Estimation of Cost Efficiency of Australian Universities

Jocelyn Horne and Baiding Hu[1]

Abstract

The purpose of this paper is to quantify the efficiency with which Australian universities utilise their teaching resources. The study estimates the cost efficiency of 36 universities over the period 1995-2002 using stochastic frontier analysis. The present study differs from previous cost and efficiency studies of Australian universities in two respects. First, it employs stochastic frontier analysis for the specification of a cost function for Australian universities which allows for the estimation of cost efficiency for each university under study. Second, a panel data set is utilised in the estimation of the cost function which enables not only comparisons of cost efficiency between universities but also an econometric testing of the assumption of an identical cost function for every university. The main finding is that universities are not operating efficiently as measured by cost efficiency and in relative terms. An efficiency ranking is derived and policy inferences are discussed.

JEL Classification: C23; I20
Keywords: cost efficiency, stochastic frontier analysis, higher education

[1] The authors thank Chris Heaton, Daehoon Nahm and David Throsby for helpful comments and George Milunovich for data assistance with the usual disclaimers.

I. Introduction

The incentive structure facing Australian universities has changed in the past three decades. Over the past three decades, government funding per Australian university student has fallen progressively and now stands at 40 percent of total university revenue as compared to almost 100 percent in the early 1970s. This factor alone has put pressure on Australian universities to find new revenue sources and contain costs. Australian universities also face increased competition from technology developments and globalisation of education services. While recent reforms have freed some resource constraints, especially on the revenue side, the higher education system remains partially deregulated. Consequently, universities have new incentives to use their resources more effectively.

The purpose of this paper is to quantify the efficiency with which Australian universities utilise their existing resources. The study estimates the cost efficiency of teaching of Australian universities over the period 1995-2002 using stochastic frontier analysis. Its contribution to the literature is primarily empirical: the paper is the first attempt to estimate the cost efficiency of Australian universities and is the first application of this methodology to Australian data. The findings also provide input into recent policy debate on performance indicators and the scope for accommodating recent cutbacks in government funding to universities through increased efficiency and other mechanisms.

There is no shortage of empirical studies of the cost function of the higher education sector in Australia (see Throsby, 1986; Lloyd, Morgan and Williams, 1993; Heaton and Throsby, 1997). The methodology used in these studies is to estimate either an aggregate output or multiple output cost function. The main finding of this literature is to demonstrate the existence of internal economies-of-scale. However, these studies assume that the cost function of each university is the same and also lies along the minimum cost efficiency frontier. The empirical methodology used in the present study provides a means of testing both null hypotheses.

A growing empirical literature has also estimated the technical and cost efficiency of universities using data envelopment analysis (DEA) as well as the stochastic frontier (SFA) methodology (see Salerno, 2003 for a survey). However, Australian empirical work is restricted to technical efficiency (defined as the ability to minimise input use for a given output) and cross-section DEA studies (see Coelli, 1996; Avkiran, 2001; Abbot and Doucouliagos, 2003). The relative merits of the two methodologies are discussed below. The main findings are to demonstrate "high" technical efficiency of academic and teaching models in 1994-5 based upon mean scores within the mid to high 90 percent range relative to a 100 percent (most efficient) benchmark. However, there is no empirical information on cost efficiency (defined as the ability to minimise costs for a given output vector) of Australian universities nor whether efficiency has changed over time.

The empirical methodology of the present study uses stochastic frontier analysis based upon panel data that enables testing of key hypotheses, including the null hypothesis of optimal efficiency, similar cost functions of universities and similar "technology" of producing students across universities. Stochastic frontier analysis has been used extensively in other areas of economics such as airlines (Cornwell, et al, 1990) and the manufacturing sector (Hay and Liu, 1997**)** and, to a limited degree in the higher education sector in overseas studies (see Salerno, 2003).

Reform of the higher education sector in Australia has been the subject of ongoing policy debate, especially in the wake of Commonwealth funding cutbacks to universities in a period of expanding student load (see King, 2001; Chapman, 2001). The main thrust of reform efforts have centred upon partial deregulation of fees with the introduction in 1989 of government subsidised HECS fees for domestic students and full-fees levied on other domestic and foreign students. Reforms introduced in the 2003-4 Commonwealth Budget for implementation in 2005 extend the scope for universities to raise non-government revenue in various ways; by widening the HECS bands, by extending income-contingent loans to non-HECS students and by increasing the proportion of fee-paying domestic students from 25 to 33 percent (see Commonwealth of Australia, 2003). But the reforms stop short of full fee deregulation and maintain centralised control of Commonwealth government funding of HECS-supported places.

At a policy level, the issue of university efficiency has not been addressed in any systematic way but did receive attention in the 2001 Senate Inquiry on universities and discussion papers preceding the new reforms (see Australian Senate Committee, 2001; Department of Education, Science and Training, 2002). These documents give conflicting views, reflecting the different definitions of efficiency and relative paucity of empirical evidence. For example, at the Senate Inquiry, policymakers argued that further efficiency gains might be achieved while universities felt that this scope was exhausted.

Further understanding of the scope for efficiency gains is of considerable interest for policymakers at a government and university level. Decisionmakers at both levels have an interest in knowing whether government funding to the sector (2.4 percent of Commonwealth expenditures in 2003-4) is being used efficiently. But the issue extends beyond this interest: if scope exists for further efficiency gains, less adjustment is borne by other variables such as student fees for meeting present and projected funding gaps. The potential usefulness of efficiency estimates as performance indicators of universities is also of policy interest.

The remainder of the paper examines in more detail the above issues. Section II discusses the issue of cost efficiency in the context of the debate on financing of Australian universities. Sections III discusses the empirical methodology used in the analysis while estimation results and their interpretation are given in Section IV. Section V presents the policy implications, main conclusions and directions for future research.

II. Background and issues

The sample period chosen for the study covers 1995-2002 and is dictated by the availability of a uniform data set for all 36 universities based upon university-wide statistics collected by the Department of Education, Science and Training. Since this period is also one of considerable shifts in education policy and financing sources in the tertiary sector, the findings need to be interpreted with caution.

The changes in financing sources of Australian universities over the sample period (1995-2002) are given in Table 1 and need to be viewed within the context of longer-term trends in government financing of higher education (see Marginson, 2001). Government expenditure on higher education has halved as a percentage of GDP since its peak of 1.5 in 1976-77. Over the same period, student numbers increased by a multiple of three with a rise of one third recorded in the past decade.

Table 1. Revenues and expenditures of Australian universities, 1995-2002 (in percent)

Revenues	**1995**	**2002**
Common. Govt. grants	57.2	40.1
HECS	12.0	15.8
Fees and charges	11.7	21.2
Investment income	4.0	1.8
State govt.	1.4	4.0
Other	13.8	17.1
	100.0	100.0
Costs		
Salaries	63.6	58.7
(academic)	(33.1)	(31.2)
Other	36.4	27.5
	100.0	100.0
Memorandum items		
Average real revenue per EFTSU (in $)	7,535	11,614
Average real costs per EFTSU (in $)	15,069	15,677
EFTSUs	544,146	626,749
Student/staff ratio	15.3	21.4

Source: DEST Selected Higher Education Statistics

Given the size of the government cutbacks, a key policy issue is how these changes are being accommodated at a university level. A number of variables may bear the burden of adjustment, including student numbers, revenue and costs, financial solvency, quality of education and efficiency. Not all the variables are observable, in particular, the latter two. But based upon available data, the picture that emerges is that most of the adjustment has been borne by revenue, and, especially in terms of revenue composition.

One adjustment mechanism at a university level is a reduction in student load or numbers. The increase in total student numbers is spread across all universities and reflects the tying of Commonwealth funding through the base operating grant to government funded places for domestic undergraduate students. At a university level, there is little incentive to cut total student numbers and even greater incentives to increase the share of full-fee paying overseas students with consequent distortions across disciplines in favour of more business-oriented studies. The data reflect this: at an aggregate level, the share of full-fee paying foreign students in total students rose from 8 to almost 14 percent over the sample period.

A second adjustment mechanism is through changes in revenues and costs. Average real revenue per full-time student rose from $ 7,535 to $11,615 from 1995 to 2002 but average real costs per student remained stable at around $15,000, leaving an average negative operating margin of 29 percent of average revenues in 2002 (Table 1). (In aggregate terms, there is a positive gap but, in any event, both the average and aggregate pictures are deceptive because the financing gap has moved in different directions for universities.) Since universities are non-profit institutions, the concept and measurement of financial criteria such as insolvency are not clearly defined. Most universities have incentives to prevent a widening and negative financing gap since the resulting debt buildup acts as a constraint upon recurrent expenditures and thereby reduces their flexibility of policy options.

A third mechanism is through a downward adjustment in the quality of teaching and other services. The perception of declining quality of higher education dominates much of the policy debate as reflected especially in the 2001 Senate inquiry. Trends in the quality of higher education are difficult to measure. If measured in terms of staff/student ratios, quality of higher education has declined with an increased ratio from 15.3 in 1995 to 21.4 in 2002 with rises recorded for all universities and in all disciplines. Anecdotal and survey data such as that presented on economics students (see Economic Society of Australia, 2004) support this interpretation but the issue of quality changes remains contentious.

Assuming unchanged quality and a stable financing gap, this leaves adjustment either from the composition of revenues and costs or from efficiency. The data in Table 1 show that the share of Commonwealth grants in total revenue fell from 57.2 to 40.1 percent over 1995-2002 and was offset partially by increased shares from full-fee paying students and from subsidised HECS fees. Non-HECS fee share rose from 11.7 to 21.2 percent while that of HECS rose from 12 to 15.8 percent with the remainder from other smaller share items such as donations.

On the cost side, the composition remained fairly stable, reflecting the dominant share of wage costs: the share of the staff wage bill in total costs fell from 63.6 percent in 1995 to 58.7 percent in 2002. Given the retrenchments that have taken place in the past few years and the pressure placed on universities from inadequate wage indexation to allow for enterprise bargaining, there is little scope for any significant further reduction in total costs or their composition.

This leaves one further option, increasing efficiency. The concept and measurement of efficiency depend upon the definition used (see below). As noted earlier, the available empirical evidence for Australia is restricted to DEA studies of technical efficiency of various performance models (academic, teaching, administration) based upon either 1994 data (see Coelli, 1996) or 1995 data (see Avkiran, 2001; Abbot and Doucouliagos, 2003). With the exception of administration, Australian universities are found to be operating at "high" efficiency based upon mean scores of 95-97 percent relative to a benchmark of 100 percent (most efficient universities). The interpretation of whether efficiency scores are assessed as high or low is subjective (a problem common to both methodologies). But a sizeable empirical gap remains on identifying changes in both technical and cost efficiency of teaching (and research) output and the scope for further increases in efficiency. The issue of cost efficiency of teaching output is addressed below.

III. Methodology

A number of different concepts of efficiency are discussed in the literature and policy discussion, including technical, cost (allocative) and economic (overall) efficiency (see Kumbhakar and Lovell, 2000). The focus of this study is upon cost efficiency of university teaching resources: cost efficiency is defined as ability of a university to minimise costs for a given output vector and measured by the ratio of minimum to observed cost. This concept differs from technical efficiency, defined as the ability to minimise input use for a given output vector. Unlike cost efficiency, technical efficiency does not involve the imposition of behavioural assumptions such as cost minimisation. Further, not all cost inefficiency need reflect technical efficiency. For example, an input vector may be technically efficient but cost inefficient because of misallocation of inputs in terms of their relative prices. Economic efficiency includes both technical and cost efficiency.

In the following analysis, it is assumed that universities do attempt to minimise costs. This assumption may be questioned on the grounds that universities are non-profit institutions but, as noted above, the changing environment has altered the incentive structure significantly and especially in the sample period.

The analytical framework of the present study is based upon cost frontier analysis, which defines cost inefficiency as the ratio of the estimated cost frontier to observed cost (Kumbhakar and Lovell, 2000). Figure 1 provides an illustration of the concept of cost inefficiency. Assuming that cost is determined by output, the cost inefficiency for university A with output, Q, and cost, E_A, is the ratio of the distance CQ to the distance AQ, where C is the minimum feasible cost or the cost frontier for producing output, Q. University A is more efficient than university B since the distance AC is shorter than distance BC. As E_A and E_B are observable, estimation is required to "locate" C in order to calculate cost inefficiency.

Two approaches have been used to estimate a cost frontier; stochastic frontier analysis (SFA) and data envelopment analysis (DEA) (for surveys, see Lovell, 1993; Coelli et al (1998)). A major drawback of DEA is that it does not allow hypothesis testing and assumes that every observation unit operates under the same technology. In the context of a panel data set, DEA virtually treats individual differences as fixed, ignoring the possibility of them being random. As noted, Australian tertiary education sector has undergone substantial changes during the past decade and it is expected that the environment under which a university operates may be different from university to university. Hence, it is advisable to subject such individual differences to a formal screening process. SFA allows statistical hypotheses testing with regard to differences in university cost frontiers and is therefore chosen over DEA for the present study.

Figure 1. An illustration of cost inefficiency

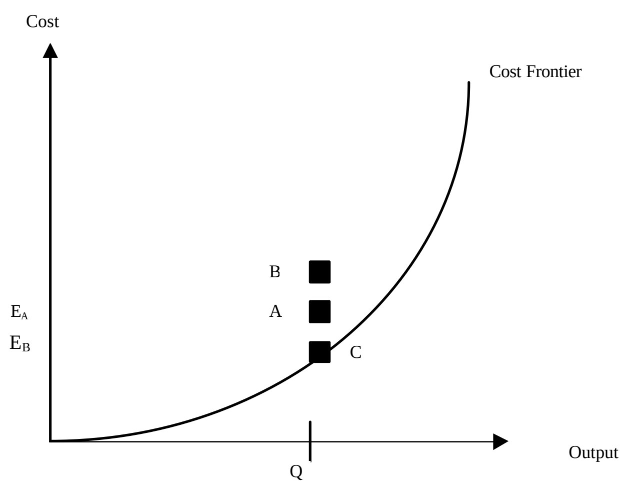

Figure 1 assumes that universities *A* and *B* have an identical cost frontier and there is single output for each of them. For a more general analysis, it is conjectured that universities have different cost frontiers, C_i, for given vectors of output and factor prices, Y_i and P_i, respectively, where i indexes the university. The C_i may be represented by a function such as, $C_i = f(Y_i, P_i)$, where $f(\bullet)$ characterises the underlying technology. The observed cost (nominal expenditure) for Y_i is denoted by E_i which equals $P_i' X_i$, where X_i is a vector of input factors (P_i and X_i are conformably dimensioned).

To take into account random shocks to the cost frontier, a stochastic component, e_i, is included in the cost frontier, namely,

$$C_i = f(Y_i, P_i, e_i) \qquad (1)$$

Assuming a Cobb-Douglas functional form for the $f(\bullet)$ and omitting P_i since factor prices (salaries of academic and non-academic staff) facing Australian universities are similar (Lloyd et al, 1993), equation (1) is written as,

$$C_i = a_{i0} \prod_j Y_{ij}^{b_{ij}} e_i \qquad (2)$$

where Y_{ij} is the jth element of Y_i, a_{i0} (intercept term) and b_{ij} s (university cost responsiveness to output change) are parameters to be estimated. Equation (2) represents the stochastic cost frontier for university i.

It follows by definition that $E_i = P_i' X_i \geq C_i = f(Y_i, P_i, e_i)$, which implies that cost inefficiency has led to University i to overspend by an amount of $E_i - C_i$ (the difference between observed and estimated minimum cost).

Denote cost inefficiency by $u_i(\geq 0)$ and following Kumbhakar and Lovell (2000), the university expenditure function is written as:

$$E_i = a_{i0} \prod_{j=1}^{k} Y_{ij}^{b_{ij}} e_i \, e^{u_i} \qquad (3)$$

so that the cost efficiency (CE) can be measured by the ratio of C_i to E_i,

$$CE_i = \exp(-u_i) . \qquad (4)$$

Equation (3) can be rewritten in the following panel data model specification,

$$\ln E_{it} = \ln a_{i0} + \sum_j b_{ij} \ln Y_{ijt} + v_{it} + u_i$$

$$\text{or } e_{it} = b_{i0} + \sum_j b_{ij} y_{ijt} + v_{it} + u_i \qquad (5)$$

where the lower case letters denote logarithms, subscript t indexes time period and v is white noise.

Estimation of the inefficiency component depends on whether equation (5) is specified as a random or fixed effects model. A random effects model suggests that inefficiency differences between universities are independent of differences in university attributes, that is, the u_is, are independent of the y_{ijt}s. A fixed effects model, however, is indicative of the u_is being conditional on the y_{ijt}s. Since the sample period spans only eight years, such a difference in model specification has a significant impact on coefficient estimates (Hsiao, 2003, p. 37), which, in turn, affect estimation of cost inefficiency. This gives rise to the use of a specification test, such as Hausman (1978) to select one of the two model specifications.

Equation (5) indicates that cost inefficiency is different between universities but remains unchanged over time. To overcome this limitation, the procedure proposed by Cornwell et al (1990) is followed, which assumes that cost inefficiency is a function of linear as well as a quadratic time variables. To reflect the influence of teaching quality on cost efficiency, the student-staff ratio (SSR) is also included with a negative a priori sign. Namely, cost inefficiency is assumed to change according to,

$$u_{it} = d_{i0} + d_{i1}t + d_{i2}t^2 + d_{i3}SSR_{it} \tag{6}$$

where d_{i0}, d_{i1}, d_{i2} and d_{i3} are university-specific parameters to be estimated. There are two steps involved in estimation of the ds. In the first step, equation (5) is either estimated by a least squares dummy variable estimator (LSDV) if a fixed effects model specification is accepted, or by an estimated generalised least squares estimator (EGLS) if a random effects model specification is accepted. In the second step, the estimated residuals in step one are regressed on t, t^2 and SSR_{it} to obtain the estimates of the d_{i0}, d_{i1}, d_{i2} and d_{i3}, denoted by $\hat{d}_{i0}$, $\hat{d}_{i1}$, $\hat{d}_{i2}$ and $\hat{d}_{i3}$. Thus, the estimates of the u_{it} are computed by $\hat{u}_{it} = \hat{d}_{i0} + \hat{d}_{i1}t + \hat{d}_{i2}t^2 + \hat{d}_{i3}SSR_{it}$, which are consistent estimators when both the numbers of time period and panel units are large (Greene, 1993).

To ensure the non-negativeness of the inefficiency component (ruling out the possibility that observed cost lies below minimum cost) requires a normalisation of the $\hat{u}_{it}$s, which amounts to re-defining inefficiency as $\hat{u}_{it} - \hat{u}_{\min t}$, where $\hat{u}_{\min t}$ is the smallest $\hat{u}_{it}$ for period t. For example, suppose university A's inefficiency at time t is $\hat{u}_{At} = 0.8$ and university B's is $\hat{u}_{Bt} = -0.6$, then, the $\hat{u}_{\min t}$ will be $\hat{u}_{Bt} = -0.6$, namely, university B is the most efficient university since its cost efficiency is 100% ($\hat{u}_{Bt} - \hat{u}_{\min t} = -0.6 - (-0.6) = 0$), and using equation (4) gives $CE_B = \exp[-(\hat{u}_{Bt} - \hat{u}_{\min t})] = 1$). The estimation procedure allows for time-varying costs and, hence, the possibility that the most efficient university is endogenously determined and may alter over the time period.

IV. Estimation and Empirical Results

The data set for the present study are comprised of student, staff and expenditure statistics for 36 Australian universities over the period 1995-2002, obtained from the Department of Education, Science and Training (DEST). The student statistics enable a breakdown of student numbers by field of study and mode of attendance. As noted above, a number of studies have been conducted to estimate cost functions for the Australian tertiary sector, including Throsby (1986), Heaton and Throsby (1997) and Lloyd et al (1993). A commonality among these studies is that costs are assumed to be a function of student numbers only since universities face similar factor prices (staff salaries are more or less identical across universities ignoring salary loadings).

The cost determinant variables that appear on the right hand side of equation (5) include the following: (a) postgraduate students (PG); (b) undergraduates (UG); (c) share of science-engineering students (SE); (d) share of business students (SB) and (e) share of other students (SO).

Since interest is in estimating educational services, the five cost determinants listed above do not include research output. Research costs are measured by the difference between total expenditure and research expenditure. Data on research costs are not published either by DEST or the Australian Bureau of Statistics (ABS). However, shares of research income by institution from 1995 to 1999 and total research expenditures by all the universities from 1995 to 2002 are available from DEST and ABS, respectively. It is assumed that the share of research income at an institution is positively correlated with its share of research expenditure. Thus, research expenditure for each university is estimated by applying its share of research income (expenditure) to total research expenditure.

The panel data model is as follows,

$$e_{it} = b_0 + b_{i1} \ln PG + b_{i2} \ln UG + b_{i3} \ln SE + b_{i4} \ln SB + b_{i5} \ln SO + v_{it} + u_i \qquad (7)$$

for a random effects specification; and

$$e_{it} = b_{i0} + b_{i1} \ln PG + b_{i2} \ln UG + b_{i3} \ln SE + b_{i4} \ln SB + b_{i5} \ln SO + v_{it} \qquad (8)$$

for a fixed effects specification; where i =1 to 36, t =1995 to 2002.

The first step in the analysis is to test if each of the universities has a different cost function. This amounts to conducting an F-test for the following hypotheses.

$H_0: b_{1,0} = \cdots = b_{36,0}; b_{1,k} = \cdots = b_{36,k}; k = 1 \text{ to } 5 \quad H_1: \text{at least one of the } bs \text{ is different.}$

The F-test indicates that the above null hypothesis should be rejected which vindicates use of a panel data modelling approach. Further F-tests are conducted to find out whether the universities share the same intercept or the same slope coefficients. Such tests reveal that the universities share the same slope coefficient, namely, $b_{1,k} = \cdots = b_{36,k} = b_k; k = 1 \text{ to } 5$. This implies that the universities have the identical "technology" to produce students of various fields in terms of cost elasticity of student. However, the universities do have a different intercept coefficient, namely, the null hypothesis $H_0: b_{1,0} = \cdots = b_{36,0}$ is rejected. The estimated model in both the random and fixed effects specifications are presented in Table 2.

Table 2. Estimated coefficients of the cost function

Variable	Coefficient	t-ratio
Random Effects Specification (Estimated by EGLS)		
Constant	8.3211	11.681
$\ln PG$	0.1284	3.0654
$\ln UG$	0.4221	6.3087
$\ln SE$	0.6616	3.4679
$\ln SB$	0.3836	3.0089
$\ln SO$	0.3961	1.9127
Fixed Effects Specification (Estimated by LSDV)		
Constant	-	-
$\ln PG$	0.1430	3.1907
$\ln UG$	0.2837	3.5842
$\ln SE$	0.6139	2.8822
$\ln SB$	0.4345	3.0062
$\ln SO$	0.3535	1.5487
$R^2 = 0.47 \quad F = 50.26 \quad Hausman\ test = 0.0001$		

The computed Hausman test of 0.0001 failed to reject the random effects specification for the panel model. Given the small differences between the estimated coefficients of the two specifications, the fixed effects specification added little explanatory power to that of the random effects specification. This implies that university cost inefficiency is exogenous to student numbers. The t-ratio of the variable, $\ln SO_{it}$, is insignificant at a 5 percent level, which suggests that students in fields other than science/engineering and business have an insignificant impact on university cost, *ceteris paribus*. All other independent variables are significant at a 5 percent level; each coefficient measures the cost elasticity response. For example, the estimates show that a 10 percent increase in undergraduates increases university costs by about 4.2 percent. Increasing the relative share of business students has a smaller effect on costs compared to non-business students. The elasticity of university costs in response to the proportion of science to business students is almost double that of business students alone while the cost elasticity of undergraduates is nearly four times that of postgraduates.

The estimated model coefficients are cost elasticities of students and are not directly comparable with those of previously estimated cost functions for Australian universities (Heaton and Throsby, 1997; Lloyd et al, 1993) since the coefficients in the latter studies are marginal costs of student. Further, a constant cost elasticity which is the case in the present study, implies a variable marginal cost. However, it is noted that the cost elasticity for postgraduate students was found to be smaller than that for undergraduate students in the present study. Lacking knowledge of various student proportions in 1991 and 1994, the elasticity estimates in the present study would be consistent with the previous studies which point to the marginal cost of postgraduate students being higher than that of undergraduate students if the proportions of undergraduate students in the years were high enough.

Residuals from the model specified by equation (7) are used as the dependent variable for the auxiliary regression outlined in Section III for estimation of time-varying cost inefficiency. The estimated coefficient of the variable student-staff ratio, $\hat{d}_{i3}$, was insignificant for some universities and significantly negative for other universities. This indicates that a higher student-staff ratio will never increase cost inefficiency and may reduce it as evidenced at some universities. Table 3 contains estimates of cost efficiency calculated using equation (4) for 36 Australian universities: efficiency rankings are presented in Table 4.

In interpreting the results, it is recalled that the normalisation procedure estimates university efficiency relative to the most efficient university (benchmark) in a given year. The benchmark is endogenously determined and hence, can change over time as shown in the Table. It appears that the non-Go8 universities have dominated the top 10 places in terms of cost efficiency. Only the University of Western Australia is in the top 10 throughout the sample period. The most efficient universities are the University of Western Australia, the University of Ballarat, Southern Cross University and Flinders University which dominated other universities in the last four years of the study period. The finding that the least efficient university in every year is ANU deserves comment. ANU is primarily a research university and consistently ranks highly as such within

Australia and internationally. To test the sensitivity of the results to ANU, it was excluded from the sample but the rankings were unaffected.

The mean efficiency scores fall within the range of 0.64 to 0.45 against a benchmark of unity (most efficient university). Since the efficiency estimates are of cost rather than technical efficiency, they are not directly comparable with the higher mean score for technical efficiency of academic and teaching services (in 1995) of Australian universities noted earlier. In common with other efficiency studies, the interpretation of “high” or “low” is subjective but there is no discernible pattern of increased efficiency over time nor of convergence. The reverse seems the case for efficiency trends with standard deviations around the mean fairly stable.

Estimated efficiency rankings also need to be interpreted with care. The main qualification is that the rankings are based upon point estimates. It is possible that, for example, the finding of the University of Western Australia as more efficient than ANU could be a sampling fluke in the absence of formal hypothesis testing. Such testing presently lies outside the SFA methodology that restricts all but one institution in one time period to being inefficient. A second qualification concerns the sample period during which universities were subject to unprecedented pressures of adjustment and hence, the results may not be representative of longer trends in efficiency.

Table 3. Efficiency estimates (ratio of minimum feasible cost to actual cost)

Year	1995	1996	1997	1998	1999	2000	2001	2002
ACU	0.54	0.56	0.56	0.58	0.61	0.52	0.47	0.42
CQU	0.79	0.74	0.74	0.72	0.65	0.51	0.52	0.42
CSU	0.64	0.60	0.62	0.62	0.63	0.57	0.60	0.54
CUT	0.52	0.48	0.50	0.50	0.48	0.35	0.38	0.34
DU	0.51	0.50	0.53	0.53	0.48	0.40	0.38	0.33
ECU	0.52	0.50	0.54	0.52	0.53	0.45	0.45	0.42
GU	0.54	0.53	0.49	0.50	0.50	0.42	0.38	0.34
JCU	0.55	0.53	0.57	0.60	0.63	0.54	0.51	0.45
LTU	0.49	0.48	0.60	0.60	0.56	0.39	0.39	0.37
MQU	0.63	0.56	0.66	0.60	0.70	0.52	0.47	0.36
MOU	0.46	0.40	0.45	0.44	0.43	0.35	0.34	0.29
MDU	0.82	0.77	0.79	0.78	0.78	0.66	0.59	0.52
NTU	0.74	0.82	0.93	0.93	0.89	0.63	0.81	0.53
QUT	0.52	0.47	0.53	0.53	0.49	0.42	0.41	0.41
RMIT	0.48	0.53	0.53	0.52	0.52	0.43	0.41	0.28
SCU	0.88	0.94	1.00	0.96	0.94	0.75	0.66	0.67
SUT	0.77	0.79	0.92	0.85	0.77	0.58	0.69	0.34
ANU	0.17	0.17	0.19	0.20	0.21	0.18	0.16	0.15
FU	0.85	0.80	0.81	0.89	1.00	1.00	1.00	1.00
UAD	0.91	0.77	0.71	0.69	0.71	0.64	0.64	0.63
UML	0.49	0.53	0.54	0.57	0.58	0.49	0.42	0.34
UNE	0.53	0.52	0.56	0.58	0.60	0.49	0.47	0.42
UNSW	0.41	0.42	0.47	0.50	0.52	0.45	0.44	0.38
UNC	0.62	0.58	0.66	0.67	0.67	0.55	0.48	0.44
UQ	0.65	0.60	0.64	0.59	0.56	0.40	0.39	0.32
USD	0.32	0.32	0.41	0.45	0.48	0.40	0.35	0.33
UWA	1.00	0.88	0.83	0.78	0.74	0.60	0.62	0.54
UB	0.96	1.00	0.98	1.00	0.99	0.83	0.71	0.57
UC	0.82	0.78	0.79	0.80	0.81	0.70	0.64	0.59
USA	0.55	0.52	0.54	0.55	0.58	0.51	0.50	0.47
USQ	0.84	0.77	0.76	0.75	0.76	0.66	0.75	0.71
UTAS	0.72	0.68	0.73	0.74	0.76	0.64	0.57	0.52
UTS	0.58	0.54	0.61	0.62	0.62	0.53	0.48	0.42
UWS	0.50	0.47	0.52	0.54	0.54	0.43	0.45	0.41
UW	0.69	0.66	0.71	0.70	0.72	0.60	0.65	0.62
VUT	0.61	0.67	0.69	0.65	0.64	0.53	0.50	0.37
Mean	*0.63*	*0.61*	*0.64*	*0.64*	*0.64*	*0.53*	*0.52*	*0.45*
S.D.	*0.18*	*0.18*	*0.17*	*0.16*	*0.16*	*0.15*	*0.16*	*0.15*

Table 4. Rankings of universities by cost efficiency (most efficient to least efficient).

1995	1996	1997	1998	1999	2000	2001	2002
UWA	UB	SCU	UB	FU	FU	FU	FU
UB	SCU	UB	SCU	UB	UB	NTU	USQ
UAD	UWA	NTU	NTU	SCU	SCU	USQ	SCU
SCU	NTU	SUT	FU	NTU	UC	UB	UAD
FU	FU	UWA	SUT	UC	USQ	SUT	UW
USQ	SUT	FU	UC	MDU	MDU	SCU	UC
UC	UC	UC	MDU	SUT	UAD	UW	UB
MDU	USQ	MDU	UWA	UTAS	UTAS	UC	CSU
CQU	UAD	USQ	USQ	USQ	NTU	UAD	UWA
SUT	MDU	CQU	UTAS	UWA	UWA	UWA	NTU
NTU	CQU	UTAS	CQU	UW	UW	CSU	MDU
UTAS	UTAS	UAD	UW	UAD	SUT	MDU	UTAS
UW	VUT	UW	UAD	MQU	CSU	UTAS	USA
UQ	UW	VUT	UNC	UNC	UNC	CQU	JCU
CSU	CSU	MQU	VUT	CQU	JCU	JCU	UNC
MQU	UQ	UNC	CSU	VUT	UTS	VUT	ECU
UNC	UNC	UQ	UTS	JCU	VUT	USA	ACU
VUT	MQU	CSU	JCU	CSU	MQU	UNC	UNE
UTS	ACU	UTS	MQU	UTS	ACU	UTS	UTS
USA	UTS	LTU	LTU	ACU	USA	UNE	CQU
JCU	GU	JCU	UQ	UNE	CQU	ACU	UWS
ACU	UML	UNE	ACU	UML	UML	MQU	QUT
GU	RMIT	ACU	UNE	USA	UNE	UWS	UNSW
UNE	JCU	UML	UML	UQ	ECU	ECU	VUT
QUT	USA	USA	USA	LTU	UNSW	UNSW	LTU
CUT	UNE	ECU	UWS	UWS	UWS	UML	MQU
ECU	ECU	DU	DU	ECU	RMIT	QUT	GU
DU	DU	QUT	QUT	UNSW	QUT	RMIT	CUT
UWS	LTU	RMIT	RMIT	RMIT	GU	LTU	SUT
UML	CUT	UWS	ECU	GU	USD	UQ	UML
LTU	QUT	CUT	GU	QUT	UQ	GU	DU
RMIT	UWS	GU	UNSW	CUT	DU	CUT	USD
MOU	UNSW	UNSW	CUT	DU	LTU	DU	UQ
UNSW	MOU	MOU	USD	USD	MOU	USD	MOU
USD	USD	USD	MOU	MOU	CUT	MOU	RMIT
ANU	ANU	ANU	ANU	ANU	ANU	ANU	ANU

Below are the abbreviations of the university names.

ACU	Australian Catholic University
CQU	Central Queensland University
CSU	Charles Sturt University
CUT	Curtin University of Technology
DU	Deakin University
ECU	Edith Cowan University
GU	Griffith University
JCU	James Cook University
LTU	La Trobe University
MQU	Macquarie University
MOU	Monash University
MDU	Murdoch University
NTU	Northern Territory University
QUT	Queensland Univ. Technology
RMIT	RMIT University
SCU	Southern Cross University
SUT	Swinburne Univ.of Technology
ANU	Australian National University
FU	Flinders Univ. South Australia
UAD	The University of Adelaide
UML	The University of Melbourne
UNE	The University of New England
UNSW	University of New South Wales
UNC	The University of Newcastle
UQ	The University of Queensland
USD	The University of Sydney
UWA	The Univ. of Western Australia
UB	University of Ballarat
UC	University of Canberra
USA	University of South Australia
USQ	Univ. of Southern Queensland
UTAS	University of Tasmania
UTS	Univ. of Technology, Sydney
UWS	University of Western Sydney
UW	University of Wollongong
VUT	Victoria University

V. Policy implications and conclusions

Three main policy issues arise from the empirical findings: the scope for efficiency adjustment in response to government funding cutbacks, the use of efficiency rankings as performance criteria for government funding of teaching resources and measures to increase relative efficiency. In each instance, qualifications are necessary for policy usefulness as explained below.

An earlier study by Heaton and Throsby (1997) examined the policy implications of estimated university cost functions of Australian universities, including the effects of cuts in government funding. Their study demonstrated that, barring other adjustment mechanisms such as efficiency and assuming unchanged fees and quality, costs can be reduced through a redistribution of students from universities operating above minimum scale. The difficulty with this reform is that there are disincentives for universities to reduce student numbers under past and current Commonwealth funding arrangements that tie funds to a specified number of government supported undergraduate places in particular course disciplines.

The main finding of this study is that universities are not operating efficiently, as measured by cost efficiency and in relative terms. In terms of movement towards greater efficiency, not all universities can improve their rankings since it is a zero sum game. But on average the size of efficiency gaps in 2002 is below 0.5 suggesting scope for further gains in cost efficiency. The main qualification for policy usefulness concerns translating this scope into dollar terms. The normalisation procedure converts cost efficiency residuals into the difference between the benchmark university and that of a specific university. Hence, any dollar transformation of the efficiency rankings has little meaning.

A second issue concerns the potential policy use of the efficiency rankings as performance criteria in allocating government funding of teaching resources. Unlike research funding which is based upon a competitive set of performance criteria, the previous system of block operating grants and its successor (Commonwealth Grant Scheme) are input based with educational and other performance criteria having little or no effect on government funding for teaching. Although each university has an incentive to manage its costs effectively, there is no information on how they compare to others or rewards for relative efficiency.

The main qualification to using efficiency rankings as performance criteria, at least in isolation is as already noted, namely that the efficiency rankings are based upon point estimates and, in the absence of formal hypothesis testing may be misinterpreted by policymakers. A second qualification concerns the subjective nature of interpretation of mean scores as “high” or “low” efficiency. The methodology used (whether SFA or DEA) also does not rule out the possibility that the entire Australian tertiary education sector may ranked as inefficient in a larger sample set of overseas universities. At best, the efficiency rankings provide quantitative information on one dimension of university performance that might be used in conjunction with other criteria such as quality control benchmarks and degree completions.

A third issue follows from the second: if the rankings are to be of operational use, what measures are within university control to improve relative efficiency? Statistical support for the random effects model implies that student numbers are exogenous to efficiency. In other words, reducing student numbers will not raise cost efficiency. Further empirical work is needed to identify the various factors that might explain the efficiency rankings. For example, overseas studies reported in Salerno (2003) point to potential roles for the initial level of efficiency (the higher the initial efficiency level, the less efficient the university) and a positive relationship between tuition fees and efficiency.

The main product of this paper is a cost efficiency ranking of Australian universities over the sample period 1995-2002. The period encompasses the peak of the debate on reform of higher education, including conflicting policy and university views on this dimension of university performance. Further econometric research in the directions indicated would help strengthen the robustness of the results for policy purposes.

References

Australian Bureau of Statistics (2004), Research and Experimental Development, Higher Education Organisations, Australia.

Abbot, M. and C. Doucouliagos (2003) "The Efficiency ofAustralian Universities -a data envelopment analysis" Economics of Education Review, 22, February, 89-97.

Australian Senate Committee (2001) Universities in Crisis, Senate Employment Workplace Relations, Small business and Education Reference Committee, www.aph.gov.au/senate/committee/eet-ctte/public%20uni/report/index.htm

Avkiran, N (2001) "Investigating Technical and Scale Efficiencies of Australian Universities through Data Envelopment Analysis", Socio-Economic Planning Sciences, 35, 57-80.

Chapman, B (2001) "Australian Higher Education Financing: Issues for Reform", The Australian Economic Review, 34, 195-204.

Cornwell, C, P. Schmidt and R.C. Sickles (1990) "Production Frontiers With Cross-Sectional And Time-Series Variation In Efficiency Levels", Journal of Econometrics, 46, 185-200.

Coelli, T.J (1996) "Assessing the Performance of Australian Universities Using Data Envelopment Analysis", Mimeo, Centre for Efficiency and Productivity Analysis, University of New England.

Coelli, T.J, D.S.P. Rao and G. Battese (1998) An Introduction to Efficiency and Productivity Analysis, Kluwer Academic Publishers, Boston.

Commonwealth of Australia (2003) Our Universities Backing Australia's Future, www.backingaustraliasfuture.gov.au

Department of Education, Science and Training, Selected Higher Education Statistics, DEST, Canberra, www.dest.gov.au

________(2002) Setting Firm Foundations Financing Australian Higher Education, DEST, Canberra, www.dest.gov.au

Economic Society of Australia (2004) A Survey of Student Standards in Economics in Australian Universities, Sydney, www.ecosoc.org.au

Greene, W. (1993) The Econometric Approach to Efficiency Analysis, in H.O. Fried, C.A.K. Lovell and S. Schmidt (eds.), The Measurement of Productivity Efficiency: Techniques and Applications, Oxford University Press, New York, 69-119.

Hay, D. and G.S. Liu (1997) "The Efficiency of Firms: What Difference Does Competition Make?", The Economic Journal, 107, 597-617.

Hausman, J.A (1978) "Specification Tests in Econometrics", Econometrica, 46, 1251-1271.

Heaton , C and D. Throsby (1997) "Cost Functions for Australian Universities: A Survey of Results with Implications for Policy" Centre for Economic Policy Research Discussion Papers, No. 360, February.

Hsiao, C (2003) Analysis of Panel Data, Cambridge University Press, Cambridge.

King, S (2001) "The Funding of Higher Education in Australia: Overview and Alternatives", The Australian Economic Review, 34, 190-4.

Kumbhakar, S and C. Knox Lovell (2000) Stochastic Frontier Analysis, Cambridge University Press, Cambridge.

Lloyd, P, M. Morgan and R. Williams (1993) "Amalgamation of Universities: Are There Economies of Scale or Scope?" Applied Economics, 25, 1081-1092.

Marginson, S (2001) "Trends in the Funding of Australian Higher Education", The Australian Economic Review, 43, 205-15.

McMillan, M and D. Datta (1998) "The Relative Efficiencies of Canadian Universities: A DEA Perspective", Canadian Public Policy, XXIV, 485-511.

Salerno, C (2003) "What we know about the efficiency of higher education insitutions. The best evidence", Mimeo, The Centre for Higher Education Policy Studies, University of Twente, December.

Throsby, D (1986) "Cost Functions for Australian Universities", Australian Economic Papers, 25, 175-92.