Workshop on the Implications of Convergence
for How the NCSES Measures the S&E Workforce
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From unidimensional indicators to portfolio analysis of convergence

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Summary of the argument

Problem-oriented understanding of convergence

- How **various types of knowledge** help in
- finding solutions to **societal challenges**...
- ... and foster **innovation**

Which research for Covid?

Vaccines? clinical treatment? population dynamics? healthcare management? risk comms? social effects of lockdown (inequality)? → all inter/multidisciplinary

Innovation :

- combines knowledge → Epistemic integration (enhanced by social diversity)
- a vector (directions!), not a unidimensional scalar
  - NOT about more or less // about balance of pathways undertaken

Proposal:

- Focus on description of portfolios
- Report distributions: tables / networks / maps (not indicators of IDR)

No robust general/national measures of IDR/convergence

- Work on measures of IDR for 10 years, work related to Leahey's (Alan Porter @GT)
- These are valuable indicators under controlled analytical conditions / contexts
- But fail as measure for systemic comparison

Reports on IDR in the UK research councils (HEFCE & MRC - expert advisor) (2015)

Elsevier: China is more IDR than UK

(not credible -an artifact of Chinese journals)

Digital Science (Jonathan Adam now Clarivate)

- **inconsistent** and actually **conflicting** outcomes datasets and analytical methodologies.
- Some indicators seem to reflect **confounding factors** in the background data rather than real country and subject differences.
- provide specific measures of the interdisciplinarity of the input and output metadata, **not the activity of interest**.

Recent comparisons of IDR indicators

Wang and Schneider (2020) (QSS)

- Comparison of existing measures of IDR '...current measurements (...) are both **confusing and unsatisfying**. We find **surprisingly deviant** results when comparing measures that supposedly should capture similar features (...) of interdisciplinarity.'

Shift of focus: from atomistic to portfolio approaches

Atomistic approaches dominate previous measurement approaches:

- **IDR is the average of individual paper IDR**
  - **In Elsevier and Digital Science IDR (2015) – nat'l analysis is the sum at paper level**
  - **Compare Cassi et al. (2015) & – analyse dept, or Leahey et al. (2017) -- individuals**

Ecological approaches – relate structure to function

- **A "wealthy" and "healthy" forest not made out of same-sized trees!!!**
  - **Seeing like a state (James Scott,)**
- **Co-existence** of plants, trees, bacteria, fungi and animals in symbiosis – in the forest, not in each tree.
- **Soil background – relate research to socio-economic conditions**

Mapping convergence of a topic, territory or organisation?

- variety of knowledge in the **landscape** (not individual papers)?
- linkages between bodies of knowledge in **landscape?**
- **Balance and directions** of knowledge?

Research portfolios →

relate science "supply" to orginizational missions or societal "needs"

Wallace and Rafols (2015)

Towards portfolio descriptions in Sci. & Eng. Statistics

Multidimensional ways of presenting statistical data

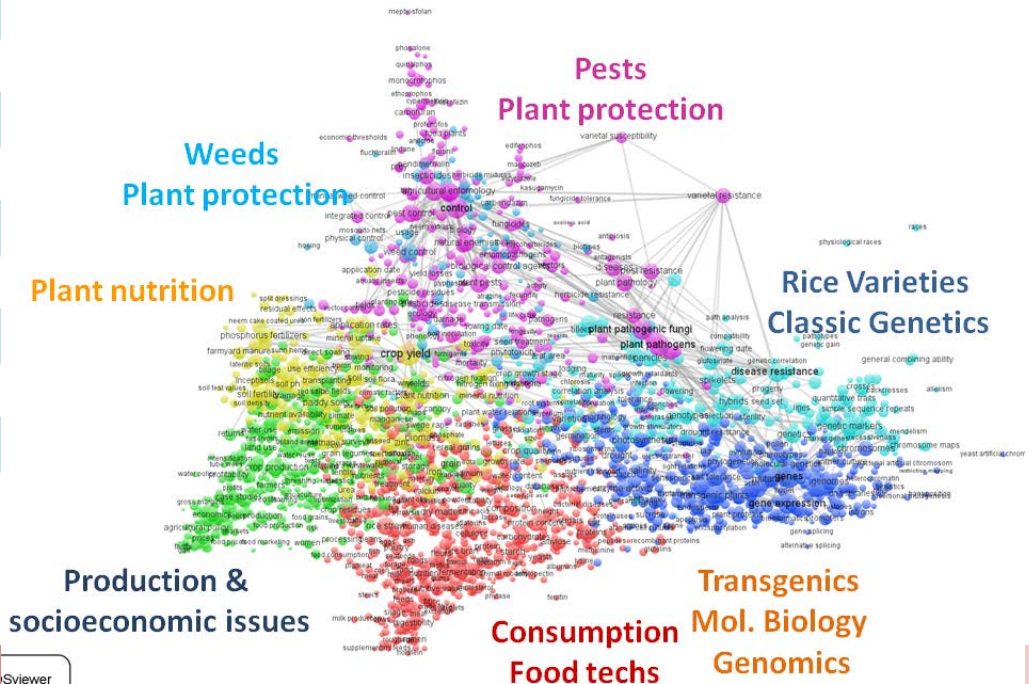
Model of Unidimensional indicators:
Unique and (often read as) prescriptive

which way?
which combinations?
what alternatives?

Model of multiple options
Exploring complementary choices
Divergent ways of addressing a challenge

Academic Ranking of World Universities - 2011

World Rank	Institution	Country	National Rank	Total Score
1	Harvard University			
2	Stanford University			
3	Massachusetts Institute of Technology (MIT)			
4	University of California, Berkeley			
5	University of Cambridge			
6	California Institute of Technology			
7	Princeton University			
8	Columbia University			
9	University of Chicago			
10	University of Oxford			



Portfolio approach for addressing societal challenges?

Convergence = Topic distribution + Integrative efforts

Various meaningful perspectives depending on question

Two examples:

- **Degree and type of IDR at the level of organizations**
  Useful to understand which organizations are doing convergence
  And the type of convergence that they do.

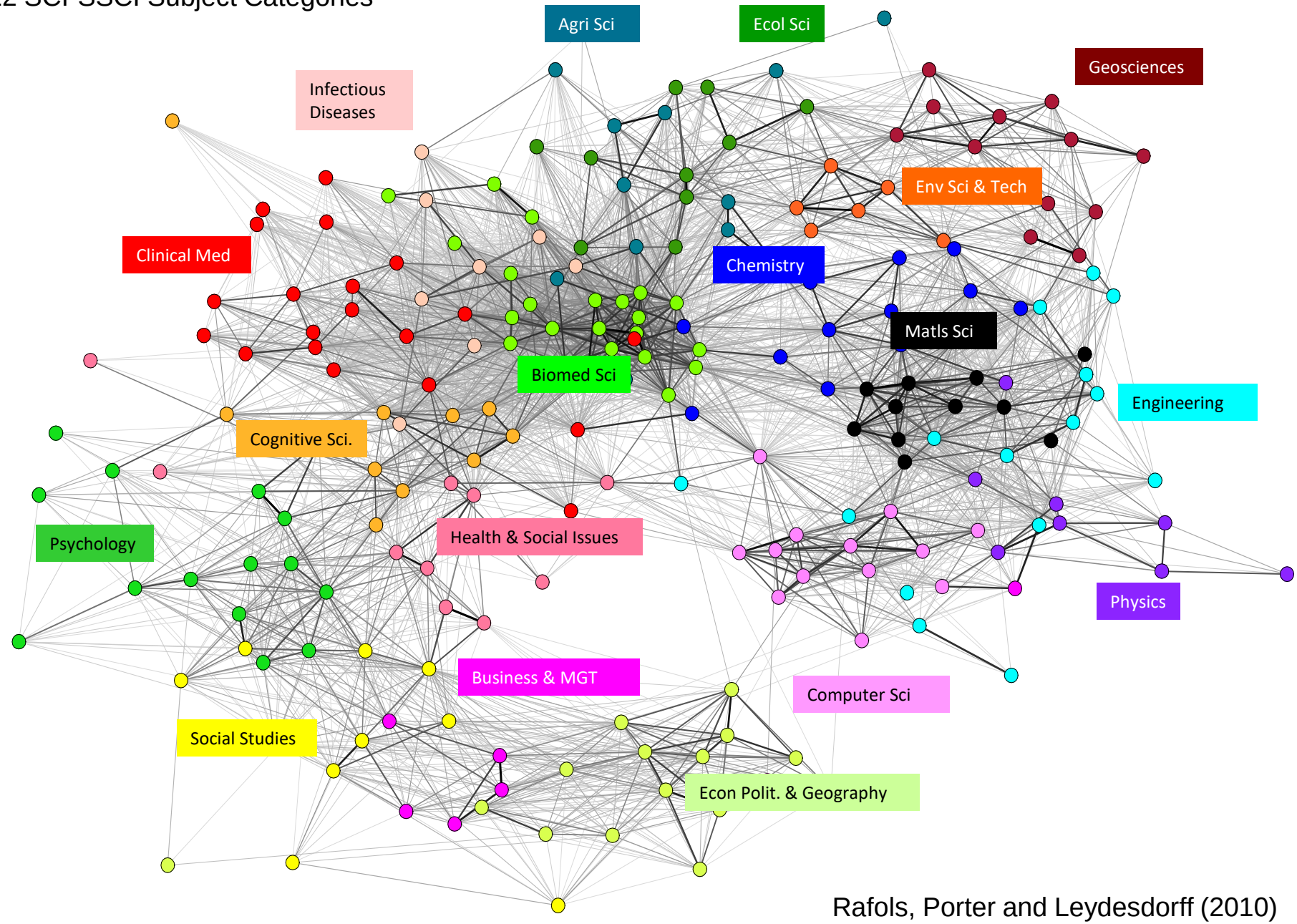
- **Type of convergence of societal challenges**
  Useful to understand the dominant directions of research
  Gaps, existing and missing synergies

Wallace and Rafols (2015)

Convergence efforts in **Organisations**

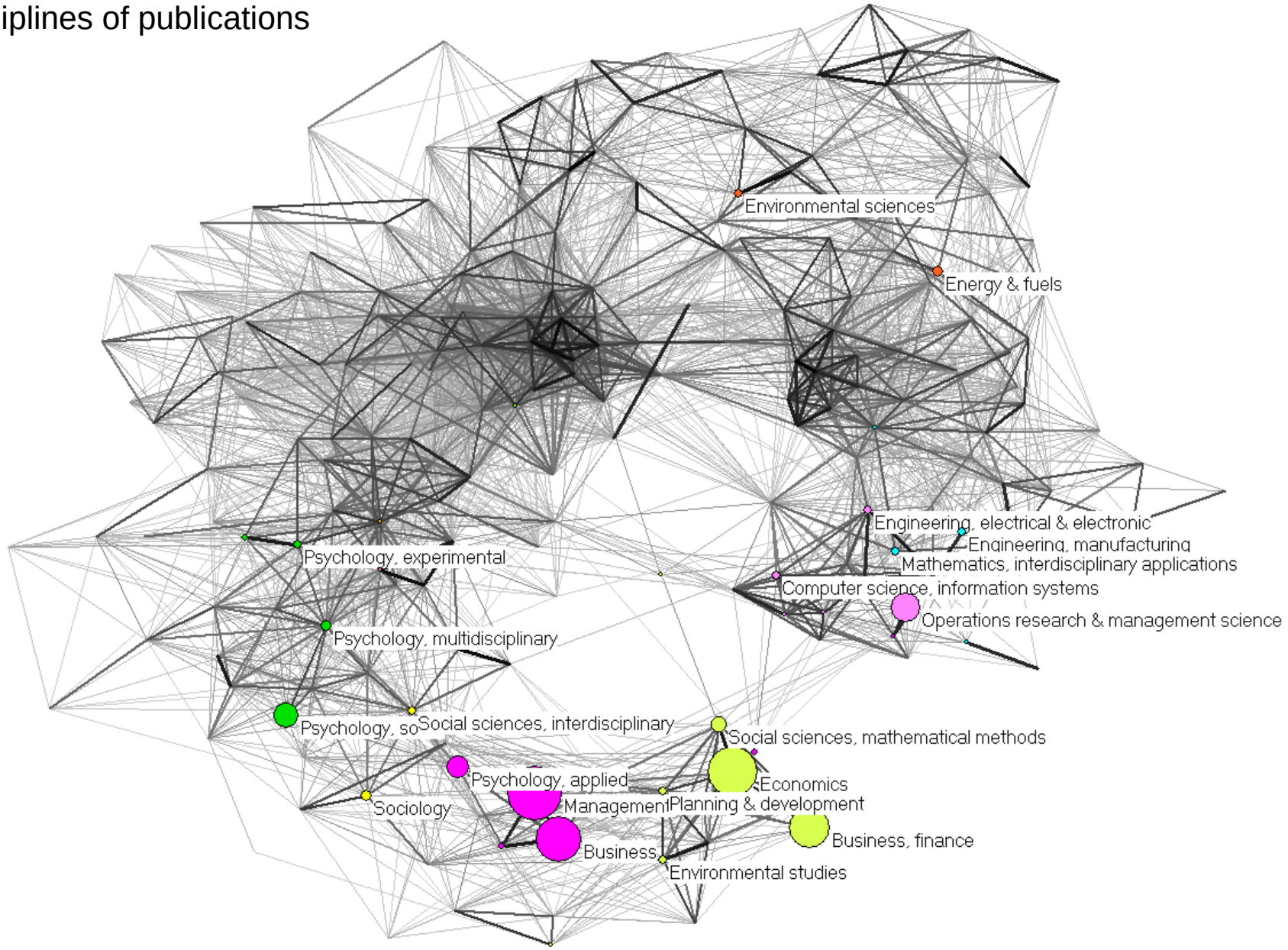
A Global Map of Science

222 SCI-SSCI Subject Categories



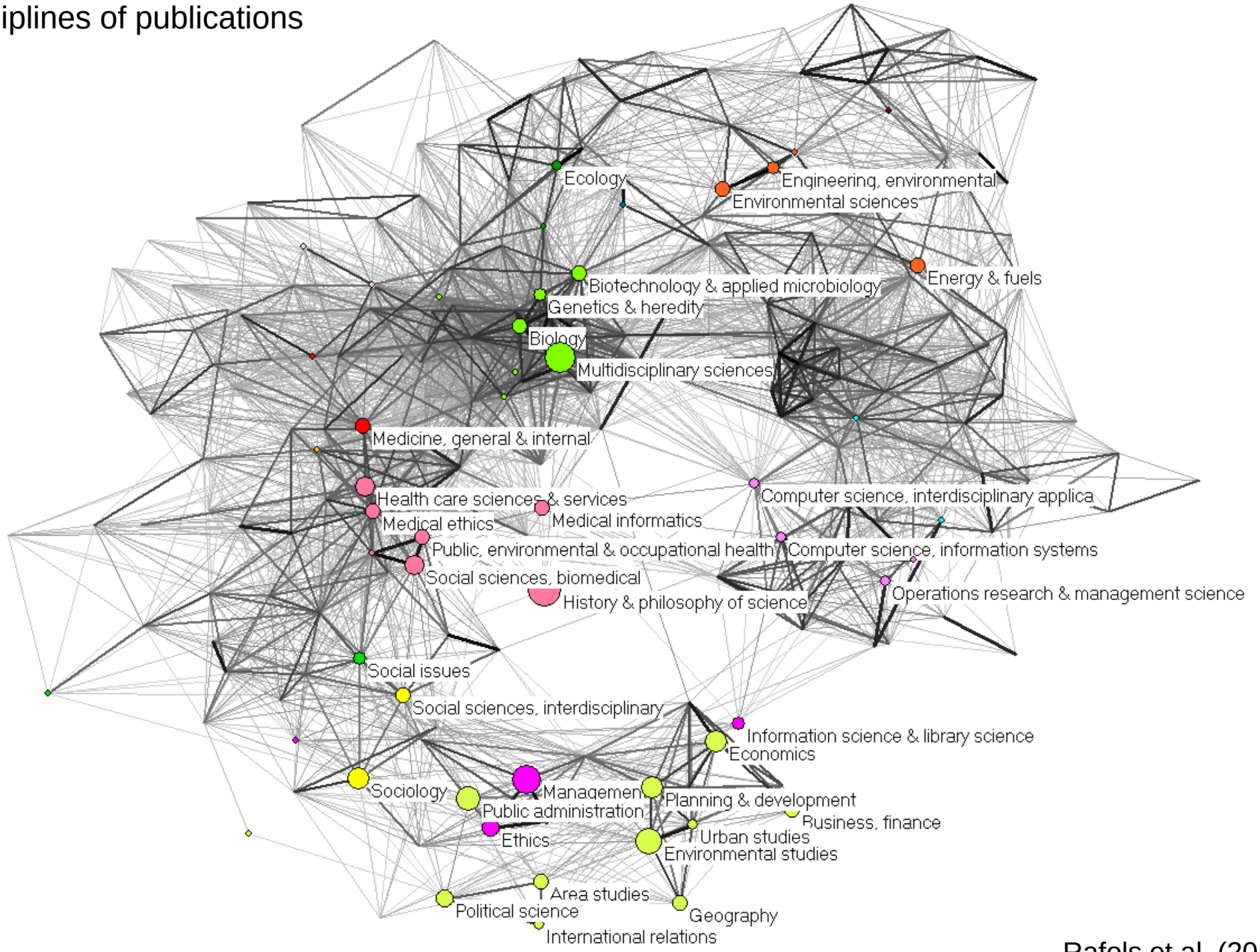
Rafols, Porter and Leydesdorff (2010)

London Business School
Disciplines of publications



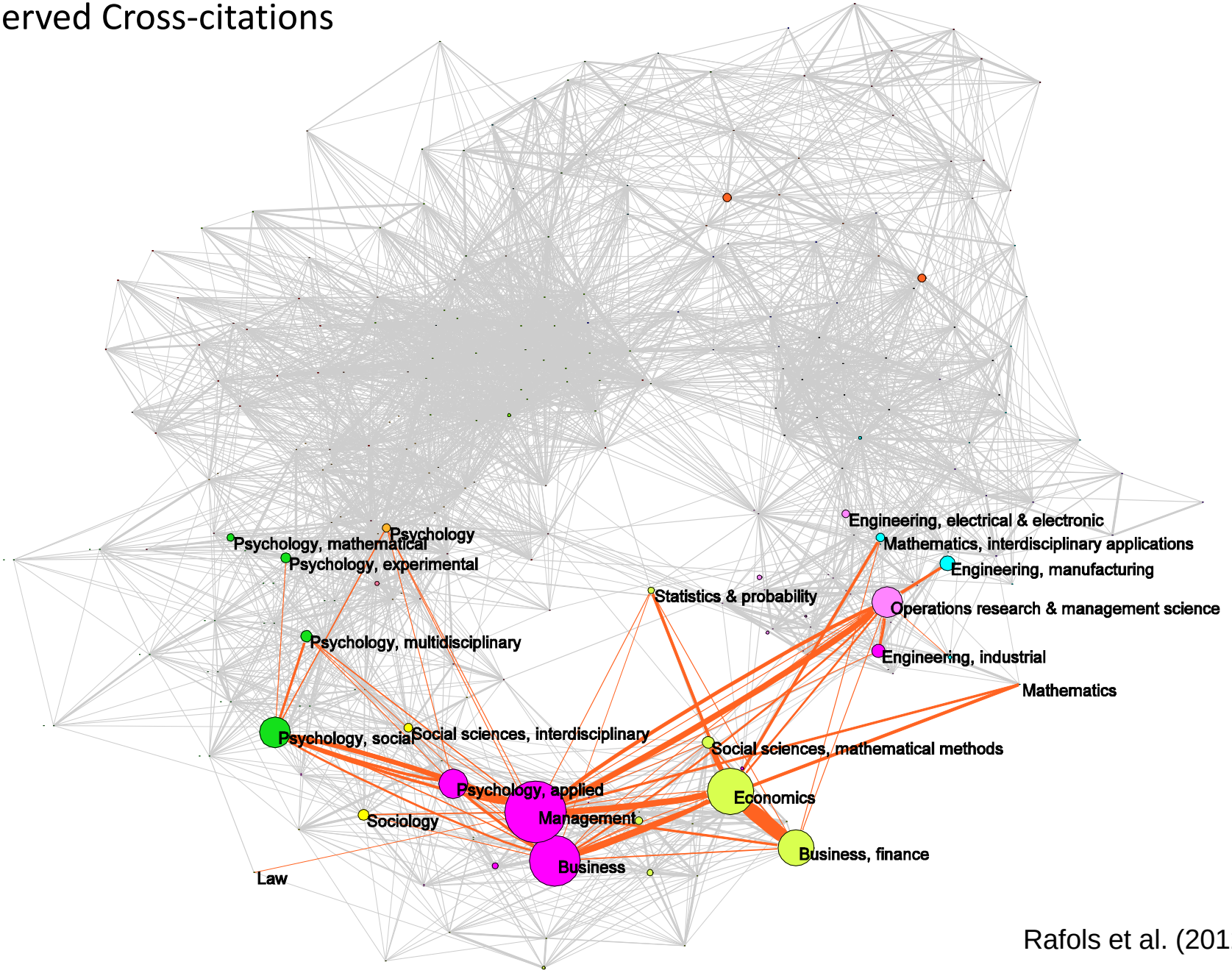
Rafols et al. (2012)

ISSTI Edinburgh
Disciplines of publications



Rafols et al. (2012)

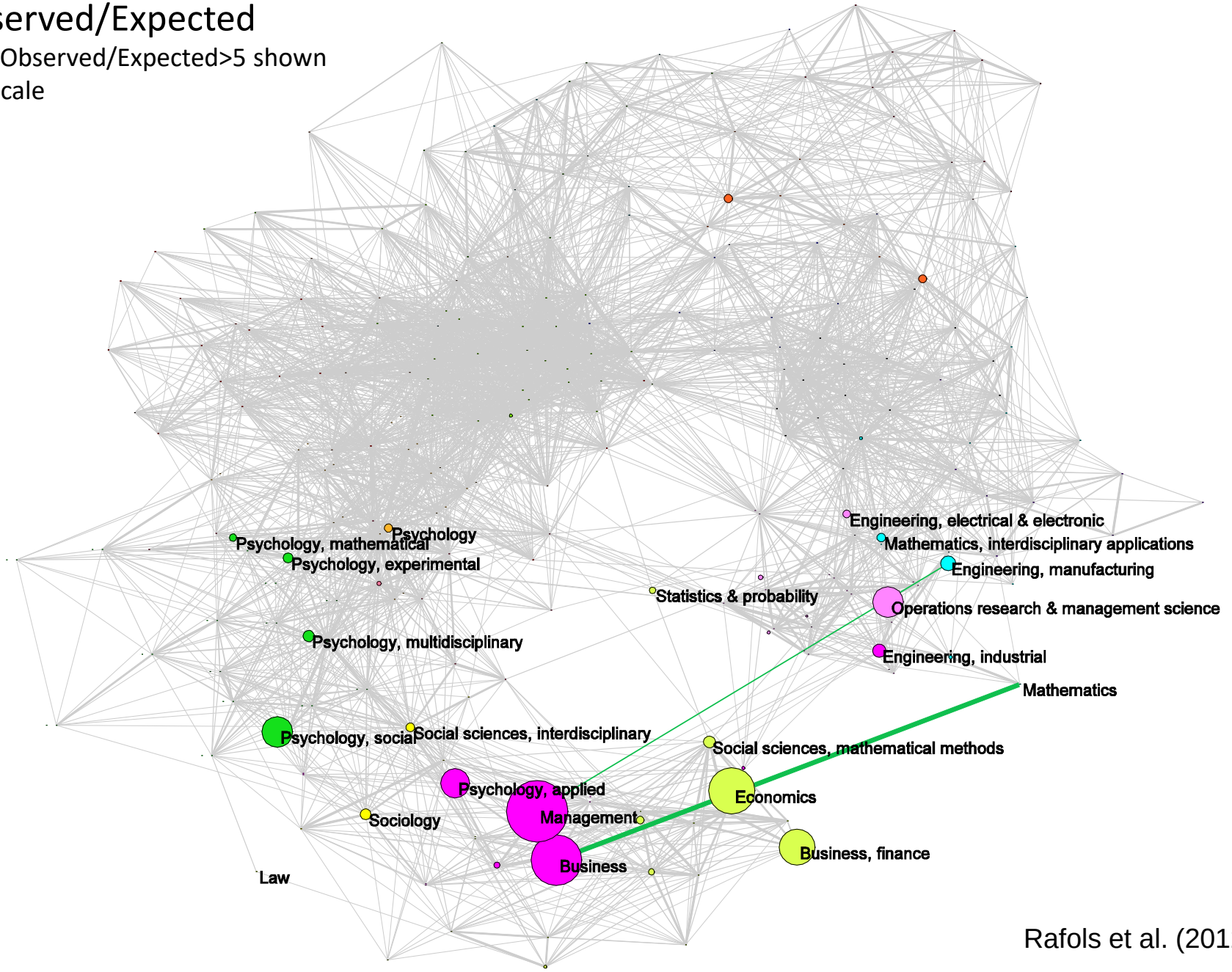
London Business School
Observed Cross-citations



Rafols et al. (2012)

London Business School
Observed/Expected

Only Observed/Expected>5 shown
Log-scale



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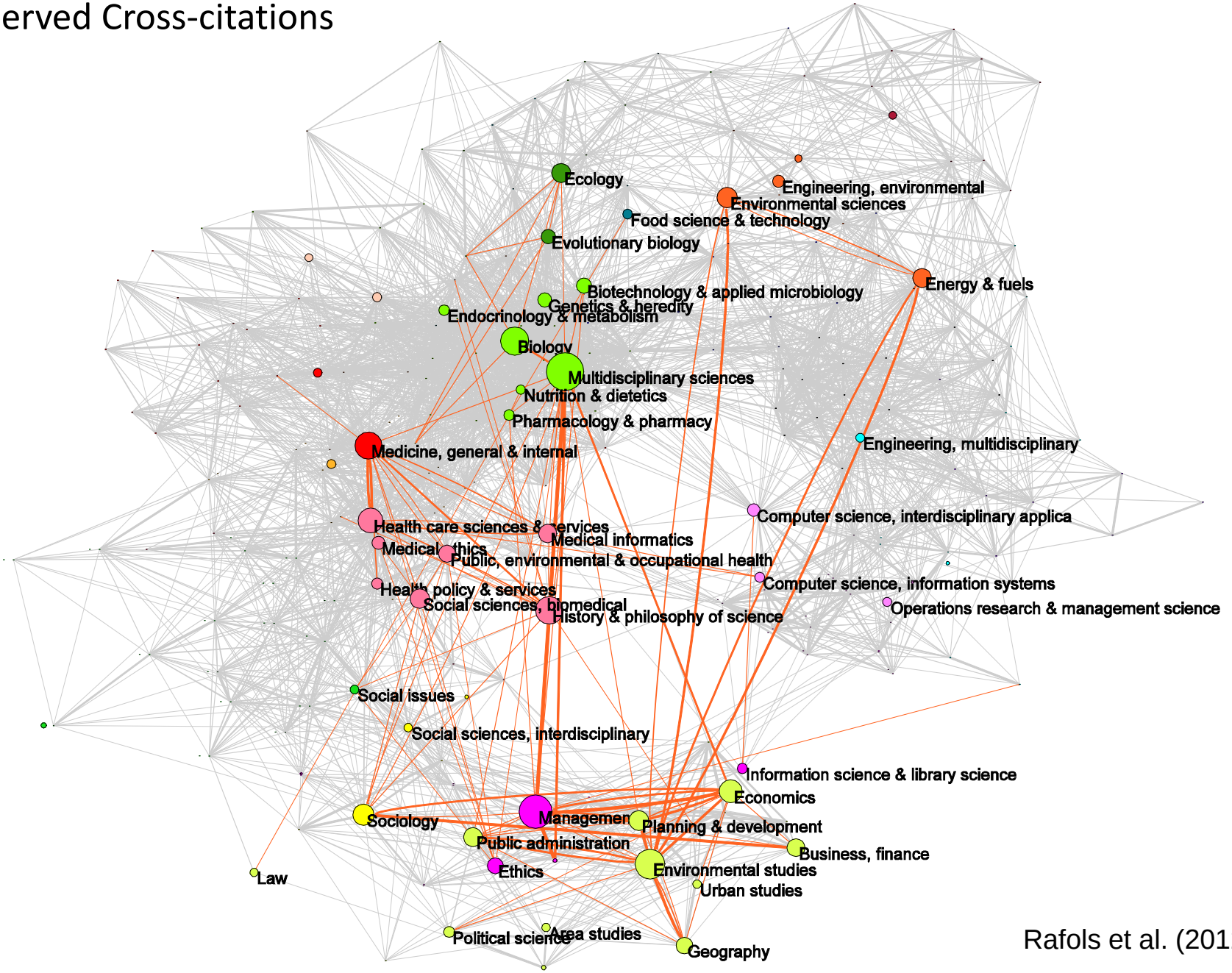

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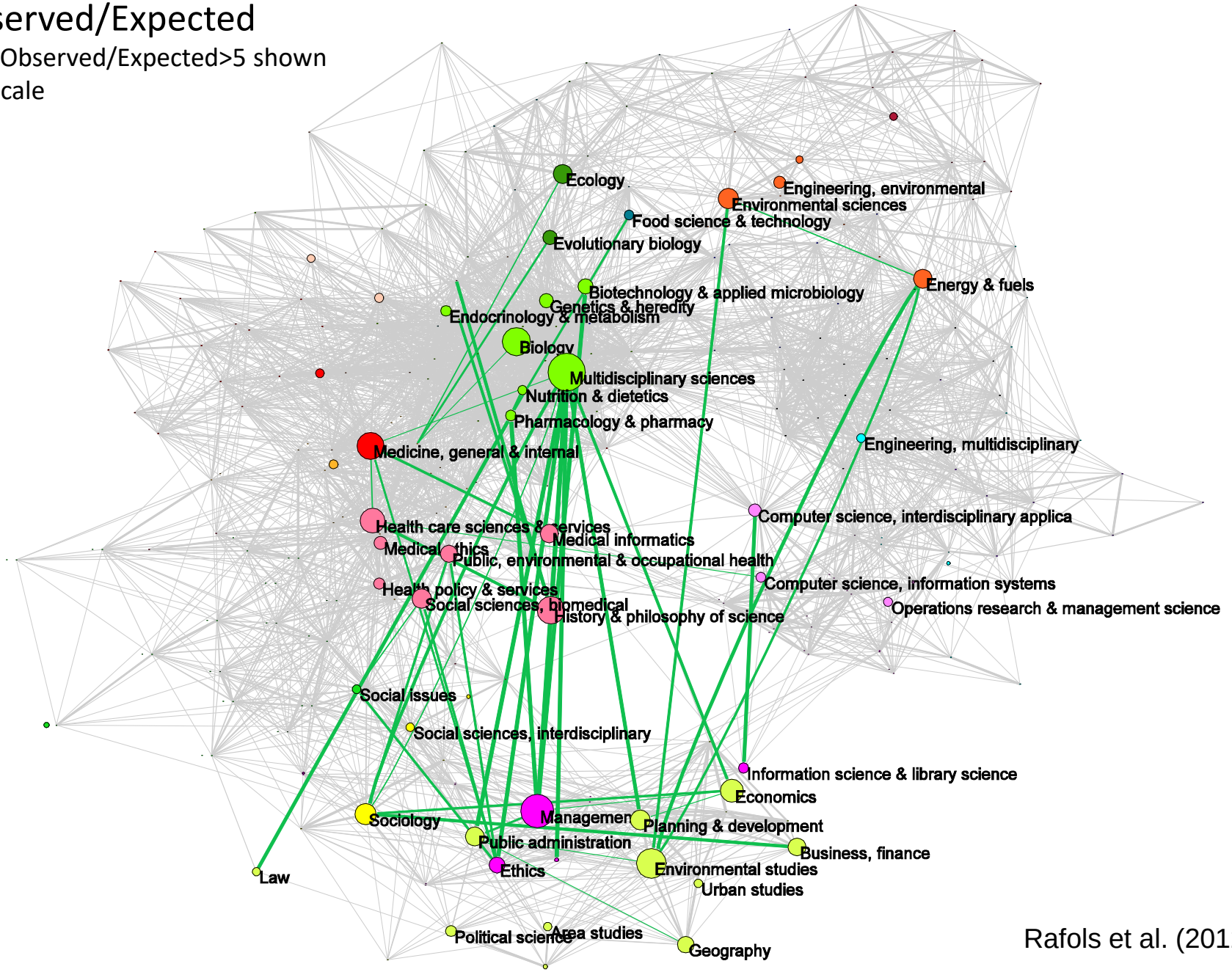
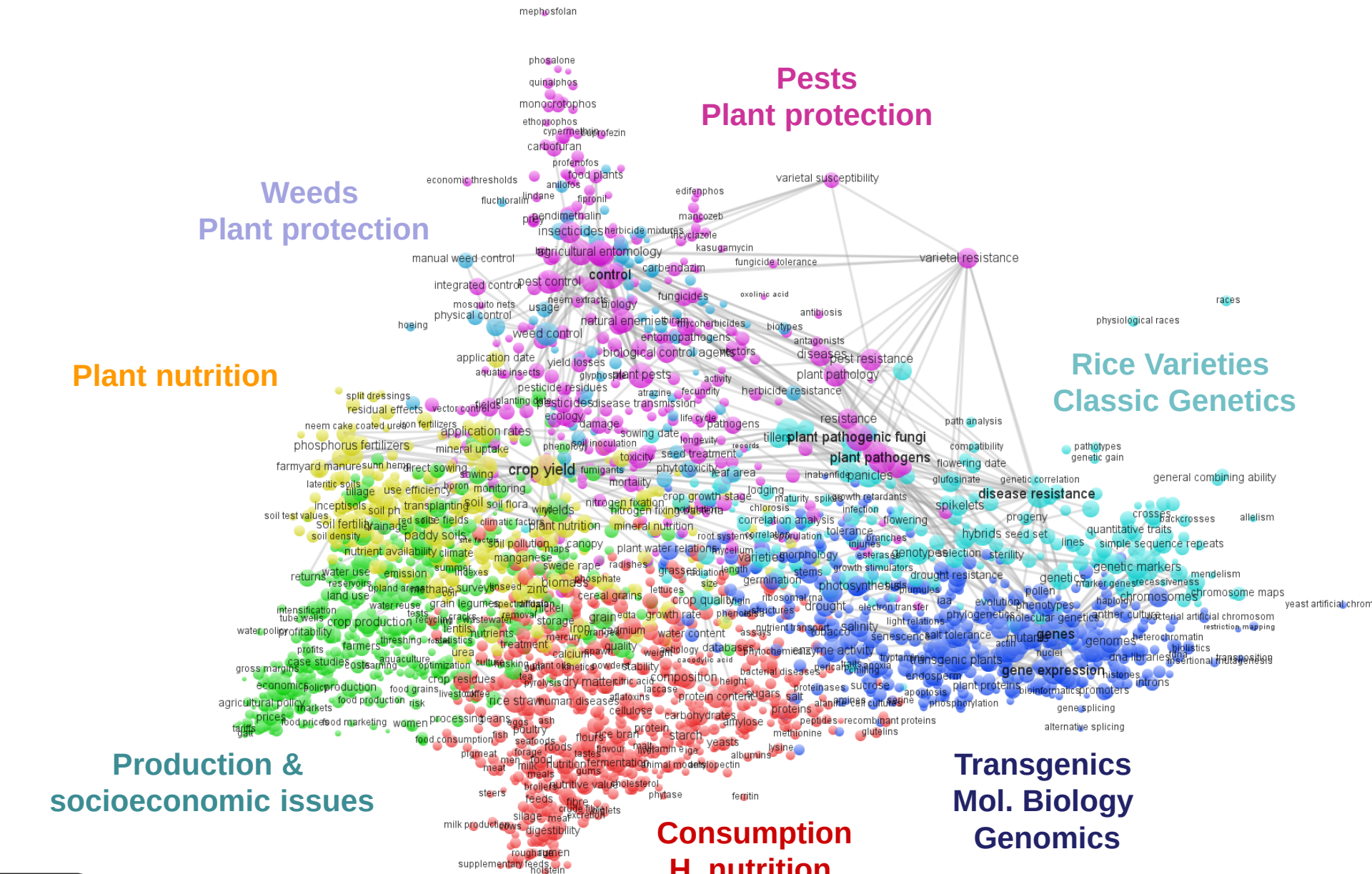


Rafols et al. (2012)

Convergence dynamics in **topics**

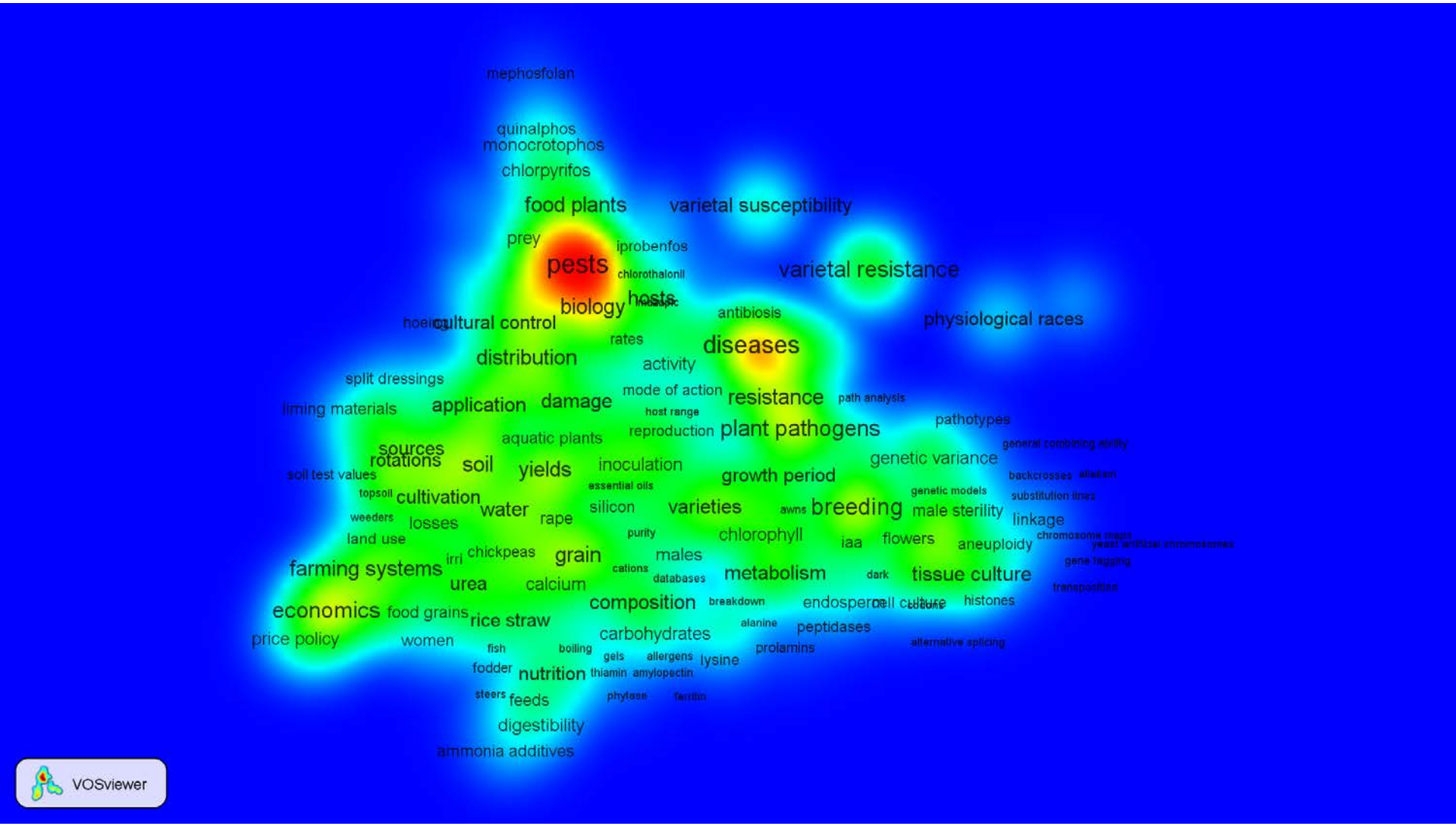
Porfolio approach: What are the “options” in rice research?



Ciarli and Rafols (2019)

SVviewer

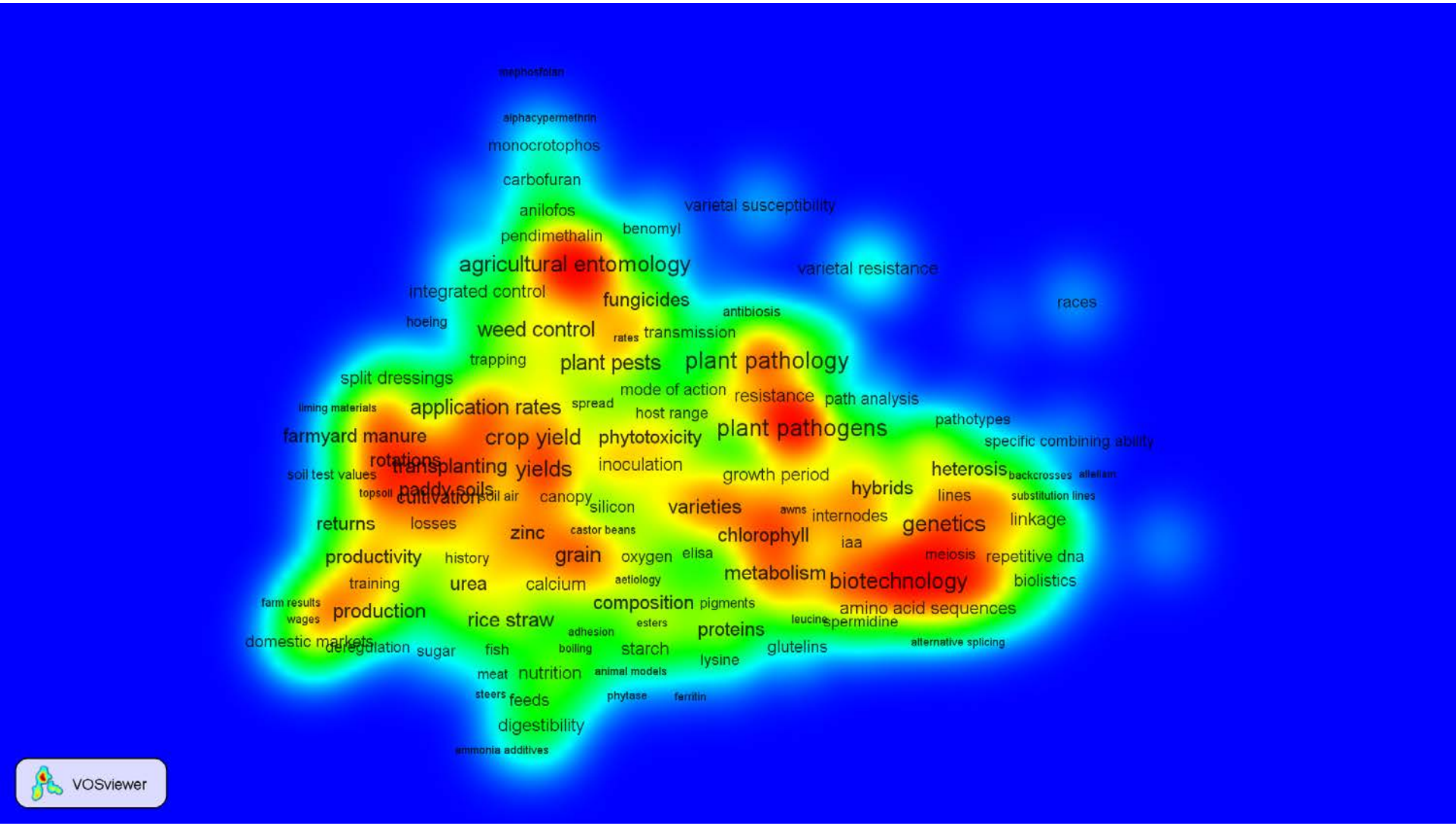
Trajectory of rice research,1983-2012



1983-87

Ciarli and Rafols (2019)

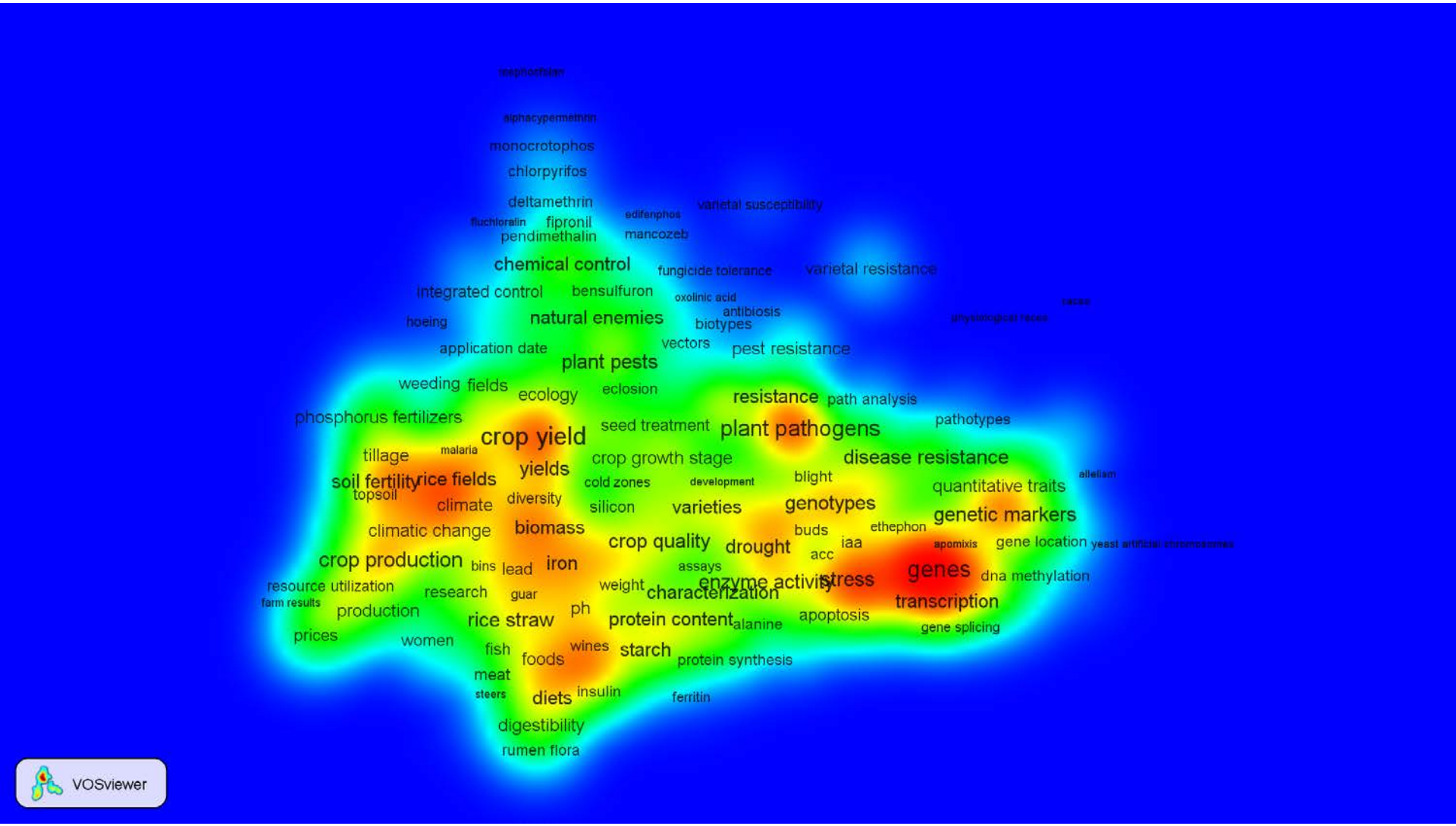
Trajectory of rice research,1983-2012



1996-99

Ciarli and Rafols (2019)

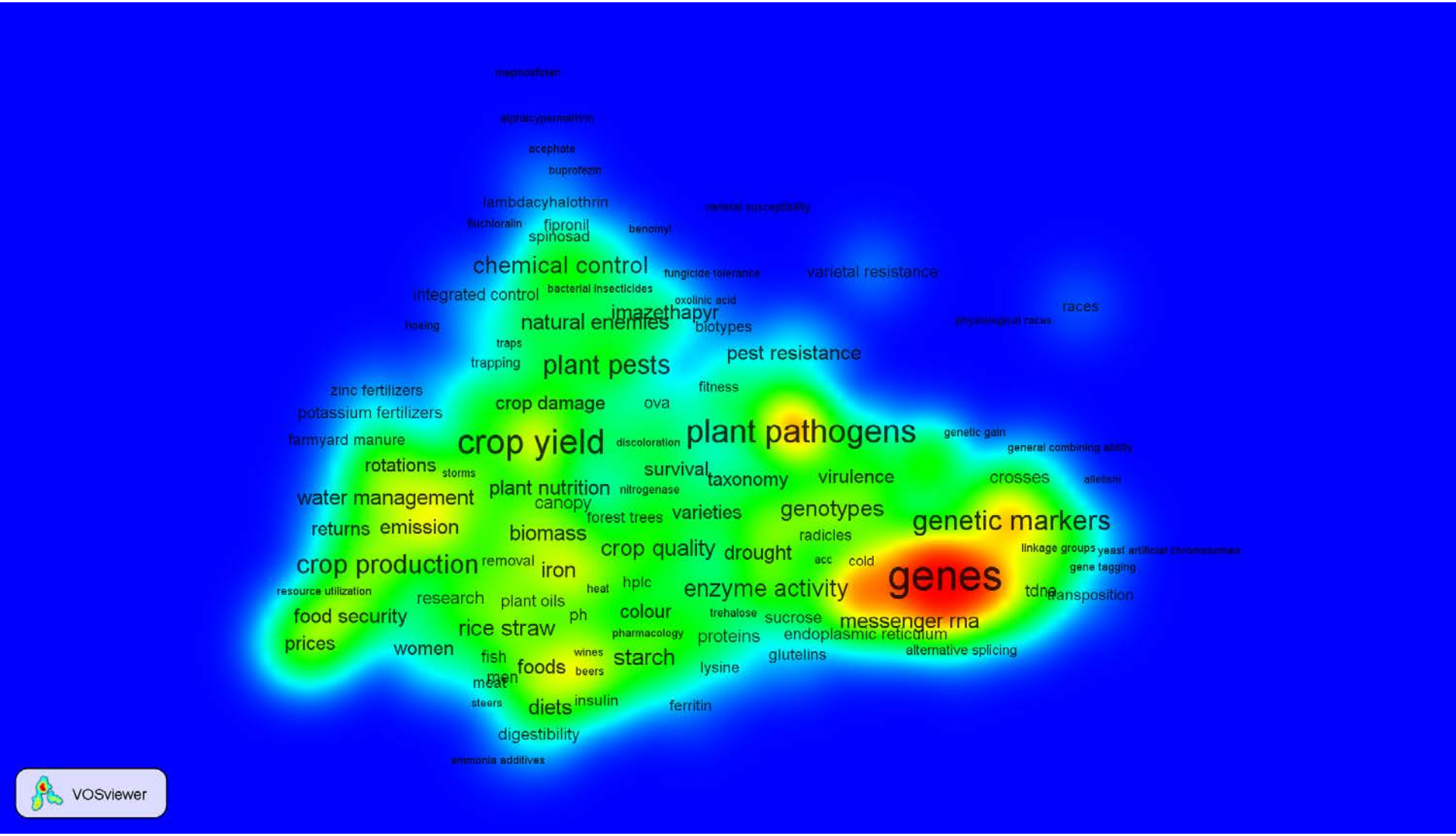
Trajectory of rice research,1983-2012



2011-12

Ciarli and Rafols (2019)

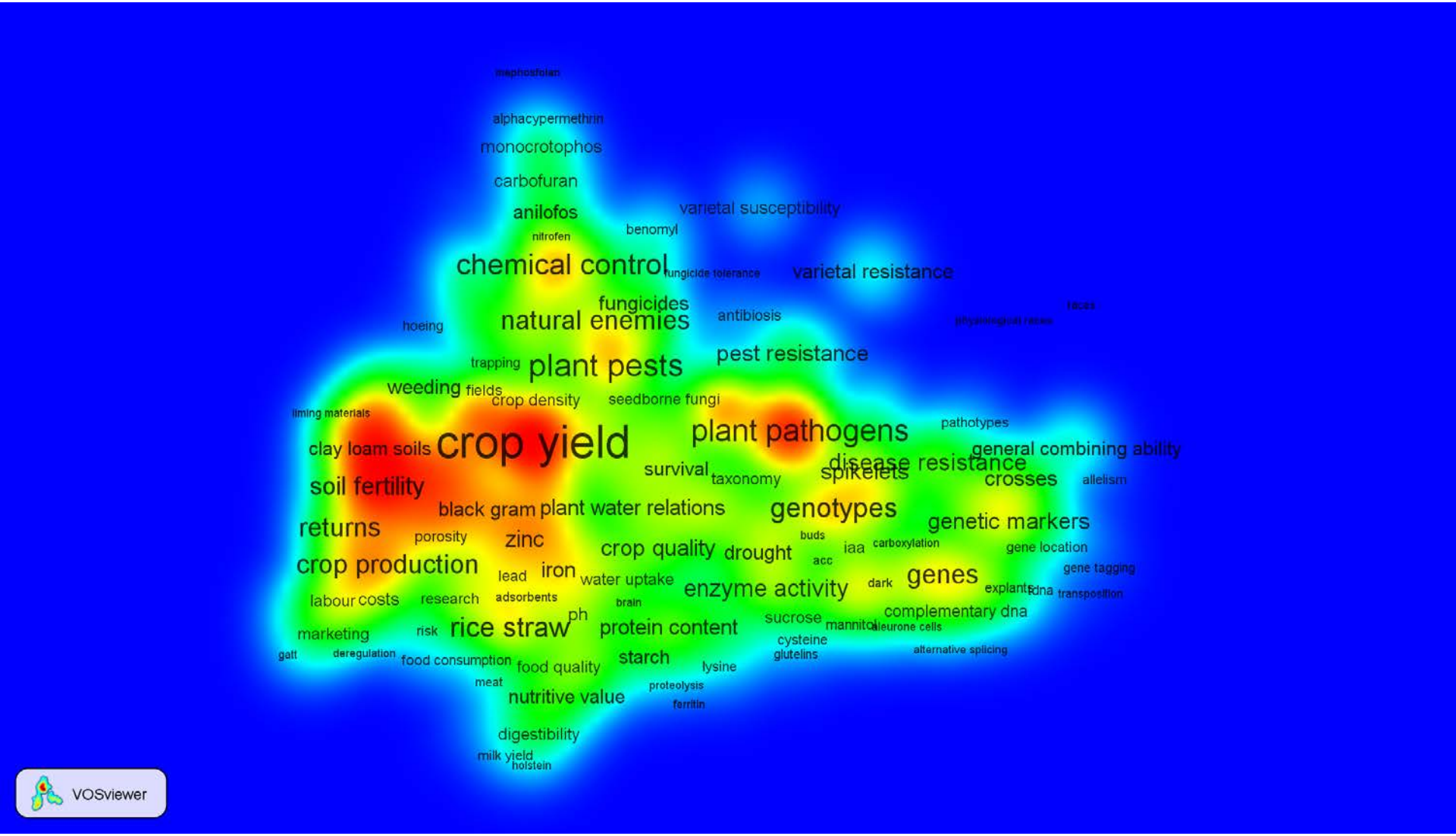
How research priorities differ by country



US, 2000-12

Ciarli and Rafols (2019)

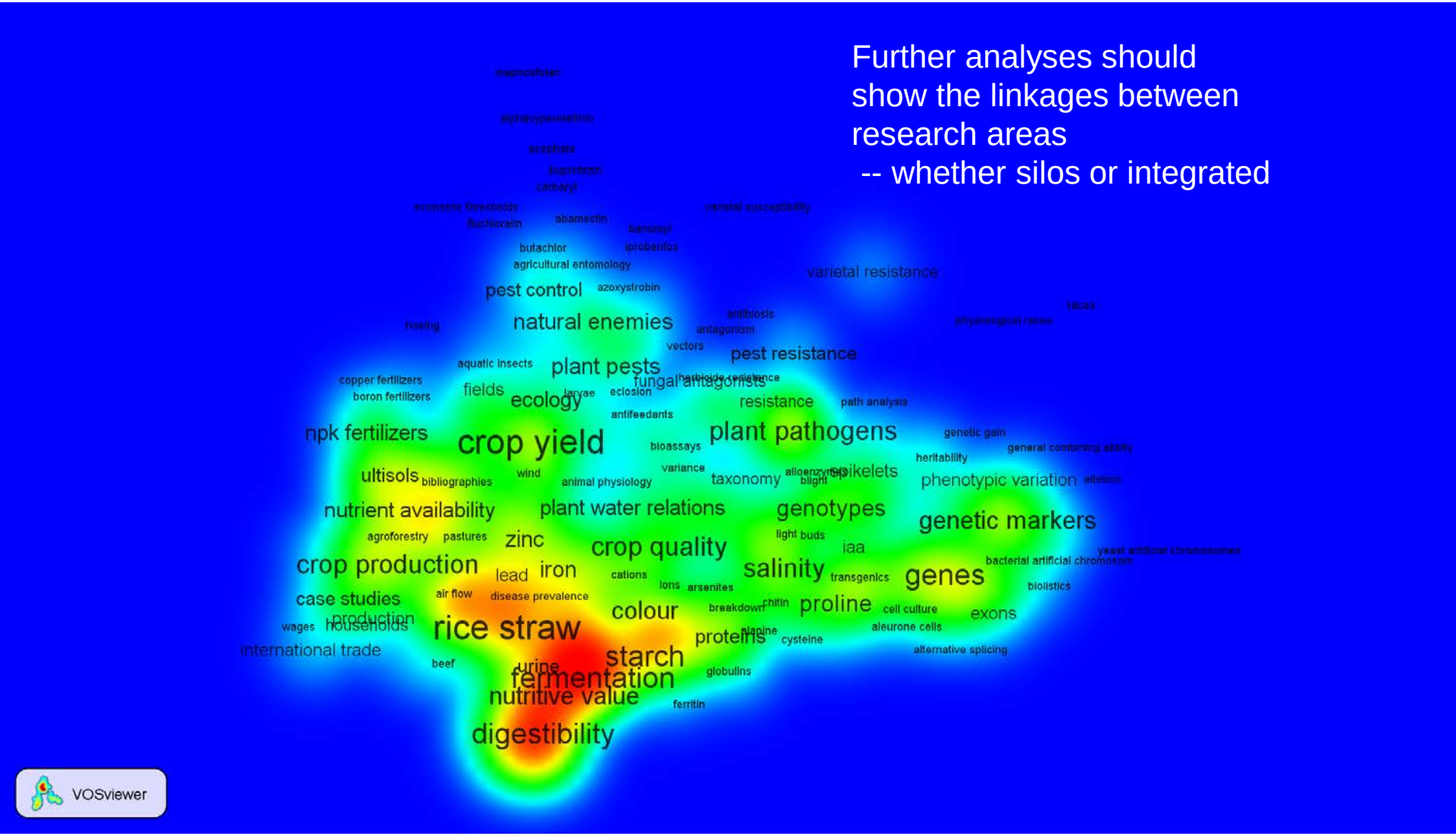
How research priorities differ by country



India 2000-12

Ciarli and Rafols (2019)

How research priorities differ by country



Thailand 2000-12

Ciarli and Rafols (2019)

From indicators to maps, from maps to statistics of distributions?

Convergence for Societal challenges

- not about more or less -- Conventional Indices
- types of combinations, directions -- Maps / Distributions

(How) Can this be shown in a statistical report?

- Maps??
- Distribution of research over disciplines / topics
- Tables of interactions / linkages

Measure/map convergence where it is relevant:

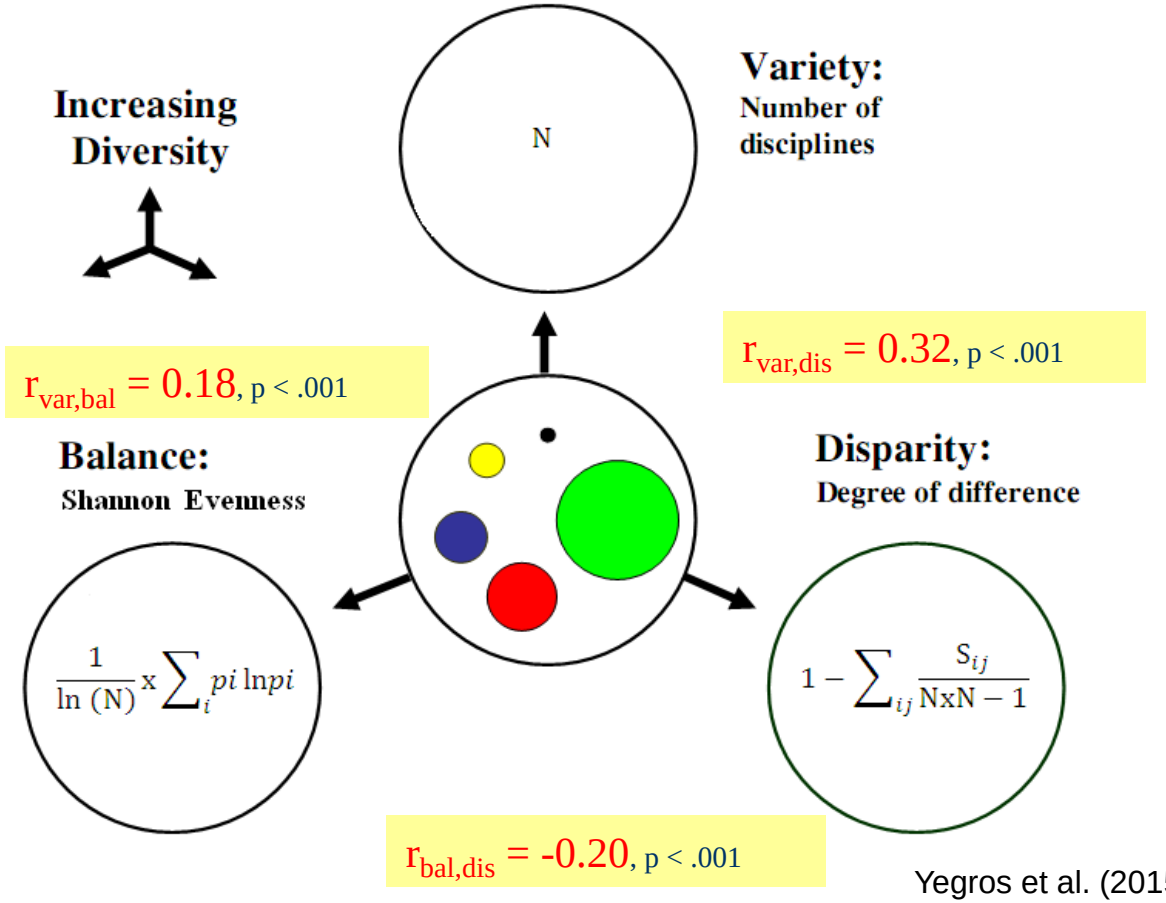
- Is it part of the mission of the organization?
- Distribution of research over disciplines / topics

Combination of approaches

- bottom up (fields / challenges) and top down (org. / admin categs.)
- epistemic (as here) and social networks (as in McFarland)

Problem 1: Properties measured are multidimensional

Even the simplest property of IDR (diversity) is a distribution – it needs two or three dimensions for description.



Yegros et al. (2015)

Problem 2: Appropriate aggregation levels of analysis needed

Level of measurement

- **Micro:** Article, individual – conventional categories too coarse, no stats
  - Course-grained categorisation not fit for knowledge dynamics.
  - Fine grained needed
    - Boyack & Klavans, and Waltman & van Eck
  - Dynamics –→ the dynamic nature of knowledge integration
    - Peter van den Besselaar
  - Structural approaches more appropriate (Chen, 2012)?

- **Meso: Field level and department level –meaningful comparison of related fields or related departments (Cassi et al., 2015)**

- **Macro:** At higher levels of aggregation, full university, regions, country
  - Differences across fields -- citation norms change with field
  - Differences across countries --- cognitive spaces may differ (China, Brazil)
  - Failure of MRC, Hefce reports on IDR → individual paper but national analysis

Most common studies on IDR

Choices in operationalisation:

- **Elements: Article or reference or affiliation**
- **Cats: WoS Cats or journals**
- **Links: Citations**
- **Distances: based on citations**

Experiments using text analysis such as topic modelling to describe degree of IDR have yielded confounding results (DigitalScience).

Diversity measures:

- Herfindahl or Entropy (Shannon)
- Rao-Stirling --disparity
- Leinster-Cobbold diversity.

Digital Science Report for MRC, 2016
– to be released soon, please don't quote.

"The analysis reported here reveals both **inconsistent** and actually **conflicting** outcomes from different datasets and analytical methodologies.

Some indicators seem to reflect **confounding factors** in the background data rather than real country and subject differences.

It is necessary to conclude that these proxy indicators do not provide sufficiently direct information about the interdisciplinary nature of the research itself to be useful for management purposes.

They appear to provide specific measures of the interdisciplinarity of the input and output metadata, **not the activity of interest**. "

What is the activity of interest??
What is the level o?f analysis?

Multiple understanding of interdisciplinarity:

Compositional understanding

Integration (cognitive diversity & coherence)

- Research that **draws on diverse** bodies of knowledge
- Research that **links different** knowledges **(coherence)**

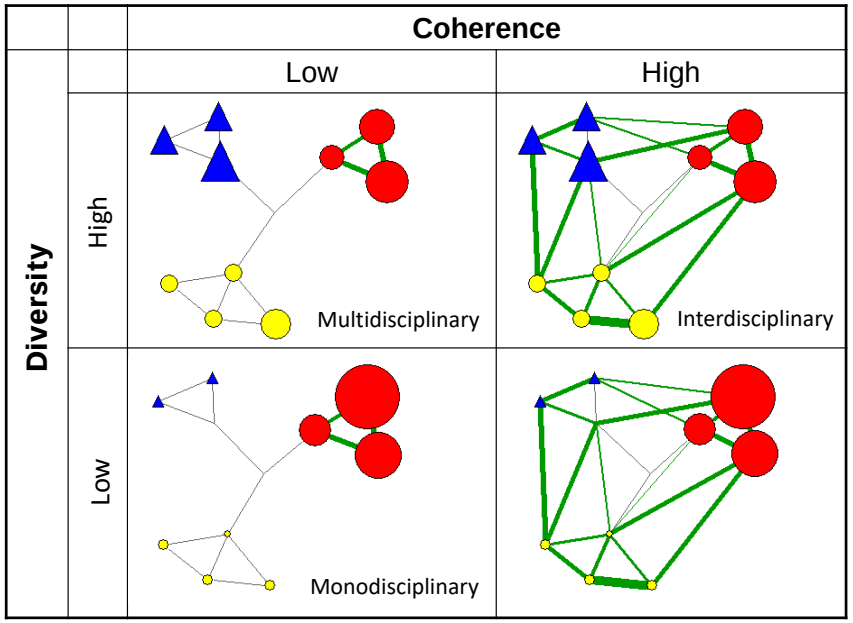
More associated with innovation, problem solving

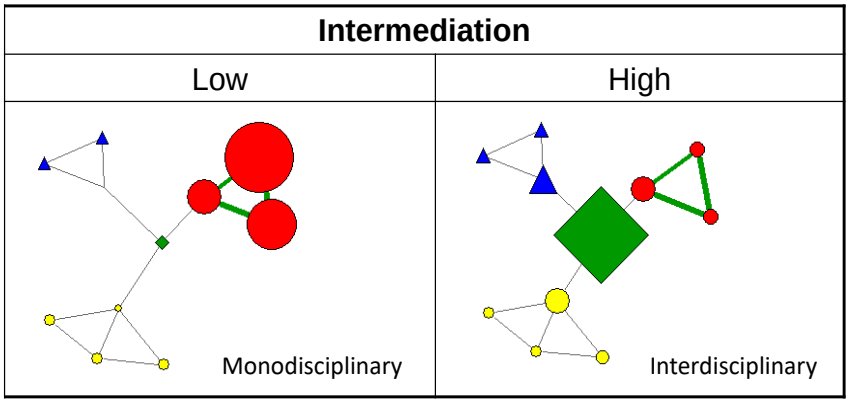
Structural or positional understanding

Bridging or Intermediation

- Research that **lies between or outside** the dominant bodies of knowledge

More associated with breakthrough and critical movements

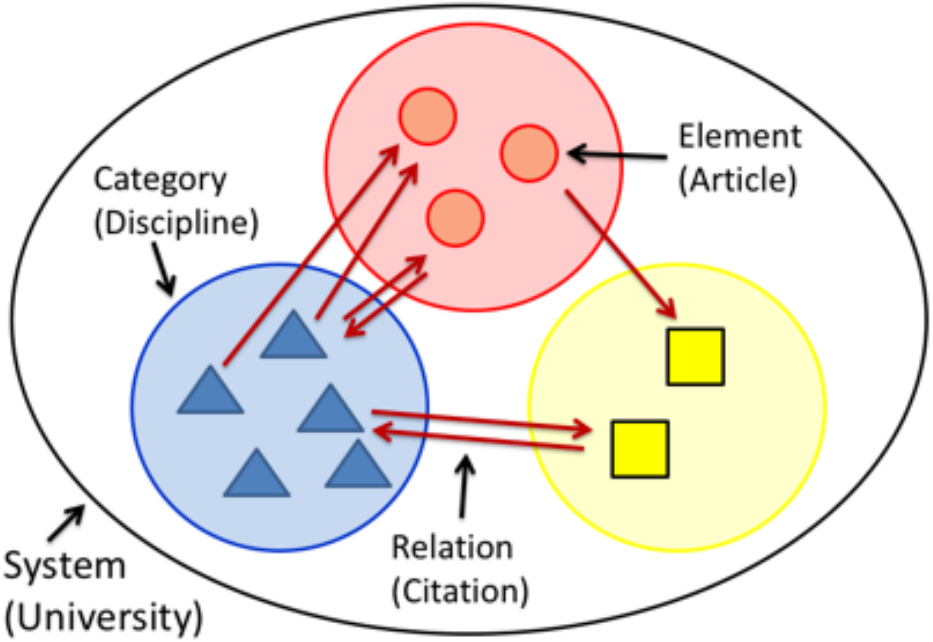




Multiple definitions of interdisciplinarity:

Choices in operationalisation:

- **elements?** articles, references, authors, keywords
- **categories?** WoS cats (subdisciplines), journals,
- **links?** citations, co-occurrences,
- **distances?** based on citations, co-occurrences… how to define them?



Rafols (2014)