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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-six 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 Seven' (Go7) 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

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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 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 output².

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 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.

Data and Descriptive Analysis

Thirty-six 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 Seven (Go7); 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. It should be noted that the Australian National University (ANU) has been excluded from this study because accurate and consistent research output data could not be obtained. However, the exclusion and inclusion of ANU did not change the ranking and clustering results of this study significantly. In fact the changes in the results were hardly noticeable. Thus we have decided to use the acronym "Go7" in lieu of Go8.

<TABLE 1 HERE>

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 2 presents a summary of descriptive statistics of the annual averages for the thirty-six 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 99 per annum (Macquarie lies closest to the average) with a range between less than one (Sunshine Coast) and 366 (Melbourne); publications average 732 (La Trobe lies closest) with a range between 48 (Sunshine Coast) and 2585 (Melbourne); while grants average \$27.833 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 818 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 25,705 (at 2002 prices) in grants per academic staff member, per year during the period 1998-2002.

<TABLE 2 HERE>

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 1.88 (PhD completions per academic staff) to 4.50 (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 .01 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:

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

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. 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 34 and 35 shows a

significant increase from 36.94 to 105 (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 34 and 35 increasing from 17.88 to 105 (last and second-to-last rows in column 7 of Table 3). However, given that the use of the agglomeration coefficient as a stopping 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 3 HERE>

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 Go7 members (Adelaide, Melbourne, Monash, New South Wales, Queensland, Sydney, 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 fourteen. This cluster of high-performing research universities then comprises the Go7, 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.

<TABLE 4 HERE>

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 ($A-B1 = 2.31$; $A-B2 = 3.72$ and $B1-B2 = 1.50$) 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 justifying 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, $(\bar{X}_{1k}, \bar{X}_{2k}, \bar{X}_{3k})$, 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.

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, two members of the Go7 (Adelaide 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 salient points are noted from the cluster analysis of Australian university research performance. First, it is clear that the scale and long tenure of the Go7 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 Go7 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. Put otherwise, the least (most) research-productive universities are 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 [$\chi(3) = 231.5$, p-value = 0.000 and $\chi(3) = 78.1$, p-value = 0.000]; (ii) the Kaiser-Meyer-Olkin measure of sampling adequacy for total and per academic staff performance are 0.787 and 0.760, respectively; (iii) all of the elements on the diagonal of the anti-image correlation matrix are at least 0.730; and (iv) the lowest communality is 0.849. 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-six universities are presented in Table 5 in descending order. In total research performance terms the results are once again fairly unsurprising with the Go7 universities ranking highest. However, when research performance is expressed in per academic staff terms Monash is longer among the top-seven Australian universities and is replaced instead by the University of Tasmania. 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 0.858 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 twelfth to twentieth-ranked and La Trobe from eighth to fifteenth-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-second to eleventh-ranked), Tasmania (tenth to seventh-ranked), and Wollongong (sixteenth to eighth-ranked).

<TABLE 5 HERE>

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 0.934 (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-six 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 Go7 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 Go7 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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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	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 (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. 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)	27.833	127.000	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.

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	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.

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

University (1)	Research performance per academic staff		Total research performance	
	2 Clusters	3 Clusters	2 Clusters	3 Clusters
	(2)	(3)	(4)	(5)
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.

TABLE 5. Ranking of universities based on factor scores

Institution (1)	Normalised factor scores				Melbourne Institute Index (6)	Rank (7)
	Research performance per academic staff		Total research performance			
	Score (2)	Rank (3)	Score (4)	Rank (5)		
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.

Appendix

A hierarchical clustering technique has been employed to define clusters of similar universities. At the beginning of the hierarchical procedure we had thirty-six clusters each containing only one university. Then, at each stage that followed, the two most similar clusters were combined until, at the final stage, a single cluster of thirty-six universities was created. The results of hierarchical analysis can be different depending on the way in which the most similar pair of clusters is defined at each stage. The Ward's (1963) method has been used in this paper, which identifies the two clusters whose merger would result in the minimum increase to the aggregate sum of squared deviations within clusters. The sum of squared deviations within Cluster k is calculated as follows:

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

where X_{ijk} is the i^{th} measure of research output by university j in Cluster k , and \bar{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 total sum of squared deviations within clusters resulting from the combination of Cluster k and Cluster K to make Cluster $(k \cup K)$ can be computed by:

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

Table A.1 shows the proximity matrix among the thirty-six 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 (39.434); Sunshine Coast-Melbourne (35.085); Australian Catholic University-Adelaide (31.094); Charles Sturt-Melbourne (30.504); and Central Queensland-Melbourne (27.512). On the other hand, the five most similar pairs are: UTS-Swinburne (0.002); Queensland University of Technology-Deakin (0.046); Curtin-Griffith (0.060); New South Wales-Queensland (0.081); and Western Australia-Adelaide (0.091). 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	31.094	16.151	12.607	20.864	23.349	9.588	10.279	16.165	4.340	9.041	9.818	8.750	4.315	0.568	2.581	2.780	5.303	0.097
2	Australian Catholic	31.094	0.000	2.777	4.746	1.382	0.624	6.636	7.736	6.255	12.530	7.128	9.268	9.452	17.432	39.434	17.192	17.895	18.816	28.497
3	Ballarat	16.151	2.777	0.000	0.309	0.323	0.848	1.276	1.801	1.415	3.814	1.262	3.877	3.236	7.143	22.115	6.687	7.597	8.154	14.344
4	Canberra	12.607	4.746	0.309	0.000	1.241	2.130	0.968	1.575	1.421	2.161	0.785	3.811	2.943	5.691	17.967	4.831	5.888	6.758	11.136
5	Central Queensland	20.864	1.382	0.323	1.241	0.000	0.213	2.487	2.905	1.906	6.320	2.592	5.137	4.619	9.699	27.512	9.596	10.487	10.650	18.734
6	Charles Sturt	23.349	0.624	0.848	2.130	0.213	0.000	3.251	3.993	3.353	7.833	3.565	5.522	5.405	11.509	30.504	11.372	12.026	12.649	21.051
7	Curtin University of	9.588	6.636	1.276	0.968	2.487	3.251	0.000	0.385	2.520	1.503	0.060	0.979	0.556	2.716	14.133	2.505	2.786	3.568	8.017
8	Deakin	10.279	7.736	1.801	1.575	2.905	3.993	0.385	0.000	1.700	2.226	0.320	1.343	0.546	2.074	14.427	2.588	2.955	2.444	8.583
9	Edith Cowan	16.165	6.255	1.415	1.421	1.906	3.353	2.520	1.700	0.000	4.617	2.072	5.796	4.143	6.152	21.157	6.596	8.000	6.347	14.396
10	Flinders	4.340	12.530	3.814	2.161	6.320	7.833	1.503	2.226	4.617	0.000	1.183	3.266	2.356	2.204	7.762	0.907	1.599	3.290	3.530
11	Griffith	9.041	7.128	1.262	0.785	2.592	3.565	0.060	0.320	2.072	1.183	0.000	1.392	0.742	2.486	13.430	2.224	2.690	3.273	7.558
12	James Cook	9.818	9.268	3.877	3.811	5.137	5.522	0.979	1.343	5.796	3.266	1.392	0.000	0.235	2.501	13.932	2.887	2.305	3.262	8.043
13	La Trobe	8.750	9.452	3.236	2.943	4.619	5.405	0.556	0.546	4.143	2.356	0.742	0.235	0.000	1.530	12.591	1.990	1.761	2.082	7.077
14	Macquarie	4.315	17.432	7.143	5.691	9.699	11.509	2.716	2.074	6.152	2.204	2.486	2.501	1.530	0.000	6.396	0.484	0.485	0.152	3.174
15	Melbourne	0.568	39.434	22.115	17.967	27.512	30.504	14.133	14.427	21.157	7.762	13.430	13.932	12.591	6.396	0.000	4.852	4.971	7.115	0.916
16	Monash	2.581	17.192	6.687	4.831	9.596	11.372	2.505	2.588	6.596	0.907	2.224	2.887	1.990	0.484	4.852	0.000	0.198	1.111	1.750
17	Murdoch	2.780	17.895	7.597	5.888	10.487	12.026	2.786	2.955	8.000	1.599	2.690	2.305	1.761	0.485	4.971	0.198	0.000	1.132	1.849
18	New England	5.303	18.816	8.154	6.758	10.650	12.649	3.568	2.444	6.347	3.290	3.273	3.262	2.082	0.152	7.115	1.111	1.132	0.000	4.078
19	New South Wales	0.097	28.497	14.344	11.136	18.734	21.051	8.017	8.583	14.396	3.530	7.558	8.043	7.077	3.174	0.916	1.750	1.849	4.078	0.000
20	Newcastle	5.623	11.291	2.938	1.529	5.126	6.751	1.142	1.410	2.975	0.208	0.747	3.210	2.045	1.992	9.162	1.135	1.997	2.807	4.650
21	Northern Territory	12.687	4.499	1.109	1.296	1.861	2.020	0.460	1.410	3.759	2.915	0.786	1.186	1.296	5.027	18.094	4.593	4.647	6.226	10.913
22	Queensland	0.336	25.675	12.361	9.451	16.428	18.606	6.505	7.003	12.458	2.646	6.095	6.594	5.669	2.332	1.494	1.083	1.192	3.199	0.081
23	Queensland Universit	10.980	6.768	1.281	1.126	2.266	3.295	0.318	0.046	1.338	2.241	0.243	1.593	0.782	2.637	15.399	3.006	3.489	3.091	9.272
24	Royal Melbourne Inst	15.356	3.541	1.251	1.876	1.584	1.493	0.937	1.786	4.065	4.368	1.389	1.401	1.677	6.169	21.132	6.081	5.998	7.298	13.335
25	South Australia	10.982	5.314	0.655	0.471	1.663	2.350	0.114	0.636	2.078	1.773	0.150	1.607	1.141	3.800	15.949	3.396	3.871	4.761	9.384
26	Southern Cross	13.793	6.751	3.487	4.038	4.126	3.976	1.480	2.152	6.372	5.008	2.114	0.415	1.035	4.894	18.813	5.300	4.587	5.849	11.729
27	Southern Queensland	25.274	0.323	1.467	2.950	0.657	0.131	4.127	5.226	4.788	9.071	4.578	6.257	6.436	13.303	32.846	12.969	13.498	14.663	22.907
28	Sunshine Coast	27.556	0.970	1.564	2.936	0.597	0.717	5.438	5.760	2.940	10.091	5.468	9.176	8.424	14.562	35.085	14.482	15.817	15.501	25.227
29	Swinburne University	12.731	4.694	0.682	0.857	1.357	1.922	0.229	0.467	1.907	2.752	0.350	1.384	0.985	4.037	17.829	4.127	4.462	4.809	10.903
30	Sydney	0.463	26.492	13.328	10.473	17.443	19.404	6.973	7.683	14.029	3.275	6.715	6.421	5.819	2.694	1.590	1.436	1.235	3.668	0.176
31	Tasmania	1.683	20.013	8.698	6.574	11.972	13.763	3.665	3.921	8.904	1.540	3.432	3.528	2.794	0.805	3.552	0.174	0.149	1.517	0.988
32	University of Techno	12.949	4.502	0.618	0.818	1.263	1.800	0.256	0.533	1.915	2.814	0.383	1.457	1.072	4.222	18.116	4.277	4.624	5.020	11.115
33	Victoria University	16.132	3.232	0.299	0.820	0.503	1.036	0.962	1.009	1.193	4.156	1.025	2.797	2.201	5.908	21.771	6.157	6.780	6.590	14.133
34	Western Australia	0.091	28.727	14.293	10.896	18.781	21.278	8.369	8.970	14.104	3.383	7.770	9.055	7.848	3.713	0.943	2.014	2.409	4.665	0.122
35	Western Sydney	18.894	1.726	0.360	1.239	0.213	0.284	1.646	2.186	2.386	5.490	1.896	3.439	3.232	8.190	25.261	8.169	8.678	9.182	16.763
36	Wollongong	2.955	19.390	8.226	6.402	11.168	13.112	3.380	2.940	7.358	2.039	3.091	3.215	2.217	0.129	4.735	0.258	0.286	0.407	2.029

No.	University	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	Adelaide	5.623	12.687	0.336	10.980	15.356	10.982	13.793	25.274	27.556	12.731	0.463	1.683	12.949	16.132	0.091	18.894	2.955
2	Australian Catholic	11.291	4.499	25.675	6.768	3.541	5.314	6.751	0.323	0.970	4.694	26.492	20.013	4.502	3.232	28.727	1.726	19.390
3	Ballarat	2.938	1.109	12.361	1.281	1.251	0.655	3.487	1.467	1.564	0.682	13.328	8.698	0.618	0.299	14.293	0.360	8.226
4	Canberra	1.529	1.296	9.451	1.126	1.876	0.471	4.038	2.950	2.936	0.857	10.473	6.574	0.818	0.820	10.896	1.239	6.402
5	Central Queensland	5.126	1.861	16.428	2.266	1.584	1.663	4.126	0.657	0.597	1.357	17.443	11.972	1.263	0.503	18.781	0.213	11.168
6	Charles Sturt	6.751	2.020	18.606	3.295	1.493	2.350	3.976	0.131	0.717	1.922	19.404	13.763	1.800	1.036	21.278	0.284	13.112
7	Curtin University of	1.142	0.460	6.505	0.318	0.937	0.114	1.480	4.127	5.438	0.229	6.973	3.665	0.256	0.962	8.369	1.646	3.380
8	Deakin	1.410	1.410	7.003	0.046	1.786	0.636	2.152	5.226	5.760	0.467	7.683	3.921	0.533	1.009	8.970	2.186	2.940
9	Edith Cowan	2.975	3.759	12.458	1.338	4.065	2.078	6.372	4.788	2.940	1.907	14.029	8.904	1.915	1.193	14.104	2.386	7.358
10	Flinders	0.208	2.915	2.646	2.241	4.368	1.773	5.008	9.071	10.091	2.752	3.275	1.540	2.814	4.156	3.383	5.490	2.039
11	Griffith	0.747	0.786	6.095	0.243	1.389	0.150	2.114	4.578	5.468	0.350	6.715	3.432	0.383	1.025	7.770	1.896	3.091
12	James Cook	3.210	1.186	6.594	1.593	1.401	1.607	0.415	6.257	9.176	1.384	6.421	3.528	1.457	2.797	9.055	3.439	3.215
13	La Trobe	2.045	1.296	5.669	0.782	1.677	1.141	1.035	6.436	8.424	0.985	5.819	2.794	1.072	2.201	7.848	3.232	2.217
14	Macquarie	1.992	5.027	2.332	2.637	6.169	3.800	4.894	13.303	14.562	4.037	2.694	0.805	4.222	5.908	3.713	8.190	0.129
15	Melbourne	9.162	18.094	1.494	15.399	21.132	15.949	18.813	32.846	35.085	17.829	1.590	3.552	18.116	21.771	0.943	25.261	4.735
16	Monash	1.135	4.593	1.083	3.006	6.081	3.396	5.300	12.969	14.482	4.127	1.436	0.174	4.277	6.157	2.014	8.169	0.258
17	Murdoch	1.997	4.647	1.192	3.489	5.998	3.871	4.587	13.498	15.817	4.462	1.235	0.149	4.624	6.780	2.409	8.678	0.286
18	New England	2.807	6.226	3.199	3.091	7.298	4.761	5.849	14.663	15.501	4.809	3.668	1.517	5.020	6.590	4.665	9.182	0.407
19	New South Wales	4.650	10.913	0.081	9.272	13.335	9.384	11.729	22.907	25.227	10.903	0.176	0.988	11.115	14.133	0.122	16.763	2.029
20	Newcastle	0.000	2.720	3.595	1.391	3.995	1.330	4.890	8.135	8.429	2.076	4.455	2.082	2.141	3.090	4.461	4.561	2.079
21	Northern Territory	2.720	0.000	9.190	1.195	0.159	0.363	0.874	2.414	4.513	0.381	9.414	5.837	0.356	0.981	11.423	0.932	5.859
22	Queensland	3.595	9.190	0.000	7.629	11.407	7.763	9.982	20.384	22.579	9.119	0.136	0.515	9.316	12.098	0.238	14.565	1.380
23	Queensland Universit	1.391	1.195	7.629	0.000	1.544	0.426	2.238	4.454	4.839	0.291	8.382	4.463	0.337	0.665	9.570	1.694	3.538
24	Royal Melbourne Inst	3.995	0.159	11.407	1.544	0.000	0.788	0.682	1.764	3.973	0.528	11.575	7.494	0.491	0.913	14.009	0.647	7.269
25	South Australia	1.330	0.363	7.763	0.426	0.788	0.000	1.857	3.125	4.148	0.153	8.362	4.771	0.150	0.600	9.593	1.071	4.535
26	Southern Cross	4.890	0.874	9.982	2.238	0.682	1.857	0.000	4.319	7.621	1.413	9.694	6.193	1.436	2.485	12.875	2.484	5.910
27	Southern Queensland	8.135	2.414	20.384	4.454	1.764	3.125	4.319	0.000	1.070	2.694	21.034	15.359	2.545	1.794	23.207	0.656	14.946
28	Sunshine Coast	8.429	4.513	22.579	4.839	3.973	4.148	7.621	1.070	0.000	3.702	23.982	17.485	3.555	2.035	25.015	1.436	16.375
29	Swinburne University	2.076	0.381	9.119	0.291	0.528	0.153	1.413	2.694	3.702	0.000	9.688	5.634	0.002	0.288	11.290	0.730	5.027
30	Sydney	4.455	9.414	0.136	8.382	11.575	8.362	9.694	21.034	23.982	9.688	0.000	0.647	9.889	12.948	0.541	15.261	1.701
31	Tasmania	2.082	5.837	0.515	4.463	7.494	4.771	6.193	15.359	17.485	5.634	0.647	0.000	5.805	8.111	1.363	10.216	0.359
32	University of Techno	2.141	0.356	9.316	0.337	0.491	0.150	1.436	2.545	3.555	0.002	9.889	5.805	0.000	0.261	11.491	0.656	5.220
33	Victoria University	3.090	0.981	12.098	0.665	0.913	0.600	2.485	1.794	2.035	0.288	12.948	8.111	0.261	0.000	14.372	0.299	7.175
34	Western Australia	4.461	11.423	0.238	9.570	14.009	9.593	12.875	23.207	25.015	11.290	0.541	1.363	11.491	14.372	0.000	17.070	2.481
35	Western Sydney	4.561	0.932	14.565	1.694	0.647	1.071	2.484	0.656	1.436	0.730	15.261	10.216	0.656	0.299	17.070	0.000	9.569
36	Wollongong	2.079	5.859	1.380	3.538	7.269	4.535	5.910	14.946	16.375	5.027	1.701	0.359	5.220	7.175	2.481	9.569	0.000

Source: The Authors' calculations using the normalised data