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ABSTRACT

This paper *identifies new classifications of Australian universities based on their total and per-academic staff research outputs using the data for the period 1998-2002. We define research performance in terms of audited numbers of PhD completions, publications and grants (in accordance with rules established by the Department of Education, Science and Training). Our analysis indicates that (a) the highest achievers consists of the seven Group of Eight (Go8) universities; (b) the top-three research performers are the Universities of Melbourne, Sydney and Queensland in terms of total research performance and the Universities of Melbourne, Adelaide and Western Australia in per academic staff terms.*

JEL classification: Higher education, Hierarchical cluster analysis, Research performance, Factor analysis

Keywords: A11; A19; C63; I29

I. INTRODUCTION

Australian universities contribute to national research and the scholarship of research, partially justifying sizeable Commonwealth government funding. However for some decades, such funding has been provided independently of any specific performance indicators. Prior to 1988, for example, a dichotomous division was well-recognised in the higher education sector whereby the smaller number of research-orientated 'universities' were automatically funded at a higher level than the larger number of teaching-orientated 'colleges of advanced education' and 'institutes of technology'. To a large extent, such funding was more concerned with this classification and institutional size and course mix, rather than any endeavour to recognise and reward research.

Since 1989 a series of policy changes, collectively known as the 'Dawkins reforms', established a *'unified national system'*, in so doing removing the funding division between universities and non-universities. Within this system, during the 1990s, Commonwealth research funding was directed through four main channels. First, support for research training was provided through operating grants made on the basis of enrolments and disciplines, as well as in the form of Australian Postgraduate Research Awards (APRA) scholarships for postgraduate research and exemptions for domestic students from the requirement to pay fees (in the form of HECS, the Higher Education Contribution Scheme). Second, funding in the form of a Research Quantum was allocated on the basis of a composite index to support university research and research-training more generally, taking into account both research inputs (private research and special government research funding) and research outputs (publications and postgraduate completions). Thirdly, Research Infrastructure Block Grants supported project-based infrastructure within an institution. Finally, program-specific funding was also allocated, encompassing, amongst other things, Australian Research Council (ARC) awards for projects (both wholly and industry-linked) and fellowships. This system was modified with the implementation of the 1999 White Paper, Knowledge and Innovation; in particular the Research Quantum was replaced with the Institutional Grants Scheme. Despite these changes and the apparent dissimilarity of these funding channels, all have been allocated, at least indirectly, on the basis of an institution's research performance, partially facilitated by the Commonwealth's DEST (Department of Education, Science and Training) monitoring and assessment of research output.

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The Commonwealth government has recently initiated discussions about moving to a differentiated trinary system of classification with universities categorised as ‘research intensive’, ‘teaching and research’ or ‘teaching intensive’, which it labels ‘building diversity’ in a recent discussion paper (DEST, 2005, p. 2). Not unexpectedly, this reclassification is generally thought to be associated with a move away from the current unitary system of performance-based funding. The means by which such a classification is to be obtained is subject to some conjecture, and there are concerns, especially by newer universities, that it would fall more or less along the lines of the older binary divide, despite argued gains in research performance in the interregnum. In this manner, the larger, more established universities (comprising the Go8) would be classified as research intensive, with the remaining universities (comprising the Innovative Research Universities Australia, the Australian Technology Network, New Generation Universities and Ungrouped Universities) taking up the lesser role, funding and status of ‘teaching and research’ or ‘teaching only’ universities.

Unfortunately, there has been very little quantitative work on the ranking of Australian university research performance that would provide guidance on these proposed policy changes. DETYA (Department of Education, Training and Youth Affairs, 1998), for example, classified Australian universities on a wide range of research and teaching characteristics for 1996/1997 using cluster analysis. More than twenty different indicators were used to operationalise six performance measures: size, overseas orientation, diversity, internal/full-time orientation, financial research orientation and staff research orientation. Based on these six measures, universities were grouped into between four and seven clusters and ranked on the basis of a single composite indicator. While arguably “a workable measure of the characteristics and performance of institutions in terms of their teaching and research activities” (DETYA, 1998, p.41), this study was cross-sectional and rather unwieldy.

As an alternative study, Abbott and Doucouliagos (2003) examined the technical and scale efficiency of Australian universities with data envelopment analysis. After considering different measures of output and inputs (both teaching and research), it was concluded that the results were insensitive with respect to the selection of the chosen output-input mix, suggesting that Australian universities overall recorded high levels of relative efficiency. More recently, Abbott and Doucouliagos (2004) investigated the relationship between research output, research income, academic and non-academic labour and other university characteristics. They concluded that research income, academic staff and postgraduates were all positively correlated with research output, but that substantial differences exist, since a number of newer universities are finding it difficult to catch up with the more established universities in terms of research performance. Clearly, such analyses add to our understanding of the production process in universities in Australia and overseas [see, for instance, Johnes and Johnes (1995), Coelli (1996), Glass et al. (1998), and Ng and Li (2000)], but are computationally complex, rely on data that is difficult to obtain over time, and are prone to misspecification and misinterpretation. Worthington (2001) provides a useful survey outlining the limitations of efficiency measurement techniques in educational contexts.

Finally, Williams and Van Dyke (2004) conducted a recent study on the international standing of Australian universities using a range of performance measures. These included the international standing of academic staff, the quality of the graduate and undergraduate programs, resource availability, and a subjective assessment of standing by surveyed educationists in Australia and overseas. In part, this study was intended to complement and confront some of the well-publicised (and often contentious) international rankings produced by the Institute of Higher Education at Shanghai Jiao Tong University (2003) and the Times Higher Education Supplement (2004) [for Australian media coverage see Aitkin (2004), Dodd (2004), Illing (2004) and Perry (2005)]. While encompassing a broad scale of measures, the resultant index indicated that the Group of Eight universities were highest ranked on an Australian basis, thereby confirming similar results from the international studies. However, given the reliance on surveyed perceptions of standing, the study by Williams and Van Dyke (2004) is unlikely to be easily replicated in the future. Other work on the ranking of university performance in Australia and overseas, either wholly or in part, include Bowden (2000), Filinov and Ruchkina (2002), Yonezawa *et al*. (2002) and Pomfret and Wang (2003).

The aim of this paper is to complement this nascent body of work with an analysis of the recent research performance of Australian universities. We take advantage of the audited quantitative information on research performance periodically gathered by governmental authorities. This ensures the objectivity of the results which may also be easily replicated in the future as additional data come to hand.

The paper itself is structured as follows. The next section provides a description of the data employed in the analysis. Then we discuss the clustering of university research performance followed by the ranking of research performance using factor analysis. The paper ends with some concluding remarks and policy recommendations in the final section.

Table 1. Average PhD completions, publications, academic staff and grants, 1998-2002

No.	University	Group	Academic staff (persons)	PhD completions (persons)	Publications (DEST weighted points)	Grants ($m-2002 prices)
1	Adelaide	Go8	1,109	172	1236	64.30
2	Australian Catholic University	NGU	344	8	125	1.66
3	Ballarat	NGU	135	7	90	2.27
4	Canberra	UGU	270	14	200	6.39
5	Central Queensland	NGU	332	13	199	3.24
6	Charles Sturt	UGU	451	19	225	4.01
7	Curtin University of Technology	ATN	851	82	624	19.10
8	Deakin	UGU	734	74	606	11.16
9	Edith Cowan	NGU	538	25	484	4.54
10	Flinders	IRUA	699	65	619	26.97
11	Griffith	IRUA	939	85	733	21.59
12	James Cook	UGU	502	69	333	10.29
13	La Trobe	UGU	1,019	131	771	19.80
14	Macquarie	IRUA	660	96	661	17.07
15	Melbourne	Go8	2,084	366	2585	126.95
16	Monash	Go8	2,078	275	2017	74.35
17	Murdoch	IRUA	467	70	430	16.47
18	New England	UGU	458	69	483	9.76
19	New South Wales	Go8	1,905	297	2060	102.08
20	Newcastle	IRUA	833	72	767	26.85
21	Northern Territory	UGU	155	14	91	3.45
22	Queensland	Go8	2,234	337	2349	111.71
23	Queensland University of Technology	ATN	996	91	803	15.25
24	Royal Melbourne Institute of Technology	ATN	989	91	529	16.88
25	South Australia	ATN	797	65	565	17.66
26	Southern Cross	NGU	254	33	136	4.28
27	Southern Queensland	NGU	357	14	150	3.54
28	Sunshine Coast	NGU	85	1	48	0.335
29	Swinburne University of Technology	UGU	369	32	255	6.00
30	Sydney	Go8	2,226	364	2232	114.48
31	Tasmania	UGU	631	93	614	25.31
32	University of Technology, Sydney	ATN	728	62	498	11.90
33	Victoria University of Technology	NGU	510	34	349	5.59
34	Western Australia	Go8	1,227	175	1370	68.22
35	Western Sydney	NGU	901	54	513	10.32
36	Wollongong	UGU	583	86	597	18.23

Notes: PhD completions and academic staff are in persons, publications are in DEST-weighted points, grants (total average sum of national competitive grants and industry grants, public and other funding) are at the constant 2002 prices based on the author's calculations. Go8=Group of Eight; IRUA=Innovative Research Universities Australia; ATN=Australian Technology Network; NGU=New Generation Universities; and UGU= Ungrouped Universities.

Sources: Department of Education, Science and Training (DEST), Higher Education Report for the 2002 to 2004 Triennium. (www.dest.gov.au); Higher Education Statistics Collection-various years; Australian Vice-Chancellor's Committee (AVCC) (www.avcc.edu.au); Australian Bureau of Statistics (2005), Consumer Price Index, Cat. No. 6401, Canberra.

II. THE DATA EMPLOYED

In this analysis we used the data on thirty-six Australian universities, all of which are publicly funded and members of the Australian Vice-Chancellor's Committee (AVCC). Twenty-nine of these universities belong to one of four groupings: the Group of Eight (Go8); the Innovative Research Universities Australia (IRUA), the Australian Technology Network (ATN) and the New Generation Universities (NGU). See Table 1 for a full list of these university groupings. It should be noted that the Australian National University (ANU) has been excluded from this study because the Institute of Advanced Studies at the ANU did not fully participate in the competitive research schemes of the ARC and NHMRC until 2004. However, the exclusion and inclusion of ANU were inconsequential as the changes in the results were hardly noticeable.

The performance indicators specified in the analysis have all been obtained from DEST and comprise those measures included in its Composite Research Index. We calculated this index using an audited mix of the competitive funding and industry funding received, public sector research funding, research and scholarly publications and the number of PhD students. To avoid the bias in our results we consider only those academic staff members who are classified as 'research-only' and 'teaching-and-research'. We do not include 'teaching only' staff in this analysis. The three performance measures in our analysis are as follows: (i) the average annual number of PhD completions; (ii) the average annual number of publications as weighted by DEST; and (iii) the total annual average amount of grants at 2002 prices measured by the sum of national competitive grants and industry grants, public and other funding. These three average measures have been computed using data spanning from 1998 to 2002.

Table 2 presents a summary of descriptive statistics of the data stated above. Sample means, maxima, minima, standard deviations, skewness, kurtosis and Jacque-Bera statistics and *p*-values are reported. As can be seen, on average, academics across all universities supervised about one-tenth of a PhD completion, contributed less than one publication and earned less than $A 25,705 (at 2002 prices) in grants per academic staff member, per year during the period 1998-2002.

Table 2. Descriptive statistics of the data employed, 1998-2002

Variables	Mean	Maximum	Minimum	Std. dev.	Skewness	Kurtosis	Jarque-Bera	P-value
Academic Staff (persons)	818	2234	84	597	1.231	3.615	9.666	0.008
PhD completions (persons)	99	366	1	103	1.548	4.286	16.857	0.000
Publications (DEST points)	732	2585	48	688	1.476	4.077	14.819	0.001
Grants (2002 $million)	27.83	127.00	0.335	35.602	1.691	4.510	20.585	0.000
PhD completions per academic staff (persons)	0.101	0.176	0.010	0.046	-0.191	1.884	2.088	0.352
Publications per academic staff (DEST point)	0.797	1.240	0.365	0.220	0.022	2.089	1.247	0.536
Grants per academic staff (2002$)	25705	60910	4006	16048	0.802	2.549	4.166	0.125

Sources: Based on Table 1 and the authors' calculations.

III. CLUSTERING RESEARCH PERFORMANCE

In order to classify the research performance of Australian universities we use cluster analysis. This method is a multivariate statistical technique that has been widely utilised to categorize objects or items based on the similarity or dissimilarity of the characteristics they possess. Cluster analysis is particularly pertinent in the current context as it permits the minimisation of within-group variance and maximisation of between-group variance based on a range of research output measures, leading to heterogeneous groups with homogeneous contents (Hair, *et al.,* 1998, p.470). This approach has been used to determine how many similar research clusters exist and define exactly which comparable cluster each Australian university belongs to. Based on our analysis, it appears that the optimal number of clusters is two. The agglomeration coefficient as a stoping rule has a tendency to indicate too few clusters (Hair, 1998, p.503), we thus examine the results of three-cluster solutions for both total and per academic staff research performance. The alternative cubic clustering criterion could have been used as a stopping rule, but this rule has the tendency to indicate too many clusters.

Table 3 shows the cluster membership for the 2-cluster (columns 2 and 4) and the 3-cluster (columns 3 and 5) solutions for per academic staff research performance and total research output, respectively. Nothing should be inferred from the ordering of universities in the first column outside of their cluster membership. For the ease of exposition the cluster membership codes are sorted according to the second, third and fourth columns. A quick look at Table 3 reveals that in any two-cluster solution, the Go8 members (Adelaide, Melbourne, Monash, New South Wales, Queensland, Sydney, and Western Australia) always are accommodated in cluster A. But in a two-cluster solution based on per academic staff research performance, seven additional universities (Flinders, Macquarie, Murdoch, Newcastle, New England, Tasmania and Wollongong) are also added, raising cluster A membership to fourteen. This cluster of high-performing research universities then consists of the Go8, four Innovative Research Universities Australia (Flinders, Macquarie, Murdoch and Newcastle) and three Ungrouped Universities (New England, Tasmania and Wollongong). It is interesting to note that there were no Australian Technology Network and New Generation Universities in this grouping.

Table 3. Cluster membership based on per staff and total research output measures

University	Research performance per academic staff		Total research performance	
	2 Clusters (2)	3 Clusters (3)	2 Clusters (4)	3 Clusters (5)
(1)				
Adelaide	A	A	A	A2
Melbourne	A	A	A	A1
Monash	A	A	A	A1
New South Wales	A	A	A	A1
Queensland	A	A	A	A1
Sydney	A	A	A	A1
Western Australia	A	A	A	A2
Flinders	A	A	B	B
Macquarie	A	A	B	B
Murdoch	A	A	B	B
New England	A	A	B	B
Newcastle	A	A	B	B
Tasmania	A	A	B	B
Wollongong	A	A	B	B
Australian Catholic University	B	B2	B	B
Ballarat	B	B2	B	B
Canberra	B	B2	B	B
Central Queensland	B	B2	B	B
Charles Sturt	B	B2	B	B
Edith Cowan	B	B2	B	B
Southern Queensland	B	B2	B	B
Sunshine Coast	B	B2	B	B
Victoria University of Technology	B	B2	B	B
Western Sydney	B	B2	B	B
Curtin University of Technology	B	B1	B	B
Deakin	B	B1	B	B
Griffith	B	B1	B	B
James Cook	B	B1	B	B
La Trobe	B	B1	B	B
Northern Territory	B	B1	B	B
Queensland University of Technology	B	B1	B	B
Royal Melbourne Institute of Technology	B	B1	B	B
South Australia	B	B1	B	B
Southern Cross	B	B1	B	B
Swinburne University of Technology	B	B1	B	B
University of Technology, Sydney	B	B1	B	B

Source: The authors' calculations using the normalised data.

With a three-cluster solution based on per academic staff research performance, the universities in cluster A, as in the two-cluster solution, would not change but cluster B is now reclassified into clusters B1 and B2 with twelve and ten universities, respectively. The distances between final cluster centers can be used to compare clusters A, B1 and B2. The pairwise distances between clusters are A-B1 = 2.31; A-B2 = 3.72 and B1-B2 = 1.50. Therefore, we may conclude that in terms of research performance the universities in clusters B1 and B2 are more similar than either are with cluster A. In other words, there is little performance difference between the bottom twenty-two universities in Table 3. This provides further *ex post* justification in the agglomeration coefficients in Table 4 justifying the formation of just two clusters.

Table 4. Agglomeration schedule based on the Ward linkage

Stage	Research performance per academic staff			Total research performance		
	Combined cluster		Coefficients	Combined cluster		Coefficients
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	29	32	0.001	2	3	0.002
2	8	23	0.024	7	36	0.004
3	7	11	0.054	5	6	0.006
4	19	22	0.094	21	27	0.010
5	1	34	0.140	32	35	0.014
6	14	36	0.205	4	5	0.018
7	6	27	0.270	2	21	0.025
8	17	31	0.345	18	32	0.035
9	7	25	0.423	29	33	0.044
10	21	24	0.502	7	14	0.058
11	19	30	0.593	7	24	0.075
12	16	17	0.692	2	28	0.094
13	10	20	0.796	11	20	0.114
14	5	35	0.903	17	25	0.136
15	12	13	1.020	1	34	0.161
16	3	33	1.170	8	18	0.190
17	14	18	1.335	4	26	0.220
18	3	5	1.578	10	31	0.256
19	7	29	1.839	10	11	0.297
20	1	19	2.118	8	17	0.341
21	2	6	2.412	9	29	0.393
22	7	8	2.855	22	30	0.445
23	12	26	3.300	8	12	0.512
24	2	28	3.899	2	4	0.584
25	3	4	4.521	7	23	0.656
26	1	15	5.364	7	10	0.795
27	14	16	6.234	7	13	1.000
28	7	21	7.366	15	22	1.237
29	3	9	8.566	2	9	1.539
30	7	12	10.582	16	19	1.866
31	10	14	13.144	7	8	2.582
32	2	3	16.820	15	16	4.263
33	1	10	25.798	2	7	10.207
34	**2**	**7**	**36.941**	**1**	**15**	**17.882**
35	**1**	**2**	**105.000**	**1**	**2**	**105.000**

Source: The Authors' calculations using the normalised data.

As far as cluster membership based on total research performance is concerned, the results of a three-cluster solution are also analogous to a two-cluster solution in that the universities in cluster B continue to be in the same cluster. The difference is that cluster A is now sub-divided into clusters A1 and A2. In cluster A2, two members of the Go8 (Adelaide and Western Australia) separate from the others. Once again changes in the magnitude of the agglomeration coefficient does not justify the formation of three clusters. The results of an analysis of variance (ANOVA) across the three variables used in the clustering process also indicate that the cluster differences in terms of the standardised magnitudes of the means of the three measures are all highly significant. This result lend further support that all three measures are important in differentiating the resulting clusters (the ANOVA results are not reported but they are available upon request from the corresponding author).

The important findings of our study can be summarised as follows. First, the scale and long tenure of the Go8 universities places them unsurprisingly in the highest (relative) grouping of research performance, whether in total or partial productivity terms. Second, it is interesting to note is that once the vastly different scales of universities are taken into account, and research performance is expressed in per capita forms, an additional seven universities (Flinders, Macquarie, Murdoch, New England, Newcastle, Tasmania and Wollongong) are virtually indistinguishable. Third, none of the remaining twenty-two universities can be classified with any of the Go8 in total or per academic staff basis. These universities, particularly those listed in cluster B2 in column 3 of Table 3, are not only producing less research output, but also their productivity is relatively lower. Therefore, one can argue that the most research-productive universities are those with the highest total research output.

IV. RANKING RESEARCH PERFORMANCE

It would be useful if we can provide a full ranking of Australian universities based on both total and per capita research performance. In stead of three performance indicators, one can extract their first principal component to calculate a single normalised factor score for each of total and per academic staff research performance. These two composite indices are found to explain 99 and 87 percent of total variation of the three totals and per academic staff measures, respectively.

Table 5. Ranking of universities based on factor scores

Institution	Normalised factor scores: Research performance per academic staff		Normalised factor scores: Total research performance		Melbourne Institute Index	Rank
	Score	Rank	Score	Rank		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Melbourne	2.091	1	2.707	1	100	1
Adelaide	1.660	2	0.827	7	70	8
Western Australia	1.517	3	0.941	6	76	6
New South Wales	1.516	4	1.993	4	85	5
Sydney	1.398	5	2.412	2	95	3
Queensland	1.347	6	2.355	3	87	4
Tasmania	0.968	7	-0.101	10	53	12
Wollongong	0.862	8	-0.196	16	50	15
Murdoch	0.798	9	-0.348	20	51	14
Monash	0.754	10	1.640	5	76	6
New England	0.703	11	-0.389	22	47	19
Macquarie	0.681	12	-0.144	13	54	11
Flinders	0.379	13	-0.172	14	56	9
Newcastle	0.234	14	-0.080	9	52	13
La Trobe	0.007	15	0.048	8	55	10
James Cook	-0.048	16	-0.455	24	46	22
Griffith	-0.166	17	-0.102	11	49	16
Deakin	-0.196	18	-0.300	19	47	19
Curtin University of Technology	-0.216	19	-0.190	15	49	16
Queensland University of Technology	-0.293	20	-0.109	12	49	16
South Australia	-0.374	21	-0.288	18	44	24
Southern Cross	-0.401	22	-0.726	28	39	30
Northern Territory	-0.496	23	-0.818	33	41	27
Swinburne University of Technology	-0.498	24	-0.656	27	46	22
Canberra	-0.519	25	-0.738	30	42	26
University of Technology, Sydney	-0.521	26	-0.385	21	47	19
Edith Cowan	-0.644	27	-0.581	25	41	27
Royal Melbourne Institute of Technology	-0.690	28	-0.227	17	43	25
Victoria University of Technology	-0.777	29	-0.606	26	41	27
Ballarat	-0.816	30	-0.854	35	38	33
Western Sydney	-1.008	31	-0.417	23	39	30
Central Queensland	-1.151	32	-0.770	31	37	34
Charles Sturt	-1.320	33	-0.731	29	39	30
Southern Queensland	-1.438	34	-0.787	32	36	36
Sunshine Coast	-1.560	35	-0.912	36	32	37
Australian Catholic University	-1.783	36	-0.839	34	37	34

Source: The Authors' calculations using the normalised data.

Based on the results of the factor analysis presented in Table 5, in total research performance terms the results are once again fairly unsurprising with the Go8 universities ranking highest. However, on a per capita basis Monash is excluded from the Go8 and is replaced by the University of Tasmania. Irrespective of the type specification, the University of Melbourne always appears at the top, followed by the Universities of Sydney, Queensland, New South Wales and Monash University in total research performance and by the Universities of Adelaide, Western Australia, New South Wales and Sydney in per academic staff research performance. Given a correlated Spearman rank correlation coefficient of 0.858 significant at the 0.01 level (two-tailed) between the total and per academic staff research performance rank, it can be argued that many universities not only produce less output but also their per staff output is lower. If this trend continues, the gap between the high achievers and low achievers will exacerbate.

Furthermore, the twenty one universities right in the bottom of Table 5 (beginning with James Cook) have all negative factor scores (see columns 2 and 4), and thus their normalised research outputs are below average, in terms of both total research output and research output per staff member. All less productive universities shown in the bottom of Table 5 are among the twenty-two universities in Table 3 belonging to cluster B (either B1 or B2 depending upon the number of clusters) with the only exception being La Trobe. In addition, all the top performers in terms of total or per academic staff research output in Table 5 were grouped in cluster A in Table 3. It is coincidental that both the cluster and factor analyses have produced similar results in relation to the groupings and the ranking of universities.

It should be recognised that to a large extent the rankings provided in this analysis are surprisingly consistent with Williams and Van Dyke's (2004) *Melbourne Institute Index of International Standing of Australian Universities.* The Melbourne Institute index is a composite measure of overall international standing (percentage weights in brackets), encompassing the standing of staff (40), quality of graduate programs (16), quality of undergraduate entry (11), quality of undergraduate programs (14), resource levels (11) and opinions of educationists (8). Nevertheless, it is very likely that research performance, however defined, is correlated with any and all of these measures of international standing. Based on this observation it is believed that the most productive institutions in terms of 'quantity' of research output also demonstrate a higher international standing by delivering quality research output.

V. CONCLUDING REMARKS

We examine the reorganization of the Australian university system under the "Dawkins Reforms" and outline our empirical results in support of the classification of universities as "research intensive", "teaching and research", and "teaching only". The averaged data in the period 1998-2003 on the following three key research indicators were used: the average annual number of Ph.D. completions, the average annual number of publications, and the average annual amount of grant funding received. Using the data and cluster analysis technique, the 36 universities under review were divided into a number of meaningful clusters. One optimal division was to cluster the 36 universities into two groups; albeit a three-cluster solution was also possible to shed some light on the classification of universities into "research intensive", "teaching and research", and "teaching only".

We discussed the results of this analysis both in the aggregate by institution (i.e., institutions ranked according to the total gross output of research) and on an "academic per capita" basis, by expressing the research output of universities in relation to the number of academic staff members. The results of cluster analysis confirmed the obvious: big universities produce more research than smaller ones. Of the seven universities listed in the top group based on total research output, all have more than 1000 academic staff members and four have more than 2000. In contrast, of the remaining 29 universities on the list, only one has more than 1000 academic staff members and eleven have fewer than 500 academic staff members.

The "per capita" rankings were more insightful, producing a rather neat division into three groups of universities. All of the universities which appeared in the top cluster based on total research performance still remained in the top cluster based on per capita performance. They, however, joined by seven additional smaller universities. In this group of smaller universities with high per-capita research output, all but one of them were well below the average number of academic staff for all universities. This clearly suggested a feasible research-oriented niche for relatively small institutions. This was confirmed by the fact that the second cluster in the three-cluster solution model, implicitly corresponding to the "teaching and research" category, included ten universities of which only one had an academic staff larger than the average for all universities. The third cluster which can be associated with the "teaching" category was somewhat smaller than the average in academic staff and includes all five technologically oriented institutions on the list.

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