attendance also varied with family income. Whether measured by the logit coefficient or the tuition elasticity, students from the high-income stratum were least responsive, and students from the low-income strata were the most responsive. At the mean tuition of $200, the tuition elasticity of the high-income group

Table 2

Total Effect of $100 Increase in Tuition on the Log Odds of Entrance (Elasticity of College Entrance at Tuition of $200)

Income	Ability Quartile: Top	Upper Mid	Lower Mid	Bottom	All Abilities: Coef.	Prob.	Elast.
High	.019 (.006)	-.298†*(-.234)	-.195* (-.233)	.009† (.011)	-.104	-.0219	-.084
High middle	-.329*†(-.163)	-.145* (-.163)	-.563†*(-.724)	-.159* (-.224)	-.287	-.0479	-.192
Middle	-.048* (-.025)	-.211†*(-.243)	-.418†*(-.654)	.072 (.117)	-.172	-.0241	-.117
Low middle	-.204†*(-.137)	-.140†*(-.191)	-.330†*(-.550)	.033 (.057)	-.148	-.0232	-.155
Poverty	-.087† (-.076)	-.096 (-.144)	-.529†*(-.933)	-.651†*(-1.18)	-.434	-.0375	-.393
All incomes							
Coef.	-.115	-.187	-.391	-.099	-.198		
Prob.	-.0188	-.0379	-.0563	-.0069	-.0286		
Elast.	-.050	-.181	-.471	-.072	-.143		

Note: The total effect of tuition changes is given by the sum of the coefficient on tuition and the coefficient on total out-of-pocket cost of the minimum-cost means of attending college. It is an estimate of $(\beta+\lambda\gamma+\gamma)$. Elasticity = coefficient · 2 · (1-probability of entrance).

*Tuition significantly negative at the .05 level by a one tail test

†Tuition significantly more negative than travel, room, and board at the .05 level.

is -.084; for the poverty group it is -.393. Tuition elasticity was powerfully and nonlinearly related to ability: The high ability quartile's tuition elasticity was -.05, the lower-middle-ability quartile's elasticity was -.47, and the lowest ability quartile's elasticity was -.07.

Despite the difficulty of accurately measuring the costs of travel, room, and board, nine statistically significant negative coefficients are obtained (Table 3). Averaged over all the strata, a $100 increase in these other costs lowered the attendance rate by .0089. The per-dollar effect of travel, room, and board averaged about 30 percent of tuition's impact. This was expected, because tuition was measured more accurately than other costs and may have a uniquely powerful psychological impact. The hypothesis that the per-dollar effect of travel, room, and board was less negative than tuition's per-dollar effect was accepted for twelve strata. In Table 4 the travel, room, and board coefficients are used to produce estimates of the effect of specific public policy decisions. If locating the minimum-cost college in the center of a city rather than in the outskirts lowers the average travel distance by four miles, cost is reduced by $67 and the average attendance rate is predicted to increase by .006. Establishing a new public four-year college in a city without one lowers costs to a much greater degree ($471 in 1961 prices), and consequently causes a predicted rise in the attendance rate of .042. Policies that affect travel, room, and board costs seem to have their largest effect on middle-income students.

In 1961 a four-year college was the cheapest type of college for about 40 percent of the students in the nation. The cost of the four-year college has an effect, however, even when it is not cheapest (line 5, Table 4). For every $200 by which the cost of the cheapest four-year

Table 3

Impact of an Extra $100 of Travel, Room, and Board Cost on the Log Odds of College Entrance (t ratio)

	Ability Quartile									
									All Abilities	
Income	Top		Upper Middle		Lower Middle		Bottom		Coefficient	Probability
High	.006	(.15)	-.025	(.63)	-.186	(3.43)	.192	(2.99)	-.008	-.0040
High middle	-.105	(2.71)	-.103	(2.58)	.240	(4.45)	-.269	(2.73)	-.069	-.0105
Middle	-.126	(5.27)	-.095	(3.43)	-.007	(.18)	.027	(.64)	-.054	-.0106
Low middle	-.106	(3.48)	-.031	(.96)	-.196	(4.05)	-.009	(.18)	-.081	-.0118
Poverty	.140	(2.09)	.066	(.84)	-.147	(1.50)	-.197	(2.06)	-.087	-.0036
Total										
Coefficient	-.072		-.053		-.074		-.036		-.059	
Probability	-.0119		-.0114		-.0096		-.0029		-.0089	

Table 4: Change in the Percent of a Community's High School Juniors Entering College That Result from Selected Changes in Public Policy or Environment

		Ability Quartiles				Family Income				
Percent Entering College	Total 40	High 75	HM 42	LM 24	Bot 19	High 62	HM 50	Mid 41	LM 30	Pov 19
Higher Education Policies										
1) College in center rather than outskirts of town with 6 mile radius[b]	.6	.8	.8	.8	.2	.3	.7	.7	.8	.2
2) 4 year public college established in town with none before[a]	4.2	5.6	5.4	4.5	1.4	1.9	4.9	5.0	5.6	1.7
3) Transforming an extension campus into a community college[a]	5.1	2.2	7.1	.1	13.3	6.9	10.0	2.7	6.4	11.3
4) Tuition at all public colleges raised $200	-5.7	-3.8	-7.6	-11.2	-1.4	-4.2	-9.6	-4.8	-4.6	-7.5
5) Tuition at 4 year public colleges raised $200 while 2 year tuition remains constant[c]	-1.2	-2.4	-1.5	-.5	-.2	+.8	-1.5	-1.1	-2.7	-1.0
6) Open admissions replaces a 50 percent cut off	3.8	0	3.7	5.0	6.7	5.0	7.2	2.6	4.6	-1.3
7) 2 year community college established in town with none before[a]	1.4	0	1.7	3.2	1.0	3.8	1.4	2.4	-.7	-.6
8) 2 year community college with open admissions in town with none before[d]	3.3	0	3.6	5.7	4.4	6.3	5.0	3.7	1.6	-1.3
9) California versus Indiana[e]	14.8	5.2	18.2	16.2	21.3	15.7	26.3	9.7	14.7	16.7
10) California versus Newark, New Jersey[f]	14.8	6.8	18.7	27.2	9.5	13.0	25.9	11.8	12.9	12.9
Cultural and Economic Environment										
11) Move to a neighborhood with $1000 higher mean family income[g]	1.6	.3	2.2	1.0	2.8	1.2	3.7	2.3	-.6	1.7
12) Have a family with $1000 higher income[h]	2.7	2.5	2.5	3.2	2.7	-	-	-	-	-
13) In family with a standard deviation higher SES	8.0	10.1	10.4	1.8	8.8	7.2	16.2	6.5	6.4	5.6
14) Forgone earnings higher by $200 (15¢ an hour)[g]	-1.1	-.3	-2.5	.8	-2.3	-2.6	-1.6	-1.4	.2	-.5
15) Future earnings difference higher by $200 a year[g]	.4	-.2	1.0	1.8	-.6	-.3	-.3	.6	.8	1.0
16) Draft pressure increased by one standard deviation[i]	1.5	1.7	.8	-.2	3.6	3.2	.7	2.7	1.0	-1.8
17) Upper bound on finance constraint's share of tuition effect[j] $\gamma/(\beta+\gamma\lambda+\dot{\gamma})$	.33	.33	.27	.43	0	.073	.33	.31	.38	.36
18) Lower bound discount rate r_{jt} if $\phi = .25$[k]	.32	∞	.21	.16	∞	∞	∞	.24	.16	.20

Notes to Table 4

[a]A community college is a locally controlled two-year institution and had vocational as well as transfer programs. Colleges established in the community were assumed to have the same tuition and admissions policy as other four-year institutions in the state unless specifically stated otherwise. A newly established local college was assumed to be on average four and one-half miles from its clientele and to be an alternative to a college with room and board charges of $600. The net savings was $471.

[b]Average distance to college (using doubling for first three miles) went from 9.67 to 5.67, so R was reduced by $67. This assumed a constant density in the center (radius three miles) that was three times the ring's density and a uniform distribution of income and ability groups within the city.

[c]Assumes the two-year college was the cheapest college both before and after the tuition change at the four-year college. Higher tuition in the last two years of a four-year college would also cause the tabulated enrollment effects.

[d]Assumes nonlocal state institutions had a 75 percent admissions cutoff.

[e]In 1960 the typical city in Indiana had an extension campus with a 50 percent admissions cutoff and tuition of $199. This is compared to a California town with a free open-door community college but no four-year institution.

[f]Both were assumed to have had a local public four-year college, but in Newark tuition was set at $400 and the proportion of high-school graduates accepted was .45.

[g]Median real family income had a mean and standard deviation of $6100 and $1460. The mean and σ of forgone earnings were $1448 ($1.11 per hour) and $268 (21¢ per hour). The mean and standard deviation of the local labor market college high-school graduate earnings differential were $2950 and $750.

[h]This estimate holds constant student ability but not characteristics of family such as SES, number of siblings, or number and recentness of school changes.

[i]Draft pressure was the ratio of physicals passed to the stock of nonfathers under age 26 who were or would have been classified I-A, I-AO, I-S, or II-S. Its mean was 4.95 times the standard deviation.

[j]We assume that the amount of money that could be earned and saved for college was 1.5 times the cost of earnings time forgone to attend college ($G\overline{X}^w/\overline{X}^s = 1.5$). The estimate of $\gamma/(\beta+\lambda\gamma+\gamma)$ is obtained by solving $\theta_2 = \beta+\lambda\gamma+\gamma$

Notes to Table 4 (continued)

j (continued)

and $\theta_4 = \beta+\lambda\gamma - 1.5\gamma$ simultaneously. If the full-time attendance assumption were relaxed, 1.5 would become 2.0 or 3.0 and our estimate of $\gamma/(\beta+\lambda\gamma+\gamma)$ would be lowered.

[k]Using the estimate of β implicit in footnote j, we found the discount rate that makes $d^* = \theta_5/(\beta+\lambda\gamma+\gamma)$ where d^* was calculated assuming $d = .25$ and a forty year working life. When the coefficient on the earnings differential had the wrong sign ($\theta_5 < 0$), r_{jt} was assumed to be ∞. For the definition of d^* see footnote 1.

college exceeds the cost of the cheapest two-year college, college entrance rates fell by .024 in the highest ability quartile and by .012 overall.[9] Apparently, the establishment of a two-year college in a city that has no college does not increase the local college attendance rate as much as does the establishment of a four-year college with the same tuition level (compare line 2 to line 7 or 8). The Carnegie Commission has recommended that the tuition charged for junior and senior year be higher than the tuition charged for the first two years. Our results suggest that if such a policy were broadly implemented, freshman entrance rates would drop by .006 per $100 of such a tuition differential.

Except for students from poverty backgrounds, admissions requirements also had substantial effects on attendance (line 6). If a state were to go from accepting half to accepting all of its high school graduates, the proportion going on to attend college would rise by .038. As one might expect, the less able are quire sensitive to admissions policy; the proportion entering from the bottom ability quartile would rise by .067. The breadth of curriculum at the cheapest college also had an important impact on college entrance (see line 3). When the cheapest college was a two-year extension campus without vocational programs, the proportion entering college was reduced by .057.

There is a substantial degree of variation across the country in the extent to which state policies promote college attendance. Lines 9 and 10 of Table 4 present our predictions of the enrollment response in 1961 if typical cities in Indiana and New Jersey had adopted California's package of higher education policies. Enrollment rates for some groups would have risen by more than 25 percentage points, and the overall attendance rates would have risen by 15 percentage points.

Cultural and Economic Climate

The social status of the neighborhood in which the high school is located seems to have an important effect on college attendance. By a two-tail test, nine of the coefficients were significantly positive and three were significantly negative at the .05 level. Positive effects were strongest in the lowest-ability group. An improvement of one standard deviation in neighborhood status raised the overall proportion entering college by .023 (see line 11). This result is similar to the effects estimated by Sewell and Armer [1966] and other sociologists.

The sign and size of the coefficient on the wage rate of recent high school graduates provide a measure of how great an impediment to college attendance capital market imperfections were in 1961. The coefficient on the opportunity cost of study time, θ_4, provides an estimate of $(\gamma G X^W / X^S) - (\beta + \lambda\gamma)$. If unlimited borrowing is possible at a given interest rate and students have no pure debt aversion, $\gamma = 0$ and the coefficient on the opportunity cost of time, θ_4, should be at least as negative as the coefficient on tuition ($\theta_4 \leq \theta_2$). We could test this hypothesis only in the sixteen strata with negative tuition effects. In twelve of the sixteen the perfect capital market hypothesis was rejected.

The hypothesis that variations in the difficulty of financing college attendance were in 1961 the primary cause of geographic variations in college attendance rates will be called the finance dominant hypothesis. More formally, this hypothesis states that the desire condition does not in fact enter equation 3 (that is, that $\beta = 0$) and that the size of the net benefit calculation, β_j, does not change one's willingness to finance college attendance ($\lambda = 0$). This proposition would imply that $\theta_4 \geq |\theta_2| G\bar{X}^W/\bar{X}^S$. $G\bar{X}^W/\bar{X}^S$ is the ratio of the sum of student savings for college prior to and during college to the opportunity cost of four years of college attendance. If continuous full-time study is under consideration, $\bar{X}^w/\bar{X}^s$ will be less than but close to 1, and $G\bar{X}^w/\bar{X}^s$ will be about 1.5.[10] If itinerant or part-time study is contemplated, $G\bar{X}^w/\bar{X}^s$ will be larger. Consequently, a conservative formal test of the finance dominant hypothesis is $\theta_4 \geq |\theta_2|$. Only five of the twenty strata had positive opportunity cost coefficients, however, and the average effect on attendance was negative. A formal test of the pure finance constraint hypothesis in the sixteen strata with negative tuition effects results in its rejection in thirteen.

Both polar cases are decisively rejected, suggesting that in 1961 financing difficulties were an important, though not a dominating, impediment to college attendance. The availability of unsubsidized loans shifts out the finance constraint, so an estimate of γ can be interpreted as a prediction of the impact of such loans. If we assume that the coefficient on tuition, θ_2, is the best estimate of $(\beta+\lambda\gamma+\gamma)$ and that $G\bar{X}^w/\bar{X}^s = 1.5$, the financing constraint's share of the total effect of tuition, γ/θ_2, is calculated to average .33 (line 17). The finance constraint affected high-income students hardly at all; for them, $\gamma/\theta_2 = .076$. These estimates of γ/θ_2 must be interpreted as upper bounds, for the option of part-time study raises the ratio of feasible self-finance to opportunity cost above 1.5, reducing the estimate of $\gamma/(\theta_2)$. One might interpret this ratio as suggesting that the availability of a \$330 grant has approximately the same impact on enrollment as the availability of a \$1000 loan. This is, however, an upper bound on the grant equivalence of loans, because either allowing for part-time study or classical measurement error on W^m or using a weighted average of R and T coefficients as the estimate of $(\beta+\gamma\lambda+\gamma)$ lowers the estimate of $\gamma/(\beta+\gamma\lambda+\gamma)$.[11]

The local college/high-school earnings differential is a rather imperfect representation of the variable--the expected earnings payoff--suggested by theory. One might expect geographic variations in the expected earnings differential because an important source of information about this differential--direct observation of the wealthier life style associated with being a college student--is local. Even if there were perfect knowledge, students preferring not to migrate would include the local differential in their calculation. The measure available for this study is the difference between median operative earnings and an average of medians for accountants, male secondary school teachers, and electrical and mechanical engineers in the SMSA of residence or in the non-SMSA portion of the state. Its impact on college attendance did not consistently follow a priori expectations (line 15). By a two-tail test, the coefficients were significantly negative in three strata and significantly positive in seven.[12] The groups with negative coefficients were the bottom ability quartile and the strata that combine high ability and high income. Because members of the bottom ability quartile are often excluded by admissions policies, costs and returns seemed to have only a small effect on them. The most important determinants of their attendance were admissions policy, neighborhood status, and draft pressure. The absence of a positive effect for those who combined high ability and high income may reflect their greater tendency to migrate or to judge returns on the basis of national, as opposed to local, evidence.

Between 1968 and 1974 the income differential between college and high-school graduates has fallen by a third. In our data a reduction of one-third in the local earnings differential ($1000 in 1960 prices) produces an overall drop in the college entrance rate of only .021. These very small impacts suggest that future returns are heavily discounted. Line 18 of Table 4 presents the high discount rates extracted by solving the estimated equations for the underlying theoretical parameters of γ and r_j when $\phi = .25$.[13] Discount rates of this magnitude have been obtained in the consumption function literature and by Heckman [1975] in a Ben Porath model of schooling. They suggest that, unless recent declines in the economic payoff to college cause shifts in public policy, they will cause only small decline in college attendance.

In the early sixties the selective service system contended that "many young men would not have pursued higher education had there not been a Selective Service program of student deferment" [Hershey, 1961, p. 25]. The effectiveness of "channeling," as this policy objective was called, is supported by our results. The index of draft pressure used to test channeling's impact was each state's ratio of induction and preinduction physicals passed in fiscal years 1960 and 1961 to the stock of nonfathers under age 26 who were or would have been classified I-A, I-AO, IS, or II-S. Significant positive coefficients are obtained in nine of twenty strata. A rise of one standard deviation in draft pressure is predicted to increase attendance rates of high-income students by .032 and of all students by .015.

IV. Interpreting the Past

Of what significance are our results for the interpretation of past enrollment trends and for the projection of future trends? Elements of our model have appeared in specific time series studies: tuition in

Campbell and Siegel, draft pressure in Galper and Dunn, relative wages in Freeman. None has entered all three simultaneously. The recent papers by Richard Freeman and Stephen Dresch have interpreted the rise of male college enrollment rates in the fifties and sixties and their subsequent decline in the seventies as responses to changes in the relative earnings of college graduates. In Freeman's paper, measures of public policy were not entered and a dummy for the end of the draft was insignificant. While the evidence is in no sense conclusive, our study points in another direction. In this cross-sectional analysis, differences in the local payoff to college had a negligible effect on attendance. The large impacts estimated for admissions policy and the establishment of new institutions suggest that a major part of the upward trend in enrollment rates during the fifties and sixties can be attributed to the establishment of two- and four-year public colleges in states and metropolitan areas where they had not previously existed, the expansion of student aid programs, and the liberalization of admissions policies resulting from the creation of community colleges. By 1970 the impact of these policies shifts may have largely run their course. The powerful impact of draft pressure estimated in the cross section suggests that the Vietnam War and subsequent ending of the draft caused a temporary rise in college enrollment rates between 1965 and 1969.[14]

Unlike the market-driven models of Freeman and Dresch, this scenario also provides an explanation of the difference between the behavior of young men, and that men over age 25 and of women. While the proportion of males aged 18-24 (civilian and military) attending college has remained static since 1965, enrollment rates of young women have continued to rise and enrollment rates of men and women aged 25 and over have risen dramatically. The continuing increases in adult male enrollment rates are interpreted here as responses to the GI Bill and to the spread of community colleges (see Bishop and Van Dyk, 1975). Enrollment rates of women continued to rise after 1971 because the Vietnam War had not caused them to be artificially high in the first place and because of a shift in preferences away from babies and toward market work (possibly caused by the women's movement).

If the market-driven models of Freeman and Dresch are correct, the college graduate labor market is brought into equilibrium largely by the supply response of students. If the more complete model proposed here is correct, student responses to market forces are small relative to their response to public policy. Under these circumstances we cannot expect a large supply response to the current depressed state of the college graduate labor market unless the end of the shortage of college graduates induces a shift in public policy. The recent spectacular growth of the Basic Opportunity Grants program (1.1 billion dollars in 1975/76) suggests that public policy toward undergraduate education will remain expensive. Consequently, relative wage-induced substitution of college graduate workers for others must carry most of the burden of equilibrating supply and demand of college graduates. For colleges this is good news because it means that enrollments will not decline as much as predicted by the models of Freeman and Dresch. For college graduates it is bad news, however, for it means that supply and demand will come into equilibrium at a lower relative wage. Determining the relative importance of these alternative explanations of recent history requires the construction of indices of changes in public policy over time and analysis over longer periods.

V. Optimal Pricing of Undergraduate Education

Baumol and Bradford [1970] show that when lump-sum taxation is not feasible, the prices (P_i) charged for a publicly provided commodity or service should in general exceed marginal cost by an amount proportionate to the difference between marginal revenue (MR_i) and marginal cost (MC_i). Analyzing the case in which marginal externalities were zero, they obtain the following optimality condition:

$$(9) \quad P_i - MC_i = \frac{\mu}{\lambda}(MR_i - MC_i) \qquad (i=1 \ldots n) ,$$

where

μ/λ = the ratio of the shadow price of the required government revenue constraint (which is negative) to the value of leisure (the numeraire);

MR_i = the marginal revenue, including the effect on revenue of variation in all prices. If the demand functions for the i^{th} good are independent of the prices of other goods, MR_i has the conventional partial equilibrium interpretation.

A good or service can be defined by its technical characteristics, by who sells it, or, when resale is not feasible (as with higher education), by who buys it. Consequently, Baumol and Bradford's quasi-optimality condition can be interpreted as a pricing rule for higher education. If income taxes are part of the tax structure, both the price and the revenue terms must include the marginal income tax revenues generated. It is often argued that higher education creates positive marginal externalities (E_j), so these must enter the optimality condition as well. The result is

$$(10) \quad T_j + t + E_j - MC_j = \mu/\lambda\ (MR_j + t - MC_j) ,$$

where t is the present value of future taxes generated by one year of college, T_j is tuition, and j defines the individual that receives the higher education.[15] To simplify the presentation, t is assumed to be constant. If the government budget constraint is not binding ($\mu = 0$), price should be set equal to MC minus the sum of taxes generated and the marginal externality. If the budget constraint is the only one binding ($\lambda = 0$), the government behaves like a profit-maximizing monopolist--prices are set so that $MR_j + t = MC$. The negative of μ/λ may be interpreted as the benefit premium required if a particular activity is to be accomplished through a government expenditure program. In equilibrium it should equal the marginal excess burden of taxation.

The estimated demand curve and its corresponding marginal revenue curve complete the system of equations needed to solve for the three unknowns, T_j, MR_j, and the proportion attending college (q_j):

$$(11) \quad \ln\left\{q_j/1-q_j\right\} = \ln\left\{\bar{q}_j/(1-\bar{q}_j)\right\} + \tilde{\theta}_{2j}(T_j - 200) \quad ;$$

$$(12) \quad MR_j = T_j + 1/\tilde{\theta}_{2j}(1-q_j) \quad ;$$

where

$\bar{q}_j$ = the proportion of the j^{th} income/ability stratum that attends when tuition equals \$200;

$\tilde{\theta}_{2j}$ = the logit coefficient on tuition of the j^{th} stratum after normalization by a main effects model.[16]

The conventional partial equilibrium interpretation of MR applies because we assume that the j^{th} group's demand for higher education is independent of the prices charged and the numbers attending from other groups. Optimal price differentials depend upon the elasticity of the group's demand curve ($\eta = \theta_{2j}T(1-q_j)$ and the size of the group-specific externality (E_j). The optimal price for the j^{th} group is a positive function of $\bar{q}_j$ and a negative function of θ_{2j} and E_j.

In this policy model, E_j varies by parental income level only. Its rise as family income falls reflects society's desire to achieve equality of opportunity. The definition of equality of opportunity adopted here is that on average people of equal ability should have an equal probability of entering college (the unweighted average q_j's of all income groups are equal.) Higher ability is allowed to cause an increase in a group's attendance rate. The downward shift of the demand curve that occurs as family income falls (holding ability constant) is considered a barrier to equality of opportunity that must be eliminated by extra governmental subsidy of these groups. A computer program was written that for given E_j, μ/λ, and t, iteratively solves the set of three nonlinear simultaneous equations, then checks whether the goal of equality of opportunity is achieved and tries new E_j until the goal is achieved. If taxation is burdenless ($\mu/\lambda = 0$), optimal tuition levels do not vary by ability. Tuition for the highest-income group was \$200 in 1960. Equal opportunity would have required prices of -\$445 for the poverty group, -\$297 for the lower-middle-income group, -\$132 for the middle-income group and \$60 for the upper-middle-income group.[17] Table 5 presents, for two nonzero values of μ/λ, the set of prices that would have been optimal in 1960 and the enrollment rates that would have resulted.[18]

A higher shadow price on government revenue ($-\mu/\lambda$) makes the optimal set of prices for undergraduate education higher. A rise in the marginal excess burden of taxation also increases the optimal degree of price differentiation by student ability and family income. Since high-school juniors of high ability have very inelastic demands for college, the price that should be charged them averages \$918 above the price recommended

Table 5

Optimal Tuitions in 1960 and Resulting Enrollment Rates When Equality of Opportunity is a Goal and Government Budget is Constrained

Government Budget Moderately Constrained (μ=-.2)

Income	Ability: Top	Upper Middle	Lower Middle	Bottom	All Abilities
High	$2154	$630	$282	$786	$1167
E_i=0	.74	.52	.35	.32	.54
High middle	$312	$168	$114	$158	$203
E_i=$180	.70	.46	.46	.31	.51
Middle	$524	-$14	-$192	-$14	$105
E_i=$592	.70	.48	.52	.22	.49
Low middle	$163	-$253	-$377	-$259	-$197
E_i=$837	.67	.45	.60	.19	.45
Poverty	-$40	-$152	-$194	-$180	-$160
E_i=$552	.70	.49	.52	.22	.41
All incomes	$790	$70	-$128	$2	$206
	.70	.48	.51	.23	.48

Government Budget Tightly Constrained (μ=-1.0)

Income	Top	Upper Middle	Lower Middle	Bottom	All Abilities
High	$4058	$1232	$416	$1766	$2239
E_i=0	.60	.40	.26	.24	.42
High middle	$588	$340	$206	$338	$395
E_i=$300	.57	.35	.35	.23	.40
Middle	$1398	$396	-$48	$490	$617
E_i=$972	.56	.37	.40	.16	.38
Low middle	$911	$119	-$221	$185	$224
E_i=$1377	.53	.34	.47	.14	.35
Poverty	$195	$7	-$99	-$31	-$12
E=$905	.56	.37	.40	.16	.32
All incomes	$1752	$437	$5	$442	$705
	.57	.36	.39	.17	.38

for the lower-middle ability quartile even when the premium on government revenue is small ($\mu/\lambda = -.2$). Our society's higher education policies have tended to do the opposite. Holding family income constant, the ablest are subsidized the most. This has been criticized on equity grounds by Denison [1972] and others. Our results suggest that unless smarter students produce substantially greater externalities or the incentive effects of rewarding academic performance are large, subsidizing the smart is inefficient.

Awarding larger grants to those who are less intelligent is not feasible, however, for once students discovered this was the policy they could purposely do poorly on exams. The current policy of grant aid based on family income, normally justified on equity grounds, is also desirable on efficiency grounds when taxation is not burdenless.

VI. Directions for Future Research

A simple modification of the human capital model has been quite successful in explaining college attendance. Public policy has been found to have a powerful impact on attendance, and important interactions between ability and income have been uncovered. The success of this approach in predicting college entrance of males in 1961 suggests that a similar analyses of females, of college retention, and of more recent data would be profitable. The growth of student loan programs may have reduced the importance of the financing constraint. If so, the effect of the opportunity cost of student time should become more negative and the effect of tuition should become less negative in studies of more recent data. Another direction for future research is to construct time series measures of the availability of student aid and of the proportion of students living within commuting distance of a public four-year college or a public two-year college. Entering these variables simultaneously with rate-of-return measures in a time series model of college attendance would allow the determination of their relative importance and hence a better prediction of future enrollment rates.

Appendix

I. Data

The data base for this study is 27,046 males who were high school juniors in 1960 and for whom information was obtained in one of the two Project Talent follow-up efforts. Over 95 percent of our sample are in the Project Talent 5 percent stratified random sample of the nation's high schools, so the juniors originally contacted in 1960 are broadly representative of the total population of juniors [Flanagan et al., 1964]. The proportion of these juniors who responded to one of the questionnaires mailed in 1962 and 1966 was only 53 percent, however. More intensive follow-up procedures were used for a 5 percent sample of the mail questionnaire nonrespondents, and data was obtained for 90 percent of this sample of nonrespondents.

A comparison of the two samples reveals that responding to a mailed questionnaire is positively related to college attendance. Controlling for family background, the college attendance rate of the nonrespondent sample was two-thirds that of the respondents. Probability of responding to the mailed questionnaires is not solely a function of college attendance, however. Consequently, an unweighted logit model will yield biased estimates of many of the crucial parameters. The solution to this statistical problem is to treat the nonrespondent sample as a one-in-twenty random sample of those who did not respond to the mailed questionnaires and thus to give each member of nonrespondent sample a weight of twenty. The computer program used was a modified version of "Maximum Likelihood Estimators for the Logistic Model with Dichotomous Dependent Variables" written by T. Paul Schultz and Kenneth Maurer.

II. Selection of the College that Represents the College Availability Environment

Each student's cheapest college was selected from the set of colleges that met the following conditions:

1. The college had to provide a broad range of programs. Therefore, Bible schools, seminaries, and business, engineering, and teachers' colleges were excluded.

2. The college could not be so selective that it accepted less than 20 percent of its state's high-school graduating class.

3. A denominational college had to be of the same religion--Catholic, Jewish, or Protestant--as the student. This is justified by the fact that in 1967 only 2.9 percent of the freshmen at Catholic colleges were Protestant and only 7.7 percent of the freshmen at Protestant colleges were Catholic.

4. In the South a college generally had to be of the same race as the student. The only exception to this was that if the number of black students at a predominantly white college was either greater than fifteen or a higher proportion of the student body than .10 times the black proportion of the state's population that college was considered biracial. By this very liberal criterion no white colleges were biracial in Alabama, Georgia, Mississippi, and South Carolina. There were one each in Arkansas and Florida, seven or eight in Louisiana and North Carolina, ten out of thirty-eight in Tennessee, and thirty-nine out of ninety in Texas.

Since it is generally the cheapest to attend, the nearest public college typically represents the college availability environment. Use of the minimum-cost criterion is justified by the fact that the college that is least costly to attend is the one least likely to be rejected by the cash flow constraint. The cheapest college will also rank high on the utility-maximizing criterion, B_{ij}. Lower expected pecuniary and nonpecuniary benefits may in specific instances outweigh advantages of low cost, but for students near the margin on the decision to attend or not to attend this will happen only infrequently. If one of these students is admissible at the low-cost public colleges of a state, a lowering of those colleges' expenditures per student or a rise in tuition at higher-cost private colleges is not likely to dissuade the student altogether from attending college. Hopkins [1974] found that a state's college attendance rates were not related to per-student expenditures in the public and private colleges of that state.

Except for a variable describing the extra costs of a four-year college, only the cheapest college's characteristics enter the model. If the data set and computing resources had been large enough, the characteristics of other colleges would have been added to the model. It is unlikely that the explanatory power of the model would have improved, however. In linear probability models where it was possible to try out larger numbers of variables, entering separately the characteristics of the cheapest two-year and four-year public and four-year private colleges did not raise the $\bar{R}^2$ above that obtained from a model that was limited to the characteristics of the minimum-cost college no matter what its type. If our parsimonious specification is incomplete and the characteristics of the second- and third-cheapest college do enter the true model, the coefficients obtained on the cheapest college's characteristics will overestimate that college's unique effect but underestimate the total effect of simultaneous changes by all colleges.

Notes

[1] $d^* = \sum_{4}^{\infty} \phi_t \ell_t (1+r_j)^{-t} / \sum_{o}^{3} (1+r_j)^{-t}$, where t is time (with freshman year of college as time zero), r_j is the implicit discount rate by which the individual trades off present and future consumption, ℓ_t is the probability of being employed in year t, and ϕ_t is the regression coefficient on the local college-high school earnings differential, ΔY^m, predicting the unobservable expected earnings differential in year t. ϕ_t is less than one because the expected differential is an average of the local differential and a constant, the national differential.

[2] G is defined as $\sum_{t=-5}^{3} g_t h_t (1+r)^{-t} / \sum_{o}^{3} (1+r)^{-t}$, r is the rate of interest on savings accounts, g_t is the proportion of a youth's earnings set aside for college expenses ($g_t = 1$ for t = 0, 1, 2, 3) and h_t is the ratio of the youth's earnings capacity in that year to $W^m \bar{X}^w$ ($h_t = 1$ for t = 0, 1, 2, 3).

[3] In 1961 many publicly supported institutions charged lower fees to students who applied from within the district that provided financial support. Schools of this type in 1961 were the municipal universities of Kansas, Kentucky, Ohio, Nebraska, and New York and public junior colleges in Arizona, Colorado, Florida, Idaho, Illinois, Iowa, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, Oregon, Texas, and Wyoming. In some states the in-out district price differential was small--$40 or so in Iowa--but in others, Illinois and Maryland for instance, it was between $200 and $300.

[4]It was assumed that the opportunity cost of travel time was 60 percent of the hourly wage Project Talent high school graduates received for working full time ($1.25). Because distance had been measured as the crow flies, a low average speed of 30 miles per hour was assumed for the 32 weeks of 4-1/2 trips per week. For greater detail on variable definition, see Bishop [1974].

[5]An early IQ measure would have been best but was not available. The test used was the Project Talent academic aptitude composite minus one of its subtests (a math information subtest focusing on the definitions of terms like quadratic and factorial that would only have been covered in college preparatory math courses).

[6]The alternative would be to estimate a full recursive model. Curriculum, achievement test scores, and grades would be predicted with variables describing the levels of tuition and minimum cost and the relationship between minimum cost and a student's credentials at the end of his high-school career. Attendance would then be predicted with the student's credentials and the characteristics of the cheapest college his credentials make him eligible for. Finally, the total effect of public policy would be obtained by summing the direct effects and the indirect effects through credentials.

[7]The policy-making process that determines college location, tuition, and admissions policy is assumed to be independent of the error term of our equation. This assumption has also been made by all previous researchers. It can be justified either by strict exogeneity (infinitely elastic supply curves) or counteracting influences that balance out on average.

[8]Entropy is a measure of the uncertainty of a probability distribution that is defined as minus the expectation of the logarithm of the probability. If the outcome being predicted has only two alternatives, the entropy ranges between 0 and $-\ln(.5) = .693$. According to Theil [1967], it is a better measure than R^2 of goodness of fit for categorical dependent variables.

[9]An appendix with tables comparable to Table 3 for all the policy and economic variables in the model is available from the author on request.

[10]According to Parsons a full-time student requires 1300 hours (32.5 weeks + 40 hours/week) for class attendance and study. Maximum sustainable work plus study time is 50 weeks · 50 hours/week = 2500 so available work time is about 1200 hours. G is defined in footnote 2. While the student may have been saving for college ever since he was 13 years old, his wage rate is very low in these years and only a portion of his earnings will be saved. Since in 1975 the opportunity cost of four years of study is about $12,000, a G of 1.5 for full-time study means that it must be possible to save no more than $7000 out of your own earnings prior to high school graduation.

[11]Loans failed a direct test in linear probability models. A variable defined as borrowing insured by state guarantee agencies divided by the number of the state's citizens attending college generally had a sign contrary to that which would be predicted by theory. This study, therefore, cannot provide definitive evidence on the cost effectiveness of loan guarantee programs.

[12]Other measures of the local payoff to college (relative incomes of people classified by education rather than occupation) were tried in linear regression models but performed even more poorly.

[13]ΔY^m is considered here to be an imperfect measure of the omitted variable, the expected earnings differential. The discount rates tabulated are based on the arbitrary but conservative assumption that regressing the expected earnings differential on the measured local differential would yield a coefficient of .25. Higher ϕ would yield higher discount rates. The discount rate is calculated by solving the following expression for r_j: $d^* = \sum_{4}^{\infty} \phi_t \ell_t (1+r_j)^{-t} \;/\; \sum_{0}^{3} (1+r_j)^{-t} =$ $\theta_5/\beta+\lambda\gamma = \theta_5/\theta_2-\gamma$. The elements of d* are defined in footnote 1. If $\phi = .25$, our equations predict that a one-third drop in the economic payoff will produce a 21 percent drop in enrollment. This compares to a 39 percent drop predicted by a time series model estimated by Freeman [1975: equation 4 of Table 6] that, besides a measure of the economic payoff, includes an end of the draft dummy and a variable that picks up the upward trend of enrollments.

[14]The rise and then decline of male attendance rates observable in Freeman's data is largely due to contraction of the base, civilian males 18-21, due to the Vietnam War.

[15]A more rigorous mathematical derivation of (10) is available in an appendix that can be obtained from the author.

[16]It was assumed that the effect of tuition on the log odds of attendance was an additive linear function of one's ability quartile and one's parental income. The tuition coefficients were then regressed on dummies for ability quartile and dummies for income group and the

16 (continued)

predicted values for each strata were used instead of the actual values. This has the effect of smoothing the variation of the tuition coefficients. None of the predicted values are positive.

[17]In order for a \$200 tuition to be optimal for high-income students when $\mu/\lambda = 0$, $MC-t-E_{high}$ must equal \$200. Table 5 assumes a somewhat more specific version of the same thing ($E_{high} = 0$ and $MC-t = \$200$). In other words, the present value of the tax externality for high income students was only \$200 less than the marginal cost of instruction. This assumption determines the general level of optimal prices. It has only minor effects on optimal relative prices.

[18]Stephen Hoenack [1971] has also calculated a set of optimal tuitions. As in this model, outcomes are constrained by the demand functions. Instead of taking the shadow price of revenue as given, his approach takes the budget as given. In Baumol-Bradford the government is maximizing a social welfare function that takes into account each individual's valuation of each output of the economy. Hoenack's government has only numbers and types of students in its objective function.

References

W. Baumol and D. Bradford. "Optimal Departures from Marginal Cost Pricing." American Economic Review 60 (June 1970):265-283.

J. Bishop. The Private Demand for Places in Higher Education. Ph.D. dissertation, University of Michigan, 1974.

J. Bishop and J. Van Dyk. "Can Adults be Hooked on College? Some Determinants of Adult College Attendance." Institute for Research on Poverty Discussion Paper 319-75. Madison: University of Wisconsin, 1975.

R. Campbell and B. Siegel. "The Demand for Higher Education in the United States, 1919-1964." American Economic Review (June 1967):482-494.

E. Denison. "Some Reflections." Journal of Political Economy 80 (May 1972): S290.

S. Dresch. "Demography, Technology, and Higher Education: Toward a Formal Model of Education Adaptation." Journal of Political Economy (June 1975):535-570.

Flanagan et al. The American High School Student. Pittsburgh: University of Pittsburgh, Project Talent Office, 1964.

R. Freeman. "Overinvestment in College Training?" Journal of Human Resources (Summer 1975):287-311.

H. Galper and R. Dunn. "A Short-Run Demand Function for Higher Education in the United States." Journal of Political Economy (Sept.-Oct. 1969): 765-777.

J. J. Heckman. "A Life Cycle Model of Earnings, Learning and Consumption." Chicago: University of Chicago and National Bureau of Economic Research, December 1975.

S. Hoenack. "The Efficient Allocation of Subsidies to College Students." American Economic Review 66 (June 1971):302-311.

T. Hopkins. "Higher Education Enrollment Demand." Economic Review 12 (March 1974):53-65.

M. Kohn, C. Manski, and D. Mundel. "An Empirical Investigation of Factors Which Influence College Going Behaviors." Rand Corporation Report. Santa Monica: Rand Corporation, 1974.

D. Parsons. "The Cost of School Time, Forgone Earnings, and Human Capital Formation." Journal of Political Economy 82 (March/April 1974):251-266.

R. Radner and L. Miller. "Demand and Supply in US Higher Education." American Economic Review 60 (May 1970):326-334.

W. Sewell and J. M. Armer. "Neighborhood Context and College Plans." American Sociological Review 31, no. 2 (April 1966):159-168.

R. Theil. Economics and Information Theory. Chicago: Rand McNally, 1967.

U. S. Selective Service System. Annual Report of the Director of Selective Service for Fiscal Year 1960. Washington, D. C.: U. S. Government Printing Office, 1961