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Stochastic Cost Inefficiency Estimates and Rankings of Public and Private Research and Doctoral Granting Universities

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Stochastic frontier cost and inefficiency estimates are provided for research and doctoral granting universities in the U.S. Separate sector estimates are produced for public and private non-profit universities. Panel data spanning four academic years, 2005-2009, is used to estimate underlying cost structures. Inefficiency is modeled as depending on institutionally specific environmental factors. Results indicate that public universities are on average more efficient than their private counterparts. The latter exhibit greater variability and when evaluated at the median inefficiencies there does not appear to be any statistically significant difference. Time varying inefficiency estimates point to public sector efficiency gains but private sector increasing inefficiencies. Interestingly, results indicate that increases in faculty tenure lead to efficiency improvements. Inefficiency rankings place private ivies among the most inefficient universities whereas public flagships are distributed throughout their sector rankings.

Keywords: *Cost inefficiency, Stochastic cost frontier, Public and Private Universities*

Introduction

This paper provides empirical estimates and comparisons of the operating cost inefficiencies of public and private non-profit research and

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doctoral granting universities in the United States. These institutions operate in a global market with regard to attracting students, faculty, and research funding. They include and compete with some of the most elite universities in the world. Like those institutions, the efficiency with which these universities produce their mix of educational and research products should be of managerial and public policy interest from at least two broad perspectives. First, they are seen as some of the primary drivers in the pursuit of a knowledge based economy and, therefore, it seems essential that we be aware of any operating inefficiencies and the root causes of them as they exist in public compared to private non-profit ownership structures. Second, from the perspective of the consequences generated by the global financial crisis, they are likely to have to contend with additional declines in government education and research funding, as well as an expanding interest in comparative evaluations of the efficiency with which goods and services are produced in the public relative to the private sectors, including higher education.

In what follows, the cost efficiencies of these universities are estimated using stochastic frontier analysis. The application of frontier analysis to higher education efficiency evaluations has surfaced only since 2002. As indicated in the next section of this paper, there exists a total of five studies, none which examine U.S. higher education or public compared to private research universities. In the present study, panel data are employed for 142 public and 77 private Carnegie classified research and doctoral granting universities spanning four academic years, 2005-09. The underlying cost structure is estimated with a multiproduct Cobb-Douglas specification and the inefficiency model is constructed from a set of environmental determinants. Time varyig inefficiencies are reported for each sector and institutional specific inefficiencies are generated and used to provide inefficiency rankings.

Literature Background

The seminal works of Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broech (1977) are well recognized as providing the pioneering foundations for stochastic frontier analysis. The many theoretical and methodological contributions building upon those works are well documented in Kumbhakar (2003), Coelli, et al. (2005), Greene (2006) and Greene (2012) and have been made by the same authors. Those references are also the most valuable source for obtaining direction to the applied studies of frontier estimates for production and cost (in)efficiencies. Thus, presently it is sufficient to acknowledge that the methodology has been fruitfully applied to numerous industries, including U.S. dairies (Kumbhakar, et al., 1991), U.S. airlines (Kumbhakar, 1991), India paddy farms (Battese and Coelli, 1992 and 1995), the insurance industry (Cummins and Weiss, 1992), international airlines (Coelli, et al., 1999), hospital care (Bradford, et al., 2001 and Fujii, 2001), banking (Huang and Wang, 2001), U.S. electricity (Knittel, 2002), and English football (Barros and Leach, 2007), among others.

As for the application of stochastic cost analysis to education, one study by Chakraborty and Poggio (2008) has estimated cost inefficiencies for primary and secondary schooling in the state of Kansas. For higher education, the body of literature is more internationally oriented but only marginally richer in number. A fairly exhaustive search reveals a total of five studies, the first of which surfaced in 2002. The studies are as follows;

- Izadi, et al. (2002): cross section, 99 British universities, 1994
- Stevens (2005): panel, 80 English and Welsh universities, 1995-99
- McMillan and Chan (2006): cross section, 45 Canadian universities, 1992
- Johnes and Johnes (2009): panel, 121 English universities, 2000-03
- Abbott and Doucouliagos (2009): 36 Australia, 7 New Zealand universities, 1995-03

Each of these employs different combinations of cost and efficiency model specifications. In addition, two of them are cross sectional studies and three use academic years based in the 1990's. Each study does, of course, rely on a frontier cost rather than production implementation and, thereby, accounts for the multiproduct structure of universities. However, aside from the common use of enrollment and research measures as university outputs, each study takes a different path in including other cost and efficiency determinants. While the estimated inefficiencies of the English and Welsh universities provided by Stevens (2005) serve as the best comparisons to those provided in the present study, an overall attempt at comparative evaluations across studies is a difficult, at best, task and is not the objective of the present paper. Rather, the existing literature raises two obvious areas in need of attention: first is the need for an investigation of cost efficiencies pertaining to U.S. higher education and second is the need for an assessment of efficiency differences potentially arising from public vs. private non-profit ownership arrangements. This paper attempts to fill that void by providing empirical estimates for U.S. research and doctoral granting universities.

Model Specification

The university stochastic cost structure is estimated by a multiproduct Cobb-Douglas specification. Incorporating panel data observations, the total operating costs, *C*, for university *i* in time *t* is expressed as:

$$\ln C_{it} = \alpha_0 + \sum_j \alpha_{j,it} \ln Y_{j,it} + \sum_k \beta_{k,it} \ln p_{k,it} + M_{it} + T_{it} + (v_{it} + u_{it}) \qquad (1)$$

where *Y* represents the *j* university outputs and *p* the *k* input prices. A dummy variable, *M*, is included to capture the fixed costs associated with medical schools (*M*=1 for medical school presence; 0 otherwise) while a time trend, *T*, measures neutral technological change. University outputs will include undergraduate and graduate education along with research. Input prices will include wage rate and capital price measures. The precise measures of the outputs and input prices are described in the data section to follow.

The component error $(v_{it}+u_{it})$ is as usual comprised of the two-sided randomly distributed (stochastic) error term, v_{it} , and the one-sided, u_{it}, cost inefficiency term. The former can be characterized as representing the effects on university costs due to random shocks, such as hurricanes and civil wars, and is assumed to be independently and identically distributed with zero mean and variance $\Phi_v 2$. On the other hand, the nonnegative inefficiency component, $u_{it} \geq 0$, is a measure that defines the extent to which university costs exceed their feasible minimum. That inefficiency can be due to poor managerial decision-making, input characteristics, or other institutional specific influences. Following the panel data structure offered by Battese and Coelli (1995), these environmental factors, *z*, enter into the determination of the inefficiency component as follows

$$u_{it} = \delta_0 + \sum_x \delta_x \ln z_{x,it} + T_{it} + \varepsilon_{it} \qquad (2)$$

where ε_{it} is a normally distributed random error and u_{it} are independently distributed as truncations with mean defined by (2) and variance, Φ_u^2. Here, the time trend, *T*, is included to capture linear effects of time on university operating inefficiencies. There will be four environmental factors included as determinants of cost inefficiencies. These are factors that are dependent upon available data as discussed in the next section.

The full model is estimated simultaneously by maximum likelihood with Φ_v^2 and Φ_u^2 being replaced by Φ2=Φu2+Φu2 and (estimated by Φu2/Φ2 (Battese and Corra, 1977). With the reparameterization in place, (measures the proportion, 0≤(≤1, of inefficiency in the overall variance and, therefore can be used to determine the significance of inefficiency in determining university costs. For (=0, the inefficiency component, uit, vanishes and therefore, ordinary least squares estimation is appropriate. For (=1, university costs are not subject to random error, v_{it}, and, therefore, cost deviations from the minimum costs are completely due to inefficiency. Any inefficiency that exists for individual universities is determined by

$$InEff_{it} = \exp(u_{it}) \tag{3}$$

where u_{it} is as defined above (see, e.g., Battese and Coelli, 1988). Inefficiency scores are best thought to be the ratio of the inefficient level of operating costs to the level of efficient operating costs and, therefore, vary from the value of one (no inefficiency) to infinity. For example, using the same model, inefficiencies present among English and Welsh universities are reported (Stevens, 2005) to vary in the range of 1.007 to 2.011, depending upon the underlying assumptions.

The empirical analyses will proceed with separate sector estimates for public and private non-profit universities. This, of course, being justified based on the existence of structural differences between the sectors as independently established in other higher education multiproduct research beginning with the early work of Cohn, et al. (1989) and independently verified over time by Koshal and Koshal (1999), and Sav (2004) . Taking the present data to trial, Chow tests on the ordinary least squares estimates of the cost function produced an $F(16,860)=12.14$ which, at the 1% level of significance, can be taken to confirm that public-private university structural cost differences still prevail and provide additional justification to proceed with separate sector estimates. In a translog specification of the cost function, the test for structural differences led to the same conclusion. However, the translog stochastic frontier model refused to converge when applied to the private university sector. This led to the selection of the more stable behavior experienced with the Cobb-Douglas.

Data

The U.S. Department of Education, National Center for Education Statistics, maintains the Integrated Postsecondary Education Data System (IPEDS) consisting of annual surveys of individual U.S. colleges and universities. For this study, the data set construction involved the merging of various IPEDS surveys, including the surveys on institutional characteristics, finances, enrollments, tenure, and faculty salaries. Certain changes in the survey instruments over time create problems for panel data construction. In addition, there are considerable lags in the data releases. For the present study, it was possible to combine four of the most recently released academic years, 2005-06 through 2008-09. Drawing upon Carnegie defined classifications for doctoral and research universities and omitting universities that did not report the necessary finance, enrollment and other survey data, produced a balanced panel of 142 public universities and 77 private non-profit universities.

Table 1 presents the cost and inefficiency variables as well as their descriptive statistics. The university total costs, undergraduate and graduate education outputs, as well as research output are based on the successes of previous research anchored in higher education costs structures. For example, following Cohn, et al. (1989) and subsequent investigations by Koshal and Koshal (1999), Sav (2004), and Lenton (2008), the total cost measure is the academic year total operating cost in dollars. Likewise, undergraduate and graduate education is measured in full-time equivalent enrollments. As with past studies, research output is proxied by the university's success in producing externally funded research grants. On the input side, the average faculty salary is used as the measure of the faculty wage rate. An additional variable is added in an attempt to include a capital input price measure. In IPEDS, the value of university buildings is reported but is subject to large variations in local real estate valuations. A more national market is likely to exist with what is reported as the year ending value of all university equipment and art and library collections. That value is included as a capital price measure in the cost function. The university medical dummy variable, MED (=1 for the presence of medical school) is included as a control for their high operating costs. Data were not available to capture the cost associated with other individual professional schools. With the exception of research, the output and input variables are expected to have positive effects on university operating costs. Research could be either cost increasing or decreasing. Because research grants usually carry overhead and cost sharing funding components, it is possible that the contributions could have an overall cost saving effect.

Table 1. Public-Private University Means and Standard Deviations

	Public		**Private**	
Variable	**Mean**	**S.D.**	**Mean**	**S.D.**
Total Costs, TC ($)	7.57E+08	7.25E+08	9.12E+08	1.03E+09
Undergraduate FTE, UGRAD	16441	8154	7326	5059
Graduate FTE, GRAD	3912	2802	3913	3329
Research, RCH ($)	1.58E+08	1.76E+08	1.60E+08	2.33E+08
Faculty Salary, SAL ($)	78258	12135	94598	17005
Equipment and Libraries, CAP ($)	2.68E+08	2.63E+08	6.65E+08	7.04E+09
Medical School, MED (0,1)	0.42	0.49	0.41	0.49
Student Faculty Ratio, SF (%)	20.37	4.51	12.56	5.23
Student Retention, RET (%)	79.50	9.07	88.18	9.91
Non-tenure Track Faculty, NTEN (%)	17.02	7.16	19.19	9.84
Tenured Faculty, TEN (%)	47.52	9.07	50.97	11.80
N	568		308	

Note: FTE is full-time equivalent.

The inefficiency term includes four environmental factors. Similar to Stevens' (2005) and Chakraborty and Poggio (2008), institutional and student and faculty characteristics purportedly affect cost inefficiencies. Included here is the student to faculty ratio as a measure of the potential teaching quality or teaching oriented mission of the university. Data were not available for measuring the allocation of other institutional resources to the teaching mission. A student retention variable is also included in the inefficiency component. It is based on the percentage of fall entering students that return the following fall term. Holding teaching quality constant, retention is used as a measure of student academic preparedness, although there are obvious maturity and other student characteristics at play that we cannot control. For faculty employment characteristics, included is the percentage of faculty employed in non-tenure track positions. These include instructors and adjunct faculty that may or may not have terminal degrees but generally have relatively high teaching loads and are not expected to produce scholarly research activity. In contrast, included is the percentage of faculty employed that have received tenure.

A priori, the effects of these environmental factors on the cost inefficiency are uncertain and must be left to empirical testing. For example, lower student-faculty ratios are generally thought to be more expensive to maintain but they might attract a different mix of students, faculty, and even administrators so as to produce different operating cost efficiencies relative to institutions with higher student-faculty ratios. The overall effect on inefficiencies could be positive of negative. Similarly, one would likely expect greater student retention to be more cost efficient. Yet, if retention is a proxy for academic preparedness, then it might be more efficient in say, weeding out, unprepared students and signaling to them that some remedial education or another type of educational pursuit may be more appropriate. Or perhaps the university student admission process is somewhat failing and creating inefficiencies.

On the matter of faculty employment, the American higher education landscape has changed quite dramatically over the past few decades as non-tenure track hiring has partially substituted for tenure track positions. From a managerial cost perspective, it seems clear that lower non-tenure track faculty wages can produce lower payroll accounting cost entries. However, such substitution could generate inefficiencies resulting from greater labor turnover and the potential sacrifice of research grant income. With tenured faculty, there are some administrative arguments that tenure interferes with needed employment flexibilities in adjusting to market forces, including enrollment changes. In contrast, others argue that tenure is cost saving in providing labor force stability and, relative to non-tenure track employment, tenured faculty (and the tenure system) generate research grant income. The empirical analysis to follow will hopefully shed some light on these issues.

The sample statistics presented in Table 1 show that while the average graduate education and research outputs are nearly identical in both public and private university sectors, the public university undergraduate education is more than twice that of private universities. On the input side, the average private compared to public university faculty salary is twenty percent greater. Also, private universities employ or hold more than twice the capital. For the factors entering the inefficiency component, private universities have a student to faculty ratio that is nearly forty percent lower than public universities and have a retention rate that is about ten percent higher. Privates employ only slightly more non-tenure track faculty and have, on average, a bit more tenured faculty among its ranks. Both sectors have equivalent proportions of medical schools. Overall, the average academic year total operating costs are approximately twenty percent greater among the private compared to public universities with the latter exhibiting substantially more variability across institutions.

Empirical Results

The model estimates are presented in Table 2. For both the public and private sectors, nearly all the cost and inefficiency coefficients reach statistical significance at the five percent level and better and the equally significant likelihood ratios indicate that frontier specifications are superior to ordinary least squares estimates. The estimate of the composed variance,F^2, is only slightly different between the sectors. However, per the estimated (, the portion of the variance due to the measure of inefficiency is greater among public (0.93) relative to private (0.77) universities. Yet, it's statistical significance suggests that inefficiency is an issue of importance in both public and private university costs.

Table 2. Stochastic Cost and Inefficiency Estimates

	Public		Private	
Variable	**Coeffi-cient**	**t value**	**Coefficient**	**t value**
$\forall_0$	0.279	0.36	4.978	*3.88
UGRAD	0.405	*13.75	0.477	*14.29
GRAD	0.098	*4.82	0.177	*7.86
RCH ($)	0.156	*10.07	0.192	*11.88
SAL ($)	0.533	*6.78	0.258	*2.02
CAP ($)	0.310	*13.32	0.143	*6.42
MED	0.140	*7.17	0.219	*5.18
TIME	0.027	*2.73	0.007	0.40
$*_0$	3.504	*3.37	-7.510	*-9.50
SF (%)	-0.654	*-4.56	-0.743	*-8.02

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RET (%)	0.174	0.88	2.340	*11.14
NTEN (%)	-0.151	*-3.66	0.008	0.24
TEN (%)	-0.467	*-3.24	-0.273	*-2.34
TIME	0.000	0.02	0.021	0.66
Φ^2	0.081	*4.98	0.089	*7.70
(	0.924	*42.00	0.768	*10.23
LL	136.131		18.332	
LL Ratio	*110.479		*80.110	
N	568		308	

Note: LL is log likelihood."*" denotes significance at ≥ 5%.

For the cost estimates, all the coefficients carry the expected signs. In comparing the two sectors, the three output coefficients, which also serve as cost elasticities, are smaller for public compared to private universities. That is true despite the fact that the mean output for the public sector undergraduate education is more than twice that of private universities. On the other hand, given that both public and private institutions tend to produce the same graduate education on average, the private sector graduate education cost elasticity is eighty percent greater. That can be considered to be somewhat offset by the faculty salary coefficient in the private sector that is half of that which enters public sector costs. That private sector cost advantage exists despite its higher average faculty salary. The difference could potentially be due to some underlying productivity differences either in research or teaching that escapes measurement with the aggregated institutional data at hand. A similar problem might exist with respect to the capital measure that carries half the cost effect in the private compared to public sector. Not surprisingly, medical school education is more costly than not for both types of universities, but more so for private institutions: again there is not a quality control or even a medical school output measure that was available. The time trend variable indicates that the rate of cost increases in the public sector are statistically significant and on the order of approaching three percent per year. In contrast, private universities appear to have contained annual cost increases.

Proceeding to an examination of the inefficiency results, Table 2 reveals that the environmental variables enter with different degrees of statistical significance in the two sectors. In the data section of the paper, we were not willing to venture very far with regard to hypothesized effects of any individual factors. Rather, it was decided to await the empirical results. As can be noted, with the exception of non-tenured faculty employment, all the environmental factors carry the same public and private sector sign effects on inefficiency. However, the inefficiency increasing effect of better student retention weighs in as statistically insignificant in affecting public universities. But it carries the largest single inefficiency increasing effect for private universities. If retention is acting as a suitable measure of student academic preparedness, then it is possible that the higher average rates already achieved through private relative to public university admissions is at a level of efficiency diseconomies. Therefore, further attempts at retention improvement produces inefficiency. As for the public sector, the positive effect of inefficiency is also present but its insignificance is unexpected. From the negative and significant effect of student to faculty ratio, it is apparent that running small class sizes is cost inefficient. However, the missing link here might reside with the absence of student cohort and degree completion data as it correlates with student to faculty ratios. More refined data along those lines might produce different results.

Turning to the potential for inefficiency effects arising from faculty employment characteristics, it would not be surprising to find cost efficiency gains in the trend of administrative decisions to substitute non-tenure track for tenure track faculty employment. However, the negative sign and significance of non-tenure track employment holds only in the public university sector. Also, its effect is relatively weak in efficiency improvement when, for example, compared to the student to faculty ratio effect. For the private sector, non-tenured faculty employment has the opposing inefficiency increasing effect, albeit it is statistically insignificant. Advocates of the advantages to be derived from the tenure system can be pleased with the empirical result that in both public and private universities, increases in the proportion of faculty that are tenured lead to improvement is university operating cost efficiencies. The larger size of the coefficient in the public compared to the private sector, suggests that additions to the tenured faculty ranks has a slightly more powerful efficiency increasing effect among public universities.

The linear effect of time on cost inefficiency is insignificant in both public and private university sectors. However, given its small to nearly non-existent marginal effect, a re-specification and estimation of the model with the time trend omitted had inconsequential effects on the parameter estimates obtained for the inefficiency components. But that does not contradict the appeal of the time varying inefficiencies pertaining to the model structure and the need to provide an examination of those inefficiencies by sector.

Table 3 provides such a summary for university inefficiency scores over time. The overall mean inefficiency for 2005-09 is significantly (at the 5% level) greater for private universities (1.537 or 53.7%) compared to public universities (1.343 or 34.3%). However, the median inefficiencies lie below the means and are not significantly different between the two sectors: 1.260 vs. 1.293, public and private, respectively. The lowest achieved university inefficiency is obtained within the private sector, but the maximum is also lodged there. Examining the inefficiencies over time, it can be noted that public universities managed a slight efficiency improvement, i.e., a reduction in inefficiency, in the 2006-07 academic year and again in 2008-09. That occurred with regard to all the descriptive measures. The private university sector is harder pressed to claim any efficiency improvements. Aside from a reduction in the maximum incurred inefficiency from 2005-06 to 2006-07, the results indicate that private universities suffered consecutive inefficiency increases over the four academic years.

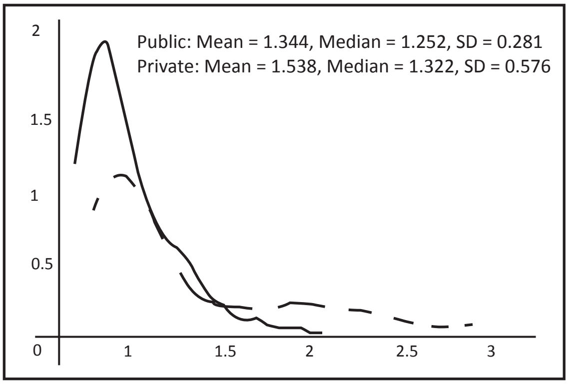
Table 3. Dynamics of Inefficiency Estimates

Public	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2005-09**
Mean	1.350	1.327	1.361	1.338	1.343
Median	1.249	1.237	1.277	1.263	1.260
Minimum	1.032	1.031	1.035	1.031	1.031
Maximum	2.893	2.267	2.798	2.437	2.893
S.D.	0.307	0.278	0.301	0.278	0.290
Private	2005-06	2006-07	2007-08	2008-09	2005-09
Mean	1.496	1.524	1.556	1.574	1.537
Median	1.282	1.286	1.314	1.327	1.293
Minimum	1.029	1.035	1.039	1.040	1.029
Maximum	3.572	3.480	3.540	3.601	3.601
S.D.	0.564	0.555	0.596	0.604	0.574

For comparative purposes, Stevens' (2005) inefficiency scores for the English and Welsh universities vary between 1.007 and 2.011. For the American research universities presented here, the inefficiency ranges exceed those levels for both public (1.031-2.893) and private (1.029-3.601) universities. However, in addition to the possible effects due to inter-country structural differences, the two estimates are based on a decade of difference in data along with differences in included variables and model specifications. As earlier suggested, inter-country comparative studies should be an agenda item for future investigations, but will require much upfront effort in attempting to refine and gather parallel institutional data sets for cost and inefficiency measures.

On a different level, there is interest in examining the inefficiency results for individual universities. For convenience these are presented in the Appendix Table 1. Universities are listed in rank order according to their average inefficiency. These range from 1.044 to 2.294 in the public sector and from 1.034 to 3.553 in the private sector. In the private sector, it is but one university that has an estimated efficiency (1.034) below the minimum of the public sector (1.044). At the other end of distribution there are only ten of the seventy-seven private universities that exceed the maximum public sector inefficiency (2.294); that begins with the 68th ranked Harvard. As a distributional summary, Figure 1 presents the kernel densities for the mean inefficiencies. As indicated, the few private universities that have large inefficiency estimates have a substantial influence on the distributional properties. However, the difference in the medians remains statistically insignificant.

Figure 1. Kernel Densities of Mean Inefficiencies



In a final observation, it is interesting that within the private sector, the Ivy League institutions, so named for their academic excellence and selective admissions, are disproportionately represented among the more cost inefficient universities. Of the prestigious eight Ivies identified by an asterisk in the Appendix Table 1, seven are ranked in the bottom third of the inefficiency rankings. The public ivy universities, as named by Greene and Greene (2001), are also identified by an asterisk. Unlike the private ivies, these public universities tend to be distributed throughout the inefficiency rankings. These observations are just that. The results are a product of the inefficiency model and beyond that there may not be anything to disentangle. For sure, one would not wish to venture to any notion that deliberately creating university operating inefficiencies will beget academic prestige. And for informational purposes, but statistically taboo, a re-estimation of the model with the private ivies omitted resulted in an insignificant drop in the mean inefficiency from 1.513 to 1.486.

Conclusions

This paper uses stochastic frontier analysis to provide estimates of operating cost inefficiencies for public and private non-profit research and doctoral universities in the United States. The estimates are based on panel data observations for the four academic years 2005-09. The results show that both public and private universities operate at some cost inefficiency. However, the separate sector results indicate that the mean private university cost inefficiencies (1.537) are approximately fourteen percent above that of their public (1.343) counterparts. But there is less than a three percent and statistically insignificant differential in the median inefficiencies; 1.293 vs. 1.260, private vs. public, respectively. When examined over time, public university inefficiencies have slightly declined over the four year period while private universities experienced increased inefficiency.

The paper also presents inefficiency rankings based on individual university scores. That exercise revealed that ten of the seventy seven private institutions exceeded the maximum public university inefficiency. It also resulted in eight private ivy league universities populating the bottom third of the inefficiency rankings. The rankings and overall inefficiency estimates, however, are subject to the usual caveats. Those caveats are no different than the ones applicable to the many higher education scale and scope studies and admitted to therein. They also apply to the education based stochastic frontier studies. Here and elsewhere, data availability has made it necessary to rely on enrollment based measures of university educational outputs. Research has been loosely proxied by grant revenue success. In the present paper, some additional proxies were introduced into the inefficiency model in an attempt to control for institutional and student academic quality. A faculty tenure factor, also included, generated the subsequent finding that tenure improves university operating efficiencies. Yet, all the findings are subject to accepting the quality of the data as reasonably accurate measures of university production, costs, and institutional characteristics. Refinements in the quality and quantity of data along with additional future years of observations could prove productive in testing the sensitivity of the current findings to other results.

Appendix Table 1. University Mean Cost Inefficiency Score Rankings

Rank	Score	Public	Rank	Score	Private
1	1.043	U Nevada	1	1.034	U Bridgeport
2	1.045	Florida Intl U	2	1.065	Marquette U
3	1.049	Virginia Poly	3	1.066	Loyola U Chicago
4	1.049	Colorado St U	4	1.076	U Dayton
5	1.053	U South Dakota	5	1.077	Drexel U
6	1.058	U N Colorado	6	1.078	Clarkson U
7	1.058	U LA Lafayette	7	1.080	Adelphi U
8	1.059	U AL Huntsville	8	1.084	St. John's U-NY
9	1.060	U North Texas	9	1.084	Northeastern U
10	1.065	Florida St U	10	1.089	Pace U-NY
11	1.066	U Central Florida	11	1.090	Nova Southeastern
12	1.077	U South Florida	12	1.095	Brigham Young U
13	1.077	Wright St U	13	1.097	U Hartford
14	1.083	Ohio U	14	1.100	U San Francisco
15	1.089	U Wisconsin	15	1.101	U La Verne
16	1.089	U Texas Dallas	16	1.107	DePaul U
17	1.093	U Georgia*	17	1.110	Hofstra U
18	1.093	U Colorado*	18	1.110	Polytech U
19	1.093	U Florida*	19	1.115	Baylor U
20	1.093	SUNY Albany	20	1.129	Boston U
21	1.096	Portland St U	21	1.143	George Wash U
22	1.098	U North Dakota	22	1.145	U St Thomas
23	1.107	U Mississippi	23	1.161	U Pacific

24	1.110	Florida Atlantic U	24	1.196	Rensselaer Poly
25	1.110	U Illinois Urbana*	25	1.197	Syracuse U
26	1.115	Auburn U	26	1.203	Clark U
27	1.122	SUNY Binghamton*	27	1.207	Clark U America
28	1.122	Wayne St U	28	1.211	Fordham U
29	1.124	Oakland U	29	1.233	Lehigh U
30	1.124	George Mason U	30	1.237	Tulane U
31	1.124	Kent St U	31	1.237	Seton Hall U
32	1.125	U TX Arlington	32	1.239	National-Louis U
33	1.125	U MD-Baltimore	33	1.240	TX Christian U
34	1.128	U New Orleans	34	1.246	Widener U
35	1.136	Louisiana St U	35	1.268	Stevens Inst Tech
36	1.144	U Arizona*	36	1.268	Duquesne U
37	1.147	Georgia St U	37	1.286	Biola U
38	1.149	U Missouri	38	1.292	Boston College
39	1.149	U Montana	39	1.322	Illinois Inst Tech
40	1.151	New Jersey Inst	40	1.326	Saint Louis U
41	1.152	VA Comonwealth	41	1.326	U San Diego
42	1.159	Texas Tech U	42	1.330	Cornell U*
43	1.163	Kansas St U	43	1.332	Breis U
44	1.164	Louisiana Tech U	44	1.349	New School
45	1.170	West Virginia U	45	1.349	U Denver
46	1.177	Cleveland St U	46	1.367	American U
47	1.181	U Massachusetts	47	1.368	Georgetown U
48	1.182	Iowa St U	48	1.369	Worcester Poly
49	1.183	U TX El Paso	49	1.383	U Southern Calif
50	1.184	Wichita St U	50	1.383	U Tulsa
51	1.186	Old Dominion U	51	1.400	Tufts U
52	1.189	Arizona St U	52	1.421	S Methodist
53	1.196	S Dakota St U	53	1.507	New York U
54	1.196	U Maryland*	54	1.522	Case Western
55	1.201	U MO St Louis	55	1.546	Brown U*
56	1.202	Oklahoma St U-	56	1.665	Carnegie Mellon
58	1.217	SUNY Buffalo	58	1.728	U Miami

59	1.225	William Mary*	59	1.743	U Notre Dame
60	1.225	U Mass-Amherst	60	1.747	Dartmouth*
61	1.227	Indiana St U	61	1.782	Pepperdine U
62	1.228	U AR Little Rock	62	1.832	Rice U
63	1.232	U Nevada-Reno	63	2.058	Wash U St Louis
64	1.233	Oregon St U	64	2.206	Wake Forest U
65	1.234	Washington St U	65	2.237	U Pennsylvania*
66	1.235	U Houston	66	2.293	Princeton U*
67	1.241	U Southern Miss	67	2.302	Stanford U
68	1.242	U Hawaii Manoa	68	2.329	Harvard U*
69	1.249	W Michigan U	69	2.442	Emory U
70	1.250	Purdue U	70	2.553	Columbia U*
71	1.251	U Wisconsin*	71	2.658	Johns Hopkins
72	1.253	Georgia Inst Tech	72	2.662	U Rochester
73	1.253	U Oregon	73	2.666	Yale U*
74	1.264	U Louisville	74	2.899	U Chicago
75	1.270	Central Michigan	75	2.969	Duke U
76	1.275	Montana St U	76	2.969	Vanderbilt U
77	1.277	TX Woman's U	77	3.548	Mass Inst Tech
78	1.277	N Arizona U			
79	1.286	U Texas Austin*			
80	1.288	U Alabama	Public (continued)		
81	1.290	U South Carolina	112	1.527	Clemson U
82	1.291	N Illinois U	113	1.534	Southern Illinois U
83	1.298	Michigan St*	114	1.534	E Tennessee St U
84	1.300	U Idaho	115	1.536	U Connecticut*
85	1.300	N Dakota St U	116	1.540	TX AM-Commerce
86	1.302	Indiana U*	117	1.543	U Rhode Island
87	1.303	Utah St U	118	1.565	Bowling Green St
88	1.310	U Cincinnati	119	1.580	U Washington*
89	1.314	Indiana U Penn	120	1.588	U NC Greensboro
90	1.315	Mid Tennessee	121	1.596	U New Mexico
91	1.319	U Akron	122	1.632	U Nebraska
92	1.328	U Wyoming	123	1.642	U South Alabama

93	1.344	Texas A & M U	124	1.669	U Alaska
94	1.345	New Mexico St U	125	1.670	Indiana-Purdue U
95	1.348	U Oklahoma	126	1.684	U Toledo
96	1.353	TX AM Kingsville	127	1.697	U Maine
97	1.354	Idaho St U	128	1.710	Ball St U
98	1.371	U Arkansas	129	1.715	U Iowa*
99	1.402	U Memphis	130	1.799	E Carolina U
100	1.417	SUNY Env Sci	131	1.800	Ohio St U*
101	1.418	Illinois St U	132	1.820	U Virginia*
102	1.432	N Carolina St U	133	1.883	U Kentucky
103	1.443	U Kansas	134	1.888	U MO-Columbia
104	1.444	U New Hampshire	135	1.957	Stony Brook U
105	1.479	U MO-Kansas City	136	2.033	U North Carolina*
106	1.479	San Diego St U	137	2.053	NM Inst Tech
107	1.501	Michigan Tech U	138	2.058	U Utah
108	1.502	U Tennessee	139	2.115	U IL Chicago
109	1.521	Rutgers U*	140	2.265	U Vermont
110	1.523	U Minnesota*	141	2.318	U AL Birmingham
111	1.524	Miami U-Oxford*	142	2.318	U Michigan*

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