Indicators of Knowledge Transfer, Utilization and Commercialisation

Facing the challenges

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“National and institutional perspectives of metrics-based research evaluation”
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Outline

- Complex realities
- Methodological and measurement challenges
- Additional performance indicators?
- Food for thought
“User valued research”

“… research activity which is valued by users but which is not recognised for excellence within the academic community in the usual way for its field. … This body of research resists definition in terms of “basic” or “applied”.

Source: Sweeney, HEFCE (2008)

Which ‘users’?

What kind of usage? (and when?)

How to define ‘value’? (for society? for money?)
<table>
<thead>
<tr>
<th></th>
<th>Direct impacts</th>
<th>Indirect impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short term</td>
<td>Long term</td>
</tr>
<tr>
<td>Science</td>
<td>Research findings</td>
<td>Knowledge and capabilities, competitive science base</td>
</tr>
<tr>
<td></td>
<td>Improved teaching, experience, and skills</td>
<td>Improved teaching, experience, and skills</td>
</tr>
<tr>
<td></td>
<td>Spill-overs to business sector and society</td>
<td></td>
</tr>
<tr>
<td>Economy</td>
<td>Improved methods and technologies</td>
<td>Improved technical skills, innovations</td>
</tr>
<tr>
<td></td>
<td>Improved know-how and productivity</td>
<td>Increased competitiveness and improved welfare</td>
</tr>
<tr>
<td>Society</td>
<td>improved understanding</td>
<td>Improved problem-solving capabilities</td>
</tr>
<tr>
<td></td>
<td>Increased problem awareness</td>
<td>Increased general satisfaction, cultural enlightenment and increased well-being</td>
</tr>
</tbody>
</table>
Downstream effects of public sector research

Research

Human resources and capabilities

Funding and facilities

TRANSFER

Research papers

Industrial standards

Training PhDs

Patents

Mass media

Governments

Environment policies

Social policies

Social benefit

Utilization

Mass media

Governments

New companies

Existing companies

Industrial regulation

New processes

New products

Commercial benefit

Commercialisation

Industrial standards

Existing companies

New companies

New products

Research

Commercialisation income

Source: Adapted from G. Lewison (2009)
Feedback model of public science-driven economic growth
Measurement categories of downstream effects

**Outputs**
- Research papers
- Industrial standards
- Training PhDs
- Patents

**Impacts**
- Mass media
- Governments
- Existing companies
- New companies

**Outcomes**
- Social benefit
- Commercial benefit
- New products
- New processes
- Industrial regulation
- Environment policies
- Social policies

**3-5 years**
- Human resources and capabilities
- Funding and facilities

**4-8 years**
- Research

**6-10 years**
- Outputs and impacts

Source: Adapted from G. Lewison (2009)

CWTS, Leiden University, Netherlands
Assessment tools, approaches and information sources

1. Bibliometric analysis
2. Expert review (of outputs)
3. Other available statistical indicators
4. Information submitted by institutes

- All inputs need to be collected and interpreted with advice from experts
- Performance measurements and statistical indicators might not be feasible, nor the primary approach for assessment
SMART indicators

Criteria for developing performance indicators
• Specific
• Measurable
• Acceptable
• Relevant
• Time dependent

Criteria for implementation
• Objective information
• Transparent methods
• Comparable across units
• Workable solutions
• Cost-effective for users and producers
Outcome indicators
Output indicators?

Prizes and awards
• Prestigious (innovation) prizes awarded by business sector associations (national/international)
• Prestigious prizes awarded by public sector organisations (national/international)

Acknowledged substantial contributions to policy debates, governments decision-making, laws and regulations

Entrepreneurial indicators?

Sales, revenues, profits, jobs generated by (spin-off) companies research-based innovations sold to other companies
Impact indicators
New processes
Industrial regulation
New companies
Environment policies
Social policies
Mass media
Governments
Industrial standards
Existing companies
New processes
New products
Training PhDs
Patents
Research papers
Research
Human resources and capabilities
Funding and facilities
Human resources and capabilities

IMPACTS
Social benefit
Commercial benefit

4-8 years

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REPP of research unit *Crop and Grassland Science* at *Wageningen Agricultural University - KCW* (1998)

Source: Sci-Quest, Research Embeddedment and Performance Profile (1999)

CWTS, Leiden University, Netherlands
REPP Indicators

**Education and training**
- PhD training
- Junior staff

**Science and certified knowledge**
- Publication output
- Scientific cooperation
- Research council funding

**Internal cooperation and visibility**
- In-house cooperation and funding
- In-house citations

**Public Policy**
- Government funded research
- Mobility of staff to government

**Innovation and professional activities**
- Member of advisory boards
- Professional publications
- Patents
- Contract income
- Mobility to industry
Other impact indicators

Citations in non-academic publications to research publications
Policy reports
Clinical guidelines
Patents
Technical manuals

Appearances and citations in the media and popular press
Radio
TV
Newspapers
Magazines
Blogs

Authorship of authoritative reviews
Scientific journals
Other publication outlets
Indicator: Patent references to the research literature

Definition
• quantity of references within patents to research articles that were (co)produced by an organisation

Relevance
• process indicator reflecting the ability to conduct scientific research that is relevant in the context of patented knowledge and technologies

Data retrieval
• data can only be extracted from appropriate patent databases (EPO/PATSTAT, USPTO)

Challenges
• ensure that all references to research articles are identified (Web of Science, Scopus or other databases)
## Patent citations to WoS-indexed research publications by Australian and New Zealand universities

### Top 20 most highly cited universities

<table>
<thead>
<tr>
<th>University</th>
<th>Citations</th>
<th>University</th>
<th>Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Univ Melbourne</td>
<td>458</td>
<td>Univ Canterbury</td>
<td>75</td>
</tr>
<tr>
<td>Univ Sydney</td>
<td>392</td>
<td>Macquarie Univ</td>
<td>73</td>
</tr>
<tr>
<td>Univ Queensland</td>
<td>306</td>
<td>Griffith Univ</td>
<td>72</td>
</tr>
<tr>
<td>Univ New S Wales</td>
<td>289</td>
<td>La Trobe Univ</td>
<td>72</td>
</tr>
<tr>
<td>Monash Univ</td>
<td>279</td>
<td>Royal Melbourne Inst Techn</td>
<td>60</td>
</tr>
<tr>
<td>Australian Nat Univ</td>
<td>212</td>
<td>Flinders Univ S Aust</td>
<td>59</td>
</tr>
<tr>
<td>Univ Adelaide</td>
<td>176</td>
<td>Massey Univ</td>
<td>51</td>
</tr>
<tr>
<td>Univ Auckland</td>
<td>172</td>
<td>Univ Technol Sydney</td>
<td>48</td>
</tr>
<tr>
<td>Univ W Australia</td>
<td>144</td>
<td>Queensland Univ Techn</td>
<td>40</td>
</tr>
<tr>
<td>Univ Otago</td>
<td>90</td>
<td>Univ South Australia</td>
<td>37</td>
</tr>
</tbody>
</table>

Sources: CWTS/PATSTAT database (1996-2005); CWTS/TR Web of Science database (1980-2008)
Output indicators
Additional output indicators?

PhDs moving outside the Higher Education system
  Government
  Industry

Inventors
  Patents assigned to non-HE institutes

University-Industry research co-publications
  Academic journals and conference proceedings
  Other publication outlets
Indicator:
Mobility and employment of PhDs

Definition
• institutional sector where PhDs find employment

Relevance
• outcome indicator of knowledge transfer and utilization within society

Data retrieval
• university alumni databases and/or national registries

Challenges
• creating and maintaining these databases
Indicator: author/inventor R&D outputs

Definition

- researchers listed as (co-)authors on research publications and as (co-)inventors of patents

Relevance

- process indicator reflecting flows of embodied knowledge and skills; science-technology linkages
- output indicator of science-based technical inventions and innovations

Data retrieval

- data extracted from publication databases (WoS, Scopus) and patent databases

Challenges

- matching author names and inventor names
# Hidden university inventors

USPTO and EPO patents filed by an assignee based in the Netherlands (2002-2003)

<table>
<thead>
<tr>
<th></th>
<th>Biotech</th>
<th>ICT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected patents</td>
<td>701</td>
<td>2380</td>
</tr>
<tr>
<td>Inventors residing in the Netherlands</td>
<td>1100</td>
<td>2435</td>
</tr>
<tr>
<td>Inventors employed by universities in the Netherlands</td>
<td>293 (27%)</td>
<td>45 (2%)</td>
</tr>
</tbody>
</table>
Indicator:
Public-private research co-publications

Definition
• quantity of research publications that are co-authored by researchers employed by a public sector organisation and those employed by a private sector organisation

Relevance
• process and output indicator that reflects the ability to conduct successful scientific research in cooperation with the private sector

Data retrieval
• data can only be extracted from databases with full information on author affiliate addresses (e.g. Web of Science or Scopus)

Challenges
• ensure that all these co-publications are (unambiguously) identified within the database(s)
University-industry cooperation and co-publications

Publications listing a university and a private sector organization within the author affiliate address information are classified as university-industry co-publications (UICs):

• “Domestic UICs”: private sector partner based in the same country as the university
• “Foreign UICs”: private sector partner based abroad

Information source: Thomson Reuters Web of Science database

UICs reflect effective and fruitful research that not only produced valuable results worth disseminating to a wider international public of peers, but also inspired collaborating partners to invest time and money to draft a high-quality research article for publication in a peer-reviewed journal
# Top 10 universities by UIC output

World Top 350 Universities (2002-2006)

<table>
<thead>
<tr>
<th>Rank</th>
<th>University</th>
<th>Country</th>
<th>UIC Output</th>
<th>UIC Intensity</th>
<th>Domestic Industry Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Univ. Tokyo</td>
<td>Japan</td>
<td>2353</td>
<td>8%</td>
<td>91%</td>
</tr>
<tr>
<td>2</td>
<td>Harvard Univ.</td>
<td>USA</td>
<td>2127</td>
<td>5%</td>
<td>87%</td>
</tr>
<tr>
<td>3</td>
<td>Osaka Univ.</td>
<td>Japan</td>
<td>1631</td>
<td>9%</td>
<td>93%</td>
</tr>
<tr>
<td>4</td>
<td>Kyoto Univ.</td>
<td>Japan</td>
<td>1473</td>
<td>7%</td>
<td>89%</td>
</tr>
<tr>
<td>5</td>
<td>Tohoku Univ.</td>
<td>Japan</td>
<td>1401</td>
<td>8%</td>
<td>93%</td>
</tr>
<tr>
<td>6</td>
<td>Univ. Calif. - Los Angeles</td>
<td>USA</td>
<td>1325</td>
<td>6%</td>
<td>91%</td>
</tr>
<tr>
<td>7</td>
<td>Johns Hopkins Univ.</td>
<td>USA</td>
<td>1175</td>
<td>5%</td>
<td>87%</td>
</tr>
<tr>
<td>8</td>
<td>Stanford Univ.</td>
<td>USA</td>
<td>1161</td>
<td>6%</td>
<td>86%</td>
</tr>
<tr>
<td>9</td>
<td>Univ. Washington Seattle</td>
<td>USA</td>
<td>1045</td>
<td>5%</td>
<td>87%</td>
</tr>
<tr>
<td>10</td>
<td>Tokyo Inst. Technol.</td>
<td>Japan</td>
<td>1006</td>
<td>10%</td>
<td>96%</td>
</tr>
</tbody>
</table>

Source: CWTS Scoreboard of University-Industry Research Cooperation
### Australian and New Zealand universities

Included in World Top 350 Universities

<table>
<thead>
<tr>
<th>University</th>
<th>Country</th>
<th>UIC intensity</th>
<th>Domestic industry partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Univ Auckland</td>
<td>New Zealand</td>
<td>2.5%</td>
<td>31%</td>
</tr>
<tr>
<td>Univ Melbourne</td>
<td>Australia</td>
<td>2.2%</td>
<td>10%</td>
</tr>
<tr>
<td>Univ New S Wales</td>
<td>Australia</td>
<td>2.2%</td>
<td>25%</td>
</tr>
<tr>
<td>Monash Univ</td>
<td>Australia</td>
<td>2.1%</td>
<td>12%</td>
</tr>
<tr>
<td>Univ. Queensland</td>
<td>Australia</td>
<td>1.9%</td>
<td>18%</td>
</tr>
<tr>
<td>Univ Otago</td>
<td>New Zealand</td>
<td>1.9%</td>
<td>46%</td>
</tr>
<tr>
<td>Univ Adelaide</td>
<td>Australia</td>
<td>1.8%</td>
<td>32%</td>
</tr>
<tr>
<td>Australian Nat Univ</td>
<td>Australia</td>
<td>1.1%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Source: CWTS Scoreboard of University-Industry Research Cooperation
Food for thought

Conclusions and recommendations
Methodological challenges

• What are the main gaps in our understanding?
• Which statistical information and performance indicators may add relevant new information?
• Which sources (field-dependent) criteria are suitable for assessment?
• How to reconcile data from various sources and indicators?
• Are the data “fair” (reliable, valid and verifiable)?
• How to interpret statistical results? (avoiding ‘mechanical’ approaches)

• What is the added value of bibliometric indicators? (as a replacement or supplement to peer review panel data)
• What are the major trade-offs? (added value vs. cost effectiveness)
How can we judge the value of indicators?

**Relevant and appropriate**
- Are these the tools that scientists and scholars would use?
- Are ‘metrics’ correlated with other performance estimates?
- Do metrics really distinguish ‘performance’ as we see it?

**Cost effective**
- Data accessibility, coverage, validation & verification

**Transparent, equitable and stable**
- Is it clear what the metrics do?
- Are all institutes, staff and disciplines treated equitably?
- How do people respond, and can they manipulate metrics?
Goodhart’s Law

“… any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes”

Charles Goodhart, "Monetary Relationships: A View from Threadneedle Street". Papers in Monetary Economics (Reserve Bank of Australia), 1975

Once an indicator, or other surrogate measure, is made a target for the purpose of conducting social or economic policy, then it will gradually lose the information content that would qualify it to play such a role.
Entrepreneurial performance indicators?

- Indicators should act as incentives (to institutions and individuals) in order to focus research cultures towards the user value of applications.
- Suite of output and impact indicators (PhD careers, UICs, co-inventors, patent citations, IP, research commercialisation income).
- Analysts and users should recognize complexities (feedback loops) and timescales required from lab bench to wealth generation.

- A modified indicator system should encourage the formation of sustainable entrepreneurial infrastructures within universities, and raise visibility of entrepreneurial individuals (career mobility) and be used in departmental ranking (attracting students, staff and income).
- Establish cross-disciplinary panels (or several discipline-based panels) with experts capable of assessing evidence portfolios dealing with specifically with (longer term) applications of research.
Performance indicators should be discipline-specific
Few will be applicable across all or most disciplines (or discipline clusters)
Replace/supplement inappropriate indicators by institute-specific ones?

No generally acceptable indicators (yet)?
Apply peer review! (on samples)

Challenge for the (near) future
• Tailored ‘many sizes fits all’ assessment frameworks
• More information sources, better indicators and feedback-driven mechanisms
... where peer reviews, external indicator-based assessments, and (indicator-based) self-assessments reinforce each other!
Thank you for your attention

More information?

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www.socialsciences.leidenuniv.nl/cwts/