How journal rankings can suppress interdisciplinarity. The case of innovation studies and business and management

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Abstract
This investigation illustrates how allegedly 'excellence-based' journal rankings have a bias in favour of mono-disciplinary research and how this negatively affects the assessment of interdisciplinary organisations. First, we use various mappings and metrics to show how innovation studies units are more interdisciplinary than business and management schools. Second, we provide evidence that the journals in the top ranks of the Association of Business Schools' rankings span a less diverse set of disciplines than lower ranked journals. Third, we show that this bias results in a more favourable performance assessment of the more disciplinary-focused business and management schools. Fourth, we demonstrate that a citation-based analysis of the units' performance challenges the ranking-based assessment. We conclude that this case study illuminates a general mechanism through which unduly narrowly-conceived rankings can suppress interdisciplinary research.

Introduction
In a moment in which science is under pressure to be relevant to society, interdisciplinary research (IDR) is often praised for its contributions towards generating scientific breakthroughs, addressing societal problems and fostering innovation. Reasons given for these kinds of benefit include that IDR is better at problem-solving, that it generates new research avenues and is a source of creativity, thus 'rejuvenating' science. However, in practice IDR efforts are often found wanting, accused of being too risk averse, lacking under disciplinary notions of quality or not meeting policy expectations. Irrespective of perspective, IDR presents important downsides. These include, for example, poor career structures for academic interdisciplinary researchers, low esteem by colleagues, discrimination by reviewers in proposals or difficulty in publishing in high-ranking journals (Bruce et al. 2004, p. 464).

While these institutional barriers are often acknowledged, driving mechanisms are neither well documented nor deeply understood. In this UK-based case study, we provide novel quantitative evidence of an institutional barrier to IDR by exploring the conflict between the so-called race for 'excellence' in academia generally – focusing particularly here on business and management schools (BMS) – and the pursuit of a specific form of IDR in departments or institutes of innovation studies (IS), in a broad definition of the field. Under current funding conditions in the UK, many IS units have been (at least partly) incorporated into BMS (e.g. in Oxford, Imperial, Manchester, Cardiff and recently Sussex). BMS face particularly acute pressure to achieve high performance in publication rankings, both for reputational purposes and due to financial incentives associated with assessment procedures of the national funding council HEFCE, now referred to as the 'Research Excellence Framework (REF). Given the disciplinary organisation of the specific assessment panels of the REF, IDR departments are viewed in some quarters as experiencing a suppressive effect in evaluation, although such claims have been disputed (Adams et al., 2007).

That evaluation of IDR is problematic is not a surprise—rather it is a natural consequence of IDR. Any evaluation needs to take place over established standards. These standards can be defined within a discipline, but what standards should be used for research in between or beyond disciplinary practices? A variety of studies have found that what happens, even in the case of multidisciplinary panels, is that IDR ends up being assessed under one of the disciplinary perspectives to which it relates. Here, we investigate quantitatively the relationship between interdisciplinarity in IS and (perceived) performance as shown by the journal rankings provided by the Association of Business Schools (ABS). The results show that ABS journal rankings favour business and management disciplinary approaches—and thus disadvantage IS units by comparison with more traditional BMS. We suggest that this case is an example of a much wider phenomenon: the 'ethnocentrism of disciplines' associated with reinforced mainstream styles of research.

The assessment of performance and interdisciplinarity

In order to investigate the relationship between interdisciplinarity and performance we need to define and operationalise frameworks under which to assess both performance and interdisciplinarity. For the assessment of scientific performance, we follow convention and compute the mean ABS rank and the number of cites per paper. The open question is how to normalise cites by discipline. The most extensively adopted practice is to normalise by the discipline where the article is published. Though widely used, this is known to be problematic for two reasons. First, due to the heterogeneity of research even within disciplines. Second, because some papers do not conform to the disciplines of the journal. We will explore an alternative normalisation recently proposed by Zhou and Leydesdorff (2011).

The conceptualisation of interdisciplinarity is even more ambiguous, plural and controversial —inevitably leading to a lack of consensus on indicators. In order to assess the degree of integration, we use three concepts: *diversity, coherence,* and *intermediation*. Building on an understanding of interdisciplinarity as the integration of various bodies of knowledge (Porter et al., 2006) we can think of IDR as that research which is not only disciplinarily diverse, but which is at the same time coherent in the sense that it actively interconnects various bodies of knowledge (rather than simply grouping them together). The further attribute assigned to IDR –a concept that we here call intermediation— refers to the property of being positioned outside or in between disciplines (Leydesdorff, 2007).

Diversity: A given body of research, as represented for example in the publications of a university department, is seen as more interdisciplinary if it publishes in diverse disciplines and the publications are coherent in the sense of linking the various disciplines. Diversity is a multidimensional property, which has three attributes (Stirling, 2007): *Variety,* the number of categories of elements, in this case, the disciplines into which publications can be partitioned. *Balance,* the distribution across these categories, in this case, of output publications, or references in, or citations of, these. *Disparity*, the degree of distinctiveness between categories, in this case, the cognitive distance between disciplines as measured by using citation similarities (see below).

An overlay representation of publications in the map of science captures these three attributes (Rafols et al., 2010; see Figure 1). It shows whether the publications (or references or citations) of a department scatter over many or a few disciplines (*variety*), whether the proportions of categories are evenly distributed (*balance*) and whether they are associated with proximate or distant areas of science (*disparity*). Since this is a multidimensional description, scalar indicators will either have to consider one of the attributes as a proxy or make a compositional choice spanning the various possible scaling factors. Here investigate indicators that explore each of the dimensions separately and in combination. As a metric of distance we use $d_{ij} = 1 - s_{ij}$ with s_{ij} being the cosine similarity between categories i and j (the metrics underlying the global science maps), with p_i being the proportion of elements (e.g. references) in category i. We explore the following indicators of diversity:

Variety (number of categories) n

Balance (Shannon evenness) $-\frac{1}{n}\sum_i p_i \ln p_i$

Disparity (average dissimilarity between categories) $\frac{1}{n(n-1)}\sum_{i,j} d_{ij}$

Shannon entropy $-\sum_i p_i \ln p_i$

Rao-Stirling diversity $\sum_{i,j} p_i p_j d_{ij}$

Coherence: One way to look at coherence is to compare the observed average distance of cross-citations as they actually occur in the publications in question with the average distance of cross-citations that one would obtain (the 'expected distance') if simulated cross-citations are generated across the categories following the distribution of cross-citations found for all the publications in the WoS (for 2009). Such estimate is computed taking into account that the expected proportion of citations from SCs i to j, $p_{ij}(\text{expected})$, is equal to the proportion of citations made from i, p_i, multiplied by the conditional probability that citations go to *j* when they originate in *i*, $p_{\frac{j}{i}}$, namely $p_{ij}(\text{expected}) = p_i p_{\frac{j}{i}}$. The conditional probabilities $p_{\frac{j}{i}}$ are assumed to be those from all the observed cross-citations in the WoS. In summary, the measure of coherence is the ratio of observed of expected distance of cross-citations.

Coherence $\frac{\sum_{i,j} p_{ij} d_{ij}}{\sum_{i,j} p_i p_{\frac{j}{i}} d_{ij}}$

Intermediation: Intermediation aims to capture the degree to which a given category of publication is distant from the most intensive areas of publication —those dense areas of the map representing the central disciplinary spaces. Since this measure is highly sensitive to the creation of artefacts due to classification, we here carry out the analysis at a finer level of description, namely the journal level (i.e. we use each journal as a separate category). We propose to use conventional network analysis measures to characterise the degree to which the publications of an organisation lie in these 'open' (or 'interstitial') spaces. The first is the clustering coefficient, which identifies the proportion of observed links between categories over the possible maximum number of links. This is then weighted for each category (now a , according to itsproportion p_i of publications (or references/cites), i.e. $\sum_i p_i cc_i$. The second indicator is the average similarity (degree centrality) weighted by the distribution of elements across the categories.

Average similarity $\sum_i p_i \sum_j \frac{s_{ij}}{N}$

Methods

Data

We investigate three of the leading British Business Schools, namely London Business School (LBS), Warwick Business School (WBS) and Imperial College Business School. From innovation studies, we study the Institute for the Study of Science Technology and Innovation (ISSTI) at the University of Edinburgh, SPRU (Science and Technology Policy Research) at the University of Sussex and the Manchester Institute of Innovation Research (MIoIR) at the University of Manchester. The publications of all researchers identified on institutional websites as members of the six units were downloaded from the Web of Science (WoS) for the period 2006-2010, limited to document types: 'article', 'letter', 'proceedings paper' and 'reviews'. Publications by a researcher previous to their recruitment to the unit were also included. In order to fully disentangle results of publications from citing articles, all cites coming from the same unit were removed.

Data processing and indicators of diversity and coherence

The software Vantage Point was used to process data. A thesaurus of journals to WoS Subject Categories (SCs) was used to compute the cited SCs from the cited references. The proportion of references which it was possible to assign in this way ranged between 27% for ISSTI to 62% for LBS. In order to avoid counting SCs with very low proportions of references, a minimum threshold for counting an SC in the variety and disparity measures was applied at 0.01% of total publications. No threshold was applied in calculating balance, Shannon entropy, and Rao-Stirling measures; since these inherently take into account the proportion of elements in categories.

Disciplinary overlay maps

The software Pajek was used to make all networks except the heat maps. First, disciplinary overlay maps were made as explained in Rafols et al. (2010), using 2009 data for the basemap (grey background). Second, cross-citations maps (green links) between SC were generated and overlaid on the disciplinary maps in order to generate Figure 1. Lines are only shown if they represent a minimum of 0.2% of cites and more than 5 fold the expected proportion of cross-citation.

Journal maps and indicators of intermediation

The freeware VOSviewer (http://www.vosviewer.com/) was used to make a journal map in the heat-map format. A sub-set of 391 journals was made from the journals where each unit published (excluding journals <0.5% publications per unit) and the top 100 journals which all units (collectively) referenced. The cross-citations between these journals were obtained from 2009 Journal Citation Report (JCR) also available from the WoS. This was used to compute the cosine similarities matrix in the cited dimension, which was input into VOSviewer. The size of nodes was determined by the number of publications/references per journal/cited journal, normalised to the sum of all publications/references. The average clustering coefficient (at 2 neighbours) was computed with a 0.2 threshold in Pajek.

Analysis of ABS rankings and performance measures

The ABS rank for each journal was obtained from the Academic Journal Quality Guide Version 4 http://www.the-abs.org.uk/?id=257. This was used to calculate the average ABS rank for each unit. For simplicity, 4* rank were converted into 5. Additionally, SCs were assigned to *all* Journals in the ABS Ranking guide which were in the JCR (which amounted to 60% of the ABS list). This data was used to map the disciplines of each ABS rank, with the node size corresponding to the proportion of journals in that particular rank belonging to each SC. Cites/paper were computed using the WoS field *Times Cited* (TC) in the WoS record. As a result of the earlier download of SPRU data, an estimate of an 8.5% increase was applied based on the extrapolation of the difference between TC data and citing records from other units to SPRU. The possible inaccuracy introduced by this extrapolation is small compared with a standard error of more than 11%. The journal field-normalised cites/paper was made by dividing cites/paper by the average Impact Factor (IF) of a SC (i.e. $\sum_{Journals} Cites$ /

$\sum_{Journals} Publications$ in a given SC). The citing field-normalised was made using only the citing records downloaded (i.e. excluding unit-wide self-cites), then giving each a cite weight inverse to their number of references. Only cites with more than 10 references were used, since papers with less are expected not to be a 'normal' publication outlet and have a disproportionately high weight.

Results: Interdisciplinarity of organisations

Diversity and coherence

Figure 1 shows the overlay of the publications of ISSTI (top) and LBS (bottom) over the global map of science –as a representative illustration of the findings in this analysis regarding the general contrast between the three IS units (including ISSTI) and the three comparator BMS (including LBS). We skip the details of this overlay technique, since it is discussed at length in Rafols et al. (2010). These overlay maps were generated for the six units using the SCs of publications, references and cites (excluding self-citation). The full set of maps for this article are available at http://www.interdisciplinaryscience.net/maps/. These results show that IS units are cognitively more diverse in the sense that they spread their publications (and references, and cites) over a larger number of disciplines (*variety*), do so more evenly (*balance*), and across larger cognitive distances (*disparity*). The differences are more pronounced in the case of publications and cites than for references, which tend to be relatively widely spread both for IS and BMS. These insights are shown in the form of indicators in Table 1.

Second, not only are IS units more diverse, but their publications cite more widely across distant SCs than might be expected. This is show by the green links overlaid in Figure 1, which show which cross citations between SCs are 5-fold larger than the average proportion in the global map of science. For example, ISSTI has major citation flows between management and biomedical sciences, which are rare in the global citation patterns, and SPRU between economics and planning with ecology, environment and energy. This is evidence that these IS units are not only diverse in the sense of 'hosting' various disciplines, but are actually doing interdisciplinary work. On the contrary, the leading BMS examined here are not only less diverse, but also more fragmented in disciplinary terms, in the sense that they tend to cite more within disciplines. For example, Imperial is the most diverse of the BMS, thanks in part to its research on health services, but this line of research is not strongly linked to other Imperial social sciences. The bridging function between the natural sciences and social sciences carried out by IS units is captured by the coherence indicator (Table 1).

Intermediation

The third property of IDR we investigate is whether a given body of research lies within or between, existing disciplinary boundaries. For this purpose the WoS SCs are too coarse. Instead of using the SC disciplinary maps, we created maps of the main 391 journals in which the six units examined here publish. In this case we used VOSviewer, since it allows us to make a 'heat map' depicting the density of nodes and links of a different parts of the map. This density visualisation is helpful to distinguish between dense areas (associated with disciplinary cores), and sparser interstitial areas (associated with IDR). To make the map we followed again the overlay technique: cross-citation data from the WoS was used to generate a similarity matrix, which then served as input for the visualisation programme. The publications, references and cites associated with each unit were then overlaid on this map.

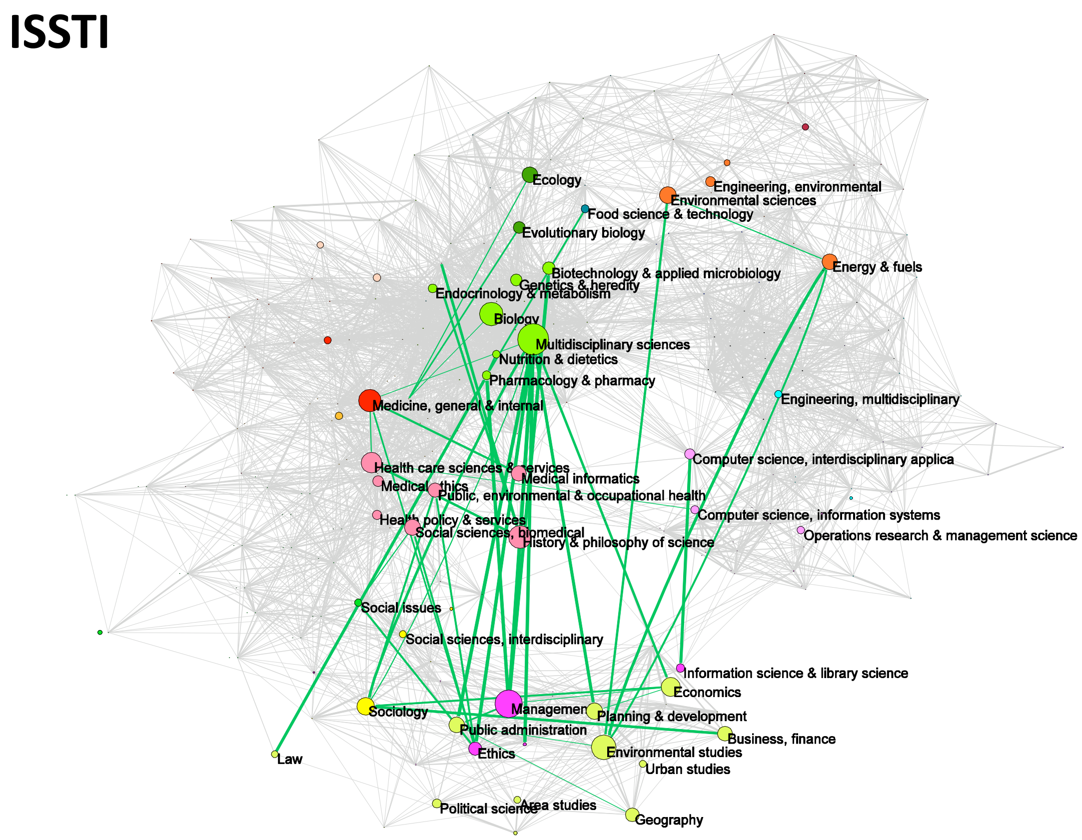
The IS-BMS journal maps (Figure 2) show three poles: management, economics, and natural sciences. This latter encompasses the various particular natural sciences in which these focal units work. This reveals that within the combined IS-BMS context, journals of different natural sciences are cited similarly, in comparison to the differences among the citations to social science journals. Thus, unlike the economics and management areas, this third pole can be interpreted as an artefact rather than a genuine disciplinary core in its own right. It is nevertheless useful since it provides an axis to show the degree of interaction with the natural sciences that social sciences have. More science-oriented journals such as Social Studies of Science are closer to this pole.

The overlay maps in Figure 2 show that BMS units publish, reference and are cited by journals in the dense areas of management and economics. The partial exception is Imperial, with a research subgroup that is active in health sciences. IS units, on the contrary, have most of their activity in the interstitial areas lying between management, economics and the natural sciences, in journals such as *Research Policy*, or in journals of application areas such as *Social Science and Medicine* or *Energy Policy*. This difference between the degree of activity in intermediation is shown by the indicator of clustering coefficient and the average similarity of the journals (Table 2). In summary, what the journal maps show is that IS units carry out their boundary-spanning role, at least in part, by means of interdisciplinary journals.

Table 1. Indicators of diversity and coherence for each organisational unit

	Innovation Studies Units			Business & Management Schools		
	ISSTI	SPRU	MIoIR	Imperial	WBS	LBS
# of Publications	129	155	115	244	450	348
SC of Publications						
Variety	28	20	19	15	20	9
Balance	0.653	0.566	0.543	0.485	0.460	0.370
Disparity	0.832	0.839	0.817	0.788	0.770	0.768
Shannon Entropy	3.558	3.243	2.966	2.970	3.078	2.343
Rao-Stirling Diversity	**0.810**	**0.783**	**0.726**	**0.720**	**0.680**	**0.603**
# of References	1737	2409	1558	6017	8044	10381
SC of References						
Variety	28	18	17	17	20	15
Balance	0.510	0.420	0.415	0.347	0.325	0.287
Disparity	0.829	0.842	0.846	0.832	0.780	0.825
Shannon Entropy	4.115	3.575	3.378	3.251	3.153	2.802
Rao-Stirling Diversity	**0.833**	**0.791**	**0.729**	**0.731**	**0.689**	**0.682**
# of Cites	316	767	419	1229	1246	1593
SC of Cites						
Variety	32	21	22	20	24	15
Balance	0.669	0.513	0.505	0.452	0.454	0.379
Disparity	0.852	0.844	0.836	0.819	0.801	0.767
Shannon Entropy	4.222	3.723	3.415	3.482	3.503	2.985
Rao-Stirling Diversity	**0.851**	**0.810**	**0.771**	**0.755**	**0.736**	**0.679**
Cites between SC						
Coherence	**1.131**	**1.054**	**0.993**	**0.710**	**0.744**	**0.549**

NB: higher values for each metric, indicate higher levels of the indicated property.



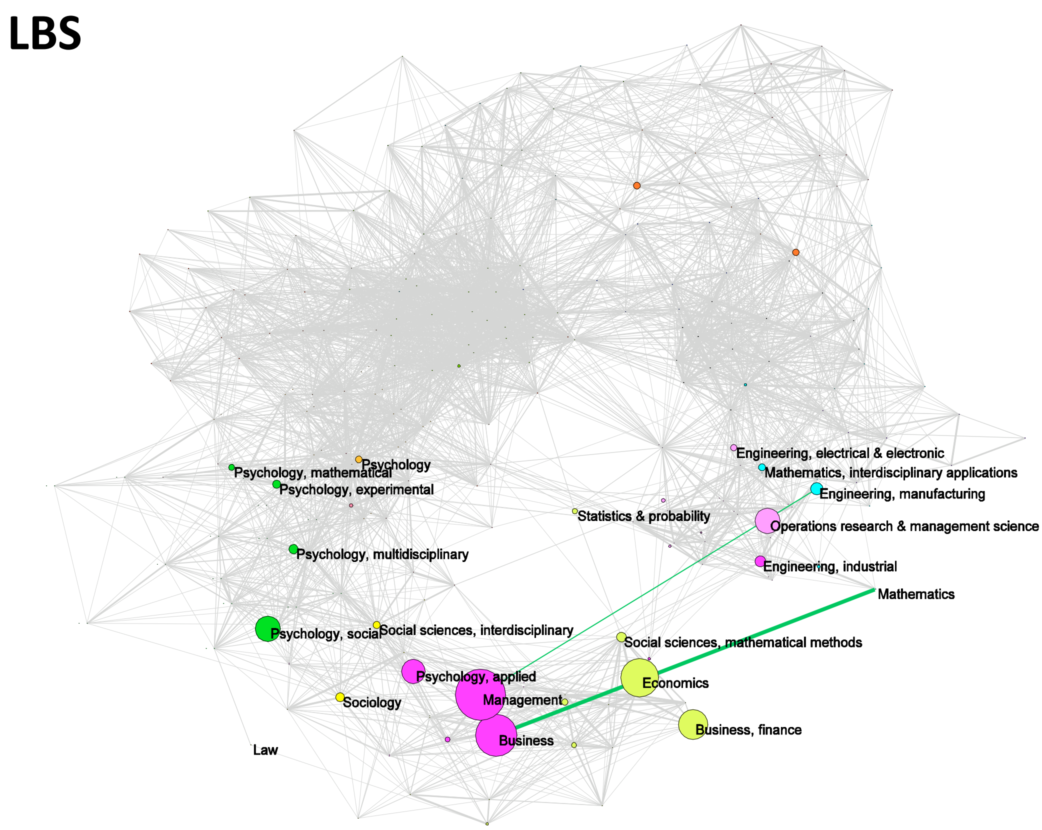


Figure 1. Overlay of SCs of references by a unit on the global map of science (grey background). Cross-citations are shown (green links) only for observed values 5 fold larger than expected.

Table 2. Indicators of intermediation by organisational unit.

	Innovation Studies Units			Business & Management Schools		
	ISSTI	SPRU	MIOIR	Imperial	WBS	LBS
Journ. of publication						
Clustering Coeff.	0.128	0.098	0.075	0.189	0.165	0.202
Average similarity	0.028	0.034	0.036	0.050	0.045	0.060
Journals of references						
Clustering Coeff.	0.178	0.182	0.166	0.236	0.221	0.235
Average similarity	0.044	0.050	0.058	0.066	0.065	0.068
Journals of cites						
Clustering Coeff.	0.120	0.096	0.074	0.157	0.167	0.183
Average similarity	0.029	0.034	0.037	0.046	0.044	0.055

NB: lower values for each metric, indicate higher levels of intermediation

Disciplinary bias in journal rankings

Now we turn our attention to the disciplinary profiles of the journals under different ranks in the ABS classification. For each Rank, from 1 (the lowest quality), to 4* (the highest), we used the JCR to assign journals to SCs. The coverage of assignation was low for rank 1 (14%), but reached an acceptable level for rank 2 (56%), and was almost complete at the highest ranks. Then, we looked at the disciplinary diversity of each rank, by looking at its distribution of journals in SCs, following the same protocol as in the previous sections (only now the basic elements are journals, rather than articles). The results are shown in Figure 3 and Table 3.

Table 3. Disciplinary diversity indicators of the Association of Business Schools' rankings

	Rank 1 Modest standard	Rank 2 Acceptable standard	Rank 3 Highly regarded	Rank 4 Top in Field	Rank 4* World Elite
# of Journals	205	295	231	73	21
% of Journals in JCR	14%	56%	86%	100%	100%
SC of Journals					
Variety	27	58	56	31	10
Balance	0.797	0.611	0.558	0.606	0.573
Disparity	0.866	0.737	0.657	0.755	0.767
Shannon Entropy	2.979	3.454	3.280	2.940	2.002
Rao-Stirling Diversity	**0.779**	**0.733**	**0.703**	**0.685**	**0.571**

NB: higher values for each metric, indicate higher levels of the indicated property

These data show that the highest rankings are much less diverse than lowest rankings. In particular, the top rank (4*), narrowly focuses on three SCs: management, business and finance. Lower ranks are spread across various social sciences, including economics, geography, sociology, psychology, and some engineering-related fields such as operations research and information science, as well as some application such as environment or food. Thus, while ABS rankings include journals from many disciplines, only some of those in their core subject matters are perceived by ABS as 'World Elite' journals.

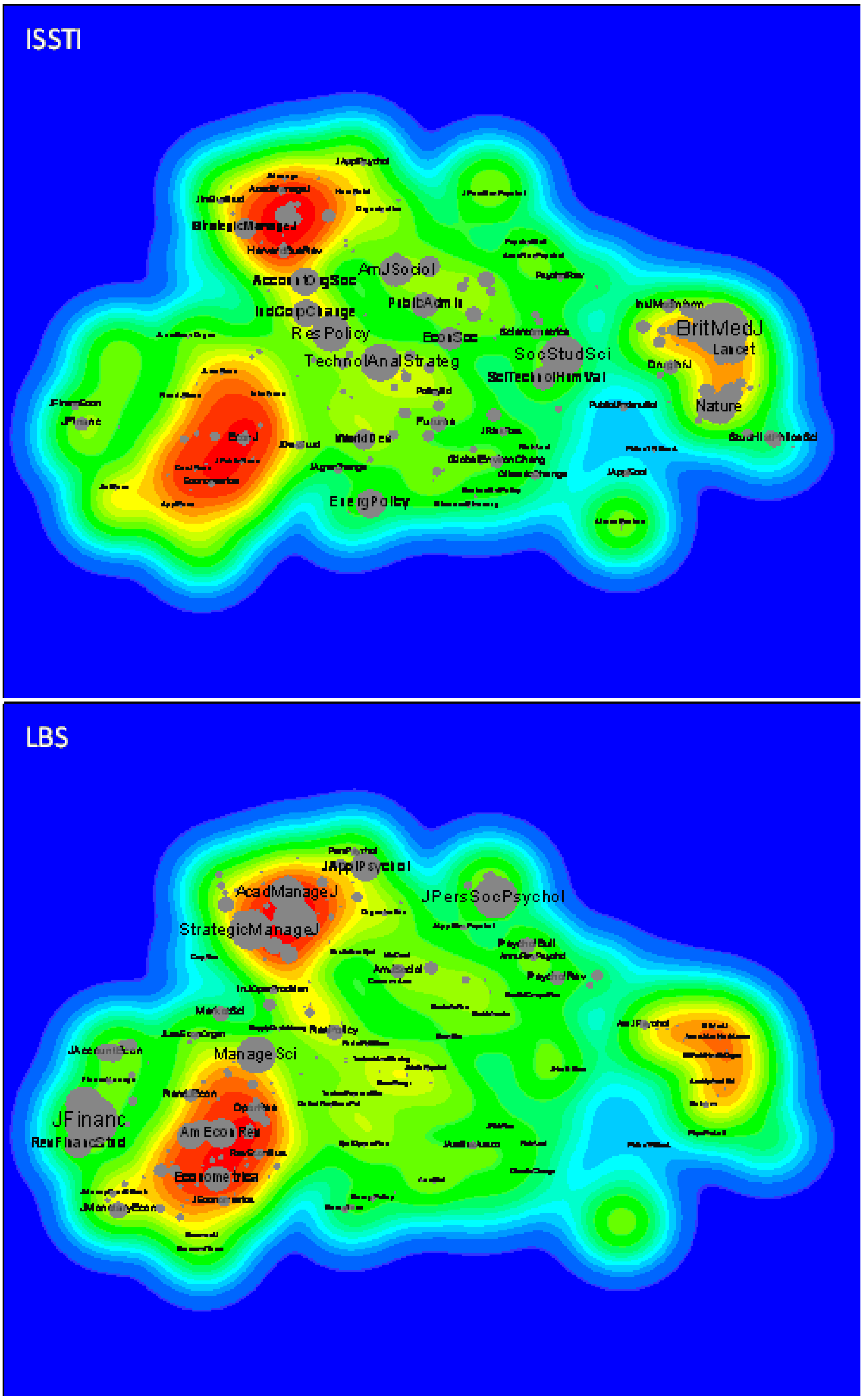
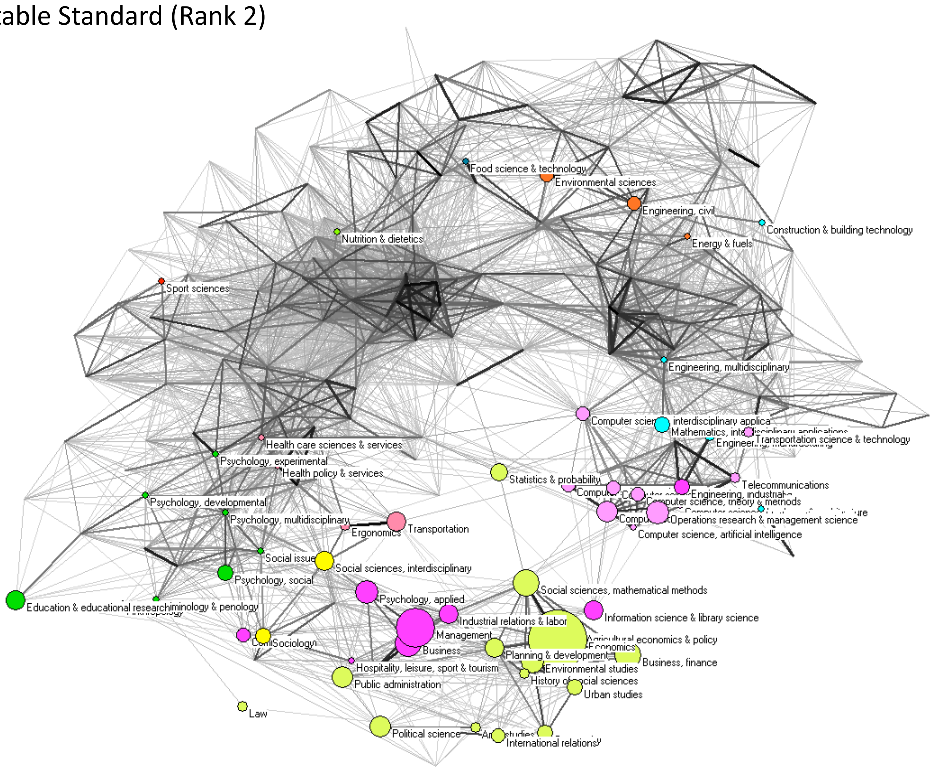


Figure 2. Overlay of journals in the references by ISSTI and LBS on the heat map based on the citation-similarities between journals (based on WoS 2009).

Acceptable Standard (Rank 2)



World Elite (Rank 4*)

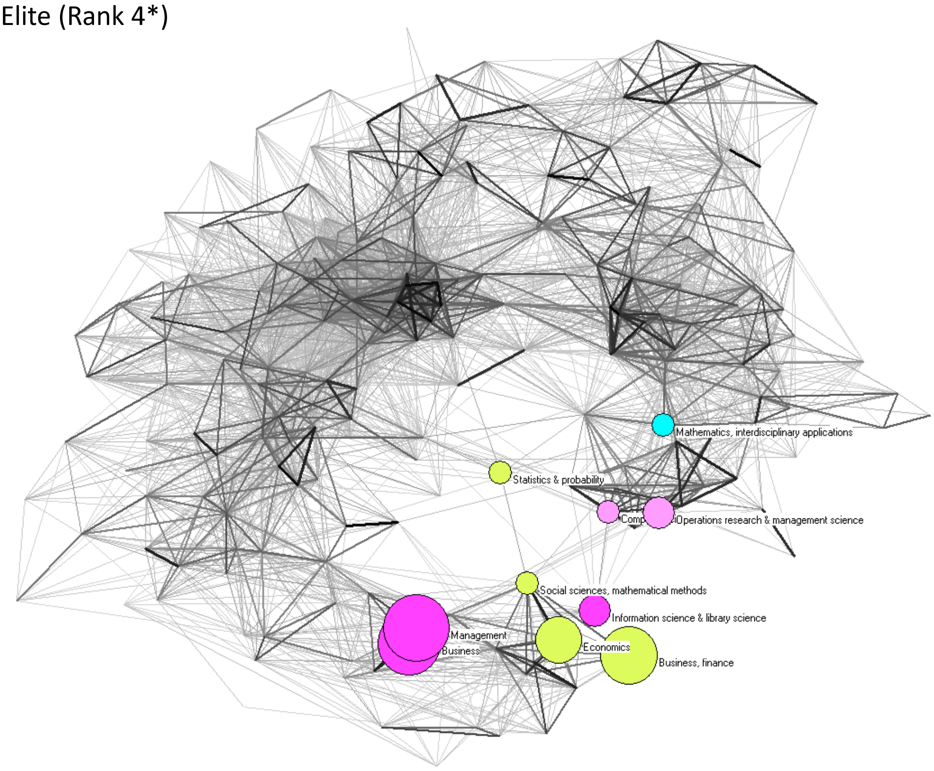


Figure 3. Distribution of journals across different categories for the Association of Business Schools' Rank 2 (Acceptable Standard) and Rank 4 (World Elite).

Performance assessment of organisational units

Finally, we can now explore how the disciplinary bias in the ABS journal rankings affects the assessment of organisational units. To do this, we took the mean of the ranks of journals in which the units publish. In doing so, we first notice a problem of assignation: whereas only 43% of ISSTI journals are in the ABS rankings, coverage reaches 93% in the case of LBS. The results are shown in Table 4. What is clear, is that the three BMS perform significantly better than the IS units. Within BMS, the narrow disciplinary profile of LBS achieves a much higher figure than the other two BMS. This is associated with the strong negative Pearson correlation between degree of interdisciplinarity across any metrics and ABS-based performance: -0.78 (Rao-Stirling diversity), -0.88 (coherence), -0.92 (Intermediation: clustering coefficient).

Next we compare the ABS-based performance with citation-based performance. We should emphasize that this is only an exploration. Since we are counting cites received by groups of papers in the whole 2006-2010 period and analysing the cites received in 2010 instead of using fixed citation windows, the results should be interpreted as only indicative. Nevertheless, we believe the estimate obtained is illustrative of the inherent difficulties and ambiguities, and sufficiently robust to provide tentative insights. Following conventional (but acknowledgedly flawed) practice we use the mean of highly skewed citation distributions. As a result the standard error of the mean is so high (in the ~8-18% range) that ranking units becomes problematic.

Table 4. Performance indicators for each organisation unit.

	Innovation Studies Units			Bus. & Management Schools		
	ISSTI	SPRU	MIOIR	Imperial	WBS	LBS
ABS ranking-based Mean (std error)						
Mean ABS Rank	2.82 (0.13)	2.65 (0.10)	2.54 (0.10)	3.36 (0.07)	3.01 (0.05)	3.92 (0.05)
% Papers Ranked	43%	51%	74%	69%	79%	93%
Citation-based Mean (std error)						
Cites/paper	2.69 (0.45)	5.11 (0.59)	3.50 (0.63)	5.30 (0.73)	2.91 (0.23)	5.04 (0.39)
Journal field normalized Cites/paper	1.67 (0.28)	2.79 (0.35)	2.10 (0.43)	3.34 (0.47)	2.11 (0.16)	3.60 (0.28)
Citing field normalized Cites/paper	0.18 (n.a.)	0.12 (n.a.)	0.09 (n.a.)	0.13 (n.a.)	0.07 (n.a.)	0.11 (n.a.)

It is found, first, that in terms of raw number of cites, there is no clear relation between IS units and BMS, although there is a weak correlation with ABS-performance (0.47). Second, using a normalisation based on the field of publication (the average impact factor of the SC of publication), one obtains significantly higher performances by BMS, with a 0.76 correlation with ABS-performance. One can advance a cause for this result: if IS papers are normalised by field, they are doubly disadvantaged in respect both of their publishing in natural sciences (because even if they receive many cites, they may – all else being equal – tend to be less so than natural science papers), or in the social sciences (because they have disproportionate difficulties in publishing in the most prestigious journals). Third, following Zhou and Leydesdorff (2011), we use a normalisation which weighs each citation by the number of references in the citing paper. In doing so, it achieves a much more accurate description of the citing context of each individual paper. Most interestingly, under this normalisation, the correlation between citation based and ABS-based performance vanishes to a negligible -0.03.

In summary, this exploratory analysis of different performance measures highlights the problems of commensurability in appraising IDR publications, and challenges the performance assessment of ABS-rankings. In short, a high performance in ABS terms is a mark of disciplinary compliance, but is not necessarily related to high citation performance.

Conclusions

This empirical investigation has demonstrated that IS units are more interdisciplinary than leading BMS under various perspectives. It has shown that ABS rankings have a disciplinary bias which translates very directly into a low assessment of interdisciplinary units' performance. We have shown that this low assessment is not warranted by citation-count performance. In this way, the present pilot study suggests that the use of ABS rankings serves systematically to disadvantage against IDR – a finding that might be tested in analysis of a wider array of BMS-related IDR. To the extent that ABS ranking are becoming increasingly used to evaluate individual and organisational research performance in this field, it does seem likely that they have a suppressive effect on IDR, including that in the IS field.

From a qualitative perspective these findings are not new. Science studies and policy documents have longed observed that criteria of excellence in academia are based on disciplinary standards, and that this hinders interdisciplinary endeavours in general, and policy and socially relevant research in particular (Bruce 2004, NAS, 2004). In recent decades these criteria of quality have become institutionalised in the form of rankings that can have major (often negative) reputational and funding implications. The use of this kind of ranking procedure is predicated on the assumption that the resulting ranks constitute *objective assessments* that can be treated as robust proxies for academic excellence. These empirical results challenge such claims to objectivity and suggest that the resulting picture presents a rather narrow and idiosyncratic view of excellence. When used in helping to determine assignments of esteem and resources, rankings that remain uncorrected for these effects can have the effect of suppressing forms of interdisciplinarity that are otherwise widely acknowledged to be academically and socially positive.

Further details of this study are available at www.interdisciplinary.net

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