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G. Thomas Sav
Wright State University - Main Campus, tom.sav@wright.edu

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G. Thomas SAV, Professor of Economics, Department of Economics, Raj Soin College of Business, Wright State University, Dayton, OH, USA
tom.sav@wright.edu

The primary objective of this paper is to determine whether tenure in comparison to non-tenure faculty employment is efficient in producing the academic success of university students. A stochastic production frontier is estimated for university graduation rates while the inefficiency specification includes measures of tenured, tenure-track, and non-tenure track faculty employment. Using panel data for U.S. doctoral and master level public universities, the evidence indicates that the employment status does matter and that increases in the proportion of tenured faculty employment lead to efficiency gains in graduation rates. Effects of tenure-track and non-tenure track faculty are somewhat mixed with non-tenure track employment being inefficient among doctoral universities but efficient in the less research intensive master level institutions. From a policy perspective, the findings suggest that university administrators might improve both student academic success and government appropriated funding by reversing the non-tenure track hiring trend and advancing tenure among the faculty ranks. However, improvements in the quality of data along with investigations into the effects pertaining to the growth of online instruction and e-education would be most desirable in providing additional tests.

Keywords: *graduation, efficiency, stochastic, tenure, non-tenure, university*

Introduction

This paper estimates the effects of faculty employment status on the efficiency of producing student academic success. The status of interest includes university faculty employed under contractual arrangements

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defined by tenure, tenure track, and non-tenure track employment. Using undergraduate student graduation rates, a stochastic production frontier is estimated using panel data for 318 public U.S. universities operating over the 2005-09 academic years. The employment standings of faculty enter as determinants of the inefficiency term in the stochastic specification. Thus, university efficiencies in producing graduation success are conditioned on the employment status of faculty and, therefore, administrative decision-making regarding the allocation of university resources in support of the traditional academic tenure system relative to relying on non-tenure track faculty employment.

The efficiency of faculty in relation to a university's graduation rate success is of importance from many perspectives, two of which follow. First, universities seek to successfully educate students. Graduation rates represent one measure of that success. Second, in funding public universities, state governments are increasingly abandoning traditional enrollment driven measures in substitute for student success measures. Legislated funding has already been tied to university graduation rates (Dougherty and Reddy, 2011). Thus, from both perspectives university administrators, public policy decision-makers, tax-payers, and students should be cognizant of how the allocation of university resources and subsequently the composition of faculty employment impacts graduation success.

That composition has undergone some dramatic changes over the past several decades and has, for the most part, been attributed to the widespread decreases in government appropriations for the funding of public higher education. With that, university administrators have attempted to hold down or reduce labor costs by hiring less expensive non-tenure track faculty that do not hold doctorates, are not required to produce research, and are contractually held to higher teaching loads. It is further claimed that non-tenure track labor provides university administrators the needed managerial flexibility to adjust to ever changing funding and budgetary conditions. The end result over three decades has been a decrease in the percentage of tenured and tenure-track faculty employed throughout higher education from 57% to 35% (August, et al., 2006). Full-time non-tenure track faculty employment has increased from 13% to 19%. And among all of higher education institutions, part-time faculty status increased from 30% to 46%, although the percent of classes or student credit hours taught by part-timers is unknown (American Association of State Colleges and Universities, 2006). In addition, information is unavailable as to the inclusion or exclusion of graduate student teaching employment in those statistics. However, at the very micro level, studies involving a single college or university have found a mixture of negative and positive student performance effects associated with graduate student teaching. Other studies have concentrated on adjunct employment and have also reported such mixed effects on student outcomes, depending on how outcomes are measured.

The literature review to follow reveals only six studies that investigate such effects on student retention, major selection, or graduation that can be attributed to differences in instructor status. Those studies have empirically employed variations of a production function approach using different measures of instructor employment as inputs. However, none of the studies have considered how differences in the employment status of faculty affect university efficiency. As throughout economics, efficiency plays a critical role in evaluating the allocation of resources and the effects of managerial and public policy decision-making. Since professional qualifications and workload (including teaching, research, and service) vary across faculty employment statuses, it would be likely that there exist efficiency differences in the university production of student academic success. The present paper's focus on these efficiency effects represents the departure from previous studies and the contribution of the present study to understanding how differences in faculty employment might affect university graduation rates.

The next section of the paper proceeds with the literature review. That is followed by the development of the empirical model, an explanation of the data source and variables, and then the empirical results. The final section contains a summary of the conclusions.

Literature Review

Studies of the effect of faculty employment status on university student academic success are scare, at best. That conclusion is supported by the Bettinger and Long (2010) review that finds "effects of instructors on student outcomes in higher education is virtually absent from the literature." Their review identifies five studies relevant to investigations at the four year college and university level. A literature review indicates that no new studies have been produced since their review. Thus, the following is principally a summary of the studies referenced by Bettinger and Long (2010).

Three studies focus only on the effects of graduate teaching assistants

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and primarily on foreign born assistants. Norris (1991) examines the effect of non-native English speaking teaching assistants on the average course grades at the University of Wisconsin during the 1983-87 fall semesters. He finds that such teaching assistants do not result in lower student performance compared to students taught by U.S. born assistants. Results presented by Borjas (2000) indicate that foreign born teaching assistants employed at an undisclosed large public university have negative effects on the performance of undergraduate students in economic principles classes. A study by Fleisher, et al. (2002) also draws upon the performance of economics students at a single public university, Ohio State. The data are for 1995-96 through 2000. They find that when foreign graduate assistants receive English speaking training and teaching skills, they are no different in overall teaching effectiveness when compared to native born teaching assistants.

Another three studies are largely concentrated on the effects of adjunct faculty or part time vs. full time faculty rather than on graduate teaching assistants. Ehrenberg and Zhang (2005) employ institutional level data for the academic years 1986-87 to 2000-2001 to explore the effects on graduation rates attributable to the use of part time and non-tenure track faculty. Institutional data are drawn from national data bases and include postsecondary colleges and universities reporting SAT scores. The empirical results indicate that increases in the employment of faculty under both contractual arrangements reduce student graduation rates. Moreover, the adverse effects are more pronounced at public universities. While the Ehrenberg and Zhang study samples institutions across states in the U.S., the Bettinger and Long (2004) study more narrowly utilizes data for 18 to 20 year old students who took the ACT and entered public universities in a single state, Ohio. Their paper estimates the impact of adjuncts and graduate assistants on the retention of student interest in a subject. Findings indicate a negative effect due to both types of instructor employment but the negative adjunct effects are associated with younger adjuncts (under 40 years of age) and vary by disciplines with negative effects in the humanities but positive effects in professional disciplines. In their second study, Bettinger and Long (2010) use the same data on Ohio universities but use a different econometric model and, unlike their first paper, include only adjuncts in the analysis, thereby dropping graduate assistants. Their results on adjunct employment are basically the same as in the first paper, concluding that the impact varies by discipline with a positive effect in professional fields.

The approach used in the present study is most closely aligned with that of Ehrenberg and Zhang (2004). The likeness derives from the use of public universities drawn from throughout the U. S. systems of higher education as the units of observation and the use of university graduation rates as the measure of student success. The likeness ends there and from the other five studies in that the paper represents the first to provide empirical estimates of the "efficiency" of faculty in the production of student academic success when faculty are employed under different contractual arrangements. Thus, unlike previous studies, the empirical approach employs a stochastic frontier analysis and estimates an underlying production frontier for university graduation rates with faculty being a production input but the proportions under which they are contractually employed being determinants of production inefficiency. Unlike previous studies, the approach allows efficiency effects to be estimated for three employment classifications of faculty, including tenured faculty, tenure track faculty, and part-time and full-time non-tenure track faculty. The details of the approach are explained in the empirical model to follow.

Empirical Model

The empirical model from which the efficiency estimates are derived rests with the application of stochastic frontier analysis. Originally proposed by both Aigner, et al. (1977) and Meeusen and van den Broeck (1977), stochastic frontier analysis has become the standard econometric technique for evaluating the efficiency of firms, agencies, and institutions in the private and public sectors. The basic notion is that production is bounded by a maximum level given current quantities of inputs. Failure to obtain the maximum achievable output results in inefficiency. In extending the measurement of efficiency, Kumbhakar, et al. (1991) and Battese and Coelli (1995) introduced the notion that environmental factors and input characteristics can affect inefficiency. Battese and Coelli (1995) developed the panel data specification for incorporating these covariates in the technical inefficiency effects. Applications of that model have successfully migrated to the evaluation of production and cost efficiencies existing among colleges and universities (Stevens, 2005, Sav, 2012a, Sav 2012b). However, the extension in the present paper represents the first empirical evaluation of faculty employment efficiency in the production of university graduation rates.

Employing panel data, the university production frontier for $i=1,\ldots,N$ universities producing student graduation rates, GradRate, over $t=1,\ldots T$ years is defined by

$$GradRate_{it} = f(X_{it};\alpha) + V_{it} - U_{it}$$

where X is a vector of education production inputs and α is the vector of associated coefficients to be estimated. In this formulation, V represents the stochastic error that is assumed to be independently and identically distributed as $N(0,\sigma_V^2)$. That is, graduation rates can be affected by random shocks such as union strikes, natural disasters (e.g., the 2005 Hurricane Katrina) and terrorism (e.g., the 2007 Virginia Polytechnic Institute and State University massacre). On the other hand, U is a non-negative random variable intended to account for potential technical inefficiency in producing graduations. That inefficiency or efficiency can be due to university managerial ineffectiveness or effectiveness, governmentally imposed regulatory constraints, or embedded in the characteristics of university inputs. The interest here rests primarily with the inefficiency or efficiency that could arise from variations in the employment status of university faculty, which, of course, is also under the control of management, albeit to varying degrees depending upon the institution. The employment status as determined by the contractual arrangements under which faculty are employed include, tenured faculty, tenure-track faculty, and non-tenure track faculty.

Following the Battese and Coelli (1995) panel data specification, the potential inefficiency effects arising from faculty employment status and university managerial hiring decisions are specified as

$$U_{it} = Z_{it}\delta + W_{it}$$

where Z is a vector of university specific variables and the δ are the respective coefficients relating the possible inefficiency effects due to differences in faculty employment status. W is a random error that follows the truncated normal distribution with zero mean and variance σ_U^2 with $-Z_{it}\delta$ being the point of truncation (Battese and Coelli, 1995). The model is simultaneously estimated using a maximum likelihood method. The re-parameterization is employed so that the composed error is $\sigma^2 = \sigma_V^2 + \sigma_U^2$ and $\gamma = \sigma_U^2 / \sigma^2$. Since the latter lies between zero and one in representing the proportion of inefficiency in the composed error, it can be used to test the validity of the stochastic specification relative to the use of ordinary least squares (Coelli, et al., 1999). If gamma is not significantly different from zero, then the inefficiency term in should be removed from the model.

With inefficiency present, the model permits an estimate of the technical efficiency (EFF) of each university over time as determined by the following:

$$Eff_{it} = \exp(-U_{it}) = \exp(-Z_{it}\delta - W_{it})$$

Thus, as university inefficiency increases, technical efficiency decreases. However, negative δ coefficients associated with specific *Z* variables represent inefficiency reductions and, therefore, technical efficiency improvements.

Empirical implementations of stochastic frontiers generally proceed with either a Cobb-Douglas or translog specification. In preliminary tests using both specifications, the empirical results were not so different as to warrant use of the more taxing translog with its lack of economic meaning in the estimated coefficients. The Cobb-Douglas specification, in supporting the same results, offers the advantage that estimated coefficients are interpreted as elasticities. Thus, by Occam's razor we choose the following simpler Cobb-Douglas form for the production function

$$\ln GradRate_{it} = \alpha_0 + \sum \ln X_{it} + V_{it} - U_{it}$$

and for the inefficiency term, following Coelli, et al. (1999),

$$U_{it} = \delta_0 + \sum \ln Z_{it} + W_{it}$$

where the production, *X*, and inefficiency, *Z*, variables are defined in the subsequent data section of the paper.

Data

Individual university level data come from the Integrated Postsecondary Education Data System (IPEDS) maintained by the U.S. Department of Education, National Center for Education Statistics. A panel data set is employed for 318 U.S. universities operating during the four year period involving the 2005-09 academic calendars. The sample contains two basic categories of Carnegie classified universities: research-doctoral universities and master level colleges and universities. To account for possible efficiency differences between the two levels, the empirical analysis will include a dummy control variable in the inefficiency equation (Doctoral=1 for doctoral level universities; 0 otherwise). Preliminary tests conducted on the production function indicated that there were some structural differences in the underlying technologies among doctoral vs. master level. Thus, in addition to the pooled dummy variable estimates, separate model estimates will be presented for each university classification.

The determinants defining and entering the stochastic production function are, of course, limited by the availability of data. The graduation rate, GradRate, is defined as the completion within 150% of the normal time to degree completion. For the baccalaureate, this rate is the percentage of students that have graduated in the six year time from university admission. While the data covers 2005-09, the rate is a continuous measure that reasonably captures the overall graduation rate success of universities and the variation in success across universities. For the determination of graduation success, it was possible to construct and include the following production variables, *X*:

SAT=Scholastic Aptitude Test score;

Persistence=fall percentage of returning students who have not graduated;

LowIncome=percentage of students enrolled on low income federal grants;

UnderGrad=total full-time equivalent undergraduate enrollment;

GradEnroll=total full-time equivalent graduate enrollment;

StudentExp=university expenditures per student on student services;

Grants=university provided grants and scholarships per student;

Research=percentage of total university expenditures devoted to research;

Faculty=total university faculty;

Year=time trend for academic year of observation.

The first three variables are intended to measure some of the characteristics associated with the university's student body, including academic preparation per the average SAT admission test score, student persistence as determined by the average student retention from fall to fall semester, and the percentage of students enrolled on low income federal grants.

It would be expected that the first two are positively related to academic success and student graduation rates. Even with federal assistance, low income grant students would be expected to have more financial difficulties with higher education financing and are more likely to come from underfunded primary and secondary school districts. Overall, the low income grant recipients are likely to have lower graduation success.

Both UnderGrad and GradEnroll are included as measures of institutional size and production at both the undergraduate and graduate educational levels. Many studies (e.g., see Sav, 2004 and references therein) have found substantial economies of scale in the production of both undergraduate and graduate education when university output is measured by enrollments or credit hours. How those economies might translate into the production of educational success as measured by institutional graduation rates is uncertain. Hopefully, the empirical results will provide useful guidance on the matter. The data did not permit a division of graduate education by doctoral and master level student enrollments and did not make available the employment of graduate assistants in undergraduate teaching. However, as an aggregate measure, the GradEnroll variable can act as an indicator of the extent to which the university is involved in the production of graduate education. And in that capacity, it is possible that increased graduate education production or focus can have differential effects on undergraduate graduation success. Whether those effects are positive or negative is to be empirically determined.

The remaining four variables are related to university inputs. Greater expenditures on student services per student, StudentExp, suggest greater student oriented universities that should lead to positive effects on overall graduation rates. The same positive effect should derive from university provided scholarships and grants. All doctoral and master level universities in the sample produce research. Here, the degree to which the research focus varies across institutions is proxied by the university expenditures on research as a percentage of all total expenditures, i.e., the Research variable. A priori, it is uncertain as to what effects greater research focus has on student graduation success. It could be a detraction from undergraduate education or complementary to it. However, as a university input, the faculty employment variable, Faculty, is expected to carry positive influences on graduation rates. And finally, a Year variable is included in the production frontier to account for possible technical changes in the production of graduation rates.

Technical inefficiency is modeled with three faculty employment status variables and a faculty wage variable. The Z's are as follows:

Tenure=percent of faculty that are tenured;

Track=percent of faculty on tenure track;

NonTenure=percent of faculty in non-tenure positions;

Salary=average faculty salary;

The faculty salary variable is included to control for wage differentials across universities and their possible effects on inefficiency. The full specification includes a control variable for university type: Doctoral=1 for doctoral university, 0 for master university. In addition, empirical implementation includes the two separate sector estimates.

Table 1 contains a summary of the means, standard deviations, and percentage changes over time for all variables entering the frontier model.

Table 1: Variable Statistics and Annual Changes

Variable	Mean	Std. Dev.	2006-07	2007-08	2008-09
GradRate (%)	48.83	14.82	0.58%	0.69%	1.59%
SAT (#)	931	106	0.00%	0.36%	0.05%
Persistence |(%)	75.34	9.11	-0.06%	0.55%	1.40%
LowIncome (%)	29.72	14.44	0.00%	0.00%	-0.24%
UnderGrad (#)	11,988	8,060	1.53%	1.68%	1.67%
GradEnroll (#)	2,878	2,695	1.80%	5.48%	9.05%
StudentExp ($)	1,309	566	5.98%	11.32%	3.32%
Grants ($)	1,139	1,231	8.98%	9.17%	5.26%
Research (%)	6.55	8.41	0.25%	1.12%	1.25%
Faculty (#)	514	366	1.93%	2.46%	0.15%
Tenure (%)	53.78	10.55	-0.11%	-0.70%	2.25%
Track (%)	27.24	7.25	-0.44%	0.07%	-2.56%
NonTenure (%)	18.98	9.73	0.95%	1.87%	-2.57%
Salary ($)	68,145	11,928	3.88%	3.13%	1.41%
N (#)	1272	1272	1272	1272	1272

As indicated, the mean student graduation rate is approximately 49% with slight increases occurring with each academic year. That is accompanied by small improvements in the mean SAT score and student persistence. Of the nearly 12,000 undergraduate student enrollments, approximately 30% are recipients of low income federal grants. Over the four year period, a fairly steady increase occurs with respect to undergraduate enrollments, but the real enrollment growth exists at the graduate level. That can be attributed to the high unemployment induced by the financial crisis and subsequent recession driving baccalaureate degree holders back to school. The crisis also appears to have slowed the growth in university expenditures on student services, as well as institutionally provided student grants and scholarships. Expenditure reallocations resulted in a substantial increase in the proportion of expenditures devoted to research activities. Total faculty employment averages a little over 500 with a relatively large percentage increase occurring in the 2007-08 academic year. Of the faculty employment, tenure averages around 54 percent and non-tenured employment at approximately 19%. The 2008-09 academic year witnessed a large percentage increase in tenured faculty accompanied by a somewhat larger decrease in the percentage change in tenure track faculty. Based on the data, it is only possible to assume that most of the tenure increase came from tenure track promotions. That shift was met in 2008-09 with a decline in the proportion of non-tenure track faculty employment. Surprisingly, faculty salary increases, although small, were present even following the financial crisis.

Results

The empirical estimates are presented in Table 2 for the pooled dummy variable model and separately for the doctoral and master level classified universities.

Table 2: Stochastic Frontier Estimates

Production	Pooled Dummy		Doctoral		Master	
Constant	*-1.387	0.228	*-2.453	0.340	*-2.544	0.582
SAT	*0.017	0.006	*0.017	0.006	***0.161	0.083
Persistence|	*1.406	0.046	*1.666	0.069	*1.331	0.066
LowIncome	*-0.157	0.011	*-0.095	0.019	*-0.146	0.018
UnderGrad	*-0.144	0.018	*-0.163	0.028	*-0.089	0.026
GradEnroll	*-0.045	0.007	*-0.062	0.018	*-0.029	0.009
StudentExp	0.016	0.010	-0.009	0.014	*0.048	0.012
Grants	*0.012	0.003	0.013	0.008	*0.012	0.003
Research	*-0.012	0.003	*-0.022	0.007	*-0.012	0.004

Faculty	*0.195	0.020	*0.231	0.032	*0.113	0.030
Year	-0.003	0.003	0.004	0.006	*0.031	0.005
Inefficiency	Pooled Dummy		Doctoral		Master	
Constant	*19.259	3.623	*3.165	1.200	*57.422	20.230
Tenure	*-0.785	0.123	*-4.221	0.185	***-2.266	1.177
Track	*0.192	0.052	*-1.157	0.142	0.088	0.178
NonTenure|	**0.085	0.037	0.063	0.040	**-0.855	0.412
Salary|	*-1.655	0.322	*1.378	0.118	*-4.643	1.678
Doctoral	*-1.245	0.225				
Sigma^2	*0.239	0.033	*0.144	0.010	*0.712	0.362
Gamma	*0.961	0.004	*0.947	0.007	*0.988	0.007
LL	634.2		343.8		361.7	
LR	*490.6		*370.6		*148.7	
Note: Significant at the 1% (*), 5% (**), and10% (***) level or better						

As Table 2 results indicate, in all three cases, gamma is statistically significant at the 1% level and better, thereby supporting the inclusion of inefficiency effects over an ordinary least squares specification. In addition, based on the highly significant likelihood ratios, the hypothesis that the inefficiency effects are jointly absent from the model is rejected.

Eight of the ten coefficients (plus the constant term), in the production function for the pooled dummy variable model are statistically significant at the 1% level or better. The first three student related variables, SAT, Persistence, and LowIncome carry the expected signs. That is, academic preparation (SAT) and student retention (Persistence) have positive effects on graduation. The negative effect associated with LowIncome indicates student enrollments supported by low income government grants have negative effects on six year graduation rates. Again, that effect may due to those students facing greater financial difficulties and having lower quality primary and secondary schooling. They may be enrolling in remedial type classes and taking longer to graduate, dropping out for financial reasons, or transferring to another institution.

Not surprising is the finding that undergraduate enrollment size matters and has a negative effect on graduation rates. That supports the general belief that universities can offer more attention to the academic needs of smaller relative to larger student bodies and, therefore, produce higher graduation rates. Increases in faculty employment (Faculty) have positive effects on that production. Added results, however, show that increased focus on graduate education and research, as measured by GradEnroll and Research, carry negative effects on undergraduate graduation rates. The findings offer some support for more specialization in the provision of U.S. public higher education.

For the remaining three production variables, only the institutionally provided scholarships and grants variable (Grants) is statistically significant at any reasonable level significance. As expected that financial support has a positive influence on student graduation. Student service expenditures (StudentExp) also have the expected positive coefficient but are statistically too weak in affecting student graduation. The negative Year effect suggests technological regress but is also too weak to support a statistically based conclusion. Except for these three variables, all of the production variables and estimated coefficients carry the same sign and level of statistical significance in the separately estimated models for doctoral and master level universities. This lends support to the robustness of the estimates. However, in the separate sector estimates, university provided student services and scholarships are statistically significance and positive in their effects on graduation rates for the master level universities. In addition, the positive and significant Year effect supports the existence of positive technological improvements occurring among those universities.

Of particular interest are the results of the inefficiency effects presented in Table 2. For the pooled dummy variable estimates all the inefficiency effects are found to be statistically significant at the 1% level or better. The negative effect of Tenure indicates that increases in the proportion of tenured faculty employment at universities are effective in increasing the technical efficiency of producing student graduation rates. The estimates indicate that both tenure track (Track) and non-tenure track (NonTenure) faculty are inefficient in this regard. The tenure track result is in accord with our general intuition in that research requirements imposed by the bid for tenure largely takes priority over teaching at many institutions. Yet, teaching workloads and specific research requirements, which are unavailable for the present data, obviously work to affect both outputs. Given that research requirements are heavier at doctoral relative to master level institutions but teaching loads are the opposite, it is difficult to postulate what overall inefficiency effect might arise from tenure track faculty employment. The separate sector estimates in Table 2 produce different effects. Among doctoral universities, tenure track faculty, as with tenured faculty, have the same inefficiency reducing and technical efficiency improving effects; albeit, based on the size of the coefficient, the Track inefficiency effect is substantially smaller. In contrast, as with the pooled dummy variable estimate, the tenure track faculty effect remains positive in the master level inefficiency equation, but its statistical insignificance (at 62%) suggests that so-called junior faculty cannot be considered as inefficiency producing. Similarly, increases in the proportion of non-tenure track faculty, while inefficiency creating in doctoral university employment is insignificant when evaluated the 10% level. Yet, its effect can be declared to be statistically significant with a small compromise to an 11.5% level of significance, thereby tending to reinforce the pooled dummy variable result. Counter to that is the efficiency improvements delivered by non-tenure track faculty among master level universities. The differential effects of the NonTenure variable in doctoral vs. master universities could be accounted for by differences in class size teaching assignments: e.g., larger introductory classes at the larger doctoral universities that escape the present analysis. However, to the delight of all faculty, the pooled findings invite increases in faculty salaries as a mechanism for improving university efficiency. On the other hand, the separate doctoral relative to master level university estimates suggest a salary reallocation away from the doctoral to master universities as means to overall efficiency gains. That is, of course, absent the differential effects on research productivity.

Table 3 reports the results pertaining to university technical efficiencies. The mean efficiency under the pooled dummy variable estimation is approximately 89%, thereby indicating that with given resources, universities are producing close to the maximum graduation rates within the six year graduation window. Doctoral relative to master level universities are more efficient according to the estimates (t-tests of mean equalities produced a t=7.91).

Table 3: University Efficiencies

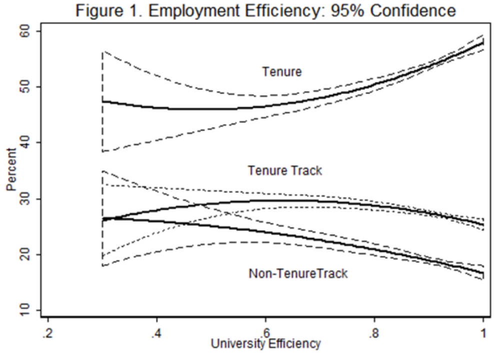
	Pooled	Doctoral	Master
Mean	0.889	0.929	0.878
Median	0.917	0.944	0.885
Minimum	0.448	0.434	0.748
Maximum	0.981	0.983	0.949
Std. Dev.	0.085	0.062	0.043
Skewness	-2.363	-5.246	-0.70
Academic Year Changes			

2006-07	0.46%	-0.36%	-0.20%
2007-08	-0.36%	-0.44%	2.15%
2008-09	-0.06%	-0.06%	0.02%

As Table 3 shows, the variability of efficiencies is much greater within the doctoral sector compared to the master level universities; the skewness of the doctoral efficiency distribution is more than seven times that of the master level universities. The difference can be due to the greater heterogeneity embedded in the research-doctoral classified group of universities. It includes the premier flagship public universities in the U.S. along with much lower research intensive and doctoral producing institutions. Academic year changes in mean efficiencies are calculated and appear in the lower portion of Table 3. In the pooled model, there occurs a small efficiency improvement in the 2006-07 academic year. Thereafter, universities witnessed declining efficiencies, although as minor as 0.06% in 2008-09. Examining the performance according to the separate sector estimates, the doctoral universities closely mirror the pooled estimation results. In comparison, master level universities managed a relatively large efficiency gain of 2.15% in 2007-08 followed by a flat but still positive 0.02% improvement in 2008-09.

In a summary analysis, university efficiency scores are examined along with faculty employment compositions. Figure 1presents the results using the pooled dummy variable estimates. Mean university efficiencies and employment percentages are presented as the solid lines on the basis of the 1,272 observations over the four academic years. The bands represent the 95% confidence intervals and are illustrative of the negative skewness of the estimates previously presented.

Figure 1. Employment Efficiency: 95% Confidence



In Figure 1, the more powerful appearing tenure to efficiency relationship emanates, of course, from the larger coefficient associated with the Tenure variable in the inefficiency term (Table 2). The tenure track to efficiency relationship indicates that tenure track faculty are efficiency producing employees over a fairly wide employment range. That result is consistent with the effect found among doctoral universities. The eventual tenure track efficiency decrease is then the effect that takes hold with respect to the empirical findings associated with the master level universities. Non-tenure track faculty effects on efficiency, on average, are illustrated as being comparatively weak up to about the 60% efficiency mark. Following that, smaller proportions of non-tenure track faculty employment is associated with more efficient universities.

Conclusions

The objective of this paper was to investigate whether or not and to what extent there exist efficiency differences in the production of student graduation rates that might arise from differences in the tenure employment status of faculty. Using a panel of 318 public doctoral and master degree classified U.S. universities, stochastic frontier results indicate that statistically significant efficiency differences are present. To check the robustness of results, efficiencies were estimated using a pooled dummy variable model and the same stochastic specification separately for doctoral and master level universities. Across all model specifications, increases in the proportion of tenured faculty was found to produce efficiency gains in producing student academic success as measured by graduation rates. In pooling observations, the findings suggest that tenure track faculty presumably immersed in tenure producing research requirements are inefficient in increasing student graduations. However, tenure track faculty and their research output appears to be valuable and efficiency producing among research intensive, doctoral level universities. In contrast, the inefficiency effect of tenure track faculty emerges as insignificant in the less research intensive master level sector. Employing non-tenure track faculty also produced some mixed results. As a group they found to be inefficient in the pooled estimates and among doctoral universities. Yet, in the less research intensive master level universities, increased employment of non-tenure track faculty led to graduation efficiency improvements.

Overall, the findings offer caution to university administrators and public policy decision-makers responsible for public higher education funding legislation. While there are obvious cost savings accruing from faculty hiring outside of the traditional tenure and tenure-track system, those savings can be potentially accompanied by negative effects regarding the production of student academic success. Any production or efficiency loss in that sense runs counter to the educational mission of higher education. Moreover, from a university funding perspective, employment cost savings that results in efficiency regress may exacerbate university budgetary problems as public higher education funding formulas become increasingly tied to university graduation success rates. However, it is quite likely that there are more and perhaps dramatic changes on the horizon for publicly provided higher education in the U.S., as well as internationally. That pertains not only to funding changes but to the ever increasing growth of on-line, e-education. The efficiency effects of the latter have not been rigorously evaluated from the perspective of U.S. higher education or publicly produced education in other countries. That should be placed on more immediate rather than delayed research agendas.

As future research unfolds it is important that it seek improvements in the quality of data. In particular, much greater attention is needed in improving measures of student academic preparation. Here, as with other studies, the results had to rely on student's standardized test scores. In addition, student graduation success depends upon the quality of university teaching. That quality measurement continues to escape empirical studies of student outcomes. In this study, one must assume that better teachers are tenured. However, if quality research is complementary to quality teaching, then, by the same token, better measures of faculty research output are also in order. With recognition of such weaknesses, the empirical results presented here are consistent with the bulk of conventional wisdom that academic tenure produces positive outcomes. And although the present study offers advances toward a more rigorous empirical support of that contention, the totality of studies is anything but widespread in the literature. As more and hopefully improved data becomes available, additional tests are needed before any definitive conclusions can be put forth.

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