THE EFFECT OF MARKET-BASED POLICIES ON ACADEMIC RESEARCH PERFORMANCE: EVIDENCE FROM AUSTRALIA 1992-2004

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ABSTRACT

Maarja Soo: The effect of market-based policies on academic research performance:
evidence from Australia 1992-2004
(under the direction of David D. Dill)

As many other advanced countries, Australia has substantially reformed its research policies in the last two decades. In order to encourage efficiency and performance in the higher education sector, the Australian government has introduced various policy instruments that stimulate competition and establish market incentives in the sector. The effect of such market-based policy instruments on research performance is the subject of this dissertation. The dissertation focuses on three interrelated questions.

The first empirical analysis examines the effect of market-based policies on the structure of the academic research market. A theory that higher education is a winner-take-all market has triggered a concern that market mechanisms may lead to the concentration and stratification of the higher education market. The analysis develops a convergence model for the Australian research market and observes that the gap in research performance between universities declines over time. Furthermore, the new policy incentives have encouraged universities not only to improve their research inputs but also to maximize the productivity of these inputs.

As a response to government research policies, universities have developed various research management practices in order to improve research performance. The second analysis examines the effect of seven management practices on institutional research performance over time. The results indicate that research management practices indeed have a positive effect on research performance. The most consistent effect is demonstrated by practices that target individual schools and faculties.

The third part uses the Data Envelopment Analysis in order to examine the productivity and efficiency change in the sector more broadly.

The dissertation concludes that market-based policies have had a considerable effect on Australian universities. Universities all across the sector improved their research performance, even though the invigorating effect of the market-mechanisms seems to fade over time. The government policies have also encouraged universities to implement internal research management practices and the effect of these practices outlives the immediate post-reform responses. Although the market-based policies may also have unintended effects, the reform in Australia seems to have achieved its primary goal: to provide incentives for productivity improvement in the higher education sector.

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LIST OF ABBREVIATIONS

ANU	Australian National University
ARC	Australian Research Council
ASSDA	Australian Social Science Data Archive
AUQA	Australian Universities Quality Agency
AVCC	Australian Vice-Chancellors' Committee
CAE	College of Advanced Education
CRC	Cooperative Research Center
CRS	Constant returns to scale
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEA	Data Envelopment Analysis
DEETYA	Department of Employment, Education, Training and Youth Affairs
DEST	Department of Education, Science and Training
EU	European Union
FE	Fixed effects
FEVD	Fixed Effects Vector Decomposition
FTE	Full-time equivalent
HECS	Higher Education Contribution Scheme
HRM	Human Research Management
IGS	Institutional Grants Scheme
ISI	Institute for Scientific Information
NHMRC	National Health and Medical Research Council
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares

R&D	Research and Development
RE	Random effects
RIBG	Research Infrastructure Block Grants Scheme
RMI	Research Management Index
RQ	Research Quantum
RQF	Research Quality Framework
RRTMP	Research and Research Training Management Plan
UK	United Kingdom
VRS	Variable returns to scale

CHAPTER ONE

INTRODUCTION

Introduction to the study

Only in the last two or three decades has academic research policy become one of the main issues of policy agenda in all advanced economies. Traditionally, research tended to be outside of governments' direct interest and active steering, unless perhaps related to national defense, however, new expectations from the 'knowledge based economy' have put the sector in the forefront. Knowledge is now widely recognized as the "engine of economic growth and social development" (OECD 1996, World Bank 2000, World Bank 2002). Research capacity, i.e. capacity to generate new knowledge and to transfer that knowledge to the economy, is perceived as vital capital for a country. Therefore most national governments as well as some supranational entities now develop strategies to actively advance this capacity. In the European Union the emphasis on knowledge for economic success is clearly presented in the Lisbon Strategy (European Commission 2000), which sets a goal to make the EU "the most competitive and dynamic knowledge-driven economy by 2010". This strategy has significant effects on national policies related to innovation, science and research in all European countries. In Australia, *Backing Australia's Ability,* a major policy package produced by the government in 2001, was inspired by the "recognition that success in the 21st century will depend predominantly on the innovative capacity of nations, their industries and their research and educational structures" and that "more needs to be done in response to an increasingly competitive world environment" (Howard 2001).

The new emphasis on research and development has affected academic research in many ways. The traditional notion of research has been replaced by the "Mode 2" research that is oriented towards application and crosses disciplinary boundaries (Gibbons 1994). Knowledge production is also now seen as cooperation between various actors, most importantly a "triple helix" of universities, industry and government (Etzkowitz and Leydesdorff 1997). Universities face a pressure to engage in research relevant to industry, form industry-university partnerships, and commercialize their research outcomes. Not only has the nature of academic research changed over the years, but also government policy approaches to funding university research have significantly altered during this time. Universities as main knowledge producers have been raised to public scrutiny and made publicly accountable for their activities. Concerns over the increasing costs of research in universities and the "value for money" have been raised in many countries in the last two decades (Noll 1998, OECD 1987).

The funding system of public research has been significantly reformed in many European countries and Australia in the 1990s. The traditional dual model of research funding – a combination of general institutional funding and targeted research funding (grants and contracts) – has been replaced by a more dynamic, market-based mechanism. The United Kingdom and Australia are two early examples of countries that introduced a "commercial" approach to government allocation of funding. Universities were not seen any longer as public institutions funded by the government, but instead the government became the "buyer" of academic services (Geuna and Martin 2003). As a result of this change, a higher proportion of research funding was distributed in the form of research grants and contracts, at the expense of institutional block grants, and the government started to monitor overall research performance in the institution and link performance to resource allocation. The government policy has thus created a research market where universities compete with each other for financial resources and are forced to demonstrate performance results for their survival. These trends significantly transform the environment and incentive structure for universities: universities must seek external funding, be responsive to economic and societal demands, and be profit-minded in their management.

While the UK and Australia have been the earliest and most pronounced in their reforms, these developments are now rapidly diffusing. In the last two decades governments in many countries have implemented performance indicators to monitor academic research activities, established regular research evaluations, and conducted audit reviews (OECD 1997). Governments have also started to use active policy instruments to maximize research productivity, such as performance-based funding schemes. In most countries, the share of institutional grants has declined and the share of direct government funds to contracts and research projects has increased (Geuna 2001).

The expectations of the change have been manifold: to strengthen the accountability for public funds; to provide incentives for universities to foster government objectives (e.g. quality, concentration, cost-efficiency), and to encourage universities to attract more funding from external sources. The aim of this dissertation is to analyze empirically the effect of such market-based research policies on actual research performance. The dissertation focuses entirely on public academic research, i.e. on research that is conducted in universities. While the attention of recent policy discussions tends to be dominated by the commercialization value of research, effective policies towards (basic) academic research are equally important. Academic research is a critical input to industrial R&D and the various outputs of public research, such as published papers and reports, and public conferences and informal information exchanges, have contributed directly to starting new, and finishing existing, industrial R&D projects (Cohen et al 2002). The effectiveness of academic research policy is thus also important for the commercialization goal. Public policies that overemphasize knowledge commercialization, university-industry partnerships and "usefulness" of research my even harm the overall goal they are trying to achieve. Dosi et al (2005) examine the "European paradox" – that research results are not effectively converted into wealth-generating innovations – and conclude that the primary source of the problem is not university-industry cooperation but the quality of (academic) research (together with the industrial structure of European economies). The EU policy in this area that attempts to overcome the problem by encouraging university-industry cooperation and "useful" research, at the expense of basic research, is in this light strongly misplaced.

This analysis hopes to contribute to the theoretical understanding of how market-based policy instruments work in the academic research sector as well as provide advice on effective research policies for the future.

Motivation and policy relevance

This study is motivated by its potential policy relevance as well as its theoretical contribution. From a practical perspective, solid evidence about the effect of market-based policies on the higher education sector would contribute to informed policy making. The market-based policies are not only increasingly copied and adopted in advanced countries but also recommended to less developed countries (e.g. de Ferranti et al 2003). Literature describing such policies and their effect on university governance structures and internal research management practices is rapidly growing (Connell 2004, Marginson and Considine 2000). Yet empirical evidence of the effect of such policies on actual research performance is scarce. There is a lot of evidence from other sectors, both private and public, that management practices are often overenthusiastically adopted due to fad and fashion, or ideology and belief (Staw and Epstein 2000). Birnbaum's (2000) specific analysis of academic management fads in the US context demonstrates that universities are equally susceptible to new management practices considered more modern and efficient, even though their actual effect on outcomes may be questionable. In light of recent calls for "evidence-based management" and "evidence-based policy" (Pfeffer and Sutton 2006, Heinrich 2007), empirical evidence of the effect of research policies on research performance is much needed. This study hopes to contribute to this body of evidence. The policies have been in place now for more than a decade and some insights on the short-term and long-terms effects could be developed. Better knowledge about the impact of the policies may suggest new ideas for improved research policies, advise policy makers who plan to implement market-based instruments in academic research policies, and hopefully lead to more informed policies in the future.

At the theoretical level, the effect of market-based incentives is an interesting study object because of the nature of academic organizations. The reforms have had a significant impact on the entire higher education system in many countries, the United Kingdom and Australia among them. The effect of these policies is not necessarily self-evident from a theoretical perspective. Universities embody most of the organizational characteristics that are associated with the failure of external incentives: multiple goals and principals, strongly developed professional values, long term career concerns, and difficulties with measuring outcomes (Dixit 2002). Moreover, academic organizations have a peculiar organizational structure. Universities are known to be “organized anarchies” (Cohen and March 1974) and “loosely coupled systems” (Weick 1976). In such an organization individual units in the organization preserve their own independence and separateness, which can function as an effective buffer to any reforms in the organization. The incentives for the institution as a whole or practices implemented at the central administration level of the organization may easily remain unattached to the technical core (i.e. education and research units) in the organization. Yet the basic academic units constitute the level where professional values are to a large extent shaped and transmitted (Trow 1976; Becher and Trowler 2001), and this most directly influences the behavior of individual academics. Birnbaum (2000:137), studying management fads in American universities, also hypothesizes that it is possible to “publicly” adopt management practices in universities without actually affecting the technical core because of the dual authority structure of administrators and academics. Indeed, not all higher education systems have proven as responsive to performance-based reforms in higher education. Many states in the US have implemented performance-based funding or budgeting mechanisms, but with questionable success. While extensive research by Joseph Burke has indicated only a very limited impact of performance-based funding in the US context (Burke and Minassians 2002), initiatives in Europe and Australia seem to have demonstrated a more substantial impact. An effective policy must thus overcome two "principal-agent" hurdles in the higher education sector: first, it must create incentives that make universities behave in the best public interest, and secondly, it must ensure that the incentives will be transmitted from the central administration at a university down to academic units.

This study explores the effect of market-based research policies in the empirical framework of Australia. Australia serves as a good example for several reasons. Australia is well known for its clear-cut reforms in the sector. The key characteristics of their reforms are quite similar to developments elsewhere: increased financial contribution from students, enhanced national and international competition both for students and for research income, greater accountability of government funding, greater deregulation within the higher education sector, and diversification of the funding base (Wood and Meek 2002). Higher education reforms in Australia have been highly visible in Australia as well as in the international higher education community. Moreover, Australia started with reforms relatively early, at the end of 1980s, which provides a sufficient time trend to observe actual changes. Compared to other countries, public fiscal support for the universities fell relatively rapidly in Australia throughout the reform period (Marginson and Considine 2000). Conclusions from Australia cannot be generalized for other higher education systems without further reflection and adjustments. However, considering the similar nature of academic organizations, the conclusions about general effects and time trends in Australia provide important insights not only for Australian research policy but also for other higher education systems. Exploring the impact of market-based policy instruments in Australia will contribute to the empirical evidence-base that could be useful in designing more effective market-based instruments in other countries.

Research objectives

While the reforms are triggered by the belief that financial performance incentives and competition between universities contribute to performance, efficiency and productivity in academic research, the evidence needed to reject or support this claim is scarce. This study seeks an answer to three interrelated questions:

i. Do market-based research policies lead to unequally distributed research performance and exacerbate the gap between research-intensive and less research-oriented universities?
ii. Do internal research management practices, which universities develop as a response to the market-based government policies, have an effect on research performance in the university, regardless of the peculiar characteristics of an academic organization?
iii. Can we conclude that market-based research policies increase overall market performance of the higher education system and that actual productivity of the system has improved?

The same issue inspires each question: does the competitive research environment lead to better research performance? Performance is analyzed at two levels, the organizational level (i.e. universities) and the market level (i.e. academic research system). At the organizational level we will explore whether the new incentives make an organization adjust its internal policies in an effective way. At the market level we will see how the policy affects the structure of the research market and whether it leads to the better performance of the entire market. These three questions are approached in a larger context of the structure-conduct-performance framework. The first question addresses the issue of whether competitive research environment affects the structure of the higher education market; the second question examines the conduct of universities in a changed environment, and the third question analyzes the overall performance of the system.

Structure of the dissertation

The three research questions are studied respectively in three empirical chapters. Chapter 4 explores the extent to which market-based research policy leads to research concentration and stratification between universities, or, on the contrary, potentially leads towards higher diffusion of research activities across the sector. The argument is developed based on a theoretical discussion of winner-take-all markets. Chapter 5 analyzes internal research management practices in universities and explores their effectiveness with respect to research performance. Chapter 6 takes a bigger perspective and examines whether the policy reform has helped the higher education sector to perform better; i.e. whether more research and educational outputs are produced with given inputs. Chapter 7 summarizes and synthesizes the results of the empirical papers.

The conceptual framework in Chapter 2 presents the general perspective that is a foundation for all three studies and that connects the studies. In this perspective universities are seen as economic agents and changes in the research market are approached from the viewpoint of industrial economics. The chapter also reviews existing literature on the determinants of research performance, which serves as a basis for developing models and identifying control variables in later chapters. Chapter 3 discusses issues related to measuring research performance and describes the nature and sources of the data that are used for the empirical analyses.

The next section provides an overview of the main changes in Australian research policy that have reshaped research environments for Australian universities and presents a general picture of market-based reforms in the Australian research system.

Institutional background of the Australian research system

Australia currently has 37 public universities, two private universities (Bond University and Notre Dame University) and a few specialized private and public institutions. The higher education sector is the dominant performer in basic and applied research in Australia. In 2004-5, 62 per cent of basic research in Australia was performed in universities, 17 per cent in the federal government sector (which is mostly the Commonwealth Scientific and Industrial Research Organization – CSIRO), almost 10 per cent by industry, and the remaining 10 per cent by state governments and private non-profit organizations (DEST 2006). This dissertation focuses only on academic research, i.e. research conducted in the higher education sector.

Responsibilities for the higher education sector are divided between the Commonwealth government at the federal level and eight states and territories at the local level. According to the constitution, education is one of the sectors over which states have legal authority. Consequently higher education institutions are within the jurisdiction of the states, but financial responsibility for the sector lies with the Commonwealth. The division of authority between the two levels has fluctuated over time and occasionally caused some tension. The role of the Commonwealth government increased considerably in the middle of the 1970s when the government abolished tuition fees and accepted full responsibility for providing capital funds to universities (Meek 2002). This meant that the Commonwealth government was responsible for almost all financial resources of universities. With this step the Commonwealth government became the main player in regulating the higher education sector. Although states still own universities' land and capital assets, regulate the use of degree and university titles, and until recently accredited university courses, it is mostly the Commonwealth policies that shape the fundamental direction of the higher education sector (Meek 2003). In very recent years, the ministers of education have proposed to take full financial and legislative control over the higher education sector.

Academic research policy: towards competition and performance

The Australian higher education sector has experienced several substantial policy changes since World War II[1], but reforms that triggered the current processes started at the end of the 1980s. As in most other countries, the higher education sector started to expand rapidly in the mid-1980s, which imposed additional burdens on public funds. Increasing costs in higher education brought up questions about the efficiency and effectiveness of the system (see Meek 2002). But reforms were not driven only by external factors. The ideas of New Public Management had made a strong entrance into the Australian public sector (Kettl 2000) and these ideas also diffused into the higher education sector (Harman 2001a). As elsewhere in the public sector, a call was made for greater efficiency and accountability, and the assumption that competition is the primary guarantee of quality, productivity, and 'customer' satisfaction was also introduced into higher education. The changes affected equally the education side and the research side in universities. While the reforms went through different cycles, the general direction of the reforms is towards increased competition between universities, i.e. competition for financial resources, for students, for prestige, and eventually for research talent.

Market reforms started in 1987/88 when John Dawkins, the Minister for Employment, Education and Training in the labor government issued the Green Paper (*Higher Education: a policy discussion paper)* and White Paper (*Higher Education: policy statement).* These plans introduced several major changes to the structure and management of the sector. The higher education sector in that time consisted of two types of institutions: *Universities* and vocationally oriented *Colleges of Advanced Education (CAE).* The reform of 1987/88 replaced the binary system with a unified system. After a series of amalgamations of old institutions and establishment of new institutions, by 1994 the sector consisted of 36 universities instead of the

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[1] See Marginson and Considine (2000) for an excellent summary on these changes.

[2] Davies et al (2005) give an excellent overview of different theoretical perspectives on studying the topic of incentives and performance in the case of health care system, very similar to that of higher

more than 70 higher education institutions of earlier times. Unlike previously, all higher institutions were now expected to be research active and all universities, both new and old, were expected to contribute more to economic growth.

The 1988 reform also directly addressed research management issues. The White paper suggested that greater competition and selectivity in research were needed if funding were to be fully effective. The goals of competition and selectivity were achieved with several policy instruments. Some of the institutional research funding was reallocated to the Australian Research Council (ARC) for competitive grant allocations. This included two grant schemes: ARC Large Grant scheme was a competitive research grant scheme and ARC Small Grant scheme allocated money to universities based on their success with Large Grants.

Elements of competition were also introduced to institutional research funding. In 1990 the government introduced a plan whereby 6 per cent of the total operating grant to universities was distributed based on research performance, while the rest was allocated on the basis of student load. The performance-based component – *Research Quantum* – was expected to function as "the general "fabric" which underpins the research base; it should support and develop the general research capacity of an institution" (in Harman 2000:117). *Research Quantum* was derived from a *Composite Index,* the components of which varied somewhat in the first years, but stabilized according to the following proportions: 80 per cent of the Quantum is dependent on success in attracting external funding, most importantly competitive research grants from the Australian Research Council; 10 per cent comes from publications count, and 10 per cent from successfully completed advanced degrees. The Research Quantum constitutes only between 1 and 10 per cent of universities' total operating budget but it has a strong effect in conveying the message of research performance and competition. In addition, *Research Infrastructure Block Grants* (RIBG) serves as additional funding meant to support research that was allocated to universities based on their success with attracting external funding.

Besides the changes that linked research funding with research performance, the government encouraged strategic planning in research management and also promoted competitive practices at the institutional level. Universities were required to design research management plans and specify principles as to how internal research funding would be competitively allocated to academic staff. Management in higher education institutions was directly a part of government reforms from early on. The 1988 policy statement by Minister Dawkins addressed the issues of institutional management, pointing out that "while the Commonwealth has no role in dictating management structures to institutions … it will assist institutions in undertaking reviews of their internal management structures" and among other goals "help institutions to achieve strong managerial modes of operations" (Dawkins 1987:103).

The reforms in the higher education sector did not end with the 1987-88 cycle. Competition for resources was further sharpened with a new coalition government in 1996. The government intended to cut costs in the higher education sector. As a result operating grants to universities were reduced by 5 per cent over the next three years and no financial supplements were to be allocated for academic salary increases. This put universities under serious budget constraints; it made government resources even more valuable and made universities search more actively for external funding sources.

The year 1999 introduced another step in making the research environment more competitive. The new liberal coalition government issued the discussion paper *New Knowledge, New Opportunities* and subsequent policy statement *Knowledge and Innovation,* which suggested further steps toward make funding for research and research training more competitive. The Australian Research Council (ARC) was significantly reformed and gained independence and authority for distributing research funding. The ARC subsumed almost all the public research funding, including funding for doctoral education, and led to what has been called the "fully performance-based funding approach in research and research training" (Meek and Hayden 2005). Research student places were from now on also distributed based on performance.

Funding for research training is based on a formula that consists of the number of research students completing their degree (50 per cent), research income (40 per cent) and a publications measure (10 per cent). Universities were now also required to submit Research and Research Training Management Plans (RRTMP) to the DEST and thereby report annually on their research activities, research strengths, graduate outcomes and other aspects of their research activities. As a result of the policy changes, not only has the funding formula changed but institutions have been forced to revise their internal practices by identifying research priorities, concentrating on certain research areas, and developing a set of performance indicators and information systems (Wood and Meek 2002).

Research funding is channeled to universities now via two main streams. The Institutional Grants Scheme (IGS) supports the general research and research training activities and combines the former RQ and ARC Small Grant funding. Its allocation principles are similar to the former RQ scheme: success in attracting research funding (60 per cent), success in attracting research students (30 per cent) and quality and output of research publications (10 per cent). The second stream of funding is channeled to universities via ARC competitive grants. While these schemes constitute the great majority of research funding, there are also some other sources. The Government has recognized that not all universities are capable of competing for research funding on equal ground and established a Regional Protection Fund. The share of this funding source is however a marginal 0.1 per cent of total research funding (AVCC *University Funding and Expenditure*). Although research is primarily funded and steered at the federal level, states have become more involved in recent years. Many individual states have developed and implemented innovation strategies that usually also include a reference to university research. *Innovation – Queensland's Future*, for example, encourages university-industry cooperation in Queensland and *BioFirst* is a five year strategy for creating a cluster of excellence in biotechnology in New South Wales. Similar initiatives have been created by many other states.

Empirical analysis in this dissertation ends with the year 2003, but reforms in research policy continue and many new developments are currently taking place. In 2004, within the framework of the *Backing Australia's Ability* document, the Australian government proposed a new *Research Quality Framework (RQF).* This framework is designed after the UK Research Assessment Exercise, which is based on regular peer evaluation of individual subjects in universities. The RQF aims to measure more accurately the quality and impact of publicly funded research. While promoting universities to define the areas of concentration, the government has defined its own, national research priorities. In early 2002, government allocated a large proportion (33 per cent) of ARC funding to the priority fields: nano- and biomaterials, genome/phenome research, complex/intelligent systems, and photon science and technology. In May 2002 a review of national research priorities for publicly funded research was undertaken and identified broader priority areas for Australian research, such as environmentally sustainable Australia, promoting and maintaining good health, frontier technologies for building and transforming Australian industries, and safeguarding Australia.

There is a whole range of additional policies and instruments to strengthen university-industry cooperation and knowledge commercialization. For example, *The Chance to Change* proposes various changes to increase scientific capacity in Australia and encourage commercialization; *Backing Australia's Ability* encourages commercialization and research in industry; and the Cooperative Research Center (CRC) scheme supports university-industry partnerships. This dissertation focuses on academic research broadly and across disciplines - the policies that narrowly target knowledge commercialization are beyond the scope of this study.

Although this study focuses on research performance, rather than on higher education, research and education are deeply interlinked in universities, and major reforms related to education are likely to also affect research. Most importantly, student fees have become an important revenue source for universities. The 1987/88 reforms introduced a tuition fee for all students, known as the Higher Education Contribution Scheme (HECS). The HECS initiative also enabled universities to enroll fee-paying overseas students, which became an important income for universities and initiated a strong competition for international students. Increase in international student enrollment has been remarkable over the last years and exceeded 25 per cent of all students in 2005 (DEST 2007:3.1.10). In 1994 the option of fee-paying enrollment was expanded also to domestic students, but only to a limited extent. In 1998, the restrictions were further relaxed and universities were allowed to enroll up to 25 per cent of domestic undergraduate students on a full fee-paying basis. In fact, less than one per cent of domestic undergraduate students used the option of fee-paying enrollment (Meek and Hayden 2005). With the new millennium the process continued in a similar direction: student contribution in the HECS scheme was increased and the restriction on the number of full-fee paying students was relaxed.

Fee-paying students have become an important revenue source for universities. As a result, universities are actively engaged in attracting international students and marketing their institution. Competition for students also affects research activities in the university. University ranking is one point where competition for students and research activities intersect. International university rankings are a highly visible and relevant information source for international students when choosing a university (Marginson 2007). Such rankings, e.g. Shanghai Jiao Tong or Times Higher university ranking, are driven by research performance measures. Research reputation is thus an important capital in Australian universities as a mean to be competitive in the student market and consequently to ensure necessary financial resources.

The Australian higher education sector has gone through a wave of policy reforms and changes over the last two decades. These reforms have been cumulative and have pushed Australian universities consistently towards a competitive environment. The "market-based higher education reforms" in the title of the dissertation refers to the aggregate set of policies that have created an environment where universities must compete with each other for a large part of their financial resources: they must compete for individual research grants, institutional research allocation, external funding, and fee-paying students. The term "performance-based funding" is a more commonly used term in the higher education literature and refers to many similar processes (Herbst 2007, Massy 2003, Jongbloed and Vossensteyn 2001, Orr et al 2007). The difference between "performance-based" and "market-based" government reforms is in the accent and the scope of the reform. Performance-based funding refers to a resource allocation mechanism that funds universities based on their achievements, rather than on last year's budget, negotiations and contracts, or inputs. This practice is associated with performance measurement, performance indicators, and formula based funding. There are performance-based funding elements in the Australian higher education system. The 1988 White Paper directly expressed the intention to introduce a funding system that "responds to performance" and "takes into account a range of output, quality and performance measures". Performance-based funding elements in the Australian context include, for example, Research Quantum funding or funds that were linked to the Quality Assurance exercises in 1993-1995 (Anderson et al 1997). The goal of such funding systems is usually accountability, efficiency and performance improvement. Competition between universities can be a result of performance based funding, as Orr et al (2007) argue in the context of Germany, but it is usually not the primary goal of performance-based funding. The "market-based reforms" are a broader set of policies. The term attempts to cover all the policies and initiatives that directly trigger but also indirectly intensify competition between universities. It includes performance-based research funding, reorientation towards competitive research grants, quality assessment exercises, budget cuts that pressed universities to seek external funding sources and intensified competition for fee-paying domestic and international students.

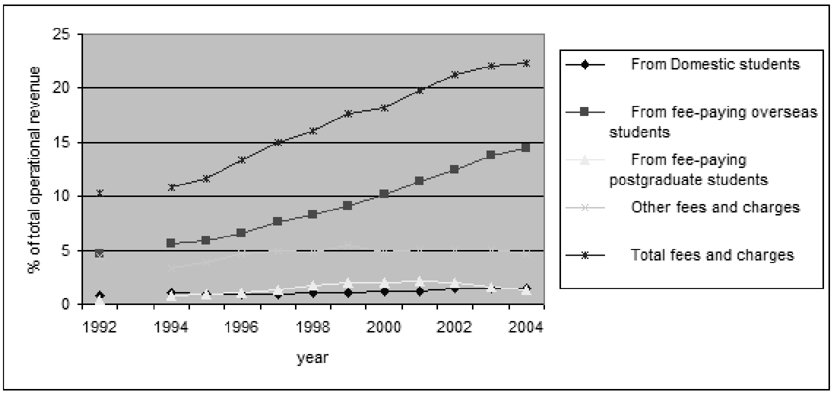
The purpose of this dissertation is to test whether Australian policies in the last two decades have been able to create an incentive structure that indeed improves and maximizes research performance.

Changes in the academic research system: funds and performance

The change towards competition for financial resources, both in teaching and research, has unfolded gradually since the end of 1980s. While the last section described policy change over the 1992-2004 period, this section points out main trends in research funding and research performance over the period.

Universities now face a more diverse funding system than in the beginning of the 1990s. Commonwealth government grants, HECS, fees and charges, investment income, state government allocations, and donations and bequests are the main revenue sources in universities. In the last two decades the share of Government grants has declined, mostly as the share of fees and charges has increased. Student fees, especially international student fees, constitute now a significant part of universities' budgets (see Figure 1.1). The private income sources have thus become considerably more important funding sources. Universities have become dependent on private markets, fee-paying students and contract research, in order to secure their financial resources.

Figure 1.1. A contribution from domestic students, international students, and other services to universities' total operational revenue, 1992-2004.



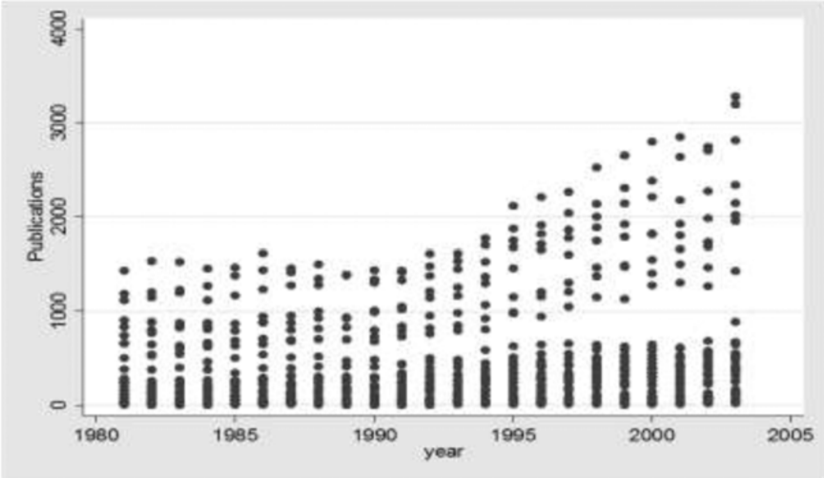
Data source: Finance (1992-2004): Selected Higher Education Statistics, DEST.

Also research funding has become more diverse over time. The public sector is still the main provider for academic research. In 2004, 44 per cent of universities' research budgets came from national competitive grants, 18 per cent from other public sector funding sources, 31 per cent from private sources (including contract research, donations etc), and 8 per cent from funds to Cooperative Research Centers (CRC), a form of university-industry partnerships (DEST *Finance Collection*). These shares exclude the money that government pays for staff salaries, which cover teaching time but also some research time. This would increase the government share in research expenditure.

Most government research funding is now allocated based on some performance or competitive measure. Table 1-1illustrates the distribution of Commonwealth research funding. The biggest proportion is distributed through ARC and NHMRC on a competitive basis. The Research Training Scheme and Institutional Grants Scheme and RIBG are based on research performance. The regional protection program and some other programs are based on criteria other than research performance.

The effect of the pressure to perform can be noticed also in performance outcomes. Over the last decade the number of publications has consistently increased in Australia. The fact that policy reforms have had at least some effect on research behavior can be illustrated with a simple scatter plot of published articles. Figure 1.2 presents the total number of publications for each university over the 1980-2005 period as listed in the Thomson-ISI (*Institute for Scientific Information)* database. The results show no statistically significant change in publication activity from 1981 until 1991 but a considerable increase in publication numbers over the 1991-2004 period. This result suggests that the reforms that started at the end of 1980s had an effect on research performance. Moreover, this trend does not characterize other research organizations, such as CSIRO, government agencies, and hospitals (Butler 2001). The trend is thus unique to universities and cannot be assigned to some factor common to research environment more generally.

Figure 1.2. ISI total publication count for each Australian university, 1981-2004



Data source: ISI database. Note: Data for colleges and universities that later merged are treated together, based on the AVCC guidelines (see AVCC 2004).

Australia performs quite well when compared to other countries. In the early 1990s there was quite a concern about Australian research performance. The 1993 report *A Crisis for Australian Science?* revealed that the Australian share in total world publications (and especially citations) declined during the 1980s (Butler 2001). Since the 1990s the share of publications (and citations) has risen consistently. This trend is also characteristic of many other OECD countries, and occurs primarily at the expense of the share of the publications by US academics, yet the trend in Australia is steeper than in other countries.

Butler (2001) examines thoroughly Australian research performance in comparison to other countries. Her analysis shows that the Australian share of world citations is somewhat lower (2.0 per cent) than the share of publications (2.2 per cent). This result raises a concern that perhaps the increase in publication numbers has happened at the expense of their impact (Butler 2001: 12). Detailed citation analysis shows that Australian academics publish in lower impact journals. Yet in absolute terms the number of citations has kept pace with publication numbers.

There are some concerns that the publication numbers may be inflated and do not reflect changes in actual research performance. First, as mentioned above, the higher number of publications may be achieved by lowering the quality of the publications. Second, the importance of publishing in ISI-cited journals may be higher in the 1990s due to evaluation policies. The DEST collects information on and rewards universities for all types of publications: all refereed journals, book chapters, conference proceedings, etc. The status of ISI cited publications is however easier to establish and makes it a more attractive publication (Butler 2003). The increase in publication numbers may thus not be attributable to more research but to changed publishing preferences. The increase in the number of articles has been indeed most consistent over the years, compared to books, book chapters, conference papers and other publication forms (see Abbott and Doucouliagos 2004), indicating that preferences in terms of where to publish research results may indeed be shifting in Australia.

The issue of measuring research output and limitations of bibliometric measures in th context of this study will be discussed in greater detail in Chapter 3. The next chapter attempts to establish a conceptual link between market-based research policies and research performance in universities.

TABLES

Table 1-1 Commonwealth research funding to universities according to scheme, 2004

Funding scheme	($'m)	%
Research Training Scheme	541	32,2
Institutional Grants Scheme	285	16,9
Research Infrastructure Block Grants	160	9.5
Regional Protection Scheme	6	0.4
ARC & NHMRC Grants	619	36,8
Other Research Programs	66	3.9
Total Research Funding	1,677	100

Source: AVCC.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

General conceptual framework

The response of (semi-)public organizations to the incentives of a competitive environment is a multi-faceted issue that can be effectively analyzed from different theoretical perspectives: the perspectives of governance, economics, organizational studies, public management, organizational psychology, etc.[2] This dissertation approaches universities from an economic point of view. Universities are often seen as "organized anarchies" (Cohen and March 1974) rather than as the rational goal-oriented agents that an economic perspective would assume. Yet the economic perspective is most aligned with the ideas behind the higher education policies, i.e. that universities respond rationally to new incentive structures and competitive environments. Moreover, the more competitive environment itself may force universities to behave more like economic agents because in order to survive they need to adapt to market principles. Research on universities' behavior from an economic perspective is more developed in the US (and to a lesser extent in the UK) where indeed universities have been functioning in a more market-like environment. The economic approach to universities' behavior may have a higher explanatory power in Australia now than before.

The economic perspective in this dissertation covers two levels of analysis: micro level (individual universities) and macro level (academic research industry). At the micro level, we will assume that universities function as economic organizations, characterized by a specific

[2] Davies et al (2005) give an excellent overview of different theoretical perspectives on studying the topic of incentives and performance in the case of health care system, very similar to that of higher education system.

production process and a unique objective function. While the micro perspective helps to conceptualize universities' behavior, it sees universities as relatively atomistic and detached from their environment. Another explanatory layer is therefore needed that helps to analyze system-level performance in the academic research sector and to conceptualize the relationship between environmental conditions (including public policies) and changes in the sector. The field of Industrial Organization (IO), which focuses primarily on the performance of the entire sector rather than individual organizations in the sector, provides an instrumental framework for such macro level analysis. The main emphasis of the IO framework is interaction between sector-specific market conditions, public policies, and the behavior of individual organizations. The academic research sector can be approached as an economic sector where universities compete for market share and conceivably for market power. Public policies (e.g. resource allocation principles) affect the way the research market organizes itself, how universities behave in the environment, and finally how the entire sector performs.

Universities as economic organizations

When approaching a university as an economic organization, i.e. as any other firm, two aspects must be defined: the university's production process and the overall objective of the university.

Production process is an activity that transforms inputs into final outputs; that is, it converts raw materials, employee's work, and technology into final products. Such production process can also be developed for producing educational services (Hanushek 1987, Cohn and Geske 1990) and for modeling universities' activities (Cohn and Geske 1990, Hopkins 1990). Universities produce multiple products, such as undergraduate education, graduate education, basic and applied research, consultancy, transferring knowledge to society, etc. In order to do so, universities use multiple inputs, such as academic staff, administrative staff, infrastructure etc. The exact formulation of the production process is quite complex because universities produce multiple outputs and inputs, many of them intangible. Hopkins (1990) summarizes inputs and outputs of higher education (Table 2-1). The question of production process concerns the optimal choice of output and input mix, including issues like teaching-research interaction (joint production function) and optimal size and breadth of the institution (economies of scale and scope).

The other crucial element when modeling universities as economic enterprises is the objective function, i.e. what universities try to achieve when choosing an optimal input and output mix. Private firms are modeled as profit-maximizers but universities are overwhelmingly either public or nonprofit organizations and the assumption of profit-maximization does not hold. On a very general level, the social purpose of universities is not contested. It has to do with educating citizenry, preparing an educated work force, and creating, storing and transferring knowledge. However, even though universities are at the service of society and are to a large extent funded by the public it does not mean that the general expectations of universities guide everyday decisions in a specific university. The literature suggests a few different objective functions that steer universities' behavior. Garvin (1980) argues that universities try to maximize prestige. Hoxby (1997) models universities behavior assuming that universities try to maximize their endowment. The literature review by James (1990) suggests multiple specific objectives: the university maximizes an objective function that depends positively on research, student quantity and quality, and small class size. The underlying meta-objective for these objectives is twofold: prestige and the satisfaction of academic staff. Prestige is valuable for several reasons: it provides professional fulfillment for faculty and administrators, it enhances the value of the degree and therefore improves application and acceptance rates, and it improves prospects for gifts and sponsored research support (Massy 1996).

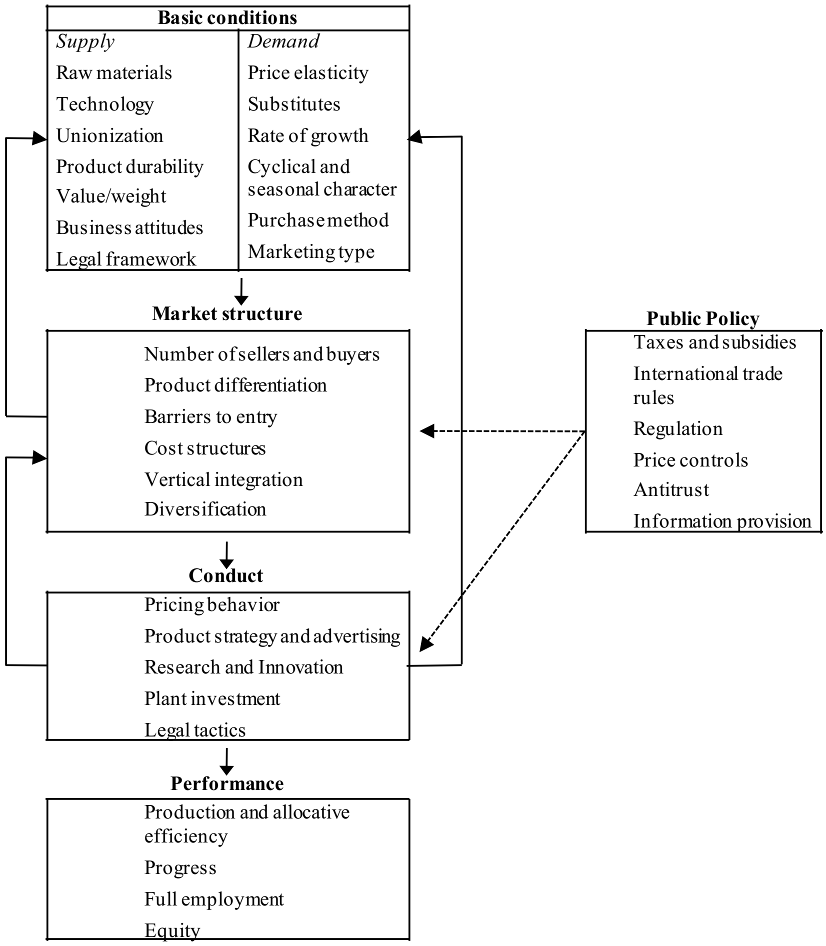
An economic approach to universities is clearly a simplification and can be challenged on many grounds. Universities not only strictly maximize prestige, but also have a broader range of goals. Moreover, there may be no single objective for the entire institution. Groups within an institution may work toward different and sometimes conflicting goals. Faculties are often more interested in strengthening the prestige of their departments than the institution as whole (Massy 1996). This makes a single objective function an unrealistic assumption. Although these are legitimate concerns, they are not uniquely characteristic of the higher education sector but are rather a matter of degree. Also, traditional firms have goals other than profit maximization, such as maximizing market share or revenue. Also, in the case of traditional firms, different organizational levels and people within the organization have individual objective functions that are not completely aligned with those of the assumed organizational objective function. This conflict is the subject of the principal-agent literature in private firms (Eisenhardt 1989). In the case of universities the organizational structure, goal ambiguity and un-measurable outcomes may exacerbate some of the problems, but they do not make the model inapplicable. Moreover, many of the unique characteristics of university governance have themselves been subject to change. The collegial nature of university governance is substituted with a more managerial type of governance, a process that makes the organizational objective function a more plausible assumption.

Higher education sector as an industry

The economic perspective helps to conceptualize general behavioral principles of individual universities at the micro level. This perspective is however limited in its approach and does not incorporate environmental conditions and unique characteristics of the higher education sector, the interaction between universities, and the performance of the sector as a whole. The Industrial Economics (IO) perspective helps to build a link between different environmental characteristics, universities' behavior, and the general performance of the higher education market. This perspective recognizes that even though we assume the same kind of profit-maximizing behavior from organizations in all economic sectors, in reality sectors differ in their structure and performance. Some sectors are highly concentrated (even monopolistic) and others highly dispersed and competitive. It is therefore not only the individual behavior of universities, but also unique characteristics of the higher education sector and public policies that affect the structure and performance of the sector.

The basic logic of the IO is summarized on Figure 2.1, as conceived by Mason (1939) and Bain (1956). The IO model links together market structure, conduct of individual firms, and performance of the industry. How the industry performs in terms of economic efficiency or progress depends on the decisions that firms make with respect to pricing, investments, innovation, etc. For example, a monopolistic firm has an opportunity to set prices above the competitive price levels and thereby make the market perform inefficiently from the welfare maximization point of view. The conduct of individual firms is thus dependent on the structure of the market and the extent to which some actors have higher market power. Market structure, on the other hand, is a function of market conditions that are unique to the industry; such as access to input markets, substitutability of the product, technology etc. Public policies intervene in this cycle mostly on two levels – on the level of market structure and on the level of firms' conduct. For example, policies related to accreditation, licensing or antitrust affect the market structure; price controls, subsidies, and information provision directly affect the conduct. In the case of higher education, public policies have a strong effect also on market conditions. Government is the main "customer" for academic research and to a large extent also teaching (via regulated enrollment and subsidies) and thereby affects demand conditions. Government policies may have a strong effect also on supply conditions – for example government may have a role in planning and preparing academic staff for future generations or it may centrally regulate salary and work conditions.

Figure 2.1. The Structure-Conduct-Performance paradigm



Source: adapted from Scherer and Ross (1990), based on Mason (1939).

The central concern of the IO framework is related to the negative effect of market concentration and restricted competition on the performance of the sector, that is, the effect of monopolistic price discrimination, merges and acquisitions, and exit and entry barriers on the efficiency of the market. This will be the guiding logic in this study as well. We will first analyze whether the policies that promote competition have contributed to the concentration of the academic research market and, secondly, whether the market is now performing more efficiently. The higher education market has many peculiarities: entry, exit, and voluntary merges are rare, the market structure itself is often regulated by government policies, customers are inputs, and prices of the outputs are non-existent. Therefore the notions "market structure", "conduct" and "performance" need to be redefined and elaborated for the higher education sector.

The structure of the higher education market

Traditionally the structure of the market is captured by the number of providers, relative revenue shares and relative number of employees – all of which aim to indicate the relative market power of individual actors. By these standards, the structure of the higher education market is static to a significant extent. The number of universities does not change much because entry and exit in the sector is very limited, and relative revenue and the number of academic and administrative staff are quite stable. Although new, private providers have emerged and are encouraged in Australia, the entry barriers are still quite high. However, changes in market concentration and market power can still be analyzed when the concepts are adjusted to the specific nature of the higher education sector. As discussed above, universities are not traditional profit-maximizers, but rather prestige-maximizers. Market power is thus not derived so much from size, profit and revenue, but from prestige. Marginson (2001), for example, points out that the market power of elite universities is quite high in Australia. In this case traditional measures of market concentration that are related to relative size do not reflect market power in the higher education sector; instead relative prestige may be conceptualized to reflect the concentration of the market.

The higher education sector has some unique characteristics that shape the structure of the market and affect the strategic choices of universities. Two of the most important and interrelated characteristics are informational problems and the winner-take-all nature of the market. Lack of information about educational quality makes students (and employers) use the prestige of universities and their selectivity as a quality measure (Dill and Soo 2004; Dill 2003). This has a significant effect on universities' behavior – universities have an incentive to invest in prestige as a goal of its own, even if this does not contribute to the quality of service (Brewer, et al. 2002). This behavior may increase the costs in the industry and distort the market (Massy 2003, Ehrenberg 2000), thus potentially hurting the overall efficiency of the system. Secondly, several researchers have proposed the idea that higher education is a winner-take-all market – a market where small differences in performance translate into extremely large differences in reward and where success breeds success and failure breeds failure (Frank 2001, Winston 2000, Marginson 2001, Marginson 2004). Successful universities attract more and more resources – research funding and fee-paying students – that can be reinvested in order to attract even more resources. Successful universities can thus invest in strengthening their market position. As a result, universities may diversify increasingly in their relative performances. This diversification is reflected for instance in large differences in per student spending across universities (Frank 2001).

The higher education market can simultaneously move towards greater quality differences and greater homogeneity in the nature of institutions. Bessant (1996) points out that in Australia the intense competition for research funds put pressure on all institutions to increase their research output; this is an attempt to achieve international recognition and build their status in Australia. If student demand is primarily a function of institutional prestige and status, as is argued by many higher education researchers in the US (Trow 1984, Winston 1994), then universities have an incentive to imitate universities that possess these qualities. The "status market" produces homogeneity among universities. Because status is primarily determined by the credentials of faculty and by research activities, universities increasingly tend to prioritize research. Consequently universities become increasingly similar: they expectations research interest and qualifications from their academic staff; they invest into research infrastructure; they favor research activities over teaching. Moreover, the strong research orientation will be passed on to the new generation of academics who will continue the "academic drift" (Fairweather 2000). The conflict between increasing performance differences and increasing homogenization has started to become more apparent also in Australia (see Meek 2000).

The conduct of universities

The decisions that individual universities make determine the performance of the academic research sector as a whole. Most importantly, university decisions on technical efficiency – such as decisions on input allocation, scale and scope – contribute to performance. The extent to which competition between universities contributes to technical efficiency is an ambiguous issue and will be discussed in the next session.

Next to the technical efficiency issue, competition also affects X-efficiency, i.e. the assumption that universities maximize the output and/or minimize costs with any given resource allocation (Frantz 1988). X-inefficiency arises from an agency type of a problem, when the "owners" and managers diverge in their objectives and managers deviate from the overall objective of the cost-minimization. X-inefficiency is a potential problem both in the private and public sector, but the public sector is more vulnerable to the X-inefficiency for several reasons. Public sector organizations are not subject to competitive mechanisms; information is often incomplete, they do not have necessary flexibility to choose resources, and the principal may be more disengaged from monitoring the outputs (Weimer and Vining 1999, Dixit 2002, Vining and Weimer 1990). These issues also characterize the university sector. Universities in a non-competitive environment thus are not subject to the ultimate market test and they are not driven out of the market in the event they fail to perform efficiently. Organizations in a non-competitive environment therefore also face weaker incentives to perform efficiency and to be innovative in their production and management. It is also difficult to adequately measure and price the outputs of universities, which makes it difficult to observe whether a university is actually performing efficiently or not. Managerial incentives are an important factor in influencing the extent to which universities attempt to achieve their efficiency (Ferris 1991). The effort and motivation of the government, which determines the university budgets and oversees the operations of a university, affect the ability of the managers to deviate from the efficiency goal.

Introducing more “market” into a higher education system may thus alleviate some of the factors that make X-inefficiency highly likely, even though it does not address all the issues. Competitive environment strengthens the incentives to perform well as it is necessary for securing the resources of a university. The competition also strengthens the incentives to be innovative, to introduce managerial practices that improve the performance in the organization, and to seek better ways to develop organizational strengths. Furthermore, as the policies are associated with a closer monitoring and performance evaluation by the government, the “principal” has become more involved in observing the “agent’s” activities. The extent to which the outputs and costs are indeed observable and comparable is still an unaddressed issue. However, performance reviews have attempted to make the outputs more observable and better monitored.

The principal-agent dilemma is not only limited to the relationship between the government and university as a whole, but is also extended to the internal relationships in the university. The efficiency gain in the university is thus dependent on the ability of the government to align its interests with those of the university managers, as well as on the ability of university managers to align their interests with those of the deans and academic personnel. Without external incentives, internal management practices are likely to ignore efficiency issues in the university as a whole (Massy 1996, Johnes 1999).

The discussion on appropriate policy mechanisms for delivering public services is part of a larger discussion on market failures and government failures. Public services are provided outside of the market structure usually due to some market failure: information asymmetry, externalities, market power, or public good. Due to these failures, markets cannot ensure the efficiency in production and distribution. However, as Wolf (1993) points out, such market failures does not automatically mean that government provision is more efficiency. Government provision has its own “failures”. The most efficiency mode of provision is thus a result of weighing (or balancing) market failures and government failures. In the 1980s and 1990s governments attempted to address the issues of government failure by introducing some market-like elements in the provision of public services (Osborne and Gaebler 1992). The "quasi-market" reforms in the UK and also in Australia are a direct example of government attempts not to be both a provider and funder of public services but instead purchase public services from private, public and non-governmental organizations that compete with each other (Le Grand 1991). The term "quasi-market" refers to the unique nature of such an exchange. On the one hand it is a market because competition replaces a monopolistic state provider. On the other hand it is *quasi*-market because of the peculiarities in both the demand and supply side: the providers are usually not normal profit-maximizers and consumers do not necessarily express their preference with money, often delegating the decision making to intermediary bodies or managers (Le Grand 1991).

The extent to which, and if at all, such quasi-market incentives enable increasing performance depends on various factors. Quasi-markets may even increase costs in various ways (Le Grand 1991). There are costs related to setting up the infrastructure, signing contracts, monitoring and enforcing the contracts. Competing organizations also use their resources on advertising and other ways of increasing their market share that do not add directly to the quality of the output. Quasi-markets also increase labor costs that otherwise may have been suppressed by the government using its monopolistic position. Moreover, in the sectors where the quality of the product is often hard to measure and demonstrate, organizations may choose to invest in inputs that symbolize performance, rather than actually make a real impact on performance, such as hiring "star scientists". Often the costs also go up due to short-term political pressures. In order to gain support for the changes by providers, the government increases salaries or provides extra resources to the sector. Moreover, the argument of self-selection has been used to justify the role of the non-profit sector. Non-profits are seen as less costly in terms of transaction costs of monitoring because they have no incentives to sacrifice quality for the purpose of profit.

Introducing competition and profit-assumption may shake the underlying incentives of non-profit providers.

Performance of the higher education market

The relationship between competition and performance in the higher education sector is quite controversial. Traditional IO framework would assume a negative relationship between market concentration and performance of the system. The stronger the competitive mechanisms in a market, and the lower the individual market power of any single actor, the better the sector is equipped to function efficiently without market distortions. The belief that competition between universities would contribute to efficiency in the sector has also directly guided the policy reforms in Australia. However, several researchers have articulated concerns that market competition may have a negative effect on the efficiency of the sector. The "pursuit of prestige" may increase the costs of universities to provide educational services, redirect attention from teaching to research, encourage investments that do not contribute to the quality of universities' services and engage universities in a wasteful "arm's race" (Brewer et al. 2002, Massy 2003, Ehrengerg 2000). The relationship between market competition, concentration and performance in the higher education is therefore an interesting policy issue. A competitive environment in the higher education sector may lead to a greater concentration because of the winner-take-all mechanism and informational problems. The competitive environment may trigger processes that actually do not increase efficiency in the sector, but on the contrary encourage wasteful use of resources.

The relationship between concentration and performance can be more complex in other industries as well. Demsetz (1973) argues that de-concentration or anti-merger policies may in certain circumstances have a negative effect on efficiency. If concentration has happened because of the superior efficiency of these firms then concentration contributes to overall performance. In the case of the Australian higher education market, it is important to ask if competition between universities, and potential concentration of resources, has increased performance because resources are concentrated in better performing universities, or whether concentration of resources leads to wasteful use of resources. Johnes (1997) finds a positive effect of scale and scope in the British higher education system and he argues from the IO perspective that concentration would contribute to the performance of the system. The logic of industrial organization is implicitly applied also in the analysis of universities' behavior in Hoxby (1997), Noll's (1998) analysis of research universities, and Feller's (1996) analysis of research markets.

This conceptual approach will frame the analysis of the Australian higher education sector over the 1992-2003 period and helps to formulate hypotheses about the changes in the sector. Three interrelated aspects will be examined in the dissertation, which will be studied individually in the three chapters below. First, to what extent and for what reason has market concentration changed in Australian higher education? Secondly, to what extent have universities revised their organizational practices and has this affected their individual productivity? Thirdly, to what extent has the higher education market increased its performance? As previously discussed, these three questions will be explored through an analysis of research performance in the Australian university sector. A more specific line of argumentation will be developed in the empirical chapters.

Literature review: determinants of academic research performance

The usage of terms 'performance' and 'productivity' requires some clarification for further discussion. In the last section we used the term 'performance' in the sense of market performance, i.e. as an indicator of economic efficiency and we understood it in the perspective of social welfare. Productivity in economic terms means the ratio of outputs to inputs. When talking about change in the universities' productivity (especially in Chapter 6) we indeed mean the extent to which a university is able to maximize its teaching and research outputs with a given input mix. With performance we mean market level efficiency and with productivity an organization level efficiency. However, the terms "research performance" and "research productivity" are used in a narrower sense, consistent with colloquial use rather than economic theory. 'Research performance' of a university means the quantity and quality of universities research output, i.e. how well the university performs in the area of research. At the individual level it is more common to talk about 'productivity'; i.e. a productive researcher is the one who is actively engaged in research (both in the quantitative and qualitative sense). Although the colloquial use and economic terminology of "productivity" and "performance" may intersect occasionally, the context should be sufficient to avoid a major misunderstanding.

A long tradition of research has attempted to identify the factors that contribute to research performance. The topic has been approached from different levels: some studies analyze research productivity of individual researchers, others study the performance of laboratories and institutes, and the third group analyzes the performance of entire universities. The level of analysis is an important issue. The factors that contribute to research performance of universities are not necessarily the same that would make an individual academic staff member perform better. Individual level studies and aggregate organizational studies, however, are complementary and inform each other.

Level of analysis

Earlier studies that attempt to identify factors that contribute positively to research output focus mostly on the lowest level of analysis: the individual staff members. Individual research productivity has been demonstrated to be a function of a number of personal and organizational characteristics (see overviews Fox 1985, Creswell 1986, Tien and Blackburn 1996, Harris and Kaine 1994, Stephan 1996). This research demonstrates consistently the effect of age (Diamond 1986; Levin and Stephan 1991), gender (see Ward and Grant 1996), academic position (Fox 1992, Clark and Lewis 1985), and academic origins (Williamson and Cable 2003). Merton (1968) suggests that individual research productivity has a dynamic trend: there is a positive feedback effect over the career and future productivity is strongly influenced by previous productivity (see David 1994 for an application). Individual research productivity is not only a function of personal characteristics and qualifications, but also of the research environment. Future research productivity is strongly influenced by the academic affiliation of the researcher (Long et al 1998, Creswell 1986) and funding opportunities in the research unit (Crow and Bozeman 1987). Individual productivity is thus a function of both individual characteristics and organizational factors.

Next to the individual level analysis, organizational level analysis could give valuable insights on the nature of research productivity and suggest what instruments and tactics could be used to improve research performance in an organization (Stephan 1996, Dasgupta and David 1994). The unit of analysis in these studies is a laboratory or research group, where the interaction between individual researchers is most active and the potential spillover and interaction effects are the strongest (Carayol and Matt 2004, Crow and Bozeman 1987). The studies identify the effect of size, promotion principles and a combination of different types of academic staff.

University level research performance has increased in visibility and political importance; and university administrators are looking for ways to promote research performance in their institution. Therefore the interest in institutional level determinants of research performance has risen. Only a few attempts have been made to explicitly model the determinants of research output at the institutional level. Abbott and Doucouliagos (2004) and Adams and Clemmons (2006) are grounded in the framework of educational production function and specify the effect of various inputs on research outcomes. Abbott and Doucouliagos (1999) look at the academic and non-academic staff, the research income, the number of undergraduate and graduate students, the disciplinary mix, and university type in Australian universities. Johnes (1988) limits the study to only economics departments and tests the effect of the number of staff, student-staff ratio, age of university staff, and the library stock in the UK economics departments. Dundar and Lewis (1998) concentrate on the effect of the size of the organization, the stock of the library, graduate students, and senior faculty.

Individual, organizational and institutional level studies to a large extent give consistent results and point to the same contributors. In some cases, however, the effect can be quite different at the aggregate level and individual level. Therefore the interpretation of results also has to stay to the right level. If certain aggregated staff characteristics demonstrate an important effect on research productivity in the organization then the effect cannot be interpreted at the individual level. For example, the negative relationship between average age of staff and research productivity has been demonstrated at the organizational level. This does not necessarily mean that younger researchers are more productive. Bonaccorsi and Daraio (2002) argue that the negative relationship is an indicator of the quality of the organization: institutions of higher prestige and research performance have more resources available for young researcher positions. Carayol and Matt (2004) interpret the effect of the average age to be an indicator of the optimal combination of staff in a research organization. Similarly, the effect of the proportion of senior staff in the university, for example, is not only related to the productivity of the senior staff, but also to a potential spillover effect on other staff.

Next to the issue of ecological fallacy, heterogeneity bias in interpreting results is another serious concern. Universities are different not only by their observable characteristics like staff qualifications and other inputs, but also by many underlying non-observable characteristics, such as prestige or research culture. These unobserved characteristics are likely to drive the input factors as well as research productivity. An observed relationship may thus be heavily biased. For example, the number of PhD students demonstrates a very strong and consistent effect on research productivity (Abbott and Doucouliagos 2004, Dundar and Lewis 1998). It is unlikely that PhD students, either as authors of research articles or as research support, have such a strong effect on publication outcomes; rather universities that have many doctoral students tend to also be research intensive universities.

Determinants of institutional research performance

In order to build an explanatory framework for the next chapters, in this section we will generalize existing research in the area and identify factors that are likely to influence research performance at the university level. We will approach universities as economic agents and analyze research performance as a universities' "production process". Research "production" requires various inputs, but is also influenced by organizational level policies and environmental characteristics.

Research inputs

Staff characteristics are important determinants of research productivity. Staff qualification, age and seniority are important determinants of individual level productivity (Creswell 1986, Levin and Stephan 1991, Clark and Lewis 1985). In the institutional level studies again average staff characteristics are the most studied factors and the best predictors of research performance. The studies consistently demonstrate a statistically significant effect in terms of the proportion of staff with PhD degrees, average age, and percentage of senior academic staff (Abbott and Doucouliagos 2004, Dundar and Lewis 1998, Ramsden 1999).

The effect of the size of the research organization has received much attention, but the results are still not conclusive. A number of studies demonstrate a positive effect of department size on research productivity (e.g. Johnson et al 1995, Jordan et al 1988, 1989). Bigger departments may provide more opportunities for collaborative research and thus create a synergy between researchers (Kyvik 1995). Crewe (1988) suggests that the positive relationship between the size and productivity is instead explained by the fact that bigger departments have better facilities and resources for research. There are also studies that demonstrate that department size has no effect. (Martin and Skea 1992, Kyvik 1995). The effect of size may also be different across countries. Positive size effect is primarily found in the US, where departments (and especially research institutes) function in a more competitive environment and the size of the unit itself is a function of its performance. The positive relationship between size and performance may thus be explained in the opposite direction: units that perform well may be able to secure necessary resources and grow in size.

Work organization is one aspect that influences research behavior. Teaching and research compete for faculty members' time and teaching load is expected to be negatively associated with research productivity. Empirical evidence about the relationship between research and undergraduate teaching is ambiguous. A meta-analysis by Hattie and Marsh (1996) demonstrates no systematic relationship between research and teaching while some studies demonstrate a negative relationship (e.g. Fox 1992), and some studies argue that the relationship varies across disciplines (e.g. Stevens 2001).

Research is not only dependent on human resources but also on financial resources and infrastructure. Johnes (1988) and Dundar and Lewis (1998) study the effect of library expenditures as a proxy for research infrastructure and observe a positive relationship. Adams (2006) demonstrates that research funding has a strong positive effect on research performance and observes that government research funding has a more positive effect than industrial funding on research output.

Organizational factors

The studies that approach research performance from a standpoint of production function tend to focus narrowly on the quantity and quality of input factors: such as student-staff ratio, percentage of full professors, teaching-only staff etc. The effect of organizational practices or managerial strategies on research performance is considerably less examined quantitatively.

A supportive research environment is one important factor for research performance. The supportive research environment has many dimensions. Organizational culture that values research increases individual research productivity (Long and McGinnis 1981, Allison and Long 1990). A supportive research environment also has to do with resources: opportunities for research funding in the institution, good research facilities and infrastructure have a positive effect on performance (Stahler and Tasch 1994). Also, organizational policies that emphasize the importance of research in the university enhance research productivity. Deans and department heads setting research as a high priority has been identified as an important contributor to research performance (Stahler and Tasch 1994).

Organizational structure has a significant effect on research performance. Several scholars have pointed out the importance of research centers for research productivity. Geiger (1990) argues that American universities have gained considerably from setting up research centers and institutes in parallel to the traditional department structure. He points out that such structure is effective because of the "capacity to add, expand or terminate 'organized research units' in a highly flexible manner". Feller (1996) points out another valuable aspect of organized research units: cross-disciplinary research institutes facilitate researchers' ability to get around bureaucratic procedures and decision-making systems in order to secure resources.

Research activity can also be boosted with strategic decisions if universities make a strategic decision to focus on growth areas, such as health sciences and engineering, for example (Stahler and Tasch 1994). The effect of organizational research management practices, such as remuneration, promotion, and tenure policies, on research performance has not been empirically studied in quantitative analyses.

Bland and Ruffin (1992) review academic literature on research productivity and summarize that an effective research environment is described by the following characteristics: clear goals that serve a coordinating function, research emphasis, distinctive culture, positive group climate, assertive participative governance, decentralized organization, frequent communications, accessible human resources, sufficient size, age and diversity of the research group, appropriate rewards, concentration on recruitment and selection, and leadership with research expertise and skills.

The base model in subsequent chapters is developed considering the body of empirical literature. The set of control variables includes the following variables: staff age, seniority, and qualifications; teaching load, and disciplinary mix. From the commonly used variables the model excludes two: research infrastructure costs (such as library expenses) and PhD students. Both are omitted because of their potential reverse causality with respect to research performance. Universities with strong research orientation and performance are likely to invest a lot into research infrastructure and recruit a high number of PhD students. These variables are thus likely to have a strong positive association with research performance, but the associations should not be interpreted as causal.

The effect of organizational management practices on research performance are analyzed in depth in Chapter 5 and will be described in greater detail in that chapter. In the next chapter we will turn to a more technical aspect of research performance, namely how to measure research performance.

TABLES

Table 2-1 Identification of inputs and outputs of Higher Education

	Tangible	Intangible
Inputs	New student matriculating	Quality and diversity of matriculating students
	Faculty time and effort	Quality of effort put forth by faculty
	Student time and effort	Quality of effort put forth by students
	Staff time and effort	Quality of effort put forth by staff
	Buildings and equipment	Quality, age and style of buildings; age and quality of equipment
	Library holdings and acquisitions	Quality of library holdings and acquisitions
	Endowment assets	
Outputs	Student enrollment in courses	Quality of education obtained
	Degrees awarded	Quality of education obtained
	Research awards, articles and citations	Quality of research performed
	Services to the general public	Quality of services rendered
		Goodwill
		Reputation

Source: Hopkins (1990).

CHAPTER THREE

MEASUREMENT ISSUES AND DATA

The empirical chapters in this dissertation use the same sample and the same base data. Two of the three empirical chapters use also the same dependent variable – research performance. This chapter describes the sample and provides descriptive information on the data. More detailed descriptive statistics on the dependent variable and its variance across universities and over time is provided in the end of this chapter. We will start however with a more general discussion on measuring research performance.

Measuring research performance

Measuring research performance is a challenging task because the measure should ideally capture the true contribution of research to advancing knowledge and understanding, as well as its potential social value. While such a measure does not exist, different performance indicators have been invented to capture some of the dimensions that are valued in research. Quantification of research performance is an issue not only by which researchers can study research performance but it has also received much attention from policymakers (in the UK and Australia) who attempt to monitor research activities or use the information for performance-based funding models. Many analyses of research performance are initiated by government agencies.

Research income and bibliometric measures are the two most commonly used proxies for research output. Studies that are interested in the commercialization aspect of research also use measures such as registered patents, licenses and income from patents. Peer review is another option for performance measurement in research. In the UK the results of the Research Assessment Exercise, a peer-review-based assessment of subjects, are used. All these measures have their strengths, but none of them is able to entirely capture the contribution of any research activity – in its quantity, quality and scientific and social impact.

The measure of external research funding, primarily competitive grants from Research Councils and/or industry, is one of the most commonly used measures (Worthington & Lee 2005, Avkiran 2001; Abbott & Doucouliagos 2003, Flegg et al. 2004). The measure has several conceptual and practical advantages. Most external grants are very competitive, especially the ones from research councils, and based on rigorous peer review. The measure thus reflects not only the quantity but also the quality of research undertaken. The measure can be justified further as an indicator of the true 'market value' of research, i.e. it demonstrates the monetary value that the market is willing to pay for the research. Moreover, research income is a timely measure. While the number of publications reflects already completed research and indicates past research activities with considerable time lag, research income refers to ongoing research. Koshal and Koshal (1999) also demonstrate empirically that research grant funding is highly correlated with other research output measures. Since it is often a more easily accessible measure than other output measures, it is an attractive measure also from the practical perspective.

Research income has significant weaknesses as well. Research funding is a measure of input, rather than a measure of output. This is a serious conceptual problem especially in analysis that approaches research as a production process through which inputs are transformed into outputs. Research income would thus enter on both sides of the equation – as an input as well as the output. The measure also does not take into account cross-disciplinary differences. Some disciplines require fewer financial resources for research (e.g. humanities) and distribution of funding across disciplines may be a strategic decision et al. Carrington 2004). Moreover, some types of research require less funding. For example theoretical and abstract research is often not as expensive as experimental as applied research, yet it is often associated with the greatest prestige (Cave et al 1991). In the context of this study the most serous weakness of the income measure is its unsuitability for a time-series study. In the case of Australia, the main source of external research income originates from the Australian Research Council. The total budget of the Council is however determined each year by a political decision (and historical continuity) rather than by changes in the quality of research. Therefore fluctuations (or stability) in the total budget cannot be assigned to changes in total research performance. Research income therefore may be an effective measure for comparing research output between universities, but cannot be effectively used for comparisons over time. The research income has thus many strengths and weaknesses. In this study the measure will be used, but only as a secondary measure for the purpose of sensitivity analysis. We will use the research income measure in order to check whether estimation results are robust to the choice of the dependent variable.

Some studies on research behavior in Australia use Research Quantum allocation as a measure of research performance (e.g. Ramsden 1999). Research Quantum is measured in dollars and reflects relative performance in terms of external grants, publications, and research students. Research Quantum has the same problem for comparisons over time as the external funding measure above. The total allocation of the funds from the Government to the sector is fixed and then distributed between universities based on their relative performance. While cross-university differences reflect performance differences across universities, variation in Research Quantum on the time dimension does not reflect actual performance variation over time. Research Quantum is thus a relative, but not an absolute measure.

Bibliometric measures are an equally common performance indicator, used in research as well as by policymakers. The most commonly used bibliometric measure is the number of publications in peer-reviewed journals, which can be used either at the individual, departmental or institutional level. Research productivity and publication productivity are not strictly identical, but one (publication) is an indicator of the other (research) and many consider them to be the best-established measure of research productivity (Fox 1992). The bibliometric measure has a number of limitations. The main problems of the publication count are as follows (Cave et al 1991, Geuna 1999, Adams et al 1998, Johnes and Taylor 1990).

Biblometric measures ignore the differences in publication behavior across disciplines. The bibliometric measure usually counts only publications in the peer-reviewed journals. While in some disciplines this is indeed the primary way of publishing the results, in others (in arts and humanities) it is also common to publish books and book chapters. Moreover, scholarly production in arts and humanities has been found to be a lengthier process than in other fields (Adams et al 1998). As a result the publications are fewer in number, lengthier and more time consuming. A bibliometric measure thus discriminates against the disciplines with alternative publication behavior.

The problem that there are publications other than peer-reviewed journals can be fixed with self-reported publication measures. Abbott and Doucouliagos (2004) use publication index, which is one component in calculating the Research Quantum. Unlike Research Quantum this measure does not aggregate multiple highly correlated measures and reflects true differences over the years. The publication index is based on self-reported publication counts and the index assigns a weight to different kinds of publications (books, journal articles, conference papers, reports, etc). Although it may seem like an attractive measure, it has been rejected in this study because of its questionable reliability. DEETYA ordered a publication audit from KPMG in 1996 and 1997, which found a high level of error in presenting results – 59 per cent in the 1996 audit and 34 per cent in 1997 audit (Harman 2000).

The main weakness of the publication count is that it concentrates on quantity and ignores the quality of the research. The measure has some quality aspect incorporated into it because journal articles go through a peer review process (Warning 2004). Other than the minimum threshold that a publication has to pass, the publication count does not differentiate between ground breaking and relatively modest research. The quality dimension can be incorporated with the count of citations. Citations are an indicator of the impact of the research.

The rationale behind the measure has been explained with the analog of market signaling (Laband 1985, Cave et al 1991): during research, relevant research is surveyed and articles that improve the understanding of the subject matter are chosen for citation. The more citations an article accumulates, the more impact it has had on advancing understanding. Quality by this definition means the extent to which the research is used. Citation counts have also several weaknesses: the problem of self-citation, indicating controversy rather than furthering understanding, circular citation, etc. In spite of the weaknesses, the citation count has become a commonly used measure of research quality and will be used also in this dissertation.

The most commonly used database for the number of publications and citations is Thomson Science (formerly known as *Institute for Scientific Information – ISI*) citation database. Although it is the most comprehensive database it does not include all peer-reviewed journals. Much Australian research is published in journals that are not cited in the database (Butler 2001). This is a problem when comparing Australian research with research in other countries. If this omission is consistent and random in the entire sample of Australian universities then it is not necessarily a serious problem in this study. It may be however the case that some disciplines (like sciences) are more internationally oriented and cited in the database while others (social sciences) are more embedded in the local tradition and published in national journals that are not included in the databases. In this case the profile of universities may distort the citation count.

In some areas research publications may not be the only major output of research, but the impact of the research may be in the form of patents, copyrights and licenses. Patents are ignored in this research because such data is not available at the university level. The number of patents is a significant impact indicator only in a very limited number of disciplines and it should not bias the university level aggregation significantly. It is also unclear if patenting is a substitute of a complement to the process of fundamental research (Agrawal and Henderson 2002). This dissertation deals with the academic research in a comprehensive university. Patents and licensing apply only to a small part of research in universities and should be better studied separately. The topic of research commercialization is therefore to a large extent ignored in this dissertation.

Sample

The sample that is used in the empirical studies in the dissertation consists of 36 universities. Australia has 39 comprehensive universities, of which 37 are public and 2 are private universities. The private universities (Bond University and Notre Dame University) are excluded from the sample because they are not required to submit data to the Department of Education according to the same standards as public universities and many crucial statistics are therefore missing. These two universities are very small in terms of research output and consume only 0.02 per cent of national competitive grants (AVCC 2006). One public university, University of Sunshine Coast, is excluded from the sample because it was established only in 1996 and this not only makes the time-series incomplete, but the data on early years is volatile and does not fairly represent the relationship between inputs and outputs. In the case of Charles Sturt University the time-series starts in 1994. In addition to the comprehensive public universities, there are also specialized universities, such as Australian Maritime College; Australian Film, Television and Radio School; Australian Defense Force Academy and a few others. These institutions are excluded because of their unique mission and limited research activities.

For Charles Sturt University the time-series starts in 1994. Southern Cross University and Ballarat University were also formally established after the beginning of the time-series, in 1993, but they were created as a result of merges and the pre-merge data can be used for earlier years. Australian National University (ANU) is a special case in the Australian higher education landscape. It was established as a research university and instruction was limited only to post-graduate education, but now ANU also provides undergraduate education. The university still has a very strong research focus and the university has a unique organizational structure. Parallel to traditional schools/colleges exists the Institute of Advanced Studies that specializes in research and supervision. Traditionally a different model funds ANU than the other Australian universities. Despite its specificity ANU remains in the sample. The output mix of ANU is similar to that of other universities, even though individual outputs may be represented in somewhat different proportions. There is thus no conceptual need to exclude the university from the sample. However, the peculiar output mix may considerably influence the results of empirical analysis, especially considering that the small sample size makes results vulnerable to any potential outlier. Therefore the robustness of the results was tested, and since the results did not change considerably if ANU was included or excluded, ANU stayed in the sample.

This dissertation uses a 12-year panel of university-level data. The starting point is 1992 because by then the unification of the system had been to a large extent completed and the system had stabilized. The panel stops with the year 2003 because of data availability reasons.

Dependent variable: ISI publication and citation data

Information on publications is extracted from three major *Institute for Scientific Information (ISI)* Indices (now known as *Thomson Scientific*): Science Citation Index, Social Science Citation Index, and Arts and Humanities Citation Index. This source maintains the most complete international data on research journal publications and their citations (Adams 2006) and is widely used in similar studies. Of course not all publications are published in ISI-cited journals. Especially in the humanities and social sciences, a lot of research is published in book chapters and books as well as in journals that are not included in the ISI system. Differences in university-level aggregation of publications may therefore also reflect differences in the subject mix of universities.

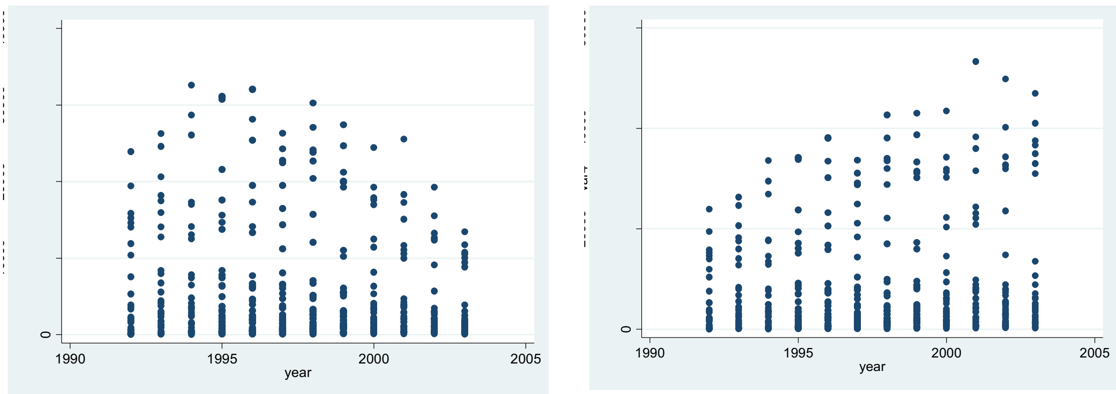
In this study the number of publications is counted as a simple aggregate for each university without correcting for co-authored papers. This means that when a paper has several authors from the same university it counts as one publication, but if a paper has multiple authors from two or more universities, the paper counts as one publication for each university that is represented in the authors' list. The total number of publications may be thus somewhat inflated. The publication count is not corrected for the length of the paper or the type of the paper. Another issue for publication counts is time lag. Publications do not reflect current research performance because the research already has been completed by the time the paper gets published. To correct some of this time bias, the publication count is included with a one-year time lag. This means that the last year for which the number of publications is extracted from the ISI database is 2004, but this number is assumed to represent research performance in 2003.

Since the dependent variable is research output per academic staff member, as explained earlier, we divide the total number of publications per university by the full-time-equivalent academic staff numbers. As shown in Table 3-1, the number of publications has consistently increased over years in Australian universities. Both the minimum and maximum values have consistently increased along with the mean value.

The measure of citation numbers has additional complications. The lagged nature of citations makes citations analysis more difficult. Citations accumulate over time and therefore there is an unavoidable bias against more recent publication years. One way to correct for the bias is to extract only citations in the first 3 or 5 years (e.g. Butler 2001). These data however cannot be extracted from the ISI database without prohibitive manual work. An alternative manipulation technique is used in this dissertation. Analyzing the time distribution of citation numbers from 100 publications in 1992, and in 1993, reveals quite a consistent pattern in how citations are distributed over time. The highest number of citations accumulates in the 3rd, 4th and 5th year (ca 30 per cent) and after that citations decline gradually. Based on the quantitative analysis of the time distribution of citations, the actual citation numbers are thus multiplied with a coefficient that increases in time (see column 3 in Table 3-2). This transformation gives a measure of "expected citations" and is based on the assumption that early citations are an accurate predictor for later citations. The assumption may be not completely accurate. It may be the case that the highly influential (i.e. the articles of the highest quality) collect relatively more citations in the future years: i.e. using the number of citations in the immediate years introduces a bias against good quality articles. However, the transformation is at least able to correct the main bias that is caused by the time factor. Alternatively, the problem may be dealt by inserting dummy variables for each year in models below. However, since we will model not only research performance but also growth in research performance, the growth measure would turn negative due to the time trend and the interpretation of results would be less intuitive. Figure 3.1 illustrates the transformation and compares the distribution of actual citations and time-corrected "expected" citations.

Figure 3.1 Actual and "expected" citations in Australian universities, 1992-2003

a) Actual citations **b) "Expected" citations**



Data source: ISI database

Data Source: ISI database

The expected citation numbers do not have as consistent and increasing trend as publication numbers. Mean citations per academic staff seem to increase until the year 2001 and then start to decline. The decline starts earlier in the maximum number of citations (1999) than in the minimum number of citations (2001). The last column in the table presents the ratio of citations to publications, indicating that the number of citations per publications has a negative trend. The data thus seem to confirm the concern that even though publication output has increased over the years, the impact of each publication may have dropped.

Explanatory variables

Although the Australian government gathers higher education data regularly and in relatively great detail, no unified, comprehensive dataset exists. The dataset in this dissertation is compiled from different governmental and semi-governmental sources.

The majority of data is aggregated from *Higher Education Statistics Collection*, managed by the Department of Education Science and Training (DEST) in the Australian government. These are publicly available data. The Collection consists of different sub-sets. Data on university staff are compiled in the *Staff Collection*; data on university revenues are retrieved from the *Finance Collection and Research Collection,* data on research funding comes from the AVCC; and data on students are retrieved from the *Student Collection.*

Data on staff qualifications were not included in the *Staff Collection* before the year 2000. In order to fill gaps in the time-series, equivalent data has been obtained from other sources. In 1992 a national survey, 'Sources of Australian Academics' Qualifications, 1992', was conducted, and these data have been obtained from ASSDA (*Australian Social Sciences Data Archive*). A similar study was conducted in 1996 and university level results are published in Anderson et al. (1997). These additional sources do not fill all gaps. The time series thus misses a number of entries between 1992 and 1996 and between 1996 and 2000. It is assumed here that staff qualifications are a relatively stable measure, at least compared to number of publications, and therefore missing values are constructed as a linear change based on existing data in neighboring years.

In addition to these data that are common to all three empirical studies below, individual studies use also data unique to the studies. The description and sources of the additional data will be provided in the chapters respectively.

In sum, empirical work that attempts to measure research productivity faces serious challenges in terms of measurement and data availability. While data is far from perfect on many grounds – both conceptual and technical – they enable an analysis that gives insights on the determinants and time-dynamics of the research performance. After discussing the conceptual framework of the dissertation (Chapter 2) and measurement and data issues (Chapter 3) we are now ready to proceed with empirical studies. The next chapter examines research concentration in Australian universities, Chaper 5 explores the effect of management practices on research performance, and Chapter 6 studies the efficiency change in Australian universities.

TABLES

Table 3-1 Summary statistics on the number of publications per FTE academic staff member in Australian universities, 1992-2003

Year	Obs	Mean	St. dev.	Min	Max
1992	35	0.341	0.297	0.018	1.198
1993	35	0.362	0.307	0.025	1.222
1994	36	0.397	0.320	0.035	1.244
195	36	0.433	0.336	0.041	1.318
1996	36	0.460	0.347	0.049	1.428
1997	36	0.493	0.358	0.058	1.461
1998	36	0.524	0.372	0.064	1.560
1999	36	0.554	0.387	0.077	1.628
2000	36	0.642	0.417	0.094	1.674
2001	36	0.688	0.436	0.107	1.742
2002	36	0.689	0.443	0.107	1.644
2003	36	0.704	0.445	0.109	1.709

Table 3-2 Descriptive statistics on (expected) citation numbers per academic staff, 1992-2003

Year	Obs	Coefficient	Mean	St. dev.	Min	Max	Cit/public
1992	35	1.00	4.849	4.792	0.050	20.104	14.221
1993	35	1.003	5.379	5.257	0.082	21.960	14.860
1994	36	1.03	5.917	5.640	0.130	24.131	14.905
1995	36	1.10	6.393	5.897	0.139	25.710	14.764
1996	36	1.19	6.763	6.300	0.162	29.359	14.703
1997	36	1.28	7.146	6.302	0.176	29.664	14.496
1998	36	1.41	7.555	6.536	0.236	31.303	14.417
1999	36	1.57	7.969	6.379	0.300	27.713	14.385
2000	36	1.78	9.199	6.914	0.490	27.374	14.329
2001	36	2.09	9.292	7.201	0.564	27.327	13.506
2002	36	2.59	8.814	7.246	0.527	31.119	12.792
2003	36	3.50	8.471	7.221	0.414	30.656	12.033

Table 3-3. Descriptive statistics on explanatory variables and input-output measures

Variables	Explanation	Mean	St dev	Min	Max	Source
PhD	Share of academic staff with PhD degrees (%)	46.784	16.533	18.400	87.600	1992 – ASSDA 1996 – * 2000-Staff Collection
Age	Average age of academic staff (8 age groups)	5.435	0.287	4.691	6.419	Staff Collection
Senior staff	Share of staff on Level D (=Associate professors) and Level E (=Professors) (%)	14.250	4.149	4.115	30.582	Staff Collection
Student/staff	The ratio of FTE students to FTE academic staff	15.534	4.981	4.893	28.653	Staff Collection,
Teaching only	Share of FTE academic staff with teaching responsibilities only (%)	18.645	15.583	0.000	98.588	Staff Collection,
MedSchool	Binary variable if a university has a Medical faculty	0.280	0.449	0	1	Web research
Campuses	The number of independent and geographically separated campuses	0.27	0.44	1	10	Andrews et al (1997)
Revenue	Total operational revenue ('000 AUD real 2000)	247,238	166,384	42,398	834,960	Finance Collection
Acad. staff	Total FTE academic staff	912	585	155	2,560	Staff Collection
Admin. staff	Total FTE administrative staff	1,152	736	160	3,063	Staff Collection
Non-staff expenditures	Total non-staff expenditures	89,512	69,621	10,667	412,530	Finance Collection
Undergrads	Total FTE undergraduate student enrollment	11,877	6,086	2,102	29,930	CaPIoHEI** and Selected Higher Education Statistics
Coursegrads	Total FTE course-based graduate student enrollment	1,680	1,125	245	6,359	CaPIoHEI and Selected Higher Education Statistics
Researchgrads	Total FTE research-based graduate student enrollment	744	663	9	2,942	CaPIoHEI and Selected Higher Education Statistics
Publications	Total number of publications in the ISI database	590	706	7	3,212	ISI database
Citations	Total number of citations in the ISI database	8,655	11,441	18	53,334	ISI database
Grants	Commonwealth and state level competitive grant funding (real 2000)	11,500	15,300	104	77,600	AVCC
Share Grants	Share of commonwealth grant funding (%)	2.843	3.686	0.030	14.197	AVCC

Note: N=430. Sources: *=Anderson et al. (1997).**CaPIoHEI = Andrews et al 1998.

CHAPTER FOUR

POLICY ENVIRONMENT AND RESEARCH CONCENTRATION

Introduction

In the last decade or two, many countries have implemented or enforced the performance-based component in their research funding system. Research councils and science foundations distribute a larger share of research funding, based on peer review and competing project proposals. Not only project based grant money but also institutional research funding is increasingly performance-based. Research Assessment Exercise in the UK and Research Quantum in Australia are well-known examples where institutional research funding is linked to the evidenced research performance in the institution. Performance-based funding of research is expected to be beneficial for several reasons. Performance monitoring is expected to increase the accountability of higher education institutions; performance-based funding provides universities with incentives to improve their research performance; and performance-based research funding may channel scarce financial resources to those universities where the most can be produced with the resources.

Changes in funding policy have raised the question of whether the new funding mechanism affects the structure of the higher education market. Is competition based research funding likely to concentrate research in fewer universities or perhaps, on the contrary, level the playing field? There seems to be a widely held hypothesis that performance-based funding is likely to “reinforce status quo”, “widen the gap between the haves and have-nots”

(Nadin 1997), increase the differences in research performance (Geuna 2001) and enforce the dominance of the top research universities (Ramsden 1999).

The concern over increasing research concentration has received a lot of publicity in Australia and the magnitude of research concentration has been studied carefully. The government report *The Concentration of Research in Australian Universities* points out that eight universities produce 70 per cent of publications and consume 65 per cent of R&D resources (Bourke and Butler 1998). Garrett-Jones et al (2000) conclude from the 1995 data that research activities are highly concentrated in 14 to 16 universities. This is the case for most of the output and input measures: the number of publications, total research expenditures, total labor costs, etc. It is clear that research in Australia is not equally distributed between universities. Universities differ in their academic profile, student characteristics, staff qualifications and historical background. A four-cluster typology of universities, to a large extent based on research performance, is widely accepted in Australia (e.g. Ramsden 1999, Valadkhani and Worthington 2006, Marginson 1997). This evidence, however, does not answer the question of whether the research concentration has a static nature or is dynamic in time.

Research concentration is an issue not only in Australia. Concerns over research concentration have been articulated also in the United States, for example, where the top 20 universities accounted for 30 per cent of the total federal academic S&T funding in 2005 (NSF 2008). The concentration however does not seem to expand over time. Geiger and Feller (1995) study the research market in the US and demonstrate that the 1980s was a decade in which almost all of the 200 leading research universities had an absolute increase in R&D expenditures, at the same time that relative shares became more equal. Ville et al (2005) study the distribution of research in Australian universities and conclude that inequality in research performance seems rather to decline in the last 10 years.

Funding mechanisms clearly have an effect on the distribution of research output. Some funding instruments may directly attempt to balance the unequal research funding that necessarily accompanies a competitive funding scheme, or a funding instrument may on the contrary enforce the concentration of funding. In the US, for example, National Science Foundation established the EPSCoR program in 1980 that specifically offers research funding to states and territories that historically have received lesser amount of federal research and development funding. This program has been extended also to various government agencies that distribute research funding. "Earmarked" research funding in the US is another, indirect balancing mechanism. Earmarked funds are allocated by the Congress and President through the budgeting process. They are much criticized because of intransparency and lack of peer review, but on the other hand defended exactly on the grounds of more equitable distribution of funding. EPSCoR and earmarked funds have contributed to more equal distribution of research funding, although only to a modest extent (Payne 2006). The UK on the other hand enforces the differences that emerge from the competitive grant system. Institutional research funding by the Higher Education Funding Council is allocated only to universities that score highly at the Research Assessment Exercise and other universities are deprived from such funding. Australian funding system also rather exacerbates existing gaps in research funding. Institutional research budget is linked to success in attracting competitive research grants. In 2001 the government established the Regional Protection Fund to support research in regional universities that are not able to compete for research funds on equal grounds. The scope of the fund is however quite small and is not likely to have a major impact on research distribution.

The aim of this study is to provide more systematic analysis of the time trend in research concentration in Australian universities. While research concentration has been a widely discussed topic, no formal methods have been applied for studying concentration in this field. The convergence trends are analyzed with informal descriptive methods such as visual graphs, share comparison, and deciles analysis (Geiger and Feller 1995). Ville et al (2005) use the GINI coefficient for research funding and research outputs. While these tools provide important evidence and examples, they do not allow a more systematic analysis of the time trend in the process. A more developed method would make the assumptions more explicit and the analysis more rigorous. This study adapts formal convergence models in order to examine the time trend in the distribution of research. The chapter is structured as follows. Section 2 will develop theoretical links between policy environment and research concentration, including a brief summary of crucial policy changes in Australia. Sections 3 and 4 describe the model and data respectively. Section 5 presents the empirical results on convergence trends.

Higher education policy and market structure

Changes in Australian policy environment

Two major reforms in Australian higher education are particularly relevant for analyzing potential research concentration: unification of the higher education market and increasingly competitive funding schemes.

The reform of 1987/88 replaced the binary system of *Universities* and more vocationally oriented *Colleges of Advanced Education* (CAE) with a unified system. As a result of the reform, many CAEs merged with each other or with former universities and thus became larger and more traditional university-like institutions. All higher education institutions became identical not only in their legal status but also were all expected to be engaged in research.

The Australian higher education system has moved towards more competitive funding schemes in gradual steps. In 1990 the government introduced a plan whereby 6 per cent of the total operating grant to universities was distributed based on research performance, while the rest was allocated on the basis of student load. The performance-based component – *Research Quantum* – was based on a formula that included success in attracting external funding (mostly competitive research grants from the Australian Research Council), the number of publications, and successfully completed research degrees. In 1996 the government indicated that operating grants to universities would be reduced by 5 per cent over next three years and no financial supplements were allocated for academic salary increases. This put universities under serious budget constraints. Secondly, in 1999 the Australian Research Council was significantly reformed and gained independence and authority for distributing research funding. The Australian Research Council subsumed within its authority almost the entirety of public research funding, including funding for doctoral education. This led to what has been called the "fully performance-based funding approach in research and research training" (Meek and Hayden 2005).

The competitive forces were further strengthened through changes in the student market. Australia introduced subsidized tuition fees for all students, but more importantly, allowed universities to enroll full-fee-paying students – both domestic and international. Income from student fees became a significant revenue source for universities, and 1995 budget cuts made this source even more crucial. As a result, universities compete with one another fiercely, especially for international students.

The relationship between the policy changes and the structure of the research market will be approached in the framework of industrial economics.

Policy environment and market structure

Industrial Economics (IE) literature helps to formulate a link between policy environment and research concentration. Market concentration is a well-studied topic in the IE literature because market concentration is expected to have a direct effect on market performance. In a highly concentrated market, a few firms (or one firm) dominate the market and eliminate the efficiency gains that are normally generated by free competition. The relative growth of firms in terms of their size and market power is therefore carefully studied in the IE literature. The effect of public policies that may affect market structure – e.g. anti-trust policies, policies related to entry barriers, common market policies – are therefore also of great interest in this field.

The higher education sector can be interpreted as an industry where multiple universities compete for market share and potentially for market power. The higher education market has many peculiarities, however. The traditional view of market concentration in terms of the number of universities and their relative size (in terms of revenue or number of employees) is hardly reasonable in the case of universities. The structure of the higher education market is quite static if analyzed according to traditional categories. The number of universities does not change much because entry and exit is very limited in the sector. Although a few new private providers have emerged and are encouraged in Australia, the entry costs are too high for significant mobility. Also the size of universities does not change much over time. However, the ideas of market concentration and market power are not alien to the sector, if adjusted to the peculiarities of the sector.

Universities are not usually traditional profit-maximizers but rather prestige-maximizers, as argued by Garvin (1980). The physical size of a university is not a measure of market position, and may even be inversely related to the market position. Universities are more likely to face a tradeoff between prestige and size. Many universities have an excess demand but they constrain their size in return for higher prestige and quality, which is generated by selectivity (Hoxby 1997). Moreover, the size of a university is not an expression of market success, but of government money allocations. The major constraint on university size is the operational grant from the government that is based to a large extent on the historical trend in student numbers. The source of market power in this industry is thus not expressed in size, but in prestige. And as Marginson (2001) points out, the market power of elite universities can be very high.

Traditional measures of market concentration – number of firms, revenue shares or client shares – cannot be used for measuring market power in the higher education sector. When market power is generated by prestige, market concentration must be defined through a prestige measure. Prestige in the sector is primarily driven by research excellence (Brewer et al., 2002). While in the traditional industries firms' size is measured according to the number of employees, sales, and the value of assets, the 'size' of a university in the higher education market can be equivalently measured through research performance. The question of this study can thus be rephrased as: how does the change in competitive policy environment affect the distribution of research in the Australian higher education market? Is the performance-based competitive funding likely to increase or decrease the concentration of research among Australian universities? From a theoretical standpoint, an argument can be developed in either direction.

The case for a decreasing concentration of research

Australian universities clearly differ in their research performance. Significant performance differences are not characteristic only of the higher education sector. Industrial economists identify *strategic groups:* groups that are defined by the commonality of the strategies that firms follow in setting key decision variables, such as investment levels, R&D, etc (Caves and Porter 1977, Porter 1979, Oster 1982). Caves and Porter (1977) developed the idea of mobility barriers that prevent firms from moving from one strategic group within an industry to another, which provides an explanation for intra-industry performance differences. In case of Australian universities the barriers can be geographical or based on reputation and status. Unification of the system may be interpreted as an attempt to break down the barriers that have protected different performance levels in the system. All universities are now exposed to the same environment and the same market conditions.

Financial incentives have been the primary mechanism by which the government steers universities' conduct. Research performance evaluation and *Research Quantum* increased the attention to research in the country. Research performance generates important financial benefits from the government but also makes the university more attractive to students and external partners. University rankings, such as those provided by *Shanghai Jiao Tong* or the *Times Higher Education Supplement*, are based primarily on research performance. Since it is perceived that university rankings affect considerably the choice of international students, all universities have now an incentive to improve their research performance. Research emphasis characterizes now all universities; teaching concentration is not sufficient even for universities that by their mission do not have high research ambitions. Expectations of academic staff have therefore also become more uniform throughout the entire system and research pressure is felt by all academics. Even though the government hinted that it has no intention of supporting 36 research-intensive universities (Meek and O'Neill 1996), it has not declared or proven through money allocations that the concentration of resources to fewer universities would be beneficial (unlike the RAE funding principles in the UK, for example). In later years the government strongly encouraged each university to concentrate on specific research areas, but no explicit plans were articulated for concentrating research in fewer universities. The market forces may be thus triggering a convergence in research behavior and research performance among universities.

However, it would be an oversimplification to assume that the CAE sector had no research ambitions before the reform and that market unification introduced a fundamental change in aspirations and values. The idea of prestige was not alien to the sector before the reform. A considerable 'academic drift' had been present as well within the CAE sector. Colleges increasingly upgraded diplomas for degrees; research qualifications and research experience became progressively more valued; and there was a continuous hierarchy of higher education institutions instead of discrete classification (Moses 2004). Consequently the effect of the unification on the aspirations of former CAE's should not be overstressed. Although unification certainly enforced research culture in the sector, the pressure to increase the academic status of institutions was there already before the unification.

The case for an increasing concentration of research

The unification lifted some of the "mobility barriers" that kept some institutions from research activites. While the unification may have eliminated formal finance or status barriers for the CAE sector, those barriers may have protected the institutions from the market. Abolishing the market barriers may leave former CAE sector universities more vulnerable because they are now competing with more established research universities on equal grounds. The CAE sector universities may find themselves in an impossible competition, considering the specific nature of the higher education market as a winner-take-all market.

Frank and Cook (1995) describe certain markets as winner-take-all markets. These are markets where rewards are not given on the basis of absolute productivity but on the basis of relative performance against competitors. This type of market enforces relative advantage and increases inequality between actors. Several researchers have argued that higher education is a winner-take-all market: a market where small differences in performance translate into extremely large differences in reward (Frank 2001, Winston 2000, Marginson 2001). Successful universities attract more and more resources and can further strengthen their market position. As a result, the research performance gap between universities is expected to increase in time.

If higher education is a winner-take-all market then the competitive environment is likely to enforce the existing positions of universities and promote concentration of research. Universities that have a good research potential are able to attract more research funding, in the form of competitive grants from either government funds or external sources. They can then invest these resources into better research infrastructure, and use the resulting financial resources and prestige to attract the most qualified researchers and further financial resources. Prestige and better infrastructure will make the universities a more attractive partner for external partners (e.g. industry) and students, which will channel even more resources to these universities. Research potential is thus cumulative and makes advanced universities to grow even faster. Geuna (2001: 624-625) among others believes that concentration is an unintended inevitable consequence of performance based funding system in higher education.

The cumulative rewards in science and research performance have been thoroughly studied and confirmed at the individual level (Allison et al 1982; Cole 1970). Merton (1968, 1973) developed a well-known argument for cumulative effects in research output. Since it is difficult to predict the future productivity of scientific work, the scientific community is more likely to allocate resources to those scholars that have been successful in the past. As a result, the gap between less able and more able researchers is likely to grow over time. Additionally, Merton pointed out that scientists with greater reputations would gain greater rewards for the same standard of research achieved by scientists with lesser reputations (defined as Matthew effect). Rosen (1981) explained cumulative effects in science from a different angle. He developed a theory of 'superstars', arguing that small differences in talent are translated into disproportionately greater market rewards and thereby exacerbate inequality in the final outcome. Visible not only at the individual level, such cumulative effects are also reflected at the aggregate university level, and similar mechanisms of cumulative advantage can be present at the institutional level.

From a theoretical perspective, research can be seen as increasingly either concentrating or converging in Australian universities. We know that universities have improved their research productivity over the period of interest, at least if measured by the number of publications (as shown in Figure 1.2.). The question is whether the growth has been the same for all universities. Have the better performing universities been able to grow faster due to the cumulative effects in research and is the research market increasingly more concentrated? Or have lower performing universities been able to profit from their underused potential and demonstrate faster growth, which leads to convergence with better performing universities? A model for estimating the trend will be discussed next.

Modeling concentration

The process of cumulative effects has been modeled and estimated in different settings. For example, research in career development, income inequality and scientific productivity apply the pattern of cumulative effects at the individual level (see DiPrete and Eirich 2006 for an overview). Industrial economics and development economics have developed the concentration and convergence models for macro level units – firms and countries. All the models have the same general logic and estimate the relationship between the growth rate of the variable of interest and the initial level of the variable.

In industrial economics, market concentration is an important market characteristic and temporal trends in the concentration are therefore carefully studied. Many studies test Gibrat's law of proportional effects (see Goddard et al 2002). Gibrat argued that if individual firm growth rates are independent of firm size then the market will nevertheless be increasingly concentrated and the distribution of firm size would be skewed (Sutton 1997). Some firms become large due to a random shock and are able to establish a dominant market position. A rich set of empirical research has followed to test Gibrat's assumption of the independence of the growth rate in relation to the firms' size, and the evidence is leaning towards rejecting the assumption of independent growth rate (e.g. Liu et al 1999; Evans 1987; Dunne and Hughes 1994).

Another stream of research that informs the model in this paper is growth economics. Neo-classical growth economics assumes that per capita income in the world converges over time (Solow 1956) and convergence models test the assumption and estimate the speed of the process (Baumol 1986; DeLong 1988; Barro 1991; Barro and Sala-i-Martin 1995; Abramowitz 1986; Dollar and Wolff 1988). The convergence model is in general terms identical to the concentration model in the industrial economics literature, only assuming that the relationship between growth and the initial level of development is negative. The contribution of the convergence model in studying research outputs in Australian universities is the idea of 'conditional' convergence. In the context of growth economics, convergence between countries may be not absolute, but conditional on technology and other structural country-specific factors. Similarly research output in universities may be converging (or concentrating) not absolutely, but conditionally, based on internal resources in a university.

Drawing from the two streams of research, a model of research concentration is developed. The evidence supports the hypothesis of research concentration if strong research universities raise their research output faster than lower performing universities. If this is so then the gap between stronger and weaker universities grows in time. If, on the contrary, universities with initially low level of research productivity have a higher growth in research outputs, then we can expect that lower performing universities are catching up. The mathematical form of the relationship in the cross-sectional form is thus the following:

$$\Delta y_{it} = \alpha + \beta\, y_{it-1} + \sum_{j=1}^{J} \gamma_j X_{ji} + u_{it} \,,$$

where y_{it} is the research output on a logarithmic scale of university *i* at time *t*. Δy_{it} is the growth rate of research performance. u_{it} is random disturbance characterized as E(u_{it})=0 and var(u_{it})= σ_{it}^2 across *i*. This specification assumes that the growth rate is not entirely explained by the initial level of research productivity, but must also take into account university characteristics. X_i is the vector of *j* characteristics of universities. (Theoretical justification for including university level characteristics and the set of variables included in *X* will be discussed below.) γ_j and β represent parameters to be estimated. If β=0 then there is no relationship between universities' research output and the growth in research output. If β>0 then it means that universities that perform well improve their performance faster. In both of these cases (i.e. $\beta \geq 0$) the gap between universities is increasing in time and universities do not converge. When β<0 then universities of lower level research output improve faster. This is a necessary, but not sufficient, condition for convergence.

Adopting from Geroski and Gugler (2004), the estimation model has the following conceptual foundation. If there is evidence of convergence (or concentration) among universities and all universities are indeed moving towards (or away from) a common ceiling of research output then the rate of growth depends on their distance from that ceiling. If y* represents the unobserved ceiling of the research productivity,

$$\Delta y_{it} = \beta \ (y_{it}^{*} - y_{it-1}) + u_{it} \quad \text{(Theoretical model)}$$

β is thus the parameter to be estimated and represents the speed with which universities approach the ceiling. Relationship between the growth rate and the distance from the output ceiling is assumed to be exponential (β) meaning that the further a university is from the capacity ceiling the faster it is approaching the ceiling.

The model cannot be directly estimated because the ceiling *y** is not observable. If we assume that *y** is the same for every university then it would transform the term into a constant and the model could be estimated as a direct relationship between the growth rate and y_{it-1}. This would give an estimate for the *absolute convergence (β-convergence),* which is the first empirical estimation model in this study:

$$\Delta y_{it} = \alpha + \beta \ y_{it-1} + u_{it} \qquad \text{(Model 1)}$$

Since we will use a panel data set, the disturbance term $u_{it} = \rho u_{it-1} + \varepsilon_{it}$, where ε_{it} is random noise and ρ allows for serial correlation. In this model, negative β would be a necessary, but not sufficient condition for convergence. Negative β may actually increase dispersion of units in the unlikely case that the growth rate of smaller units is excessively higher than that of larger units. In such a case the smaller units grow so fast that they pass larger units and the gap between units may be bigger at the end of the period (Sala-i-Martin 1996).

Regression to the mean is another and more serious concern in terms of why β coefficient alone is not an entirely reliable measure of convergence. Quah (1993) draws attention to a potential Galton's fallacy in convergence models that interpret a negative relationship between growth rate and initial level of economic productivity as a sign of decreasing dispersion across economies. He shows that even if there is no change in the cross-section distribution of productivity across countries, the β may easily be negative. This can be explained with the 'regression to the mean' argument. Exceptionally high measurements – due to random fluctuation in the sample or measurement error – in period t are likely to be followed by more moderate measurements in period $t+1$; and exceptionally low measurements are likely to be followed by higher measurements. There is thus some systematic mobility in the sample but the dispersion itself remains unchanged over time.

This is the purpose of estimating *σ-convergence* in addition to *β-convergence.* Universities are converging in the sense of *σ (sigma)* if the dispersion in their research output tends to decrease over time. For this test, we will calculate σ, which is the standard deviation of the (ln) research output, and analyze its time trend. In order to make the measure unit-neutral, standard deviation is divided by the mean of research output.

Model 1 assumed that the productivity ceiling y^* is identical for all universities. This is however an unrealistic assumption because universities are endowed with a different set of resources which cannot be changed rapidly. All universities can still be assumed to increase their research productivity, which is constrained by the university level characteristics. The unobserved productivity ceiling y^* can be thus defined through university characteristics that encourage or discourage research output:

$$y_i^* = f(\sum_{j=1}^{J} \gamma_j X_{ji})$$

where X is the vector of j observable exogenous factors that drive the individual y*.

The factors that define research output in universities are derived from existing empirical literature that uses multivariate models and tries to identify the determinants of research productivity at the university level (Johnes 1988, Abbott and Doucouliagos 2004, Dundar and Lewis 1998, Adams and Clemmons 2006, Ramsden 1999). These studies were discussed in Chapter 2. The set of variables is quite uniform across the studies and the models demonstrate quite high explanatory power. We will use this "conventional set" as input in the convergence model. Staff qualifications and characteristics clearly contribute to research productivity: measured by the share of academic staff with PhD degrees. The proportion of senior staff in the university affects research performance not only because of their own productivity but also through a potential spillover effect on other staff. The average age of academic staff has been found to have consistently negative or quadratic effect on research performance (e.g. Stevens 2001, Johnes 1988). This can be explained either directly by the diminishing productivity of older staff, or by the staff profile in research-intensive universities (Bonaccorsi and Daraio 2002). Teaching and research compete for faculty members' time and teaching load is expected to be negatively associated with research productivity. Empirical evidence about the relationship between research and undergraduate teaching is however ambiguous (Hattie and Marsh 1996). Since different disciplines have different publishing behavior, the disciplinary mix in a university is likely to affect the total research output. The most conventional way to capture the effect of the disciplinary mix is to include a binary variable for the presence of a medical school in the university (e.g. Abbott and Doucouliagos 2004).

The vector X includes thus the following variables: share of academic staff with PhD degrees, share of senior staff (full and associate professors), average age of staff, student-staff ratio, proportion of academic staff with teaching only responsibilities, and the presence of the medical school.

When constructing y^* through the vector of X variables, the estimation model takes the following form:

$$\Delta y_{it} = \alpha + \beta\ y_{it-1} + \sum_{j=1}^{J} \gamma_j X_{jit} + u_{it} \quad \text{(Model 2)}$$

where the vector X_j includes the identified university level variables. This is a *conditional convergence* model - universities are assumed to converge, but to an individual capacity ceiling as determined by their resources and structural characteristics.

Model 2 is less restrictive because it allows university-specific capacity ceilings, but it still imposes the assumption that all universities have a homogeneous convergence rate β . The rate may however be different for different universities. Some universities may be improving their research performance at a slower rate because of structural reasons. Australian quality audit reports from 1995 often pointed out the problem of unequal developments in multi-campus universities. Often universities had been able to improve their research infrastructure on the main campus but improvements lagged behind on other regional campuses (CQAHE 1995). The convergence rate β in the theoretical model is consequently not identical for all universities but is a function of the structural characteristic (z). The model will be thus augmented for the following final model specification:

$$\Delta y_{it} = \alpha + \beta y_{it-1} + \sum_{j=1}^{J} \gamma_j X_{jit} + \sum_{j=1}^{J}\ \delta_j X_{jit} z_i + \varphi y_{it-1} z_i + u_{it} \quad \text{(Model 3)}$$

There is a conceptual difference between an x variable and z variable. If the number of campuses were considered as an x variable then we would assume that on average universities with more campuses have a lower research capacity ceiling y^*, everything else being equal. When we consider the number of campuses as a z variable *then* we assume that the number of campuses does not lower the expected research productivity in universities, but only the time needed to reach the productivity ceiling y^*. We hypothesize that universities that are divided into multiple campuses cannot implement internal research policies as quickly throughout the institution. Eventually the university will reach the ceiling of y* as predicted by X variables, only the trajectory is slower. At the conceptual level we thus assume that the β itself is a function of the number of campuses (in the Theoretical model above). Under this assumption, an empirical estimation would include interaction terms with the constructed y* (i.e. X vector) and the initial performance.

Measurement: time period and unit

Growth period

This study examines the changes during the decade from 1992-2002. What period to use for measuring growth rate is a question that arises particularly in the context of panel data. Measuring growth rates over the shortest periods possible would maximize the number of observations in the sample. Yearly growth rates may, however, contain a lot of noise because of random fluctuation in research output from one year to another. Considering that there is often a time lag between when research is completed and when it is published, and that this lag varies, publications may happen to accumulate in a given year after a previous year of relatively low research output. While in the case of big universities with high publication numbers such fluctuation is not significant, in smaller universities with low levels of research performance these fluctuations are a more serious problem. One university demonstrated a near 100 per cent growth in one year, followed by a severe decline the next year. Comparing outputs from years that are further apart may therefore give more meaningful growth estimates. Goddard et al (2002) justify using yearly growth rates (of firm size) with the argument that aggregating data cannot possibly increase the amount of information in the dataset and is more likely to reduce available information for estimations. In order to alleviate the problem of random fluctuations in research outputs, a moving average smoothing technique has been applied in this paper: instead of using the nominal count of research output for each year, the average output of the year *t*, *t-1* and *t+1* is used. This technique will construct a series of data with a more consistent long-term time trend. Research output measure on the right hand side is kept in its original, t-1 form. In this way we can also avoid the problem of linear dependency between the dependent and independent variable.

Measurement unit

The concentration can be estimated either in terms of total research performance or research performance *per academic staff* in a university. The choice between *per capita* or absolute measures comes from the theoretical assumptions – what is an accurate prestige estimator. University rankings (e.g. *Shanghai Jiao Tong* ranking of world universities), for example, count total research productivity, which would suggest total research output as a prestige measure. On the other hand, there is evidence that universities do not grow in size when they have the option, but instead increase their selectivity (e.g. Hoxby 1997). In this paper we will assume that selectivity is part of the prestige generating mechanism and therefore we will use *per capita* measures. *Per capita* measure of research performance is also perhaps more informative and intuitive.

Empirical results

In this chapter the empirical results for the absolute, sigma-, and conditional convergence will be presented first with respect to the publication numbers. At the end of the chapter the same models will be run for the citation numbers in order to check the robustness of the results to the choice of the output measures and to test whether the convergence trends may be different with respect to the quantity and quality of research.

Unconditional model

Absolute convergence model estimates (Model 1) suggest clear convergence in publication numbers between universities (Table 4-1). The β-coefficient is clearly negative and statistically significant. This means that research productivity is growing significantly faster in lesser performing universities and this evidence suggests potential convergence across the sector.

The first column in Table 4-1 presents the results from a pooled OLS estimation. There is likely to be a heteroscedasticity problem because universities with lower publication numbers have more fluctuation over years and the growth numbers are also more dispersed. The analysis of residuals indeed shows a minor correlation with the explanatory variable and therefore Huber corrected errors are presented. The speed of convergence is a considerable 6.4 per cent. There is also a significant stable growth in all universities at the average rate of 2 per cent.

Since we are dealing with a panel dataset, one potential problem is error correlation over time periods. The random effect model is therefore estimated in parallel with the OLS. The Breusch-Pagan test finds only a very minor clustering effect for the observations over the years (*Chi-square* (1) 0.32) and the correction leaves the results basically unchanged. Random effect model indicates expectedly that the model explains more effectively the variance in growth between universities than that within universities. This result encourages analyzing further the dynamics of the convergence trend over time. The results of the random effect model suggest that the relationship between growth rate and the initial level of research performance is perhaps not homogeneous throughout the time period. Table 4-2 presents the results of the growth regressions by years. The convergence speed declined from 9.4 per cent in 1992 to negative 2.4 per cent in 2003. The coefficient is statistically significant and negative until the year 2000. The relationship between the initial publication numbers and the growth is fading out gradually over the years, as illustrated in Figure 4.1. This indicates that universities with lower performance indeed grow faster, but only until the year 2000 and at the declining rate. Starting with the year 2001 the relationship seems to disappear and there is some fluctuation between convergence and divergence.

Figure 4.1 Beta coefficients (with standard errors), 1992-2002

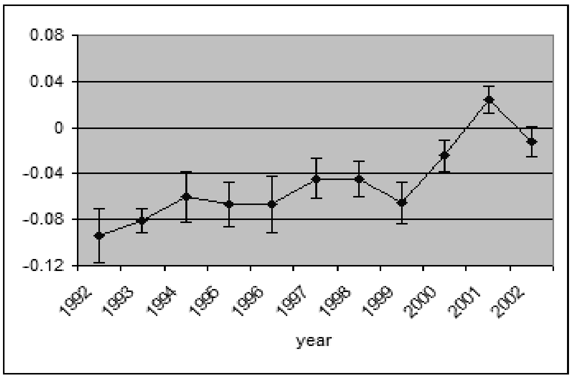
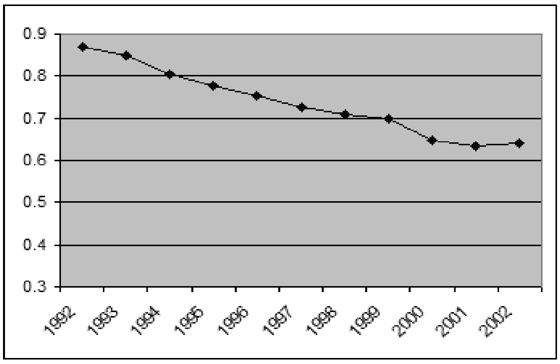


Figure 4.2 Sigma-convergence, 1992-2002



β-convergence is not a sufficient condition for convergence. Negative β-coefficients may indicate the regression to the mean rather than a systematic decrease in the variance. In order to check the concern of the regression to the mean, the change in the standard deviation of the research output across universities over years needs to be examined. The analysis of standard deviation, i.e. σ-convergence, confirms the results of the β convergence (6th column in Table 4-2). The higher education market is consistently converging (σ drops from .871 to .634), with the exception of the year 2001. As illustrated in Figure 4.2, the dispersion of publication numbers is declining, but stabilizing at the year 2000. This means that Australian universities are indeed becoming more similar in their per capita publication numbers.

The relationship between growth rate and the initial performance level thus demonstrates a significant convergence over the period. However the convergence trend is consistently slower every year and stops around the year 2000. This pattern suggests that as a result of the policy shock, lower performing universities increased their research performance faster than universities with higher research performance, but there seems to be a limit of how much these universities are able to reduce the gap. By 2000 the lower performing universities seem to have used all their growth potential and stabilized their research performance. This could be the case for several reasons. Lower performing universities may have upgraded their research infrastructure and thus gained research productivity, but they might not have been able to increase resources to the same level as research intensive universities. Alternatively, all universities reacted to the change in the policy environment similarly, i.e. by increasing their research productivity. It may be relatively easier to improve research performance at the lower end of the scale, and it gets more difficult when research performance increases. Because of this phenomenon, the growth speed may be equalizing in the sector. The conditional convergence model can therefore provide more evidence on relative growth in the sector.

Conditional convergence and different convergence rates

It is unrealistic to assume that all universities are approaching the same level of research performance, given that performance is influenced by the level of resources and other institutional characteristics. The conditional convergence model assumes that the growth speed is not determined by the absolute level of performance, but by the distance of the performance level from the capacity ceiling, as constrained by resources and other institutional characteristics.

Conditional convergence model (Model 2) confirms the relationship between optimal research productivity and university characteristics (Table 4-3). Considering individual capacity ceilings, universities demonstrate even faster convergence speed: at the rate of 12.2 per cent compared to 6.4 per cent in the unconditional model. The Model 2 estimation shows that the growth is significantly associated with the university characteristics as well as the initial level of research output. Staff characteristics seem to have a significant effect on the maximum productivity ceiling: the share of senior staff (associate and senior professors), and the average age of the academic staff have a positive effect on the productivity ceiling. Also a medical school seems to raise the capacity limit. The student-staff ratio, the share of academic staff with only teaching responsibilities and the share of staff with the doctoral degree all have an expected sign but do not quite pass the 5% confidence level threshold.

What this evidence shows is that universities seem to approach a long-run level of research productivity that is captured by the *X* variables, and the growth rate falls as the university approaches this long-run level. Not only lower performing universities improve their research performance faster, but the further a university is from its capacity ceiling the faster it improves its performance. Universities are thus not converging so much absolutely with each other but they are moving quickly towards their individual capacity ceiling. The evidence seems to indicate that starting from the beginning of the 1990s universities started to maximize the potential of their existing resources.

We also hypothesized that the speed of convergence can be influenced by structural factors such as the number of campuses. Model 3 tests the hypothesis that universities with multiple campuses have experienced a slower speed in converging to their optimal research productivity. Individual interaction terms are not only non significant, the F test of joint significance confirms that the number of campuses has a negligible effect on convergence speed (Table 4-3). The direction of the relationship is however the opposite of what was expected. Moreover, the sign of most interaction terms is negative, suggesting that multi-campus universities demonstrate faster growth rather than slower growth. The only interaction term that is statistically significant is the interaction with the student-staff ratio. When interpreted individually, this indicates that multi-campus universities with high student-staff ratio have been able to improve their research performance the most.

The analysis of publication numbers thus shows that universities are converging over the 1992-2002 time-period, meaning that universities with lower research performance improved their performance faster than universities with good research performance. The convergence trend was particularly fast in the early period and faded away by the end of the period. The conditional convergence model indicates that universities quickly maximized their own capacity, as dictated by their internal inputs and characteristics, rather than heading towards a common productivity level. Universities seem to have reached their long-run productivity level by the end of the period.

Citation numbers: conditional and unconditional models

Citation numbers and publication numbers can potentially give quite a different picture. It is possible that the number of publications has grown in lesser performing universities, but the publications would not be equal in quality to those of more research-intensive universities. Thus it could be the case that while universities are converging in terms of publication numbers, the gap in citation numbers would remain unchanged, or even grow.

The empirical results of citation analysis seem to give quite a similar overall picture as the number of publications (Table 4-4). While both the OLS and RE results are presented, the coefficients of the two estimates are significantly different and random effect estimates should be preferred. Error correlation can be expected considering that the citation numbers have been multiplied with a constant to correct the time bias. Growth in citation numbers is significantly and negatively correlated with the initial number of citations, indicating convergence over time. The convergence speed of 7.5 per cent is even faster than in the case of publication numbers. This likely reflects the fact that citations themselves have a cumulative pattern and the gap in citation numbers was even larger in the beginning of the period than the gap in the publication numbers. The initial level of research output explains better the variance of growth rates between universities rather than within a university. In general, the model has a much lower explanatory power than the model of publication numbers.

The time trend of the β-coefficients over the years is not as consistent as in the case of publication numbers (Table 4-5). The β-coefficient first decreases (1992-1994), then increases (1995-1996) and then again decreases and stabilizes in 1999. After the year 1999 the time trend will be flat. σ shows however a more stable convergence trend. Standard deviation drops consistently until the year 2000, with the exception of the year 1995. After the year 2000 σ seems to start increasing again. Compared to the number of publications, distribution of the number of citations is more diverse, indicating a bigger gap between universities. This is an expected result considering that citations have an exponential distribution pattern.

Unlike in the case of publication numbers, the conditional convergence model does not add much explanatory power (Table 4-6) . University level characteristics fail to define the capacity limit in the citation output. Convergence speed is increased only marginally, from .075 to .077. Citation numbers seem to be more resistant to changes in university resources. Student-per-staff is a measure that seems to define the citation behavior in the university, suggesting that high student numbers reduce expected citation numbers. Lower performing universities are increasing their research performance relatively faster, but the growth does not seem to be determined by the research characteristics of the university.

In the Model 3 estimation, the interaction terms seem to replace the direct effect of the university characteristics. The addition however reduces the general convergence speed and rather again seems to suggest that more spread-out universities have improved their research performance to an even greater extent.

The convergence model applied to the number of citations thus suggests the following: Australian universities increased their citation numbers over the time period and lower performing universities indeed grew faster than better performing universities. The growth pattern, however, does not seem to be explained by the gap between actual performance and expected performance. It can be argued that universities' policies in terms of staff qualifications, senior staff, and research staff may increase publication numbers, but citation numbers are more resistant to quick changes. This may explain why these resources do not explain the growth pattern. The problem with this argument of course is that universities did increase their performance, but this seems to be independent of the universities' resources. This is not meant to say that the university characteristics do not affect research performance if measured with citations. The regression of citations on the university characteristics confirms that all these variables are indeed significant for the performance (see the next chapter). Simply the gap between the expected performance and actual performance does not seem to affect the growth rate. Data problems perhaps should be kept in mind, too. While publication numbers are actual numbers, the citation numbers are constructed based on a historical pattern.

Research funding: the conditional and unconditional model

The final analysis focuses on convergence in research funding. Research funding is an alternative measure of research quality and another dimension in prestige, but in terms of research convergence it has significance of its own. The primary concern behind research concentration is concentration in resources, which subsequently leads to concentration in research output. As seen in the results (Table 4-7), the trend in research funding is very similar to the trend in publication numbers. Lower performing universities are moving closer also to better performing universities. So also in terms of research funding universities have become more similar and there are no signs of concentration. The convergence is the case in the absolute sense, but the catching-up is even faster in the conditional model. Controlling for university-specific characteristics, research funding has considerably increased in universities that had less funding in the starting point. Similarly to publication and citation numbers, the convergence trend stops in the year 2000 and shows a sign of a reverse trend (Table 4-8). It is still possible that after the initial 10-year stage of convergence the concentration mechanism starts to play a role.

Discussion

This study shows that the policy reforms that started in the end of 1980s have had an important impact on research performance in Australian universities. Universities have improved their research output over the years. There is also evidence of different growth rates in the sector. The concerns that a more competitive research environment has resulted in a greater gap between universities are not confirmed by this analysis. We found evidence of absolute convergence – i.e. universities have become more similar in their research productivity. Lower performing universities have been catching up to better performing universities.

The analysis of publication numbers also shows that universities are not approaching a uniform level of research productivity, but they are approaching individual ceilings determined by their structural characteristics. The speed of adjustment is faster when individual capacity ceilings are taken into account. Universities have thus rapidly maximized their research output according to the limits of their individual capacity and then the research performance stabilizes.

This evidence is in line with research productivity trends in the UK – another country that implemented a large-scale performance reform in the end of 1980s. The researchers have suggested in the case of the UK that the performance reform in higher education has a one-time effect; the reform improves the system, but the improvement is not constant (Geuna and Martin 2003). Evidence in Australia seems to confirm this idea. The performance reform has behaved like a one-time shock, increasing the productivity level in the system, but it is not a mechanism for constant improvement. Productivity increase may be technically easier to achieve at a relatively low starting point. This of course does not undermine the value of the performance reform since all the universities are now performing at a higher level. It is also unlikely that the government can bring additional change by intensifying competitive pressures even further. As discussed in the introductory chapter, policy changes have been gradual, inserting more and more elements towards greater competition. Yet the trend in publication activities and publication convergence seems to be quite consistent over the period. The speed of the catching-up trend has consistently declined over time and finally seems to have reversed.

We started the study with two hypotheses: the sector may experience convergence because of a homogenized research market or, alternatively, the sector may be concentrating due to the winner-take-all mechanism in the sector. The evidence supports the idea of convergence, but it is conceivable that both hypotheses are correct. Unification of the system was a structural change, which had a major impact on the market structure. This impact lasted for 10 years and faded away around 2000. It is conceivable that only now will the potential winner-take-all mechanism, which is more nuanced, demonstrate its effect. It will be interesting to see how the market behaves in the first decade of the new century, now that the decade of convergence seems to be over. The evidence shows that the dispersion has systematically declined, but the decline was completed by the year 2000. In this decade we could expect the market to be either stable or concentrating. It is possible that the universities have achieved optimal long-run research performance and that the market has achieved optimal structure. But it is also conceivable that we will observe the forces that earlier were hidden by the effect of the structural reform.

The idea of convergence and market structure in research performance adds interesting evidence in light of current discussions in the Australian higher education system. A recent proposal suggests that the Australian higher education market should be more formally segmented: research intensive universities, regional universities, and teaching oriented universities should have a different treatment and funding formula from the government in order to best fulfill their function in the society (Meek et al 2008). Strictly within the limit of this study, it could be an appropriate timing for this kind of market segmentation. Potential effects of the performance reforms have been utilized and by now exhausted. The catching up effect has stopped and no further spontaneous integration of the market is likely. Creating different strategic groups in the market may function as a protective framework against the potential winner-take-all mechanism.

While this paper cannot conclude that the gap between Australian universities is expanding, inequalities between universities may nevertheless be perceived as more severe. Research results are now more visible and easily comparable between universities, which makes performance gaps more obvious. The differences may have also become more real because performance differences are increasingly expressed in unequal financial rewards.

Ten years has thus been a critical period in the Australian higher education market and the year 2000 completed one era. The stabilizing of the market structure in 1999/2000 should not be attributed to major policy changes or environmental changes, but to gradual fading of the long-term performance improvement. The next ten years is likely to reveal a very different dynamics.

TABLES

Table 4-1 Absolute convergence in the number of publications

	OLS		RE	
	Coeff.	St. err.	Coeff.	St. err.
(ln) publications	-0.064***	0.006	-0.065***	0.005
Constant	.02***	0.005	0.02***	0.007
R-square	0.261		Within: 0.243 Between: 0.664 Overall: 0.261 rho 0.009	

Note: Dependent variable: (ln) growth rate of publications. *** p<.01; **p<.05, *p<.10.

Table 4-2. Absolute convergence in the number of publications by years

	B-coeff.	St.err.	Const	R-sq.	σ	N
1992	-0.094***	0.024	-0.026	0.435	0.871	35
1993	-0.081***	0.011	0.055***	0.496	0.848	35
1994	-0.060***	0.023	0.047**	0.229	0.804	36
1995	-0.066***	0.019	0.014***	0.375	0.776	36
1996	-0.066***	0.025	0.027***	0.238	0.754	36
1997	-0.044***	0.018	0.037**	0.203	0.725	36
1998	-0.045***	0.016	0.030***	0.127	0.709	36
1999	-0.065***	0.018	0.122***	0.247	0.698	36
2000	-0.024*	0.013	0.061**	0.057	0.648	36
2001	0.024**	0.012	0.007**	0.114	0.634	36
2002	-0.012	0.013	0.019	0.024	0.641	36

Note: Dependent variable: (ln) growth rate of pc publications. *** p<.01; **p<.05, *p<.10.

Table 4-3 Conditional convergence in the number of publications, OLS

	Model 1		Model 2		Model 3	
	Coeff	St. err	Coeff	St. err	Coeff.	St. err
(ln) pc publications	-0.064***	0.006	-0.122***	0.023	-0.095**	0.046
PhD			0.0012	0.0009	0.002	0.001
Age			1.406***	0.379	1.448***	0.396
Age squared			-0.131***	0.033	-0.135***	0.037
Senior staff			0.003*	0.001	0.001	0.003
Student/staff			-0.001	0.0017	0.003	0.003
Teaching only			-0.0003	0.0006	0.001	0.001
Med School			0.046***	0.013	0.044**	0.022
Interactions w the number of campuses						
PhD					-0.0002	0.0002
Age					0.008	0.008
Age squared					-0.009	0.001
Senior staff					0.001	0.0009
Student/staff					-0.0014*	0.0008
Teaching only					-0.0003	0.0002
(ln) pc publications					-0.006	0.008
Med School					-0.001	0.004
F test (interactions)					1.20	
p values					0.30	
Constant	.02***	0.005	-3.87***		-4.07***	
No obs.			394		394	
R-square	0.261		0.344		0.351	

Note. Dependent variable: (ln) growth rate of publications. *** p<.01; **p<.05, *p<.10.

Table 4-4 Absolute convergence in the number of citations

	OLS		RE	
	Coeff.	St. err.	Coeff.	St. err.
(ln) citations	-0.059 ***	0.008	-0.75***	0.10
Constant	0.166 ***	0.017	0.190***	0.19
R-square	0.124		Within: 0.180 Between: 0.260 Overall: 0.124 Rho: 0.09	

Note: Dependent variable: (ln) growth rate of citations. *** p<.01; **p<.05, *p<.10.

Table 4-5 Absolute convergence in the number of citations by years

	β -coeff.	St.err.	Const	R-sq.	σ	N
1992	-0.082***	0.023	0.235	0.355	0.988	35
1993	-0.067***	0.013	0.251	0.392	0.977	35
1994	-0.044**	0.017	0.176***	0.156	0.953	36
1995	-0.069**	0.027	0.191***	0.247	0.922	36
1996	-0.074**	0.030	0.218***	0.192	0.931	36
1997	-0.062***	0.016	0.181***	0.161	0.881	36
1998	-0.030	0.020	0.120**	0.03	0.865	36
1999	-0.066**	0.028	0.291***	0.115	0.800	36
2000	-0.030	0.038	-0.074	0.056	0.751	36
2001	-0.002	0.031	-0.070	0.000	0.774	36
2002	-0.029	0.018	-0.114***	0.005	0.822	36

Note: Dependent variable: (ln) growth of citations *** p<.01; **p<.05, *p<.10.

Table 4-6 Conditional convergence in the number of citations, RE

	Model 2		Model 3	
	Coeff	St. err	Coeff.	St. err
(ln) pc citations	-0.077***	0.018	-0.037	0.022
PhD	-0.001	0.001	-0.002	0.002
Age	0.155	0.806	0.803	0.862
Age squared	-0.027***	0.072	-0.08	0.077
Seniority	0.003	0.003	0.003	0.006
Student/staff	-0.006***	0.002	-0.002	0.005
Teaching only	-0.0001	0.0008	0.002	0.001
Med School	-0.025	0.035	-0.016	0.056
Interactions w campus				
PhD			0.001**	0.0005
Age			-0.015	0.01
Age sq.			0.0006	0.001
Senior staff			-0.0005	0.001
Student/staff			-0.0006**	0.0003
Teaching only			-0.028***	0.008
ln (citations)			0.003	0.014
Med School			14.48	
F test (interactions) p values			0.03	
Constant	-0.292	2.23	-1.755	2.42
No obs.	394		394	
R-square	0.187		.208	

Note: Dependent variable: (ln) growth of citations. *** p<.01; **p<.05, *p<.10.

Table 4-7 Absolute and conditional convergence in research funding

	Model 1		Model 2	
	Coeff	St. err.	Coeff	St. err
(ln) pc research funding	-0.074***	0.015	-0.167***	0.038
PhD			0.002	0.001
Age			1.810**	0.763
Age squared			-0.161**	0.069
Seniority			0.002	0.004
Student/staff			-0.004	0.003
Teaching only			-0.003**	0.001
Med School			0.066**	0.03
Constant	0.806***	0.159	-3.418*	2.006
No obs.	422		422	
R-square	0.09		0.15	

Note: Dependent variable: (ln) growth of research funding. *** p<.01; **p<.05, *p<.10.

Table 4-8. Absolute convergence of research funding by years

	B-coeff.	St.err.	Const	R-sq.	σ	N
1992	-0.143**	0.066	-1.39**	0.223	0.863	34
1993	-0.013	0.056	0.291	0.004	0.814	34
1994	-0.071***	0.025	0.707***	0.241	0.816	35
1995	-0.060***	0.019	0.655***	0.097	0.808	35
1996	-0.141**	0.060	1.48**	0.370	0.806	35
1997	-0.090**	0.037	0.9198**	0.192	0.758	36
1998	-0.127**	0.046	1.336***	0.264	0.735	36
1999	-0.106**	0.039	0.125***	0.214	0.698	36
2000	-0.061	0.047	0.673	0.082	0.663	36
2001	-0.035	0.044	0.364	0.023	0.652	36
2002	-0.024	0.026	-0.171	0.018	0.677	36
2003	0.058	0.045	-0.562	0.029	0.690	36

Note: Dependent variable: (ln) growth rate of research funding. *** p<.01; **p<.05, *p<.10.

CHAPTER FIVE

THE IMPACT OF RESEARCH MANAGEMENT PRACTICES ON RESEARCH PRODUCTIVITY

The capacity to generate new knowledge is nowadays widely recognized as an engine for economic growth and social development (OECD 1996, World Bank 2002). This recognition has put universities under great pressure and public scrutiny. Universities are one of the main institutions where new knowledge is produced and governments have therefore become significantly more involved in monitoring and steering university research in almost all advanced economies. Various government level mechanisms aim to encourage and support university research.

In the last two decades the Australian government became considerably more involved in steering university research. Research funding to universities is now based on research performance, a higher share of research funds is distributed via competitive grants, universities must present their research strategies to the government, and university research is regularly evaluated at the institutional and discipline level (Harman 1998, Wood and Meek 2002 and Chapter 1 above). Universities now face a more competitive research environment and stronger incentives to excel in research. The impact of these changes on research performance, however, depends on the extent to which universities actually respond to the new incentives, revise their internal procedures and organizational structures, and consequently change their research behavior. Burke and Minassians (2002), for example, conducted thorough research on performance-based (teaching) funding in the United States and concluded that, first of all, the policy had only a marginal effect on performance because the incentives were not reflected in organizational policies, and secondly, that most people in the organization were not even aware of such incentives and consequently the policies had no effect on performance. Internal policies in a university are thus a necessary link between the governmental research policy and actual research performance in the university.

While research policies at the government level have received much attention in the academic literature, research management policies at the university level have not received equally thorough examination. 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 passively through market mechanisms or actively through direct control and support. A recent OECD study conducted a thorough case study analysis on research management policies in eight selected universities from eight different countries (Connell 2004). The study found several common trends in research management practices. According to this study, universities establish research priorities and develop strategic plans, evaluate research performance both internally and externally, and have developed principles for ethical conduct of research. The case studies also revealed that research management has become more 'professional'; i.e. universities appoint high-level academic and administrative staff responsible only for research, and universities nurture research careers in the institutions. All these trends are characteristic of Australia as well. Universities in Australia created research leadership positions, developed strategic plans, and established ethical codes and intellectual property regulations. Universities have also adopted other managerial tools, such as organizational benchmarking, performance-based funding, and internal performance assessment.

While knowledge of general trends in research management practices is accumulating, evidence about the actual impact of these practices on research performance is still lacking. When universities are indeed "seeking ways to best manage research" (Connell 2004) it is the information on the effective practices, not merely the possible practices, that is crucial. There is a lot of evidence from other sectors, both private and public, that management practices are often overenthusiastically adopted due to fad and fashion, or to ideology and belief (Staw and Epstein

2000). In the light of recent calls for “evidence-based management” and “evidence-based policy” (Pfeffer and Sutton 2006; Heinrich 2007), empirical evidence on the effect of research management practices on performance is much needed. This knowledge would be helpful not only in universities when designing appropriate management tools, but also for guiding national research policy. Implementation of the national research policy goals at the university level is an important link in the chain from the national research policy to research performance. How research incentive structures and related policies influence or impact university-level research management practices can be an important contributor to policy outcomes. As Weimer and Vining (1999) point out, implementation research can make a significant contribution to policy design.

This study aims to test the hypothesis that specific university level research management practices, adopted following the previously described Australian research policy reforms, contribute to better research performance in universities. The effect of the practices on performance will be studied over the period of 1992-2003. The paper makes several contributions to the literature on academic research management. First, it analyses the interrelationship of research management practices in universities and develops a systematic index of research management practices. Secondly it provides empirical evidence on the extent to which research management practices, jointly and individually, contribute to research performance.

The study is structured as follows. The next section will discuss the research management practices in Australian universities and the reasons for adopting the practices. Section 3 sketches theoretical arguments as to why we might expect such practices to improve research performance. The following two sections discuss data and measurement issues and develop estimation models. Section 6 presents the empirical results of the estimations and is followed by a discussion on the implications of the results and limitations of the study.

Background discussion

The ways in which research is organized in Australian universities has been restructured in the last two decades. In early 1990s most universities revised their organizational structure and strengthened their research leadership. Universities established a new high-level administrative position that was entirely devoted to research, usually called *Vice Chancellor (Research)*, if such a position did not exist before. Most universities also strengthened the role of the Dean in managing research in the academic units. As another important trend, inter-disciplinary research centers became a new locus for research activities, in parallel to traditional faculties and departments. In the experience of other countries, such organizational structure is an effective and flexible structure to facilitate and encourage research (Geiger 1990).

Some research management practices are now uniformly adopted across the sector while others are implemented only in a few universities. Strategic planning has now become a regular management practice in all universities. With a stimulus from government, universities started to develop institution-wide research strategies already by the beginning of the 1990s. In later years the *Research and Research Training Management Report*, a report that describes present performance and future goals in research and post-graduate training, became a mandatory document and a starting point for budget negotiations with the government. Research performance data has been collected in universities for more than ten years, 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 research conduct. These practices are common to all universities and were developed in a relatively early phase of the higher education reform.

Some other practices are less uniformly developed. In this study we will focus on these practices that are developed in universities to a different extent and therefore provide an opportunity for a systematic empirical analysis. They include:

- Regular school/faculty performance reviews;
- Performance-based resource allocation;
- Benchmarking;
- Strategic priorities/concentration of research;
- Research incentives for individual academic staff members;
- Research training and support;
- Upgrading staff qualifications.

Before examining the practices in greater detail we should discuss the forces that triggered universities to advance their research management. Institutional research management practices are first of all a reaction to a more aggressive research environment. As discussed in Chapter 1, research performance became significantly more important for universities' financial health and sustainability. Performance based funding of universities and a competitive research grant system provides universities with incentives to improve their research performance. Government agencies also collect and publish data on research performance. This data is further distributed by several private actors in the form of university rankings that affect revenues from the student market. Moreover, government has introduced several research review initiatives: e.g. the Australian Research Council reviewed research performance by disciplines, and the Commonwealth Tertiary Education Commission (CTEC) instituted a series of disciplinary reviews of teaching and research. Differences in research performance between universities thus have become more visible. As a result of these government initiatives, universities now face greater pressure to perform well and design organizational structures and practices that they believe will encourage and facilitate research.

Managerial practices in Australian universities nevertheless are not entirely an autonomous reaction to new incentive structures. Government has prescribed in many ways how universities should manage their research. Already one of the earliest Higher Education reform documents made explicit that the government expects a more ‘managerial’ approach to governance in universities (Dawkins 1987). Strategic planning became a common practice in Australian universities as a response to direct government action. The CTEC instituted a requirement that all universities must develop a research management plan, which in 1999 became a mandatory document that had to be submitted to the government annually. The Committee for Quality Assurance in Higher Education (CQAHE) audited all universities in 1995 and examined not only research outputs but also specific research management practices. The audit reports for example specifically analyzed benchmarking, research concentration, and the use of performance indicators in universities. Furthermore, universities that demonstrated good performance and sound practices in this audit were financially rewarded. Government policies thus directly pressured universities to strengthen their research management and to implement certain management practices.

Such pressure from the Australian government is in line with more general trends in the public sector. The prevailing tendency of public governance in the 1980s was towards performance management (Moynihan and Pandey 2004). It was based on the belief that managers can significantly influence the performance of an organization and are expected to measurably improve organizational effectiveness. The central target of public governance was to develop effective practices that would then produce performance in an organization. This ‘managerial revolution’ in the public sector also entered universities in many countries (Amaral et al 2003). The practices that Australian universities adopted for research management are not unique to universities or to research. They are identical to new management practices in public agencies more generally, as identified for example by Boyne (2003): they are related to leadership, performance oriented organizational culture, strategic planning, and human resource management.

The third factor that shapes management practices in universities is related to mimetic tendencies. Management practices often spread not because of their clear effect, but because organizations imitate the practices of others (Pfeffer and Sutton 2006). This is also the case with research management practices in Australia. Harman (1998) remarks that university practices were much more similar by the second round of the CQAHE audits in 1995, only two years after the first round, because universities studied the evaluations of other universities and adjusted their own teaching and research management practices. DiMaggio and Powell famously proposed the idea of mimetic forces that drive similarity across organizations (1983). Their argumentation well characterizes the Australian universities where a combination of coercive, mimetic and normative processes has contributed to developing specific practices.

The forces that have driven research management practices in Australian universities are thus manifold. It is universities' response to the new incentive structure, to 'managerial' expectations by the government, and to "peer pressure". But all these forces are triggered by the belief that such practices promote research performance in universities.

Theoretical perspectives

The determinants of universities' research performance have been repeatedly studied. Performance has been consistently linked to resources and input characteristics: staff qualification, age and seniority, the number of students per staff, and financial resources (Abbott and Doucouliagos 2004, Dundar and Lewis 1998, Ramsden 1999, Steven 2001). The effect of organizational practices or managerial strategies on research performance is not studied in the context of universities production function, but many empirical studies offer valuable insights into what environmental aspects characterize a productive research environment. A thorough literature review by Bland and Ruffin (1992) in the US context identifies the following characteristics at the research group level: clear goals that serve a coordinating function, research emphasis, distinctive culture, positive group climate, assertive participative governance, decentralized organization, frequent communications, accessible human resources, sufficient size, age and diversity of the research group, appropriate rewards, concentration on recruitment and selection, and leadership with research expertise and skills.

The practices that will be examined in this study are quite different in their nature. They target different organizational levels: schools and faculties, the organization overall, and individual academics. Their assumptions and mechanisms in terms of performance improvement are also different: incentives, rational planning, information, and facilitation. Theoretical understanding of research management practices and their effect on performance therefore must link different theoretical perspectives – from organizational sociology, economics, and management theories. A comprehensive theory of research management would be too ambitious a goal within the limits of this study. The discussion below only aims to clarify the main assumptions behind individual management practices and clarify the causal mechanism to potential performance improvement.

An empirical rather than a theoretical orientation seems to be characteristic of studies that evaluate the effect of organizational practices on performance in the public sector. Boyne (2003: 369) points out critically that "rigorous causal reasoning and integrated sets of precise propositions do not characterize the literature on organizational success in the public sector." The focus of such research tends to be on empirical testing of whether practices affect performance. In recent years meta-analyses have emerged that try to aggregate the experience of individual practices and create a more comprehensive understanding of factors that affect organizational performance in the public sector (e.g. O'Toole and Meier 1999, Boyne 2003, Pollitt and Bouckaert 2000). An empirical approach has its uses, keeping in mind however that management practices are often proposed and implemented on the basis of simple assumptions and expectations about human nature and organizational behavior, not drawn from the complexity of organizational theory. Empirical studies test whether these practices have the expected effect and indirectly provide evidence on the validity of these assumptions. We will now discuss briefly the general assumptions associated with each of the seven research management practices, grouping them by the organizational level they target – faculties/schools, institutions as a whole, and individual academics. Some of the practices attempt to change the behavior of individual academics and thereby improve research performance at the institutional level; the others target more the organization as a whole, e.g. concentrating research on certain fields for maximum performance improvement, and do not aim at changing the behavior of individual researchers but at organizational policies in order to play out its strengths and comparative advantages. It is thus not only narrowly the productivity of individual academics that will aggregate for the performance at the institutional level, but also strategic choices that allow universities to, for example, concentrate on certain fields where the performance is the highest or to invest in those fields to improve the performance of the university as a whole.

Faculty/school practices

The practices that affect the level of faculties and schools are likely to be of key importance. Universities are known to have a unique organizational structure. Weick (1976) makes the well-known argument that universities are 'loosely coupled systems' – where sub-parts of the organization preserve their own identity and physical and logical separateness. Basic academic units – faculties and schools – are particularly crucial building blocks in universities. An academic unit is the organizational level where main professional values are shaped and transmitted (Trow 1976; Becher and Trowler 2001). Therefore any institutional practice or government policy that aims to affect research performance probably needs to interact at the level of faculties and schools. Burke and Minassians (2002) for example suggest that the reason why performance-based funding to universities has had no effect on universities in the U.S. lies primarily in the failure to make these incentives known and tangible in the academic units.

Regular school/faculty performance reviews focus attention on what each of the university's research units has accomplished. Theorists advance quite different explanations for how regular performance reviews help management shape the behavior of others in the organization. One explanation focuses on the challenge that principals have in controlling their agents. The attempts by the government to steer universities' behavior are commonly explained within the framework of a principal-agent problem (Kivisto 2005, Liefner 2003, Ferris 1992). The public interests and the interests of universities are not necessarily aligned. Government cannot directly interfere with the everyday actions of a university, but it can provide rewards to universities in such a way as to align the interests. The principal-agent dilemma however is not limited to government-university relationships but extends as well to internal relationships within the university. The interests and incentives of the central administration of the university are not necessarily aligned with those of the academic units. A new incentive structure that government imposes on universities is not likely to be effective unless the incentives can be transmitted to lower level units. In most cases lower level units are better positioned to affect actual academic performance.

Many universities have implemented regular formal faculty/school reviews. This is a thorough examination of performance outputs in research and teaching as well as an evaluation of resources and practices, usually every 4 or 5 years. A more intense form of performance monitoring often accompanies these thorough reviews. Annual or biannual reviews of main quantifiable performance outputs are an increasingly common form of regular performance monitoring. The reviews are a direct reaction to the principal-agent problem. As Ingraham and Kneedler (2000: 238-9) point out, "After all, the central concern of the principal-agent theory is how principles can control the behavior of their agents."

Performance review in itself does not improve performance, but some mechanism has to trigger performance improvement. Reviews and evaluations in universities are first of all a control mechanism and their purpose is to increase accountability in the academic units. Sanctions related to poor performance review are likely to encourage attention to performance. Also, performance improvement requires an adequate overview of present performance and information on weaknesses. The mere existence of performance evaluation and performance indicators in particular may lead to higher achievement (Boyne and Chen 2006). Behm (2003) sees the contribution of performance measurement, among other factors, in an organizational cultural aspect. Evaluations and performance measurement can be part of the rituals that tie people together, give them a sense of their individual and collective relevance, and motivate future efforts. Faculty reviews in Australian universities may thus improve the performance for a combination of reasons: the evaluation may provide information that is needed for performance improvement, it may encourage more effort in the fear of financial or moral sanctions, or it may help to consolidate academic staff for performance improvement.

Performance-based money allocation is another reaction to the principal-agent type problem. Government uses a performance-based formula when allocating research funds to universities. This formula considers publication outputs, external funding, and doctoral degrees. Some universities have adopted a similar formula also for their internal money allocation from the central budget to schools and faculties. Some 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 the student load or other input related criteria. The arguments for performance-based funding are twofold. First, it is a mechanism that channels funds to the most productive units, and secondly, it provides direct financial incentives for academic units to improve their performance. This is thus the purest form of aligning the interests of the university and of the academic unit as conceptualized in the principal-agent framework. Internal performance-based money allocation is therefore expected to increase research performance because it motivates faculties to increase their research output and it channels resources to where most output can be achieved.

Institutional level practices

The two institutional-level practices that we will examine are benchmarking and research concentration. The practices are quite different in nature but they both have to do with institutional level strategic decision-making. They are management tools that are expected to improve performance in a university.

Benchmarking is a management tool associated with the Total Quality Management approach, in the context of both private and public organizations (Yasin 2002). In a benchmarking exercise organizations compare their performance outcomes and processes to the *best practice* in their sector. To some extent all Australian universities compare their performance data with those of their competitors because performance data are made easily available by the government. However, benchmarking is a more systematic exercise than merely comparing outputs. Benchmarking is defined as "analyzing performance, practices, and processes within and between organizations and industries, to obtain information for self-improvement" (Alsete 1995:20). The extent to which Australian universities are engaged in such activities varies greatly.

The Commonwealth government has strongly encouraged Australian universities to develop benchmarking practices. The government also initiated and funded the development of a detailed benchmarking manual for Australian universities (McKinnon et al 2000), which is a well-known and widely used source in universities. By now universities with similar backgrounds have cooperated in sharing information that can be effectively compared. For example, the Group of 8 (i.e. research intensive universities) has made arrangements to exchange data that could be used for benchmarking exercises, and a similar initiative has been developed in universities with a technical profile. 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. In the time period that is analyzed in this study only a few universities had a mature benchmarking system: i.e. had identified important performance indicators, selected local and international peer institutions and compared the performance of each discipline with these peers. On the other hand, benchmarking has become a more common practice in universities over the years.

The mechanism from benchmarking to improved research performance in universities is somewhat like a "black box". The hypothesis that benchmarking exercise improves performance in universities, as assumed by the government, is based on the idea that knowledge about "best practices" in the field would necessarily lead to more knowledge-based governance, reflection on one's own performance, organizational learning, adjustment of organizational practices, and consequently to better management. Better management would then lead to better research performance. Benchmarking can also be seen as another accountability mechanism. When an institution benchmarks the research output of each faculty with respect to local or international competitors, then the mechanism functions as another monitoring mechanism for individual faculties.

The causal link between benchmarking and actual university-level research performance remains here intentionally generic. Instead of trying to deconstruct how benchmarking affects performance – for example through adjustments in human resource policies, governance structures, or research management practices –, benchmarking is taken as a factor of its own. Universities may for example consider adjusting internal resource allocation, research infrastructure, internal research policies, division between teaching and research – all of which may affect research productivity in the institutions. A generic benchmarking measure tests the hypothesis that benchmarking as a management practice helps universities to identify the weakest aspects in organizational management or performance, whatever that might be in any given university, and address these weaknesses effectively.

Concentration of research activities in certain disciplines or study areas is another institutional-level policy that is expected to improve research performance. The government has encouraged universities to identify their areas of strength and concentrate resources to these areas, especially in the more recent documents. Universities have developed the concentration to a varying degree. Some universities have clearly identified their research priorities and prioritize these areas when allocating resources or hiring new staff. Other universities have identified areas of strength but do not provide any additional resources or preferential treatment. Some universities use research centers as a bottom-up selection mechanism for research priorities. These universities have not chosen directly strategic fields but they have identified criteria when research groups qualify for an institutionally supported research center. These research centers then enjoy some preferential treatment.

The assumptions as to why strategic research concentration would improve research performance in a university are twofold. First, concentration would allow universities to strengthen their competitive advantage, focus investments, create critical mass and high quality research infrastructure, and thereby improve performance in selected fields. The improvement in the selected fields would raise the overall performance of the university. Secondly, concentration would mean that scarce resources are used in areas of high performance - and thus give the highest return - and would be shifted away from weaker areas. A university would thus specialize and thereby increase its efficiency and performance.

Research concentration is one aspect in strategic planning in universities. It requires a decision from the university leaders about what fields would be strategically wise to concentrate. Strategic planning in general terms started to develop in Australian universities in the early phase of the reform at the end of 1980s and the practice has developed since then (Anderson et al 1997). By now all universities have a strategic plan and more detailed objectives are specified in operational plans. There is considerable evidence of the positive relationships between planning and performance in private firms (Miller and Cardinal 1994), but the relationship between planning and public organizations is less clear (Boyne 2001). Strategic planning is likely to face particular complications in the academic sector. Universities have a unique, fragmented nature where identities, loyalties and norms are often more linked to the faculty and disciplines than to the institution as a whole (Trow 1976). This is likely to complicate the strategic planning approach that often requires trade-offs between different academic units in the interest of the organization as a whole. Such decisions would be in conflict with the traditional collegial decision-making system in the academic sector, which is based on consensus and consideration of the interests of all. The collegial management style was explicitly criticized as ineffective by the Commonwealth government at the beginning of the reform cycle (Dawkins 1987).

Research concentration would increase university level research performance if indeed specialization and "critical mass" in universities have positive benefits; it would have no effect if it could not be carried out, even when stated, because of organizational obstacles or if specialization would only shift resources away from other fields without a relatively bigger impact on the preference fields (i.e. that the losses for secondary fields would exceed the gains of priority fields); or it may have a negative effect if there are scope effects in universities where the balance of disciplines actually promotes performance.

Human resource management

Human resource practices are perhaps the most studied element of organizational management in the context of performance. The practices are widely studied in the private sectors and in most studies reveal a positive effect on performance (Huselid 1995, Black & Lynch 2001, etc.). Human resource practices differ in their approach toward how to achieve performance improvement. Legge (1995) distinguishes hard and soft styles of Human Resource Management (HRM). The hard style of HRM sees staff as instruments that can be manipulated for better performance. This approach focuses 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 components.

Individual incentives that reward research productivity have become more common in Australian universities. Universities have strengthened individual level accountability and monitoring measures in various ways. Regular staff appraisal, unknown 20 years ago, is becoming a widespread practice. Some universities have created direct incentives such as performance-based pay for individual academics or adjustments in teaching-load depending on research productivity. Individual incentive practices are motivated again by the principle-agent logic. The practices assume that without external motivators researchers are not interested in maximizing their research output. Therefore agents' activities must be either monitored (through performance monitoring) or encouraged with direct incentives (like salary benefits or adjustments in teaching load). The extent to which academics are responsive to external incentives is an intriguing issue. Indirectly all academic staff now has incentives to perform well in research, as research excellence ensures prestige, recognition and opportunities for career mobility. There are thus strong incentives in place via career benefits. Moreover, in the academic profession the reason for choosing the profession may be more intrinsic (interest and enjoyment of research) and external incentives such as salary bonus may not really affect the actual incentive structure of researchers. Kreps (1997) moreover suggests that in the case of professions with strong intrinsic motivation extrinsic incentives may actually harm the motivation.

Support structure that facilitates research activities may be an equally or even more effective way of encouraging research performance than external incentives. Many efforts in Australian universities in the area of HRM focus on support and staff development. Mentoring of early-career researchers, providing workshops on grant and publication activities, offering methodological help, providing near-miss grants and other funding opportunities – all these efforts create an environment that enables academic staff to become more productive.

Upgrading staff qualifications is another HRM measure that is likely to improve research productivity at the individual level. Lack of academic staff with adequate research qualifications was a significant problem in Australian universities, especially in early years. As a result of the unification of the higher education system, many universities lacked qualified research staff due to the fact that staff in former CAEs rarely had research training. Upgrading Staff Qualifications was an official government program in early 1990s. The program provided opportunities for academic staff, especially in the former CAE sector, to complete their PhD training. Universities' commitment to the program varies however, especially since the completion of the unification. Universities that take this upgrading seriously have developed policies of time release and incentive schemes for the degree completion. This scheme is likely to increase research performance because not only does it provide necessary research qualifications but it also strengthens research culture within the organization. It may be the case that the measure has a more of a significant time lag than other measures.

There are thus three human resource practices that will be analyzed in this paper: incentives (staff appraisal and performance rewards), support structure (workshops, mentoring, certain funding mechanisms), and upgrading research qualifications.

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

Research management practices: measurement and index

The study estimates the effect of research management practices on research performance. The dependent variable is thus research output, which will be measured as the number of publications and citations in a university. The justification of the measures, their limitations and data sources, were discussed in Chapter 3. The chapter also described the nature, sources and descriptive statistics of control variables. The measure of research management practices requires a more detailed discussion in this section.

Data source for management practices

Tracking management practices retroactively over a 15-year period could be a difficult task but 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 information on universities that is verified by external evaluators. We will use audit reports from two audit cycles: that conducted in 1995 by the CQAHE (Committee for Quality Assurance in Higher Education), and the one carried out in 2002-2007 by the AUQA (Australian Universities Quality Agency).

The tradition of institutional audits goes back to early 1990s. In 1991 the Minister of Employment, Education and Training announced a quality assurance program (*Higher Education Quality and Diversity in the 1990's)* and subsequently established a Committee for Quality Assurance in Higher Education as a non-statutory ministerial advisory committee. The quality assurance program arguably was implemented primarily for political reasons. The Minister needed to demonstrate his commitment to assuring quality in the higher education sector in order to negotiate from the cabinet additional funding for the sector (Harman 1998). The quality assurance program had a unique structure. It invited universities to participate in a regular review of their quality improvement policies and their research and teaching outcomes. Participation in the review process was voluntary for universities. Since participation was linked to additional funding, all universities chose to participate. The program was also unique because it evaluated institutions rather than individual disciplines. The committee believed that such a holistic approach had the advantage of "involving much of the university in a process of self-analysis on a regular basis" and of evaluating "policy and commitment to the future rather than a 'snapshot' of current activities" (CQAHE 1995). As a result of the program, universities had an evaluation round every year. In 1993 all aspects of universities' activities were evaluated, while the 1994 audit concentrated on teaching, and the 1995 audit focused on research, research training and community service.

The 1995 audit cycle provides systematical information on internal research policies and is a good source for this study. The Committee and its team evaluated universities' research activities and placed universities into three groups sorted by their research processes, research outcomes, and research improvement. All universities received a score for each of the components, which were then aggregated into an overall score. Based on the overall score the government awarded a financial bonus to universities. For the purpose of this study, the overall score is however too broad a measure. The score includes not only policies that support research productivity but also policies on doctoral training and community development. Fortunately the narrative review reports provide detailed information on universities' research management practices. The individual reports are almost identical in their structure and comparable in depth. Guidelines of the audit exercise (CQAHE 1995) specified a list of organizational instruments that were under special attention – e.g. concentration of research, the use of performance indicators, benchmarking, and staff development – which enforces consistency in the evaluation reports.

After the 1995 audit round the program was terminated because of high administrative costs. Instead of the regular external audits, all institutions were now required to present a quality assurance and improvement plans to the Ministry. These plans are publicly available (see DETYA 1999), but their quality and format varies too much for a valid cross-institutional comparison. In 2000, the DEST established Australian Universities Quality Agency (AUQA) with one of its tasks being to conduct periodic quality audits in universities. The first universities were audited in 2002 and by 2007 all comprehensive universities had gone through the audit cycle. These audit reports are broader than the ones from 1995 because in addition to research they also evaluate teaching, community service, human resource management, governance and other factors. Therefore research management practices are often not discussed as fully as in the

1995 reports. Moreover, some practices that were examined in the 1995 report were ignored in the later report because they had become common and expected (e.g. internal performance-based money allocation). In order to avoid the bias against the later time period, an additional source was consulted. As part of the 1999 *Knowledge and Innovation* reforms (Kemp 1999) in universities are now required to develop and submit a Research and Research Training Management Reports (RRTMP) to the DEST. These reports provide detailed information on internal research policies and help to fill the gaps that the audit reports may have had. In this study RRTMPs are used only to verify whether information in the audit reports is complete. Since RRTMPs are used in the funding negotiations with the government, they have a strong promotional character and are not always neutral and objective. Nevertheless, factual information, such as, for example, the internal mechanism for money allocation, is probably trustworthy in this source.

Operationalization of research management practices

The audit reports provide descriptive details on research management practices in universities but the information is in a narrative form and needs to be made operational for a quantitative analysis in this study. First each university's audit reports of the 1995 and 2002/7 audit cycle were collected and then the reports were analyzed with respect to the seven major clusters of research management practices identified earlier. Each university achieved a score from 0 to 2 for each of the seven policies, based on a scoring rubric (Table 5-1). A score zero indicates the absence of the practice or very weakly developed practice; the score two means that the practice is fully developed and functioning. The score one indicates that the practice has been applied and developed to a limited extent. In the later period practices had become more nuanced and on some occasions half-units were used to accurately capture differences between universities.

As seen from the rubric, the emphasis is on the functional presence of certain practices, not the evaluation team's judgment of universities' management practices. This is to avoid potential problems, such as different audit teams having different expectations that lead to assessments that are not comparable, or evaluation teams being subject to a 'halo effect' that inclines them to give higher scores to well-known universities. The evaluation of the audit team is considered only when a practice is formally present but has not really been implemented and is functioning by the judgment of the evaluation team. The nature of the data does not permit a more rigorous scale development for each management practice.

Descriptive statistics (Table 5-2) show significant variance in management practices across universities. It is also evident that on average all management practices were more developed in 2002/7 compared to 1995. The only exception to this rule is the practice that upgrades staff qualifications. This is an expected result since improvement of staff qualifications is strongly associated with the problems of the structural unification of the system. In the early 1990s some universities were lacking qualified staff and had a very low share of academic staff with doctoral degrees. While most universities developed some policies in this area, including the highly performing universities that were often merged with former colleges, the importance of this activity faded with time. Although all practices are more developed in the second period there is still considerable variance across universities. All scores vary between 0 and 2 in the second period, with the exception of research concentration that is consistently above 1 in the second period. This probably reflects the strong pressure from government on universities to develop research concentration plans, even if these plans are not fully implemented.

The correlations between the same research management practices in the first and the second period is not very high, varying between 0.009 and 0.497. Low correlation coefficients suggest that practices in the later period were not heavily influenced by earlier choices of universities. Universities that did not implement practices early on were capable to catch up easily in the later period. While correlation coefficients tend to be low, they are still all positive.

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 not very high. Upgrading staff qualifications has a consistent negative correlation with other management practices. Upgrading staff qualifications is a priority in universities with lower research performance and these universities either do not have the resources, capacity, or do not see the need to develop other practices as soon, and focus on staff qualifications. In the early period, performance-based budgeting has the strongest correlation with other practices and the correlation is mostly positive. The only exception is the staff upgrading, which has a strong negative correlation. This seems to suggest that performance-based funding is a fairly advanced management practice that is in place if other practices are in place. The relationship is much stronger in the first period than in the second period. Concentration is another management that shows some minor negative correlation with other practices. It may suggest that it is a strategy that focuses attention on certain fields, not on management practices in the institution as a whole. Interestingly the correlation between the same practices in two time periods is not very high, indicating that management practices have been quite volatile.

Research management index

The effect of the seven research management practices could be studied either individually or as an aggregated system of practices. Both approaches have their advantages. A technical problem of the management practices is that they are not independent. Some universities have been more active in developing the practices or developing them faster, and this initiative is reflected in most practices. The correlations between practices are not very high but clearly present (Table 5-2). This interdependence points to the weakness of studying only one or a few practices. A study that focuses only on one practice would attribute an effect on the single practice, ignoring that the specific practice is likely to me associated with other research management practices. A statistical estimate for the individual practice would be thus biased upward.

The practices could be included simultaneously in a study which would alleviate the bias. Alternatively the practices can be aggregated. This would lead not only to a more parsimonious model, but may also provide with more informative and conceptually more accurate results. An index implies that it is the single system of practices that is a strategic asset to the organization and drives performance (Becker and Huselid 1998). There may be multiple ways how universities can design their management practices. For example, a strong emphasis on one or two practices would have the same effect as more modest attention to a range of policies. An aggregated index would thus test the hypothesis that "more is better". The primary focus of this study is the extent to which universities with active research management practices demonstrate better performance and the aggregated approach is well suited for this purpose. In addition, an index has also a technical advantage. It makes the scale of research practices closer to an interval scale while individual practices are measured on an ordinal scale from 0 to 2 where a unit change in a score is arbitrary.

An aggregate measure of university's research management system may be therefore conceptually more accurate. We would assume that it is a system of management practices that drives performance. Such measure can be constructed in two different ways – either by a simple aggregation of individual practices (e.g. Koch and McGrath 1996 for sub-grouping HRM practices) or by a factor analysis (e.g. Huselid 1995). Empirical literature on research management practices is basically absent and therefore cannot provide the assurance that it is theoretically appropriate to focus on a single comprehensive measure of research management system by aggregating individual scores. Therefore we have to depend on exploratory data analysis to verify the reliability of such uni-dimensional scale. Factor analysis may indicate for example that the practices represent more than one distinct dimension of the management system and an arbitrary combination of multiple dimensions into one measure would create unnecessary reliability problems.

Potentially universities can choose multiple strategies and adopt different sets of performance policies. The correlation table (Table 5-2) gives some preliminary insights on how the policies are interrelated, but a formal factor analysis can give a more systematic understanding for constructing an index. Considering the smallness of the sample size, the results should be taken as suggestive rather than definitive. In order to discover the underlying factor structure associated with these practices, and not hypothesizing an underlying latent variable, the exploratory factor analysis using principal component extraction is used without rotation. The factor solutions are presented in Table 5-3.

Policies are separately analyzed for the two periods. Two factors emerged in the first period and three in the second period when keeping the factors that have eigenvalue greater than one. There is some difference in the structure of the practices in the two periods but the overall pattern is quite consistent. In the first period, most practices load unambiguously on the first factor, even though the loadings are not always very high. The exception is research concentration, which seems to be an independent dimension and constitutes the second factor. Benchmarking loads both to the first and the second factor, although with a negative sign on Factor 2. Upgrading staff qualification is a part of the first factor, but with a negative sign. In the second period again most management practices load on the first factor, except concentration, and upgrading staff qualifications. In general, loadings in the second period are much higher, suggesting that universities have become more segregated in terms of their management practices. The second period confirms the patterns of the first period. Research concentration and upgrading staff qualifications forms an independent dimension.

To generalize from these results for the two time periods, five practices can be considered as one dimension of research management system: faculty reviews, performance based funding, benchmarking, incentives, and research support structure. The concentration of research seems to be an independent dimension in research policies 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, the qualifications upgrading is expected to loose its explanatory power when the model will explicitly include staff qualifications as a control variable, which presumably will mediate the effect. We will therefore treat this practice also separately. In sum, the index of management practices consists in simple aggregation of the scores of the five management practices. The concentration and upgrading staff qualifications are both treated separately.

The index used here is thus a simple aggregation of scores, not a scale that is based on factor loadings. The logic of using such aggregated score comes from a conceptual meaning of the index. The aggregated index is meant to test the hypothesis that more (and more intensive) research practices improve universities' research performance. A scale that is based on factor loadings would have a different conceptual meaning. It would assume an unobserved commitment by the university to research management that expresses itself through various research management practices. The practices that have higher factor loadings would thus be better predictors of the unobserved commitment. With a measure like this we would be exploring the effect of such unobserved commitment on performance, not the effect of the practices itself. This is however not what is being assumed in this paper, but the scale measure is nevertheless used to check the robustness of the results.

Time period

We will combine the data of management practices from two points in time with annual data of research outputs and control measures over a 10 year period. It is reasonable to assume that policies do not change on yearly basis and their effect also evolves over years. The year 1995 is the first point for the 'snapshot' of the research management practices in universities and represents well the situation in early and mid 1990s. The 1993 audit described a somewhat chaotic era when universities were reacting to major policy changes but the 1995 audits give a clearer picture of what practices the organization had implemented and whether they were functioning. The performance data that will be linked with the 1995 management 'snapshot' goes back to 1992. Organizational policies cannot have a retrospective effect on outcomes but it is reasonable to assume that policies – internal performance based funding, for example – take time before they are fully implemented and effectively functioning and must have been around in the institution for years. Also the planning phase itself – e.g. designing formula for internal resource allocation – is likely to trigger a response from subunits before the formal implementation of the policy. On the other hand, policies are not changing drastically from year to year and their effect can be expected to last also for the subsequent years. The 2002-2007 audit reports represent a more mature phase of universities' policies. The effect of 2002-2007 policies also goes back to previous years, assuming that there is some consistency in policies. The analysis is therefore separated into two time-periods, plus/minus three years from the point of measurement: 1992-1998 and 1999-2002. The year 1999 is a valid break point also because of an important change in research policy. Among other reforms universities were obliged to submit Research and Research Training Management Report (RRTMR) to the Ministry where they must report not only on their performance but also on concentration and internal research management. The reports indirectly forced universities to revise their internal practices (Wood and Meek 2002) and thus it is more likely that universities changed their practices around this time. The second period ends with 2002 as the data series stops there.

Models

In order to study the effect of research management practices on research productivity we will augment the commonly used research productivity function with the measure(s) of research management practices. Research production function is usually an adaptation of a firm's production function where a firm's output is a function of its capital and labor inputs. The basic function can be further augmented to allow differences in technology or organizational practices (e.g. human resource management in Black and Lynch 2001). Research output can be approached in a similar way. Research output is a function of capital, such as research funding and infrastructure, and of quantity and quality of labor (e.g. Adams and Clemmons 2006, Johnes 1988, Abbott and Doucouliagos 2004). The contribution of this study is to expand the commonly used production function and include also research management practices among the determinants of research productivity.

The dependent variable in this study is labor productivity in a university, i.e. the number of publications per academic staff member. The study hypothesizes that productivity is a function of research management practices, either in the form of the aggregated management index or individual policies. Productivity is influenced also by other characteristics as demonstrated by earlier research (see Chapter 2). Academic staff characteristics influence productivity, such as the position and age of staff, research qualifications (measured with the share of staff with PhD degrees), and division between research and teaching functions. Research productivity is influenced by alternative time commitments, most importantly teaching load. The number of students per staff member is a measure of alternative time commitments that constrain research and publishing. Different disciplines have demonstrated different publishing practices. A dummy variable for universities that have a Medical School is expected to capture some of the disciplinary mix in universities that may affect research productivity.

Including research capital in a labor productivity model is more controversial. Research funding is a widely used measure of research capital (Adams and Clemmons 2006, Abbott and Doucouliagos 2004). Research requires financial resources and research funding is important for research performance. The problem of including research funding in the productivity model is the direction of this relationship and causality between research output and financial resources. The main source of research funding is either competitive research grants or the performance based element in the operational grant. These funds are clearly dependent on research productivity. Research funds and research productivity are so closely related that research funding has often been used as a measure of research productivity (e.g. Koshal and Koshal 1999). We will therefore omit research funding from the list of control variables. Omitting research funding may be also conceptually more accurate. Research funding is probably a mediating variable: i.e. well performing universities are successful in attracting research funding which then leads to good research output. If research funding is a mediator between university inputs/characteristics and performance then controlling the model for research funding would bias the estimates downward. The effect of management practices would not capture the entire effect of positive practices on research productivity, but only the effect on publishing activity with fixed research funding. However, research income is a widely used output measure because it has many advantages over bibliometric measures, such as reflecting the quantity and quality of ongoing research instead of completed research and being based on rigorous peer evaluation, etc (see Chapter 3).

In the literature on organizational performance, it is not uncommon to make inferences about the effectiveness of organizational practices based on the positive association between outputs and practices in a cross-sectional format (Koch and McGrath 1996, Huselid 1995, etc). The first estimation model is thus a pooled OLS model.

$$y = \alpha + \sum_{k=1}^{K} \beta_k x_k + \sum_{m=1}^{M} \gamma_m z_m + \varepsilon \qquad \text{(Model 1)}$$

where y is natural logarithm of the number of publications per academic staff members in the university; x signifies k control variables, and z signifies management practices. Since we have the measurement of management practices from the two points in time, we will estimate Model 1 also for two time-periods – 1992-1998 and 1999-2002 period. This is a reasonable compromise between having a sufficiently large number of years to obtain potential fixed effects and few enough to assume that the management practices as measured in the one-time period is a valid generalization for the period as a whole. This division into two periods also gives a better insight to potentially different effects of management practices in different stages of policy reforms and organizational reforms.

A pooled OLS is likely to have two problems in this particular case. First, the identified control variables are not likely to capture the variance in research productivity in an unbiased way. There is likely to be unobserved heterogeneity in the sample, causing a significant omitted variable bias in an OLS estimation of research productivity in Australian universities. While variables like staff composition may indicate to a significant effect on research productivity, it may be rather a certain type of university (with a strong research culture) that influences both the staff composition as well as research productivity. In a cross-sectional format, the coefficient of the staff composition would be consequently biased upward. Using panel data will alleviate the problem.

With a fixed effect model we can control for the time-invariant omitted component and correct the coefficients. While fixed effects are likely to be a more accurate form for capturing the true effect of control variables, information on management practices, which is collected only from two time-points and is not fully time-variant, cannot be included directly. Conceptually it should not be a problem because practices tend to change slowly and need time to be implemented and to have an effect. Technically it is a problem though because the potential effect of management practices would be entangled in the time-invariant university specific component. Therefore a three-step Fixed Effect Vector Decomposition (FEVD) procedure is used, as described in Plümper and Troeger (2007). In the first step, a fixed effect model is run for obtaining unit effects. In the second step, the unit effects are decomposed into two parts: a part explained by time-invariant variables and the unexplained part (i.e. the residual). In the third step, the model is reestimated by pooled OLS, including time-variant variables, time-invariant variables, and the error term in stage 2 (which counts for unexplained unit effect). The estimation model is in the following form:

$$y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{kit} + \sum_{m=1}^{M} \gamma_m z_{mi} + u_i + \varepsilon_{it} \qquad \text{(Model 2)}$$

where y_{it} is natural logarithm of the number of publications per academic staff members in the university i and time period t; x signifies k time-variant control variables, z signifies time in-variant management practices; u is time-invariant unit effect, and ε is random error. The estimation will be run for two time-periods separately.

This three step procedure does not solve all the problems. The heterogeneity bias is a serious concern in performance models like this. A positive relationship between performance and practices does not mean necessarily the positive effect of such practices. Productive firms may have more resources and capacity to develop better human resource policies, for example, and the positive effect between human resource policies and performance is perhaps not causal. Universities are probably not equally likely to develop and adopt research management practices. It is likely that universities that have strong research performance and research culture have the capacity and motivation to develop such practices. A positive relationship between performance and management practices may actually indicate a reverse causality, from performance to management practices. It is therefore likely that the unexplained variance and the management practices are both still triggered by a common, unexplained variable. One solution to this problem is to examine the growth in research productivity, not the absolute productivity. Last chapterdeveloped a model for growth in research productivity. The model assumed that the rate of growth is the function of the distance between the actual level of research performance and the capacity limit as determined by the input quantity and quality measures. The input measures were identical to the control variables identified above. In this paper we will add the research management practices to the growth model. We will assume that effective management practices raise the capacity limit and have thus a positive effect on the growth rate. The model would thus take the following form:

$$\Delta y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{kit} + \sum_{m=1}^{M} \gamma_m z_{mi} + \delta\ y_{it-1} + \varepsilon_{it}\ , \qquad \text{(Model 3)}$$

where Δy_{it} captures the logarithm of the growth rate in publication numbers, y_{it-1} is research productivity in the previous year, and the other parameters are the same as above. Previous chapter demonstrated no significant clustering and omitted variable bias across the universities over time and therefore the model will be estimated with the OLS.

The growth model alleviates the problem of selection bias, but there may be heterogeneity bias also in growth rates. The heterogeneity bias can be tested in this study because the policy data is available for two time periods, for the year 1995 and 2002-7. Policies can thus be treated also as time-variant measures. This permits us to analyze the effect of change in management practices to change in research productivity. The last model will thus be a full fixed effect model with time variant research management policies:

$$y_{it} = \alpha + \sum_{k=1}^{K} \beta_k x_{kit} + \sum_{m=1}^{M} \gamma_m z_{mit} + u_i + \varepsilon_{it}\ , \qquad \text{(Model 4)}$$

where t signifies the year 1995 or 2002.

Huselid and Becker (1996) compare cross-sectional and panel method in studying the link between human resource policies and performance. They conclude that while traditional cross sectional estimates may be biased upwards due to the heterogeneity bias, panel estimates exacerbate the effect of the measurement error in management practices and bias the estimates downward. Therefore the results of both Model 1 and Model 3 should be analyzed and compared.

Results

We will now analyze separately the results of the Model 1, Model 2, Model 3 and Model 4 applied on publication numbers. After this analysis the results of a series of sensitivity analyses will be presented to check the robustness of the results to the choice of the dependent variable or the construction of the management index. The models will be thus rerun with citation numbers and research income as alternative measures of research performance and with a normalized scale based on factor loadings as an alternative index of management practices.

Pooled OLS model

The pooled OLS model (Model 1) demonstrates quite high explanatory power for both time periods, R-square being 0.87 and 0.92 respectively (Table 5-4). All the control variables have an expected effect on research performance: PhD share and staff seniority have a positive effect, age has a positive but declining effect, students per staff have a negative (later period) or insignificant (earlier period) effect, and the medical school has a positive effect. The staff with only teaching responsibilities has a negative effect in the earlier period, but positive effect in the later period.

Research management practices seem to have a somewhat different effect in the early and later period. RMI is not statistically significant in the early period. In the later period, RMI has a significant positive effect and one unit increase in the index improves research performance by 2.2 per cent. In terms of individual practices, benchmarking and individual research incentives are associated with lower research performance in the earlier period, in the later period individual incentives keep the negative association but benchmarking and performance based budgeting have a significant positive association.

The pooled OLS model is likely to suffer from an omitted variable bias and the effect of control variables in particular is likely to be overestimated in this model. Universities that have strong research focus are likely to be different in terms of their general profile. This profile may also have an effect on the age structure, teaching load and other identified control variables. In this case the empirical effects of these variables that we observe may not reflect an actual causal link between the variables and research performance. An attempt to change one of those characteristics that the model identifies as significant would be futile because the effect may be entirely due to structural differences between universities. Not only the control variables are likely to be biased, but also the relationship between management practices and performance is likely to be not causal but due to the unobserved university profile. The next model addresses the problem of the potential bias.

Fixed effect vector decomposition

The results for the FEVD model (Model 2) are presented in Table 5-5. While the effects of the control variables are still to a large extent as expected, the size of the effects is in most cases smaller than in the OLS model. This indicates that indeed some of the effects are strongly associated with the differences between universities. The coefficients in the later period are quite expected: staff qualifications have a positive effect, the number of students and teaching-only staff have a negative effect, age has a positive but diminishing effect, but the proportion of senior staff seems to have no effect. The earlier period shows somewhat different results: again staff qualifications have a positive effect and teaching-only staff negative effect, but age has a negative but diminishing effect and most surprisingly the number of students has a positive effect.

The latter is likely to reflect the simultaneous increase in student numbers and research performance over the period, and the variance in research performance is not entirely captured by other control variables. When comparing the results to the pooled OLS models, then the difference in results indicates some omitted variable bias. In the fixed effect model, PhD share is in the same range, but staff seniority is not as important, teaching only staff has a clear negative effect, age has a much smaller effect. This means that many of those variables in the pooled OLS model explained more of the differences between universities that are carried by some underlying characteristic of the university.

The results of the FEVD model show that research management practices are clearly associated with the fixed effects. RMI is statistically significant and positive for both periods (Column 1 and 3). The effect is higher in the earlier period than in the second period. One point increase in the index raises research productivity by 9.1 per cent in the early period, compared to the 2.8 per cent in the later period. This is likely to indicate that in the early years research management practices were more developed in universities with higher research orientation.

When we analyze research management practices individually we see quite diverse effects. Three practices that have consistently positive effects are faculty reviews, benchmarking, and performance based funding. A negative association between staff qualifications and research performance confirms the expectation that this practice was implemented in universities with lower research performance. Concentration has a minor or non-significant negative effect in both periods. Interestingly individual incentives have a negative effect and the effect even seems to intensify in the second period. Support structures have a positive effect in early years but not in later years. This is an interesting result, suggesting that perhaps lower performing universities needed such kind of incentives and support more explicitly. Better performing universities had high research expectations to everybody which were implemented through recruitment and promotion and no external incentives or support were needed. A bolder interpretation would suggest that extrinsic incentives may be in conflict with internal incentives and eventually worsen research performance, in lines with Kreps (1997).

In general, management practices have thus a positive correlation with the time-invariant unit-effects in the research performance model. This suggests either that management practices indeed contribute to research productivity but considering that management practices started to develop rapidly only in early 1990s this may be a sign of heterogeneity bias, i.e. that practices are more developed in universities with higher research capacity that is not entirely captured by the control variables.

Growth model

The third specification (Model 3) provides a further check on whether the positive effect of management practices is associated with the heterogeneity bias or whether we can be more confident in the causal link between management practices and performance. Instead of linking research management policies with research performance we examine whether universities with more developed research management policies grew faster over the years. Table 5-6 presents estimation results for the Model 3 where the growth rate rather than the performance itself is the dependent variable.

The effects of the control variables are consistent to those in the previous chapter and were there discussed in detail. The effect on management practices is different in the earlier and in the later period. In the later period, RMI has a positive although a small effect. Increasing the index score by one unit would increase the log growth rate by 0.008, which is roughly 10 per cent of the standard deviation. In the earlier period the management practices do not have a significant effect on productivity improvement. The result may be indicating that productivity improvement in the earlier period is fast and driven by changes in the quantity and quality of resources. The effect of management practices is minor in this stage of development. In the later stage the productivity improvement is much slower, nuanced and organizational policies may start to matter.

When analyzing the effect of individual policies on research output the results call for some caution. In the later period performance budgeting and faculty reviews are statistically significant at the 10 per cent confidence level. Individual level incentives seem to have a negative effect and so does the concentration policy. The worrisome issue about these results is the way they compare to the results of the earlier period. The results of the earlier period are exactly opposite to the later period: individual level incentives have positive effect, faculty reviews negative, and concentration positive. It is conceivable that policies have different effect in different stages of development. Personal incentives may be an effective tool to introduce performance culture in the beginning of the reform cycle, but such incentives loose their effect in the later stage and may even hinder performance due to the loss of intrinsic motivation. Similar argument could be made for concentration or even faculty review. Considering how clearly the effects are opposite to each other in these two periods, it is hard to give up the suspicion that there may be also some heterogeneity bias in the growth rates. There may be systematic unexplained variance in growth rates that is correlated with the choice of management practices. The final, fully time-variant model should provide more light into this.

Full panel model

Model 4 is the most complete model because it targets heterogeneity bias directly. Since we have panel data also for policies we can see how the change in research management policies affects change in research productivity. The results are presented for an OLS, random effect and fixed effect model for comparison (Table 5-7). The model has quite high explanatory power, above 80 per cent of the variance explained. According to the Hausman test ($F[35,29]=4.95$ and $p<0.001$) the fixed effect estimates are the most accurate estimates, although coefficients are quite stable across all three specifications.

According to the full panel model, research management practices are important for research performance. RMI has a significant positive effect – at around 3.3 per cent increase per one unit increase in the index. Individual practices are mostly statistically insignificant. Upgrading staff qualifications is most consistently and not surprisingly negative. The only other individual policy that has a small but significant effect is regular faculty reviews. Such modest results may be influenced also by technical problems. First of all, the full panel dataset is very small which may hide systematic effects. Secondly, as mentioned above, fixed effect model exacerbates measurement errors and is likely to bias coefficients downwards. OLS and random effect models reveal similarly low associations though.

Sensitivity analyses

In order to check the robustness of the results with respect to the choice of the dependent variable we will rerun the tests with the number of citations and research income as a dependent variable. Secondly, in order to test the sensitivity of the results to the construct of the management practices we will run the test also with a management practices scale that is based on factor loadings.

Citations

One problem when using publication numbers as a measure of research output is the tradeoff between the quantity and the quality of research. The concerns have been articulated that the publication numbers are inflated because of the enormous pressure to publish. The model with citation numbers has in general a somewhat lower explanatory power (Table 5-9). It may refer to the fact that citations are less predictable by these explanatory variables. But the lower explanatory power may be influenced also by the fact that citation numbers are noisier because they are not real but year-adjusted.

The results using citation numbers are quite consistent with those applied to the number of publications. The control variables are quite expected, and even more so than with publication numbers. Student numbers have a consistent negative effect, suggesting that while publication years over years increased rapidly, the citation numbers did not quite follow the same trend. Teaching only staff has again positive effect in the later period, indicating that perhaps separation of teaching and research staff may be efficient for high quality research. RMI does not pass the threshold for a two-tailed significance test in the early period, but does so in later years in Model 1. FEVD model indicates that there is a very strong correlation between time-invariant university fixed effect and RMI: stronger than in the case of publication numbers and slightly stronger in the early period than in later period. In terms of growth, RMI has again positive effect on growth in the later period but not in the earlier period. In the difference model again RMI has a positive effect. While in the case of publications one unit increase in RMI increases publication productivity by 2.8-3.3 per cent, a similar change increases citation numbers by 6.6 per cent.

In general, citation numbers give a similar picture and confirm the results of the publication numbers.

Competitive research funding

Competitive research funding is another measure that is often used to reflect research performance. The dependent variable is a deflated per capita research funding. While publication and citation numbers show relatively similar results, research income gives a somewhat different picture (Table 5-10). In the OLS model, RMI is associated with better performance in the earlier period, but not in the later period – exactly opposite to the publication results. In the FEVD model, the fixed effect and RMI are also correlated in the earlier years but not in the later years. Relationship between practices and growth in research funding is non-existent and the model as a whole has a very low explanatory power. Difference-in-difference model confirms the effect of RMI on research funding.

Research management scale

Using the research management scale (RM scale) that is based on factor loadings rather than a simple aggregated index does not change significantly the results. In the OLS model, the RM scale has a positive effect in the later period, but not in the earlier period; it is positively related to the fixed effect; and it explains growth in the later period but not in the earlier period. All these results are identical to using aggregated index and show that the results presented above are not sensitive to the specifics of aggregating management practices.

Discussion

Research management practices have developed significantly in Australian universities over the last two decades. In this paper we identified seven main practices that target different organizational levels: institution, faculty, and academic staff. As demonstrated by the factor analysis, most of the practices form one dimension in the larger management system and can be most effectively analyzed together. Two practices: concentration of research and upgrading the research capacity of academic staff are not part of this dimension.

The empirical analysis confirms that Australian universities have been able to improve their research performance in last two decades, which to a large extent can be associated with changes in inputs. Changes in staff qualifications, age structure, teaching load and teaching-research nexus significantly affect research performance. The analysis also demonstrates that not only the quantity and quality of inputs affects productivity but also research management in a university matters. Research management practices indeed have a positive effect on research productivity. Research management index, which aggregates institutional, school and individual level practices, is consistently positive and the result is robust to different model specifications. Universities with higher research management index demonstrate higher performance and their research productivity improves faster.

The effect of research management on performance seems to vary in different stages of the reform. In the early period (1992-1998) research management index has a strong association with the performance, but its effect on performance improvement is low. On the contrary in the later period (1999-2003) the association between practices and performances is lower but practices seem to have a bigger effect on productivity improvement. This evidence indicates that universities with high research performance are probably more apt to implement advanced research management practices and do it fast. This advantage and learning curve is probably equalizing over time. Although the association between performance and management is partly due to the heterogeneity bias there is still evidence that universities with better management improve their research performance faster. This is true for the later period when universities are in a more stable and systematic phase of development, while in the earlier phase the growth rate is likely to be more chaotic and a function of major structural changes in the higher education system. We also saw that even when we control for the original status of research management practices, universities that developed management system also improved their performance. Research management practices thus matter. The effects are not large but consistent in a more stable stage in research environment.

When analyzing individual practices then some interesting patterns emerge. First of all, we saw that research concentration is a practice that stands alone from other management practices. There is also no evidence that universities with clear research concentration strategies have actually significantly improved their research performance and the coefficient for the concentration is more often negative. There may be multiple reasons for this. It may be that the benefits of such concentration reveal itself only after many years and therefore do not reflect in the results. It may be the case that universities with such strategy indeed suffer from a temporary backlash because the funding and other support has been retrieved from many other units and invested into new units, which do not produce benefits yet. It may be the case that universities presently suffer from the concentration of resources, which may or may not be overcome in the long run.

Interestingly the most consistently positive effect is related to the faculty level practices. Faculty performance reviews and performance based funding has a positive effect in most models. This result suggests that perhaps faculty level pressure for research productivity is the most effective form of research management. This confirms the hypothesis that academic units are a crucial organizational level for individual identity and socialization. Moreover, academic units are usually responsible for recruiting, promoting and rewarding its academic staff. The academic unit therefore is not only closer to individual academics but has more instruments to affect academic staff. The faculty/department level may be therefore a more effective organizational level to be targeted by management practices and more so than the institutional (i.e. university as a whole) or even the individual level. Even though institutions strengthen their central role and develop their institutional identity, practices that influence the identities and incentives of faculties and schools still seem to keep their importance.

Individual level research practices demonstrate most inconsistent effects. Especially individual level incentives have either a negative or an insignificant effect. Research support structures are in most cases statistically insignificant. Why individual level incentives and support structures do not have a desired effect is an intriguing issue. One of the important components in the incentive structure is the annual performance appraisal. According to the evaluation reports, the staff was in general very satisfied with this procedure which was seen as supportive and helped to clarify goals and expectations. The other elements included financial rewards, recognition, teaching load adjustments. It may be the case that academics have a strong internal motivation and the external motivators do not add significantly to performance. It may be also related to some heterogeneity bias. It is likely that universities where staff is less research-oriented and has lower internal motivation are inclined towards such external incentive mechanisms. Finally, it may also be the case that these practices are more ambiguous, their measurement is not as precise and therefore their effect is underestimated.

Limitations

While the analysis provides some interesting insights on the potential effect of research management practices on research performance, the study is constrained by certain assumptions, technical limitations and the nature of the data.

One of the limitations is the nature of the time period that is studied in the paper that may significantly affect the reliability of the results. The 1990s was a turbulent era on the Australian higher education landscape and everything was in transformation – 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 decompose 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. The very small sample size that is limited by the number of universities in the country makes the problem also more severe from a technical standpoint.

The time-period may be a problem also for measuring management practices. In the 1995 cycle all universities are measured in the same year. In the later audit cycle universities were evaluated over a five year period – between 2002 and 2007. While in general research management practices do not change quickly, practices may develop significantly over a 5-year period. Universities that were evaluated later may therefore score higher with respect to management practices. There is no clear pattern in when universities were evaluated that could systematically bias the results. The problem may however introduce more random noise in the data.

As discussed above, when practices are interrelated, as they often are, then focusing on one policy without controlling for others necessarily biases the estimates. Therefore in this study we tried to identify all major management practices that showed some variance across time and between universities and could explain the variance in research performance between universities. The set of practices however only includes practices that are 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, Maquarie university keeps all research funding at the institutional level and allocates directly to individuals and research groups as competitive grants and other support mechanisms while University of New England allocates research funding to faculties who then handle most of the financial support (like research startups, support for preparing grant applications, etc) (AUQA audit report). This choice may be partly explained by the size of the university, but it may also be a deliberately chosen management strategy in a particular university. The research question in this study is about institutional level practices, but if university level and faculty level practices are supplements of each other then the results may be again biased. The problem 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 as an institutional level policy in this study. Moreover 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, and concentration, with the exception of benchmarking that could be conceivably implemented only at a school level.) This may be however partly a reason why individual level policies showed very weak and inconsistent results in the analysis. If information could be collected on faculty level practices then a multi-level analysis would provide most precise picture on the effect of all different practices.

We assumed in this study that all universities react to these practices in a similar way. The competition among Australian universities on equal grounds is interestingly leading to the realization that universities are different and perhaps should be treated differently by the government. Perhaps they should be also differently governed and managed – depending on their size, mission, and organizational structure. Perhaps some universities would gain more from a support structure and the others from incentives. This needs further exploration in future studies. The number of universities in the dataset sets a limit on tools that can be used for analyzing the effect of organizational practices on performance. Even some of the analysis above should be taken as suggestive rather than conclusive due to the limit. Larger dataset would not only make the results more reliable, but it would allow analyzing the bundles of practices and potential synergies between policies.

In spite of the limitations, the study provided some insights on the extent to which research management practices matter for research productivity. Heterogeneity bias is a serious threat in such studies – that organizations with better performance are also more likely to adopt advanced management practices. In order to alleviate the problem we used three different models that address the same question from a different angle. Comparing the results from the different models gives a more nuanced picture about the relationship between research management practices and research productivity.

TABLES

Table 5-1: 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	Policies like time release.	A systematic effort to increase the proportion of staff with PhD degrees
Developing research skills	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

Table 5-2 Descriptive statistics and correlations of management practices

			1995							2002/7						
	Mean	St dev	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

Table 5-3. Factor structure of research management practices, 1995 and 2002/7

	1995		2002/7		
Management practice	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*	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*	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. * Omitted from the scale (and from Cronbach alpha calculation).

Table 5-4 The effect of research management practices on research performance, pooled OLS

	1992-1998				1999-2003			
	(1)		(2)		(3)		(4)	
	Coef	St. err	Coef	St. err	Coef	St. err	Coef	St. err
Management practices								
RMI	-.009	.010			0.022***	0.008		
Faculty performance reviews			-.031	.027			0.007	0.026
Performance based budgeting			.050	.034			0.097**	0.027
Benchmarking			-.108***	.037			0.085***	0.035
Concentration	.013	.024	-.021	.026	-0.006	0.037	0.021	0.037
Individual incentives			-.050*	.027			-0.079**	0.034
Support structure			.041	.031			-0.035	0.030
Upgrading qualifications	.0001	.031	.034	.037	0.078**	0.037	0.043	0.040
Control variables								
PhD	.037***	.002	0.041***	0.003	0.024***	0.002	0.022***	0.002
Age	11.14***	2.36	10.344***	2.382	11.251***	1.454	8.237***	1.561
Age-sq	-1.04***	.219	-0.969***	0.220	-1.009***	0.125	-0.745***	0.135
Senior staff	.023***	.008	0.024***	0.008	0.035***	0.005	0.035***	0.005
Student/staff	-.006	.006	-0.001	0.006	-0.021***	0.004	-0.026***	0.004
Teaching only	-.009***	.002	-0.009***	0.002	0.006**	0.002	0.003	0.002
Med School	.375***	.057	0.394***	0.057	0.383***	0.050	0.298***	0.053
Constant	-32.701	6.410	-30.909	6.438	-33.682	4.205	-24.826	4.534
Adj. R-sq	.893		0.897		0.918		0.925	
N	250		250		180		180	

Note: Dependent variable: (ln) per capita publications. *** p<.01; **p<.05, *p<.10.

Table 5-5 The effect of management practices on research performance, FEVD

	1992-1998				1999-2003			
	(1)		(2)		(3)		(4)	
	Coef	St. err	Coef	St err	Coef	St. err	Coef	St err
Management practices								
RMI	0.091***	0.007			0.028***	0.004		
Faculty performance reviews			0.147	0.017			0.029**	0.014
Performance based budgeting			0.034*	0.018			0.157***	0.014
Benchmarking			0.096***	0.022			0.090***	0.018
Concentration	0.000	0.013	-0.009***	0.014	0.000	0.018	-0.003	0.019
Individual incentives			-0.051***	0.015			-0.144***	0.018
Support			0.094***	0.017			-0.037**	0.016
Upgrading qualifications	0.000	0.017	-0.188***	0.022	0.000	0.018	-0.084***	0.022
Control variables								
PhD	0.028***	0.001	0.028***	0.001	0.029***	0.001	0.029***	0.001
Age	-4.817***	1.380	-4.817***	1.422	2.801***	0.805	2.801***	0.858
Age-sq	0.543***	0.130	0.543***	0.134	-0.220***	0.070	-0.220***	0.075
Senior staff	-0.008*	0.005	-0.008*	0.005	0.002	0.003	0.002	0.003
Student/staff	0.023***	0.003	0.023***	0.003	-0.013***	0.002	-0.013***	0.002
Teaching only	-0.004***	0.001	-0.004***	0.001	-0.006***	0.001	-0.006***	0.001
Med School	0.881***	0.036	0.799***	0.035	0.520***	0.026	0.422***	0.028
Constant	6.958*	3.67	7.278*	3.797	-11.021***	2.296	-10.926***	2.470
Eta	1.000**	0.038	1.000**	0.040	1.000***	0.0348	1.000	0.046
Adj. R-sq	0.971		0.970		0.979		0.979	
N	250		250		180		180	

Note: Dependent variable: (ln) per capita publications. *** p<.01; **p<.05, *p<.10.

Table 5-6 The effect of management practices on growth in research performance, OLS

	1992-1998				1999-2003			
	(1)		(2)		(3)		(4)	
	Coef	St. err	Coef	St err	Coef	St. err	Coef	St err
Management practices								
RMI	-0.002	0.002			0.008*	0.004		
Incentives			0.012*	0.006			-0.057***	0.016
Support			-0.003	0.009			0.020	0.012
Upgrading qualify.	0.006	0.008	0.015	0.010	-0.015	0.019	-0.019	0.019
Faculty reviews			-0.017***	0.007			0.019*	0.011
Concentration	0.017**	0.008	0.016*	0.009	-0.030**	0.014	-0.034**	0.014
Benchmarking			-0.010	0.008			0.014	0.015
Performance budgeting			0.004	0.010			0.042***	0.014
Control variables								
ln pc public	-0.168****	0.027	-0.169***	0.028	-0.039***	-5.520	-0.239***	0.038
PhD	0.004***	0.001	0.004***	0.001	0.002	0.001	0.001	0.001
Age	2.725***	0.682	2.439***	0.710	2.331***	0.766	1.393*	0.716
Age-sq	-0.260***	0.064	-0.235***	0.067	-0.220***	0.068	-0.139**	0.063
Senior staff	0.004	0.003	0.005	0.003	0.004*	0.002	0.004	0.002
Students	0.002	0.002	0.002	0.002	-0.011***	0.002	-0.015***	0.002
Teaching only	0.000	0.001	0.000	0.001	0.001	0.001	-0.001	0.001
Med School	0.073***	0.014	0.068***	0.015	0.019	0.025	-0.013	0.024
Constant	-7.509***	1.856	-6.733***	1.931	-6.163***	2.224	-3.317	2.073
R-sq	0.44		0.45		0.387		0.46	
N	250		250		180		180	

Note: Dependent variable: (ln) growth in per capita publication numbers. *** p<.01; **p<.05, *p<.10.

Table 5-7 The effect of research management index on research performance, 1995 and 2002, OLS, RE and FE.

	OLS		RE		FE	
	Coef	Robust St error	Coef	St. err	Coef	St. err
Management practices						
RMI	0.028*	0.017	0.032**	0.015	0.033**	0.018
Concentration						
Upgrading qualifications						
Control variables						
PhD	0.033***	0.004	0.037***	0.004	0.042***	0.006
Age	8.836***	3.129	7.389***	2.755	7.021**	3.313
Age-sq	-0.776***	0.276	-0.644***	0.242	-0.615**	0.289
Senior staff	0.021*	0.012	0.012	0.011	0.007	0.018
Students	-0.013	0.009	-0.007	0.008	-0.002	0.013
Teaching only	-0.006*	0.004	-0.007**	0.003	-0.008**	0.003
Med school	0.401***	0.110	0.386***	0.125	(dropped)	
Constant	-27.867***	8.837	-24.068***	7.769	-23.052**	9.356
R-sq	0.867					
within			0.8714		0.8769	
between			0.8813		0.8268	
overall			0.8778		0.8351	
rho			0.529		0.745	
N	72		72/36		72/36	

Note: Dependent variable: (ln) per capita publications. *** p<.01; **p<.05, *p<.10.

Table 5-8 The effect of management practices (normalized scale) on research performance (Model 1-4), 1992-2003

	1992-1998						1999-2003							
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3		Model 4	
	Coef	St. err	Coef	St err	Coef	St. err	Coef	St. err	Coef	St err	Coef	St. err	Coef	St. err
Management practices														
RMScale	-0.019	0.017	0.159***	0.011	-0.003	0.005	0.035**	0.014	0.049***	0.007	0.012*	0.007	0.050*	0.029
Control variables														
ln pc public					-0.167***	0.028					-0.214***	0.038		
PhD	0.037***	0.002	0.028***	0.001	0.003***	0.001	0.023***	0.002	0.029***	0.001	0.002	0.001	0.033***	0.003
Age	11.201***	2.355	-4.817***	1.374	2.727***	0.695	10.824***	1.433	2.801***	0.776	2.201***	0.740	8.812***	2.903
Age-sq	-1.049***	0.218	0.543***	0.129	-0.260***	0.065	-0.970***	0.123	-0.220***	0.068	-0.209***	0.065	-0.774***	0.256
Senior staff	0.024***	0.008	-0.008*	0.005	0.005	0.003	0.032***	0.004	0.002	0.002	0.007***	0.002	0.022	0.016
Student/staff	-0.006	0.006	0.023***	0.003	0.001	0.002	-0.022***	0.004	-0.013***	0.002	-0.010***	0.002	-0.013	0.014
Teaching only	-0.010***	0.002	-0.004***	0.001	0.000	0.001	0.005**	0.002	-0.006***	0.001	0.001	0.001	-0.006	0.006
Med School	0.371***	0.056	0.873***	0.035	0.066***	0.015	0.369***	0.049	0.519***	0.025	0.031	0.025	0.398***	0.067
Constant	-32.859***	6.378	7.409**	3.669	-7.469	1.903	-32.315***	4.151	-10.887	2.216	-5.860***	2.145	-27.643***	8.023
eta			1.000***	0.038					1.000***	0.042				
R-sq	0.893		0.971		0.429				0.980		0.368		0.882	

Note: Dependent variable: (ln) per capita publication numbers. *** p<.01; **p<.05, *p<.10.

Table 5-9 The effect of management practices on citation numbers (Model 1-4), 1992-2003

	1992-1998						1999-2003							
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3		Model 4	
	Coef	St. err	Coef	St err	Coef	St. err	Coef	St. err	Coef	St err	Coef	St. err	Coef	St. err
Management practices														
RMI	0.023	0.018	0.173***	0.010	-0.002	0.004	0.054**	0.021	0.113***	0.011	0.024**	0.009	0.066**	0.028
Concentration	0.071*	0.042	0.000	0.021	0.016	0.011	0.086	0.094	0.000	0.046	-0.037	0.048		
Qualification	0.036	0.053	0.000	0.027	-0.016	0.016	-0.094	0.093	0.000	0.046	-0.041	0.034		
Control variables														
ln pc citations					-0.113***	0.023					0.040	-0.170		
PhD	0.029***	0.004	0.024***	0.002	0.000	0.001	0.026***	0.004	0.006**	0.002	-0.002	0.002	0.034***	0.007
Age	13.646***	3.950	-11.024***	2.166	1.802	1.012	10.879***	3.697	-4.908**	1.944	-2.476	1.621	8.481	7.424
Age-sq	-1.293***	0.366	1.140***	0.203	-0.171*	0.095	-1.004***	0.317	0.447***	0.168	0.209	0.143	-0.762	0.669
Senior staff	0.038***	0.014	-0.020***	0.007	0.005	0.004	0.033**	0.013	-0.050***	0.007	-0.002	0.006	0.003	0.027
Student/staff	-0.028***	0.009	0.020***	0.005	-0.002	0.003	-0.051***	0.009	-0.030***	0.005	-0.011***	0.004	-0.046**	0.023
Teaching only	-0.022***	0.003	-0.005***	0.001	-0.001	0.001	0.012**	0.006	-0.012***	0.003	0.002	0.003	-0.016	0.011
Med School	0.529***	0.095	1.163***	0.053	0.078***	0.022	0.070	0.128	0.718***	0.069	-0.215***	0.063	0.172	0.158
Constant	-35.941***	10.695	25.613***	5.789	-4.498*	2.704	-29.080***	10.693	15.573***	5.608	7.617*	4.536	-23.069	20.477
eta			1.000***	0.036					1.000***	0.042				
R-sq	0.815		0.953		0.281		0.721		.932		0.170		0.733	

Note: Dependent variable: (ln) per capita citation numbers. *** p<.01; **p<.05, *p<.10.

Table 5-10 The effect of management practices on research income, Model 1-4

	1992-1998						1999-2003							
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3		Model 4	
	Coef	St. err	Coef	St err	Coef	St. err	Coef	St. err	Coef	St err	Coef	St. err	Coef	St. err
Management practices														
RMI	0.054***	0.016	0.097***	0.010	0.006	0.008	-0.003	0.013	0.006	0.006	0.011	0.007	0.051*	0.028
Concentration	0.103***	0.036	0.157**	0.022	0.039**	0.019	-0.068	0.058	-0.100***	0.028	-0.015	0.026	0.149*	0.082
Qualifications	0.016	0.046	-0.012**	0.028	-0.005	0.021	-0.082	0.057	-0.211***	0.028	-0.010	0.033	-0.132	0.096
Control variables														
ln research income					-0.260***	0.047					-0.153**	0.067		
PhD	0.027***	0.003	0.039***	0.002	0.005*	0.003	0.018***	0.003	0.033***	0.001	0.000	0.002	0.028***	0.006
Age	12.373***	3.438	-7.024***	2.247	2.325	1.776	7.642***	2.284	3.115***	1.108	1.957*	0.994	2.328	4.638
Age-sq	-1.183***	0.319	0.702***	0.210	-0.220	0.167	-0.691***	0.196	-0.229**	0.096	-0.181**	0.087	-0.213	0.409
Senior staff	0.064***	0.013	0.015*	0.008	0.013*	0.008	0.029***	0.008	-0.013***	0.004	-0.004	0.005	0.011	0.018
Student/staff	-0.034***	0.008	0.010*	0.005	-0.002	0.005	-0.030***	0.006	0.005	0.003	-0.014***	0.004	-0.034***	0.013
Teaching only	-0.013***	0.002	-0.002*	0.001	-0.004**	0.002	0.003	0.004	-0.003	0.002	-0.001	0.002	-0.018***	0.005
Med School	0.255***	0.092	0.531***	0.057	0.105**	0.041	0.393***	0.081	0.689***	0.040	-0.029	0.049		
Constant	-24.563***	9.308	24.090***	6.013	-3.959	4.588	-11.989*	6.609	-1.957	3.186	-3.344	2.728	2.316	13.031
eta			1.000***	0.047					1.000***	0.041				
R-sq	0.815		.934		0.255		0.801		.954		0.171		0.757	

Note: Dependent variable: (ln) per capita research funding. *** p<.01; **p<.05; *p<.1.

CHAPTER SIX

MARKET-BASED REFORMS AND EFFICIENCY CHANGE IN THE AUSTRALIAN HIGHER EDUCATION SECTOR

Introduction

The drive for efficiency and accountability has characterized higher education reforms in Australia since the end of 1980s. As in most other countries, the higher education sector started to expand rapidly in the mid-1980s, which imposed additional burdens on public funds. Increasing costs in higher education brought up questions about the efficiency and effectiveness of the sector (Meek 2002). The spread of the New Public Management ideas in the public sector strengthened the attention to accountability even further and pointed to potential inefficiencies in government funded universities. As a response to the new pressures, government implemented a series of quasi-market mechanisms. The 1987-88 reform was triggered by the idea that competition between universities is a source for greater efficiency and quality improvement in the system (Dawkins 1987). The reform also emphasized the idea that more “managerial” type of governance, in contrast to traditional collegial governance, makes universities more efficient, dynamic, and responsive to the environment (Ibid.).

The emphasis on competition and efficiency materialized in a cycle of changes – concerning teaching, research, and university governance, and the structure of the sector more generally. The 1987/88 reforms established a unified system, which resulted in numerous merges and amalgamations. Related to teaching, the reform reintroduced tuition fees (HECS), emphasizing not only the idea of cost sharing but also of students as customers. In subsequent years universities became competitors for full-fee-paying domestic and international students.

The 1996 budget cuts strengthened the competition for student funding and other external funding opportunities even further. Although government allocations to institutions were not made dependent on teaching performance, the performance was monitored through quality audits and government mandated graduate surveys. Market mechanisms entered even more powerfully the research sector. The reform introduced the principle of performance based research funding through *Research Quantum,* awarding money based on publication output, success in attracting external funding, and completed research degrees. The funding increasingly shifted from institutional research grants to competitive research grants and contracts allocated by the Research Council or other funding bodies. The government policies also directly influenced internal university management and governance. Quality audits in the early 1990s assessed not only success in terms of performance and outputs, but also managerial aspects such as strategic planning, internal incentives to manage performance in the organization, and internal quality policies.

Through the various incentive and monitoring mechanisms the government hoped to make the Australian higher education sector perform better and become more efficient. This study will examine the extent to which this goal was really achieved. The paper will concentrate primarily on the idea of technical efficiency, i.e. whether universities have increased their output relative to the resources used for producing the output. Efficiency change in Australian universities has been studied before. Worthington and Lee (2005) study universities over a five year period (1998-2003) and observe that universities have indeed become more efficient over the period. This study hopes to contribute two elements to the existing evidence. First, it observes efficiency changes over a longer 12 year period (1992-2004) in order to get a clearer understanding about the efficiency since the early years of the reform cycle. Secondly, the study specifies different input sets and attempts to clarify the source of efficiency improvement.

Market-based higher education policies and efficiency of the sector

Market provision of goods and services is seen as superior to public provision from an efficiency point of view; and public sector reforms that introduce market elements into the sector – so called *quasi-market* reforms (Le Grand 1991) – aim to achieve the efficiency gains of the free market. Markets are perceived more efficient because of inherent incentives for cost-reduction, securing thus the technical and allocative efficiency in the system. Whether market-based reforms increase efficiency in Australian higher education depends on several assumptions about universities' behavior.

Ferris (1991) identifies four main forces that influence production costs and that are affected by choosing either a more market or public organizational model. The four forces are managerial incentives, managerial flexibility, scale economies, and market conditions. The extent to which the goal of cost-efficiency is achieved in an organization is influenced by the strengths of incentives that managers have to work towards the goal. This is the issue of X-inefficiency (Frantz 1988). X-inefficiency arises from an agency type of a problem, when the "owners" and managers diverge in their objectives and managers deviate from the overall objective of the cost-minimization. X-inefficiency is a potential problem both in the private and public sector, but the public sector is more vulnerable to the X-inefficiency on several reasons. Most importantly, in a non-competitive environment where funds are granted despite the performance and cost-efficiency organizations do not face the ultimate market test – they are not driven out of the market in case they fail to perform efficiently. Organizations in a non-competitive environment therefore also face weaker incentives not only to perform efficiently but also to be innovative in their production and management (Weimer and Vining 1999, Dixit 2002, Vining and Weimer 1990).

Secondly, public organizations tend to have higher constraints on managerial flexibility. The itemized organizational budgets, for example, restrict managerial discretion and forbid shifting resources between capital investments and operational expenditure. The government may also specify and limit academic salaries. All such constraints limit managerial freedom to acquire the desired input mix and increase efficiency in the organization. Assuming that managers have an incentive to increase the efficiency of the organization and that they are better informed for such decisions, greater managerial flexibility is thus likely to improve efficiency.

Thirdly, scale efficiencies may be enforced either by government action or market processes. Consolidation of the higher education system in the end of the 1980s was forced by the government with the aim to increase efficiency. The optimal size of universities, and distribution between, for example, teaching and research output affects the overall efficiency of a university. Finally, the extent of the competition between universities influences the gains from more market-oriented approach to higher education.

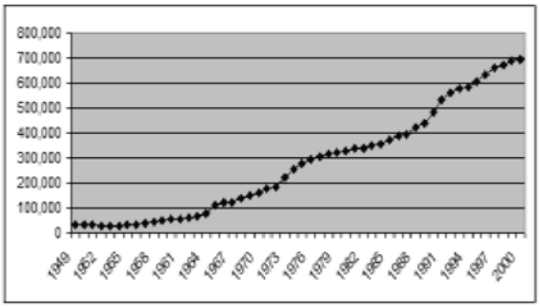
From a production cost perspective, government provision of higher education is likely to increase the costs. The system lacks the necessary incentives for cost-minimization and constrains managerial freedom to achieve greater flexibility. This generalization, however, ignores several important characteristics of the higher education sector. It is difficult to adequately measure and price the outputs of universities that make it difficult to observe whether a university is actually performing efficiently or not. Quasi-markets may even increase costs in various ways (Le Grand 1991). There are costs related to setting up a contractual relationship between a university and government, and monitoring and enforcing the contracts. Competing organizations also use their resources on advertising and other ways of increasing their market share that do not add directly to the quality of the output. Investments into prestige and status, instead of quality and performance, may significantly increase the costs of higher education provision (Brewer et al. 2002). In the sectors where the quality of the product is often hard to measure and demonstrate, organizations may choose to invest into inputs that symbolize performance rather than actually making a real impact on performance, such as hiring "star scientists". Often the costs also go up due to short term political pressures. In order to gain support to the changes by providers, the government increases salaries or provides extra resources to the sector. Quasi-markets may also increase labor costs that otherwise may have been suppressed by the government using its monopolistic position. Moreover, the argument of self-selection has been used to justify the role of the non-profit sector. Non-profits are seen as less costly in terms of transaction costs of monitoring because they have no incentives to sacrifice quality for profit purpose. Introducing competition and profit-assumptions may shake the underlying incentives of non-profit providers.

In sum, market-based higher education reforms in Australia strengthened the incentives to perform better, increased managerial flexibility, and enforced performance monitoring by the government. Before analyzing the change in efficiency empirically, it would be helpful to illustrate changes in the main outputs and inputs in Australian universities over the 1992-2003 period.

General trends in teaching, research, and universities' finances

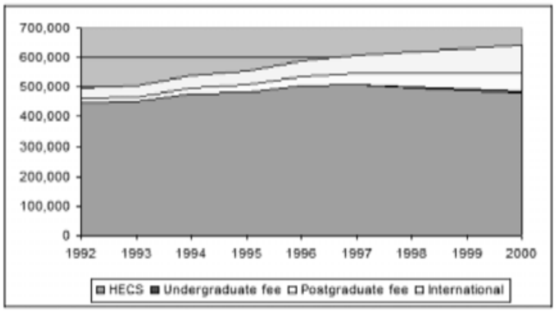
The number of students has consistently increased in Australia since the 1960s (see Figure 6.1). The growth in student numbers also continues over the 1992-2003 period, but the source of the growth is different from the earlier periods. The number of publicly funded students increased very modestly until the mid-1990s, but the policy reform of 1995 froze the numbers for the following years. The total student number has continued to increase due to fee-paying post-graduate students and international students (Figure 6.2). The number of international and fee-paying students started to increase considerably in 1995. This reflects the impact of the budget cuts in 1995, which put universities under a serious cost pressure and made them to search for alternative revenue sources. As a result, fee-paying students, both domestic and international, became an important revenue source and universities started to actively recruit the students. In 1998 universities also started to enroll fee-paying undergraduate students, but they constitute only a marginal proportion of the overall student body.

Figure 6.1. Total student enrollment



Source: DEST Time Series data

Figure 6.2. Changes in different student types



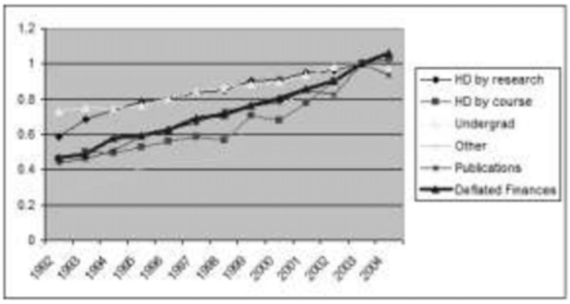
Data source: DEST Student Collection

Roughly two thirds of students in Australia are undergraduate students. The proportion of undergraduate students has however slightly decreased over the period. The fastest growth has been among course-based postgraduate degrees (on average 6.8 per cent annually) and among non-degree students (10 per cent annually). The number of research-based students has increased on average 4.7 per cent annually. While the number of undergraduate students has been growing at the slowest rate, only 2.3 per cent annually, in absolute terms the increase has contributed the most to the total student numbers.

Research output has also grown rapidly over the period. As illustrated in Chapter 1, publication numbers started to increase significantly in the early 1990s (Figure 1.2). While this trend is characteristic also to many other OECD countries, the trend in Australia is steeper than in other countries (Butler 2001). There are some concerns that the publication numbers may be inflated and do not reflect changes in actual research performance. The higher number of publications may be achieved by lowering the quality of the publications. Academics may have developed a preference to publish in ISI cited journal because of greater legitimacy. The increase in publication numbers may thus not be attributable to more research but to changed publishing preferences. Evidence on research quality and impact indicators is inconclusive (see Chapter 1).

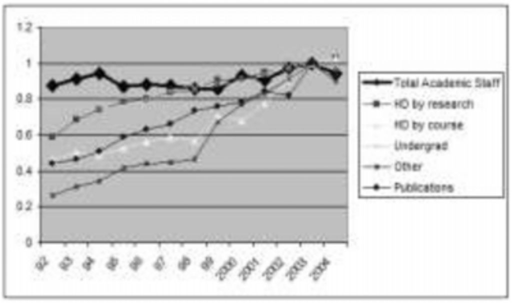
Universities have thus increased their teaching and research output over the period, but changes in the output do not mean necessarily changes in the productivity. While universities produce more undergraduate and graduate students and do more research, they also use more resources for their activities. As shown in Figure 6.3, universities' operational expenditure follows roughly the same trend as changes in outputs. Universities' revenue has grown roughly proportionally to research outcome; it has grown more than the number of undergraduate students and research-based postgraduate students, but less than the number of course-based postgraduate and other, non-degree students.

Figure 6.3. Growth of university outputs and financial resources in 1992-2003



Data source: DEST Higher Education Statistics Collection. Year 2003=1.

Figure 6.4. Growth of university outputs and academic staff in 1992-2003



Data source: DEST Higher Education Statistics Collection Year 2003=1.

While universities' revenue has increased consistently, the composition of the revenue sources has changed drastically. The biggest change is the share of the government funding in universities' total revenue. The funding from Commonwealth Government Grants includes institutional grants, grants from the Australian Research Council, Research Financial Assistance, and various other grants. The amount of funding from these sources has remained roughly the same but its share in universities' total revenue declined rapidly. While in 1995 the Commonwealth Government Grants covered 57 per cent from universities' expenses, by 2002 the proportion had dropped to 40 per cent (Table 6-1). The proportion of government grants and HECS funding together has dropped from 69 to 56 per cent. The main gains in revenue are from fees and charges, a majority of which comes from international students. Consultancy and contract research contributes to the total revenue to a modest extent. In spite of conscious efforts, including the CRC (Cooperative Research Centers) program, the private industry still contributes relatively little to universities' revenue.

Higher education has thus become relatively cheaper for the government but this does not mean that the sector has become more efficient. It only refers to the fact that some of the costs of the higher education have been shifted to other partners – mostly to students. The efficiency analysis in this chapter seeks to understand whether universities have responded positively to the cost-pressures in 1990s and been able to improve their performance and cost-efficiency.

While the outputs have significantly changed, it is curious to see the changes in the main input – academic staff. While the finances have kept pace with the increase in outputs, the number of academic staff has not gone through equal change (Figure 6.4). On the other hand, the composition of the staff has changed. The number of senior staff, at the associate and full professor level has increased while the proportion of lower level staff has remained the same or declined (DEST).

Studying efficiency in the higher education sector

In the economics literature, the production process in universities is approached similarly to other industries. Universities are multi-product organizations: they produce teaching, research, and potentially other services (see Hanushek 1987). In this production process universities apply inputs – like academic staff, non-academic staff, technology, capital etc. Technical efficiency in universities indicates how efficiently universities produce their outputs relative to their inputs. Measuring universities' efficiency is however quite complicated because universities are different from many traditional industries: universities produce multiple products from multiple inputs, and output and input prices can often not be identified. Moreover universities are not profit-maximizers. These limitations require special treatment in efficiency studies.

Universities efficiency has been analyzed with traditional production or cost minimization models. Early studies used single output cost models (e.g. Brinkman 1981, Hoenack et al. 1986). Developments in the field of economics in the 1980s introduced more advanced models and permitted cost model specifications for multi-product firms (Dundar and

Lewis 1995). Multi-product cost minimization models have been used extensively in higher education research (e.g. Cohn et al. 1989; Koshal and Koshal 1999; Glasset al. 1995; de Groot et al. 1991). The cost function approach has been applied also on Australian universities (Lloyd 1994, Lloyed et al. 1993, Thorsby 1986). These cost-minimization studies are primarily concerned with the scale and scope effect in higher education, and most of them indeed demonstrate the positive effect of scale and scope in the sector. However, these studies assume that all universities function at the maximum possible efficiency and assign productivity differences to scale and scope effects (or some other observable characteristic). The assumption that universities indeed produce at the technology frontier is highly questionable. Recent public policies attempt to target potential inefficiencies in the system and attempt to make universities to function more efficiently. The efficiency assumption in the cost models has become less convincing and new methods have been adopted in order to study inefficiencies in the system.

As the interest in efficiency differences across universities has increased, also new, and more appropriate techniques have been developed for studying efficiency. The efficiency in higher education is now primarily approached with a frontier analysis. This technique constructs empirically a frontier of maximum efficiency – the frontier of "best practices" – and the distance of each university from the frontier signifies its inefficiency. There are two ways of constructing the frontier: parametric Stochastic Frontier Analysis and non-parametric Data Envelopment Analysis (DEA). Both approaches have been applied to the higher education sector. Stochastic Frontier Analysis has been successfully used for example in Stevens (2001) and Izadi et al. (2002), but the Data Envelopment approach has become more popular in the field. The advantage of the non-parametric model over parametric models lies in the specific nature of the higher education production process. The stochastic (statistical) approach assumes implicitly that all universities share an identical cost structure. For the DEA there is no need for this assumption or any assumption about universities' behavior (e.g. cost-minimizing or profit maximizing).

The first DEA studies in the field of higher education were conducted in the US, in order to study efficiency differences between private and public universities (Ahn et al 1988; Ahn et al 1989). In the late 1980s and 1990s, efficiency became a concern in many countries in Europe and elsewhere, and the DEA technique has now been extensively used to contribute to the efficiency discussions. The DEA has been used for studying efficiency in the UK, the US, Australia, Canada, South Africa and other countries. Table 6-2 lists major empirical studies in the field. In addition to institutional level analysis, DEA has been used also at the departmental level (e.g. Beasley (1990) on chemistry and physics and Johnes (1995) on economics) or for one specific research output (e.g. Ng and Li (2000) on research performance).

In the recent years the DEA has been further developed to incorporate time dynamics in panel data. The productivity change in British universities has been studied in the UK by Johnes (2006a), Flegg et al. (2004) and Glass et al. (1998). The last study observes that on average productivity declined by 4 per cent in the UK universities over the 1989-1992 period; the first two studies observe a 1.5 per cent (1996-2002) and 3.5 per cent (1980-1992) annual increase in productivity respectively. In Australia, Worthington and Lee (2005) have found a 3.3 per cent (1998-2003) annual increase in productivity and Carrington et al. (2004) found a 1.8 per cent (1996-2000) increase.

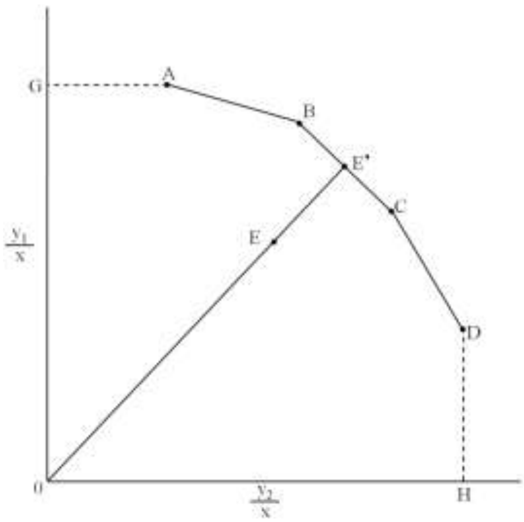
DEA has thus become a dominant technique for studying efficiency in the higher education sector. The method addresses the specific characteristics of the higher education sector that make traditional efficiency measurement difficult: absence of input and output prices, multiplicity of inputs and outputs, and ambiguous objective function. A brief description of the methodology will be provided next.

Data Envelopment Analysis: description of the methodology

The DEA methodology was developed for estimating efficiency in the outputs and inputs of not-for-profit entities (Charnes et al. 1978). Since these organizations do not follow general behavioral assumptions like profit maximization or cost minimization, the standard efficiency techniques are not useful. DEA is useful in situations when efficiency cannot be estimated with direct market results, i.e. profitability. The technique was inspired by the work of Farrell (1957), but the real impetus for using DEA in the efficiency studies came from Charnes et al. (1978). Since then the method has been used in different settings and it has been further advanced to incorporate variable return to scale, panel data and other specificities.

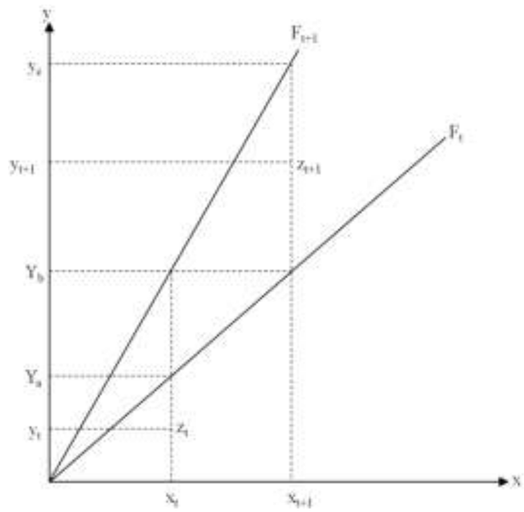
DEA is a non-parametric programming technique to measure the efficiency of one organization relative to other similar organizations. The technique constructs a technology frontier- i.e. the maximum output that can be produced with given inputs or outputs. The frontier is constructed entirely from empirical data, without any assumptions about the production process or behavior. The general logic of the method is illustrated in Figure 6.5.

Figure 6.5 Diagrammatic representation of an output-oriented DEA



Adapted from Coelli et al. (2005) and Johnes (2006)

Figure 6.6 Efficiency, technology and productivity changes



Adapted from Coelli et al. (2005); Worthington & Lee (2005)

The technique defines efficiency as a ratio of weighted outputs to weighted inputs and the weight structure is calculated by mathematical programming. The organization on the frontier (A, B, or C) is defined as fully efficient and get a score of 1. Other organizations (E) get an efficiency score between 0 and 1, depending on their distance from the production frontier (E-E'). Charnes et al. (1995) present further details. For the empirical estimation in this study, the program by Coelli et al. (2005) has been used.

DEA also gives an insight in the source of inefficiency. Technical efficiency demonstrates the extent to which the organization is successful in maximizing output from existing inputs. Allocative efficiency measures the extent to which inputs are used in optimal proportions. Allocative efficiency is rarely examined in the higher education sector because the optimal balance between inputs depends on their relative price, but input prices are often not easily available in the sector.

Scale efficiency is another form of potential efficiency. Universities may be technically efficient but they may provide too much or too little output for maximum efficiency. On the other hand, universities are often not flexible in adjusting the scale. The size of the university is to a large extent under the control of the central administration that makes decisions about the number of publicly funded students and allocates institutional grants. Therefore, the DEA model must allow varying rates of return for meaningful results. On the other hand, information on scale efficiency may give valuable insights about the potential efficiency loss because of sub-optimal distribution of resources between universities.

The Malmquist index has been adapted for the panel data and it allows the DEA to explore productivity change more specifically. The Malmquist index decomposes changes in the technical efficiency into two parts: pure technical efficiency and technological change. This means that the productivity change over time may be explained either by the movement relative to the frontier, or by the shift of the frontier itself. The idea is illustrated in Figure 6.6. The frontier F represents the efficient level of output (y) that can be produced from a given level of input (x). The frontier may shift in time (from F_t to F_{t+1}), which indicates technological change. When a university operates in point z_t (using inputs of x_t and producing y_t outputs), the university operates below the production frontier. With the available technology it could produce outputs at the level y_a. In the next period the university shifts to the point z_{t+1}, which is again inefficient, but with respect to the new higher production frontier. The Malmquist index attempts to decompose the change in the output/input ratio into two components: technical efficiency change (moving closer to the frontier) and technological change (the shift of the frontier). Technical efficiency change is further decomposed into scale efficiency change and pure technical change.

While DEA has proven to be a helpful tool in the economics of higher education, the technique has limitations. Most importantly, the measure only captures relative efficiency. The best performing organizations are assumed to be fully efficient and are assigned the maximum score of 1. The efficiency of other organization is measured relative to the best performing organizations. The measure, however, does not say how efficient the best performing organizations actually are. The final result would demonstrate high average efficiency when all organizations are performing relatively poorly, but are homogenous in their poor performance. Secondly, there is no test of statistical significance of efficiency scores and inferences are based on geometrical averages.

Finally, the quality of the DEA results depends on the quality of data. The model requires that all relevant outputs and inputs are specified. Often, however, all output variables (or input variables) are not easily measurable. Furthermore, even when the output is quantifiable, the quality differences of the output cannot be measured. These imperfections may bias the results considerably. Since the choice of output and input measures are critically important for DEA results, the next section discusses the measures in detail.

Output and input measures

Defining universities' outputs, inputs, and performance measures more generally, is a difficult task and the strengths and weaknesses of different measures have been discussed in length (Cave et al. 1997, Meyerson and Massy 1994). The consensus about outputs and inputs in higher education has been achieved only in very general terms. Universities' outputs include education, research, and public service; inputs are a combination of academic and non-academic staff and capital (Hopkins 1990). Operationalization of these measures in empirical studies varies considerably. The variation in measures is partly explained by the country of study and availability of data, but there are also some more philosophical differences about the measures.

Output measures

Table 6-2 provides a concise overview about the measures used in existing DEA studies on higher education. The output measures use various combinations of teaching and research outputs.

Teaching

Education is clearly one main output of universities, but a search for the best measures for the quantity and quality of the education output has led to different results. The main disagreement about the student measure is between using the number of graduates vs. using the number of students. The proponents of the former see the degree as the final outcome of the educational process (e.g. Worthington and Lee 2005, Johnes 2006). Such a definition raises a question as to what extent education is itself a valuable outcome, even when the studies do not lead to the completed degree. From a human capital perspective, the skills and abilities are developed throughout the educational process. The rate-of-return studies demonstrate that each year in a university has a positive effect on individual income, even though the effect of the degree is disproportionally higher (Borland et al. 2000). According to this evidence, also a year at school should be considered as a positive output, not only the degree.

The studies that define educational output in terms of degrees also tend to include enrolled students as inputs in the educational process. This approach may have clear advantages. If data is available on the quality of the entering students, such as entrance exam scores, then comparing final student output and the quality of student input is the most accurate measure of the "value added" of the education (e.g. Johnes 2006). When the quality of incoming students is not available and student enrollment is compared with degrees (Flegg et al, 2004; Worthington and Lee 1996) then the measure is likely to be strongly biased. Such comparison would indicate a drop-out rate, which is strongly correlated with student characteristics (Cave et al. 1997). Focusing on degrees only would thus punish those universities that attract non-traditional and academically less advanced students that are more likely to drop out of university, independent of their effort and performance.

Because of these reasons, the full-time equivalent student load, rather than degrees, is included as an output measure in this study. The student load is also a more precise measure for a time-series study because degrees have a long time-lag. The number of degrees does not reflect the teaching that is actually done in the year of interest, and using the resources of that year. Since education on different study levels is likely to require different set of resources, three categories are used: undergraduate students, course-based postgraduate students, and research-based postgraduate students. Student data from the early 1990s does not allow differentiation between doctoral and master level students.

Both graduate numbers and student load ignore the issue of quality of the education output. If the quality of education is ignored, universities that provide a higher quality but more expensive education may be discriminated against. Moreover, concerns have been articulated that the pressure for efficiency and the focus on research performance has hindered the quality in teaching (Marginson 2001). The quality of education is difficult to measure. Australia is relatively progressive in collecting data from university graduates. The Course Experience Questionnaire surveys graduate satisfaction with the program and the Graduate Destination Survey collects data on labor market outcomes. These data sources however, are not valid for the purposes of this study. Job market outcome cannot be meaningfully used as a measure of educational quality in a time series study. Yearly changes in labor market outcomes would hardly reflect changes in educational quality, but rather reflect changes in economic environment. Moreover, it would be unrealistic to assume that employers can accurately estimate yearly changes in the “market value” of new graduates. Secondly, labor market outcomes could be used only if the quality of incoming students is effectively controlled for and differences across fields of study are taken into account. Otherwise the income differences would to a large extent reflect the selectivity barriers of the university, not the quality of education.

The Course Experience Questionnaire could be a valuable source for teaching quality. However, evidence demonstrates that student satisfaction varies primarily across fields of study and depends primarily on student characteristics (Ramdsden 2003). Differences between institutions are virtually non-existent and all institutions demonstrate a marginal improvement in quality each year. Based on the existing evidence of student surveys, it seems more justified to assume equal teaching quality between institutions than significant quality differences across universities.

Research

Research output has also been operationalized in different ways. The three main options are a bibliometric measure, research income, or some form of peer evaluation of research (Table 6-2). Research income has become the most commonly used measure. Since competitive grants go through peer evaluation, the measure effectively combines both the quality and the quantity of research. It has been demonstrated that competitive research income has a high correlation with other research quality measures (Koshel and Koshel 1999). Another advantage of the measure is that it reflects current, on-going research, not already completed research. Easy availability of the data is also likely to have contributed to the popularity of the measure.

Research income has also significant weaknesses. First, it does not take into account cross disciplinary differences. Some disciplines require less financial resources for research (e.g. humanities) and distribution of funding across disciplines may be a strategic decision (Carrington

2004). Most importantly, however, it is a measure of research input (Carrington 2004) that would enter the production function both as an input and as an output. Yet the efficiency of using resources is the question that we are trying to answer.

Because of the weaknesses of the research income measure, this study uses the commonly used bibliometric measure: total number of publications in the ISI database. Since publication of research results takes time and does not reflect ongoing research, the measure is used with a one-year lag. The number of publications in ISI journals is not without weaknesses. The number of publications is likely to vary across fields; some fields may rely more on other types of publications than ISI cited journal articles. Harris and Kaine (1994) has also pointed out that Australian researchers publish in journals that are not cited in common indices.

Education and research are the two outputs that are commonly used in educational production functions. The "third mission" of universities, such as contribution to society and knowledge commercialization, are increasingly valued outputs of universities' activities. Current research increasingly includes the number of patents as one of the university output measures. This reflects an overall trend toward greater cooperation between universities and industry, and the role of universities in the national innovation system. The number of patents would help to correct for a potential bias against universities that do more applied work and do not publish as much in scientific journals. Reliable information on patents exists only since a few years and unfortunately cannot be used for this study. Omitting patent information may bias the results against universities that have a more technical focus. On the other hand, evidence shows that patents tend to coincide with publications and it is not clear to what extent they are joint products and to what extents they are competing for time and resources (Agrawal and Henderson 2002).

Input measures

Input measures in the education production function are equally difficult to operationalize. The research and teaching process is some combination of academic staff, support staff, and support structure (buildings, equipment, libraries, laboratories etc). While staff numbers are usually easily obtainable, the value of capital is often non-existent even in universities' own accounting systems. Empirical studies have used the measure of aggregate non-staff operational expenditure, expenditure on libraries and other academic services, or some other operational expenditure as a proxy for capital measure. Measuring non-staff inputs with operational expenditures has become a standard solution in the literature (see Table 6-2).

An alternative way to analyze efficiency would be not to identify individual inputs (such as academic staff and non-staff expenditure), but instead include universities' operational budget as a single input. This approach would directly estimate the cost-efficiency of universities (Carrington 2004, Athanassapoulos and Shale 1997). Separating academic staff as an input without considering the quality differences and costs of the input is likely to bias results toward research-intensive universities. A university that is primarily oriented to teaching may be more efficient when focused on relatively cheaper but less research-oriented staff. Including the quantity of staff, but ignoring the differences in the price and the quality of the input, is likely to bias the results. Due to this reason, Ahn et al. (1988) prefer faculty salaries (i.e. instructional costs) to faculty head count, assuming that faculty ranks and abilities are reflected in their salaries. On the other hand, salary differences do not fully reflect productivity differences among Australian academics, even though in time they may indeed increasingly reflect performance differences. Until 1993, the operation of a national higher education award system provided uniform remuneration across institutions. Since the introduction of enterprise bargaining, dispersion of salaries across institutions has proceeded and loadings and remuneration have led to the emergence of merit and performance based pay (Horsley and Woodburne 2005). Yet data exist only on salaries specified with enterprise agreements, not on actual paid salaries.

The main model in this study distinguishes three inputs: academic staff, non-academic staff, and non-staff (operational) expenditures. Operational expenditures include expenditures on academic infrastructure (libraries and support services), non-staff administrative expenditures, student services, and capital and buildings. These expenditures are aggregated together because they could conceivably be exchanged for each other. Operational expenditure is deflated for the 2000 real value. One of the limitations of the study is that it includes only operational expenditures as costs and ignores the value of the capital investments for the future. Higher education experts have articulated a concern that efficiency orientation hinders long-term investments and has actually contributed to the depreciation of the research infrastructure in Australia (Marginson 2001). The second specification therefore explicitly analyses cost efficiency and uses total operational revenue as the only input measure. Finally, the productivity trend of the academic staff is examined, and academic staff is further decomposed as professors (professors and associate professors), lecturers (senior lecturer and lecturer) and below lecturers.

Output orientation and input orientation

In DEA, efficiency can be modeled in two ways: as an input-oriented or as an output-oriented model. Output-oriented technical efficiency poses the question as follows: *how much can output quantities be increased without changing input quantities*? Input-orientation asks the question of *how much can input quantities be reduced without changing the output*? Choosing one over the other is a conceptual decision. What characterizes better the choices that universities actually face? Efficiency models assume that units can exercise control over their inputs and/or over their outputs and can obtain the maximum possible efficiency level if they wish. Do universities have a greater freedom to manipulate their outputs or to choose inputs?

Australian universities are relatively constrained in their decisions about the production process. Even though institutional autonomy has been greatly enhanced over the period, the government still has substantial power in determining both the outputs and inputs in a university. Student enrollment in universities is a combination of government allocated student places and fee-paying domestic and international students. Universities have freedom in relation to the fee-paying and international student numbers, but not in setting the number of government allocated students. Also, the number of fee-paying students is not unrestricted. The restriction set by the Commonwealth is that the number of fee-paying students cannot exceed 25 per cent of the HECS students (35 per cent since 2005), and all places for HECS students have to be filled before fee-paying students can be admitted. Non-research degree programs (like MBA programs) have no restrictions on tuition or student numbers and the expansion in these programs is also noticeable in Australia. The tuition and number of international students is not restricted. The number of international students has increased significantly. Universities thus have a limited freedom over student numbers. In terms of research output, universities can choose the "amount" of research they produce. The restrictions on research output come from "market demand", i.e. the ability to attract necessary research funding from the research councils.

In terms of inputs, universities also have limited discretion. In terms of academic staff, in the short run universities are restricted by tenure contracts, but they can choose an appropriate mix of junior or senior staff, and adjunct staff. Universities can also change the distribution of work load between research only, teaching only, and combined personnel. How much administrative staff to hire, to substitute some of the time of the academic staff or technologies, is another potential strategic choice.

The main source of revenue is the operational grant by the government. In accordance to the *Higher Education Act*, the operational grant to universities is allocated on the basis of negotiations between the university and the DEST. The negotiation process is built on a university profile that presents a mission statement, strategic plans, quality assurance policies, and various performance and input characteristics (student numbers, staff numbers etc). The size of the operational grant depends primarily on the targeted number of students in each discipline and the level of the course.

Research funding is more dependent on actual performance outcomes. Universities' research budgets come from two main sources: performance based (RQ) grants to universities and the research councils' funding to research projects. Some funding also comes from other agencies, the state government, and private sources. The total amount of science funding is primarily a function of political decisions and political priorities, but the allocation to universities is based on the performance of the university.

It is not unambiguously clear whether universities should be analyzed as input-oriented or output-oriented units. In this study we made a choice for the output-oriented approach on several reasons. The primary restriction on universities is the operational grant, which is outside of the discretion of individual universities and sets serious limits for down-sizing or up-sizing in the short run. Moreover, the rhetoric by the government and in the universities is about increasing performance and productivity. As Massy (1996) points out, in academia productivity is perceived as doing more with given inputs, rather than doing the same with fewer resources. It therefore is more in line with the currents policies, incentives, and pressures to ask if universities could produce more with given inputs rather than to ask whether universities could produce the same outputs with fewer resources.

Empirical evidence

General efficiency

The first specification includes four output measures and five input measures. The outputs include the number of publications, undergraduate/non-degree students, course-based postgraduate students, and research-based postgraduate students. The inputs include the FTE total academic staff, FTE administrative staff, and non-staff expenditures. The DEA results are presented in Table 6-3 and the results break the productivity growth down into individual components. 'Total factor productivity change' in the last column indicates the overall change in productivity which aggregates all individual components. 'Technological change' refers to the shift of the possible production frontier. 'Technical efficiency change' refers to "catching up" with the frontier, which can be either due to scale effects ('scale efficiency change') or just efficiency improvement ('pure efficiency change').

As shown in the last column in Table 6-3, universities' productivity has increased on average 4.5 per cent annually. This improvement can be almost entirely assigned to the outward shift of the frontier, i.e. technological progress (3.9 per cent). The scale efficiency contributes to the change 0.4 per cent and the scale efficiency only a marginal 0.1 per cent. The efficiency gain in the sector has thus been due to the expansion in the frontier relating inputs to outputs. There is no significant increase in efficiency. It should be pointed out that in general universities are very efficient with respect to each other. The geometrical mean of the constant-return-to-scale efficiency scores varies only between 0.90 and 0.95 over the years. High relative efficiency seems to be common to the higher education sector: very high efficiency has been observed also in the UK (Johnes 2006), the US (Salerno, 2002) and by other studies in Australia (Abbot and Doucouliagos 2003). A small sample size and large number of input-output variables explains partly why many universities are defined as being on the frontier. It is also likely that input/output ratio is quite homogenous across the sector. Since the efficiency of universities is already high (i.e. they are already close to the frontier), it can be expected that efficiency can be changed only by shifting the production possibility frontier. However, it is remarkable that all universities seem to have been able to keep up with the shifting frontier.

While the system as a whole demonstrates quite clearly a frontier shift, there are some differences between universities. All universities have improved their productivity, but Sydney University of Technology (9.4 per cent), Ballarat (8.4 per cent), Charles Darwin University (8.3 per cent) have experienced very high productivity increases. In the first case, the productivity increase is entirely due to the shift in the production frontier. Charles Darwin University is an interesting case that demonstrates the highest gain from the scale increase – 4.7 per cent. It is a university that was given a university status in 1989 as a result of the abolishment of the binary system and the university has grown ever since. Ballarat university has had the most balanced efficiency improvement where the frontier shift contributes 4 per cent, scale efficiencies 1.7 per cent and pure technical efficiency 2.5 per cent. In general, scale efficiency improvements have been very low, with a few exceptions over 1 per cent. Four universities have had very minor loss in scale efficiency (University of Canberra, The University of New England, The University of New South Wales, Flinders University).

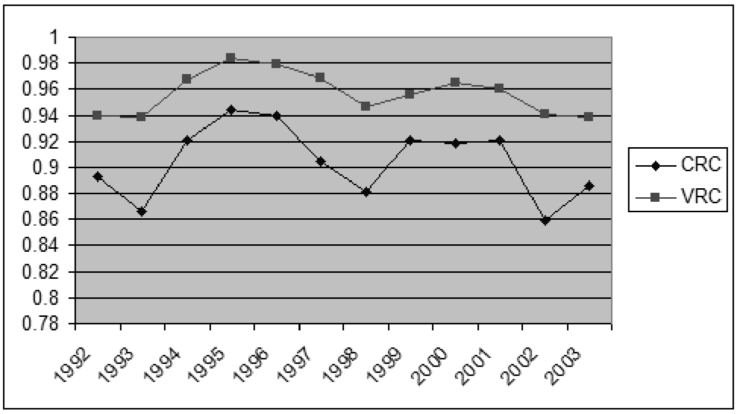
In sum, while there are some minor differences in the sector, there is no consistent trend that universities either move closer or further from the frontier in time. There is also no evidence of some universities strengthening their market position and developing higher unit costs. If some universities have been able to accumulate more resources they have also increased their outputs correspondingly. However, the procedure of decomposing inputs into academic staff, administrative staff and non-staff expenditures, hides one important aspect of efficiency. Academic staff is not identical across the sector, especially in terms of research capacity. These differences are increasingly reflected also in the remuneration packages of academic staff (Horsley and Woodburne 2005). Separating academic staff as an input, ignoring its different costs, may give a biased estimate on the efficiency in the system. While it points to the productivity in terms of main inputs, it does not provide the answer to whether the system operates more efficiently from a pure cost-efficiency viewpoint.

Cost-efficiency

The cost-efficiency model includes the same four output measures (3 teaching outputs, and 1 research output) and total operational revenue as a single input measure. This specification links outputs only with total costs of production and thus provides information on cost-efficiency most directly (Athanassapoulos and Shale 1997).

The results show relatively high efficiency across the sector, between 86 per cent and 94 per cent for the constant return to scale and 93 per cent and 98 per cent for the variable rate of return (Table 6-4). Figure 6.7 illustrates changes in relative efficiency. It should be reminded that the figure does not demonstrate changes in efficiency, but only changes in relative efficiency between universities in each time period. The peaks are years when efficiency differences between universities were the smallest. The graph points out two peaks: 1995 and 2000, which could be explained by the policy changes. As discussed in Chapter 1, the years 1996 and 1999 were the years of big changes in higher education and the peaks may potentially be an effect of the policy changes. Since 1996 the government imposed serious budget cuts for the university. As discussed earlier, since then universities started more actively to attract fee-paying students and search for external funding. It is likely that some universities were able to replace the missing funds more quickly. Since outputs (like student enrollments) cannot be easily manipulated annually, universities were forced to maintain their output levels with fewer resources. In 1999, the government announced a plan of revising the research funding system and linked the funding more towards performance. As a result of the policy change, it is likely that universities again had a different time to cope with the reform. According to this explanation, policy reforms shake the system and increase output/input ratio differences across the sector.

Figure 6.7. Average efficiency score, 1992-2003.



The analysis of different types of universities may give an insight how different universities react to the policy changes. Based on a typology by Margisnon (1997), Australian universities are divided by their main characteristics into four clusters: traditional research-intensive Sandstone universities; universities who aspire to become research intensive comprehensive universities, the so called "Wannabe Sandstone universities"; "Technical universities" that focus on technological study areas; and "New universities" that were created with or after the 1987/88 unification reform. As shown in Table 6-4, Sandstone universities have the highest average efficiency score, which is quite a surprising result. Research intensive universities are characterized by low student-staff ratio and high costs on research infrastructure (Ramsden 1999), but according to this evidence these universities also manage to deliver the results to justify their costs. Technical universities have the lowest mean score, but do not demonstrate a consistently lowest efficiency score over the years. Their relative inefficiency can be expected due to the higher costs of technological programs. Relatively inefficient are also the"Wannabe" Sandstone universities. The last column in the table shows that the efficiency gap between Sandstones and Wannabe Sandstones is increasing. This gap may suggest that the wannabe sandstone universities may need to invest resources into building up research prestige and to position themselves on the market, but the investments are not yet actualized through improved outputs. The gap may be also due to productivity differences of academic staff in these two types of universities, which is not fully balanced by salary differences.

There is no considerable change in universities' cost-efficiency over the period 1992-2004 (Table 6-5). Total productivity has improved 0.6 per cent and the change fluctuates between -3.1 per cent and 4.8 per cent. There is also no clear time-trend in efficiency changes. Both the scale efficiency and the pure technical efficiency have no change (0 per cent). There is not much change in scale efficiency. In 2002 as a model year, the scale inefficiency was 9 per cent. Quite a few universities have scale inefficiencies larger that 10 per cent: some universities seem to be too large (University of Sydney, Deakin, Monash, RMIT, University of Melbourne, University of Queensland) and some too small (Ballarat, Canberra).

This evidence suggests that while the total output of universities has increased over the period, the total revenue of universities has increased proportionally. There has thus been no efficiency gain in the system, despite strong government action such as severe budget cuts, efficiency pressures, and output control. However, a more optimistic interpretation is also possible. Universities could still be performing more efficiently if the prices of the inputs in the higher education have grown faster than consumer prices, yet the universities are able to produce at the same cost-level. Cost-escalation in the higher education sector has received a lot of attention in the US and several factors contribute to the cost increase (Ehrenberg 2000). Most importantly, higher education is a relatively labor intensive industry and the growth in wages, especially among highly skilled labor, has a substantial impact on overall costs in the sector.

The growth in the price of labor has indeed surpassed the growth of consumer prices in Australia; on average 0.7 per cent annually over the period (ABS 2007). However, a time-series study of Australian academic salaries indicates that the real salaries in academia have constantly declined since the end of the 1970s, especially those of the more senior academics (Horsley and Woodburne 2005). Academic salaries rather seem to be an instrument to keep the costs in universities down, similarly to the US during the growth period in 1970s (Froomkin 1990).

Table 6-6 illustrates the dynamics of the total salary costs in Australian universities over the 1992-2003 period. Total real staff costs have increased on average 2.4 per cent annually. As seen in the last column, however, the proportion of academic salaries in universities' total expenditure has constantly decreased. Salaries and salary related costs have dropped consistently from 34.5 per cent of all academic expenditures in 1992 to 29.0 per cent per cent in 2003. These developments indicate changes in the cost structure of Australian universities.

Similar changes in the cost structure have also been observed elsewhere. Rhoades and Sporn (2002) explore the growing importance of administrative and other non-academic services over direct academic activities in the US and in Europe. They have associated the changes with changes in the environment: universities have now greater independence, which also means greater responsibilities, such as quality control, seeking external revenue, admitting different types of students. These trends have changed the structure of professional labor. They observe as a general trend in the US a movement toward a matrix model of production, i.e. where production is less a function of isolated professors' activities than of the interrelated activities of professors and various managerial professionals. Academic salaries are consequently becoming a smaller proportion of universities' budgets. Other researchers have more explicitly associated the changes with the rise in the administrative sector and bureaucratization in universities (Kogan 1999, Gornitzka et al. 1998, Leslie and Rhoades 1995). Increasing administrative costs may thus be a price for greater autonomy of Australian universities and for new responsibilities associated with this autonomy. The other costs compared to salary costs started to increase since 1996, when the market pressures in universities were intensified with budget cuts.

The changes in the cost structure inspire deeper analysis of academic labor productivity as a driving force behind productivity change. As Mahoney (1988) points out, a simplified analysis of partial-factor productivity, which links outputs only to one input, can be more informative for understanding performance differences in complex organizations.

Labor productivity

When focusing only on labor productivity, universities have become significantly more productive. On average, the total factor productivity increases 4.9 per cent annually (Table 6-7). It is almost entirely attributable to technological change (4.4 per cent) – i.e. the possibility frontier is moving outward. Scale efficiencies contribute 0.5 per cent of the productivity improvement. At the same time, universities in general are able to keep up with the trend and the distance from the frontier is not expanding. A small 0.5 per cent increase is due to the change in pure technical efficiency, but scale efficiency has no effect. Changes across universities are quite different. The biggest change has occurred in Charles Darwin University (8.4 per cent), Ballarat University (8.3 per cent), and University of Technology Sydney (UTS) (8.9 per cent). With the exception of the UTS, in general, productivity seems to increase more in universities that have a low average productivity. Sandstone universities demonstrate high productivity, over 0.9 per cent. This indicates that there is some catching up in productivity between universities. When labor inputs are divided into three categories – professors, lecturer and others – the results do not change much (see row 2b in Table 6-8)

How does increase in labor productivity affect the overall cost-efficiency? This depends firstly on the extent to which salary payments have compensated the productivity increase. Considering that real salaries have been constants or even slightly diminishing, the salaries have not kept up with the productivity increase (5 per cent) and labor productivity increase must have a positive effect on overall cost-efficiency.

On the other hand, academic labor cannot be analyzed separately from other inputs. Labor productivity may have increased because it has been substituted with other inputs. The productivity of academic staff may increases due to information technology and e-learning (Johnes 2006). Technological developments can make information more easily accessible to users, may cause changes in teaching, and make administration more efficient. Communication technology may also facilitate collaborative research. Labor productivity change would therefore suggest that technology may successfully substitute some of the labor, or at least make it more productive. The explanation of technology change may however be much more prosaic. Surveys of Australian academics demonstrate that all the policy changes (especially the increase in enrolments and falling funding levels) have considerably increased the work pressure of academics (Harman 2006). In quantitative terms, a survey of academic staff shows that in 20 years, academic faculty works on average 5 hours more each week. Surprisingly, the biggest increase in the time commitment is not related to teaching responsibilities, as could be hypothesized based on increased students-per-staff ratio, but to the administrative commitments. Australian academics perceive a significant decline in their working conditions and career prospects, and job satisfaction has consequently dropped from 67 to 51 per cent (McInnis 1999). At the same time the average working hours have increased only from 47.7 to 49.2 between 1993 and 1999.

Discussion

In this paper we examined whether the reforms since the end of 1980s have made Australian higher education more efficient. Comparing three specifications of the DEA analyses provides some interesting insight about the changes in the sector and helps to answer the question whether the system has become more efficient over time. For a better overview, Table 6-8 compares the main outcomes of the models discussed above.

First, there is no unambiguous answer to the question of whether the higher education sector performs more efficiently. Existing DEA studies on Australian universities (Worthington and Lee 2005) point to the increase in productivity. The first model specification that separates academic staff, non-academic staff and non-staff expenditures confirms the result – universities have improved their productivity by 4.5 per cent. On the other hand, from a pure cost-efficiency standpoint, universities are not more efficient – there has been only a marginal 0.6 per cent change. The change in the productivity that is claimed in the studies seems to be entirely the function of academic staff productivity.

We hypothesized that market reforms contribute to efficiency in several ways. Budget constraints, competition and autonomy for input and output use are likely to provide incentives for decreasing technical inefficiencies in the system, to choose the appropriate scale level, to design incentives that encourage academics to deliver more. On the other hand, competition may bring also additional costs on evaluation, monitoring, seeking external funding, branding and marketing.

Based on this analysis, academics in universities have become much more productive. This may be the result of policies that encourage primarily research productivity. Also budget pressures force universities to increase student numbers without a proportional increase in staff numbers. Academic staff thus work harder and deliver more. The cost-efficiency however does not increase in spite of the productivity increase of the academic staff. Australian universities are experiencing changes in the cost structure, where academic staff salaries and the academic sector as a whole receives a diminishing part of universities' revenues. The explanation here can be twofold. First, although the productivity of academic staff increases, the system requires more administrative and other kind of support, such as marketing, prestige building, and coping with the government evaluation and quality control requirements etc. Secondly, academic productivity may have increased due to changes in "technology", such as computerization, information technology and electronic resources for research. Technology alone does not however explain the productivity increase. As shown above, Australian productivity increase has surpassed that of other countries while there is no evidence that the technology in Australia has been adopted to a greater degree or at a faster speed. However, educational technologies add to non-staff expenditures in universities and this may be one factor that increases non-staff costs in the sector. The increase in academic staff productivity may have been achieved also by deteriorating working conditions and increasing work load or by sacrificing other duties such as teaching.

When we examine how different universities develop over time, there are no patterns that show that some universities develop market dominance and increase higher than average unit costs. Most prestigious research intensive universities are among the most productive ones in all specifications, i.e. by cost-efficiency, academic productivity and mixed input models. Even though it may be true that research-intensive universities are able to attract more resources in the market environment and pay higher salary premiums to their staff, their outputs compensate the increase in the resources. On the other hand, universities that have the lowest productivity (primarily "wannabe sandstones" and technological universities) seem to increase their efficiency fastest and thus catch up with the most efficient universities. Yet the shift even in these universities is rather due to technological change, indicating the outward shift in total productivity frontier in these universities, rather than catching up with the frontier.

Conclusion

The Australian government implemented a cycle of reforms in the higher education sector since the end of the 1980s and strengthened the market mechanisms both in teaching and research areas. The reforms were triggered by the idea that markets encourage competition, which provides universities with necessary incentives for performance improvement and cost-efficiency. This study shows that Australian universities have not become significantly more cost-efficient over time. Increase in research and teaching outputs have been balanced by the increase in operational expenditures, producing 0.6 per cent annual efficiency gain. On the other hand, the ability to maintain the cost level over the 12 year period may be quite an achievement considering increasing income levels in the country and potentially increasing research costs. The productivity of academic staff has considerably increased over time.

The evidence also shows that the level of efficiency in Australian universities is high. There is no sign of increasing cost-differences across universities which could be expected because strong universities are able to secure more resources on the market and thereby strengthen their market position. On the contrary, the gap between research intensive universities and aspiring research intensive universities seems to increase. This may indicate the ability to attract better qualified staff and increase the productivity in the research intensive universities.

TABLES

Table 6-1. The operational revenue of Australian universities by categories, 1995-2002

	1995	1996	1997	1998	1999	2000	2001	2002
Commonwealth Government Grants (HEFA and other grants)	4,308,070	4,566,307	4,420,183	4,294,818	4,190,836	4,218,886	4,470,211	4,655,949
HECS	902,046	932,780	1,209,560	1,450,988	1,662,425	1,675,697	1,771,162	1,833,589
Fees and Charges	880,403	1,078,011	1,226,822	1,355,833	1,546,589	1,697,446	2,020,661	2,462,155
Investment Income	305,042	298,211	326,375	289,613	275,726	320,929	302,641	208,058
Donations and Bequests	85,304	84,247	102,531	114,556	111,550			
Royalties, Trademarks and Licenses						14,593	20,932	18,082
Consultancy and contract research						467,422	494,455	458,956
Other Sources	951,146	981,654	839,840	860,348	853,127	789,143	944,057	1,415,878
TOTAL	7,535,721	8,051,582	8,217,649	8,455,692	8,733,748	9,327,668	10,202,101	11,518,498

Table 6-2. Input and output variables in university-level DEA analyses

	OUTPUTS								INPUTS					
	TEACHING					RESEARCH			EXPENDITURES		STAFF		STUDENT INPUT	
	Number of under-graduate degrees	Quality adjusted undergrad degrees	Number of postgraduate degrees	Number of students enrolled	Course satisfaction	Research income	Publications	Research quantum/ or equivalent	Non-current assets	Various expenditures	Number of academic staff	Number of non-academic staff	Number of students enrolled (FT)	Quality adjusted students enrolled
Australia														
Abbott and Doucouliagos (2003) [1995][i]				X		X		X	X	X[ii]	X	X		
Avkiran (2001) [1995]				X				X			X	X		
Worthington and Lee (2005) [1998-2003]	X		X			X	X			X[iii]	X	X	X	
Carrington et al (2004) [1996-2000]				X[iv]	X		X	(X)*		X[v]				
United Kingdom														
Flegg et al (2004) [1980-1992]		X	X			X				X[vi]	X	X	X	
Athanassapoulos and Shale UK (1997) [1992] A	X		X					X		X[vii]				
Athanassapoulos and Shale UK (1997) [1992] B	X		X					X		X[viii]	X			X
Johnes (2006a) [2000]		X	X					X	X	X[ix]	X			X
Johnes (2006b) [1996-2002]	X		X			X			X		X		X	

	Number of under-graduate degrees	Quality adjusted undergrad degrees	Number of postgraduate degrees	Number of students enrolled	Course satisfaction	Research income	Publications	Research quantum/ or equivalent	Non-current assets	Various expenditures	Number of academic staff	Number of non-academic staff	Number of students enrolled (FT)	Quality adjusted students enrolled
United States														
Ahn et al (1988) [1984]				X		X				X[x]				
Ahn et al (1989) [1984]				X		X				X[xi]				
Ahn and Seiford (1993) [1984]	(X)*		(X)*			X				X[xii]			(X)*	
Breu and Raab (1994) [1990/1983][xiii]														
Salerno (2002) [1993]				X			X				X[xiv]			
Other														
McMillan and Datta (1998) [1992, Canada]				X		X				X[xv]	X			
Taylor and Harris (2004) [1994-1997, South Africa]	X		X				X			X (X)*	(X)*		(X)*	

* When several models specified, the variable is included in secondary specifications. Secondary specifications in parentheses

i. The year of data is in brackets.

ii. All operating expenditures, except staff salaries and salary related expenditures.

iii. All operating expenditures, except staff salaries and salary related expenditures.

iv. Weighted differently for students in sciences and humanities.

v. Total operating expenditure.

vi. Aggregate departmental revenue.

vii. General academic expenditure and research income.

viii. Two categories: Research income; Libraries and other support services.

ix. Three categories: administration; library and other support services; capital.

x. Three categories: Instructional expenditure (i.e. faculty salaries); physical investments; and support services.

xi. Four categories: faculty salaries; physical investments; state research funds; administrative costs.

xii. Three categories: Instructional expenditure (i.e. faculty salaries); physical investments; and support services.

xiii. Outputs: graduation rate and freshman retention rate; Inputs: SAT average, percentage of faculty with doctorates, faculty to student ratio, and educational and general expenditure per student.

xiv. Two categories: academic staff; teaching and research assistants.

xv. Total expenditure except salary costs.

Table 6-3. Geometric mean changes in technical efficiency and technology by year and university, 1992-2003

	Mean efficiency score CRS	Technical efficiency change	Technological change	Pure efficiency change	Scale efficiency change	Total factor productivity change
Average		1.006	1.039	1.001	1.004	1.045
1992	0.900					
1993	0.936	1.044	0.974	1.024	1.020	1.018
1994	0.901	0.958	1.064	0.977	0.981	1.020
1995	0.907	1.010	1.038	0.995	1.015	1.048
1996	0.918	1.012	1.006	1.007	1.005	1.018
1997	0.933	1.003	1.085	0.998	1.004	1.087
1998	0.919	1.015	1.013	0.994	1.021	1.028
1999	0.929	0.993	1.082	0.999	0.995	1.074
2000	0.956	1.035	1.100	1.019	1.015	1.138
2001	0.941	0.983	1.068	0.992	0.991	1.050
2002	0.946	1.005	1.040	1.000	1.005	1.046
2003	0.954	1.010	0.966	1.012	0.998	0.976
Charles Sturt University			6.6			6.6
Macquarie University			5.9			5.9
The University of New England		-1.0	3.6	-0.6	-0.3	2.6
The University of New South Wales		-0.3	4.0		-0.3	3.8
The University of Newcastle		0.8	3.8	0.3	0.4	4.6
The University of Sydney			3.9			3.9
University of Technology, Sydney			9.4			9.4
University of Western Sydney		0.1	3.1		0.1	3.2
University of Wollongong			6.2			6.2
Deakin University		1.0	3.5		1.0	4.5
La Trobe University			0.4	-0.8	0.8	0.3
Monash University		0.5	2.4		0.5	2.9
RMIT University		1.4	4.7	0.8	0.6	6.1
Swinburne University of Techn		0.3	5.1	-0.4	0.7	5.4
University of Ballarat		4.2	4.0	2.5	1.7	8.4
The University of Melbourne		0.6	3.1		0.6	3.7
Victoria University		1.6	3.4	1.4	0.2	5.1
Central Queensland University			2.2			2.2
Griffith University		0.8	2.5	0.2	0.6	3.4
James Cook University		0.6	1.4	0.7		2.0
Queensland University of Techn		1.8	4.0		1.8	5.8
The University of Queensland		0.2	3.9		0.2	4.2
University of Southern Queensland		-2.0	5.1	-2.0		3.0
Curtin University of Technology		1.4	3.3	0.5	0.8	4.7
Edith Cowan University		0.3	3.2	-0.3	0.6	3.5
Murdoch University		-0.2	3.7	-0.1		3.6
The University of Western Australia			3.4			3.4
Flinders University		0.2	3.9	0.4	-0.2	4.1
The University of Adelaide		0.6	2.2	0.5	0.1	2.8
University of South Australia		2.7	4.3	1.5	1.2	7.2
University of Tasmania		2.1	0.5	2.1		2.6
Charles Darwin University		4.7	3.4		4.7	8.3
Australian National University			4.3			4.3
University of Canberra		-2.1	5.6	-1.5	-0.6	3.4
Australian Catholic University		0.6	6.2		0.6	6.8

Note: Efficiency change for individual universities in percentages.

Table 6-4. Cost-efficiency in different types of universities

	Total CRS	Total VRS	Sandstone	Technical	Wannabe sandstone	New	Sandstone-Wannabe
1992	0.893	0.939	0.940	0.810	0.930	0.850	0.087
1993	0.866	0.938	0.844	0.869	0.855	0.894	-0.049
1994	0.921	0.967	0.935	0.927	0.908	0.921	0.014
1995	0.944	0.984	0.959	0.933	0.926	0.954	0.005
1996	0.939	0.979	0.948	0.962	0.912	0.944	0.004
1997	0.904	0.968	0.937	0.881	0.887	0.903	0.034
1998	0.881	0.947	0.896	0.905	0.870	0.869	0.027
1999	0.921	0.956	0.972	0.897	0.890	0.919	0.053
2000	0.919	0.965	0.970	0.895	0.879	0.925	0.044
2001	0.921	0.960	0.977	0.884	0.901	0.912	0.065
2002	0.859	0.941	0.950	0.755	0.811	0.876	0.074
2003	0.886	0.938	0.976	0.781	0.843	0.900	0.077
Average	0.905	0.957	0.942	0.875	0.884	0.905	0.036

Note: Arithmetic means; CRC unless otherwise specified.

Table 6-5. Changes in cost-efficiency: geometric mean changes in technical efficiency, technology, pure efficiency and scale efficiency

	Technical efficiency change	Technological change	Pure efficiency change	Scale efficiency change	Total factor productivity change
1993	0.974	1.052	1.002	0.972	1.024
1994	1.066	0.933	1.034	1.031	0.994
1995	1.029	0.985	1.018	1.01	1.013
1996	0.994	1.003	0.994	1.000	0.997
1997	0.961	1.091	0.989	0.972	1.048
1998	0.974	1.079	0.976	0.998	1.052
1999	1.047	0.936	1.011	1.036	0.981
2000	0.997	1.015	1.01	0.987	1.012
2001	1.003	1	0.994	1.009	1.004
2002	0.924	1.048	0.976	0.947	0.969
2003	1.025	0.955	0.997	1.028	1.978
Average	0.999	1.008	1	0.999	1.006

Table 6-6. Academic salaries and salary-related costs in 1992-2003

	Nominal ('000)	CPI Deflated (base yr 2000)	Growth %	% from total operational expenditure
1992	2 012 902	2449435		34.5
1994	2 242 665	2610478	3,3	35.0
1995	2 351 766	2605796	3,2	33.1
1996	2 610 956	2849697	-0,2	34.4
1997	2.553 064	2793478	9,4	33.0
1998	2 584 864	2784189	-2,0	32.1
1999	2.677.024	2832339	-0,3	31.8
2000	2 859 430	2859430	1,7	31.7
2001	3 029 962	2938213	1,0	31.2
2002	3 265 727	3073763	2,8	29.4
2003	3 431 560	3155209	4,6	29.0

Table 6-7. Changes in academic labor productivity: geometric mean changes in technical efficiency, technology, pure efficiency and scale efficiency

	Mean efficiency score CRS	Technical efficiency change	Technolo gical change	Pure efficiency change	Scale efficiency change	Total factor productivity change
Average		1.005	1.044	1.000	1.005	1.049
1992	0.869					
1993	0.881	1.015	1.011	1.025	0.990	1.025
1994	0.866	0.98	1.066	0.993	0.987	1.044
1995	0.870	1.009	1.032	0.979	1.030	1.041
1996	0.880	1.012	1.004	1.013	0.998	1.016
1997	0.864	0.978	1.098	0.963	1.015	1.074
1998	0.900	1.043	0.994	1.019	1.023	1.036
1999	0.902	0.999	1.051	1.004	0.994	1.05
2000	0.901	1.008	1.176	1.005	1.002	1.185
2001	0.897	0.999	1.039	0.996	1.003	1.038
2002	0.911	0.996	1.054	0.989	1.007	1.049
2003	0.869	1.018	0.974	1.014	1.004	0.991
Charles Sturt University	0.983	0.3	7.1		0.3	7.4
Macquarie University	0.986		5.2			5.2
The University of New England	0.964	-1.4	4.2	-1.2	-0.2	2.7
The University of New South Wales	0.939	-0.7	4.6		-0.7	3.8
The University of Newcastle	0.906	0.6	3.9	0.2	0.5	4.6
The University of Sydney	0.973	0.5	3.8		0.5	4.4
University of Technology, Sydney	0.973	0.6	8.2		0.6	8.9
University of Western Sydney	0.890	0.8	3.8	-0.1	0.9	4.6
University of Wollongong	0.957		4.3			4.3
Deakin University	0.912	0.6	4.5	-0.9	1.6	5.1
La Trobe University	0.774	-0.1	3.5	-1.1	1.1	3.5

Monash University	0.763	-0.4	4.0	0.0	-0.4	3.5
RMIT University	0.946	1.5	4.0	0.8	0.7	5.6
Swinburne University of Techn	0.849	0.5	4.7	0.5		5.3
University of Ballarat	0.772	4.0	4.2	3.8	0.2	8.3
The University of Melbourne	0.915	0.6	3.3		0.6	3.9
Victoria University	0.820	1.0	4.7	0.3	0.7	5.8
Central Queensland University	0.934		5.9			5.9
Griffith University	0.911	0.7	3.8	-0.3	1.0	4.5
James Cook University	0.874	-0.2	3.8		-0.2	3.7
Queensland University of Techn	0.924	1.9	4.6		1.9	6.5
The University of Queensland	0.966	0.3	3.8	0.1	0.2	4.2
University of Southern Queensland	0.903	-2.8	4.4	-2.7	-0.1	1.5
Curtin University of Technology	0.823	1.4	4.0	0.3	1.1	5.4
Edith Cowan University	0.820	2.1	3.3	0.6	1.5	5.5
Murdoch University	0.959	-0.4	4.0	-0.3	-0.1	3.6
The University of Western Australia	0.998		3.7			3.7
Flinders University	0.799		3.8	0.1	-0.1	3.8
The University of Adelaide	0.970	0.1	3.9	0.1		4.0
University of South Australia	0.774	2.4	4.2	0.4	2.0	6.8
University of Tasmania	0.876	1.2	3.5	1.2		4.8
Charles Darwin University	0.613	4.1	4.2		4.1	8.4
Australian National University	0.996	-0.1	3.2		-0.1	3.1
University of Canberra	0.858	-2.6	4.9	-2.5	-0.1	2.2
Australian Catholic University	0.712	0.4	6.9	0.5	-0.1	7.3

Note: Efficiency change for universities in percentages.

Table 6-8. DEA results for four model specifications (geometrical means)

Outputs	Technical efficiency change	Technological change	Pure technical efficiency change	Scale efficiency change	Total factor productivity change
Total operating expenditure	0.999	1.008	1.000	0.999	1.006
Academic labor productivity					
2a. Aggregate	1.005	1.044	1.000	1.005	1.049
2b. By groups	1.006	1.039	1.002	1.004	1.045
Full model (academic staff, administrative staff, non-staff expenditure)	1.006	1.039	1.001	1.004	1.045

Note: All models have the same set of inputs.

CHAPTER SEVEN

CONCLUSIONS

The higher education reforms in the last two decades have changed the Australian higher education system considerably. Driven by the objectives of greater efficiency and better performance, the government strengthened the role of market mechanisms in the system. The universities were made to compete with each other for resources; they have more managerial flexibility to reach optimal resource and performance levels; and they are made accountable to the government via various monitoring mechanisms. All this expresses a more substantial change in the approach: the government does not fund and provide higher education and research, but "purchases" and subsidized education and research services from universities. The effect of such market-based policies on the higher education system, particularly on research performance, is the focus of this dissertation. Markets are expected to provide necessary incentives and flexibility for performance improvement and cost-efficiency. On the other hand, the higher education sector has many peculiarities that make the effect of such market-based policies unpredictable. Unlike organizations in traditional markets, universities are not profit-maximizers; they have multiple goals and principals; they have strongly developed professional values; and their outputs are not easily measurable. Moreover, the higher education sector is often seen as a winner-take-all market where status and prestige rather than price and cost-efficiency determine the market position.

According to the results of this dissertation, Australian universities reacted to the reforms quickly and vigorously. This has affected both the fabric of the higher education sector as well as the behavior in individual universities. One of the worries with respect to market mechanisms in the higher education sector is the concentration and stratification of the system. When resources are allocated to universities based on their performance, the universities that already perform well will attract more resources, improve their performance even faster, and thereby widen the gap with other universities. The results in this study, on the contrary, indicate that universities have become more similar in their research productivity and the gap in research performance between universities is declining over time. The convergence models indicate that universities are not so much "catching up" with each other as maximizing their individual research potential. Universities have different constraints in terms of resources and staff qualifications and the reform cycle has encouraged universities to maximize their research potential with given inputs. The evidence also demonstrates that universities that had originally low research performance had more of the "unused" potential and therefore improved their performance faster. We can therefore summarize that market based policies have not increased the performance gap between universities. More importantly, market-based policies seem to achieve the intended goal: they set up incentives that make universities maximize the productivity of their inputs.

One factor that contributes to the improvement in research performance is internal research management in universities. Since the early 1990s universities have considerably revised and strengthened organizational practices in order to support their research activities. According to the empirical analysis in this dissertation, the practices indeed contribute to better research performance. Such policies are not equally developed across the sector. Research intensive universities seem to have responded to the new incentive structure sooner and implemented advanced research management practices before others. However, even considering the selectivity bias, the practices still demonstrate a positive effect on research performance. The effect, however, varies in different phases of the reform. In the early period (1992-1998) research management practices have a strong association with the performance, but their effect on performance improvement is low. In the later period (1999-2003), on the contrary, the association between the practices and performance is lower but their effect on productivity improvement is larger. This indicates that research management practices demonstrate an effect in a more stable environment; and in the turbulent times immediately after the reforms performance improvement is more chaotic and due to general restructuring.

Internal research practices that target faculties and departments demonstrate most consistently a positive effect. Faculty performance reviews and internal performance-based funding has a positive effect in different model specifications. This result confirms the traditional idea that in universities academic units are a crucial organizational level where individual identities are formed and professional norms shaped. The faculty/department level therefore seems to be the most effective organizational level to be targeted by management practices, more so than the institutional (university) or individual level. Even though market environment strengthens the autonomy and identity of the university as whole, in the organization internally academic units maintain their importance in shaping the behavior of individual academics.

Australian academics have become considerably more productive over the years, as was also confirmed by the Data Envelopment Analysis. The productivity increase characterizes the entire sector and there are no significant efficiency differences between universities when considering both research and teaching output. The extent to which the Australian higher education sector performs more efficiently is however more difficult to specify. In terms of cost-efficiency, Australian universities have maintained their existing cost-level over the years. From a skeptical perspective, this may mean that productivity increase of academic staff is counterbalanced by increase in internal bureaucracy, prestige building, and the costs of technology. From an optimistic viewpoint, considering increasing labor prices and research costs the ability to maintain existing cost levels in universities may be interpreted as a positive achievement. There are also no signs of some universities abusing their strong market position and developing higher unit costs. While universities have different resource levels, the difference in resources is reflected also in different output levels.

It is evident from the analysis that market-based policies have a sudden shock effect which over time declines and finally, the system stabilizes. The period of rapid adjustment to the new environment seems to last roughly ten years. In the 1990s lower performing universities were moving closer to research intensive universities with respect to their research performance, but the trend fades away by the year 2000. Differences are noticeable also in responses to internal research management practices. While in the early period research performance was increasing rapidly, the growth seems to be independent of internal research management practices. In the later period, when the system becomes more stabilized, internal practices start to matter. This indicates that market-based policies have a deep effect on the higher education system and the behavior of universities, but the effect does not last over time. On the other hand, universities improve their performance as a result of the policies and maintain the higher performance level also in the more stable phase.

In sum, market-based policies had a considerable effect on Australian universities. Universities all across the higher education sector improved their research performance. The government policies have also encouraged universities to implement internal research management practices and the effect of these practices outlives the immediate shock reactions. Although the policies may have also unintended effects, the policies seem to have achieved their primary goal of providing incentives for productivity improvement.

Some important questions remained unaddressed in this dissertation. While the empirical analysis provided evidence on the research concentration trend, the issue of whether concentration is good or bad for the higher education system was not examined. Public criticism of research concentration is usually driven by an assumption that concentration creates unjustified inequity in the higher education system (Nadin 1997). The effect of research concentration is however a complex issue. Concentration of research may be indeed negative. This would be so if research funding has a diminishing marginal utility. If a university with less research funding could produce more research output with a certain amount of research funds than a university that has a lot of research funds then the concentration is likely to be negative. Secondly, concentration may lead to the market power that creates inefficiency in the market. Universities with a strong market position may charge higher tuition fees without necessarily providing higher quality education and lead to cost-escalation. On the other hand, research concentration may be a positive phenomenon and research policy in several countries rather encourages such concentration. “Excellence” initiative in Germany, the core principles of “mass and focus” in research funding in the Netherlands, and call for research excellence in selected European universities at the European level are an expression of the assumption that research concentration may actually be beneficial for the country. Whether concentration improves the performance of the system is an empirical matter and requires further research. There is a lack of evidence either to criticize or promote research concentration and such evidence could help inform current research policy.

Another issue that was ignored in this study is the unintended consequences of the rapid increase in research productivity. This issue has several aspects. Some questions arise due to measurement. The incentives that are studied in this dissertation do not target directly research performance but certain proxies that aim to capture research performance, such as publications and research grants. It is likely that some of the observed increase is not due to actual performance improvement but due to the gaming of the system by the university. Besides the measurement issue, the increase in research productivity can be achieved at the expense of other duties, most importantly at the expense of teaching. While the empirical evidence does not suggest that Australian academics spend less time on teaching and course experience questionnaires show rather improvement if any change at all, teaching-research nexus in Australian universities is worth further analysis.

While this research leaves many important questions unanswered, it does provide some evidence on how universities respond to the market-based reforms and how such reforms affect the higher education system as a whole.

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