Towards Indicators for 'Opening Up' Science and Technology Policy

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Use of conventional S&T indicators has been "problematic"

Closes down policy options (as many technologies, in particular those closely associated with power, e.g. nuclear)

- Narrow inputs (only pubs!)
- Scalar outputs (rankings!)
- Aggregated solutions – missing within group variation
- Opaque selections and classifications (privately owned databases)
- Some quantitative assumptions are debatable
  - Impact Factor of journals (only 2 years, ambiguity in document types)
  - Average number of citations with power law distributions: small organisations penalised (Leydesdorff and Bornmann, 2011)

The political use of S&T indicators

- Why have S&T indicators been so "narrow"?
- S&T Indicators have a **performative** role: they don't just measure, they signal to stakeholders what is important
- For example, **scientometrics** tools
  - Not 'just happen to be used' in science policy (neutral)
  - Constitutive part of the state power machinery (loaded): e.g. evaluation of research
- Scientific disciplines and techniques such as statistics are a crucial 'part of the technology of power in a modern state' (Hacking, 1991, p. 181)
- Institutions use these techniques to:
  - Articulate framings, goals and narratives and get people to accept them

Ideas grounded on Foucault: "knowledge and power are inseparable"

Claims of the presentation

Need for more inputs (variables) to build indicators: '**broadening out**'

- Already happening

Need for multiple outputs (based on alternative assumptions) to allow for policy evaluation of the diverse options in building the indicator: '**opening up**'

Improving the use of tools for measuring S&T

Indicators using narrow inputs

Can 'open up' to multiple outputs making explicit underlying concepts and creating heuristic tools to facilitate exploration.

Complexity science tools and new science mapping tools

Have potential for a more inclusive and progressive use (broadeding and opening)

- More inputs: pubs, but also news, webs (Altmetrics), etc.
- Multidimensional outputs: interactive maps
- Multiple solutions – assumptions
  - Defining disciplinary areas not comparable
  - Different levels of aggregation
  - More inclusive and contrasting classifications
- Analysis of distributions / variance

Outline

1. Intro and motivations
2. Background: policy use of S&T indicators
3. Framework: breadth and openness
4. Examples
   - Opening up using broad inputs
   - Opening using narrow inputs: Academic performance
   - Opening using new tools: Interdisciplinarity
5. Discussion and work in progress

Policy use of S&T indicators: Appraisal

Appraisal

Policy Dynamics Framework

"The ensemble of processes through which knowledges are gathered and produced in order to inform decision-making and wider institutional commitments" (Leach et al., 2010)
Example: Allocation of resources based on research "(excell)ence"

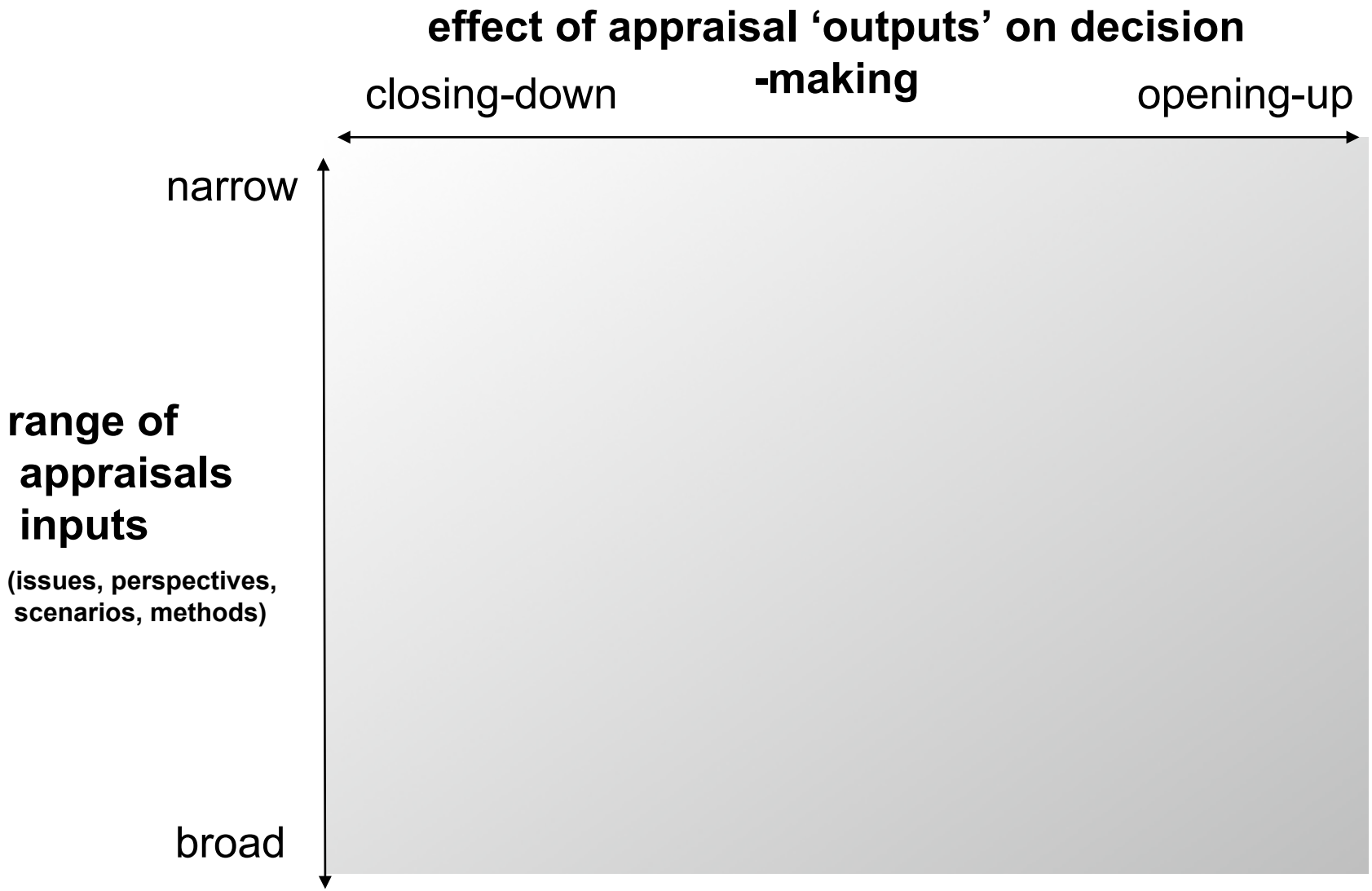
Breadth

Extent to which appraisal covers diverse dimensions of knowledge
Narrow: citations/paper
Broad: citations, peer interview, stakeholders, altmetrics, ...

Openness

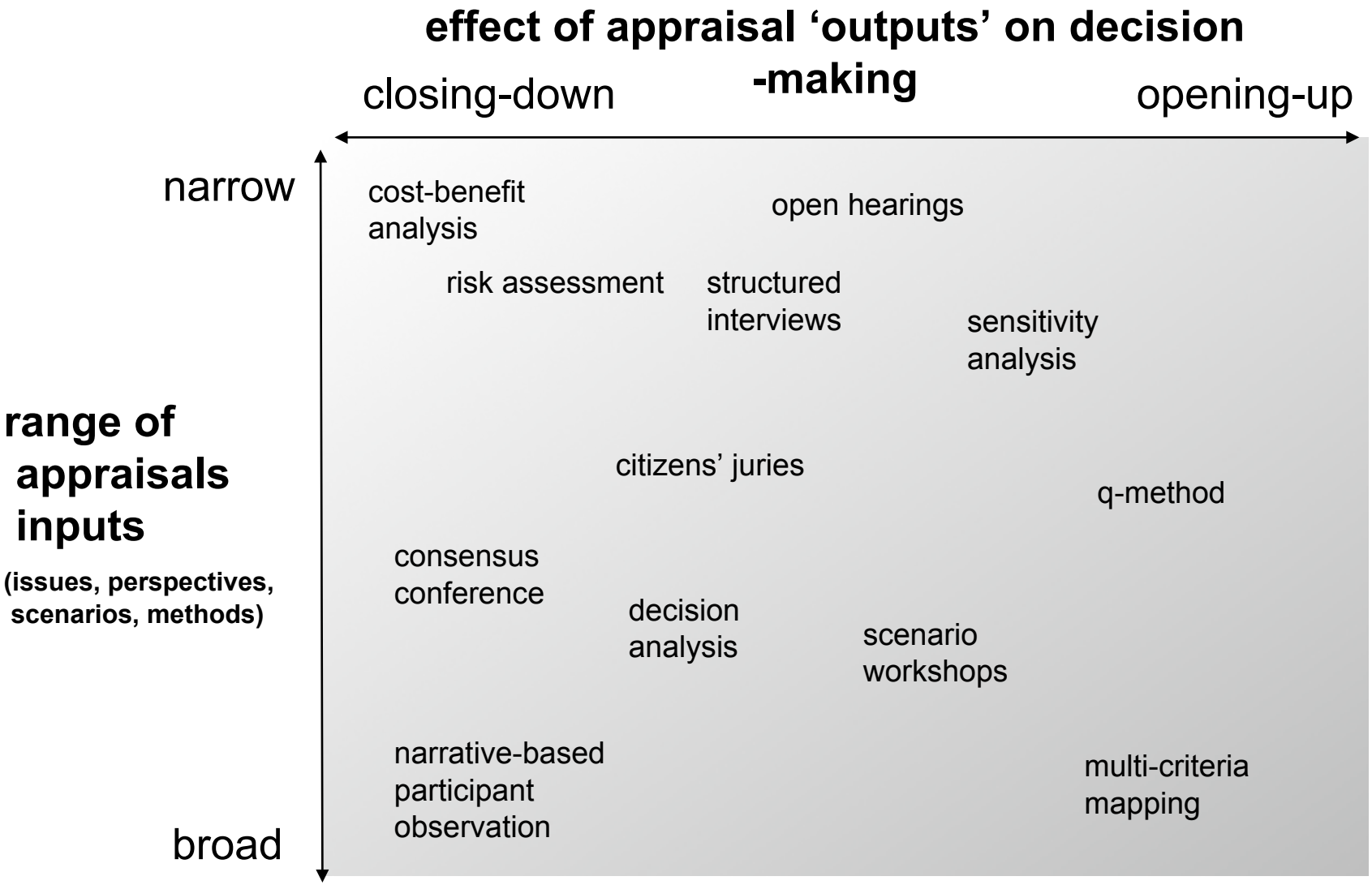
Degree to which outputs provide an array of options for policies
Closed: fixed composite measure of variables → unitary and prescriptive advice
Open: consideration of various dimensions → plural and conditional advice

Appraisal methods: broad vs. narrow & close vs. open



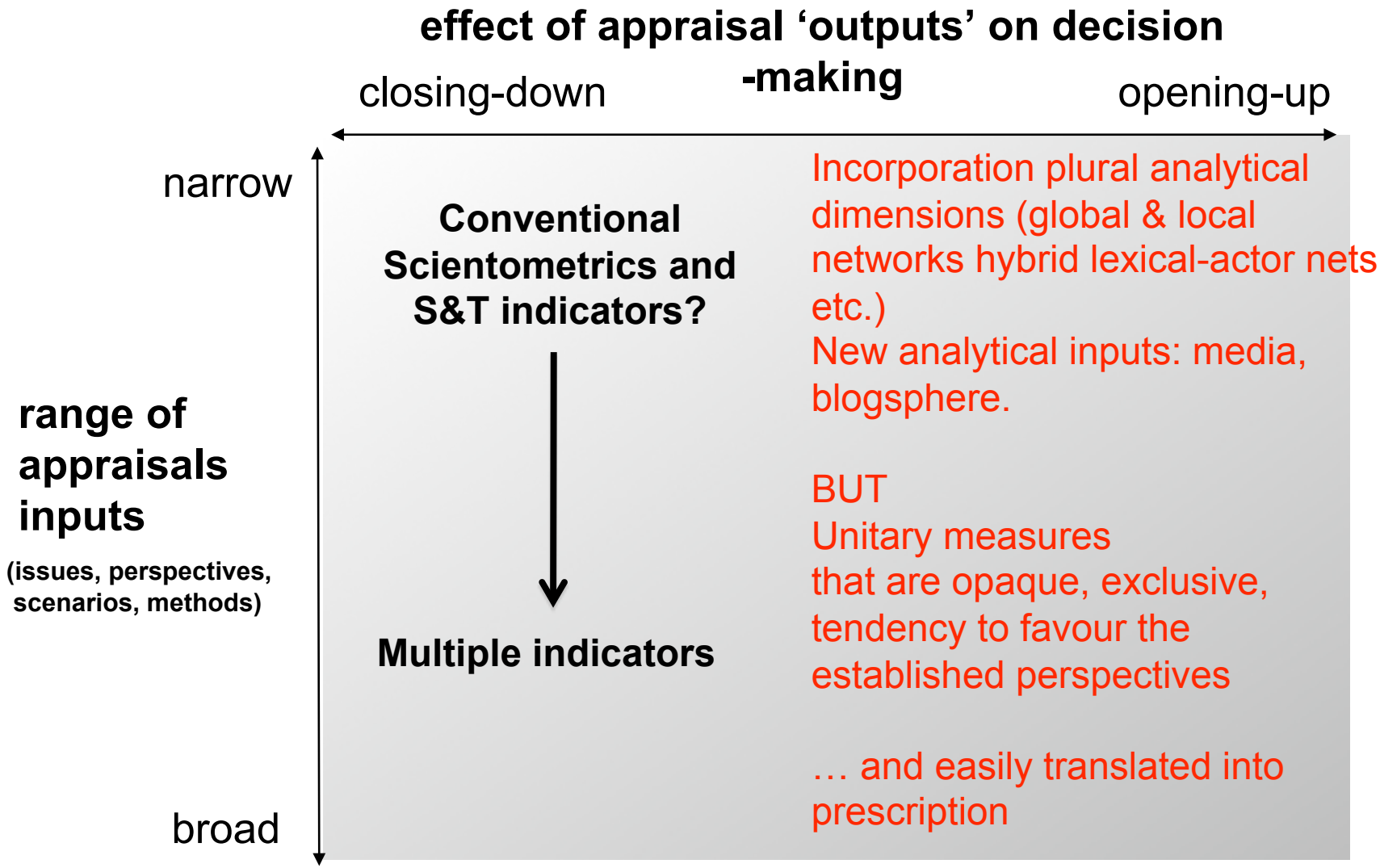
Source: Leach et al. (2010)

Appraisal methods: broad vs. narrow & close vs. open



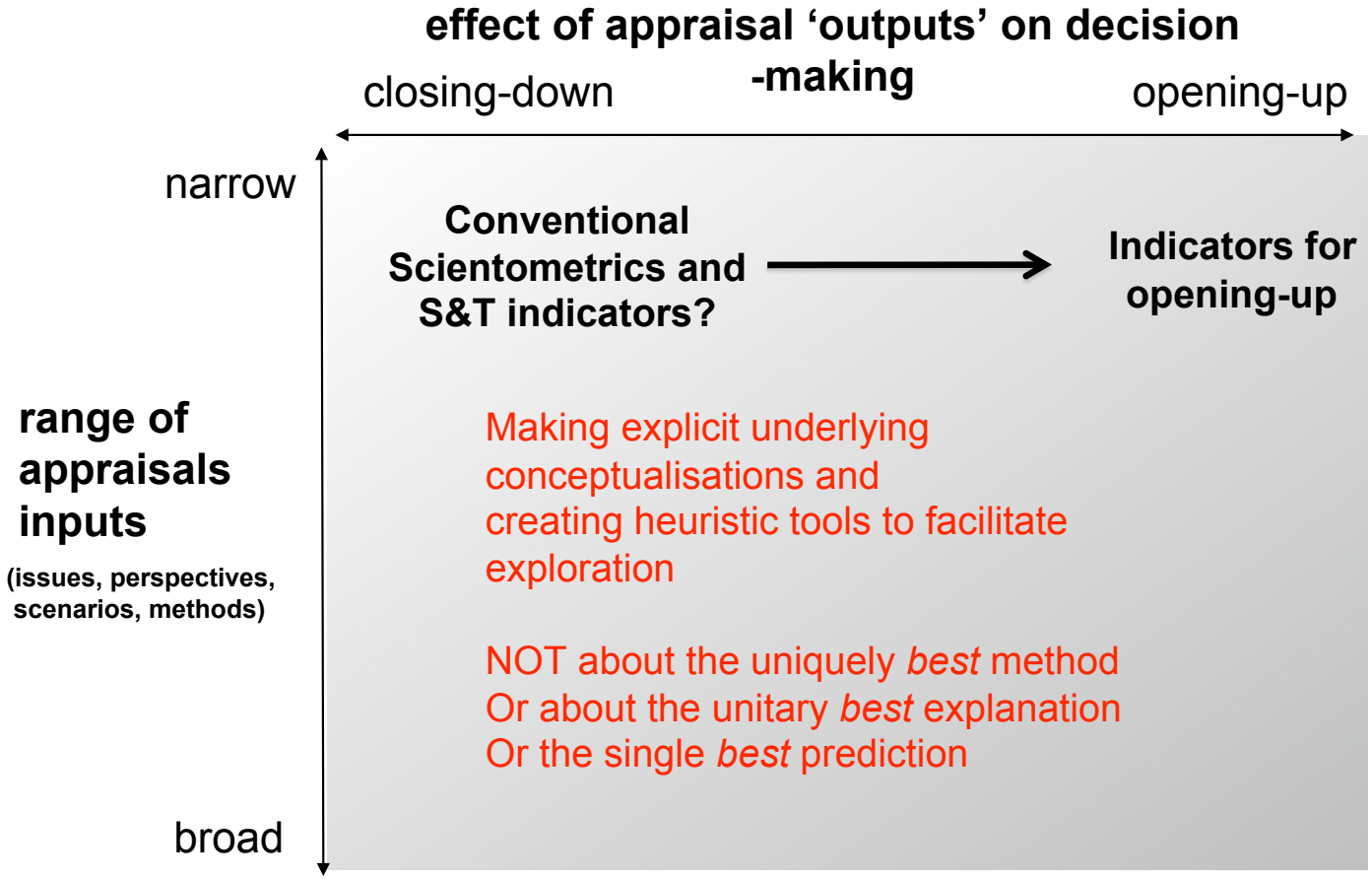
Source: Leach et al. (2010)

Appraisal methods: broadening out



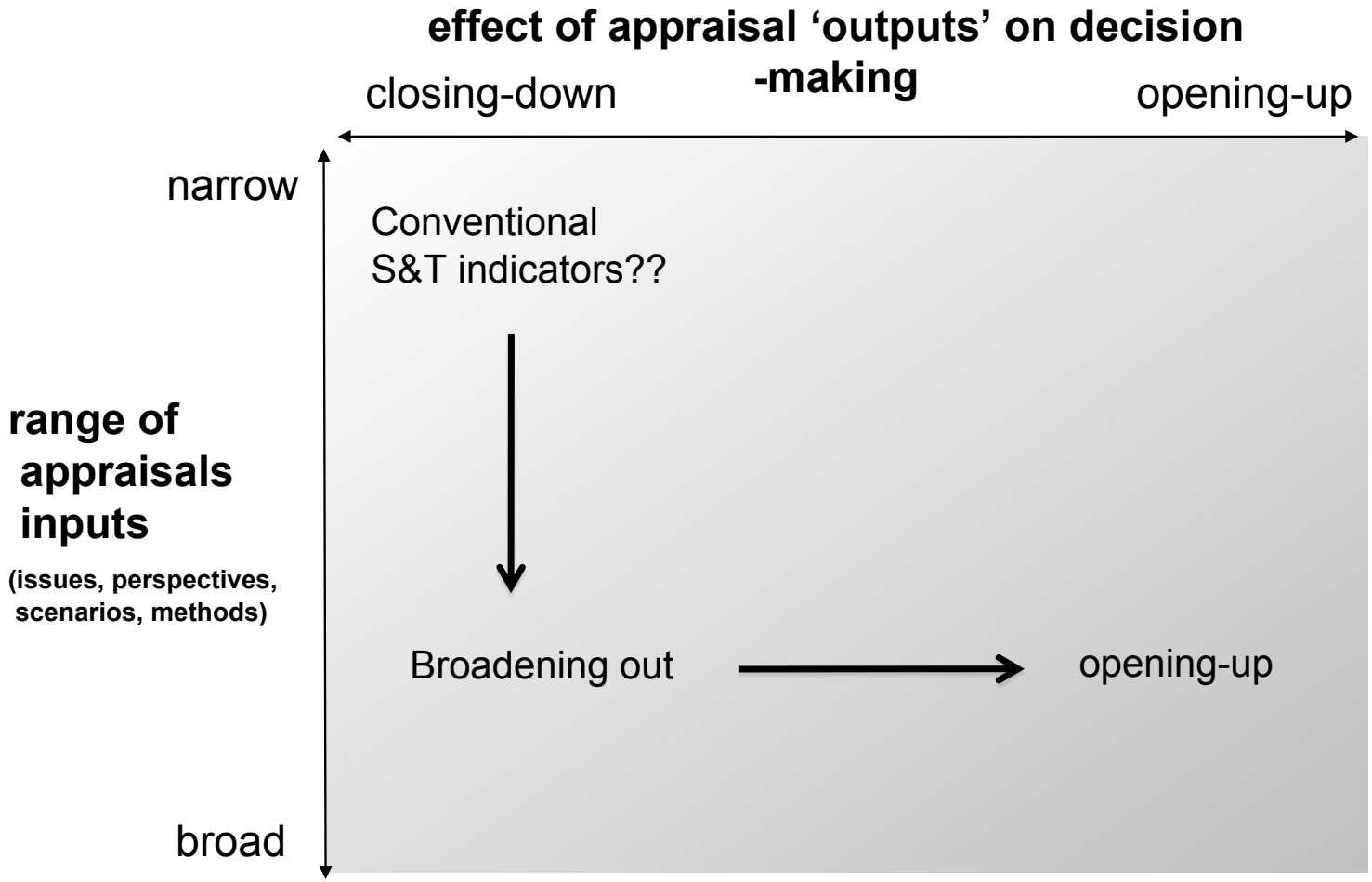
Source: Leach et al. (2010)

Appraisal methods: opening up



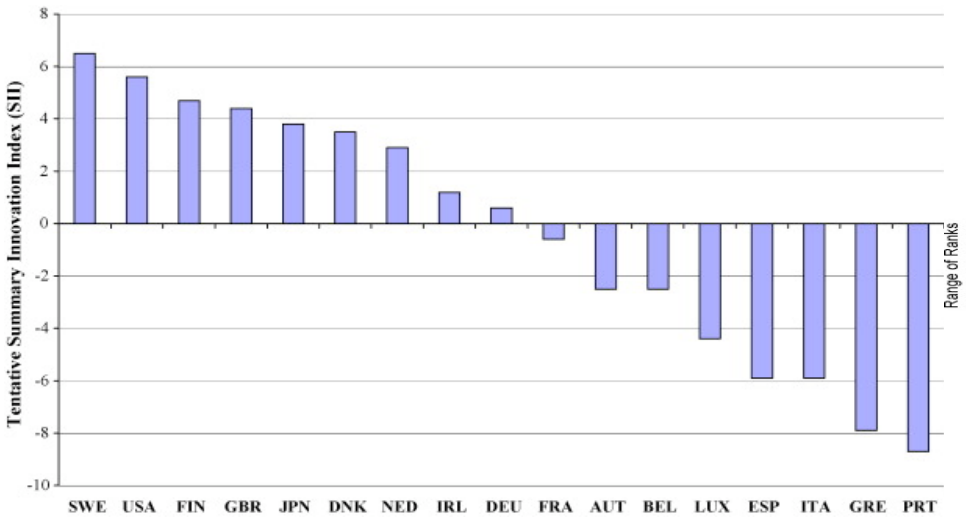
There are different ways of opening up, remaining narrow (i.e. with narrow inputs as scientometrics)

Broadening-out → Opening-up

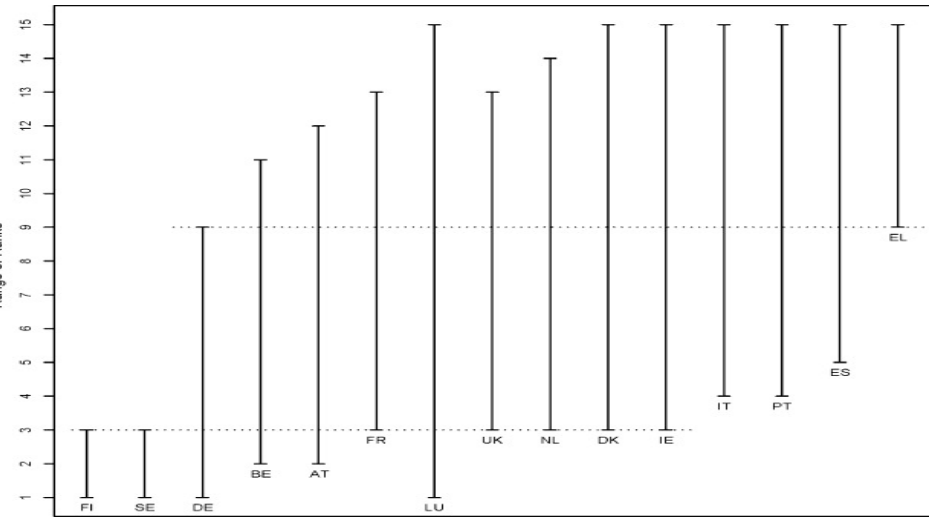


First broaden, then not collapsing the variables in one indicator

EU Innovation Scoreboard: composite indicator



(a) Country rankings



(b) Sensitivity analysis

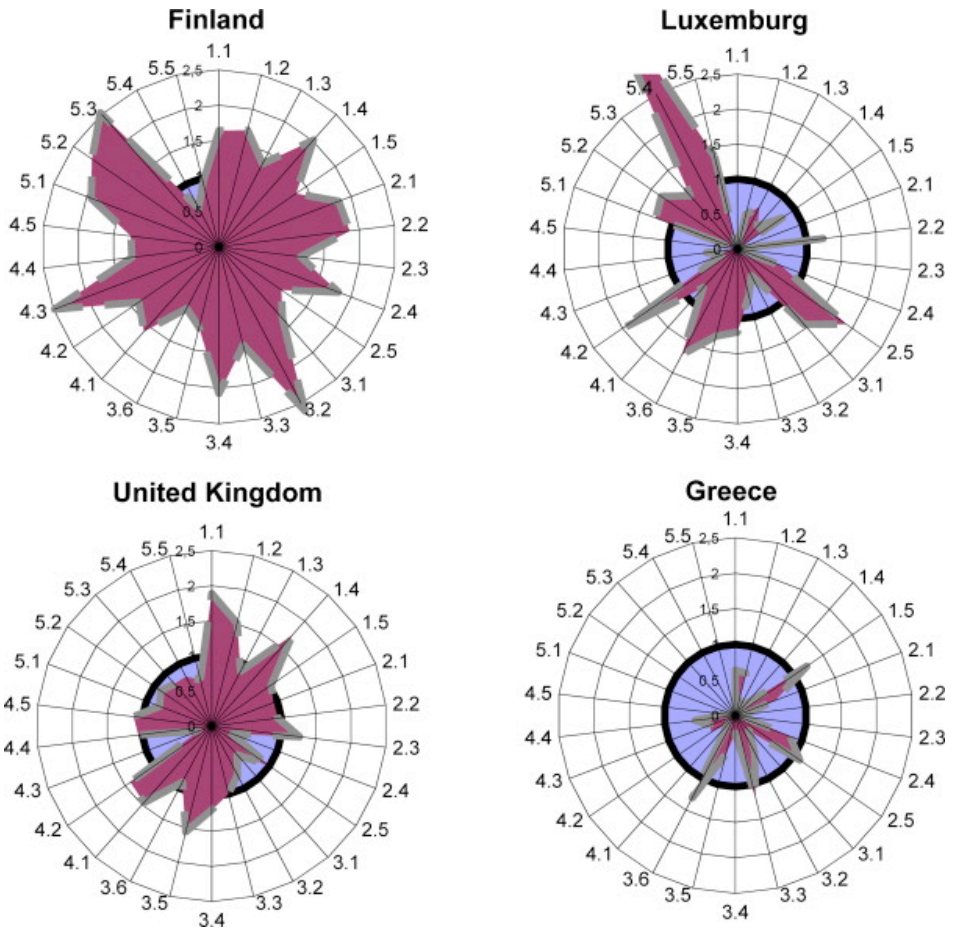
Source: (Grupp and Schubert, 2010)

Broad but narrow S&T indicator

– Ranking (1a) is highly dependent on variables weightings (Grupp and Schubert, 2010)

– Sensitivity (1b): when adopting different weights almost every country could be ranked at any position

EU Innovation Scoreboard: opening the indicator



Source: (Grupp and Schubert, 2010)

Opening

Consider the variables of the indicator contemporaneously but separated

University ranking: opening the indicator

Source: http://www.u-map.eu/finder.shtml

"U-Map offers you tools to enhance transparency"

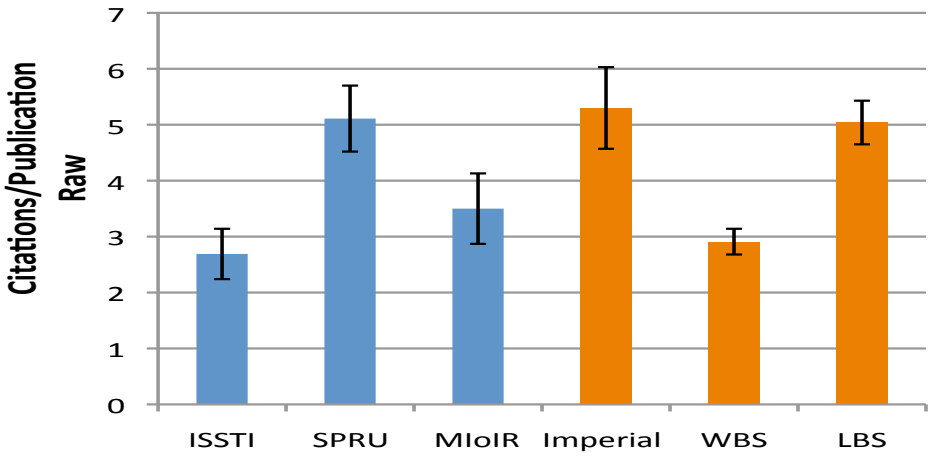
"A list of higher education institutions (HEIs) that are comparable on the characteristics *you* selected"

Difference in rankings (Innov VS BS) changing normalisation

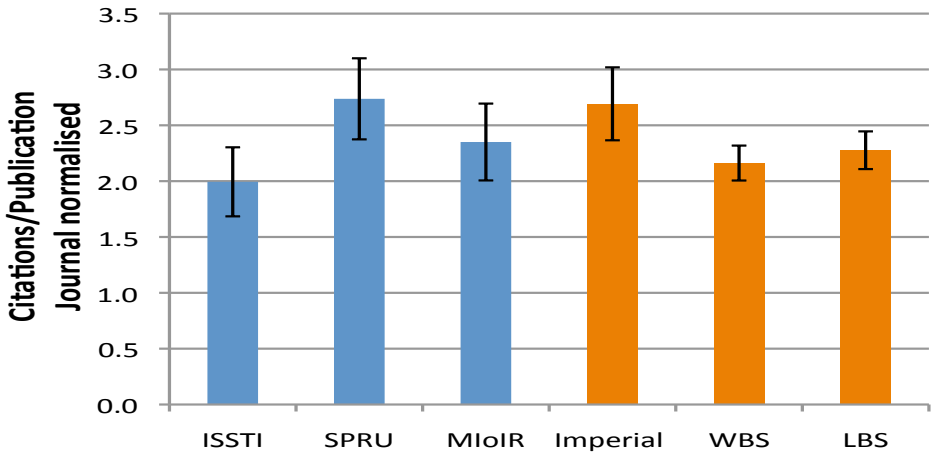
Review of a bibliometric comparison of performance in six academic organisations using different normalisations to measure the average number of citations per publication (Rafols et al., 2012)

- **a** Number of citations per publication
- **b** Number of citations weighted by average citations in the journal of publication
- **c** Number of citations weighted by average citations in field of publications – e.g. condensed matter, computational biology, atomic physics, business, management, economic finance, etc
- **d** Number of citations weighted by the number of reference in the citing article

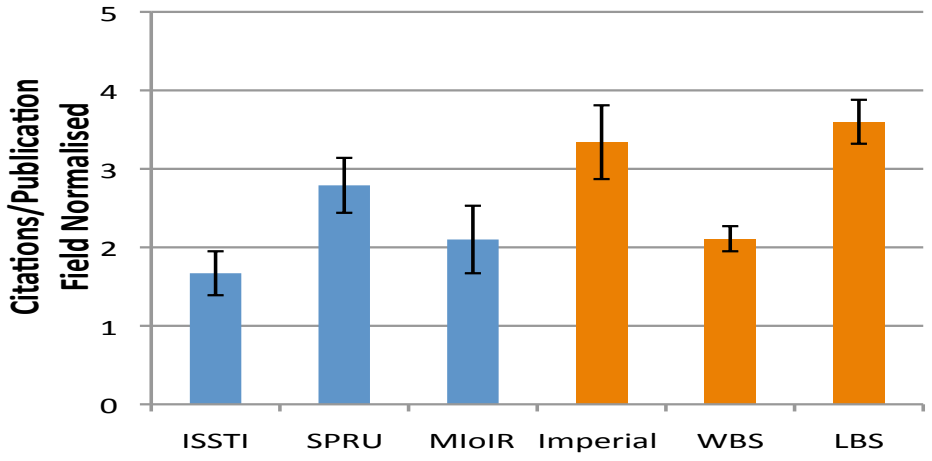
Difference in rankings (Innov VS BS) changing normalisation



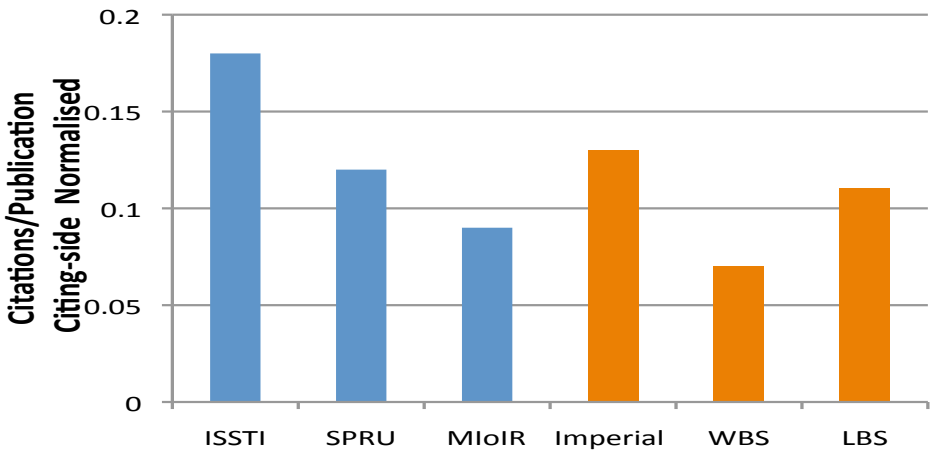
(a) Raw citations



(b) Weighted by Journal



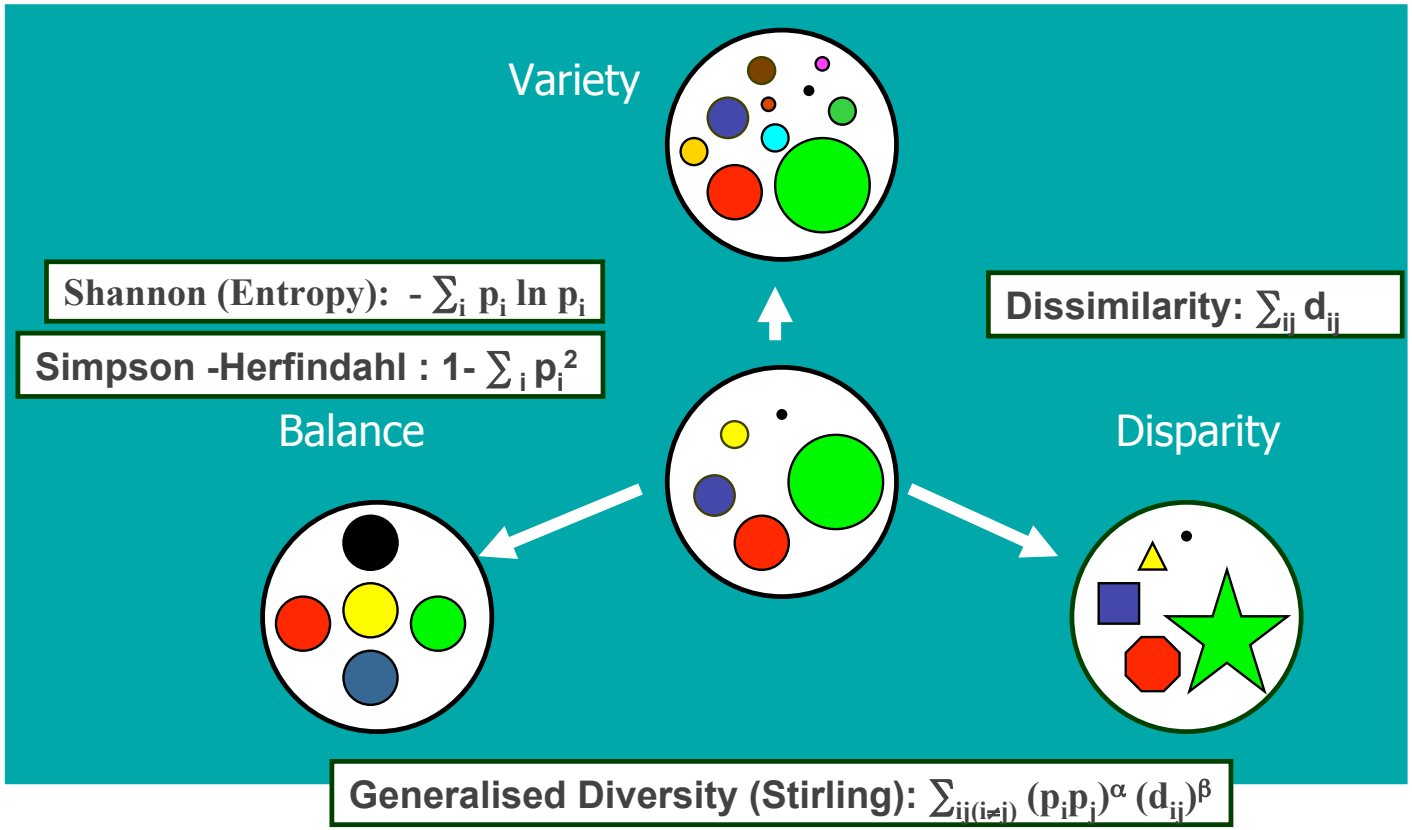
(c) Weighted by Field



(d) Weighted by References

Source: Rafols et al. (2012)

Heuristics of diversity



d: distance between categories; p: share
Source: Stirling (2007)

- Variety: Number of distinctive categories
- Balance: Evenness of the distribution
- Disparity: Degree to which the categories are different.

Interdisciplinarity as diversity

Bibliometric comparison of interdisciplinarity in different academic organisations using overlay maps (Rafols et al., 2012)

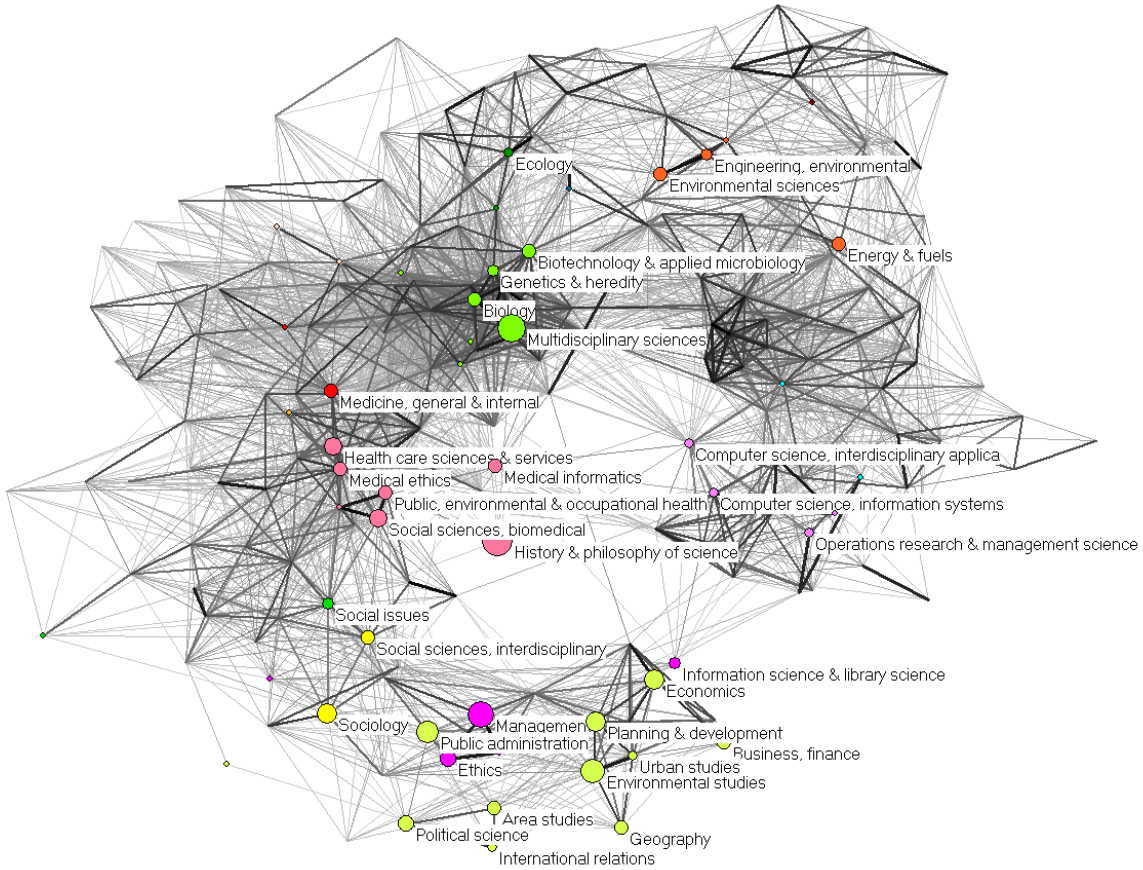
Indicators: journal attributes, publications and references

Distinguish different measures of diversity

- Variety: number of disciplines: n
- Balance: Size of each discipline: $-\frac{1}{\ln(n)} \sum_i p_i \ln p_1$
- Disparity: distance between the categories, computed using the Global Map of Science ↪: $\frac{1}{n(n-1)} \sum_{i,j} d_{i,j}$
- Shannon entropy: $-\sum_i p_i \ln p_1$
- Rao-Stirling diversity: $\sum_{i,j} p_i p_j d_{i,j}$
  where $d_{i,j} = 1 - s_{i,j}$, $s_{i,j}$ is the cosine similarity between categories i and j, and p_i the proportion of elements in category i

Different measures of diversity are uncorrelated (Yegros et al., 2010)

ISSTI Edinburgh – Disciplines of publication



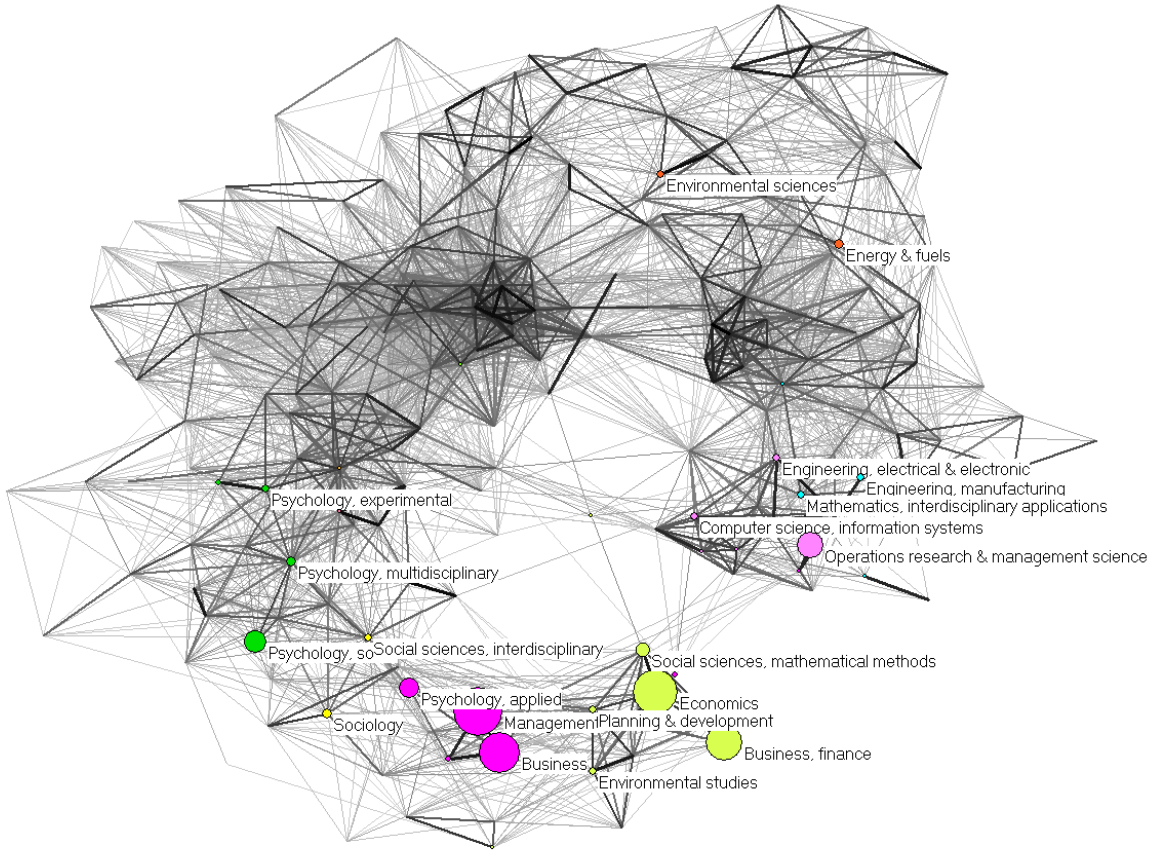
Source: Rafols et al. (2012)

Extremely diverse

Global map of Science

Social sciences, from sociology to political sciences and economics, health services, biological sciences, environmental sciences, and computer sciences

London BS – Disciplines of publication



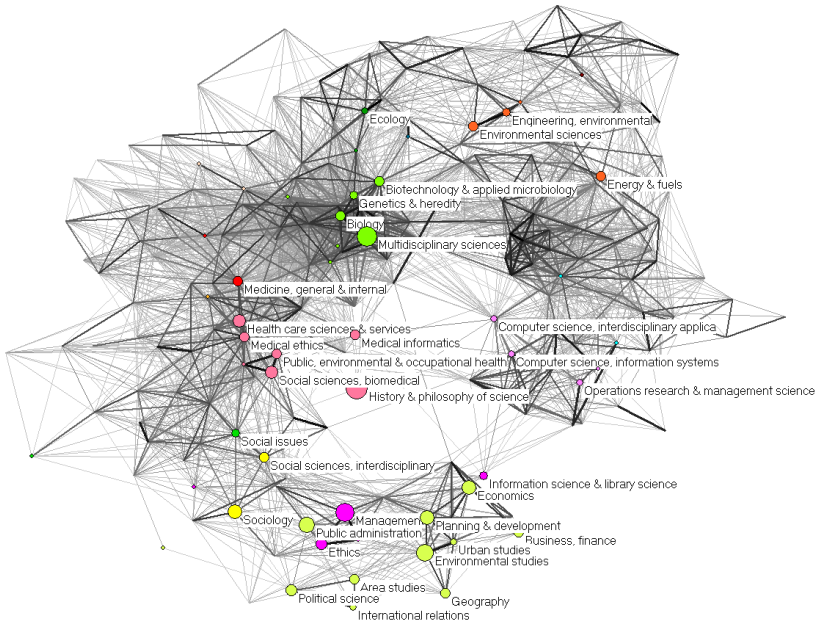
Source: Rafols et al. (2012)

Four disciplines

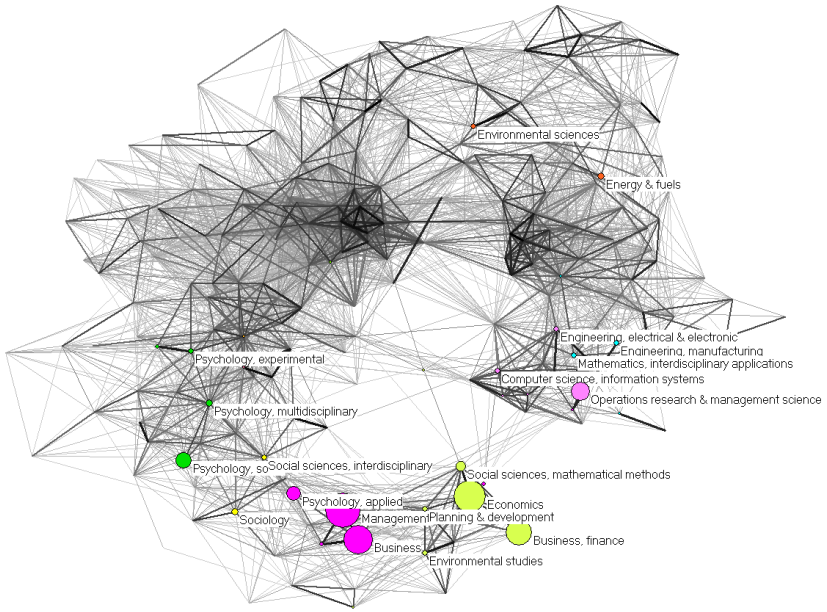
Global map of Science

Management, Business, Economics and Finance (some Psychology and Operations research).

ISSTI and LBS compared



(a) ISSTI

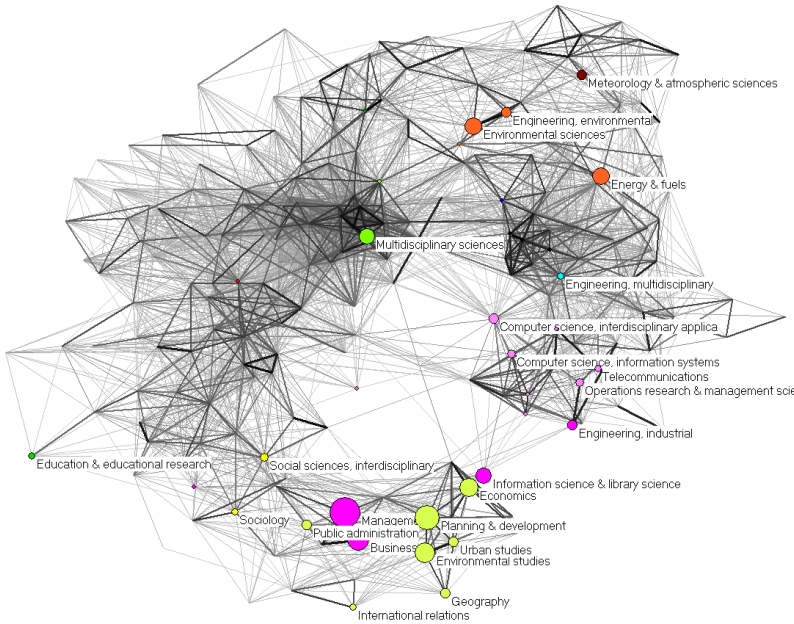


(b) LBS

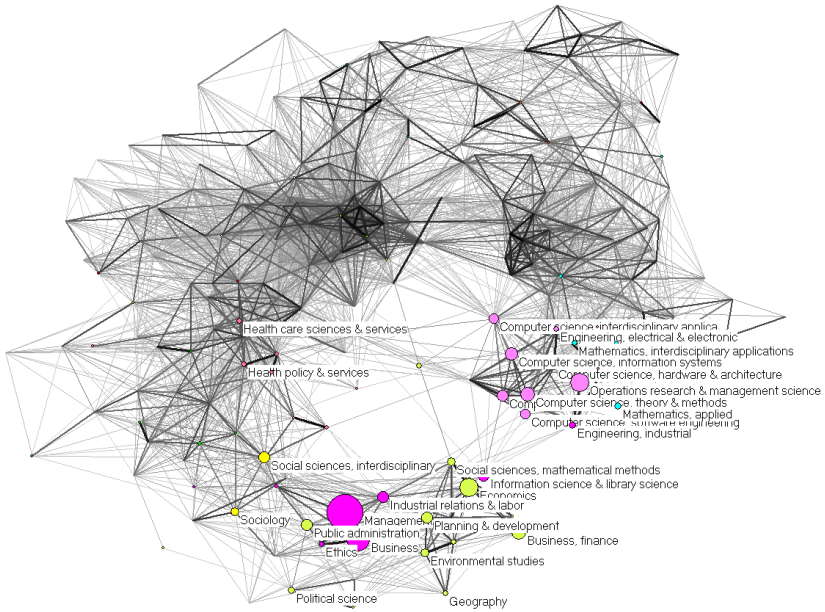
Source: Rafols et al. (2012)

Using a graphic visualisation we can study the different measures of diversity in one figure, without having to compromise as with composite indicator

MIoIR and WBS compared



(a) MIoIR Manchester



(b) Warwick BS

Source: Rafols et al. (2012)

Which one is more interdisciplinary?

Comparing diversities

	ISSTI	MIoIR	WBS	LBS
Variety	28	19	20	9
Balance	0.653	0.543	0.46	0.37
Disparity	0.832	0.817	0.77	0.768
Entropy	3.558	2.966	3.078	2.343
Rao Stirling	0.81	0.726	0.68	0.603

Source: Rafols et al. (2012)

Which measure of diversity should we use to assess interdisciplinarity? (and relate it to performance)

Strategies for opening up

Work in progress...

Presenting contrasting perspectives

Simultaneous visualisation of multiple properties / dimensions

- Allowing the viewers/policy makers to take their own perspective
- Unveiling the assumptions and the properties of the indicators and variables (distribution?)

Interactivity

- Allowing the viewer to give its own weigh to criteria / factors
- Allowing the viewer to manipulate visualisation.

Closing thoughts

Keep it complex (Stirling, 2010)

Is 'opening up' worth the effort?

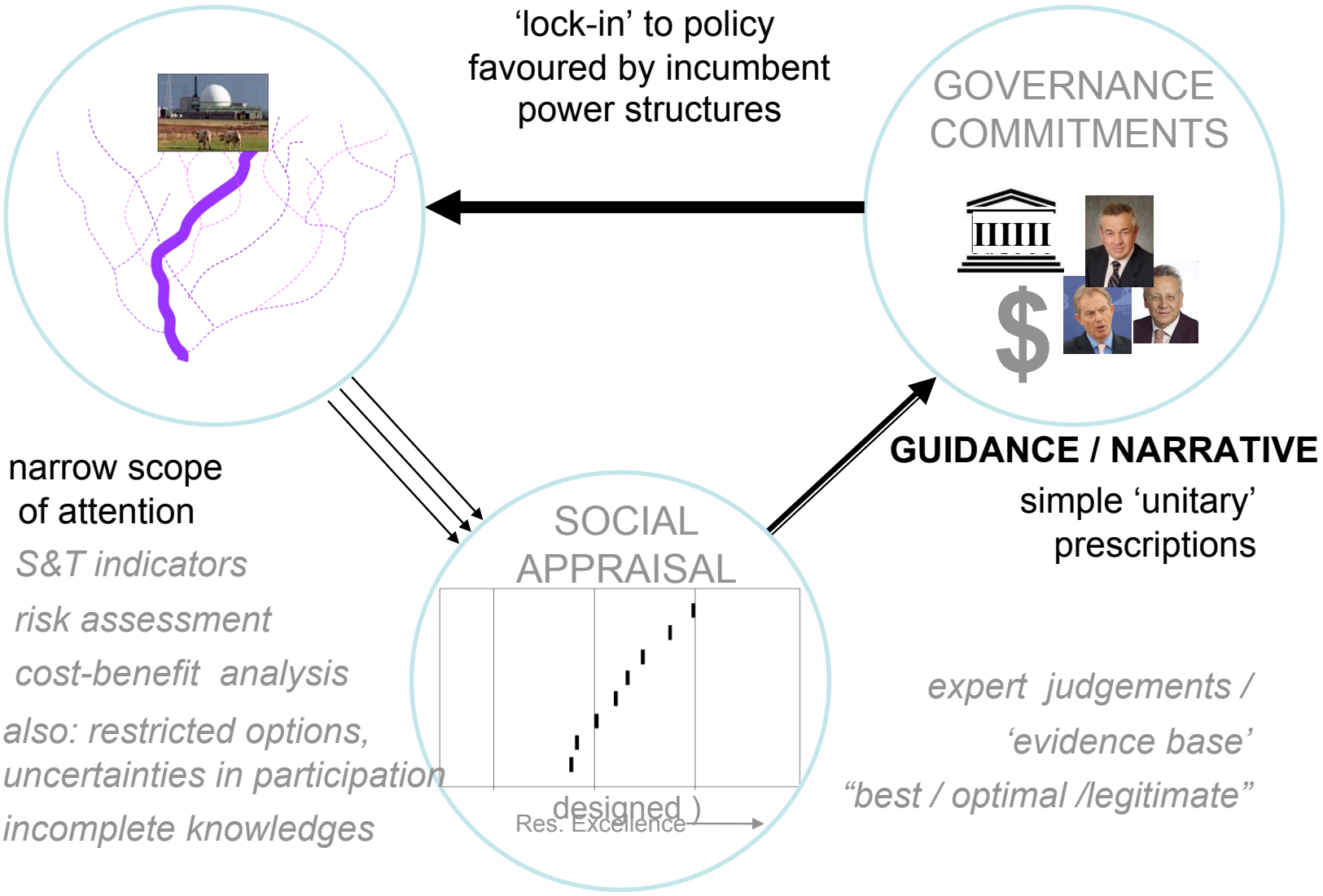
Conventional indicators tend to favour incumbents

- Incumbents have power and incentive to influence choice of indicators

Important to support diversity in S&T system

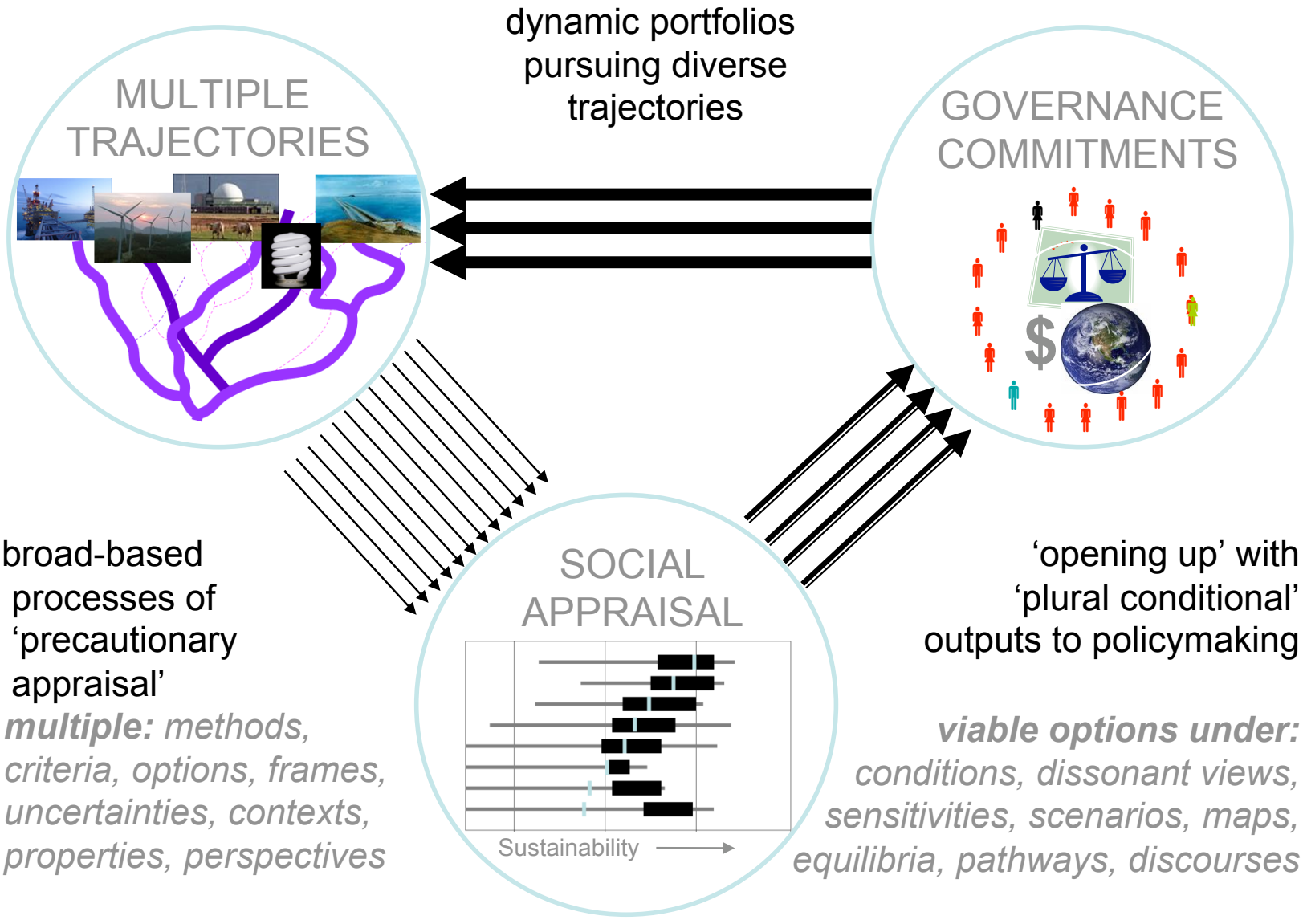
- Manage diverse portfolios to hedge against uncertainty in research
- Systemic ('ecological') understanding of the S&T
- Evolutionary understanding of excellence and relevance
- Open possibility for S&T to work for the disenfranchised
  - There aren't neglected diseases. There are neglected populations.

Conventional Policy Dynamics



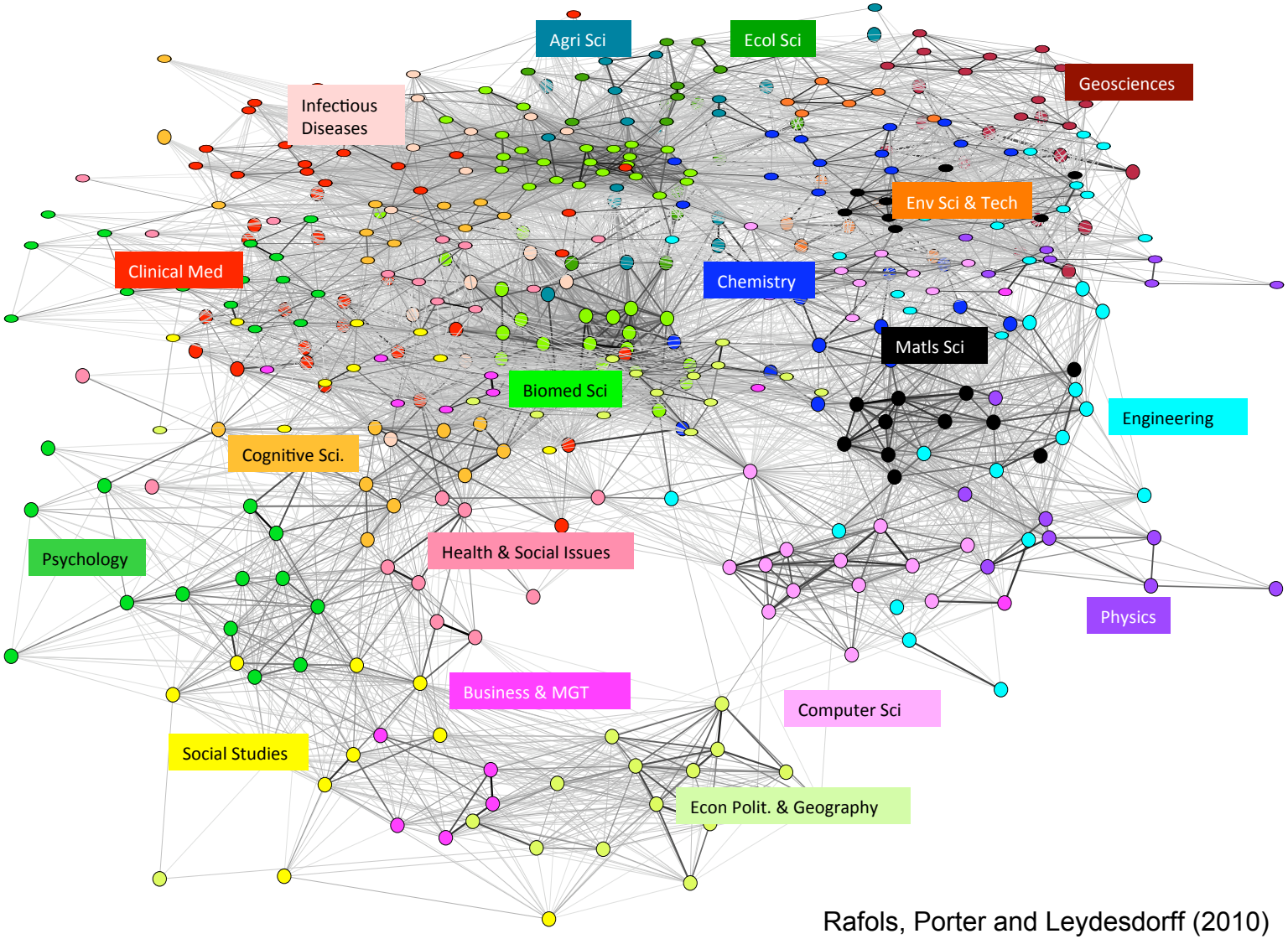
Source: Stirling 2010

Breadth, Plurality and Diversity



Source: Stirling 2010

Global map of science – 222 SCI-SSCI Subject Categories



Rafols, Porter and Leydesdorff (2010)

Source: Rafols et al. (2010)

Global map of science – 222 SCI-SSCI Subject Categories

- CD-ROM version of the JCR of SCI and SSCI of 2009
- Matrix of cross-citations between journals (9,000 x 9,000)
- Collapse to ISI Subject Category matrix (222 x 222)
- Create similarity matrix using Saltons cosine (Rafols et al., 2010)

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