Does interdisciplinary research lead to higher scientific impact?

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Introduction

Conventional wisdom: breakthroughs come from interdisciplinary research (IDR).

- Policy initiatives favouring IDR.
- Anecdotal evidence that more IDR leads to breakthrough: high risk, high reward (e.g. Hollingsworth, 2006).

However:

- Little systematic evidence of effect IDR on research performance.
- Lack of consensus on IDR measures (Wagner et al., in press, Leydesdorff & Rafols, J of Informetrics, in press).

Yet strong policy demand:

- HEFCE → IDR is not discriminated!!
- NESTA → IDR needs support!!
### Evidence on scientific performance of IDR

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<tbody>
<tr>
<td><strong>Sample</strong></td>
<td>All science articles</td>
<td>All science and social science articles</td>
<td>Articles from two UK universities</td>
<td>All academic physics groups in the Netherlands</td>
</tr>
<tr>
<td><strong>Database</strong></td>
<td>WoS</td>
<td>WoS and Scopus</td>
<td>WoS</td>
<td>WoS</td>
</tr>
<tr>
<td><strong>Unit of analysis</strong></td>
<td>Article</td>
<td>Journal</td>
<td>Article</td>
<td>Research programs</td>
</tr>
<tr>
<td><strong>IDR indicator</strong></td>
<td>• % cited refs. to other SC</td>
<td>• SC of journals</td>
<td>• % cited refs to other SC</td>
<td>• SC of journals</td>
</tr>
<tr>
<td><strong>Correlation IDR vs Impact</strong></td>
<td>No effect in some science disciplines</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td><strong>Inverted U-shape relationship</strong></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
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</table>

**Results are descriptive: graphs and (bi-variate) correlations**
“Interdisciplinary research (IDR) is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice”. National Academy of Sciences, 2004.

INTEGRATION

Most bibliometric indicators of interdisciplinarity implicitly rely on this idea:

Diversity of disciplines *Integrated* in the reference list
Conceptualisation of diversity

Stirling, 1998
Research question

Does IDR lead to a higher scientific impact?

- New methodological advances in measuring IDR: capturing the different attributes of diversity

- To what extent the different attributes of diversity have a distinct effect on scientific impact?

- Article level analysis
Diversity indexes

Shannon Diversity Index:

\[ H = - \sum_i p_i \ln p_i \]
Diversity indexes

\[ \Delta = \sum_{ij} d_{ij}^{\alpha} (p_i p_j)^{\beta} \]

Integration score in Porter et al., 2007
Different aspects of diversity

Increasing Diversity

Balance: Shannon Evenness

Disparity:

\[ 1 - \sum_{i,j} \frac{S_{ij}}{N \times N - 1} \]

Variety:
Number of disciplines

For each property other operationalisations are possible

Cognitive distance, from science maps
(Leydesdorff & Rafols, 2009)
Data and Method

Data
- CSIC research groups taking part in the Spanish Food Technology Program (SFTP) from 1988 to 1999
- 2863 unique articles and reviews retrieved from SCI-E (full abstract records were downloaded)

Diversity
- Discipline = Subject Category (SC) in SCI-E
- 285 articles with fewer than 4 references linked to SCs were excluded (final dataset = 2578 unique articles)
- Calculation of Shannon diversity, variety, balance and disparity indexes for each publication

Scientific Impact
- Citation window: 5 years
- Document type
- Field normalization: actual number of citations (C) divided by FCSm calculated for Spain (ES-FCSm) – (Van Raan A.F.J, 2004)

# authors, # institutions, collaboration type, journal country of publication
Weak degree of correlation (n=2578)

\[ r_{\text{var,bal}} = 0.18, \ p < .001 \]

\[ r_{\text{var,dis}} = 0.32, \ p < .001 \]

\[ r_{\text{bal,dis}} = -0.20, \ p < .001 \]
Illustration of correlations

References by biotech papers in 2005
(Aggregate for 990 paper sample)

Porter and Rafols (2009)
Regression analysis

Ordinary Least Squares (OLS)

- Dependent variable: normalized number of citations per paper (log transformed)
- Explanatory variables:
  - Shannon Diversity Index
  - Standardized Variety / Balance / Disparity
- Control variables:
  - No. authors / No. institutions / Collaboration type / journal country
  - For all CSIC research groups
  - Spanish regions

Total number of observations: 2578
Shannon Diversity Index

Articles' relative impact vs Shannon Diversity Index
# Results OLS regression

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shannon Diversity Index</td>
<td>0.174***</td>
<td>-</td>
</tr>
<tr>
<td>Variety</td>
<td>--</td>
<td>0.168***</td>
</tr>
<tr>
<td>Balance</td>
<td>--</td>
<td>- 0.094***</td>
</tr>
<tr>
<td>Disparity</td>
<td>--</td>
<td>- 0.050**</td>
</tr>
<tr>
<td>No. Authors</td>
<td>0.042**</td>
<td>0.044**</td>
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<tr>
<td>No. Institutions</td>
<td>-0.006</td>
<td>-0.003</td>
</tr>
<tr>
<td>Collaboration type</td>
<td>0.092**</td>
<td>0.085**</td>
</tr>
<tr>
<td>Journal nationality</td>
<td>0.614***</td>
<td>0.619***</td>
</tr>
</tbody>
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<thead>
<tr>
<th></th>
<th>Observations</th>
<th>R square</th>
<th>Adj R squared</th>
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<tbody>
<tr>
<td>(1)</td>
<td>2578</td>
<td>0.082</td>
<td>0.058</td>
</tr>
<tr>
<td>(2)</td>
<td>2578</td>
<td>0.097</td>
<td>0.073</td>
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</tbody>
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Results do not depend on normalisation of citations per field
Illustration of regression

References by biotech papers in 2005
(Aggregate for 990 paper sample)

Porter and Rafols (2009)
Limitations

- Use of problematic predefined categories (ISI SCI)
  - Other units of analysis (e.g. thematic clustering?)

- References not classified as SC.
  - Discipline analysis only for those references to other source articles in SCI-E (26.8% references not linked to SCs)
Discussion

Summary: Variety favours scientific impact. Balance and cognitive distance has a negative effect.

T-shape interdisciplinarity:

A successful article is one that has a clear disciplinary focus but that “touches upon” disciplines of its cognitive neighbourhood.

Successful research

• Building on cumulative knowledge (Pavitt, 1987)

• State-of-art expertise in one field by capacity to integrate standard knowledge from other fields (qualitative studies: Brusoni, 2001; Rafols, 2007)
Discussion

Summary: Variety favours scientific impact. Balance and cognitive distance has a negative effect.

Or is IDR is discriminated against?

A successful article is one that positions itself so that it can be read and cited by a disciplinary audience.

Disciplines can enforce the reading of papers that are considered important.

Without a community, IDR papers do not have tools to enforce citation/reading.

Normative interpretation is problematic

- The results do not explain what type of IDR should be supported. Only what type of IDR is currently rewarded given present institutions in science