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Predicting Higher Education Graduation Rates from Institutional Characteristics and Resource Allocation

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Abstract
This study incorporated institutional characteristics (e.g., Carnegie type, selectivity) and resource allocations (e.g., instructional expenditures, student affairs expenditures) into a statistical model to predict undergraduate graduation rates. Instructional expenditures, library expenditures, and a number of institutional classification variables were significant predictors of graduation rates. Based on these results, recommendations as well as warranted cautions are included about allocating academic financial resources to optimize graduation rates

Introduction and Conceptual Framework

The deployment of financial resources for institutions of higher education is a crucial aspect of institutional management. Balderston (1995, p. 6), for example, concluded, “Efforts toward more effective use of resources and a fine instinct for the inevitable trade-offs will be important and will even tend to dominate the institutional scene. Therefore, increasing weight is now given to explicit decisions about the allocation of resources.” How institutions spend their financial resources tends to reflect their priorities, although Hansen and Stampen (1996, p. 295) point out that “overall expenditure data are not particularly helpful in understanding the impact of changes on the quality of higher education,” since such expenditure totals include expenditures not related to instructional activities, and include public service, research, and auxiliary enterprises.

The conceptual framework guiding this study is to link institutional planning with the successful retention of undergraduate students to graduation, through implementing a careful fiscal strategy. While a fiscal strategy, by definition, is to establish “the basis upon which allocations are to be made” (Brinkman & Morgan, 1997, p. 291), fiscal strategies often are not integrated into the institutional planning processes that specify desired goals and outcomes (Peterson, 1999). Retention and graduation rates are central indicators of success for institutions of higher education, and a variety of negative consequences for undergraduate students are related to attrition (Tinto, 1987). However, it not clear whether, and, if so, how, institutional resource allocation decisions are linked to student graduation rates. Our approach to the study of this important problem in higher education policy is to develop a statistical model that explores resource allocation decisions as predictors of student graduation rates, together with other measures of institutional type and selected institutional traits that are suggested in the research literature and are available in a national database. If the efficacy of such a model can be demonstrated empirically, leaders of higher education institutions may be able to make more strategic resource allocation decisions in pursuit of the goal of improved graduation rates. The results of this study are intended to help promote data-driven approaches to strategic resource allocation by institutions of higher education.

Support for students is perceived in some quarters as an essential ingredient of program quality (Haworth & Conrad, 1997). They (1997, p. 143) concluded: “Throughout our study, support for students repeatedly surfaced as an important feature of high-quality programs.” Yet, during the most recent 15-year period when higher education expenditures have been tracked by the National Center for Education Statistics (2000), the percentage of budget dedicated by four-year public institutions to instruction and libraries, principal consumers of the budget on many campuses, has declined.

Cost escalation is of considerable concern to the higher education community. Rising tuition charges is a particular concern. Clotfelter (1996, p. 1) concluded, “Tuition charges rose sharply as well, making the rate of inflation in private college tuition even worse than the much-heralded run-up in medical costs.” One of the ways institutions have addressed revenue problems has been to try to improve retention of students. Indeed, how institutions of higher education deploy their resources to influence students may be an important thrust of research in the future. Pascarella and Terenzini (1998, p. 158), for example, noted that “future research on the impact of college will not be able to avoid coming to terms with issues of cost effectiveness. Examination of benefits in relation to costs will be particularly important for college impact research designed to inform policy.”

Various strategies can be used to improve retention rates (e.g., Astin, 1997; Elkins, Braxton, & James, 2000; McLaughlin, Brozovsky, & McLaughlin, 1998; Murtaugh, Burns, & Schuster, 1999). In a classic report, Tinto (1987) pointed out that as students are more likely to be integrated socially and academically in their institutions, the more likely it is that they would be retained. Berger and Braxton (1998, p. 116) studied students at a private institution and concluded that “organizational attributes play an important role not only as a source of social integration, but in the first year persistence process in general at this institution.” Murtaugh, Burns, and Schuster (1999) analyzed retention at Oregon State University, and identified several steps that the university could take to improve retention, including pointing out that out-of-state students were at greater risk than are in-state students.

In the two reports identified above, students were studied at single institutions and recommendations, consistent with Tinto’s model, were made to improve the institution’s retention rates. While such studies can be particularly useful to the institutions studied, and may have applicability at other institutions, large-scale studies of multiple institutions that focus on how institutional resource allocations influence graduation rates are rare. This study was intended to fill that void; more specifically, it was undertaken to determine how institutional resource allocations influence graduation rates at over 400 public four-year institutions of higher education.

Data and Methods

This study explored the extent to which institutional characteristics and decisions about institutional resources could be used to predict undergraduate graduation rates—a common indicator of undergraduate student success. Our analysis is based on variables derived primarily from the Integrated Postsecondary Education Data System (IPEDS) data, obtained from the National Center for Education Statistics (NCES). Institutions of higher education are required by law to participate in IPEDS annual surveys conducted by NCES (National Center for Education Statistics, 1998). Copies of these surveys are available at the following World Wide Web site: www.nces.ed.gov/ipeds. In addition, institutions may choose to participate in annual surveys conducted by publications such as *U.S. News & World Report* magazine; the results from those surveys are published at the Website www.usnews.com. Variables from the IPEDS plus a measure of admissions selectivity from *U.S. News & World Report* were utilized in the multiple regression statistical model.

Most of the data for this study came from the IPEDS relational data base, including enrollment information, financial information, and graduation rates. The Survey Year that was chosen for enrollment and financial information was 1998, since that Survey Year bridged the available years for graduation rates and selectivity rates. Graduation rates were drawn from 1997, the most current data available at the time the study was conducted. The IPEDS data set served as the primary source of cases and data for this study for a number of reasons. First, institutions of higher education receiving Title IV funding are required by law to participate in annual surveys such as IPEDS that are conducted by NCES. Second, all but one of the variables of interest was contained in the IPEDS data. Third, IPEDS data were easily accessible to the researchers via the World Wide Web.

All 513 accredited public institutions that grant at least a baccalaureate degree were selected for this study, but a number of institutions containing missing data on key variables were eliminated from this study, as were several other observations with “outlier” values on one or more variables that were markedly different from the data for the remaining observations and that threatened the assumption of normality. As a consequence, the final sample size comprised n = 444 public institutions with complete data on all variables of interest. Variables selected from the IPEDS relational database included enrollment information, financial information, and graduation rates. Graduation rates for 1997 (the most recent available) were used. All other institution-level data were from 1998 (the most recent available at the time of the study). Additionally, 1998 most closely matched the year for which institutional selectivity data were available (1999). The selectivity rates of undergraduate admissions were drawn from the annual data published by *U.S. News & World Report*.

The variables employed in the study are described in detail in the following section. We have endeavored to use least squares statistical models to provide a comprehensive look at the factors that help in understanding the effects that higher education expenditure patterns and other institutional characteristics have on student success, measured as undergraduate student graduation rates. The variables employed in this analysis include: undergraduate graduation rate (the dependent variable); Carnegie classification; U.S. region; degree of urbanization; presence of a medical, dental, veterinary, or related program; selectivity; institutional financial aid; and number of dollars allocated to each of the following categories of expenditures: student affairs, instruction, library, physical plant, institutional support, academic support minus library, and total education and general (E & G).[1]

We have chosen to predict graduation rates from a combination of institutional characteristics, some of which, such as expenditure patterns, are more or less within the discretionary control of institutional leadership, and some of which, such as region or historically black college or university (HBCU) status, are beyond reasonable control by institutional decisionmakers. Arguably, other characteristics, such as Carnegie classification (the data were collected under the pre-1999 revised Carnegie rating system), to some degree may be influenced through the decisions taken by the senior administrators of higher education institutions, but remain relatively immutable without major commitments of effort and resources. Prior to data analysis, institutional allocation categories (e.g., instructional expenditures) were transformed into “per student” dollar equivalents by dividing each expenditure category by the institution’s headcount enrollment. Due to its non-normal distribution, the institutional financial aid per headcount variable was transformed into a low-to-high quintile ordered categorical variable.

We believe this mix of institutional traits provides a set of perspectives that promise to facilitate the understanding of what makes for a more successful academic institution, measured in terms of one of its ultimate products¾its graduates. In these results there is information that may be of great use to those who plan and administer the process of higher education. Which is better, for the goal of improving graduation rates: increase spending by $100 per student headcount for library expenditures, or increase spending by $10 per student headcount on student affairs? Does the presence of a medical school improve an institution's undergraduate graduation rate? How much does the degree of selectivity of admissions decisions influence the rate at which students successfully complete their studies? How are these, and other, considerations related to each other, and what tradeoffs among these alternatives are important to know about? These are among the questions that are addressed in the results discussed below.

Results

Full-Model Multiple Regression

In a full-model multiple regression, graduation rate (GRAD) was predicted by a combination of categorical and continuous predictors. The categorical predictors include: Carnegie classification (CARNEGIE), region (REGION), the presence (coded 1) or absence (coded 0) of a medical, dental, veterinary, or other similar school (MEDICAL), whether the institution is (coded 1) or is not (coded 0) an historically black college or university (HBCU), and quintiles of institutional financial assistance (IFA5). The model also incorporates interactions between MEDICAL and URBAN and between REGION and MEDICAL. The continuous predictors include degree of urbanization (URBAN), selectivity of admissions (SELECT), expenditures on student affairs per student headcount (SAFEXP), instructional expenditures per student headcount (INSTEXP), library expenditures per student headcount (LIBEXP), expenditures on physical plant per student headcount (PPLEXP), institutional support per student (INSTIEXP), total education and general expenditures per headcount (EGEXP), and academic support minus library expenditures per student headcount (NOTLIB).

In subsequent tables, the predictive validity of models overall is evaluated by: the value of the coefficient of determination (R^2), which measures the proportion of total variation in the dependent variable associated with, or "explained by," variation in the complete set of predictor variables; adjusted R^2, an index of the proportion of dependent variable variance explained relative to the mean squared error and the number of degrees of freedom for model and error, which may assume a negative value for ill-fit models; and the F-value formed from the ratio of estimated model variance to estimated error variance, where a larger F-ratio implies a "stronger" model, and its associated p-value. The validity of the separate predictor variables included in each model is ascertained from: a partial *F* statistic and its associated p-value; eta-squared, $(\text{eta})^2$, which is the proportion of the total variability in the dependent variable accounted for by that independent variable; and by observed power, or the probability of correctly determining that there is a real effect attributable to that model component. Larger values of eta-squared indicate stronger model predictors, but often are modest (less than .10). Larger values of power (maximum of one) indicate a greater likelihood of that particular predictor having a genuine effect on the dependent variable.

The assumption of equal error variances is satisfied, as measured by Levene's test ($F = .966$, $df1 = 175$, $df2 = 268$, $p = .596$). The model provides a reasonably strong fit to the data, as measured by the coefficient of determination (R^2 = .588) and the adjusted coefficient of determination (adjusted R^2 = .550). As shown in Table 1, the following full-model effects were significant: CARNEGIE (F = 5.765, p < .001, $(\text{eta})^2$ = .090, power = .999), MEDICAL (F = 5.793, p = .017, $(\text{eta})^2$ = .014, power = .670), HBCU (F = 18.663, p < .001, $(\text{eta})^2$ = .044, power = .991), IFA5 (F = 4.588, p = .001, $(\text{eta})^2$ = .043, power = .945), URBAN (F = 22.266, p < .001, $(\text{eta})^2$ = .052, power = .997), SELECT (F = 15.911, p < .001, $(\text{eta})^2$ = .038, power = .978), INSTEXP (F = 5.867, p = .016, $(\text{eta})^2$ = .014, power = .676), LIBEXP (F = 26.523, p < .001, $(\text{eta})^2$ = .061, power = .999), NOTLIB (F = 4.844, p = .028, $(\text{eta})^2$ = .012, power = .593), and the MEDICAL*URBAN interaction (F = 4.905, p = .027, $(\text{eta})^2$ = .012, power = .593). The assumption of normality in the dependent variable also is satisfied following deletion of outliers identified by model residuals.

Table 1
Full Model Multiple Regression Tests of Between-Subjects Effects for Predicting Graduation Rates

Source	**Type III Sum of Squares**	***df***	**Mean Square**	**Observed *F***	***p* > *F***	**$(\text{eta})^2$**	**Power**
Corrected Model	64384.510	37	1740.122	15.662	<.001	.588	1.000
Intercept	3133.171	1	3133.171	28.200	<.001	.065	1.000
CARNEGIE	4483.756	7	640.537	5.765	<.001	.090	.999
REGION	614.927	7	87.847	.791	.595	.013	.342
MEDICAL	643.589	1	643.589	5.793	.017	.014	.670
HBCU	2073.618	1	2073.618	18.663	<.001	.044	.991
IFA5	2039.159	4	509.790	4.588	.001	.043	.945
URBAN	2473.897	1	2473.897	22.266	<.001	.052	.997
SELECT	1767.816	1	1767.816	15.911	<.001	.038	.978
SAFEXP	12.268	1	12.268	.110	.740	<.001	.063
INSTEXP	651.886	1	651.886	5.867	.016	.014	.676
LIBEXP	2946.915	1	2946.915	26.523	<.001	.061	.999
PPLEXP	286.785	1	286.785	2.581	.109	.006	.361
INSTIEXP	11.977	1	11.977	.108	.743	<.001	.062
EGEXP	89.049	1	89.049	.801	.371	.002	.145
NOTLIB	538.148	1	538.148	4.844	.028	.012	.593

MEDICAL*URBAN	544.985	1	544.985	4.905	.027	.012	.599
REGION*MEDICAL	1217.596	7	173.942	1.566	.144	.026	.653
Error	45109.257	406	111.107				
Total	889697.070	444					
Corrected Total	109493.767	443					

The adjusted, or estimated, marginal means for institutions at different levels of the Carnegie classification scale (CARNEGIE) are presented in Table 2. These results adjust for region, presence of a medical or related component, whether the institution is an HBCU, institutional student financial support, urbanization, selectivity, and the indicated measures of expenditures, as well as the interactions of MEDICAL*URBAN and REGION*MEDICAL. There is a general, and nearly monotonic, decline in mean graduation rates as Carnegie classification varies from Research I (the most prestigious by that measure of external research funding acquired) to Bachelor's II, although there is little difference between Research II and Doctoral I mean graduation rates and little difference in the mean graduation rates for Doctoral II, Master's I, and Master's II institutions.

Table 2
Estimated Marginal Mean Graduation Rates by Carnegie Classification (CARNEGIE) from Full Model Multiple Regression

			95% Confidence Interval	
Carnegie Classification	**Mean**	**Standard Error**	**Lower Bound**	**Upper Bound**
Research I	49.227	2.930	43.467	54.987
Research II	42.005	2.705	36.686	47.323
Doctoral I	41.948	2.802	36.440	47.455
Doctoral II	35.683	2.517	30.734	40.632
Master's I	36.751	1.886	33.043	40.458
Master's II	36.039	3.133	29.880	42.199
Bachelor's I	32.759	5.083	22.766	42.752
Bachelor's II	26.812	2.708	21.488	32.136

Note: The marginal means reported here are evaluated at the means of the following covariates that appeared in the model: URBAN (degree of urbanization) = 3.45, SELECT (selectivity = percentage of admissions applications accepted/applications received) = 75.187, SAFEXP (student affairs expenditures per student headcount) = 728.2527, INSTEXP (instructional expenditures per student headcount) = 4282.9243, LIBEXP (library expenditures per student headcount) = 360.4734, PPLEXP (physical plant expenditures per student headcount) = 925.9977, INSTIEXP (institutional support per student headcount = 1156.2228, EGEXP (educational and general expenditures per student headcount) = 11556.6124, NOTLIB (academic support minus library expenses, per student headcount) = 707.3338.

Pairwise multiple comparisons (using Fisher's Least Significant Difference method (Howell, 2002) confirm that the estimated mean graduation rate for the most prestigious institutions, measured by the Carnegie classification (Research I), is significantly greater than the estimated mean graduation rates for the institutions in each of the other Carnegie classifications. Similarly, the multiple comparison results demonstrate that the estimated mean graduation rate for the least prestigious Carnegie classification institutions (Bachelor's II) is significantly lower than the estimated mean graduation rates for all other categories of institutions other than those at the Bachelor's I level. Other pairwise differences in estimated mean graduation rates are found for Carnegie classification as expected from the rankings of the group means.

Estimated marginal mean graduation rates by region are shown in Table 3. Although there is no significant effect of regional variation in the model, it is noteworthy that estimated mean graduation rates are highest in New England (44.086%) and the Mid-East (41.005%) and lowest in the Plains (34.679%) and Rockies (35.021%). Pairwise multiple comparisons of regions show no significant differences, consistent with the finding of no overall effect of region in the full regression model including interactions. (Note 2)

Table 3
Estimated Marginal Mean Graduation Rates by Region (REGION) from Full-Model Multiple Regression

			95% Confidence Interval	
Region of U.S.	**Mean**	**Standard Error**	**Lower Bound**	**Upper Bound**
New England	44.086	5.904	32/479	55.693
Mid-East	41.005	3.023	35.062	46.949
Great Lakes	36.626	2.251	32.201	41.052
Plains	34.679	2.531	29.703	39.656
Southeast	36.853	1.820	33.275	40.431
Rockies	35.021	4.303	26.562	43.481
Southwest	37.560	3.227	31.216	43.904
West Coast	35.392	2.894	29.704	41.080

Note: The marginal means reported here are evaluated at the means of the following covariates that appeared in the model: URBAN (degree of urbanization) = 3.45, SELECT (selectivity = percentage of admissions applications accepted/applications received) = 75.187, SAFEXP (student affairs expenditures per student headcount) = 728.2527, INSTEXP (instructional expenditures per student headcount) = 4282.9243, LIBEXP (library expenditures per student headcount) = 360.4734, PPLEXP (physical plant expenditures per student headcount) = 925.9977, INSTIEXP (institutional support per student headcount = 1156.2228, EGEXP (educational and general expenditures per student headcount) = 11556.6124, and NOTLIB (academic support minus library expenses, per student headcount) = 707.3338.

In the full model including interactions, institutions with a medical, dental, veterinary, or similar component had a significantly lower estimated mean graduation rate (37.065%) than did institutions without such a component (38.241%). HBCUs had an estimated mean graduation rate of 32.877%, significantly less than the 42.429% result for non-HBCUs. The statistically significant differences in estimated mean graduation rates among quintiles of institutional financial assistance (IFA) range from 42.740% for the top quintile (level 5) to 33.665% for level 2, with intermediate values for level 1 (38.223%), level 4 (37.636%), and level 3 (36.001%). The significant interaction between MEDICAL and REGION is amplified by the range in estimated mean graduation rates from a low of just 31.708% for institutions with medical schools or similar components in the Plains to a high of 47.374% for New England institutions with medical schools or similar components.

Independent Bivariate Regression Results

The results reported above are based on the full multiple regression model. Determining how the independent variables employed in the full model play out on their own is important, because the chief consequence of including a large number of independent variables in a prediction model is to enhance the likelihood that the effect of each predictor may be masked (either enhanced or attenuated) by intercorrelations with other predictors. By examining the individual effects of each predictor within the overall analysis we can look for inconsistencies that might confound interpretations based on the full model.

IFA5 has a significant individual effect on graduation rates ($F = 3.288$, $p = .011$), although the proportion of variance explained is modest ($R^2 = .029$). Mean graduation rates are 43.103% for level 1, 37.740% for level 2, 39.900% for level 3, 44.097% for level 4, and 44.769% for level 5.

The independent effect of REGION is significant ($F = 6.247$, $p < .001$, $R^2 = .091$). Mean graduation rates were 44.369% for New England, 48.626% in the Mid-East, 42.887% in the Great Lakes, 40.074% for the Plains, 40.056% in the Southeast, 36.618% for the Rockies, 32.134% for the Southwest, and 47.712% on the West Coast.

Urbanization (URBAN) alone does not have any independent relationship with graduation rates ($F = 0.035$, $p = .808$, $R^2 < .001$).

Separately, MEDICAL is a significant independent predictor of graduation rates ($F = 52.459$, $p < .001$, $(\text{eta})^2 = .106$), although not a particularly good predictor ($R^2 = .106$). Institutions without a medical, dental, veterinary, or similar component had a markedly lower mean graduation rate (39.878%), compared to institutions with such a component (54.736%).

By itself, the fact that an institution is an HBCU has a statistically significant effect on graduation rates ($F = 18.231$, $p < .001$), although the effect size is relatively modest ($R^2 = .040$). The mean graduation rate for students at a non-HBCU (42.848%) is over 10 percentage points greater than the corresponding result for students attending HBCUs (31.397%). This comparison is confounded by the fact that HBCUs are not found at all Carnegie levels for the institutions studied in this analysis, so we also compared only those HBCU and non-HBCU institutions that share the same Carnegie rating, to provide a fairer and more nuanced appreciation of the role played by HBCUs in higher education. This refined analysis again demonstrates a significant difference in mean graduation rates between HBCU and non-HBCU institutions at comparable Carnegie levels ($F = 9.101$, $p = .003$). However, the magnitude of this effect ($R^2 = .027$) is less than for comparing HBCUs against all non-HBCU institutions, and is substantially less than the effect size for other elements of the model. There is about a 7-percentage-point advantage in mean graduation rates for students not attending an HBCU (38.440%, compared to 31.397% for students attending an HBCU).

Institutional selectivity in undergraduate admissions (SELECT) is significantly related to graduation rates ($F = 43.825$, $p < .001$, $R^2 = .090$). However, the less than overwhelming effect of admissions selectivity on graduation success is shown by the finding that admitting one percentage point more of those who apply for undergraduate admission results, on average, in a decline of .295 percentage point in graduation rates. Presumably, greater selectivity is associated with institutions having more rigorous standards that students find difficult to negotiate; similarly, the incremental students admitted under less restrictive criteria are likely to be more marginal academically and thus less likely to graduate.

By itself, Carnegie classification level (CARNEGIE) has a very pronounced ($F = 24.905$, $p < .001$, $R^2 = .286$) effect on graduation rates. Not considering the effects of any other variables employed in the full regression model, the institutions at each Carnegie classification have the mean graduation rates shown in Table 4. Comparing unadjusted (Table 4) and adjusted means (Table 2) shows the sensitivity of our estimates to the specification of the model and to the effects of the other predictor variables. The effect of the other predictors in the model is evident for the institutions at higher Carnegie classification levels. For example, the unadjusted mean graduation rate for Research I institutions (60.247%) is much lower (49.227%) after adjusting for the other circumstances measured in our model, and so is the unadjusted marginal mean graduation rate (52.567%) much higher than the adjusted (32.759%) mean for Bachelor's I institutions. Similarly, the unadjusted rate of 52.465% for Research II institutions is lowered to 42.005% by controlling for the other predictors. Less dramatic reductions occur in adjusted, compared to unadjusted, graduation rates for Doctoral I (from 47.115% to 41.948%), Doctoral II (from 38.997% to 35.683%), Master's I (from 38.348% to 36.751%), Master's II (from 39.241% to 36.039%), and Bachelor's II (from 32.384% to 26.812%) institutions. The differentially higher actual (unadjusted) compared to adjusted graduation rates are most evident for relatively more prestigious institutions (that is, Carnegie Research I and Research II classifications), moderated greatly for Doctoral I, Doctoral II, and Master's I classifications, dramatically higher for Bachelor's I institutions, and again moderated for Bachelor's II institutions.

Table 4

Mean Graduation Rates by Carnegie Classification (CARNEGIE), Unadjusted for Other Predictors

Carnegie Classification	Mean	Standard Deviation	Number of Institutions
Research I	60.247	14.249	55
Research II	52.465	12.241	26
Doctoral I	47.115	15.881	27
Doctoral II	38.997	13.323	35
Master's I	38.348	12.995	220
Master's II	39.241	14.395	17
Bachelor's I	52.567	12.121	6
Bachelor's II	32.384	13.168	58
Total	41.919	15.721	444

INSTEXP, instructional expenditures, have a pronounced effect on graduation rates (F = 207.616,p < .000), and substantial explanatory power (R^2 = .320, adjusted R^2 = .318). An increase of 10% in mean instructional expenditures (i.e., an additional $428.29) per student headcount, on average, leads to an increase of 1.99 percentage points in graduation rates, assuming a linear relationship. Expenditures on physical plant per student headcount (PPLEXP) also are significantly related to graduation rates (F = 58.778, p < .001), but this variable independently contributes modestly to explained variance in graduation rates (R^2 = .117). On average, an increase of 10% in mean per student headcount spending on physical plant (an additional $92.60) "buys" 1.07 percentage points of higher graduation rates. INSTIEXP, institutional support, similarly has a significant (F = 38.437, p < .001), but not very potent (R^2 = .080) independent impact on graduation rates. An increase of 10% in mean institutional support per student headcount ($115.62) results in an increase, on average, of 0.83 percentage points in graduation rates. The level of student affairs expenditures (SAFEXP) is a significant independent predictor of graduation rate (F = 29.828, p < .001), with rather modest explanatory power (R^2 = .063). On average, each additional 10% per student headcount spent on student affairs ($72.83) results in an increase in graduation rates of about 0.89 percentage points. Library expenditures (LIBEXP) provide a very robust and statistically significant explanation of graduation rates (F = 230.422, p < .001, R^2 = .343). Every 10% per student headcount increase in library expenditures ($36.05) results, on average, in an additional 1.77 percentage points of graduation rates. Total education and general expenditures (EGEXP) has a potent independent impact on graduation rates (F = 186.535, p < .001, R^2 = .297). On average, an additional 10% in mean EGEXP ($115.66) is associated with an extra 0.16 percentage point in graduation rates. Finally, NOTLIB, academic support minus library expenditures per student headcount, is a reasonably good independent predictor of graduation rates (F = 115.490, p <

.001, R^2 = .207). Higher values of NOTLIB are significantly more likely than lower values of NOTLIB to result in higher graduation rates. On average, an extra $100 of spending on non-library academic support expenditures per student is associated with a 0.98 percentage point increase in graduation rates.

Based on these results, the best “payoffs” in higher graduation rates from strategically targeted institutional budgetary enhancements would seem to come from increasing per student expenditures for instruction (+1.99 percentage points), followed closely by library (+1.77) and more distantly by physical plant (+1.07) and nonlibrary academic (+0.98). In a lower tier of impact are student affairs (+0.89) and institutional support (+0.83). Lagging far behind is education and general (+.16). However, these findings do not control for the simultaneous effects of changes in each expenditure category (and the often high correlation of any one budget category with another, leading to collinearity among the budgetary predictors and attenuated partial regression coefficients) together with other effects that are captured in the full model. In the full model, for the same benchmark 10% per student headcount increase in any one expenditure category, the net effects of greater spending on physical plant (-0.28) and education and general (-0.36) actually are negative, and the greatest “payoff” is attributable to enhanced expenditures on library (+0.92) and instruction (+0.80), with only modest contributions from increased nonlibrary academic (+0.27) expenditures and very minimal improvements from heightened spending for institutional support (+0.05) and student affairs (+0.05).

Hierarchical Models

A further check on the validity of our results is provided by analyzing the patterns of relationships between the predictor variables and graduation rates in hierarchical stages of model building. Stage 1 estimates graduation rates from three institutional “demographic” variables (REGION, HBCU, and URBAN) that are historically-determined traits beyond the control of current higher education decisionmakers. For Stage 2, to these three predictors are added institutional characteristics that are more likely to be controlled by longer-range actions taken by the institution’s decisionmakers (CARNEGIE, MEDICAL, IFA5, and SELECT) with the interactions of MEDICAL with URBAN and of REGION with MEDICAL. Finally, Stage 3 adds the set of expenditure variables that more proximally are under the control of institutional leaders as they set annual budget and policy priorities: SAFEXP, INSTEXP, LIBEXP, PPLEXP, INSTIEXP, EGEXP, and NOTLIB. The Stage 3 results are the same as those for the full multiple regression model shown in Table 1. Table 5 summarizes the fit of each stage of the model, showing the partial F statistic and accompanying p-value ($p > F$) testing the significance of each predictor, (eta)^2, and the power of each parameter estimate, as well as overall model F statistics, p-values, R^2, and adjusted R^2.

Table 5
Summary of Hierarchical Multiple Regression Model Results

Variable	Stage 1 Institutional demographics only: F	$p > F$	η^2	Power	Stage 2 Institutional demographics with selected traits: F	$p > F$	η^2	Power	Stage 3 Institutional demographics with select traits & finances: F	$p > F$	η^2	Power
REGION	6.653	<.001	.097	1.000	2.248	.030	.037	.834	0.791	.595	.013	.342
HBCU	20.458	<.001	.045	.995	16.117	<.001	.038	.980	18.663	<.001	.044	.991
URBAN	0.380	.538	.001	.094	10.181	.002	.024	.889	22.266	<.001	.052	.997
CARNEGIE					24.191	<.001	.291	1.000	5.765	<.001	.090	.999
MEDICAL					0.062	.804	<.001	.057	5.793	.017	.014	.670
IFA5					7.479	<.001	.068	.997	4.588	.001	.043	.945
SELECT					20.874	<.001	.048	.995	15.911	<.001	.038	.978
MEDICAL* URBAN					0.096	.757	<.001	.061	4.905	.027	.012	.599
REGION* MEDICAL					1.533	.154	.025	.643	1.566	.144	.026	.653
SAFEXP									0.110	.740	<.001	.063
INSTEXP									5.867	.016	.014	.676
LIBEXP									26.523	<.001	.061	.999
PPLEXP									2.581	.109	.006	.361
INSTIEXP									0.108	.743	<.001	.062
EGEXP									0.801	.371	.002	.145
NOTLIB									4.844	.028	.012	.593
Model	F	$p > F$	R^2	adj R^2	F	$p > F$	R^2	adj R^2	F	$p > F$	R^2	adj R^2
	7.378	<.001	.133	.115	15.065	<.001	.523	.488	15.662	<.001	.588	.550

Variable	Stage 2 without interactions: F	$p > F$	η^2	Power	Stage 3 new variables only: F	$p > F$	η^2	Power
REGION								
HBCU								
URBAN								
CARNEGIE	17.815	<.001	.225	1.000				
MEDICAL	0.002	.965	<.001	.050				
IFA5	8.339	<.001	.072	.999				
SELECT	40.195	<.001	.085	1.000				
MEDICAL* URBAN								
REGION* MEDICAL								
SAFEXP					1.849	.175	.004	.274
INSTEXP					6.382	.012	.014	.713
LIBEXP					33.166	<.001	.071	1.000
PPLEXP					2.258	.134	.005	.323
INSTIEXP					0.024	.876	<.001	.053
EGEXP					0.102	.750	<.001	.062
NOTLIB					1.181	.278	.003	.192
Model	F	$p > F$	R^2	adj R^2	F	$p > F$	R^2	adj R^2
	21.493	<.001	.394	.376	38.702	<.001	.383	.373

F (Stage 2 vs. Stage 1) = 9.29; (F, .01, 21 and 434 df ≈ 1.92); $p < .01$.
F (Stage 3 vs. Stage 1) = 8.14; (F, .01, 28 and 434 df ≈ 1.74); $p < .01$.
F (Stage 3 vs. Stage 2) = 8.09; (F, .01, 7 and 413 df ≈ 2.68); $p < .01$.

The results in Table 5 provide evidence of the predictive validity of each stage, or set, of predictors. The three Stage 1 institutional demographic variables collectively are significant predictors, accounting overall for 13.3% of the variation in graduation rates, and both REGION and HBCU are significant individually. The Stage 2 combination of institutional traits with the Stage 1 predictors are significant collectively, accounting for a combined 52.3% of the variation in graduation rates, with REGION, HBCU, URBAN, CARNEGIE, IFA5, and SELECT significant individually. A partial F-test demonstrates that the added institutional characteristic predictors contribute significantly ($F = 9.29$, $p < .01$) to explaining graduation rates beyond what is accounted for by the Stage 1 variables. Adding the financial variables in Stage 3 to the previous sets of predictors results in greater explanatory power ($R^2 = .588$), which is a significant improvement over both the Stage 1 (partial $F = 8.14$; $p < .01$) and the Stage 2 (partial $F = 8.09$, $p < .01$) sets of predictors. That is to say, the institutional financial information makes a major contribution to our understanding of what drives graduation rates beyond what we know from institutional demographics and other institutional characteristics. Table 5 also shows that the institutional characteristics variables added in Stage 2 are by themselves (without interactions, which cannot be estimated separately here because they require the URBAN and REGION variables in Stage 1) significant predictors of graduation rates ($F = 21.493$, $p < .001$), as are the financial variables added in Stage 3 ($F = 38.702$, $p < .001$). In addition, the explanatory power of the financial variables alone ($R^2 = .383$, adj $R^2 = .373$) roughly equals that of the institutional characteristics variables alone ($R^2 = .394$, adj $R^2 = .376$). Each of these additional sets of predictors considerably outweighs the explanatory power of the institutional demographics from Stage 1 ($R^2 = .133$, adj $R^2 = .115$).

Limitations

Several limitations to this study must be acknowledged. First, the study was framed with reference to public accountability for resources and student success. Consequently, data were analyzed from public higher education institutions only. While this decision allowed us to examine characteristic patterns of these institutions more closely by focusing the analysis and interpretation, the important private sector of higher education in the United States nonetheless was omitted from this analysis. The conclusions and recommendations therefore are applicable only to public colleges and universities. It is unclear whether or how these findings would apply to private institutions of higher education.

Second, although this study focuses on student success in terms of graduation rates, it is important to note that this study reveals little about the qualities of student-level experiences (Tinto, 1998) that also certainly influence graduation rates. Numerous other considerations, such as the nature of educational environments, the quality of student/instructor interactions, and students' use of available resources, reveal the more subtle finer points of successful educational experiences. This study addresses these issues only obliquely, through its focus on the deployment and allocation of institutional financial resources that enable provision and/or enhancement of the educational experience.

Third, institutional expenditure categories were compared across institutions, and expenditure categories were aggregated broadly in the original IPEDS data set.

Although the outcome variable here is undergraduate graduation rates, it was not possible to distinguish amounts expended on graduate programs and graduate students from those related to undergraduate programs and undergraduate students. Incorporating Carnegie classification into the analysis represented a partial control for this lacuna since the Carnegie classification system is based partly on the existence and scope of graduate programs, but the internal allocations of institutions for undergraduate and graduate purposes were not available.

A related limitation is the inability to disaggregate financial aid data into separate expenditures on undergraduate and graduate/professional education using the IPEDS database. Consequently, it is impossible to determine the extent to which financial aid is awarded to undergraduate or graduate students. Presumably, institutional financial aid awarded to undergraduate students could be “merit-based,” meaning that it is used to encourage enrollment by rewarding talent and therefore is seen as a way of positively connecting students to their college or university (see Astin, 1993). Graduate student aid could include fee remissions or other forms of aid that presumably have different purposes, but it is not possible to disaggregate the IPEDS financial aid data in this manner.

Finally, cross-sectional data from one year (1997-98) were used in this analysis. This study thus provides a snapshot of a single year’s allocations and expenditures across a large number of institutions. Although revenues and allocations generally remain constant with the exceptions of incremental adjustments¾a common form of budgeting (Dickmeyer, 1996; Woodard & von Destinon, 2000)¾a longitudinal design would be needed to account for multiple-year trends or changes in expenditure patterns, to test the long-range applicability and stability of this model over a period greater than one year.

Discussion, Conclusions, and Implications

As is clear from the findings above, not all categories of variables affect graduation rates equally. The institutional demographic variables contributing to a prediction of higher graduation rates were: higher status within the Carnegie classification system; the presence of a medical, dental, or veterinary program; a more urbanized location; and a lower percentage of applicants admitted. The MEDICAL and URBAN variables combined to produce an interactive effect on graduation rates. However, many of these variables represent characteristics or conditions over which institutions have little to no control.

Characteristics such as regional location are more or less fixed features of an institution. Mission (e.g., inclusion of a medical, dental, or veterinary program; admissions selectivity) and Carnegie classification represent characteristics that could be affected (and likely have been affected, as many of these institutions have “climbed” the Carnegie “ladder”) through institutional and political processes. However, these characteristics are not highly or readily malleable. Additional variables in the model, however, represent decision points that are more readily subject to policy discussions and institutional decisionmaking, and may represent promising levers for institutional decisionmakers or external policymakers. There are important differences among public institutions at different Carnegie levels (Winston, Carbone, & Lewis, 1998, pp. 21-22) in their ability to accommodate the recent trend of privatizing public sector education through the withdrawal of public support in the face of growing enrollments:

> The strongest schools were apparently able both to discourage enrollments, husbanding their subsidy resources, and to raise net tuitions, increasing their share of costs borne by their students' tuition income. The poorest schools were protected, in contrast, by a public policy that maintained their subsidies, allowing them to get by with modest sticker price increases that they used largely to increase financial aid. Relative prices changed to make the poorer schools—the Two-year Colleges prominent among them—a lot better bargain. The middling schools—the public Comprehensive Universities and Liberal Arts Colleges—were caught, absorbing large increases in enrollments with large reductions in subsidy resources so that their efforts to shift costs to their students weren't enough to prevent large reductions in educational quality.

For example, the provision of institutional financial aid was a statistically significant component of the model and modestly affected graduation rates. However, the relationship was not linear since higher graduation rates were associated with the lowest and with the two highest quintile measures of financial aid (a marginal mean graduation rate of 38.026% for the first—that is, lowest—quintile, with per student headcount support of $54 or less; and 37.354% for the fourth, and 42.521% for the fifth—highest—quintile, or a range of over $378 per student headcount). Institutions that can do so may wish to consider investing additional institutional monies in student financial support, but modest amounts of student financial support for institutional dollars are not associated with higher graduation rates.

Of the institutional expenditure categories included in the model, instructional, library, and academic support minus library expenditures were significantly related to graduation rates in the full model. These variables also had the greatest independent effects on graduation, and each explained between 21% and 34% of the variance in graduation rates when analyzed as sole predictors. The robustness of these variables singly as well as in the broader model supports the importance of funding instruction and academic support budgets. It is important to note, however, that the ultimate *nature* of the expenditures and any separate impacts remain unclear.

For example, the largest proportion of instructional expenditures clearly is salaries and benefits for instructional personnel. Due to the aggregate nature of the data, it is not possible to comment on relationships between various *levels* of instructional personnel and graduation rates. Furthermore, such an analysis would have to be planned carefully to incorporate the levels of courses and students typically taught by, say, full professors versus adjunct instructors.

As another example, library resource allocations may be expended disproportionately on digital technology and information retrieval systems rather than on periodical subscriptions and book purchases. In such cases, it is not possible to separate the effects of traditional library resources on graduation rates from the effects of advanced technological resources that libraries on many campuses increasingly house. Nonetheless, higher library allocations and instructional expenditures are associated strongly with higher student graduation rates. As mentioned in the discussion of independent effects above, expenditures on student affairs is a significant independent predictor of graduation rates, but its effects are negligible when analyzed as one variable within the context of the full model.

One issue that arose in the course of our data analysis is related to the higher graduation rates among undergraduates at institutions representing higher Carnegie classification levels. It is somewhat puzzling that undergraduate students succeeded at higher rates at research-oriented institutions than at colleges and universities with prevailing emphases on undergraduate education, as indicated by institutional mission and espoused purpose. Graduation rate is not the sole outcome indicator of students' success; stopping in and out to take coursework that satisfies individual students' needs also constitutes a successful educational experience for many undergraduates. Additionally, however, among input characteristics, more selective admissions is associated with higher Carnegie ratings, suggesting that academically better-prepared students are more likely to attend research, rather than baccalaureate, institutions. It also may be the case that research-oriented institutions are better positioned financially to offer resource-rich environments that foster higher—or at least more timely—graduation rates.

Recommendations for Further Research

In addition to contributing empirical findings, this study provides a framework for institutional planners and representatives of state systems of higher education for incorporating questions of resource allocation into strategic thinking about undergraduate persistence to degree attainment. Institutional planners, as well as various campus units, can use these findings to support their cases for dedicated or increased funding. For example, an institution's declining rank on a national survey of libraries may be seen mostly as an unfortunate condition, but evidence of a predictive relationship between library allocations and undergraduate graduation rates can help connect the need for increased library funding with an institution-wide goal of student retention. When significant new monies are not likely to be realized from state appropriations, this study also can provide guidance for fund-raising priorities and targeted capital campaigns. Conversely, however, the results from this model also may provide guidance for strategic budget reductions, as institutional planners will be better able to determine the implications for graduation rates of selective allocation reductions.

Institutional planners wishing to implement insights from this research are not likely to have infusions of new monies with which to do so. It may be decided instead to load dollars disproportionately into strategically defined categories, but this represents a balancing of resource allocations among several categories; gains and losses affect other categories as allocations are shifted and redistributed. It is not clear how shifts and reallocations in some categories will affect student graduation rates, nor whether there perhaps is a marginal or threshold proportion of funding that, if not realized or exceeded, is necessary for budgetary categories unrelated to graduation rates. Further research can pursue these questions and provide more targeted guidance to institutional planners and to policy and budget analysts. In general, better information for planners will make them more likely to attain benchmarks through thinking strategically about obtaining and spending funds. In this context, it is appropriate to consider that, based on analysis of IPEDS data, economic disparities among institutions and their students are increasing (Winston, 2000).

Finally, this study can provide useful guidance for interpreting academic work to various publics, such as legislative bodies or media representatives. It can be unclear whether or how an institution's financial decisions are related to desirable outcomes such as graduation rates. This study can assist, by demonstrating connections between institutions' accountability for their stewardship of public resources and the larger good that is served by strategic allocation of resources to support the goal of student graduation and other aspects of the institution's mission. Institutional decisionmakers may be better able to decide where to make budget cuts and to make more finely-tuned determinations of the tradeoffs and other consequences of such budgetary reallocations across areas of university activity (e.g., Kissler, 1997).

Further research can focus on examining private colleges and universities or incorporating additional variables that will enable reasonable comparisons between public and private higher education institutions. Additional research also will be necessary to see whether the revised Carnegie classification system is similarly useful, in conjunction with other variables, in examining student graduation rates. Longitudinal research also is warranted to test this analysis across time. This study combined data from two sources to analyze one year's worth of data, but it remains unclear how patterns of resource allocation decisions spanning a number of years may affect graduation rates or provide additional insights into how such decisions relate to student graduation. Finally, HBCU status and admissions selectivity warrant much more study. Each of these variables presented much more complexity than was expected initially, and the role that each plays in graduation rates is accounted for only partly in this model in conjunction with the other variables that were selected.

Additional variables that were not available for the data set employed in this analysis may be useful in future research. Disaggregating institutional expenditure and financial aid data into separate undergraduate and graduate components would be extremely useful for predicting undergraduate graduation rates. Also, it remains to be seen what differences in ability to predict graduation rates will emerge from any further revisions in the Carnegie classification system. Furthermore, within the current Carnegie classification system, it would be informative to include private institutions, to assess whether these findings are unique to public institutions. We have no direct measures of socioeconomic status at the institutional level, although future research may find it productive to employ measures of student eligibility for financial aid such as percentage of students eligible for Pell grants. In addition, a measure of the extent to which a campus is residential would be informative, particularly regarding the allocation of institutional costs for on-campus student support.

Future research may be guided, too, by the reality that many of the significant predictors in this analysis involved variables that were not directly controllable by institutional administrators. Institutional location and type are not changed easily, if at all, and selectivity is difficult to change in the short run particularly in public institutions owing to legal requirements to admit a wide range of in-state high school graduates. Nonetheless, our results suggest that controllable variables such as student financial aid, instructional expenditures, library expenditures, and nonlibrary academic support expenditures exert major influence over graduation rate outcomes. An elaboration of these controllable aspects of institutional realities, perhaps fortified by exemplary case studies, would provide valuable additional perspectives on what institutional officers and public decisionmakers can do to influence the rate at which students successfully complete their undergraduate studies.

Notes

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1. The categories listed preceding E&G are included within the E&G total, but E&G also contains other categories of expenditures (such as auxiliary enterprises) that were not included in this analysis. Thus, including E&G in our model does not produce exact collinearities with its constituent variables that are included in the same model.

2. It is important to note that, although the effect of REGION is not significant in this full model, there are significant differences in estimated mean graduation rates attributable to REGION ($F = 5.134$, $p < .001$, $(\text{eta})^2 = .080$, power = .998) when the two interactions are removed from the full model. Clearly, the effect of REGION in the full model containing interactions is attenuated in particular by the interaction with MEDICAL. In the alternative non-interaction model, URBAN is significant ($F = 25.782$, $p < .001$, $(\text{eta})^2 = .059$, power = .999). There are no other major changes between the interaction model results shown in Table 1 and the alternative model without interactions ($R^2 = .571$, adjusted $R^2 = .541$; see Table 5). For the model lacking interaction effects, the estimated marginal means are also highest for the Mid-East (43.632%) and New England (38.898%), followed by the Great Lakes (36.995%), Southeast (36.057%), West Coast (35.400%), Plains (35.232%), Rockies (32.790%), and Southwest (30.530%).

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