Research Policy 42 (2013) 1679–1693

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Facts and fads in academic research management: The effect of management practices on research productivity in Australia

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ARTICLE INFO

Article history:
Received 4 November 2009
Received in revised form 18 July 2013
Accepted 24 July 2013
Available online 6 September 2013

Keywords:
Academic research
Research management
Australia
Universities
Performance
Productivity

ABSTRACT

As a response to competitive market forces and governmental steering policies, Australian universities have strengthened considerably their internal research management in the last two decades. This paper examines empirically the effect of management on academic research productivity. The results suggest that management practices indeed seem to have some positive effect on research productivity, and the effect is consistent in the earlier (1995–2000) and later (2001–2007) time period. Universities with a more intensive management approach not only have higher absolute level of research productivity but they demonstrate also faster growth in productivity. An omitted variable bias and robustness of the results to the choice of the output measure are under a particular attention and call for some caution in interpreting the results.

1. Introduction

In the last decade or two, academic research performance has become a highly visible and much discussed issue in many countries. In today's environment universities can hardly leave their research 'unmanaged', solely a responsibility of individual academics. Taylor (2006) discovered that university administrators in the US and UK often reject the notion that they 'manage' research but nevertheless they have developed policies to steer research performance, either indirectly through internal competition or directly through monitoring and support. A comparative OECD study (Connell, 2006) found several common trends in the academic research management in different countries. Universities nowadays specify their research priorities and develop strategic plans; they evaluate regularly their research performance and develop principles for ethical conduct. Furthermore, research management has become 'professionalized', i.e. universities appoint high-level academic and administrative staff whose sole responsibility lies in overseeing research activities.

While knowledge about general trends in research management practices is accumulating, evidence about the effect of these practices on research performance is still scarce. If universities are indeed 'seeking ways to best manage research' (Connell, 2006), it is the information on the effective practices, not merely on possible practices, that is crucial for success. There is a lot of evidence from other sectors, both private and public, that management practices may be overenthusiastically adopted due to fad and fashion, or due to ideology and belief (Staw and Epstein, 2000). The university sector has proven to be equally vulnerable to these tendencies (Birnbaum, 2000). However, we can also see accumulating empirical evidence that management does matter for performance. A positive effect of human resource management is perhaps most convincingly established (Huselid, 1995; Black and Lynch, 2001), but also other performance management practices demonstrate consistent positive effects in various industrial sectors (Bloom and van Reenen, 2010; van Reenen, 2011), including complex professional organizations such as hospitals (Bloom et al., 2008).

A number of interesting studies have emerged recently that examine the effect of some organizational choices and strategies on research productivity. Carayol and Matt (2004) and Bonaccorsi and Daraio (2003, 2005) examine an optimal size and personnel composition for highly productive research units. Schubert (2009) studies the internal governance in German universities and demonstrates a positive effect of strong central leadership, operational flexibility, goal agreements, and an internal evaluation system. Goodall (2009) follows up the recent interesting research from other sectors showing that the leader (the CEO) matters significantly for organizational performance (Bennedsen et al., 2006). Goodall (2009) demonstrates that a university president who him(/her)self is an accomplished scholar has a significant positive effect on overall research performance of the university.

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http://dx.doi.org/10.1016/j.respol.2013.07.014

Management is thus an important factor in explaining research productivity. Furthermore, management practices seem to be an important mediating variable in explaining why leaders matter (Bertrand and Schoar, 2003) or why competitive environment boosts performance (van Reenen, 2011). This paper hopes to contribute to the empirical evidence about the effectiveness of management in the academic research sector and it tests the assumption that specific university level management practices indeed contribute to better research performance. Data from Australian universities over the 1995–2007 period will serve as an empirical evidence base for our study. Before describing data, methods and the results of the study, the next section will offer a brief overview of research management in Australian universities.

2. Research management in Australian universities

Australia is known for its radical reforms in the higher education sector, starting in the end of the 1980s. The binary system of universities and Colleges of Advanced Education (CAE) was replaced with a unified university system; government established performance monitoring in the sector, introduced performance-based funding, and encouraged competition between universities (Valadkhani and Worthington, 2006; Meek and Hayden, 2005; Marginson and Considine, 2000). Australian universities have become significantly more research productive over the time period and this is clearly associated with the new performance-based policy approach in the early 1990s (Butler, 2003).

While the national policy reform has received quite a lot of attention, the role of internal management in explaining the growth is rather unexplored. These two are of course closely linked. The new policies not only create strong incentives for universities to improve their performance, they target university governance and management systems also directly. The 'revolutionary' White paper by the education minister John Dawkins in the late 1980s pointed out a need for stronger internal governance and management within universities (Dawkins, 1988), and the White paper of 1999 *Knowledge and Innovation* introduced mandatory *Research and Research Training Management Reports* (RRTMRs) that required universities to report not only on their performance but also on their management. It is no surprise that internal research management has developed considerably over the last two decades.

How do Australian universities manage their research? Institutional audit reports of the Committee for Quality Assurance in Higher Education (CQAHE) in 1995 and the Australian University Quality Agency (AUQA) in 2002–2007, and institutional RRTMRs show quite an evolution in this area. Most universities revised their organizational structure and strengthened their research leadership. Universities established a new high-level administrative position that is devoted entirely to research, usually called 'Pro Vice-Chancellor (Research)', if such a position did not exist before, and strengthened the role of the Dean in managing research within faculties. Inter-disciplinary research centers became a new locus for research activities, next to traditional faculties and departments. Strategic planning became a regular practice in all universities. With a stimulus from government, universities started to develop institution-wide research strategies. Research performance data has been collected and monitored in universities for almost two decades, ever since the government required universities to present data on publication numbers and on external grant funding. Universities have also specified their internal rules and regulations related to research, e.g. intellectual property rights and codes for ethical conduct.

All these practices are common to (almost) all universities and were developed in a relatively early phase of the higher education reform cycle. Some other practices are used less uniformly. In this study we will focus on the instruments that were adopted in Australian universities in a different point of time and/or to a different extent and therefore provide an opportunity for a systematic empirical analysis. The analysis is limited to practices that are formulated at the central level, ignoring practices that are initiated at the faculty and department level. Based on a systematic analysis of the CQAHE and AUQA audit reports, we can identify seven categories of practices which are quite diverse in their nature and target different organizational levels.

2.1. Practices targeting faculties and schools

At the level of faculties and schools we will consider two practices: *performance monitoring* and *performance-based funding*. Regular performance reviews focus attention on what each of the university's schools and faculties has accomplished. Many universities in Australia have implemented regular formal faculty reviews. This is a thorough examination of performance outputs in research and teaching as well as an evaluation of resources and practices, usually every four or five years. Some universities do also an interim assessment of their sub-units with respect to main performance indicators.

The performance monitoring may be linked to the internal budget allocation system but this is not necessarily the case. Since universities receive their research budget from a government according to a performance based formula (including publication numbers, external grants, and doctoral graduates), some universities have adapted the formula for their internal money allocation. Some other universities consider research performance in internal resource allocation but have not developed a clear formula for resource allocation, and the rest base internal money allocation primarily on student load or other input related criteria.

2.2. Central institutional practices

At the institutional level, *benchmarking* and *concentration* are two prominent management tools. Benchmarking is an instrument that has been strongly encouraged by the Australian government. Government initiated and funded the development of a detailed benchmarking manual for universities (McKinnon et al., 2000), which is a well-known source in universities and often cited in institutional reports. All Australian universities seem to compare their performance data with those of their competitors to some extent, which is facilitated by the fact that performance data are easily and publicly available. However, benchmarking is a more systematic exercise than merely comparing outputs. The extent to which the comparisons are systematic, examine not only outputs but also processes, and are considered in the management system varies across the sector.

Concentration of research activities in certain study areas is another institutional level policy that is strongly encouraged by the government (e.g. Kemp, 1999) and which has been implemented in universities to a varying degree. Some universities have clearly identified their research priorities and consider these in their resource allocation or staff hiring. Other universities have identified areas of strength but do not provide any additional resources or preferential treatment to related research groups. In some cases a bottom–up selection mechanism is in use. Faculties and departments can create research centers but the center first has to prove itself. If it is successful, then the area of research becomes an official concentration area and the center can enjoy some preferential treatment.

Table 1
Descriptive statistics and data sources ($N = 468$[a]).

Variables	Explanation	Mean	St dev	Min	Max	Data source
Publications	Total number of publications in the Web of Science database per academic staff[b]	0.73	0.51	0.052	2.32	The Web of Science database
Weighted publications	A weighted total number of books, book chapters, articles and conference papers per academic staff	0.87	0.39	0.068	2.00	HERDC—Universities Australia (2012)
Grants	Total Australian competitive grants, nominal million AUD	18.1	26.7	0.13	153.6	HERDC—Universities Australia (2012)
Grants share	Share of total Australian competitive grants (%)	2.80	3.68	0.04	13.97	HERDC—Universities Australia (2012)
PhD share	Share of academic staff with PhD degrees (%)	53.38	14.84	21.1	82.28	Anderson et al., 1997; DIISR staff collection[c]
Age	Average age of academic staff (eight age groups)	6.39	0.31	5.62	7.38	DIISR staff collection
Senior staff	Share of staff on Level D (=associate professors) and Level E (=full professors) (%)	20.82	5.36	7.40	34.15	DIISR staff collection
Students per staff	The ratio of FTE students to FTE academic staff	20.40	6.57	6.80	49.63	Selected higher education statistics collection[d]/DIISR staff collection
Teaching only staff	Share of FTE academic staff with teaching responsibilities only (%)	7.01	7.90	0	85.44	DIISR staff collection
Medical school	Existence of a medical faculty (binary variable)	0.28	0.45	0	1	University websites
Research management index	Accumulated score of five management practices					
	1995	3.47	2.42	0	10	CQUAHE institutional audit
	2002+	6.26	2.15	2	10	AUQA institutional audit; RRTMP

[a] N 468 is a panel of 36 universities over 13 years.
[b] Academic staff equals a sum of FTE (full-time-equivalent) academic staff.
[c] DIISR data available since 2003, data in Anderson et al. (1997) from 1996, linear change assumed in the missing years. See DIISR (2012) for data reference.
[d] See DIISR (2012) for data reference.

2.3. Practices targeting individuals

At the *individual level* we will look at the *individual incentives* (staff appraisal and performance rewards), *support structure* (workshops, mentoring, additional funding opportunities), and *upgrading research qualifications*. Literature distinguishes a ‘hard’ and a ‘soft’ approach in human resource management (Legge, 1995). The hard style of HRM sees staff as instruments that can be manipulated for better performance, focusing on such practices as performance-pay, job security and other performance incentives. The soft style management concentrates more on personnel satisfaction, needs, and motivation as a contributor to performance. Human resource practices in Australian universities include both ‘hard’ and ‘soft’ components. Individual incentives that reward research productivity have become more common. Regular staff appraisal has become a widespread practice. Some universities have created direct incentives such as performance-based pay for individual academics or adjustments in the teaching load depending on research productivity. A study on academic salaries showed that universities make an extensive use of salary loadings and other incentives to attract and keep academic staff and the range of these incentives varies considerably between universities (Horsley and Woodburne, 2005). Furthermore, the relative decline in academic salaries that is well reported since the 1970s starts to slow down in the 1990s and slightly turns around in 2000s (Coates et al., 2009), which among other explanations has been linked to greater emphasis on productivity bargaining that has enabled academics in some universities to gain salaries above the national award guidelines (Horsley and Woodburne, 2005). Many efforts in Australian universities, however, focus on facilitation and staff development. Mentoring early-career researchers, providing workshops on grant writing and publication skills, offering methodological help, providing near-miss grants and other funding opportunities–all these efforts are meant to create an environment that enables academic staff to become more productive.

Lack of academic staff with adequate research qualifications was a significant problem in some Australian universities, especially in the early 1990s because the staff in new universities (i.e. former CAE institutions) rarely had research training. *Upgrading Staff Qualifications* was an official government program in the early 1990s that offered opportunities for academic staff to complete their PhD training. Universities' commitment to the program varied. Universities that took the upgrading seriously developed policies of time release and offered incentive schemes to support the degree completion.

This study will thus test the assumption that the seven research management practices have a positive effect on research performance. The data section below will provide more clarity on how the practices are measured and how the practices relate to each other.

3. Data and measurement

The study uses a 13-year panel of university level data. The 36 universities in the sample include all Australian public universities except the University of Sunshine Coast which was established only in 1996. The universities are observed over the 1995–2007 period. The year 1995 is the earliest for which systematic data on internal management practices is available, and it is also a good starting point since the higher education system has probably started to somewhat stabilize after the structural changes of the early 1990s.

3.1. Research productivity

Various bibliometric indicators are used and developed to measure research output, all with their own strengths and weaknesses (see Glänzel and Moed, 2013; Geuna, 1999). This study takes the *number of peer-reviewed journal articles per full-time-equivalent academic staff* as the main output measure for university level research productivity. The measure has some weaknesses, such as ignoring disciplinary differences in the publication patterns, failing to take into account the quality, and it may be somewhat manipulable. From the positive side, however, publications are the core output criterion of academic research and the simple counts are closely monitored from the level of individual academics to the level of entire university. Publications are also a core outcome indicator

Table 2
Rubric for scoring organizational research management practices.

	0	1	2
Faculty/school level practices			
Regular faculty and department reviews	None	Regular review of faculties in a 5 year or longer interval. Review of research centers	Regular review of faculties and/or departments
Performance based budgeting	None	Adjustments to budgets are based on performance, but no clear formula	A clear proportion of the operational funds is based on research performance
Institutional level policies			
Concentration of research	None	Designated priorities and criteria for choosing areas of strength but no clear preferential treatment OR Channeling research funding through centers	Clearly identified research priorities; priorities are supported with research funding and infrastructure allocations
Benchmarking	None OR performance data is collected but not compared with other institutions	Performance data is regularly collected and analyzed, performance indicators clearly identified and some comparison with other institutions	Peer institutions identified both locally and internationally for each discipline
Individual level policies			
Upgrading research qualifications	Non-existent or minimal effort to support PhD degrees among staff	One instrument, e.g. time release	A systematic effort to increase the proportion of staff with PhD degrees, multiple instruments
Support structure	Grants for early career researchers; ARC small research grants	Workshops on grants and publications (plus previous)	Active feedback mechanism, internal evaluation, seed grants, near miss grants, research skill seminars, methodological help etc (plus previous)
Individual research incentives	None	Informal performance targets and research expectations; opportunities for study leave and reduced teaching load	Regular appraisal of academic staff, funding based on individual performance, teaching load reduction, awards

collected by the government. Even though the measure may not capture perfectly the total academic research output, a potential link between research management and a simple publication count would tell us whether the system is responsive to management.

The data on publication numbers are extracted from the *Thomson Reuters (ISI) Web of Science* indices, as of July 2009. Since there is some time lag between completing research and its publication, the publication count is included with a one year lag. The publication numbers are taken as a simple aggregate for each university, without correcting for co-authored papers.

To check the robustness of the results and address some of the weaknesses of the simple count of articles, we will examine also two alternative research output measures. The *total weighted publications* in the governmental Higher Education Research Data Collection (HERDC) (Universities Australia, 2012) contain research output in four categories: books, refereed articles, book chapters, and conference presentations, where books have a weight of five. Furthermore, co-authored publications here are apportioned by the number of authors. Consequently, the weighted count is close to, but somewhat lower than, the count of *the Web of Science* publications (see Table 1 for descriptive data). Thirdly, we will examine the amount of competitive research funding as an output measure, assuming that competitively acquired funding, distributed mostly through a rigorous peer-review process, gives an indication of high quality research. We will use the dollar amount of *national competitive grants* as presented in the HERDC database.

3.2. Research management practices

Tracking management practices retrospectively over a 13-year period is a difficult task. Fortunately the Australian universities have gone through several cycles of institutional audits that record not only their performance but also their organizational practices. These audits provide comparable and externally verified information on universities' management. The audit reports are available from two audit cycles: the 1995 audit by the Committee for Quality Assurance in Higher Education (CQAHE), and an audit carried out over the 2002–2007 period by the Australian Universities Quality Agency (AUQA). The AUQA audits were broader in scope and some practices may have received less attention and mentioning. To fix this bias, also the institutional RRTMPs are consulted for possible gaps. From these sources we are able to create two 'snapshots' of internal research management in all Australian universities: one describing the year 1995 and the other describing the year 2002 plus a few years afterwards.

3.2.1. Time period

While data on research outcomes and control variables is available annually, information on management practices is available as two 'snapshots' (1995 and 2002+). It is however reasonable to assume that practices do not change on a yearly basis and their effect can be observed also after the year of measurement. We will thus expect that the research management practices measured in 1995 would show results not only for this particular year, but also for some later years, more specifically over the 1995–2000 period. Similarly, we will use the data from the 2002+ audit round to explain performance over the 2001–2007. The year 2000 seems a meaningful breaking point due to important policy initatives in the change of the millennium. In 1999 the Ministry proposed new ideas on developing the higher education sector, among others requiring RRTMRs that indirectly forced universities to revise their internal practices (Wood and Meek, 2002). Therefore, it is likely that universities changed their internal practices around the turn of the millennium.

We suppress the issue of an appropriate time lag between introducing certain management practices and realistically expecting to observe an effect. Since we do not have information about when the practices were introduced, we assume that if they are in place at the time of measurement then they can be reasonably expected to have an effect. To examine a possible lagged effect, we will include the 1995 management as an additional variable in one of the 2001–2007 model specifications.

One weakness in the data comes from the fact that the AUQA audit reports were prepared over a five year period, leaving us with ‘snapshots’ that do not come precisely from the same point of time. Universities that were audited later may have scored higher since they have had additional years to develop their management. However, we assume that major changes in universities took place by the early years of the 2000s, as a response to the explicit policy in this area, and the year of measurement does not produce a systematic bias.[1]

3.2.2. Quantifying research management

The audit reports provide a narrative description of research management. To develop quantifiable indicators, the reports were analyzed with respect to the seven major clusters of research management practices that we identified in the previous section. Each university achieved a score of 0, 1 or 2 for each of the seven policies, based on a scoring rubric (Table 2). In the later period practices had become more nuanced and on some occasions half-units were used to more accurately capture differences between universities.

Descriptive statistics (Table 3) show considerable variance in management practices across universities. It is also evident that almost all management practices were more developed in the year 2002+ compared to 1995. The correlations between individual management practices show some interesting patterns and mostly the patterns are consistent in the two periods. In general, correlations between management practices are quite low, under 0.4, and they tend to be higher in the second period. There are two management practices that stand out with negative correlations in both periods: upgrading staff qualification and concentration of research. One might expect that upgrading staff qualification is a priority in universities with a lower research culture (i.e. former CAEs) and these universities either do not have the resources or capacity, or do not see the need, to develop other practices at the same speed. Research concentration has a very low correlation with other practices, albeit consistently negative. This seems to suggest that concentration is a rather unique strategy and perhaps not part of a common performance portfolio. On the other hand, concentration policies are quite well developed within universities (mean 0.8 and 1.4, in 1995 and 2002+, respectively) and do not show much variation between universities.

Interestingly the correlation between the same practices in two time periods is not very high, indicating that management practices have been quite volatile over the study period. The most likely explanation for the low correlation is the fact that some universities set up their management system quickly in the 1990s and the others were catching up later in the 1990s.

3.2.3. Research management index

The effect of the seven research management practices could be studied either individually or as an aggregated system of practices. The latter option is commonly used in the management research, implying that it is a system of instruments that is a strategic asset to the organization and that drives performance (Becker and Huselid, 1998; Koch and McGrath, 1998; Huselid, 1995). Empirical literature on research management practices is not well developed and therefore cannot provide the assurance that it is conceptually valid to aggregate individual scores. In order to discover the underlying

Table 3
Descriptive statistics and correlations of management practices.

	Mean	St dev	1995							2002+						
			1	2	3	4	5	6	7	1	2	3	4	5	6	7
1995																
(1) Fac.per. reviews	0.725	0.871	1.000													
(2) Perf. budgeting	0.781	0.855	0.326	1.000												
(3) Benchmarking	0.446	0.645	0.219	0.279	1.000											
(4) Concentration	0.828	0.865	0.054	0.144	−0.163	1.000										
(5) Ind. incentives	0.530	0.801	0.289	0.333	0.191	0.132	1.000									
(6) Support struct.	1.000	0.709	0.091	0.323	0.122	−0.046	0.098	1.000								
(7) Upgrading qual.	1.139	0.824	−0.219	−0.631	−0.381	−0.006	−0.366	−0.096	1.000							
2002/7																
(1) Fac.per. reviews	1.223	0.714	0.009	0.172	0.330	0.107	0.282	−0.221	−0.386	1.000						
(2) Perf. budgeting	1.465	0.791	0.240	0.082	0.251	0.082	0.405	0.075	−0.207	0.287	1.000					
(3) Benchmarking	1.021	0.517	−0.034	0.105	0.497	−0.258	0.244	0.248	−0.352	0.310	0.472	1.000				
(4) Concentration	1.442	0.483	−0.432	−0.026	−0.231	0.172	−0.246	−0.122	−0.085	−0.003	−0.034	−0.009	1.000			
(5) Ind. incentives	1.244	0.607	−0.032	0.386	0.221	0.067	0.294	0.097	−0.166	0.374	0.390	0.374	0.036	1.000		
(6) Support struct.	1.317	0.555	0.131	0.067	0.386	−0.012	0.377	0.071	−0.250	0.210	0.216	0.294	0.165	0.248	1.000	
(7) Upgrading qual.	0.223	0.479	−0.121	−0.017	−0.323	0.093	−0.090	0.000	0.204	−0.391	−0.053	−0.245	0.056	0.005	−0.266	1.000

[1] There is a low correlation between the audit year and the management index (Pearson correlation coefficient 0.33). Attempts to adjust the index with the inverse of the audit year significantly worsened the explanatory power of the models.

Table 4
The factor structure of research management practices, 1995 and 2002+.

Management practice	1995		2002+		
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 3
Faculty performance reviews	**0.3533**	0.1097	**0.6957**	−0.1347	−0.2639
Performance based budgeting	**0.5274**	0.0945	**0.6776**	0.3779	0.0835
Benchmarking	0.3614	**−0.4571**[a]	**0.7178**	0.1992	−0.015
Concentration	0.0514	**0.8152**	0.0937	−0.4691	**0.7842**
Individual incentives	**0.396**	0.2597	**0.6525**	0.4009	0.2517
Support structure	**0.2329**	−0.1892	**0.5698**	−0.4011	0.2553
Upgrading qualifications	**−0.5026**[a]	0.0479	−0.4865	**0.6051**	0.5044
Alpha	0.60	(1.0)	0.69	(1.0)	(1.0)
Eigenvalue	2.41	1.16	2.45	1.10	1.07
Proportion of variance accounted for	34.5	16.6	35.06	15.8	15.3

Note: The highest loadings in bold.
[a] Omitted from the scale and from the Cronbach alpha calculation.

factor structure associated with these practices, the exploratory factor analysis using principal component extraction without rotation is used. Considering the smallness of the sample size, the results should be taken as suggestive rather than definitive.

The practices are analyzed separately for the two time periods. Two factors emerged in the first period and three in the second period when keeping the factors that have an *eigenvalue* greater than 1 (Table 4). There is some difference in the two periods but the overall pattern is quite consistent. Five practices can be considered as one dimension of a research management system: faculty reviews, performance based funding, benchmarking, individual incentives, and research support structure. The strategy of concentrating research seems to be an independent dimension and should be treated separately. Upgrading qualifications is a somewhat problematic practice. It belongs to the aggregate scale of research management in 1995, but with a negative sign. In 2002/7 it loads to all factors, but most strongly comprises a factor on its own. Moreover, this particular practice is probably strongly related to the nature of the university (and its original research productivity) and it is expected to lose its explanatory power when the level of staff qualification is included in the control variables. It is therefore left out of the index. In sum, the constructed *Research Management Index* is an aggregation of the scores of the five management practices.

The data indicates that the choice of management intensity is probably not random. We will use below four university types as originally identified in Marginson (1997), including research intensive *Sandstones*, pre-1987 universities (so called *Wannabe-Sandstones*), technical universities, and *New universities* that were established after 1987 as part of the sector reform. The Research Management Index is statistically different in different university types. Expectedly, the management score is highest in the *Sandstones*, with the average score of 5.78, compared to the average of 2.09 in the *New universities*, and the other two university types are somewhere in between ($F = 5.77$, $p < 0.003$). In the later period the differences somewhat narrow but there is still a significant difference between the average of 8.3 in the *Sandstones* and 5.4 in the *New universities* ($F = 5.08$, $p < 0.006$). This self-selection bias will get more attention in the model estimations.

3.3. Control variables

Numerous earlier studies have modeled research productivity successfully by using a number of input factors, such as research funding, staff qualifications, and the age and composition of the academic staff (e.g. Adams and Clemmons, 2006; Johnes, 1988; Abbott and Doucouliagos, 2004; Dundar and Lewis, 1998; Ramsden, 1999). We build on these models and include six commonly used controls in our estimates. *The proportion of academic staff with a PhD degree*, *the average age of academic staff*, and *the proportion of senior staff* (equivalent to associate and full professors) control for staff characteristics. Teaching load, as a competitor on research time, is likely to have a negative effect on research productivity, and is measured here by *the number of students per academic staff member*. Different disciplines demonstrate different average publication numbers. While we cannot account all differences coming from the discipline mix, we control for universities that have a *medical school*, as a source for the biggest potential bias. Finally, to capture a potential complementarity of teaching and research tasks (Marsh and Hattie, 2002), we include also *the proportion of staff that has only teaching responsibilities*.

We omit research capital in the productivity model because (competitively) obtained research funding is not only an input for research but also a proxy for research output in the past (e.g. Koshal and Koshal, 1999). Controlling the model for research funding would bias the effect of management downwards, in case good management leads to more research funds as well as more research output. Instead we will use the competitive research funding as an alternative research outcome measure to test the robustness of the results.

The department in Australian government responsible for higher education (currently abbreviated as DIISR) gathers regularly data on universities, and the staff data collection are the main data source for this study. Table 1 provides details on definitions, sources and summary statistics.

4. Estimation

An attempt to estimate the effect of management on performance faces a considerable challenge: a potential omitted variable bias. Unobserved characteristics related to history, institutional culture and research expectations, for example, are likely to play a significant role in the level of research performance. It is also likely that these unobserved factors are positively related to the motivation or capacity of universities to adopt an advanced research management approach. Observing a positive correlation between performance and management practices is therefore not sufficient to confirm the positive effect of research management. In order to address the issue we use a number of model specifications: a random effect model, a fixed effect model, and a growth model within and across periods. While none of the models is entirely problem-free, different assumptions under each model help us make a better judgment about the true effect of research management.

We will first analyze the research production function for each time period separately (1995–2000 and 2001–2007), with a panel of 36 universities and, respectively, of 6 or 7 years. We model research output as a function of various input factors, such as staff qualification, age, and seniority, as well as alternative time commitments (i.e. teaching load), and a discipline specific publishing patterns (i.e. reduced to the existence of a medical school). The function is augmented with the research management index. Since research performance may be changing over the years also due to other factors, such as governmental research policies, we add a series of year dummies.[2]

The model will be estimated with a random effect and fixed effect models.[3] Since management is time-invariant within a period in our data, we will use the Fixed Effect Vector Decomposition (FEVD) procedure from Plümper and Troeger (2007) to separate the effect of management from the rest of the unobserved time-invariant component. However, if the choice of the research management approach itself is affected by such unobserved characteristics (i.e. organizational culture, history, and prestige) then the estimates from this model may be biased upwards. Nevertheless, the model would give us a better idea about the association between unobserved university characteristics and management practices.

To overcome the omitted variable problem, we will then turn from the absolute productivity to the growth in productivity, testing whether universities with more intensive research management improve their research productivity faster. Annual growth rates are volatile, exacerbating the effect of random fluctuation. For a more robust picture we will reduce the data to a simple cross-sectional form. We will examine if the *average annual growth rate* from the beginning of the period to the end (i.e. from the year 1995 to the year 2000, and from 2001 to 2007, respectively) is associated with the *management index*.[4] Due to the small sample we include only one control variable, the log level of research output in the beginning of the period. Universities with a lower research productivity are shown to grow significantly faster (Beerkens, 2013) and, as mentioned earlier, it is likely that the level of research productivity and the choice of research management are associated, which makes this control necessary.

The problems with the omitted variable bias could be significantly reduced if research management itself could be included as a time-variant variable. We do not have annual data on management, but we do have data on two points in time. As the last step we will reduce the panel to two years of observations and examine the relationship between the *change in research performance* and *change in research management*.[5] This model raises the issue of an appropriate time period. Since we expect the main change in management to occur with the change of the millennium as a response to the policy change, an appropriate time period should include years before and after this point. For measuring the change in the productivity we need to pick a starting year when the old management system had had an opportunity to positively affect the productivity but before the new set of practices had stepped in, and for the end we need a year when the productivity could have adjusted to the new management system. We give a rather subjective three years from the beginning of the period to allow the productivity to respond to the management instruments, which takes us to the years 1998 and 2004.[6]

We need to recognize that the last two models reduce our data to 36 observations and we will additionally rely on scatter plots to give a reasonable overview of the results.

5. Results

We will examine the results in the following steps. First we will look at the effect of the research management index on research performance and the growth in performance with respect to *the Web of Science* publications, and then we will run the same models on two alternative productivity measures for a robustness check.

5.1. Productivity in the first period (1995–2000)

The random effect model in the first column of Table 5 seems to explain research productivity quite well, with an overall R-square of 0.84, with a considerable variation explained both within universities over time and between universities. The aggregated research management index is a statistically significant contributor to research performance. One point increase in the total research management index contributes about 4 percent (coefficient 0.041) to the average research productivity.

The level of qualified staff (with PhD degrees) and more senior level staff matters for productivity; low number of staff with only teaching responsibilities seems to have a positive effect, and also universities with a medical school demonstrate higher publication numbers. Contrary to expectations, high student numbers seem to have a positive effect on research, which probably refers to a technical problem in the data. The number of students has constantly increased in Australia, in all universities. In the estimation model the number of students therefore seems to take over some of the time-effect in research productivity. The coefficients of year dummies are consistently positive but unexpectedly low, confirming the suspicion that the increasing student number captures some of the ongoing productivity increase over time.

When we turn to the FEVD model, the effect of research management increases from four percent to close to 9 percent (0.088) (Table 5 column 2). When controlled for the time-invariant university effects, some variables expectedly loose their explanatory power. While the level of PhD stays associated with research productivity, the level of senior staff and teaching-only staff loose their explanatory power.

We can conclude that in the first period research management and research productivity are indeed associated. The strong effect of (time-invariant) research management in the fixed effect model should make us alert about the nature of the relationship, as discussed above. It is very likely that universities prone to high research productivity (old, prestigious universities with strong research culture–all of which remains unobserved in our data) have been able to adopt rather quickly the active research management approaches, perhaps on the vary same reasons why they are research productive. We will examine these concerns further in a growth model below, but first we turn to the results of the second period.

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[2] The basic estimation model is thus in the following format: $y_{it} = \alpha + \beta RMI_i + \sum_{k=1}^{K} \gamma_k x_{kit} + \delta z_i + \sum_{m=1}^{M} \varphi_m d_{mt} + \nu_{it}$, where y_{it} is a natural logarithm of the number of publications per academic staff member at the university i in the year t; RMI signifies the time-invariant research management index (either 1995 or 2002+ measurement), x signifies k time-variant control variables, z signifies a time-invariant control variable (medical school), and d represents year dummies. The composite error term ν_{it}consists in university specific error (u_i) and random noise (ε_{it}).

[3] The Breusch–Pagan test indicates that university specific effects are non-zero for both periods: $\chi^2(1)$ 200 and 374 for periods 1 and 2, respectively.

[4] Specification: $\Delta y_i = \alpha + \beta RMI_i + \delta y_{t0i} + \varepsilon_i$, where Δy_i represents the average annual growth rate in publication numbers from the first to the last year of the time period at the university i, RMI signifies the research management index, and y_{t0} is the log level of research output in the beginning of the period.

[5] Specification: $\Delta y_i = \alpha + \beta \Delta RMI_i + \delta y_{t0i} + \varepsilon_i$, where ΔRMIsignifies the change in the research management index from 1995 to 2002+, and other notification is the same as in the previous model.

[6] The robustness check shows that the choice of the period is not highly influential for the results. When taking the extreme 2001–2007 under the examination, the effect weakens and the significant coefficient presented later in Table 9 drops just under the 0.1 significance level and the scatter plot remains similar to Fig. 1.

Table 5
The effect of research management on research productivity, 1995–2000 and 2001–2007.

	1995–2000		2001–2007 (A)		2001–2007 (B)	
	RE	FEVD	RE	FEVD	RE	FEVD
Research management index 1995	0.041**(0.019)	0.088**(0.004)	–	–	0.042**(0.022)	0.064**(0.005)
Research management index 2002+	–	–	0.038*(0.023)	0.057**(0.004)	0.023 (0.024)	0.031**(0.004)
PhD share	0.030**(0.003)	0.020**(0.000)	0.011**(0.003)	0.004**(0.001)	0.010**(0.003)	0.004**(0.001)
Age	−0.241 (1.459)	0.980 (0.837)	−0.253 (1.24)	−0.251 (0.884)	−0.195 (1.231)	−0.251 (0.836)
Age-sq	0.022 (0.11)	−0.071 (0.065)	0.010 (0.094)	0.014 (0.06)	0.007 (0.093)	0.014 (0.063)
Senior staff	0.014** (0.006)	−0.001 (0.002)	0.024** (0.005)	0.016** (0.002)	0.021** (0.005)	0.016** (0.002)
Student/staff	0.019** (0.005)	0.038** (0.003)	−0.003 (0.004)	0.007** (0.002)	−0.002 (0.004)	0.007** (0.002)
Teaching only staff	−0.002* (0.001)	−0.0014* (0.0009)	−0.003 (0.003)	−0.006** (0.002)	−0.004 (0.003)	−0.006** (0.002)
Medical school	0.491** (0.103)	0.777** (0.025)	0.592** (0.116)	0.768** (0.025)	0.577** (0.117)	0.709** (0.024)
Year dummies:						
+1	0.03	0.03	0.13**	0.13**	0.13**	0.13**
+2	0.08**	0.08**	0.18**	0.18**	0.18**	0.18**
+3	0.07*	0.07**	0.18**	0.19**	0.18**	0.19**
+4	0.03	0.04	0.26**	0.29**	0.26**	0.29**
+5	0.04	0.07**	0.27**	0.31**	0.28**	0.31**
+6	–	–	0.32**	0.38**	0.33**	0.38**
Constant	−2.53 (4.70)	−6.35** (2.35)	−0.82 (4.11)	−0.83 (2.73)	−1.04 (4.09)	−0.89 (2.74)
R^2						
Within	0.71		0.62		0.63	
Between	0.84		0.80		0.80	
Overall	0.82	0.980	0.78	0.969	0.79	0.969
N	36 × 6[a]	36 × 6	36 × 7	36 × 7	36 × 7	36 × 7

Note: Dependent variable: *The Web of Science* publications (log). RE—random effects, FEVD—fixed effects with vector decomposition.

** $p < 0.05$. Standard errors in parentheses.

* $p < 0.10$. Standard errors in parentheses.

[a] *N* includes a panel of 36 universities and 6 (or 7) years.

Table 6
The effect of research management on productivity growth, from 1995 to 2000, and from 2001 to 2007.

	1995–2000	2001–2007 (A)	2001–2007 (B)
Research management index 1995	0.621** (0.285)	–	0.221 (0.213)
Research management index 2002+	–	0.597* (0.309)	0.536* (0.315)
Past publication level	−5.76** (1.00)	−3.924** (0.786)	−4.272** (0.803)
Constant	0.400 (1.83)	1.61 (2.23)	1.00 (2.35)
R^2	0.46	0.35	0.36
N	36	36	36

Note: Dependent variable: average annual growth rate in *the Web of Science* publications.
** $p < 0.05$. Standard errors in parentheses.
* $p < 0.10$. Standard errors in parentheses.

5.2. Productivity in the second period (2001–2007)

The estimation results in the second period are quite consistent to those in the first period and the models show again high explanatory power (Table 5, 2001–2007(A)). The effect of management practices is 3.8 and 5.7 percent per unit change in a RE and FE, respectively. The staff qualifications and composition and a medical school have an expected effect in both models. Unlike in the early period, there is a consistent yearly increase in productivity as identified by significant and increasing year dummies.

Compared to the results of the first period, the effect of research management seems to have declined slightly. This may suggest that in a more advanced research management environment, the management can make a smaller difference, and that research productivity can be more easily steered in the early reform stage. On the other hand, the random effect results in the two periods are virtually identical; it is the fixed effect model that shows a large difference. It probably means that the association between the unobserved university characteristics and research productivity has declined over the years. Universities have had more than a decade to observe what others do and to develop their own research management approach, so the initial advantage of research intensive universities has weakened over the years.

Furthermore, research productivity in the later period is more strongly associated with the management system measured in 1995 compared to 2002+ (Table 5 columns (5) and (6)). The practices of the mid-1990s have a surprisingly similar effect on productivity in the second period and in the first period. Consequently the effect of more recent practices drops significantly, but remains a significant 3.1 percent in the fixed effect model. This may suggest, on the one hand, that management practices take time before they show an effect. This may also be a reason why the coefficients in the first period are somewhat higher, since the management system measured in 1995 may have been longer in place than the management system measured in 2002+. More likely, however, it is another sign of a self-selection bias, showing that universities with a high level of research productivity developed a more intensive research management system and relatively early on. The growth models below will shed more light to this issue.

5.3. Growth in research productivity in the first and second period

In order to eliminate the possible self-selection effect, we will now examine whether universities with more intense research management show faster growth in productivity. The dependent variable is an average annual (compound) growth rate between 1995 and 2000 in the first period, which is regressed on the research management index in 1995 and the level of research productivity in 1995. For the second period, respectively, the dependent variable reflects an annual growth from 2001to 2007, regressed on the 2002+ management index and productivity in 2001.

An ordinary least square (OLS) regression shows a significant positive effect of research practices on growth. In both periods the effect is at a similar range: one unit increase in the management scale adds more than half a percentage points to the annual growth rates (0.62 and 0.60 percent, respectively) (Table 6). This result suggests that management indeed matters for research productivity and the positive associations we saw in the previous models are not only due to the fact that high-performing universities develop a more intense management system. Furthermore, in the last column we see that it is indeed the current management practices that matter for the growth rate, not the former practices as we observed in the previous model.

We can also see that universities demonstrate a strong catching-up trend; particularly in the earlier period closer to the major sector-wide policy reform. The coefficient −5.76 suggests that annual productivity growth at a university with a mean average publication rate (i.e. 0.73 articles) is about 1.7 percentage points higher than growth at a university with an average publication number of 1.00. The catching-up trend declines expectedly in the second period and the difference in growth rates declines to 1.2 (coefficient −3.92) percentage points in the same example above.

5.4. Change in management vs. change in productivity (1998 and 2004)

The most effective model considers also management policies as time variant and studies the relationship between a *change* in management practice and a *change* in productivity. Such an analysis can be expected to reduce the heterogeneity bias most directly. The first column in Table 9 confirms the positive effect of change in management practices on growth. Intensifying a research management policy by one unit increases an annual productivity growth by about 0.4 percentage points. Considering that the mean annual growth rate over the period is around 6 percent, and that productivity is exponentially accumulating, this is not a trivial effect.

This analysis reduces our data to 36 observations, which sets clear limits to a statistical analysis. For further insights we will look at a series of scatter plots that link a change in management with the change in productivity. On Fig. 1a we can observe that there is a positive relationship between publications growth and change in research management, but the relationship is noisy and we cannot establish the effect confidently. However, the relationship becomes significantly clearer when we separate the commonly known four university types in Australia (Marginson, 1997). We can observe quite a clear effect of management in research intensive "Sandstones" (Fig. 1b), in pre-1987 universities (so called Wannabe-Sandstones) (Fig. 1d), as well as among technical universities (Fig 1c). The group that demonstrates highly variable growth rates without an apparent relationship with management is the "New universities" (Fig. 1e), established after 1987 as part of the sector reform. It is probably expected that the major change in productivity in new universities comes from internal structuring and resourcing and these major effects would hide a rather subtle effect of internal management, even if there was one. In the light of the series of scatter plots we may propose with some confidence that

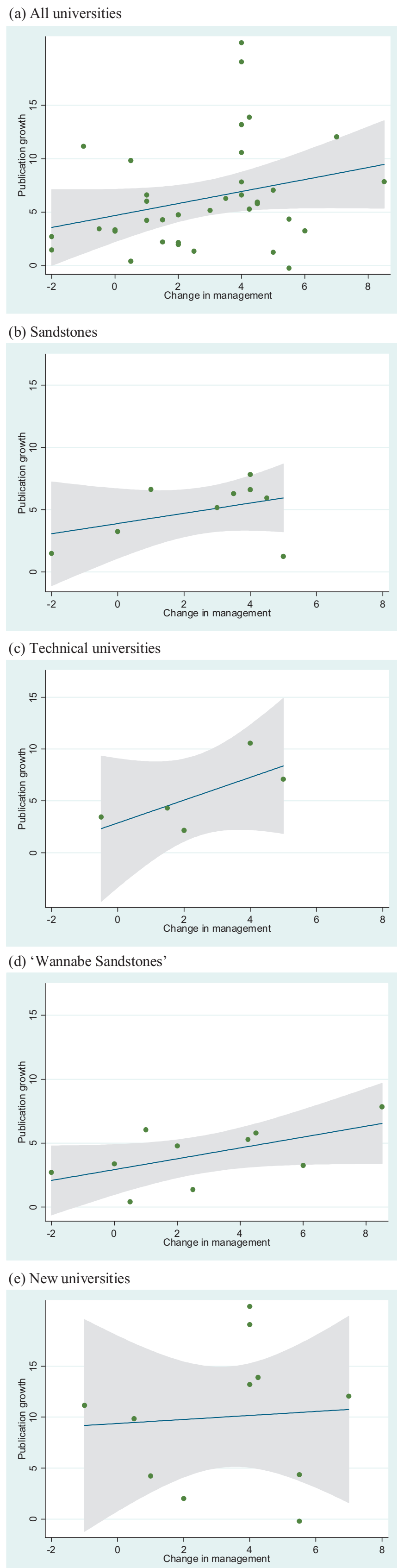

Fig. 1. Association between change in research management and change in research productivity (*The Web of Science* publications), 1998–2004 by university type.

management practices seem to matter, and they seem to matter for most university types.

5.5. Robustness check with a total weighted count of publications and competitive grant funding

In order to check the robustness of the results to the measurement of research output, we will rerun the tests with the number of weighted publications and with the competitive grants, as reported in the HERDC. For saving the space, we present here only the results of the more superior fixed effect models and the growth models. Starting with the weighted publications, the models demonstrate good explanatory power but the effect of research management is significantly weaker (Table 7). There is no statistically significant association between management and productivity in the first period, but in the second period the effect is statistically significant in the range of 2.1 percent. Furthermore, the productivity in the second period has again a stronger association with the management practices of the 1995 than of the 2002+ (column 3).

There is also no clear evidence that universities with more intense management have increased their weighted publications faster (Table 8). In the first period the coefficient is positive in the magnitude of 0.8 percentage points, but the estimate is only within a 20 percent confidence interval. In the second period, it looses any significant. We can see though that the catching-up between universities has been much stronger when all publications are included, not only publications cited in *the Web of Science* database. Management intensity, on the other hand, does not seem to play a role. Neither seems there to be an association between change in management practices and change in productivity (Table 9) if we control for the 'catching-up effect'. The examination of the scatter plot (Fig. 2) indicates somewhat more similarities between *the Web of Science* and HERDC weighted publication counts. There is a positive association within the group of research intensive '*Sandstone*' universities, and within so-called *Wannabe Sandstones*. Within the technical universities the effect disappears and among new universities it is rather negative.

Why does management have a weaker effect on total research output than on the number of cited journal articles? Universities pay more attention to publishing in internationally cited journals, i.e. cited in the *Web of Science*, and it is conceivable that universities with strong research management encourage publishing in cited journals, which comes at the expense of other venues. Academics under performance pressure may see books and national publications as an unrewarded effort, compared to academic journal articles. This explanation is undermined though by the fact that HERDC publication count is an official statistic that is used by universities and that functions as one of the performance targets. The difference in results may be affected by the calculation parameters. Unlike the *Web of Science* publication count, the HERDC weighted publications are apportioned by the number of authors. If a strong performance management leads to a dysfunctional effect of listing more co-authors for mutual benefit, the HERDC count would correct this bias.

The effect of management on competitive research grants gives somewhat more positive results. Since competitive grants are to a large extent a zero-sum-game between universities, unlike publications, we will look at the competitive grants of each university as a proportion from the total grants distributed that year. The measure is smoothed over three year periods, to avoid the noise from considerable yearly fluctuations. Research management is positively related to the proportion of competitive grants the university receives, with 0.22 percentage points increase in the university grant share per unit increase in the research management index in the earlier period and an even higher 0.44 percentage points in the later period (Table 7 columns 4 and 5). Since the mean share of

Table 7
The effect of research management on research productivity, 1995–2000 and 2001–2007, FEVD.

	Weighted publications			Competitive grants		
	1995–2000	2001–2007 (A)	2001–2007 (B)	1995–2000	2001–2007 (A)	2001–2007 (B)
Research management index 1995	0.0024 (0.007)	–	0.032** (0.004)	0.217** (0.013)	–	0.327** (0.011)
Research management index 2002+	–	0.021** (0.0038)	0.008** (0.004)	–	0.435** (0.059)	0.301** (0.011)
PhD share	0.018** (0.002)	0.009** (0.0008)	0.009** (0.0008)	−0.006** (0.003)	0.020** (0.002)	0.020** (0.002)
Age	1.6989 (1.605)	0.643 (0.796)	0.643 (0.799)	15.286** (2.960)	−0.623 (2.17)	−0.623 (2.18)
Age-sq	−0.130 (0.126)	−0.054 (0.060)	−0.054 (0.060)	−1.186** (0.233)	0.0245 (0.165)	0.0245 (0.166)
Senior staff	0.025** (0.005)	−0.005** (0.002)	−0.005** (0.002)	0.052** (0.009)	−0.012** (0.005)	−0.012** (0.006)
Student/staff	0.045** (0.005)	0.007** (0.001)	0.007** (0.001)	−0.016** (0.008)	−0.025** (0.004)	−0.025** (0.004)
Teaching only staff	−0.0019 (0.0016)	−0.010** (0.002)	−0.010** (0.002)	−0.003 (0.003)	0.0059 (0.0046)	0.006 (0.005)
Med School	0.395** (0.041)	0.140** (0.022)	0.110** (0.021)	5.927** (0.073)	4.844** (0.059)	4.544** (0.058)
Year dummies:						
+1	0.326	0.107**	0.107**	−0.010	0.013	0.013
+2	0.413	0.206**	0.206**	−0.023	0.032	0.032
+3	0.371	0.215**	0.215**	−0.038	−0.052	−0.052
+4	0.299	0.272**	0.272**	−0.046	−0.012	−0.012
+5	0.288	0.258**	0.258**	−0.079	−0.033	−0.034
+6	–	0.287**	0.288**	–	−0.046	−0.046
Constant	−8.617* (5.076)	−2.702 (2.617)	−2.702 (2.63)	−49.117** (9.351)	1.382 (7.156)	1.382 (7.156)
R^2	0.88	0.86	0.86	0.99	0.99	0.99
N	36 × 6	36 × 7	36 × 7	35 × 6[a]	36 × 7	36 × 7

Note: Dependent variable: HERDC weighted publications per staff (log) and the proportion of total competitive research grants.
** $p < 0.05$. Standard errors in parentheses.
* $p < 0.10$. Standard errors in parentheses.
a Australian National University dropped due to missing data.

Table 8
The effect of research management on productivity growth, from 1995 to 2000, and from 2001 to 2007.

	HERDC weighted publications			Competitive grants		
	1995–2000	2001–2007 (A)	2001–2007 (B)	1995–2000	2001–2007 (A)	2001–2007 (B)
Research management index 1995	0.799 (0.617)	–	0.170 (0.193)	−0.024 (0.033)	–	0.050 (0.050)
Research management index 2002+	–	−0.231 (0.292)	−0.269 (0.280)	–	0.090* (0.056)	0.076 (0.058)
Past productivity level [a]	−13.50** (1.623)	−7.42** (1.03)	−7.969** (1.383)	−0.032 (0.022)	0.009 (0.034)	−0.002 (0.036)
Constant	−0.318 (3.21)	6.27 (2.044)	5.851** (2.22)	0.034 (0.132)	−0.588* (0.331)	−0.642* (0.336)
R^2	0.64	0.56	0.57	0.12	0.10	0.14
N	36[a]	36	36	35[b]	36	36

Note: Dependent variables: average annual growth rate in HERDC weighted publications; change in the proportion of total competitive research grants.
** $p < 0.05$. Standard errors in parentheses.
* $p < 0.10$. Standard errors in parentheses.
a HERDC weighted publications (log) and competitive grants in the first year of the period, respectively.
b Australian National University dropped due to missing data before 1999.

grants per university is 2.8 percent, it is a considerable effect size. Furthermore, the share of competitive grants in the second period is explained by practices measured both in the first and in the second period.

The growth models of competitive grants have a very low explanatory power, *R*-square in the range of 0.10–0.14 (Table 8). The role of management in explaining growth is not strong but the effect seems to be present. In the earlier period we cannot establish a significant relationship, but in the 2001–2007 period an additional point in the management index adds almost a 0.1 percent (0.09) to a change in the funding share. Furthermore, the effect is primarily due to the management system in the second period, even though controlling for management in the earlier period makes the coefficient slip under the critical confidence level. Looking cross periods, the results are strongly influenced by one outlier—by a university that has achieved a major grant improvement with relatively low management intensity. Dropping this outlier, suggests that a change of one point in the management index contributes to a change of 0.045 percentage points in the share of competitive grants. The scatter plot on Fig. 3 presents the results with the outlier

Table 9
The effect of change in research management on change in productivity, from 1998 to 2004.

	The Web of Science publications	HERDC weighted publications	Competitive grants
Δ Research management index	0.393* (0.218)	−0.372 (0.316)	0.045* (0.029)
Past productivity level [c]	−3.121** (1.070)	−12.18 (1.55)	−0.020 (0.020)
Constant	2.91** (0.74)	5.79 (0.22)	−0.215 (0.123)
R^2	0.29	0.72	0.10
N	36	36 [a]	34[b]

Note: Dependent variables: average annual growth rate in the *Web of Science* publications, in the HERDC weighted publications, and change in the proportion of total competitive research grants.
** $p < 0.05$. Standard errors in parentheses.
* $p < 0.10$. Standard errors in parentheses.
a For Australian National University and Charles Sturt University the measurement of 1999 is used instead, due to unrealistic data for 1998.
b ANU dropped due to lack of data. An outlier excluded (see Fig. 2).
c The *Web of Science* publications (log), HERDC weighted publications (log), and competitive grants in the first year of the period, respectively.

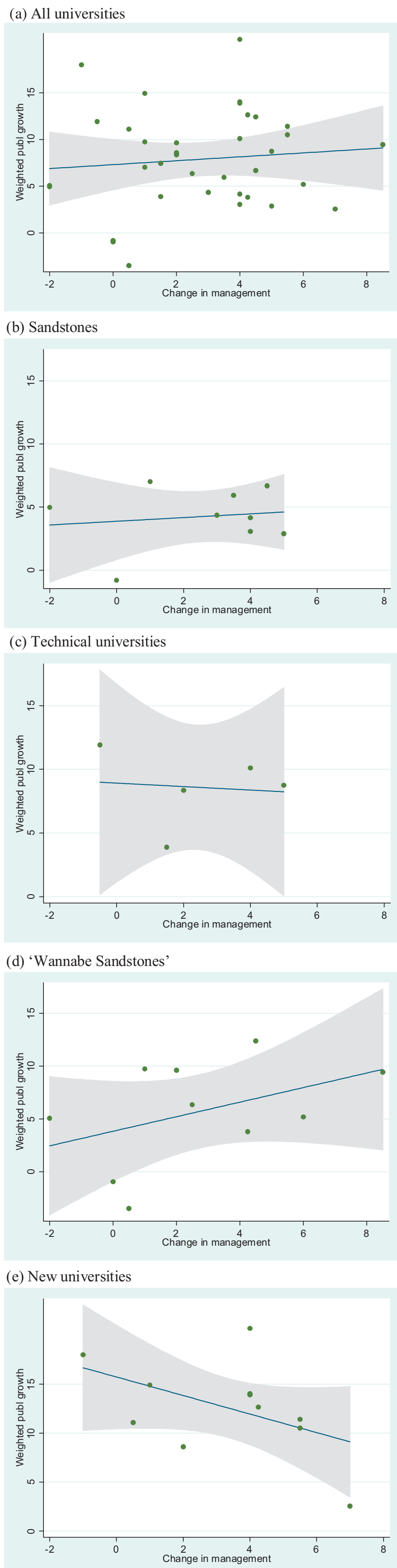

Fig. 2. Association between change in research management and change in research productivity (total weighted publications), 1998–2004 by university type.

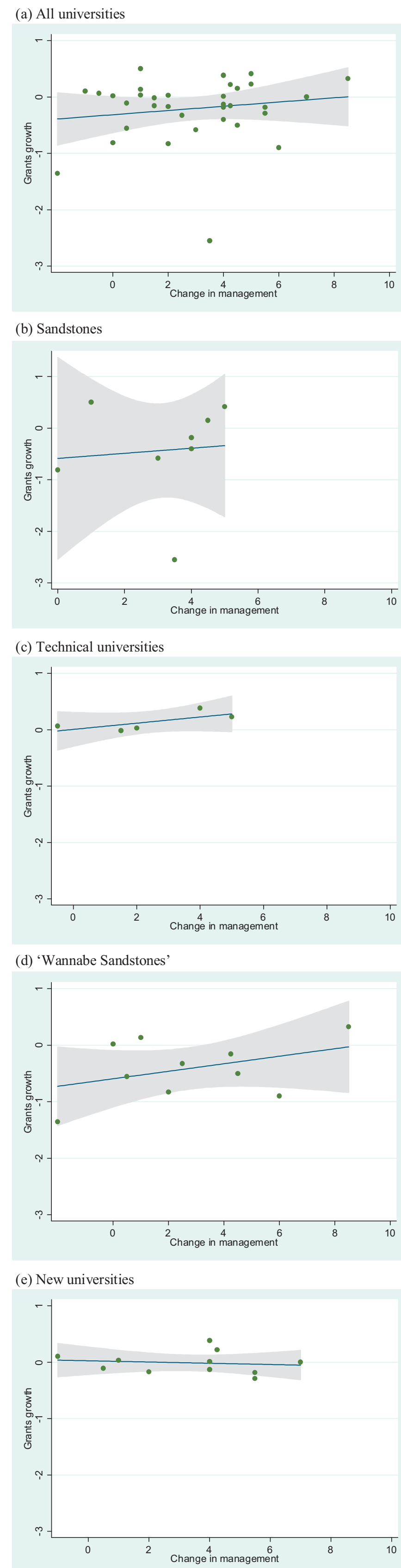

Fig. 3. Association between change in research management and change in research productivity (competitive grants funding), 1998–2004 by university type.

(see Fig. 3b) and we can see again the rather familiar picture that management has a positive association with the growth within all university types with the exception of the new universities.

In sum, research management and research performance are associated, regardless of the choice of the performance measure. There is only one exception to this statement—the total weighted publications in the early period. The association seems to be partly explained by a 'self-selection effect', whereby good universities develop more intensive management, but not only. There is some evidence that universities with more intensive research management improve their performance faster, controlled for their absolute level of performance. This can be said confidently about journal publications cited in *the Web of Science*, with some confidence about competitive funding, and with some serious doubts about total weighted publications. When we look within homogenous universities groups, the association seems to be there, with one exception. Regardless of the choice of a performance measure, the performance growth within new universities is highly varying and unrelated to its internal management. Although we need to be aware of potential problems, such as the self-selection bias and the small sample size, the evidence does seem to indicate that management matters.

6. Discussion and considerations

Several earlier papers have shown convincingly that Australian universities have become significantly more research productive in the last two decades. This study offers some evidence that not only the inputs and overall change in the policy context contribute to productivity but that research management within a university also matters. Research management index, which aggregates institutional, school and individual level practices, shows rather positive results in most specifications. Universities with higher research management index demonstrate higher productivity and with some caution we can also state that their productivity increases faster.

What is the mechanism from management to productivity increase? The management practices considered in this analysis focus on skills and support as well as incentives at the individual and faculty level. The limits of the sample size do not allow us to examine the effect of individual incentives and, furthermore, a university level study does not translate easily into individual level explanations. Yet some general observations are hard to resist. The new management orientation in Australia has not gone without a notice. A recent survey amongst academics indicated that Australian academics (together with the academics in the UK) have the lowest level of satisfaction with institutional management among 18 OECD countries studied (Coates et al., 2009). Particularly junior staff does not feel as involved in institutional decision-making as their senior counterparts, which the authors of the report interpret as a sign of switching from a flat collegial to a more triangular corporate institutional culture (p. 22). Furthermore, Australian academics at the senior level work the longest hours per week. While the issue of increasing workload has received much attention in Australia, comparing the results of a 1992 survey with those from 2007 does not reveal a significant change in the number of hours worked or a shift in reallocating the hours to research.

If it is not time spent on research that explains productivity improvement then there must be another mechanism. On the one hand, academics may have become more outcome-oriented, reallocating their time on preparing publications, and they may be better socialized and supported in these activities. On the other hand, this may also indicate some dysfunctional effects, such as adding coauthors and 'slicing' research results thinly for increasing publication numbers. The difference in results we observed in case of alternative output measures does not give us many insights about such effects. While *the Web of Science* articles might be more vulnerable to fabricated co-authoring and to a lesser extent to 'slicing', total weighted publications might suffer more from slicing, drop in quality and multiple publication of the same results. In this light it is helpful to see that competitive grants, which is arguably the least manipulable measure (even though some authors point to negative effects of competitive funding on epistemic communities, see Whitley et al., 2010), shows some positive link with the management system. More intense research management seems to create an environment that increases research productivity and the signs we receive from the competitive funding suggest that the productivity increase is not, or at least not entirely, due to gaming or at the expense of quality.

We can be easily accused in ecological fallacy—interpreting university level aggregate productivity change as a change in individual behavior. Conceivably, strongly performance oriented universities might reallocate their resources to disciplines that by common bibliometric measures seem more productive, which also coincides with disciplines that seem to attract more competitive research funds. By eyeballing the trends across faculties and disciplines, such trend does not stand out and there is no indication of such a strategy in institutional reports. However, this suggests that a hierarchical (multi-level) study, examining individual departments within universities, would make a valuable further contribution to our knowledge in this field.

Our sample is too small to study the effects of individual policies and an attempt to do so led to a serious multicollinearity problem. Yet one policy stands out—research concentration/profiling. It seems another dimension in the research management system, relatively independent from other management practices. The issue of profiling is on the policy agenda not only in Australia but also in the Netherlands and several other countries. The effect of such a policy requires further empirical analysis and the results could be helpful in informing the discussions.

Furthermore, different types of universities may conceivably react differently to management practices. Our sample has been again too small to analyze systematically a potential heterogeneity in such effects. The scatterplots (Figs. 1–3) show rather consistently that the slope is the steepest in the case of so-called Wannabe Sandstones, i.e. for these universities the management makes the biggest difference. These are aspiring research universities, trying to upgrade their research profile; they have a research base but they have probably more room for improvement than the top-league 'Sandstones'. The result that for these universities management matters the most seems quite meaningful. Technical universities and research-heavy Sandstones might be less dynamic to respond to the changes. New universities is an interesting group in this study—the only group that shows no positive association with the management. We can hypothesize that (a) research management is effective if applied on an existing research culture, but not to build up such a culture; or in a softer phrasing, (b) building up a research culture is dependent on many other factors that may hide the rather subtle effects of research management, and (c) being established primarily for educational expansion purposes, research improvement may be less of a priority in these universities (even though the management practices are put in place) next to other competing tasks.

The study has several weaknesses that need to be kept in mind when interpreting the results. First of all, the sample is quite small which in some parts has forced us to rely on soft data presentation than on rigorous statistical analysis. Furthermore, the nature of the study period creates some technical data problems. The 1990s was a turbulent era on the Australian higher education landscape and everything was in change—national policies, institutional governance and practices, the structure of the system, employee relationships, etc. Since everything changes at the same time and all the changes are interrelated then it is often difficult to sort out what affects what and what changes are only coincidental. Most of the changes have been only in one direction—the number of publications increased, staff qualifications improved, and student numbers went up. More recent years may therefore be able to give us more precise results about the true effect of management.

Secondly, a potential bias comes from the fact that universities may have different governance structures. We focus only on one set of management practices—the practices regulated at the university level. Some universities may have chosen a different strategy and delegate the decision-making on research management to the faculty and school level. As an illustration, one university in our study keeps all research funding at the institutional level and allocates the funds directly to individuals and research groups as competitive grants and other support mechanisms, while another university allocates research funding to faculties who then handle most of the financial support (like research startups, support for preparing grant applications, etc). This choice may be partly explained by the size of the university, but it may also be a deliberately chosen strategy. In this study we examined practices that are initiated at the university level (i.e. reported in institutional level audit reports), but if university level and faculty level practices are supplements to each other, the results may be somewhat biased. The issue is probably not very severe. In many occasions universities delegate the implementation of some practices to schools (like staff appraisal), but since it is required at the central level, it is still considered an institutional level policy in this study. The problem may occur to a limited extent only to the practices that target individual academics, but not the other instruments (such as performance-based funding, faculty reviews, although benchmarking could be conceivably implemented at a school level). This is another reason to recommend a follow-up study with a multi-level approach.

Thirdly, we have only scarcely touched the issue of whether the productivity growth is a 'true' improvement or rather a result of an effective gaming of the performance system ('slicing', repeated publications, fictitious co-authors, etc). While this is a legitimate concern it does not reject our conclusion that management matters. Hopefully it is made to matter for more and better research, but when inappropriately used it may also stimulate negative effects.

In spite of the limitations the study provided some evidence that research management seems to have measurable effects, and it hopes to contribute to the discussion about effective research management in universities. Furthermore, a new round of institutional audits in Australia is now being completed, which offers an opportunity to test the conclusions further and add more nuance in future research.

Acknowledgments

For valuable discussions and comments on earlier versions of this paper I would like to thank David Dill, Ashu Handa, Douglas Lauen, Michael Luger, and Aldo Geuna. The paper has been presented at the BRICK-DIME (15 July 2008 in Torino), EAIR (24 August 2009 in Vilnius) and EGPA (4 September 2009 in Malta) conferences. I am grateful to two anonymous reviewers for their insightful and constructive feedback.

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