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Ranking and Clustering Australian University Research Performance, 1998-2002*

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ABSTRACT *This paper clusters and ranks the research performance of thirty-seven Australian universities over the period 1998-2002. Research performance is measured according to audited numbers of PhD completions, publications and grants (in accordance with rules established by the Department of Education, Science and Training) and analysed in both total and per academic staff terms. Hierarchical cluster analysis supports a binary division between fifteen higher and twenty-two lower-performing universities, with the specification in per academic staff terms identifying the self-designated research intensive 'Group of Eight' (Go8) universities, plus several others in the better-performing group. Factor analysis indicates that 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

Introduction

It is well-recognised that Australian universities play a vital role in national research and the scholarship of research, partially justifying sizeable Commonwealth government funding. But for some decades, such funding has been administered independently of any specific assessment of research performance. Between 1965 and 1988, for example, a binary divide existed 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'. For the most part, such funding was more concerned with this division and institutional size and course mix, rather than any attempt to recognise and reward research.

However, from 1989 a series of policy changes, collectively known as the 'Dawkins reforms', created a Unified National System, in so doing removing the funding division between universities and non-universities. Within this system, since the 1990s Commonwealth research funding has been directed through three main channels. First, support for research training is 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

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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 is 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). Finally, program-specific funding is also allocated, encompassing, amongst other things, Australian Research Council (ARC) awards for projects (both wholly and industry-linked) and fellowships. But despite the apparent dissimilarity of these channels, all are allocated, at least indirectly, on the basis of an institution's research performance, partially facilitated by the Commonwealth's Department of Education, Science and Training (DEST) monitoring and assessment of research output[2].

Problematically, at least for some institutions, there are currently proposals by the Commonwealth government to adopt a trinary system of classification with universities categorised as 'research intensive', 'teaching and research' or 'teaching only'. And not unexpectedly, this reclassification is generally thought to be associated with a move away from the current unitary system of performance-based funding. However, 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 Group of Eight) would be automatically 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 'research' and 'teaching' or (worse still) 'teaching only' universities.

Unfortunately, there has been very little quantitative work on the ranking and clustering of Australian university research performance that would provide guidance on these proposed policy changes. DEST (1998), for example, classified Australian universities on a wide range of research and teaching characteristics from 1996/1997 using cluster analysis. More than twenty different indicators were used to operationalise six measures of size, overseas orientation, diversity, internal/full-time orientation, financial research orientation and staff research orientation. Based on these six performance measures, universities were grouped into four to seven clusters and ranked on the basis of a single composite indicator. While arguably "a

[2] The responsible Commonwealth department was known as the Department of Education, Training and Youth Affairs or DETYA until 1998.

workable measure of the characteristics and performance of institutions in terms of their teaching and research activities" (DETYA, 1998, p.41) this study is dated and rather unwieldy.

As an alternative, 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 related 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 elsewhere [see, for instance, Johnes and Johnes (1993; 1995), Johnes (1988; 1990; 1992; 1995), Beasley (1995), Glass *et al.* (1995a; 1995b), Coelli (1996), Athanassopoulos and Shale (1997), Carrico *et al.* (1997), Hashimoto and Cohn (1997), Glass *et al.* (1998), Ng and Li (2000)], but are computationally complex, rely on data 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 (2004a; 2004b) and Perry (2004; 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), Clarke (2002), Federkeil (2002), Filinov and Ruchkina (2002), Vaughin (2002), Yonezawa et al. (2002) and Pomfret and Wang (2003).

The purpose of the present paper is to complement this nascent body of work with an analysis of the recent research performance of Australian universities. However, a clear point of departure is that the study is constructed so as to take advantage of the audited quantitative information on research performance periodically gathered by governmental authorities. This not only ensures that the results are objective, but may also be easily replicated in the future as additional data come to hand.

The paper itself is organised as follows. The next section provides a description of the data employed in the analysis. Then we discusse 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.

Data and Descriptive Analysis

Thirty-seven Australian universities have been included in the analysis, 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). A full list of these university groupings is included in Table 1.

The performance measures specified in the analysis have all been obtained from DEST and comprise those measures included in its Composite Research Index. This index is calculated using an audited mix of the competitive funding and industry funding received, public sector research funding, research and scholarly publications and higher degree research completions. In order to minimise the bias in our results we consider only those academic staff members who are classified as undertaking 'research-only' and 'teaching-and-research' activities. In other words, the variable which is referred to as academic staff does not include 'teaching only' staff. The three measures of research output in our analysis are: (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 research output measures have been calculated using data for the period 1998-2002. Notwithstanding the stated objective of this study to use publicly available research performance data, the exact specification of university research output remains a matter of some contention. For example, a distinction is usually made between quantity-based (bibliometric) measures [see, for instance, Abbot and Doucouliagos (2003)] and/or quality-based (peer review or citation) measures [see, for example, Athanassopoulos and Shale (1997) and Johnes and Johnes (1993)]. Similarly, while grants are technically an input, external research finance (especially industry linked grants) through reflection of the market value of research may serve as a proxy for output.

TABLE 1. Average annual PhD completions, publications, academic staff and grants by university, 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	Australian National University	Go8	1,702	172	1460	53.52
4	Ballarat	NGU	135	7	90	2.27
5	Canberra	UGU	270	14	200	6.39
6	Central Queensland	NGU	332	13	199	3.24
7	Charles Sturt	UGU	451	19	225	4.01
8	Curtin University of Technology	ATN	851	82	624	19.10
9	Deakin	UGU	734	74	606	11.16
10	Edith Cowan	NGU	538	25	484	4.54
11	Flinders	IRUA	699	65	619	26.97
12	Griffith	IRUA	939	85	733	21.59
13	James Cook	UGU	502	69	333	10.29
14	La Trobe	UGU	1,019	131	771	19.80
15	Macquarie	IRUA	660	96	661	17.07
16	Melbourne	Go8	2,084	366	2585	126.95
17	Monash	Go8	2,078	275	2017	74.35
18	Murdoch	IRUA	467	70	430	16.47
19	New England	UGU	458	69	483	9.76
20	New South Wales	Go8	1,905	297	2060	102.08
21	Newcastle	IRUA	833	72	767	26.85
22	Northern Territory	UGU	155	14	91	3.45
23	Queensland	Go8	2,234	337	2349	111.71
24	Queensland University of Technology	ATN	996	91	803	15.25
25	Royal Melbourne Institute of Technology	ATN	989	91	529	16.88
26	South Australia	ATN	797	65	565	17.66
27	Southern Cross	NGU	254	33	136	4.28
28	Southern Queensland	NGU	357	14	150	3.54
29	Sunshine Coast	NGU	85	1	48	0.335
30	Swinburne University of Technology	UGU	369	32	255	6.00
31	Sydney	Go8	2,226	364	2232	114.48
32	Tasmania	UGU	631	93	614	25.31
33	University of Technology, Sydney	ATN	728	62	498	11.90
34	Victoria University of Technology	NGU	510	34	349	5.59
35	Western Australia	Go8	1,227	175	1370	68.22
36	Western Sydney	NGU	901	54	513	10.32
37	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 (www.detya.gov.au); Australian Vice-Chancellor's Committee (AVCC) (www.avcc.gov.au); Australian Bureau of Statistics (2005), Consumer Price Index, Cat. No. 6401, Canberra.

Table 2 presents a summary of descriptive statistics of the annual averages for the thirty-seven universities during the period 1998-2002. Sample means, maxima, minima, standard deviations, skewness, kurtosis and Jacque-Bera statistics and *p*-values are reported. As shown, PhD completions average 101 per annum (Macquarie lies closest to the average) with a range between less than one (Sunshine Coast) and 366 (Melbourne); publications average 752 (La Trobe lies closest) with a range between 48 (Sunshine Coast) and 2585 (Melbourne); while grants average $28.53 millions (Flinders is closest) and a range of $0.335 million (Sunshine Coast) and $127 million (Melbourne). The average number of academic staff is also included in Table 2, with Newcastle lying closest to the average of 842 and Sunshine Coast (84) and Queensland (2234) at the minimum and maximum, respectively. Finally, three univariate measures are calculated and included in Table 2: namely, PhD completions, publications and grants per academic staff (scaling in univariate ratio normally removes the size effects found across most organisations). On average, academics across all universities supervised about one-tenth of a PhD completion, contributed less than one publication and earned less than $A 25,841 (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)	842	2234	84	606	1.110	3.243	7.687	0.021
PhD completions (persons)	101	366	1	102	1.489	4.173	15.785	0.000
Publications (DEST points)	752	2585	48	689	1.376	3.812	12.687	0.002
Grants (2002 $million)	28.528	127.000	0.335	35.357	1.629	4.380	19.304	0.000
PhD completions per academic staff (persons)	0.101	0.176	0.010	0.045	-0.193	1.936	1.976	0.372
Publications per academic staff (DEST point)	0.798	1.240	0.365	0.217	0.000	2.138	1.146	0.564
Grants per academic staff (2002$)	25861	60910	4006	15852	0.781	2.571	4.041	0.133

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

Given that the sampling distribution of skewness is normal with mean 0 and standard deviation of $\sqrt{6/T}$ where T is the sample size, all of the series, with the exception of PhD completions and publications per academic staff, are significantly skewed. Since these are also positive, they signify the greater likelihood of observations lying above the mean than below. The kurtosis, or degree of excess, across all variables is also large, ranging from 1.936 (PhD completions per academic staff) to 4.380 (total grants), thereby indicating leptokurtic distributions with many extreme observations. Given the sampling distribution of kurtosis is normal with mean 0 and standard deviation of $\sqrt{24/T}$ where T is the sample size, then all estimates are once again statistically significant at any conventional level. Finally, the calculated

Jarque-Bera statistics and corresponding p-values in Table 2 are used to test the null hypotheses that the variables are normally distributed. Apart from the per academic staff measures, all *p*-values are smaller than the .02 level of significance suggesting the null hypothesis can be rejected. Only the three per staff research output measures are then well approximated by the normal distribution.

Clustering Research Performance

The first methodological requirement is to cluster the research performance of Australian universities. Cluster analysis is a multivariate statistical technique that has been widely used to classify objects or items based on the similarity or dissimilarity of the characteristics they possess. This technique is especially relevant 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 indicators, resulting in heterogeneous groups with homogeneous contents (Hair, *et al.,* 1998, p.470). This approach has been used to determine how many homogenous research groups exist and define exactly which comparable group each Australian university belongs to.

Before conducting the analysis, all six output variables were standardised so that they had a mean of 0 and a standard deviation of 1. The following Euclidean distance is used as a dissimilarity measure to define the pairwise distance between universities:

$$D(j,k) = \sum_{i=1}^{n=3} (X_{ij} - X_{ik})^2 \qquad (1)$$

where X_{ij} and X_{ik} represent the i^{th} measure of research output of universities j and k, respectively. The smaller (larger) is D(j,k), the more (less) similar are universities j and k. In the present analysis, n = 3, representing the number of PhD completions, the number of publications and the amount of research grant in total and per academic staff. A brief technical explanation of hierarchical analysis has been provided in the Appendix.

A dendrogram (not shown) and agglomeration coefficients (Table 3) can then be used to determine the optimum number of clusters. Table 3 shows the agglomeration schedule at the various stages of hierarchical cluster analysis using both total and the normalized per academic staff research data. The agglomeration schedule in Table 3 is employed to determine the optimal number of clusters. In this approach, small variations in the agglomeration coefficient indicate that fairly homogeneous clusters are being merged.

TABLE 3. 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	30	33	0.001	2	4	0.002
2	9	24	0.025	8	37	0.004
3	8	12	0.055	6	7	0.006
4	20	23	0.097	22	28	0.010
5	1	35	0.144	33	36	0.014
6	15	37	0.210	5	6	0.018
7	7	28	0.277	2	22	0.026
8	18	32	0.354	19	33	0.035
9	8	26	0.434	30	34	0.045
10	22	25	0.515	8	15	0.059
11	20	31	0.609	8	25	0.076
12	3	21	0.705	2	29	0.094
13	17	18	0.807	12	21	0.115
14	6	36	0.917	18	26	0.136
15	13	14	1.037	1	35	0.162
16	3	11	1.159	9	19	0.191
17	4	34	1.312	5	27	0.221
18	15	19	1.481	11	32	0.258
19	4	6	1.731	11	12	0.299
20	8	30	1.998	9	18	0.344
21	1	20	2.285	10	30	0.395
22	2	7	2.587	23	31	0.448
23	8	9	3.042	9	13	0.514
24	13	27	3.498	8	24	0.587
25	2	29	4.113	2	5	0.659
26	4	5	4.751	1	3	0.780
27	1	16	5.616	8	11	0.921
28	15	17	6.509	8	14	1.129
29	8	22	7.670	16	23	1.368
30	4	10	8.902	2	10	1.669
31	8	13	10.975	17	20	2.001
32	3	15	14.149	8	9	2.722
33	2	4	17.923	16	17	4.422
34	1	3	28.261	2	8	10.411
35	2	8	**39.715**	1	16	**20.752**
36	1	2	**108.000**	1	2	**108.000**

Source: The Authors' calculations using the normalised data.

Likewise, if the agglomeration coefficient varies markedly between stages, it indicates that more heterogeneous cases are being clustered together. Given the percentage changes in the agglomeration coefficient at each step, it appears that the optimal number of clusters is 2 as the coefficient between stages 35 and 36 shows a significant increase from 39.7 to 108 (last and second-to-last rows in column 4 of Table 3). Exactly the same procedure is used to determine the number of clusters based on total research output measures. Clearly, with either specification the optimal number of clusters is 2 as in the case of total research performance the agglomeration coefficient again shows the biggest relative percentage change between stages 35 and 36 increasing from 20.8 to 108 (last and second-to-last rows in column 7 of Table 3). However, given that the use of the agglomeration coefficient as a stoping rule has a tendency to indicate too few clusters (Hair, 1998, p.503), the results of three-cluster solutions for both total and per academic staff research performance are also included [the alternative cubic clustering criterion could have also been used as a stopping rule, but this has the tendency to indicate too many clusters].

Table 4 presents 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. It should be noted that nothing is implied from the ordering of universities in the first column outside of their cluster membership. In fact, to make the cluster membership codes even easier to analyse they are sorted according to the second, third and fourth columns. A cursory examination of Table 4 reveals that in any two-cluster solution, the Go8 members (Adelaide, Australian National University, Melbourne, Monash, Queensland, Sydney, New South Wales and Western Australia) always belong to cluster A. This indicates that this group is relatively homogenous in terms of both factor and total productivity. 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 included, taking cluster A membership to fifteen. This cluster of high-performing research universities then comprises the Go8, four Innovative Research Universities Australia (Flinders, Macquarie, Murdoch and Newcastle) and three Ungrouped Universities (New England, Tasmania and Wollongong). No Australian Technology Network or New Generation Universities are present.

With a three-cluster solution based on per academic staff research performance, the universities in cluster A, as in the two-cluster solution, remain unchanged 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, and given that the pairwise distances between clusters (A-B1 = 2.292; A-B2 = 3.771 and B1-B2 = 1.560) we may conclude that in terms of staff productivity, the universities in clusters B1 and B2 are more similar than either are with cluster A. Put differently, there is little research performance difference between the bottom twenty-two universities in Table 4. This provides further *ex post* justification in the agglomeration coefficients in Table 3 predicting the formation of just two clusters.

Following MacQueen (1967), Milligan (1980) and Hair *et al.* (1998), we finetuned the results of the hierarchical cluster analysis (HCA) using a non-hierarchical procedure known as K-means clustering. The process involves four steps: (1) the centroids, $(\overline{X}_{1k}, \overline{X}_{2k}, \overline{X}_{3k})$, of the clusters formed by the hierarchical procedure are calculated and used as 'seeds' (Hair *et al.*, 1998, p.497 and Green, 1978, p.428); (2) proceeding through the list of universities, each university is assigned to the cluster with the nearest centroid; (3) the centroids of the clusters receiving and losing the university are recalculated; and (4) Steps 2 and 3 are repeated until no more assignments can take place. The use of K-means cluster analysis technique has only slightly changed the cluster memberships produced by the HCA. Based on the "finetuned cluster centres" we have observed the distances between final cluster centres reported in the preceding paragraph.

TABLE 4. Cluster membership based on per staff and total research output measures

University	Research performance per academic staff		Total research performance	
	2 Clusters	3 Clusters	2 Clusters	3 Clusters
(1)	(2)	(3)	(4)	(5)
Adelaide	A	A	A	A2
Australian National University	A	A	A	A2
Melbourne	A	A	A	A1
Monash	A	A	A	A2
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.

As far as cluster membership based on total research performance is concerned, the results of a three-cluster solution are also similar to a two-cluster solution in that the universities in cluster B continue to be in the same cluster. However, cluster A is now sub-divided into clusters A1 and A2. In cluster A2, four member of the Go8 (Adelaide, Australian National University, Monash and Western Australia) separate from the others. But once again the agglomeration coefficient shows that the formation of three clusters is unnecessary. 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 performance measures are all highly significant, supporting the view that they all play an important role in differentiating the resulting clusters (the ANOVA results are not reported but they are available upon request from the corresponding author).

A number of salients points are noted from the cluster analysis of Australian university research performance. First, it is clear that the scale and long tenure of the Go8 universities places them in the highest (relative) grouping of research performance, whether in total or partial productivity terms. This is unsurprising. Second, what is more interesting is that once an attempt is made to take into account the vastly different scales of universities, and research performance is expressed in per academic staff terms, an additional seven universities (Flinders, Macquarie, Murdoch, New England, Newcastle, Tasmania and Wollongong) are virtually indistinguishable in terms of research performance. Third, none of the remaining twenty-two universities can be clustered with any of the Go8 even on a per academic staff basis. It would then appear that these other universities (particularly the ten classified in cluster B2 in column 3 of Table 4) are not only producing less research output, but also their productivity is at a much lower level. See also the results in the next section. In other words, the least (most) research-productive universities tend to be those with the least (most) total research output. Accordingly, if the proposed policy of classifying universities as ‘research intensive’, ‘research and teaching’ and ‘teaching only’ were to be implemented, and if this reflected recent historical research performance, guidelines to a logical grouping could be found in column 3 of Table 4.

Ranking Research Performance

The second methodological requirement is to rank Australian university research performance. In brief, the method involves using the first principal component to calculate a single normalised factor score for 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. Only the first eigenvalue in each case exceeds unity and according to the scree plot just the first principal component is sufficient. Also (i) Bartlett's test of sphericity is rejected at the 1 percent level for the respective total and per academic staff measures [$\chi(3)$ = 235.0, p-value = 0.000 and $\chi(3)$ = 80.3, p-value = 0.000]; (ii) the Kaiser-Meyer-Olkin measure of sampling adequacy for total and per academic staff performance are 0.789 and 0.759, respectively; (iii) all of the elements on the diagonal of the anti-image correlation are at least 0.730; and (iv) the lowest communality is 0.848. The results of the factor analysis, as briefly outlined, suggest that they were statistically acceptable. These results are not reported here in details but they are available from the authors upon request.

Based on the results of the factor analysis, the regression method is used and the corresponding factor scores for each of the thirty-seven universities are presented in Table 5 in descending order. In total research performance terms the results are once again fairly unsurprising with the Go8 universities ranking highest. However, when research performance is expressed in per academic staff terms neither Monash nor the Australian National University are any longer among the top-eight Australian universities and are replaced instead by the Universities of Tasmania and Wollongong. Regardless of specification, the University of Melbourne is always ranked highest, 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. For those universities which improve in rank from total research performance to per academic staff research performance, it is clear that while total product is relatively lower, labour productivity is relatively higher.

Given a less than perfectly correlated Spearman rank correlation coefficient of 0.853 significant at the 0.01 level (two-tailed) between the total and per academic staff research performance rank, one can well argue that in many universities they not only produce less output but also their staff productivity is relatively lower. But for a number of universities labour productivity is relatively less than total performance too. For example, according to columns 5 and 3 of Table 5, Monash changes from fifth to tenth-ranked in per academic staff terms, Queensland University of Technology from thirteenth to twenty first -ranked, Australian National University from seventh to fifteenth-ranked and La Trobe from ninth to sixteenth-ranked. The reverse also exists with highly productive academic staff (changes in ranks between total and per academic staff research performance in brackets) at New England (twenty-third to eleventh-ranked), Tasmania (eleventh to seventh-ranked), and Wollongong (seventeenth to eighth-ranked).

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	2.113	1	2.697	1	100	1
Adelaide	1.676	2	0.809	8	70	8
Western Australia	1.531	3	0.923	6	76	6
New South Wales	1.530	4	1.979	4	85	5
Sydney	1.410	5	2.401	2	95	3
Queensland	1.359	6	2.342	3	87	4
Tasmania	0.974	7	-0.124	11	53	12
Wollongong	0.868	8	-0.220	17	50	15
Murdoch	0.803	9	-0.372	21	51	14
Monash	0.758	10	1.624	5	76	6
New England	0.707	11	-0.413	23	47	19
Macquarie	0.684	12	-0.168	14	54	11
Flinders	0.378	13	-0.195	15	56	9
Newcastle	0.231	14	-0.103	10	52	13
Australian National University	0.226	15	0.816	7	100	1
La Trobe	0.001	16	0.026	9	55	10
James Cook	-0.055	17	-0.480	25	46	22
Griffith	-0.175	18	-0.126	12	49	16
Deakin	-0.205	19	-0.325	20	47	19
Curtin University of Technology	-0.225	20	-0.214	16	49	16
Queensland University of Technology	-0.303	21	-0.133	13	49	16
South Australia	-0.385	22	-0.312	19	44	24
Southern Cross	-0.412	23	-0.752	29	39	30
Northern Territory	-0.509	24	-0.844	34	41	27
Swinburne University of Technology	-0.511	25	-0.682	28	46	22
Canberra	-0.532	26	-0.764	31	42	26
University of Technology, Sydney	-0.534	27	-0.409	22	47	19
Edith Cowan	-0.658	28	-0.607	26	41	27
Royal Melbourne Institute of Technology	-0.705	29	-0.250	18	43	25
Victoria University of Technology	-0.794	30	-0.632	27	41	27
Ballarat	-0.833	31	-0.880	36	38	33
Western Sydney	-1.028	32	-0.442	24	39	30
Central Queensland	-1.173	33	-0.796	32	37	34
Charles Sturt	-1.344	34	-0.757	30	39	30
Southern Queensland	-1.464	35	-0.813	33	36	36
Sunshine Coast	-1.587	36	-0.938	37	32	37
Australian Catholic University	-1.814	37	-0.865	35	37	34

Source: The Authors' calculations using the normalised data.

In addition, the twenty one universities appearing in the bottom of Table 5 (beginning with James Cook) have all negative factor scores (see columns 2 and 4), and therefore their research outputs are below average, in terms of both total research output and research output per staff member. These universities are consistently the worse performers in terms of both total and per academic staff research performance. All less productive universities shown in the bottom of Table 5 are among the twenty-two universities in Table 4 belonging to cluster B (either B1 or B2 depending upon the number of clusters) with the only exception being La Trobe. Moreover, all the top universities in terms of total or per academic staff research output in Table 5 were grouped in cluster A in Table 4. Therefore, both the cluster and factor analyses have generated consistent results in relation to the classification and the ranking of universities.

As a final point, the rankings provided in this analysis are broadly consistent with Williams and Van Dyke's (2004) *Melbourne Institute Index of International Standing of Australian Universities* with a Spearman rank correlation coefficient as high as 0.914 (significant at the 0.01 level). This is surprising when it is remembered that that particular 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 result one may also conclude that the most productive institutions in terms of 'quantity' of research output also enjoy a higher international standing by offering 'quality' products.

Concluding Remarks

This paper examined the clustering and ranking of Australian university research performance over the period 1998-2002. Hierarchical cluster analysis was used to cluster research performance, defined in terms of PhD completions, publications and grants, across Australia's thirty-seven universities. The results indicate that two clusters are optimal, regardless of whether performance is expressed in total or per academic staff terms. In total research performance terms the Go8 universities comprise the better-performing cluster, but in per academic staff terms they are joined by seven other universities with high labour productivity. Clearly, when performance is expressed in total terms, the large, broad-disciplined, well-established Go8 universities outperform all others. But when appropriate recognition is made of the differing scale (and funding) of operations, the performance of the seven additional universities (Flinders, Macquarie, Murdoch, Newcastle, New England, Tasmania and Wollongong) is statistically indistinguishable. Interestingly, all of these universities were established in the pre-Dawkins era, and are not strict creations of the Dawkins reforms, whereby universities were joined by the onetime colleges of advanced education and institutes of technology. This reinforces the notion that research performance has a strong temporal component and that with time; the remaining twenty-two universities are likely to further improve.

Of course, this study does suffer from a number of limitations, all of which suggest further avenues of research. Certainly, the specification of inputs and outputs in education, especially tertiary education is difficult, as is modelling the production processes relating them. One avenue of research could examine how to expand the set of outputs used here to include, for example, measures of research quality. Another extension could incorporate the sizeable literature on frontier efficiency measurement techniques in education, especially non-parametric techniques. This could directly consider the variations in resources and scale that complicate and compromise most measures of international standing and ranking. Similarly, there is little allowance currently for changes in performance over time though 'learning by doing'. Future research should then attempt to lengthen time-series to enable such assessments to be made.

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Appendix

A hierarchical clustering technique was used to form clusters of similar universities. At the beginning of the hierarchical procedure there are thirty-seven clusters each containing one university. At each stage that follows, the two most similar clusters are merged until, at the final stage, a single cluster of thirty-seven universities is formed. Hierarchical methods differ in the way that the most similar pair of clusters is identified at each stage. We use Ward's (1963) method, which identifies the two clusters whose merger would result in the smallest increment to the aggregate sum of squared deviations within clusters. The sum of squared deviations within (say) Cluster k is given by

$$\text{ESS}(k) = \sum_{j\in k}\sum_{i=1}^{3}(X_{ijk} - \overline{X}_{ik})^2 \qquad (2)$$

where X_{ijk} is the i^{th} measure of research output by university j in Cluster k, and $\overline{X}_{ik}$ is the i^{th} measure of research output averaged across all universities in Cluster k. With the sum of squared deviations within (say) Cluster K given by ESS(K), the increment to the aggregate sum of squared deviations within clusters resulting from the merger of Cluster k and Cluster K to form Cluster ($k\cup K$) is given by:

$$d_{Ward}(k,K) = \sum_{j\in(k\cup K)}\sum_{i=1}^{3}(X_{ij(k\cup K)} - \overline{X}_{i(k\cup K)})^2 - \text{ESS}(k) - \text{ESS}(K) \qquad (3)$$

Table A.1 shows the proximity matrix among the thirty-seven universities using the normalised data on per staff research measures and the Squared Euclidean Distance (SED) as a measure of dissimilarity where higher (lower) SEDs are associated with more (less) dissimilar universities. This matrix is then quite useful for universities to identify their single most similar (and dissimilar) pairing in terms of research performance. On the basis of the three selected performance criteria (PhD completions, publications and grants all expressed in per staff), this matrix provides a comprehensive snapshot of the pairwise differences among Australian universities. For example, the five most dissimilar pairs (SED in brackets) in descending order are: Melbourne-Australian Catholic University (40.48); Sunshine Coast-Melbourne (36.02); Australian Catholic University-Adelaide (31.92); Charles Sturt-Melbourne (31.11); and Central Queensland-Melbourne (28.24). On the other hand, the five most similar pairs are: UTS-Swinburne (0.002); Queensland University of Technology-Deakin (0.047); Curtin-Griffith (0.061); New South Wales-Queensland (0.083); and Western Australia-Adelaide (0.093). These similarities and differences are not counterintuitive to the impartial observer.

TABLE A1. Proximity matrix using per staff research measures and the squared Euclidean distance as a measure of dissimilarity

No.	University	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Adelaide	0.000	31.916	5.631	16.579	12.944	21.414	23.965	9.837	10.543	16.590	4.456	9.276	10.070	8.973	4.423	0.583	2.646	2.851	5.436
2	Australian Catholic University	31.916	0.000	11.080	2.850	4.870	1.419	0.640	6.815	7.945	6.420	12.859	7.319	9.525	9.711	17.905	40.480	17.653	18.379	19.328
3	Australian National University	5.631	11.080	0.000	2.983	1.753	5.134	6.504	0.668	1.075	3.630	0.247	0.466	1.975	1.165	1.542	9.313	0.836	1.334	2.431
4	Ballarat	16.579	2.850	2.983	0.000	0.317	0.332	0.870	1.312	1.851	1.451	3.914	1.297	3.988	3.328	7.340	22.704	6.869	7.806	8.379
5	Canberra	12.944	4.870	1.753	0.317	0.000	1.273	2.185	0.996	1.619	1.457	2.218	0.807	3.920	3.027	5.850	18.449	4.965	6.053	6.947
6	Central Queensland	21.414	1.419	5.134	0.332	1.273	0.000	0.218	2.555	2.985	1.957	6.485	2.662	5.282	4.748	9.965	28.242	9.854	10.773	10.942
7	Charles Sturt	23.965	0.640	6.504	0.870	2.185	0.218	0.000	3.339	4.101	3.441	8.038	3.660	5.676	5.555	11.822	31.311	11.676	12.351	12.994
8	Curtin University of Technology	9.837	6.815	0.668	1.312	0.996	2.555	3.339	0.000	0.395	2.588	1.541	0.061	1.006	0.572	2.790	14.504	2.571	2.862	3.665
9	Deakin	10.543	7.945	1.075	1.851	1.619	2.985	4.101	0.395	0.000	1.748	2.282	0.328	1.380	0.561	2.130	14.801	2.655	3.033	2.511
10	Edith Cowan	16.590	6.420	3.630	1.451	1.457	1.957	3.441	2.588	1.748	0.000	4.736	2.128	5.957	4.258	6.323	21.717	6.773	8.219	6.525
11	Flinders	4.456	12.859	0.247	3.914	2.218	6.485	8.038	1.541	2.282	4.736	0.000	1.213	3.352	2.417	2.264	7.971	0.932	1.645	3.378
12	Griffith	9.276	7.319	0.466	1.297	0.807	2.662	3.660	0.061	0.328	2.128	1.213	0.000	1.431	0.763	2.554	13.783	2.284	2.764	3.363
13	James Cook	10.070	9.525	1.975	3.988	3.920	5.282	5.676	1.006	1.380	5.957	3.352	1.431	0.000	0.241	2.567	14.291	2.962	2.365	3.348
14	La Trobe	8.973	9.711	1.165	3.328	3.027	4.748	5.555	0.572	0.561	4.258	2.417	0.763	0.241	0.000	1.570	12.915	2.041	1.807	2.137
15	Macquarie	4.423	17.905	1.542	7.340	5.850	9.965	11.822	2.790	2.130	6.323	2.264	2.554	2.567	1.570	0.000	6.559	0.496	0.497	0.156
16	Melbourne	0.583	40.480	9.313	22.704	18.449	28.242	31.311	14.504	14.801	21.717	7.971	13.783	14.291	12.915	6.559	0.000	4.979	5.099	7.294
17	Monash	2.646	17.653	0.836	6.869	4.965	9.854	11.676	2.571	2.655	6.773	0.932	2.284	2.962	2.041	0.496	4.979	0.000	0.204	1.140
18	Murdoch	2.851	18.379	1.334	7.806	6.053	10.773	12.351	2.862	3.033	8.219	1.645	2.764	2.365	1.807	0.497	5.099	0.204	0.000	1.160
19	New England	5.436	19.328	2.431	8.379	6.947	10.942	12.994	3.665	2.511	6.525	3.378	3.363	3.348	2.137	0.156	7.294	1.140	1.160	0.000
20	New South Wales	0.100	29.253	4.505	14.726	11.436	19.231	21.609	8.227	8.804	14.777	3.625	7.757	8.249	7.258	3.254	0.940	1.795	1.896	4.180
21	Newcastle	5.772	11.588	0.193	3.015	1.570	5.260	6.928	1.172	1.446	3.052	0.214	0.767	3.297	2.100	2.048	9.407	1.167	2.054	2.885
22	Northern Territory	13.019	4.621	1.961	1.140	1.331	1.912	2.074	0.472	1.447	3.860	2.990	0.807	1.219	1.332	5.162	18.570	4.715	4.773	6.393
23	Queensland	0.345	26.358	3.395	12.692	9.706	16.865	19.099	6.675	7.184	12.788	2.719	6.255	6.763	5.813	2.390	1.534	1.111	1.222	3.279
24	Queensland University of Technology	11.263	6.951	1.141	1.317	1.157	2.328	3.384	0.327	0.047	1.375	2.297	0.250	1.638	0.804	2.709	15.801	3.085	3.582	3.176
25	Royal Melbourne Institute of	15.755	3.639	3.090	1.286	1.927	1.628	1.535	0.961	1.833	4.174	4.480	1.425	1.440	1.723	6.334	21.685	6.241	6.158	7.494
26	South Australia	11.270	5.456	1.007	0.673	0.484	1.708	2.413	0.117	0.653	2.133	1.818	0.154	1.653	1.173	3.905	16.370	3.487	3.977	4.891
27	Southern Cross	14.147	6.941	3.463	3.586	4.151	4.243	4.089	1.520	2.209	6.547	5.139	2.171	0.426	1.063	5.023	19.300	5.438	4.706	6.003
28	Southern Queensland	25.941	0.332	7.752	1.506	3.026	0.674	0.134	4.238	5.368	4.914	9.308	4.701	6.431	6.614	13.664	33.716	13.316	13.863	15.061
29	Sunshine Coast	28.289	0.996	8.872	1.606	3.013	0.614	0.737	5.587	5.920	3.019	10.357	5.617	9.434	8.659	14.963	36.021	14.874	16.249	15.929
30	Swinburne University of Technology	13.062	4.821	1.618	0.701	0.881	1.395	1.974	0.235	0.480	1.959	2.822	0.359	1.424	1.013	4.147	18.296	4.236	4.582	4.939
31	Sydney	0.475	27.199	3.971	13.686	10.758	17.909	19.921	7.157	7.883	14.403	3.366	6.893	6.585	5.968	2.761	1.631	1.473	1.267	3.760
32	Tasmania	1.725	20.550	1.630	8.935	6.755	12.295	14.132	3.762	4.023	9.144	1.583	3.525	3.619	2.865	0.825	3.644	0.179	0.153	1.555
33	University of Technology, Sydney	13.286	4.624	1.689	0.636	0.840	1.298	1.849	0.263	0.547	1.967	2.886	0.393	1.498	1.102	4.337	18.591	4.390	4.749	5.156
34	Victoria University of Technology	16.553	3.319	2.887	0.307	0.841	0.517	1.064	0.988	1.036	1.225	4.262	1.052	2.875	2.263	6.069	22.343	6.320	6.963	6.770
35	Western Australia	0.093	29.485	4.602	14.671	11.186	19.275	21.837	8.586	9.199	14.473	3.473	7.972	9.287	8.048	3.806	0.969	2.065	2.471	4.782
36	Western Sydney	19.389	1.773	4.200	0.370	1.271	0.219	0.292	1.690	2.245	2.449	5.632	1.947	3.536	3.321	8.413	25.927	8.386	8.912	9.431
37	Wollongong	3.029	19.913	1.693	8.452	6.581	11.472	13.467	3.472	3.018	7.561	2.095	3.176	3.300	2.275	0.133	4.856	0.265	0.293	0.417

No.	University	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1	Adelaide	0.100	5.772	13.019	0.345	11.263	15.755	11.270	14.147	25.941	28.289	13.062	0.475	1.725	13.286	16.553	0.093	19.389	3.029
2	Australian Catholic University	29.253	11.588	4.621	26.358	6.951	3.639	5.456	6.941	0.332	0.996	4.821	27.199	20.550	4.624	3.319	29.485	1.773	19.913
3	Australian National University	4.505	0.193	1.961	3.395	1.141	3.090	1.007	3.463	7.752	8.872	1.618	3.971	1.630	1.689	2.887	4.602	4.200	1.693
4	Ballarat	14.726	3.015	1.140	12.692	1.317	1.286	0.673	3.586	1.506	1.606	0.701	13.686	8.935	0.636	0.307	14.671	0.370	8.452
5	Canberra	11.436	1.570	1.331	9.706	1.157	1.927	0.484	4.151	3.026	3.013	0.881	10.758	6.755	0.840	0.841	11.186	1.271	6.581
6	Central Queensland	19.231	5.260	1.912	16.865	2.328	1.628	1.708	4.243	0.674	0.614	1.395	17.909	12.295	1.298	0.517	19.275	0.219	11.472
7	Charles Sturt	21.609	6.928	2.074	19.099	3.384	1.535	2.413	4.089	0.134	0.737	1.974	19.921	14.132	1.849	1.064	21.837	0.292	13.467
8	Curtin University of Technology	8.227	1.172	0.472	6.675	0.327	0.961	0.117	1.520	4.238	5.587	0.235	7.157	3.762	0.263	0.988	8.586	1.690	3.472
9	Deakin	8.804	1.446	1.447	7.184	0.047	1.833	0.653	2.209	5.368	5.920	0.480	7.883	4.023	0.547	1.036	9.199	2.245	3.018
10	Edith Cowan	14.777	3.052	3.860	12.788	1.375	4.174	2.133	6.547	4.914	3.019	1.959	14.403	9.144	1.967	1.225	14.473	2.449	7.561
11	Flinders	3.625	0.214	2.990	2.719	2.297	4.480	1.818	5.139	9.308	10.357	2.822	3.366	1.583	2.886	4.262	3.473	5.632	2.095
12	Griffith	7.757	0.767	0.807	6.255	0.250	1.425	0.154	2.171	4.701	5.617	0.359	6.893	3.525	0.393	1.052	7.972	1.947	3.176
13	James Cook	8.249	3.297	1.219	6.763	1.638	1.440	1.653	0.426	6.431	9.434	1.424	6.585	3.619	1.498	2.875	9.287	3.536	3.300
14	La Trobe	7.258	2.100	1.332	5.813	0.804	1.723	1.173	1.063	6.614	8.659	1.013	5.968	2.865	1.102	2.263	8.048	3.321	2.275
15	Macquarie	3.254	2.048	5.162	2.390	2.709	6.334	3.905	5.023	13.664	14.963	4.147	2.761	0.825	4.337	6.069	3.806	8.413	0.133
16	Melbourne	0.940	9.407	18.570	1.534	15.801	21.685	16.370	19.300	33.716	36.021	18.296	1.631	3.644	18.591	22.343	0.969	25.927	4.856
17	Monash	1.795	1.167	4.715	1.111	3.085	6.241	3.487	5.438	13.316	14.874	4.236	1.473	0.179	4.390	6.320	2.065	8.386	0.265
18	Murdoch	1.896	2.054	4.773	1.222	3.582	6.158	3.977	4.706	13.863	16.249	4.582	1.267	0.153	4.749	6.963	2.471	8.912	0.293
19	New England	4.180	2.885	6.393	3.279	3.176	7.494	4.891	6.003	15.061	15.929	4.939	3.760	1.555	5.156	6.770	4.782	9.431	0.417
20	New South Wales	0.000	4.775	11.200	0.083	9.512	13.683	9.631	12.032	23.514	25.900	11.188	0.181	1.013	11.405	14.504	0.125	17.204	2.080
21	Newcastle	4.775	0.000	2.791	3.693	1.426	4.098	1.364	5.019	8.349	8.653	2.130	4.576	2.141	2.196	3.169	4.579	4.680	2.138
22	Northern Territory	11.200	2.791	0.000	9.431	1.226	0.163	0.372	0.898	2.479	4.637	0.391	9.663	5.993	0.365	1.006	11.721	0.957	6.017
23	Queensland	0.083	3.693	9.431	0.000	7.827	11.705	7.968	10.239	20.925	23.183	9.358	0.140	0.528	9.559	12.416	0.244	14.949	1.415
24	Queensland University of Technology	9.512	1.426	1.226	7.827	0.000	1.585	0.437	2.299	4.574	4.973	0.299	8.601	4.581	0.346	0.683	9.816	1.740	3.634
25	Royal Melbourne Institute of	13.683	4.098	0.163	11.705	1.585	0.000	0.809	0.701	1.813	4.084	0.542	11.879	7.691	0.504	0.938	14.372	0.664	7.463
26	South Australia	9.631	1.364	0.372	7.968	0.437	0.809	0.000	1.909	3.208	4.261	0.157	8.585	4.899	0.154	0.616	9.843	1.099	4.659
27	Southern Cross	12.032	5.019	0.898	10.239	2.299	0.701	1.909	0.000	4.441	7.836	1.453	9.943	6.354	1.476	2.554	13.206	2.554	6.065
28	Southern Queensland	23.514	8.349	2.479	20.925	4.574	1.813	3.208	4.441	0.000	1.099	2.767	21.595	15.771	2.614	1.842	23.818	0.674	15.350
29	Sunshine Coast	25.900	8.653	4.637	23.183	4.973	4.084	4.261	7.836	1.099	0.000	3.805	24.626	17.958	3.654	2.092	25.678	1.476	16.823
30	Swinburne University of Technology	11.188	2.130	0.391	9.358	0.299	0.542	0.157	1.453	2.767	3.805	0.000	9.943	5.783	0.002	0.296	11.582	0.750	5.162
31	Sydney	0.181	4.576	9.663	0.140	8.601	11.879	8.585	9.943	21.595	24.626	9.943	0.000	0.664	10.149	13.289	0.556	15.665	1.744
32	Tasmania	1.013	2.141	5.993	0.528	4.581	7.691	4.899	6.354	15.771	17.958	5.783	0.664	0.000	5.959	8.327	1.398	10.489	0.368
33	University of Technology, Sydney	11.405	2.196	0.365	9.559	0.346	0.504	0.154	1.476	2.614	3.654	0.002	10.149	5.959	0.000	0.268	11.788	0.674	5.361
34	Victoria University of Technology	14.504	3.169	1.006	12.416	0.683	0.938	0.616	2.554	1.842	2.092	0.296	13.289	8.327	0.268	0.000	14.745	0.307	7.369
35	Western Australia	0.125	4.579	11.721	0.244	9.816	14.372	9.843	13.206	23.818	25.678	11.582	0.556	1.398	11.788	14.745	0.000	17.516	2.543
36	Western Sydney	17.204	4.680	0.957	14.949	1.740	0.664	1.099	2.554	0.674	1.476	0.750	15.665	10.489	0.674	0.307	17.516	0.000	9.828
37	Wollongong	2.080	2.138	6.017	1.415	3.634	7.463	4.659	6.065	15.350	16.823	5.162	1.744	0.368	5.361	7.369	2.543	9.828	0.000

Source: The Authors’ calculations using the normalised data