Cost Inefficiencies and Rankings of Ivy Universities:
Stochastic Panel Estimates

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Abstract

This paper employs stochastic frontier analysis in providing estimates of the operating cost inefficiencies of private non-profit and public ivy universities in the U.S. Panel data for academic years 2005-09 is used to estimate cost frontiers under two alternative specifications that lead to estimated gross and net inefficiencies. Time varying inefficiencies are reported for each academic year and used to calculate university inefficiency rankings by sector. The results suggest that private ivy universities are less inefficient or more efficient than their public counterparts. However, public ivies appear to have made significant inefficiency adjustments perhaps in response to the global financial crisis. Absent those adjustments among the private ivies, the inefficiency gap between the two sectors is found to have substantially narrowed.

Keywords: Cost inefficiency, Stochastic cost frontier, Ivy universities

1. Introduction

This paper provides operating cost inefficiency estimates for ivy universities in the United States. These universities include the prestigious private ivies and the public flagship universities that have been similarly crowned (Greene and Greene, 2001) on the basis of academic quality. Although these universities individually carry different academic strengths, as a group they comprise, but also omit, some of the most elite universities in the U.S. Many are world renowned and attract students, faculty, and research and other financial support from an international market and produce some of the world's leading scientists, historians, and business leaders. Regardless of their private or public ownership status, they are financed by private and public dollars through tuition charges, research support, and philanthropy. At one time or another, financial donors from all camps have been critical of the university management of these funds. Since the global financial crisis, accelerated interest in managerial reforms, especially in the public deficit ridden sector, has brought new criticism and pressure to bear on these institutions. From a number of perspectives these institutions are increasingly expected to be managed in a cost efficient manner. Moreover, with the growing interest in public management reform, there is expectation that there should not exist significantly detectable cost inefficiency differences between institutions in the private non-profit vs. publicly owned sectors.

Stochastic frontier analysis offers a robust methodological approach to the estimation of institutional and managerial cost efficiencies or, rather, inefficiencies. Based on certain distributional assumptions, the analysis is used to measure the extent to which universities, or more generally firms, operate at or above their minimum potential cost. The greater that deviation, the greater is the cost inefficiency. Using panel data for the four academic years, 2005-09, stochastic cost frontiers and inefficiencies are estimated for both private non-profit and public ivy universities. Using the distinction between gross and net inefficiencies, tests are conducted to determine the appropriateness of university characteristics entering as inefficiency determinants or as cost determinants. In addition to the estimation of aggregate private-public inefficiency differences, the dynamics associated with the time varying inefficiencies are reported for each academic year. In a final analysis, university mean inefficiencies are calculated and used to provide overall rankings and a comparison to individual academic year rankings in an attempt to derive conclusions

concerning the stability of rank exchanges. The time frame included in the analysis offers the potential of uncovering possible university managerial responses to the effects of the global financial crisis.

2. Literature Overview

The large body of literature focused on stochastic frontier analysis begins with the pioneering works of Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broech (1977). Since then, there have been many theoretical contributions that are beyond the purpose of the present paper but are comprehensively documented in Kumbhakar and Lovell (2003), Coelli, et al. (2005), and Fried, et al. (2008). There seems no reason to duplicate those documentations in terms of reviewing the methodological and data issues that have been resolved in order to bring empirical frontier applications to the forefront of efficiency evaluations. Rather, it should suffice to acknowledge that empirical applications of frontier analysis have been successful in the estimation of both production and cost inefficiencies in an international context for a wide array of industries. This includes, for example, U.S. dairies (Kumbhakar, et al., 1991), U.S. airlines (Kumbhakar, 1991), India paddy farms (Battese and Coelli, 1992 and 1995), the U.S. insurance industry (Cummins and Weiss, 1992), international airlines (Coelli, et al., 1999), U.S. hospital care (Bradford, et al., 2001), Japanese hospitals (Fujii, 2001), Taiwan banking (Huang and Wang, 2001), Greek olive growing (Giannakas, et al., 2003), Switzerland nursing homes (Farsi and Filippini, 2004), British railways (Mulatu and Crafts, 2005), Lisbon crime prevention (Barros and Alves, 2005) and English football (Barros and Leach, 2007), among many others.

In contrast, stochastic frontier analysis as applied to higher education has only recently surfaced. At the time of the present undertaking, literature searches uncovered but five applications, the first of which was introduced in 2002. For convenience, these studies are briefly summarized in Table 1. Two of the five are cross sectional rather than panel data studies and three of the five employ university data from the 1990's and a fourth straddles the 1990'a and 2000's. The point of those observations is not criticism, but instead the offering that data availability can be a factor to contend with in higher education studies. Any detailed attempt to review these studies in terms of the differences in methodological approaches, data sources, variable construction, and empirical results would involve a lengthy treatise. The only common ground among the studies is the recognition of the multi product nature of universities and the subsequent empirical implementation of a cost frontier rather than a more limited production frontier. Beyond that, there is wide variation in the specification of cost frontiers and the modeling of university efficiencies.

Other than using some measure of student enrollments and research revenue as output proxies, the inclusion of additional cost or efficiency determinants vary widely across these studies (from a total of 4 to more than 50 variables). Overall, the differences are too vast to make study to study comparisons. However, Stevens (2005) analysis of British and Welsh universities is the closest representation to the modeling assumptions employed in the current study. Yet, there are several hoped for contributions of this paper that are absent from the current literature, including (1) a more contemporary panel data that could potentially disclose some effects due to the global financial crisis, (2) an inquiry into U.S. higher education, and (3) an evaluation of efficiency differentials existing under private non-profit compared to public university organizational structures.

3. Methodology

The methodology hinges on the specification of a multiple product stochastic cost frontier as applied to panel data. Total cost (C) in the tth academic year for the ith university can be generalized as follows;

$$C_{it} = C(Y_{j,it}, P_{k,it}) + \varepsilon_{it} \tag{1}$$

where the $Y_{j,it}$ represent the $j=1,\ldots, J$ university outputs and $P_{k,it}$ are the $k=1,\ldots, K$ input prices. Depending upon data availability, empirical measures of outputs usually include some form of education and research while the inclusion of a faculty wage measure has been used as an input price. Data specific to the present study will be introduced in the next section of the paper.

The error term, ε, is a composed error such that

$$\varepsilon_{it} = u_{it} + v_{it} \tag{2}$$

Where v_{it} is the two-sided, normal random component independently and identically distributed as $N(0,\Phi_v^2)$. These random shocks to university costs can occur in various forms, including natural and man-made disasters such as tsunamis and labor strikes, but are generated external to the university. The remaining component, u_{it}, captures the cost inefficiency in production and is assumed to be a one-sided independently distributed variable. Following Coelli, et al. (1999), it is a truncation at zero of the normal distribution with variance Φ_u^2 and mean inefficiency of m_{it}, i.e., $N(m_{it},\Phi_u^{2})$. This non-negative, $u_{it} \geq 0$, cost inefficiency can be caused by university administrative decisions as well as characteristics and influences associated with the inputs entering the university production processes. This

set of so called university characteristics has also been dubbed "environmental" factors by Coelli, et al. (1999) but were also employed in the earlier work of Battese and Coelli (1995). The mean inefficiency, m_{it}, can be determined by these university characteristics. However, how these characteristics are accounted for in the stochastic model and their effect on cost inefficiencies depends upon the explicit formulation of the inefficiency model.

Following Coelli et al. (1999), if these environmental factors or university characteristics, say $z_{r,it}$, directly affect university operating cost inefficiencies, then the time varying model developed by Battese and Coelli (1995) is an appealing extension as follows:

$$u_{it} = \delta_0 + \sum_r \delta_r z_{r,it} + \psi_{it} \tag{3}$$

Where P_{it} is the random component with mean zero and variance Φ^2 and u_{it} have the truncated distribution with mean

$$m_{it} = \delta_0 + \sum_r \delta_r z_{r,it} \tag{4}$$

This approach produces measures of university inefficiencies that are considered to be gross measures in the sense that all universities operate under the same production technologies and cost structures while environmental factors directly determine cost inefficiencies. Inefficiency in the tth operating period is defined by

$$IE_{it} = \exp(u_{it}) = \exp(\delta_0 + \sum_r \delta_r z_{r,it} + \psi_{it}) \tag{5}$$

In contrast, if environmental factors alter university production and cost structures, then the $z_{r,it}$ directly enter the cost frontier (1). With this modified cost frontier, the mean of the u_{it} in (4) becomes $m_{it}=*_0$. In this case, the inefficiencies, IE_{it}, are said to be net efficiencies, i.e., net of any environmental influences. In both cases, an inefficiency ranking of universities across time periods can and will likely result in different rank orderings.

The method of maximum likelihood estimation is used to acquire the parameter estimates of the full model. Under the Battese and Corra (1977) reparameterization of $\sigma^2=\sigma_v^2+\sigma_u^2$, an estimate of $(=\sigma_u^2/\sigma^2$ is obtained. As a measure of the proportion of inefficiency in the overall variance, (must lie between zero and one and can be used to test the significance of inefficiency in university costs. At the end point, (=0 suggests that u_{it} is zero and ordinary least squares is appropriate for the cost estimation. A value of one indicates that the random error should be removed from the cost frontier and all cost deviations are due to university operating inefficiencies.

Empirical frontier studies have commonly employed the translog or its nested Cobb-Douglas specification. In preliminary tests for the present study, the differences in the log-likelihoods for the net inefficiency models were not statistically significant and, therefore, the Cobb-Douglas could not be rejected in favor of the translog. For the gross efficiency models, maximum likelihoods failed to converge under the translog specification. Thus, for the net inefficiency model, the following becomes the Cobb-Douglas specification with institutional (i) and time (t) subscripts omitted for illustrative convenience:

$$C = \alpha_0 + \sum_j \alpha_j \ln Y_j + \sum_k \beta_k \ln P_k + \sum_r \delta_r \ln z_r + (v+u) \tag{6}$$

Under the gross inefficiency model, the $z_{r,it}$ are removed and placed in the inefficiency component(3). Both gross and net inefficiencies will be estimated for private and public university ivies.

4. Data

Data for individual universities are supplied through the annual surveys undertaken by the U.S. Department of Education, National Center for Education Statistics and housed in the Integrated Postsecondary Education Data System (IPEDS). Culling the data from IPEDS, it was possible to construct a panel data set covering academic years 2005-06 through 2008-09. In a few cases, missing observations were replaced using the method of neighboring values. While it was possible to include all eight private ivy universities, two of the thirty public ivy universities (Delaware and Penn State) had to be omitted due to the lack of data.

The variables used in the cost and inefficiency models are listed in Table 2 along with their brief definitions, means, and standard deviations. The total cost (C), three output measures, including undergraduate (UNGRAD), graduate (GRAD) and research (RESCH), and the faculty wage (WAGE) as an input price, represent the basic building blocks of the higher education cost structures that have been employed in numerous higher education studies. Those studies include both the larger body of literature related to higher education scale and scope estimates (e.g., Cohn, et al., (1989), Koshal and Koshal (1999), Sav (2004), and Lenton (2008), among others) and the new arrivals on higher education stochastic cost frontiers previously noted in Table 1. A medical school dummy (MED) variable (also used in Sav (2004)) is included to account for the potentially higher cost effect of that output. The remaining outputs and

faculty wage would also be expected to carry positive effects on university costs. However, the manner in which research output is proxied and used in previous studies, it is possible that administrative cost sharing components of research grants could produce overall cost saving effects. Although a possibility, previous findings point to cost increasing effects.

Similar to the cost frontier study by Stevens (2005) and a primary-secondary level school study by Chakraborty and Poggio (2008), the environmental variables are constructed so as to represent some aspects of the overall university character and characteristics related to students and faculty. As usual, data availability is the hindrance. As indicated in Table 2, three measures are included in the present analysis. However, at this juncture one cannot have confidence in their expected effects on costs or inefficiency. For example, the student-faculty (STUFAC) ratio is included as an overall institutional characteristic and could be cost and inefficiency increasing as more university resources are allocated to individual student attention or small class sizes. On the other hand, lower ratios could improve educational quality, maybe attract higher quality students, and perhaps increase student retention, all of which can potentially reduce university costs and result in efficiency gains.

These ivies presumably attract the best and brightest students from abroad but the effects of the September 11 attacks on the U.S. created a mound of new administrative requirements for foreign student admissions. As a result, one would expect increased proportions of foreign/international student enrollments to be cost increasing. Although it is difficult to predict an efficiency effect, it does seem more likely that the additional administrative burdens would entail greater inefficiency. In attempting to measure this effect, it was not possible to determine the exact percentage of university foreign students enrolled so the substitute measure presented in Table 2 is based on the percent of non-white student enrollments less the percent of black student enrollments. Thus, it does include native non-black minorities. We label it STUMIN for student minority but with the assumption that foreign students comprise a substantial portion thereof and that universities do create special programs and services for other student groups that can be allocatively costly and potentially create inefficiencies.

University faculty employment can be comprised of non-tenure track, tenure track, and tenured faculty.The latter have attained that status through scholarly productivity but relative to other colleagues also command greater compensation. Increased proportions of tenured faculty (FACTEN) among the ranks would be expected to be cost increasing. However, if the continued scholarship produces increased grant revenues, then through the above effects it is possible that increased tenure could be cost saving and possibly inefficiency reducing. Hopefully, the empirical results will help in sorting out these issues.

As indicated in Table 2, private ivy universities operate under significantly higher cost, higher faculty salaries, lower student-faculty ratios, and board a greater proportion of medical schools. The public institutions are by far the larger producers of undergraduate education and lay claim to somewhat greater research output. Graduate education is not substantially different in the two sectors and the percent of tenured faculty among the ranks is nearly identical.

5. Results

Maximum likelihood estimates are presented in Table 3 for both private and public ivy universities and for both gross and net inefficiency models. Based on the statistical significance of individual coefficients and a comparison of the log-likelihoods, a fairly clear conclusion emerges. The gross inefficiency model with university characteristics determining inefficiency appears to be preferred over the net inefficiency model with university characteristics acting as cost determinants. Likelihood ratios for the gross inefficiency model in both ivy sectors indicate the superiority of the frontier specification over ordinary least squares. Unfortunately, the non-nesting of the two models precludes a gross vs. net model evaluation based on a likelihood ratio test. But in the public ivy sector the likelihood ratio for the net inefficiency model is statistically insignificant, thereby indicating that ordinary least squares would be applicable. In the private sector, the net inefficiency compared to the gross inefficiency model carries both a smaller log-likelihood and smaller likelihood ratio test. Submitting to that as a reasonable guide, the gross inefficiency model also appears to be preferred in application to the private ivy sector. In sum, the effort in taking the alternative models to task proves to be a useful one. That is, the findings suggest that it is preferable to retain the purity of the cost function in modeling the underlying cost structure of both university sectors. For these elite universities, there is reasonable confidence in concluding that university characteristics do not alter the cost structures but do affect operating cost inefficiencies.

With the remaining focus of the paper on the gross inefficiency model, the estimate of γ further supports the notion that inefficiency is a significant consideration for both types of ivy universities. However, it is somewhat greater in the cost deviations among private ivies (0.921) compared to public ivies (0.829). More noteworthy are the differences in the effects of university characteristics on inefficiency. For private universities, all three university inefficiency effects are positive and, therefore, inefficiency increasing; all are statistically significant. In the public

sector, all three are negative, thereby yielding efficiency improvements; although the tenure effect does not reach any reasonable level of significance. Turning back to the Table 2 inter-sector means, these differential inefficiency results are not unreasonable. With regard to student-faculty ratios, the already low ratios common to private universities suggest that attempts at the margin to produce even lower ratios would be managerially cost inefficient. For the public ivies, the efficiency improvements to be gained by reducing their relatively higher student-faculty ratios suggests that administrative undertakings to better, but not completely, emulate private ivies could be productive. Moreover, public ivy improvements (decreases) in student-faculty ratios offer the largest efficiency gains among the three inefficiency effects. Similarly, with the comparatively lower average foreign or minority student bodies, public universities apparently could realize efficiency improvements with additional minority enrollments. Among private universities, additional minority enrollments beyond their already high achievements are estimated to be institutionally cost inefficient.

The effect of faculty tenure on cost inefficiency also differs between the two ivy sectors. For advocates of the tenure system, the public ivy efficiency improving effect (negative coefficient) would be a welcomed finding. However, its statistical insignificance cannot support either tenure advocates or opponents, at least not as it pertains to public ivy universities. Yet, at private ivies, putting more tenured faculty among the faculty ranks is estimated to be cost inefficiency increasing. Given that the two sectors have nearly identical proportions of tenured faculty (Table 2), the inefficiency differences seem to be somewhat at odds with the other two results for inefficiency effects. Yet, given the large public vs. private faculty salary differences (also Table2),it is possible that there is interaction between tenure and the high faculty salaries prevailing in the private sector that is not being accounted for in the inefficiency model.

As with other stochastic frontier studies the interest lies with the inefficiency estimates rather than the specifics of the cost parameters. However, it should be noted that among the estimated cost coefficients, which are elasticities, the faculty wage carries the strongest effect among both private and public ivies. Being greater than one suggests that a percentage wage increase requires additional benefit compensation and, perhaps, the additional allocation of real university resources. With the exception of undergraduate education in the private sector, the output coefficients are all positive and statistically significant. The negative undergraduate enrollment coefficient in the private sector is odd but is not of any passable statistical significance. Among the outputs, the largest cost elasticity is associated with research. That holds in both sectors, but the same percentage increase in research output creates nearly twice the cost increase in the private compared to the public sector. It would be interesting to model and be able to compare the mix of research output between the ivies but the present data do not permit that level of disaggregation. Running medical schools is more costly in the public ivy sector. However, among the private universities, only Princeton does not have a medical school. Thus, the negative MED result indicates that for some reason, ceteris paribus, Princeton incurs higher operating costs.

Table 4 presents a summary of the time variation in cost inefficiencies as calculated from the gross inefficiency models. The overall mean inefficiency across the 2005-09 academic years is 1.103 vs. 1.201 for the private compared to the public university ivies. That is, private ivies are estimated to be operating at 10.3% above their cost frontiers while public ivies are at a level of 20.1%. Thus, on average, public ivies are basically ten percentage points more cost inefficient. The estimated median inefficiencies place public ivies at a fivefold difference. But as indicated by the standard deviations and skewness measures, greater variability exists among public institutions. When the time variations are examined over academic years, one observes consecutive annual mean inefficiency increases in the private ivy sector. In contrast, in the public sector, efficiency gains are achieved in 2006-07 with a 0.5% inefficiency decrease and again in 2008-09 with a 2.5% decrease. As a result, the public-private inefficiency differential narrows in each academic year and falls over time from a difference of 12.3% in 2005-06 to 5% in 2008-09.

Individual university inefficiency results and rankings are presented in Table 5. The overall rankings are based on the individual university's four year mean inefficiencies as reported in column 2. In addition, using the time varying attributes of the stochastic model, each university's rank is reported for each academic year. In both sectors there are the high inefficiency outliers that are now visible: one in the private sector and two in the public sector. Such outliers are not usual and were also found in the inefficiency results presented by Stevens (2005) for English and Welsh universities. Obviously, there is no advantage in introducing the bias that would result in a re-estimation of the model with outliers omitted. But if one momentarily disregards the U. of Pennsylvania in the private sector, then there are seven or twenty five percent of the public ivies that have inefficiencies below the highest private ivy inefficiency of 1.07 existing at Dartmouth. Beyond that, all the remaining seventy five percent of public ivies are individually more cost inefficient than the private ivies.

In Table 5, the rank orders presented for each academic year also offer an indication of the stability of individual university inefficiency estimates over time. In this sense, the private sector appears to reveal more instability as individual universities tend to exhibit greater rank shuffling. Fourth ranked Brown University, for example, ranks first in 2005-06 and then drops to next to last in 2007-08 with some recovery noted as moving to fifth in 2008-09. Cornell, on the other hand, continuously improves in moving from seventh to third ranked. In the public sector, tenth ranked Rutgers tends to bounce around in the annual rankings and moves from thirteenth to seventh and then back to thirteenth. Both SUNY as sixth ranked overall and Minnesota as thirteenth overall, improve from second to eighth and eighth to fifteenth, respectively. The rank movements do tend to be generally confined to the middle of the inefficiency distributions. In the tails of the distributions, the most inefficient and the most efficient universities tend to continue their rank dominance. The Pearson rank order correlations for the private universities vary between 0.48 and 0.88 with the lowest correlation occurring between the 2005-06 and 2008-09 academic year rankings. For the public ivies, the greater stability is evident in that the rank correlations show little to no variation being in the range of 0.94 to 0.97 over the four academic years.

Based on the maximum likelihood estimates of the cost and inefficiency coefficients, the results presented in Table 3 suggest that the gross inefficiency model performs about equally well in both private and public ivy sectors. It can be said that one variable performs better in meeting expectations in one sector compared to another, but on balance it would be unreasonable to reject the results. In fact, as guidance by Greene (2012) suggests, the inefficiencies, not the model parameters, are the principal focus of stochastic frontier analysis. But based on estimates of gamma and the likelihood ratios, there is some justification, albeit weak, to conclude that the frontier model performs better in capturing the private compared to the public sector costs and inefficiencies. Nevertheless, upon examination of the time varying changes in individual university inefficiency rankings (Table 5), one might be inclined to conclude that the greater instability of estimates exhibited in the private ivy sector are of some concern. Reconciling the marginally better stochastic model results with those concerns is beyond the scope of the present inquiry and must remain a future agenda item potentially to be resolved with more precise and higher quality data. Perhaps more importantly would be the acquisition of more academic years of observations to test the stability of the private ivy inefficiency increases and the sustainability of the public ivy efficiency gains.

6. Conclusions

This paper investigated operating cost inefficiencies among the elite ivy universities in the U.S. system of higher education. These included the private non-profit ivy league universities and the similarly crowned but publicly owned ivy institutions. Separate private-public sector cost inefficiencies were estimated using stochastic cost frontier analysis and panel data covering four academic years, 2005-09. Both gross and net inefficiency models were estimated. That proved useful in rejecting the latter and concluding that it is more likely that university characteristics determine inefficiencies rather than modifying institutional cost structures.

Results suggest that public compared to private ivies operate at higher cost inefficiencies. Both incur cost inefficiencies, but based on sector wide average scores, private ivies operate at about 10% above their cost frontier while public ivies are 20% above that efficiency mark. When examined by academic year, the evidence suggests that private ivies consecutively experienced inefficiency increases but public ivies had two years of efficiency gains. Hence, the inefficiency difference between the sectors fell from 12% to 5%. The decline was primarily due to a major public sector efficiency improvement in the 2008-09 academic year that might be the beginning of adjustments induced by the public budget cuts driven by the financial crisis. In the final piece of analysis, inefficiency rankings were presented based on calculated inefficiency scores for individual universities. Overall, the rank ordering over academic years appears more stable in the public relative to private ivy sector, i.e., the individual public ivies tend to experience less shuffling in their rank standings. However, in both sectors that occurs in the middle of the ranks, while the more efficient and more inefficient ivy universities tend to consistently maintain their rank positions over time.

From a managerial and public policy perspective it seems crucial to assess the sustainability of the public ivy university efficiency gains and the narrowing of the cost inefficiencies between those institutions and private ivies. Given the continuing declines in higher education funding and the growing interest in public management reforms brought about by the financial crisis, that research should be conducted as more academic year data becomes available.

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Table 1. Stochastic Frontier Studies of Universities

Study	Universities	Sample Size	Type	Academic Year
Izadi, et al. (2002)	British	99	Cross	1994
Stevens (2005)	English & Welsh	80	Panel	1995-99
McMillan & Chan (2006)	Canadian	45	Cross	1992
Johnes&Johnes (2009)	English	121	Panel	2000-03
Abbott &Doucouliagos (2009)	Australian & New Zealand	36 & 7	Panel	1995-03

Table 2. Ivy University Variables, Means and Standard Deviations

Variable	Private Mean	S.D.	Public Mean	S.D.
Total Costs, C ($)	2.11E+09	1.35E+09	1.86E+09	1.07E+09
Undergraduate FTE, UNGRAD	8,357	3,753	24,662	7,621
Graduate FTE, GRAD	6,550	4,892	7,099	3,955
Research, RESCH ($)	3.80E+08	2.16E+08	4.36E+08	2.62E+08
Faculty Salary, WAGE ($)	121,300	13,911	96,723	10,011
Medical School, MED (0,1)	0.88	0.34	0.65	0.48
Student Faculty Ratio, STUFAC (%)	7.95	2.41	19.34	4.03
Student Minority, STUMIN (%)	48.32	6.17	35.47	17.32
Faculty Tenure, FACTEN (%)	55.93	9.00	54.11	8.94
N	32		112	

Table 3. Gross and Net Stochastic Cost and Inefficiency Estimates

| | Gross Inefficiency Model | | | | Net Inefficiency Model | | | |
| | Private | | Public | | Private | | Public | |
	Estimate	t value	Estimate	t value	Estimate	t value	Estimate	t value
$\forall_0$	-10.258	-8.94*	-9.401	-2.95*	-16.313	-10.09*	-4.498	-4.52*
UNGRAD	-0.029	-0.80	0.318	2.07*	-0.172	-2.93*	0.358	0.51
GRAD	0.101	3.74*	0.135	1.92*	0.146	3.33*	0.146	0.38
RESCH	0.691	19.09	0.355	5.51*	0.770	15.70*	0.309	2.27*
WAGE	1.485	14.37*	1.646	6.01*	1.773	11.92*	1.266	2.25*
MED	-0.086	-2.22*	0.285	4.70*	-0.121	-2.15*	0.327	1.34
Gross: University Environment Determining Efficiency								
$*_0$	-11.106	-3.61*	12.500	1.90*	-	-	-	-
STUFAC	0.946	4.32*	-2.660	-2.13*	-	-	-	-
STUMIN	1.613	2.40*	-1.551	-1.82*	-	-	-	-
FACTEN	0.672	2.71*	-0.150	-0.40	-	-	-	-
Net: University Environment Determining Costs								
STUFAC	-	-	-	-	0.380	3.99*	-0.345	-0.46
STUMIN	-	-	-	-	0.120	0.96	-0.047	-0.39
FACTEN	-	-	-	-	0.219	1.84*	0.210	0.32
$*_0$	-	-	-	-	-4.093	-0.95	0.255	0.30
Φ^2	0.013	3.80*	0.197	2.46*	0.252	0.99	0.100	1.99*
(	0.921	22.18*	0.829	9.00*	0.996	193.11*	0.929	1.60
LL	50.60		6.05		44.00		3.28	
LL Ratio	59.51		18.13		11.54		2.85	

Note: LL is log likelihood and "*" denotes significance at $\geq 10\%$.

Table 4. Time Varying Gross Inefficiency Estimates

Private	2005-06	2006-07	2007-08	2008-09	2005-09
Mean	1.076	1.082	1.113	1.140	1.103
Median	1.018	1.023	1.038	1.049	1.027
Minimum	1.011	1.013	1.009	1.010	1.009
Maximum	1.434	1.447	1.663	1.724	1.724
S.D.	0.146	0.149	0.223	0.239	0.186

Public	2005-06	2006-07	2007-08	2008-09	2005-09
Mean	1.199	1.193	1.220	1.190	1.201
Median	1.106	1.109	1.116	1.104	1.109
Minimum	1.043	1.040	1.040	1.040	1.040
Maximum	2.328	2.372	2.346	2.186	2.372
S.D.	0.254	0.268	0.310	0.241	0.266

Table 5. Efficiency Rankings by Mean Score and Academic Year

Rank	Mean Score	University	Rank 05-06	Rank 06-07	Rank 07-08	Rank 08-09
Private Ivies						
1	1.013	Yale	2	1	1	2
2	1.018	Columbia	4	4	3	1
3	1.020	Princeton	3	2	2	4
4	1.033	Brown	1	5	7	5
5	1.037	Harvard	5	3	4	6
6	1.048	Cornell	7	6	6	3
7	1.070	Dartmouth	6	7	5	7
8	1.540	Pennsylvania	8	8	8	8
Public Ivies						
1	1.041	Maryland	1	1	1	1
2	1.049	California-Santa Barbara	3	2	2	2
3	1.054	Florida	4	3	3	6
4	1.055	California-San Diego	5	4	4	3
5	1.057	California-Berkeley	7	6	5	5
6	1.058	SUNY-Binghamton	2	5	8	7
7	1.058	California-Irvine	6	7	6	4
8	1.077	Arizona	9	8	10	9
9	1.083	California-Davis	10	13	9	8
10	1.087	Rutgers	13	9	7	13
11	1.097	Illinois-Urbana	14	10	11	10
12	1.099	Washington-Seattle	11	16	13	14
13	1.100	Minnesota	8	15	15	15
14	1.103	California-Los Angeles	15	12	12	11
15	1.108	Colorado	12	11	16	17
16	1.109	Michigan State	16	14	14	12
17	1.136	Georgia	17	17	17	16
18	1.167	Wisconsin	19	19	18	18
19	1.175	Virginia	18	18	21	22
20	1.178	North Carolina	20	21	19	19
21	1.201	Texas- Austin	21	20	20	23
22	1.219	Ohio State	23	23	22	20
23	1.237	Indiana	22	22	25	21
24	1.296	Connecticut	24	25	24	24
25	1.302	Iowa	26	26	23	25
26	1.395	William and Mary	25	24	26	26
27	1.752	Michigan	27	27	27	27
28	2.312	Miami -Oxford	28	28	28	28