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Substitution and Complementarity in the Creation and Communication of Australian University Research

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Abstract

The generation of research is one of the major functions of the University sector. In most disciplines, journal articles continue to be the main outlet for the communication of research findings. However, in Australia, government induced distortions have rewarded refereed conference papers an equal status to refereed journal papers. The aim of this paper is to explore the association between research published in journals and research published in conference proceedings. We use a panel dataset of the research output of 36 Australian universities, for the period 1995-2004. Cobb-Douglas research production functions are estimated, as well as a system of research production functions that allows for simultaneity. The results indicate that journals and conferences are contemporaneous substitutes – an expansion in conference publications displaces journal publications. There is also a "DEST effect". On average, conference papers are not converted into subsequent journal papers. The DEST effect is found also through analysis of the publication histories of 152 business and law academics. Post-graduate enrollments are shown to contribute only to conferences and have no effect on journal publications. Research income has a positive effect on both conferences and journal publications.

Keywords: Journals, conferences, DEST effect, research production functions, Australian universities.

[*] CBF Economics Pty Ltd. The views presented in this paper are those solely of the authors and not those of CBF Economics.

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Substitution and Complementarity in the Creation and Communication of Australian University Research

1. Introduction

University research is an integral component of knowledge generation. Hence, it is no surprise that the performance of Australian universities has been a major concern to policy makers. Governments are keen to place academic activity under public scrutiny, especially the quality of teaching, and both the quantity and more recently the quality of research. Overseas, scrutiny has occurred formally through the Research Assessment Exercise in the U.K. and the Performance Based Research Fund in New Zealand. These are soon to be followed by the forthcoming Research Quality Framework (RQF) in Australia.

Studies into university research productivity have, in general, revolved around four issues.[1] First, there is a large and growing literature on the relative performance of individual departments (usually economics departments) and universities. Many studies have been conducted on the efficiency on universities. Worthington (2001) reviews some of this literature. The extant research in Australia has focused on assigning outputs to individuals and departments for the purposes of ranking (e.g. Pomfret and Wang 2003; Macri and Sinha 2006), as well as the overall efficiency of Australian universities (e.g. Doucouliagos and Abbott 2003; Carrington, Coelli and Rao 2005).

Second, a growing pool of studies has explored the economic impact of research and knowledge in general. Laband and Tollison (2003) found that globally the effectiveness of research – in terms of citations – has not increased, despite the growth in public funding. Similarly, Butler (2003) found that although publication by Australian universities in journals has increased, citations of Australian research did not increase as fast as it did in other countries. Most of the existing research in this field revolves around the wider question of the contribution of proxies of knowledge to output. For example, many studies have looked at the impact of R&D on output (e.g. Nelson 1986; Jaffe 1989; Jaffe, Trajtenberg and Henderson 1993; Acs, Audretsch, and Feldman 1994a, 1994b; Acs, Fitzroy and Smith 1995; Audretsch and Vivarelli 1996; Anselin, Varga and Acs 1997, 2000). Third, there is a smaller literature on the impact of research on the careers of those who are engaged with research (e.g. Hollis 2001; Baser and

[1] There are also parallel literatures. For example, there is a large and significant bibliometrics literature. A recent example relating to economics is Clements and Wang (2003).

Pema 2003; Austen 2004). Fourth, there is literature on how funding arrangements affect performance (see Geuna 1999).[2]

Unfortunately, while most of the focus has been on issues such as measurement, relative performance and economic impact, very little is known about the underlying research production process itself.[3]

Our paper makes three important contributions to the literature. First, we explore the underlying research production process in Australian universities by estimating a system of journal and conference publication research production functions that inform on input-output associations. Second, we explore the output-output associations – the impact of conference publications on journal publication and vice versa. Third, we inform on how funding arrangements impact on the underlying output-output associations, in particular the composition of research output. The extant research focuses on the impact of funding on *aggregate* research productivity. We wish to explore also the composition effects.

There is relatively little Australian research on the communication of research.[4] This is unfortunate, as there are good reasons to expect that the generation of research and its communication may be interdependent. For example, high quality research is, *on average*, more likely to be published in higher ranked journals and conferences held in very high esteem, while research that is of lower quality may find its audience is limited to lower ranked conferences and journals, or may never be published at all. But it is possible also that the availability of certain publication outlets may also influence both the volume as well as the type of research produced. The issue is important from a policy perspective, as well as for individual universities and academics. Policy makers need to appreciate the impact that regulation has on university output.[5] With the impending introduction of a new regime of recognizing university research, and the associated financial rewards to universities, at least partly, on the basis of this, it is imperative that the experience with the existing regime and its impact be understood.

This paper is set out as follows. Section 2 discusses the analytical and econometric methodology. Data issues are discussed in section 3. The results are presented in section 4. Section 5 concludes the paper.

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[2] Harzing (2005) argues that one reason for the poor research performance of Australian universities relative to those from the U.S. is that in the U.S. universities receive higher rates of government funding.

[3] Adams and Griliches (1998) has explored the research process for the US and Abbott and Doucouliagos (2004) for Australia. However, these are aggregate studies and do not offer any information on individual research output categories.

[4] Menz (2001) and Harzing (2005) are notable exceptions.

[5] Analysis of the impact of regulation on industry performance has, of course, a long history. Rey *et al.* (1998) found that in the case of Spanish agronomy, policy had tilted researchers to devote their effort away from conferences and towards publishing in journals listed in the Social Science Citation Index.

2. Methodology

2.1 Analytical Approach

The underlying university research production associations are illustrated in Figure 1. University inputs, primarily academic and general labour, post-graduate students and research income, are used to generate research 'output'.[6] Research output is then communicated through several channels including: working papers and unpublished manuscripts; conferences, seminars and workshops; journal articles; and books.

FIGURE 1 ABOUT HERE

Figures 2 to 4 are time series graphs of the total number of books, journal articles and conference papers published by Australian universities, between 1995 and 2004. As can be seen from the figures, the number of books is effectively trendless over this period, while solid growth has been recorded in journal papers (the so-called C1 category) and conference papers (the so-called E1 category). Although the number of conferences has grown at a faster rate, journals remain the numerically largest component of research output. Refereed conference papers have grown at an average annual rate of 7.5 percent, compared to 5.8 percent growth for refereed journal publications. However, most of the growth in conferences has occurred post-2000.

FIGURE 2 ABOUT HERE

FIGURE 3 ABOUT HERE

FIGURE 4 ABOUT HERE

Our focus in this paper is only on conferences and journals, as these are the two categories that have experienced significant growth. Moreover, for the average academic, these are the most likely forms of communicating research. Many Australian academics may never publish a book, but most are expected to publish actively in learned journals, and in some disciplines are expected to present at conferences.

[6] Buildings, land, computing and library facilities are all, of course, also important but data limitations necessarily mean that these factors have to be abstracted from. We assume that these are all proportionate to academic labour and research income.

Conference and journal publications may in turn affect each other over time, so we wish to explore this possibility. In particular, we are interested in whether conferences and journals are substitutes or complements. This is related directly to the impact of DEST (Department of Employment, Science and Training) regulations on the means of communication. Since 1995, DEST has rewarded refereed conference papers by granting them the same number of DEST points as refereed journal papers. Hence, a paper published in a journal such as the *American Economic Review* is given the same weight as a local regional refereed conference (and is given also the same weight as a relatively minor local refereed journal).[7] The impact of this on both research productivity and the composition of research output is unclear. On the one hand, granting a conference paper an equal number of DEST points as a journal publication makes sense for some disciplines, such as information technology and engineering, where conferences are very important and are held in high regard. The downside, however, is that there is little institutional incentive to try and convert conferences into journal papers. A particular research publication can, in general, only be recorded once. It is not possible to have substantially the same manuscript receive both a conference and journal DEST point.[8] Since some university research funding is tied to DEST points, there is no additional reason, from an immediate short-run financial point of view, in pursuing journal articles, as opposed to conferences. From this perspective, we would expect that conference papers would *not* contribute to journal papers. We call this the *DEST effect*. Hence, the association labeled **c** (figure 1), from conferences to journals, may not exist. While this may not be an important consideration in some disciplines, it is important for most. In areas like economics, conferences are given next to no weight by the profession. Indeed, when economics departments are ranked, conferences are not considered at all.[9] Conference presentations also play a limited role in selection and promotions panel for economics positions.

There are however also forces working in the opposite direction. Conference papers may increase the skill and human capital of researchers, better enabling them to publish in journals. Institutions may take a long term view that academic success requires research recognition beyond the DEST points derived from conference papers. Depending on their discipline, individual academics may also understand that their research will have a greater impact if it is

[7] We are not, of course, the first to observe this. Harzing (2005, p. 195) notes that: "Publications in local conference proceedings with very limited peer review and very high acceptance rates carry the same reward as a journal publication in highest ranked journal in the field with extensive peer review and very low acceptance rates."

[8] Codes of practice in many universities are such that they take a rather dim view of attempts by academics to count essentially the same work twice. A conference paper that is subsequently published in a journal can be awarded a DEST point only if it has been modified.

[9] Fox and Milbourne (1998, p. 259) do not include conferences as part of economists research output on the basis that most of these: "appear later in refereed journals". However, this need not be the case for refereed conference presentations if a DEST effect exists.

published in learned journals, and that their CVs are strengthened by journal publications rather than conference papers. Hence, the associations between conference papers and journals are not clear, *a priori* and require empirical investigation.[10, 11]

In addition to the impact of conferences on the number of journal papers published, there is also the issue of the quality of journal papers. Conferences may advance the quality of journal papers if conferences result in feedback that improves the final published journal paper (for evidence relating to research in accounting see Brown, 2005). The formal recognition of refereed conference papers is likely to influence also the type of research undertaken. Anecdotal evidence indicates that there have been at least some conferences devised purely in response to the DEST policy of assigning equal weight to refereed conference papers and journal papers. There is also anecdotal evidence of new journals developed for the same motives. Unfortunately, we lack the data on quality to test for such effects.

The DEST system may thus have several offsetting effects: (a) it may stimulate the growth of low quality refereed conferences;[12] (b) it may stimulate the growth of low quality refereed journals; (c) it may reduce the incentive to convert a fully-refereed conference proceeding into a refereed journal article. This may be a problem for many disciplines; and (d) it may encourage a reallocation of scarce academic inputs away from journals. These effects will differ between disciplines and universities. The net effect on the university system is thus an empirical matter. We do not have detailed data on disciplines and, hence, the focus of this paper is to look at only one part of the picture. Specifically, we explore two issues: (Q1) abstracting from the discipline specific distribution, what is the aggregate relationship between conferences and journals? Does the generation of conference publications have a positive, neutral or negative effect on journal publications? (Q2) is it relatively easier to convert university inputs (academic and general labour, research income, post-graduate students) into conferences or journals?

Associations **a**, **b** and **c** imply a recursive structure. Inputs affect the communication of research through journals and conferences directly, and they affect journals indirectly through

[10] The effects will vary across disciplines. In an established discipline like economics, there is a large list of available journals. In other areas, such as information technology, there is a more limited range of journals. We do not have the data to estimate discipline specific research production functions.

[11] Our own experience indicates that there is a large percentage of commerce academics who are content to limit their activities to conferences, or at least devote a relatively larger percentage of their research to conferences. We are aware of several commerce departments that are currently actively promoting a substitution of research effort from conferences to journals.

[12] These effects are not derived entirely from the DEST system. There are obvious incentives to publish to build up CVs. Some conferences and journals will develop to facilitate this market. While some of these will be legitimate academic initiatives, there is the possibility that they are motivated by non-academic interests. One case in point is the example where an automatic paper generator was used to create a paper that was accepted at a conference, see http://pdos.csail.mit.edu/scigen/.

the impact of conferences on journals. We allow also the possibility that journals impact on conferences, so that there is simultaneity (association **d**, Figure 1), where journals affect conferences and conferences affect journals.

2.2 Econometric specification

We commence initially by estimating first a conference production function (association **a**, Figure 1) and then a journals production function (associations **b**), where conferences are an argument in the journals production function (association **c**). We use a Cobb-Douglas specification of the research production functions:

$$\ln C_{it} = \alpha_0 + \alpha_1 \ln A_{it} + \alpha_2 \ln G_{it} + \alpha_3 \ln Y_{it} + \alpha_4 \ln P_{it} + \alpha_5 T + \alpha_6 CAE + u_{it} \quad (1)$$

$$\ln J_{it} = \beta_0 + \beta_1 \ln A_{it} + \beta_2 \ln G_{it} + \beta_3 \ln Y_{it} + \beta_4 \ln P_{it} + \beta_5 T + \beta_6 S + \beta_7 \ln C_{it} + \beta_8 \ln C_{it-j} + v_{it} \quad (2)$$

where ln denotes natural logarithm, i and t index the i^{th} university and the t^{th} year, C denotes conferences, A is academic staff (including research only and research and teaching staff), G is general staff, Y is research income, P is the number of post-graduates,[13] T is time, CAE is a dummy variable for a former CAE, J denotes journal publications, S is dummy for the so-called Group of 8 (Go8) universities, and u and v denote random error terms.

We postulate that conference and journal research output is determined by academic and general staff input, research income and post-graduates. We postulate also that the former Colleges of Advanced Education (CAEs) will tend to focus more on conferences. Holding the discipline distribution constant, conferences are, *on average*, a more accessible forum for staff that were formally employed by the CAEs. The journals research output function is similar to the conference function except that we replace the CAE variable with the Go8 dummy. We expect that the Go8 group of universities will be more productive in terms of journal papers. This conjecture is given some support by trends in the actual data. Table 1 compares the E1 and C1 research performance for four groups of universities. Conference papers are less important for

[13] Total post-graduate student figures include those undertaking doctorate by research, doctorate by coursework, master's by research, master's by coursework, as well as other postgraduate studies.

Go8 universities (row 1), and are most important for the Universities of Technology. Nevertheless, the Go8 universities generate one third of all conference papers and almost 60 percent of all journal papers. Moreover, the Go8 is the only group that has recorded a faster rate of growth in C1 than in E1 publications.

TABLE 1 ABOUT HERE

The other difference between equation 1 and 2 is that conferences and lagged conferences enter into equation 2. The variable **Conferences** (C_{it}) is included to explore the impact of conference activity on journal research. Lagged conferences (C_{it-j}) is included to test whether conferences are converted into journal publications, or whether conference research terminates at the conference proceedings.

We have no expectations on the sign of the associated coefficients. If $\beta_7=\beta_8=0$ (from equation 2), then conferences have no effect on journal publications. One implication of this is that for most disciplines, funding conferences would not be justified on the grounds of increasing the *volume* of journal publications.[14] It is reasonable to assume that conferences precede journal publications. Hence, if $\beta_8=0$, we conclude that conference publications are not transformed into subsequent journal publications. If $\beta_7=0$, conference publications do not crowd out journal publications. If $\beta_7>0$, conferences and journals are complements. If $\beta_7 < 0$, conferences and journals are substitutes.

Figure 1 includes the possibility that journals will impact also on conference publications (association **d**). This suggests that there may be simultaneity between journals and conferences. Simultaneity in the research production functions is represented by the following system:

$$\ln C_{it} = \alpha_0 + \alpha_1 \ln A_{it} + \alpha_2 \ln G_{it} + \alpha_3 \ln Y_{it} + \alpha_4 \ln P_{it} + \alpha_5 T + \alpha_6 CAE + \alpha_7 \ln J_{it} + u_{it} \quad (3)$$

$$\ln J_{it} = \beta_0 + \beta_1 \ln A_{it} + \beta_2 \ln G_{it} + \beta_3 \ln Y_{it} + \beta_4 \ln P_{it} + \beta_5 T + \beta_6 S + \beta_7 \ln C_{it} + \beta_8 \ln C_{it-j} + v_{it} \quad (4)$$

[14] They may, of course, be justified on the basis that they contribute to the quality of journal publications. Also, to the extent that conference funding is valued by academics for other reasons (e.g. networking and travel), there may arise important work satisfaction issues that indirectly impact on research productivity.

Equations 1 and 2 can be estimated using OLS. However, given the potential endogeneity, OLS would be an inappropriate estimator to use. Accordingly, we use Generalized Method of Moments (GMM) to estimate the system of equations (equations 3 and 4). As instruments we used: academic and general staff; the number of post-graduate students; the number of books; research income; the number of undergraduate enrollments; the time trend; the dummy variables for former CAEs and Go8; the number of campuses; and the existence of a medical school.

The situation is complicated by differences between disciplines. Table 2 presents some evidence of the unevenness in the distribution of both conferences and journal papers. At the University of Melbourne, journal publications are much more important for medicine, whilst most conference publications relate to engineering. The distribution at the University of Melbourne is probably fairly representative across the university sector as a whole. Unfortunately, DEST research publications data is not available by discipline and, hence, only aggregate and university wide data can be used. However, we do control for the engineering and information technology factor by including the number of staff employed in these areas. That is, we estimate versions of equations 1 to 4 using both aggregate academic labour, as well as academic labour disaggregated into three categories: research only academic staff (**Res**); academic staff employed in engineering and information technologies (**IT&E**); and teaching and research academic staff in all other disciplines (**Others**). In this way, we hope to control for some of the differences in the importance of conferences across disciplines.

TABLE 2 ABOUT HERE

3. Data Issues

3.1 Matching research output to academic inputs

One of the major issues relating to university research output data is that research reported at a particular date will reflect research undertaken at an earlier period. For example, research recorded for 2002 is highly unlikely to have been conducted in 2002. The value of research rises when it is communicated.[15] It is not until research is publicly available that it receives wider recognition. However, from a production process perspective, it is the association between the use of inputs and the generation of research that is important, rather than the communication of research. For example, in terms of the underlying production process, we wish to investigate the research that was generated in 2002 from resources devoted to it in that year. The fact that

[15] Indeed, research that terminates in a file drawer is of little value.

research generated in 2002 will not be available in the public domain (in the form of conferences and journal papers) until 2003 or 2004 is a different issue. This is akin to the production of say a motor vehicle in 2002 that is not sold until the following year. Analysis of the underlying production process focuses on the generation of outputs from inputs, rather than the sale of outputs.

Hence, in matching staff and other variables to research output it is important to align the input and output data properly. Abbott and Doucouliagos (2004) assume that papers published in journals and recorded in time period t were actually undertaken in time period t-1. We follow Fox and Milbourne (1999) and use a two year lag. The lags involved with conferences are typically not as long as those involved with journal papers. Our approach is to assume a one year lag for conferences. That is, we assume that the DEST recorded journal publications for 2003 were actually completed in 2001, on average, and that the DEST recorded conference publications for 2003 were actually completed in 2002, on average.[16] However, we do consider also different lag structures and explore the sensitivity of the results.

3.2 The conference to journal publication lag

The other lag of importance is the time it takes for conference presentations to be converted into journal publications. Our approach is to consider both contemporaneous associations between journals and conferences, as well as one and two year lags between conferences and journals. Some support for a one and two year lag can be found by considering the lags reported in journal articles. We analyzed the acknowledgements made by authors of 469 refereed journal publications in six Australian commerce journals, for the period 2003 to 2006.[17] Table 3, Column 4 reports the average conference to journal lag among this group of publications. While this is only one sub-set of Australian journals, we speculate that a two year lag will be fairly representative of most journals.[18] Table 3 confirms also that conferences play a relatively minor role in economics, while they are relatively more important in accounting and finance.

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[16] Harzing (2005) argues that the publication lags in economics journals could be as long as five years. This however will vary from journal to journal. For example, we analysed the number of months from submission to publication in the August 2006 issue of *Economics Letters*. The median publication lag in the 22 papers published in this issue was 12 months, and the average was 13.4 months. In contrast, the May 2006 issue of the *Review of Economics and Statistics* contains 12 papers and 2 notes, with a median submission to publication lag of 31.5 months and an average lag of 32.1 months. While it may be reasonable to assume that better journals take longer time to review and publish papers, not all journals that take longer time are better. We are aware of some poorly managed journals that take two years to review manuscripts.

[17] Some authors may not have acknowledged that their paper was presented at a conference/seminar.

[18] A more detailed analysis of these lags across other business and other discipline journals is beyond the scope of this paper. In particular, it will be interesting to analyse the impact of the DEST system on changes over time to the proportion of refereed conference proceedings published.

TABLE 3 ABOUT HERE

3.3 Research quality

We do not have any consistent measures of research quality for the Australian university sector (see Doucouliagos and Abbott 2003 and Carrington, Coelli and Rao 2005). DEST research output data are not quality adjusted.[19] Hence, the use of DEST data requires that researchers assume that research quality is constant over time and across universities. Our primary focus in this paper is the volume of publications and, hence, quality unadjusted data is sufficient. However, the impact of ignoring research quality is uncertain, and results using DEST data need to be interpreted with caution.

While we do not have university wide research quality indicators, there are indications that research quality is not constant. For example, Pomfret and Wang (2003) compiled a dataset for all Australian academic economists employed by departments that also teach (hence research only academics are not included in their dataset). Using their data, we constructed figure 5, which traces the proportion of papers published in the top 88 economics journals, for all Australian universities and for the Group of 8 universities.[20] Over the period 1990 to 2001, the average annual rate of *growth* of journal publications by Australian economists was 9 percent, while the proportion published in the top 88 journals *fell* by about 5 percent per annum. Over the period, both the total number of publications and the per capita number of publications have increased. The per capita number of publications increased from 1.52 in 1990 to 2.09 in 2001.[21] At the same time, the average quality (as defined in the Top 88 journals) has decreased steadily. This pattern is consistent with a DEST inspired increase in research productivity (in terms of quality unadjusted volume of publications) but substitution for lower journal quality papers in economics.

FIGURE 5 ABOUT HERE

Our approach to the quality issue is to commence initially, like other authors, by abstracting from research quality issue.[22] We do however attempt to compile a measure of research quality by

[19] The existing DEST system rewards universities on the basis of DEST points, rather than the quality of research.
[20] The list of journals can be found in Pomfret and Wang (2003). Their data terminate at 2001.
[21] This pattern has occurred across all universities. Thus, for Group of 8 economists, the per capita publications rose from 1.59 to 2.33, and for the other universities, the per capital publications rose from 1.45 to 1.85.

[22] This problem is not unique to Australia. For example, the vast majority of university efficiency studies are forced by data limitations to ignore research quality.

using Social Science Citation Index data. For each university and for each year, we counted the number of papers that had an author who was affiliated with that university.[23] We then replace the original journal papers series with our SSCI series, and then compare the econometric results of using the SSCI series to the original DEST data. It should be noted that there are three major problems with this approach. First, we are unable to construct such a series for conferences. Second, journals not listed by the SSCI are given a zero weight in our quality series.[24] This is of particular concern as many Australian journals are not listed in the SSCI. Third, we have not adjusted the quality series for the number of authors. Hence, it is not strictly comparable to the author-adjusted DEST research output series. Nevertheless, this series may serve as a proxy and an initial analysis of research quality. With the exception of three universities, the quality series is highly correlated with the original DEST publications series. The median first order correlation of the DEST series and our quality series is 0.78, while the average is 0.88. The "quality" research series shows an annual average rate of growth of about 5 percent[25], compared to the volume series of 5.8 percent, during the 1995-2004 period, although the two series are not strictly comparable as the quality series is not adjusted for the number of authors.

4. Results

We estimate first equations 1 and 2 using OLS. These results are presented in Table 4 columns 1 and 2 for the conferences and journals equations using aggregate academic labour, and columns 3 and 4 using disaggregate academic labour, respectively.

TABLE 4 ABOUT HERE

The variable **Conferences** in the journals equation implies that conferences impact upon journals, but there is no allowance in columns 1 to 4 for journals to affect the conferences equation. When this is introduced, OLS is not the recommended estimator, as simultaneity between conferences and journal publications means that OLS estimates will be biased. Accordingly, columns 5 to 10 report the GMM estimates of the system of simultaneous equations 3 and 4. Columns 5 and 6 use aggregate labour, while columns 7 and 8 use

[23] An alternative approach is to compile citations data for each university. This however is beyond the scope of our paper. Moreover, a major problem with citations data is that newer studies will be given lower weight as they will have had less time to attract citations.

[24] To complicate matters further, the number of journals included in the SSCI has increased over time.

[25] This pattern is in sharp contrast to the Pomfret and Wang (2003) findings of a decline in the quality of economics publications. Aggregation at the university level can disguise significant discipline level differences.

disaggregate labour. Columns 9 and 10 use the research quality index.[26] Our discussion of the results will revolve around the GMM estimates.

4.1 Input-output associations

As expected, the aggregate academic labour measure is positive for both conferences and journals – expanding the number of academic staff increases both types of research output. When the three disaggregate labour measures are used a more complex picture emerges. Research only staff has a positive effect on the number of journal publications, while both the IT&E and the Others categories have no effect. For conference publications, only IT&E has a positive and statistically significant effect. These results suggest that an expansion in academic staff that teach and research has no effect on research productivity, presumably because of their teaching and administration responsibilities. When the research quality measure is used, none of the academic labour variables is individually or jointly statistically significant (see the Wald Test _ Academics).

General staff has a positive effect on both journal and conference publications, although the magnitude of the elasticity varies according to the specification. Similarly, the elasticity of research output with respect to research income is positive for both conferences and journals. The positive coefficients associated with general staff and research income highlight the importance of research funding. Those universities that are well resourced in terms of general administrative support (both in terms of administrative support for research and support that frees academics from administrative duties) are able to generate more research. Those universities that are well resourced in terms of research funding also generate more research.

The number of post-graduates has a zero effect on journal publications (and is negative when OLS is used). This suggests that the research training provided by Australian academics to post-graduate students does not stimulate journal publications. This is in sharp contrast to the positive elasticity of conferences with respect to post-graduates (columns 7 and 9).[27] In the period 1995 to 2000, postgraduate numbers rose by an average rate of about 5 percent. In the post 2000 period, this has doubled to an annual average rate of growth of over 10 percent, and may be one contributing factor behind the rapid growth in conferences (see figure 4).

The coefficient on the CAE dummy variable has the expected positive coefficient and is statistically significant. On average, the former CAEs generate more conferences than other

[26] In preliminary analysis we found the time trend to be statistically insignificant when estimating equations 3 and 4 and this variable was subsequently eliminated.

[27] Publications by post-graduates are given the same DEST points as academic staff. Our results are consistent with the notion that post-graduates find it easier, on average, to publish in refereed conferences than refereed journals.

universities. However, the Go8 dummy is not statistically significant in the GMM results (but is in the OLS results). This suggests that once differences in funding levels are controlled for,[28] there is no difference in the Go8 universities contribution to journal publications.

4.2 Output-output associations

Journals has a negative and statistically significant coefficient in the aggregate academic labour specification, but while it still has a negative sign in the disaggregate academic labour equation, it is no longer significant. **Conferences** has a negative coefficient in both specifications. We conclude from columns 5 to 10 that the impact of journals on conferences is not robust, but the impact of conferences on journals is negative. This conclusion can be drawn also with the OLS results.

The sum of the three conference coefficients in the journals regression is negative. This is driven by two factors. First, there is a negative contemporaneous effect. On average, resources devoted to conferences appear to displace activity devoted to journal publications. This effect remains even when we control for IT&E academic staff. Second, the statistical insignificance of the lagged conferences is consistent with the notion that there is little incentive to convert conferences into journal papers.[29] This is the DEST effect, arising from assigning equal weight to refereed conferences and refereed journal papers.

4.3 Sensitivity Analysis

In the construction of Table 4, recorded journal publications have been displaced by two years. Table 5 re-estimates the system of production functions using different assumptions regarding when research was actually carried out. The first row of each panel in Table 5 reproduces the results from Table 4. This is the base model specification. The coefficients reported in columns 5 and 6 are shown in Panel A, columns 7 and 8 in Panel B and columns 9 and 10 in Panel C. The results reported in the second row of Table 5 are derived by displacing recorded journal publications by three years. That is, research that is published in journals recorded in 2004 is assumed to have been produced in 2001, so that there is, on average, a three year publication lag. In the second set of results (row 3), recorded journal publications are displaced by four years. That is, journal publications recorded in 2004 are assumed to have been produced in 2000. In columns 5 to 10 Table 4, only the contemporaneous number of

[28] Funding here refers to both direct funding for research and the indirect funding of research through academic and general staff and infrastructure.

[29] We know of many cases of Australian academics who satisfy their "DEST point target" through refereed conference publications and who see no reason to then convert these into journal papers.

conferences is statistically significant. Accordingly, we reestimate the base model by eliminating $conferences_{t-1}$, $conferences_{t-2}$, and both $conferences_{t-1}$ and $conferences_{t-2}$.

TABLE 5 ABOUT HERE

Three robust results emerge from Panel A. First, the impact of journal publications on conference publications is negative and the response is elastic. The base model shows that a 10 percent increase in the number of journal publications is associated with a 12.6 percent decrease in the number of conference publications. Second, the impact of conference publications on journal publications is negative and the response is inelastic. The base model shows that a 10 percent increase in the number of conference publications is associated with a 7.3 percent decrease in the number of journal publications. Third, none of the lagged conference variables are statistically significant. That is, the conference publications do not have a stimulating effect on subsequent journal publications. Hence, the expansion in the number of conference publications illustrated in figure 4 is unlikely to be translated into journal publications in the future.

The conclusions from Panel A are largely supported by the results presented in Panel B, where an attempt is made to control for discipline differences in the importance of conferences. Conferences continue to have a negative effect on journal publications, although the effect is now shown to be elastic in some specifications. As was the case in Panel A, lagged conferences has no effect on journals. However, journal publications have no effect on conference publications in the base specification, although they do have a negative effect if longer lags are used in the publication process. Panel C confirms the existence of a DEST effect, as none of the lagged conference coefficients is positive and statistically significant.

In addition to exploring the effects of using different specifications and estimators, we consider also different samples. For example, instead of using data for the period 1995 to 2004, we used data for the period 1997 to 2004. The results are robust to these, or other, time periods.

We thus conclude that the DEST system has had a negative effect on the number of journal publications. The explosion in conference publications that has occurred post-2000, has come at a direct cost of journal publications. This should be of concern to the government and the university sector in general. It is possible that the displacement has been limited to papers that would have been published in low quality journals receiving little attention. Hence, the

welfare implications of the DEST system are unclear and are an important area for future investigations.

4.4 Analysis of individual academics

Our final piece of analysis relates to the publication histories of 152 academics employed by the Faculty of Business and Law, Deakin University.[30] This is the group of academics in this faculty who published in at least two years during the 1995-2005 period. Again we wish to see whether there is any association between conferences and journal publications, although due to data limitations we are unable to do so using the same framework as our university wide analysis. Table 6, column 1 presents the results of using pooled least squares, regressing conferences, whether the academic possessed a PhD and the researcher's main discipline area upon the number of refereed journal publications. Column 2 repeats this using the Fixed Effects estimator. Since not all individuals publish in each year, there are many zero entries. Hence, we estimate the regression also using the Tobit Random Effects model.[31] In all cases, there is a positive and direct association between journal publications and conference presentations with a two year lag. There is no contemporaneous effect of conferences on journals. The main limitation of columns 1 to 4 is that they ignore the potential simultaneity between conferences and journals. Accordingly, columns 4 and 5 report the estimates from the system of two equations (one each for both journals and conferences).[32] To ensure identification we add the researcher's gender (male = 1, female = 0) to the conference equation and whether the researcher has a PhD to the journals equation. In preliminary analysis, the control for Accounting and Finance discipline was not statistically significant in either equation and the Information Systems dummy was not statistically significant in the journals equation. Moreover, when all three conference variables are included, none are statistically significant. Hence, we present the results of using a general-to-specific modeling strategy in columns 4 and 5, after eliminating the two discipline dummies and conferences lagged once.[33]

TABLE 6 ABOUT HERE

The results for the Deakin sub-sample are at odds with those derived from exploring the entire university system. For the Deakin sub-sample we find a contemporaneous positive association,

[30] This data is available publicly from http://www.deakin.edu.au/research/performance/index.php.
[31] The estimation of Tobit Fixed Effects model is problematic and hence we focus on Tobit Random Effects.
[32] The system was estimated using the GMM estimator, with all exogenous variables used as instruments.
[33] The full set of results is available from the authors.

compared to a negative one for the university sector as a whole. The system of equations estimates for the Deakin sample show that journals and conferences are contemporaneous complements. Further, the overall effect of conferences on journal publications is positive for Deakin while it is negative for the university sector. This is so even though there is a sign reversal from the single equation estimates to the system of equation estimates in the lagged conferences variable. Several reasons can explain the disparity. First, the results presented in Table 4 may be suffering from aggregation bias. Second, the results are not strictly comparable, as the Deakin sample uses individual data and, hence, is not the same as the research production functions as for the entire university sector.[34] Third, the Deakin sample may have particular characteristics that do not generalize. The Faculty of Business and Law was traditionally a relatively poor performer in terms of research. This has changed over recent years as several initiatives promoting research were implemented and these may have stimulated both conferences and journal publications simultaneously.[35] Note, however, that the DEST effect is still detected here, as there does not appear to be an incentive to increase subsequent publications. Indeed, there is a negative effect. These results indicate strongly the need for much more research in this area, especially the use of disaggregate data at both the department and individual academic level.[36]

5. Summary

University research is coming under increasing scrutiny. Both the pace and impact of research has been questioned (see Pomfret and Wang 2003 for an analysis of academic economists and Harzing 2005 for commerce in general). The focus of this paper was to estimate the input-research output elasticities and to explore the extent of substitution between some of the different avenues through which research output is communicated. The results show that, on average, research communicated through conferences is unlikely to be published subsequently in journals. Policies that encourage conference papers – e.g. equal DEST weighting for conferences and papers – will tend to have an adverse effect on publishing in journal papers. Hence, it is possible that growth in journal papers produced by Australian academics has been lower because of DEST funding arrangements.

[34] Note that because of many zeros, we do not use the logarithm of journals and conferences, which was the case when we estimated the university wide research production functions. An alternative approach is to use count based methods.

[35] In 1995, the Faculty of Business and Law recorded 19 E1 and 46 C1 publications. By 2005, it recorded 150 E1 and 163 C1 publications. This can only partly be attributed to growth in academic staff.

[36] The other results from Table 6 are that as economics and law academics tend to publish more journal papers than academics in other disciplines and information systems staff publish more conference papers. The gender variable implies that males are less likely to publish in conferences and staff with PhD are more likely to publish in journals.

Conferences offer a number of benefits. They are a quicker way of communicating results. They enable results that are still work in progress to be subject to scrutiny, offering the opportunity for research quality to be improved. Moreover, the E1 category may have offered some research inactive academics the opportunity to engage in research. However, our results indicate clearly that conferences do displace journal publications. On balance, our view is that abandoning the E1 category is desirable for most disciplines. In the absence of an institutional distortion that an equates an E1 to a C1, researchers in most disciplines will have greater incentive to communicate through journals. In disciplines where journals are of higher quality, on average, than conferences, then academics will have to work harder to increase the quality of their research. Conferences would remain as venues for feedback and networking, and hence continue with that aspect. It may, for example, be possible to develop a system where conferences are recognized in some disciplines but not in others. Or, to develop a system that recognizes only the higher ranking conferences.

Journals obviously differ in their ranking and not all research published in journals can be regarded as superior, compared to research that is communicated through refereed (as well as non-refereed) conferences. We share the widely held view that, *on average*, in areas like economics, research published in journals is of higher quality than research that is published through conference proceedings.[37] If this view does reflect reality, then the results presented in this paper suggest that the E1 category has led to some substitution away from higher quality journal publications. Lack of data prevents analysis of the impact of conference papers on the quality of journal papers and vice versa. Hopefully, the upcoming RQF will shed light on some of these matters by providing processes and structures that both record and recognize research quality.

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[37] The refereeing process for journals is much more rigorous than it is for conferences.

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Figure 1: The University Research Production Process

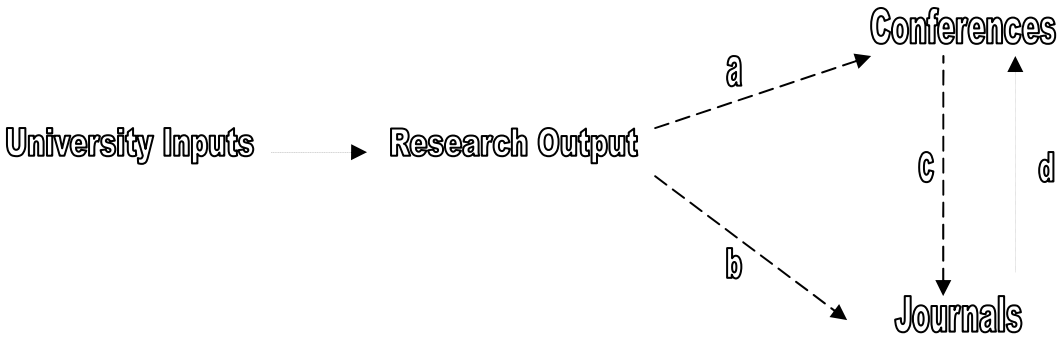


Figure 2: Annual Total Number of Books Published by Australian Universities, 1995-2004

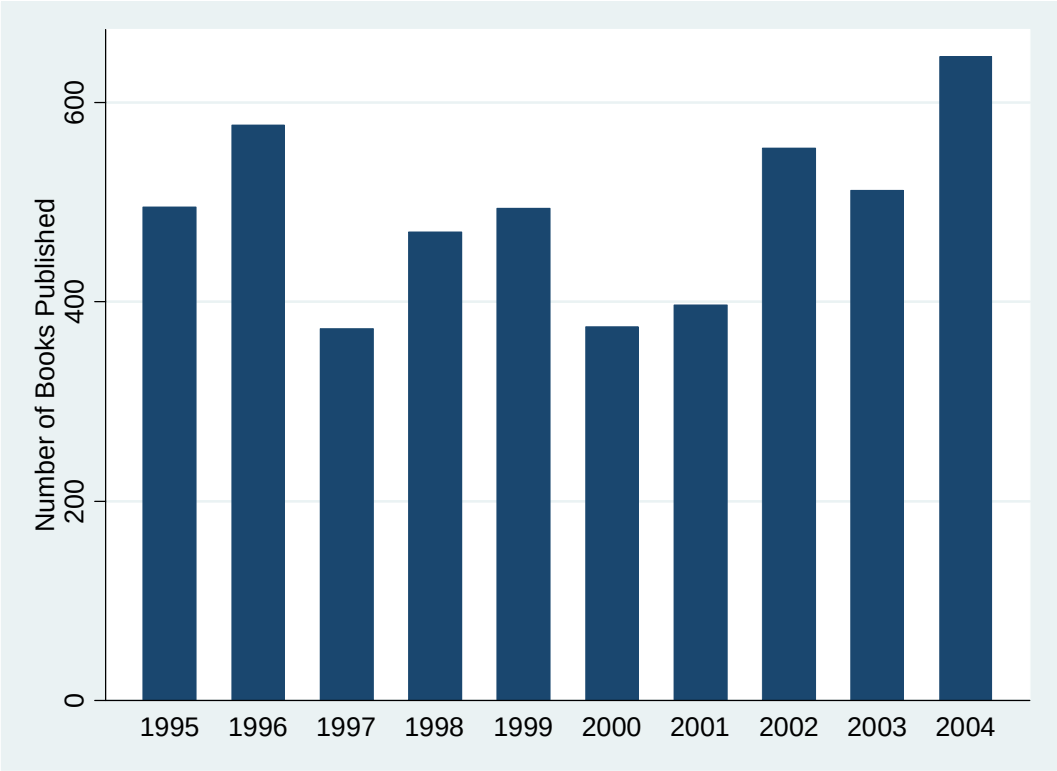


Figure 3: Annual Total Number of Journal Articles Published by Australian Universities, 1995-2004

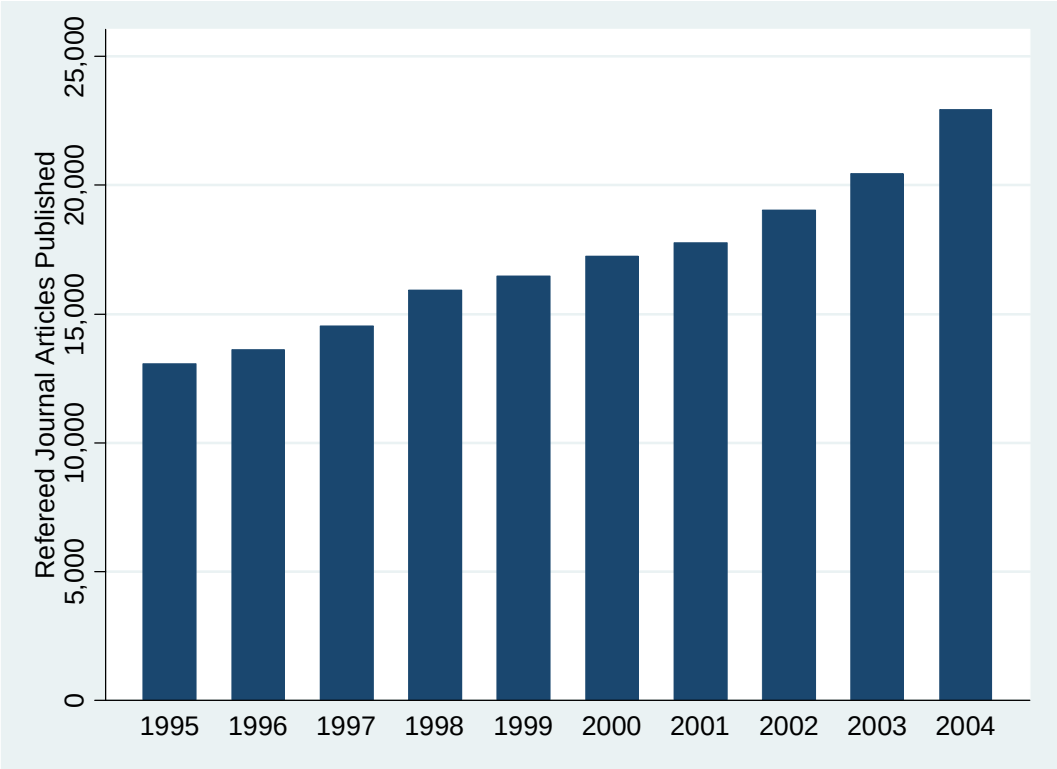


Figure 4: Total Number of Refereed Conference Papers Published by Australian Universities, 1995-2004

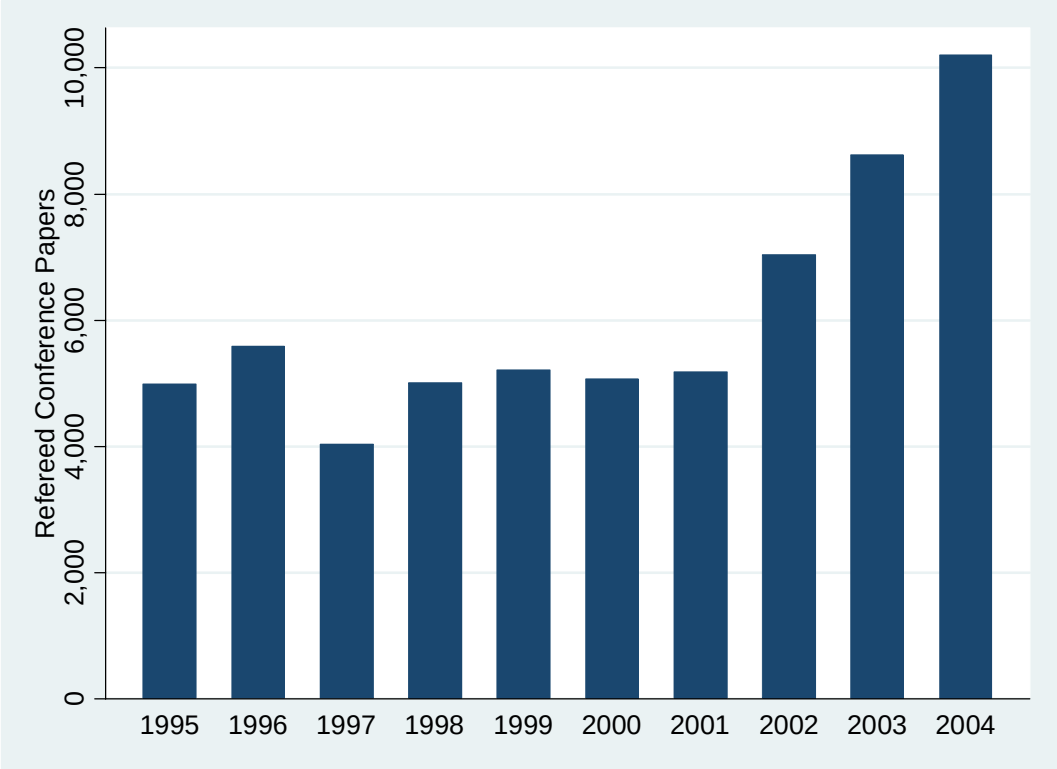
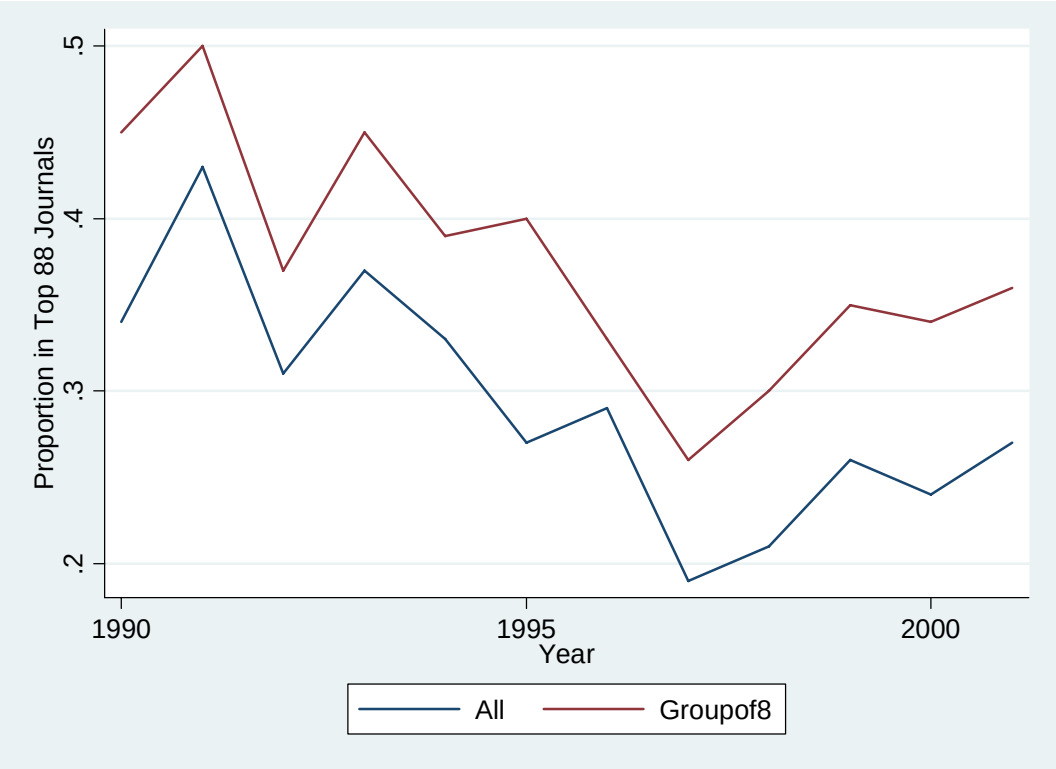


Figure 5: Proportion of Journal Publications Published in Top 88 Economics Journals, Australian Academic Economists, 1990-2001.



Source: Constructed from Pomfret and Wang (2003)

Table 1: Comparative Research Performance, University Groupings

	Go8 (1)	Universities established 1960-1986 (2)	Universities established post 1987 (3)	Universities of technology (4)
E1 as percentage of C1 & E1 (2004)	0.22	0.31	0.50	0.51
E1 percentage of all Universities (2004)	0.33	0.17	0.34	0.15
C1 percentage of all Universities (2004)	0.57	0.19	0.17	0.07
Growth in E1 publications (1995 to 2004)	56%	106%	199%	155%
Growth in C1 publications (1995 to 2004)	74%	62%	111%	78%

Source: See Appendix A. Column 2 includes: Macquarie University, Latrobe University, University of Newcastle, Flinders University, James Cook University, Griffith University, Murdoch University, Deakin University and University of Wollongong. Column 4 includes University of Technology, Sydney, RMIT University, Queensland University of Technology and Curtin University of Technology. Column 3 includes all other non-Go8 universities.

Table 2: University of Melbourne, Conference and Journal Publications by Discipline Area, 2000 and 2004

	E1 2000	C1 2000	E1 2004	C1 2004	Growth in E1	Growth in C1
Architecture	33	28	36	36	9%	29%
Arts	24	211	48	373	100%	77%
Economics & Commerce	14	93	39	158	179%	70%
Education	19	55	33	89	74%	62%
Engineering	187	191	297	208	59%	9%
Land & Food	4	56	4	80	0%	43%
Medicine	22	1479	23	1746	5%	165%
Science	34	496	90	594	18%	20%
Total	345	2822	594	3369	72%	19%

Source: Research Performance 2000 and 2004, University of Melbourne.
E1= refereed conference paper; C1 = refereed journal paper

Table 3: Conferences and Journal Publications, Selected Leading Australian Commerce Journals, 2003-2006

Journal	Number of papers published (1)	Proportion presented in conferences (2)	Proportion presented in seminars (3)	Average time from conference to journal publication (in years) (4)
Accounting and Finance	86	42%	30%	1.9
Australian Economic Papers	101	14%	9%	2.1
Australian Journal of Management	26	38%	27%	2.5
Australian Journal of Agricultural and Resource Economics	81	22%	17%	1.8
Economic Record	101	19%	18%	
Journal of Industrial Relations	74	3%	3%	1.5
Total	469	21%*	16%*	2.0

Source: Counts based on analysis of author acknowledgement statements. * denotes weighted average. Special conference issues are not included.

Table 4: Australian Universities Research Production Functions
(Dependent variable = natural logarithm of conferences or journal articles)

Variable	Conferences OLS (1)	Journals OLS (2)	Conferences OLS (3)	Journals OLS (4)	Conferences GMM (5)	Journals GMM (6)	Conferences GMM (7)	Journals GMM (8)	Conferences GMM (9)	Journals GMM (10)
Constant	-5.62	-2.17	-5.80	-0.91	-9.39	-7.12	-6.07	-5.33	-7.58	-12.52
	(-13.13)***	(-5.90)***	(-11.06)***	(-2.56)**	(-8.18)***	(-8.45)***	(-4.45)***	(-3.87)***	(-6.45)***	(-3.20)***
Academic Staff$_t$	0.14	0.21	-	-	0.45	0.38	-	-	-	-
	(1.09)	(3.28)***			(2.55)**	(2.51)**				
General Staff$_t$	0.29	0.62	0.36	0.24	1.63	1.22	0.54	0.70	1.10	2.29
	(2.33)**	(5.99)***	(2.19)**	(2.15)**	(4.89)***	(7.24)***	(1.73)*	(3.41)***	(3.43)***	(3.85)***
Research Income$_t$	0.22	0.34	0.20	0.29	0.68	0.54	0.37	0.39	0.45	0.81
	(5.34)***	(8.88)***	(3.30)***	(5.61)***	(7.08)***	(11.19)***	(2.89)***	(6.89)***	(4.90)***	(4.11)***
Post-Graduates$_t$	0.62	-0.20	0.61	-0.21	0.08	0.02	0.40	0.11	0.52	0.66
	(7.50)***	(-2.72)***	(6.39)***	(-3.46)***	(0.54)	(0.14)	(2.00)**	(0.34)	(2.60)***	(1.14)
Time	0.05	0.02	0.08	-0.01	-	-	-	-	-	-
	(4.09)***	(1.83)*	(5.54)***	(-0.94)						
CAE	0.22	-	0.20	-	0.01	-	0.19	-	0.23	-
	(3.84)***		(3.46)***		(0.09)		(1.75)*		(2.91)***	
Academic Staff – Res$_t$	-	-	-0.08	0.41	-	-	0.09	0.39	0.01	-0.11
			(-0.64)	(3.72)***			(0.37)	(2.56)**	(0.07)	(-0.28)
Academic Staff – IT&E$_t$	-	-	0.03	-0.02	-	-	0.23	0.03	0.14	-0.21
			(2.22)***	(-2.53)**			(2.28)**	(0.28)	(1.16)	(-0.60)
Academic Staff – others$_t$	-	-	0.15	0.17	-	-	0.17	0.21	-0.35	-0.63
			(1.22)	(2.20)**			(0.80)	(1.23)	(-1.57)	(-1.04)
Go8	-	0.38	-	0.25	-	0.03	-	0.00	-	-0.04
		(5.81)***		(4.58)***		(0.35)		(0.01)		(-0.11)
Journals$_t$	-	-	-	-	-1.26	-	-0.40	-	-0.39	-
					(-5.04)***		(-0.96)		(-3.14)***	
Conferences$_t$	-	-0.08	-	-0.18	-	-0.73	-	-1.06	-	-1.88
		(-1.28)		(-2.75)***		(-2.39)**		(-2.42)**		(-1.53)
Conferences$_{t-1}$	-	0.15	-	0.20	-	-0.34	-	0.72	-	0.34
		(2.11)**		(2.87)***		(-0.54)		(1.52)		(0.27)
Conferences$_{t-2}$	-	-0.02	-	0.09	-	0.32	-	-0.11	-	0.55
		(-0.27)		(1.62)		(0.70)		(-0.54)		(0.83)
Wald Test – Conferences	-	5.43	-	22.61	-	64.99	-	15.11	-	8.45
		(p=0.14)		(p=0.00)		(p=0.00)		(p=0.00)		(p=0.04)
Σ Conferences coefficients	-	+0.05	-	+0.11	-	-0.75	-	-0.45	-	-0.99

Wald Test – Academics	-	-	6.36 (p=0.09)	23.66 (p=0.00)	-	-	6.79 (p=0.08)	9.32 (p=0.03)	4.83 (p=0.18)	1.36 (p=0.71)
Adjusted R-squared	0.76	0.93	0.78	0.95	0.61	0.74	0.73	0.81	0.63	0.46

Notes: Columns 9 and 10 use the quality adjusted journal publications measure. p=prob-value. *, **, *** statistically significant at the 10%, 5% and 1% levels, respectively. t-statistics in brackets using robust standard errors.

Table 5: Australian Universities, Research Output-Output Associations, Sensitivity Analysis

Variable	Journals in the conferences equation	Conferences in the journals equation	Conferences t-1 in the journals equation	Conferences t-2 in the journals equation	Wald Test - Conferences	Net effect of conferences on journals
A: Aggregate Academic Labour						
Base model	-1.26 (-5.04)***	-0.73 (-2.39)**	-0.34 (-0.54)	0.32 (0.70)	64.99 (p=0.00)	-0.75
Journals three lags	-1.32 (-6.34)***	-0.79 (3.60)***	-0.19 (-0.43)	0.25 (0.75)	69.12 (p=0.00)	-0.73
Journals four lags	-1.05 (-4.36)***	-0.97 (-2.67)***	-0.28 (-0.40)	0.37 (0.70)	48.37 (p=0.00)	-0.88
Base without Conferences$_{t-1}$	-1.39 (-7.51)***	-0.81 (-5.53)***	-	0.09 (0.87)	80.30 (p=0.00)	-0.72
Base without Conferences$_{t-2}$	-1.32 (-5.51)***	-0.84 (-3.30)***	0.07 (0.35)	-	63.27 (p=0.00)	-0.77
Base without Conferences$_{t-1}$ and $_{t-2}$	-1.55 (-9.06)***	-0.61 (-11.69)***	-	-	136.58 (p=0.00)	-0.61
B: Disaggregate Academic Labour						
Base model	-0.40 (-0.96)	-1.06 (-2.42)**	0.72 (1.52)	-0.11 (-0.54)	15.11 (p=0.00)	-0.45
Journals three lags	-0.83 (-2.54)**	-1.11 (-2.07)**	0.50 (0.91)	0.06 (0.31)	23.95 (p=0.00)	-0.55
Journals four lags	-0.97 (-3.78)***	-0.95 (-2.08)**	0.22 (0.47)	0.09 (0.50)	34.50 (p=0.00)	-0.64
Base without Conferences$_{t-1}$	-0.45 (-1.04)	-0.16 (-1.30)	-	-0.13 (-1.06)	7.03 (p=0.03)	-0.29
Base without Conferences$_{t-2}$	-0.45 (-1.09)	-1.01 (-2.73)***	0.62 (1.63)	-	16.01 (p=0.00)	-0.39
Base without Conferences$_{t-1}$ and $_{t-2}$	-0.46 (-1.06)	-0.23 (-2.44)**	-	-	5.94 (0.01)	-0.23
C: Disaggregate Academic Labour with Research Quality Measure						
Base model	-0.39 (-3.14)***	-1.88 (-1.53)	0.34 (0.27)	0.55 (0.83)	8.45 (p=0.04)	-0.99
Journals three lags	-0.40 (-3.17)***	-1.88 (-1.64)	0.47 (0.40)	0.54 (0.85)	7.97 (p=0.05)	-0.87
Journals four lags	-0.38 (-2.87)***	-1.82 (-1.63)	0.40 (0.35)	0.56 (0.92)	8.13 (p=0.04)	-0.86
Base without Conferences$_{t-1}$	-0.40 (-3.19)***	-1.47 (-3.08)***	-	0.59 (1.06)	11.21 (p=0.00)	-0.88
Base without Conferences$_{t-2}$	-0.41 (-3.51)***	-1.73 (-1.20)	0.48 (0.34)	-	8.00 (p=0.02)	-1.24
Base without Conferences$_{t-1}$ and $_{t-2}$	-0.45 (-4.13)***	-1.03 (-3.84)***	-	-	14.73 (p=0.00)	-1.03

*, **, *** statistically significant at the 10%, 5% and 1% levels, respectively. t-statistics in round brackets. All estimates relate to the system of equations represented by equations 3 and 4.

Table 6: Conferences and Journals, Faculty of Business and Law, Deakin University, 1995-2005

	- Journals -				
	Pooled Least Squares	Fixed Effects	Tobit Random Effects	GMM – Conferences	GMM - Journals
	(1)	(2)	(3)	(4)	(5)
$Conferences_t$	0.01 (0.43)	0.03 (0.84)	0.02 (0.63)	-	1.43 (2.28)**
$Conferences_{t-1}$	0.04 (0.93)	0.05 (1.57)	0.05 (1.21)	-	-
$Conferences_{t-2}$	0.15 (3.76)***	0.15 (6.91)***	0.15 (3.72)***	-	-1.06 (-1.97)*
Information Systems	-0.12 (-1.41)	-	-0.43 (-1.31)	1.28 (4.81)***	-
Law	1.05 (4.61)***	-	1.17 (3.27)***	-1.49 (-7.13)***	0.91 (3.54)***
Economics	1.16 (7.16)***	-	0.80 (1.92)*	-1.26 (-6.80)***	1.18 (4.86)***
Accounting & Finance	0.05 (0.78)	-	-0.20 (-0.56)	-	-
PhD	0.23 (2.51)**	-	0.02 (0.26)	-	0.66 (4.78)***
$Journals_t$	-	-	-	0.92 (6.28)***	-
Gender	-	-	-	-0.23 (-2.12)**	-
Wald Test – Conferences	238.7 (p=0.00)	19.3 (p=0.00)	23.8 (p=0.00)	-	6.7 (p=0.03)
Σconferences	+0.20	+0.23	+0.22	-	+0.37
Number of academics	120	128	120	-	-
Number of observations	590	694	590	739	612

Notes: Column 2 uses cross-section and time period Fixed Effects. Dependent variable is the number of refereed journal papers, except in equation 4 where it is the number of refereed conferences.

Appendix A: Data and Sources

The data used in this analysis was primarily sourced from the Department of Education, Science and Training (DEST) and the Australian Vice-Chancellors' Committee (AVCC), as well as from individual universities. The variables are defined below.

Research output: Data on academic research output was sourced from AVCC (www.avcc.edu.au) via "*Higher Education Research Data Collection Time Series data for 1992-2004* (published June 2006) for the period 1995-2004, for 36 publicly funded universities.[38] We use the series on conferences and journal papers as the two dependent variables.

The research quality series was constructed by the authors by counting for each year and for each university, the number of times a particular Australian university had authors who published in a SSCI listed journal.

Research Income: The higher education sector receives income to fund research activities from a number of sources from both the public and private sectors. Research income, in the form of grants, is received from the Australian Research Council, the National Health and Medical Research Council, other Commonwealth competitive and non-competitive bodies, State and Local government bodies and industry bodies. Data on research income was sourced from AVCC (www.avcc.edu.au) via "*Higher Education Research Data Collection Time Series data for 1992-2004* (published June 2006) for the period 1995-2004.

Academic Staff: Data sourced from DEST (www.dest.gov.au) via the publication series, *'Staff: Selected Higher Education Statistics'*. Data represents total full-time equivalent academic and casual staff employed by the higher education sector in this period. This includes teaching and research and research only academics. Data was collected also on the number of academic staff employed as research only, the number of staff employed in information technology and all other disciplines.

General Staff: Data sourced from DEST (www.dest.gov.au) via the publication series, *'Staff: Selected Higher Education Statistics'*, for the period. Data represent total full-time equivalent non-academic staff employed by the higher education sector.

Postgraduate Students: Data sourced from DEST (www.dest.gov.au) via the publication series, *'Students: Selected Higher Education Statistics'*. Data is sourced on the basis of EFTSU – effective full time student unit which represents the standard load for a full-time student for 1 year.

Former Colleges of Advanced Education (CAEs): Colleges of Advanced Education were established following the implementation of a binary system for funding higher education. Under this system the higher education sector was divided into 'universities' which were funded for teaching, research and research training and 'other higher education institutions' such as Colleges of Advanced Education which only received funding for undergraduate and postgraduate course work. The release of the Government's 'White Papers' in 1988 effectively abolished the binary system and introduced the Unified National System (UNS). This process effectively saw the former CAEs merge together to form universities or join with existing higher education institutions. In the current analysis, CAE is a dummy variable added to investigate the impact of an institution's prior status on the results. Prior status was confirmed by accessing the historical web site of each Australian higher education institution.

[38] We do not include private universities and some of the newer public universities.

Group of 8: This is a dummy variable added to the analysis to investigate the impact of those universities regarded as the Group of 8 higher education institutions in Australia. These institutions are: University of Adelaide, the Australian National University, the University of Melbourne, Monash University, the University of New South Wales, the University of Queensland, the University of Sydney and the University of Western Australia.