Mapping an interdiscipline: Research collaboration around sustainability in the tertiary sector

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Abstract:
Universities are aggregations of units which reinforce boundaries via reward systems, administrative structures and disciplinary activities. Sustainability, by definition, considers social, cultural, economic and environmental ramifications simultaneously. Contributing to sustainability from within the university necessitates reaching across disciplinary or structural boundaries in research and teaching. Social network analysis and bibliometrics have been frequently employed to investigate academic collaboration, and are applied to this diffuse field to investigate the academic research environment sustainability faces. ISI-indexed copublication and research panel cosupervision affiliations are used as evidence of collaboration. Copublication is directed outside of the institution, while cosupervision is clustered largely within budgetary units. The network structures vary in density but include a core, aligned with umbrella institutes, and a shifting periphery of actors. Although government research incentives are passed down within the institution to dominate the motivations of individual academics, these effects can be offset by leadership and good internal policy. For the time being, the market position of interdisciplinary, sustainability units appears safe.

Introduction
Sustainable development is a higher-order social goal (Dovers 2005) that challenges the growth ethic and increasing inequity of modern life. Since the concept was formalised in the Brundtland Report of 1987, its meaning has become fuzzy and progress slow. Education is a powerful policy instrument for social change, and the UN has declared 2005-2014 the Decade of Education for Sustainable Development. Sustainability-friendly concepts are finding their way into centralised primary and secondary school systems, but the tertiary sector has been slower to react. This resistance or resilience (depending on
your perspective) may express academic freedom, but organisational, funding and incentive structures can also motivate individual behaviour in academia. Academics must rationalise and prioritise loyalties to discipline, organisational unit, career, and the public good, in a sector undergoing reinvention as a result of information technologies and neoliberalism (Noam 1995, Marginson and Considine 2000). Although ‘an environmentally sustainable Australia’ is now a national research priority, interdisciplinary topics can be particularly beset by challenges.

Sociologists have spent considerable time looking at academia and the production of knowledge in science (Price 1965; Cole 1983; Bourdieu 1984). The ‘Mode 2’ science typical of sustainability work involves more players and disciplines, and complicates sociological analyses and the research evaluation processes that feed government funding policies (Gibbons et al. 1994; Kates et al. 2001). Social network analysis (SNA) explores connections between individuals or organisations, and how linkages affect aggregate behaviour or information flows. Actual interactions can be input to create maps of interactions (sociograms), such as email exchanges or conversations, or bibliometric evidence of influence, such as joint publications or citation (Crane 1969). Well-defined disciplines facilitate sociometric analyses, but some work on interdisciplinary research has been done (Qin et al. 1997). Sustainable development is a diffuse field (Whitley 1984), often mysterious even to its practitioners, each blindly holding of a different part of the proverbial elephant. Enriching standard bibliometric methods with social network analysis to map relevant activities at several case institutions may reveal the forces at play on sustainability research in higher education.

**Method**

The project is part of a larger effort to establish how universities are addressing the need to educate and research for sustainable development goals. The institutional environment around sustainability research at two case study universities has been mapped using records of research student cosupervision and journal article coauthorship. Affiliations between actors based on such activities are not always evidence of genuine collaboration (Katz and Martin 1997), but the assumption is a common one.
Copublication data was sourced from the *Australian National Citation Report* as prepared by the Institute for Scientific Information, Inc (ISI) and address-linked by the Resource Evaluation and Policy Project at the ANU. All publications were extracted that had at least one author from the case institutions and contained in the article title or the journal name one of five key words and derivatives: *sustainable, conservation, ecology, resource* and *environment*. ISI focuses on the pure sciences, and does not index book chapters, creative works, or the grey literature. Applied science, social science, and humanities citations are underrepresented; ISI indexed between 28% and 45% of journals in these fields compared with up to 90% for pure sciences (Butler 2003). The number of times each address was used on each paper was determined manually. All of the authors listed on a paper were assumed fully and mutually connected via the work, and the date of publication is taken as the year the collaboration occurred, as time lags differ.

Individual university student databases were mined to identify supervisory teams of higher degree students working in sustainability. Details were extracted of theses where titles or ‘field of study’ classifications contained the keywords and linked to the year the student commenced. Only theses that were completed, in progress, under examination or on leave were included. Interactions were aggregated to academic organisational unit (AOU, basically budgetary units). The deeply interdisciplinary nature of sustainability research means students are likely to interact with supervisors individually, rather than as a team. Although the fully-connected method was trialed (and results shown in square brackets on tables herein), collaborations on theses were thus deemed to radiate between the student and their supervisors, at least one of which was typically from the student’s home AOU.

Many uses of the keywords did not relate to sustainability work, necessitating a culling process. A three-part criteria system was developed to identify the intended audience (generalist, disciplinary or subdisciplinary*), immediate purpose (application, methodological advance, background/history or pure research*), and values implied (integrated, social, environmental, financial* or academic*) in the work. Theses and papers were removed if they were classed with any variable identified with an asterix. In the cases of theses, whose titles are often harder to classify, 10% of the borderline titles
were checked for consistency by two colleagues. Where disagreement existed, theses were retained.

Data was moved into social network programs *UCINET* and *Netdraw* from *Microsoft Access* databases. *Microsoft Excel* was used to calculate bibliometrics and check for errors. The combination of statistics and sociograms revealed interesting patterns that relate to the institutional environment for sustainability research. The two cases will first be introduced, and results presented in an integrated fashion.

**Case profiles**

Two Australian universities were examined, both of which have structural anomalies which result in disciplinary duplication (several units covering Economics, for example). University A is a post-war, research-intensive university with a high ranking nationally and globally. Its block funded, research-intensive Institute for Advanced Studies creates a mirror research school for most teaching units. University B is a regional, multi-campus university formed in the late 1980s by the amalgamation of several vocational institutions. It is still building its research profile but its focus on rural society and natural resource management is relevant to sustainability. Disciplines are duplicated at B as schools deliver consistent content across campuses. Collaboration outside of AOUs is thus not necessarily interdisciplinary. Each institution has an AOU that acts as a natural hub for sustainability research, although the dominance of this unit is more notable in B. Each institution also has a relatively new ‘umbrella’-style institute to coordinate education and research in sustainability. Figure 1 shows the research output on sustainability for each university as collected for this study.

*Figure 1:* Number of research activities used in this analysis, over time and by case.

**Quantitative analysis**

Past behaviour shows how academics value various types of collaborations. Both universities are Janus-faced when it comes to research around sustainability (Table 1). In supervision, collaboration is oriented within AOUs. University A looked next for supervisors among other units within the university, while B bootstrapped its research capacity with external collaborators. In publication, a similar number of papers were solo
authored in each case, and external coauthorships were otherwise clearly favoured. Next in line were links internal to AOU, although University A also had nearly as many elsewhere in the university whereas collaboration was largely kept within AOU boundaries at B. Since both institutions have disciplinary duplication, the relative impermeability of AOU boundaries at B (save for outside links) suggests that internal competition exists or that multi-campus geography limits collaboration. The Vice-Chancellor at A has also explicitly encouraged collaboration across academic units.

It should also be noted that while the number of internal and external authors per paper is similar, supervisors per research panel differs (Table 1). Whether the cause is policy or workload is unclear. University A proscribes at least 3 supervisors per thesis panel and its average of 4 may reflect the impacts of such a policy, although, as discussed later, panel sizes have dropped. University B has no policy on panel size. University A has many research-only staff, however, and a much smaller student/staff ratio than B.

**Table 1:** Percent of collaborations of each orientation, by case and activity.

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<thead>
<tr>
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<th>Publication</th>
<th>Supervision</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Solo (only one address)</td>
<td>28.1%</td>
<td>23.2%</td>
</tr>
<tr>
<td>Of collaborative activities:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Links inside AOU</td>
<td>20.3%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Links to University</td>
<td>16.1%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Links outside University</td>
<td>63.6%</td>
<td>60.9%</td>
</tr>
<tr>
<td>Average number of actors per product (internal, external)</td>
<td>2.4 (1.4, 1.0)</td>
<td>2.4 (1.5, 0.9)</td>
</tr>
</tbody>
</table>

Solo publications can be prestigious, with an individual receiving all benefits, such as in promotions and performance management on a personal and organisational level. Sustainability research, however, is characterised by increasing integration of disciplines and non-academic stakeholders, which works against this pressure (Kates et al 2001). There has been an increase from 2 to 3 authors per paper on average at University A, as well as a decline in intra-AOU collaboration commensurate with an increase in collaboration across AOU since 1981. Disaggregated sociograms not shown here expose a lack of collaboration between the AOUs that comprise larger groupings like faculties,
whether disciplinary or interdisciplinary (problem- or area-focused). Academics exercise the right to choose their collaborators, if not their colleagues.

At University A, the proportion of papers with outside authors has trended upwards. External addresses were listed on 18% of papers between 1995 and 1999, compared with 37% since then, and there were only half as many outside authors as University A authors on papers in the former, compared with one-to-one later. The external orientation in publication could indicate a tendency for sustainability research to involve stakeholders in both problem-framing and research. Incentives for collaborating with industry on research grants may also be a cause. It may also attest to the decreasing impact of geographical proximity on research with the ubiquity of information filtering and communication technologies (Van Alstyne and Brynjolfsson 1996).

The ‘hoarding’ of student supervision within AOUs at University A was common through the 90s, peaking at 83% of supervisors in 1999. Funding and workload incentives may have motivated this practice. The supervisory roles are now more equivalently shared with other units in the university, although the AOU numbers have simply dropped rather than both converging. In fact, the size of supervisory panels has plummeted from 6 supervisors per thesis in 1995 to 3.2 in 2004, much closer to team sizes at University B. External collaborations declined so dramatically as to suggest that it may be an artifact of the student database; external advisors may simply be less rigorously reported and recorded as there is no operational reason to capture them. If not, there may be some systemic pressure from outside the sector.

**Structural analysis**

Since the mid-70s, when environmental concern was nascent, research on sustainability has involved increasing numbers of agencies and parts of universities. The four so-called ‘pillars’ of sustainability are economic viability, environmental responsibility, social justice and cultural vitality (Hawkes 2001). Most units at any university could potentially contribute to at least one of these elements. Engagement in the topic varies widely across the sector, however, in research as well as education (Sherren 2006). Biophysical research is most dominant in the data captured here, just as biophysical topics often dominate coursework degrees in sustainability, although the search terms and the ISI
indexing process contributed to this bias. The engagement of health units appears low at both institutions (but particularly B) given the physical and mental public health impacts of unsustainable practices.

A core periphery model is emerging in the cases, with the core centred largely on the member units of topical umbrella institutes, and a changeable periphery. The degree of clustering differs by case. Outside the core at A, there appears to be a weak relationship between collaboration around supervision and paper coauthorship. B is more clustered, and less structurally complex. The apparent lack of cohesion at B is a data artifact resulting from the presence of the umbrella institute in publication data only; members are allocated to individual schools in supervisory records. A disjoint supports the idea of social capital being built between student and supervisor, fuelling future external collaborations after graduation, more than between supervisors.

Sustainability work is more widespread at A than B, and although more units are involved in publication than supervision, networks are denser for the latter (Table 2). At University A, 89% of faculty-level units or centres have contributed to a thesis or paper on sustainability, compared to only 37.5% of analogous units at B. By year, there are always twice as many AOUs involved as there are theses at University A, but half as many AOUs as there are papers. University B is one-to-one for both activities, with a plateau at five AOUs. These apparently contradictory stories support the idea of a periphery that shifts through time due to staff or structural changes. A breadth of expertise and advice is needed for students working across disciplines, but few AOUs or individuals consider sustainability their core business.

Table 2: Statistics on shared faculty-level nodes and links (collaboration paths), as well as those only present for one of the two activities.

<table>
<thead>
<tr>
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<th>University A</th>
<th>University B</th>
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<tbody>
<tr>
<td></td>
<td>Publicatio n</td>
<td>Supervisio n</td>
</tr>
<tr>
<td>Nodes shared by both activities</td>
<td>12* 12*</td>
<td>2* 2*</td>
</tr>
<tr>
<td>Nodes unique to one activity</td>
<td>6 4</td>
<td>3 1</td>
</tr>
<tr>
<td>Percent of possible nodes involved</td>
<td>67% 59%</td>
<td>31% 19%</td>
</tr>
<tr>
<td>Links shared by both activities</td>
<td>9* [10] 9* [10]</td>
<td>0* 0*</td>
</tr>
<tr>
<td>Links unique to one activity</td>
<td>9* [10]</td>
<td>0*</td>
</tr>
</tbody>
</table>

*numbers are the same within each case because they are common to both activities.
More types of external agencies are becoming involved in collaboration with universities, and – in sustainability at least – many of these are not other research organisations. While external publication collaborations are still dominated by research organisations (CSIRO, CRCs) and other universities, the set of actors has expanded to include; hospitals, industry, and state and federal government, even local government at University B. The expansion in players maps to CSIRO’s declining share of Australian publications between 1983 (15%) and 1999 (8%) (Butler 2001). International coauthorships have outnumbered Australian ones in the past at University A, but they are now on par; University B is largely Australian in focus, consistent with its mission.

Although the infiltration of sustainability across universities like A could threaten the rationale for interdisciplinary units, this does not appear to be happening. Looking at University A, publications and graduate student enrolments in sustainability are increasing for both interdisciplinary and disciplinary units. Only supervisory relationships from interdisciplinary units have decreased. This could map to the decline in supervisory team sizes and the increased interest in sustainability across disciplines. Alternately, it could show a backlash against interdisciplinary, sustainability research supervision by those who have suffered as a result of disciplinary-focused performance management exercises. In comparison, the market position of sustainability hubs at university B is clear, although that university has not yet experienced widespread interest in sustainability.

**Conclusion**

This paper analyses the structure and vigor of sustainability research interactions at two universities and finds cause for optimism. Sustainability work is increasing, and where geography does not interfere, more academic units are involved. Academics at the two institutions have responded in remarkably similar ways to pressures within and without. Such choices are logical responses to incentive structures like promotions and workloads which are themselves expressions of external funding formulae. Universities often apply the “same stimuli internally…to avoid sending conflicting signals to its employees” (Glaser & Laudel 2005: 5). The fact that the market position of problem-based units appears secure indicates that the performance metrics so rife in the sector are no longer
hostile to interdisciplinary work, or that upper level management can offset such pressures with good policy. Curriculum change for sustainability will also benefit from such supportive institutional arrangements and networks of collegial relationships.

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References


\[ y = 0.5x^2 - 0.5x \]

The number of mutual links is \[ y = 0.5x^2 - 0.5x \] where \( x \) is the number of authors or supervisors.