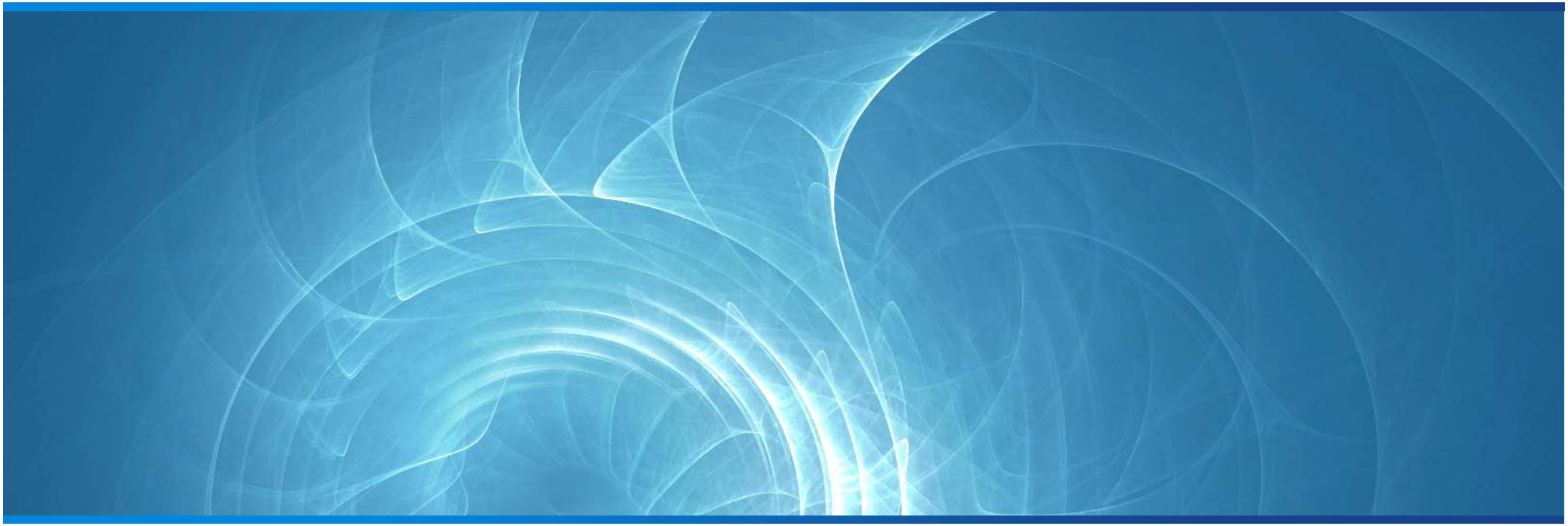
Science-Metrix

The use of multiple bibliometric indicators in science policy to support the development of collaboration strategies

Michelle Picard-Aitken, David Campbell and Grégoire Côté



Presented at **STI Conference** | Leiden 2010 | **September 10, 2010**

The use of bibliometrics in science policy

- Increased use by policy-makers of bibliometric data and analyses: implications of policy-makers as **users**
- Policy-makers have different needs, and varying levels of understanding/familiarity with bibliometrics
- Bibliometrics as a tool to support collaboration strategies in science and technology (S&T)
  - Collaboration not the ultimate goal: policy-makers seek increased impact, reach and innovation through collaboration, as well as for more cost-effective research
  - Bibliometrics can serve to identify and prioritise the countries and/or research areas for strategic collaboration, and then track the effectiveness of the strategy over time

Context: DFO and DFAIT (Canada)

Department of Foreign Affairs & International Trade (DFAIT)

- Federal government agency with a primary focus on international trade, but also administers the International S&T Partnership Program
- Seeking analytical support for its Global Innovation Strategy, both for its policy justification (i.e., for funding) and to inform negotiation of agreements with other countries on scientific collaboration
- Somewhat limited understanding of bibliometrics at ministerial level

Department of Fisheries and Oceans Canada (DFO)

- Science-based federal government agency
- Seeking to focus and direct its international collaboration practices in 12 priority research areas as per its International Science Strategy
- Bibliometrics-savvy in the Science unit, less so at management level

DFAIT Studies – Description & Purpose

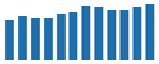
- **Description**: Bibliometric analysis of Canada's scientific collaboration with 20+ selected priority countries and identification of matching research areas for collaboration
  - First study conducted in 2008
  - Follow-up study (2010) updated the data and included additional countries
- **Purpose**:
  - Assist DFAIT in the renewal of the International S&T Partnership Program (2010 update)
  - Inform joint S&T ministerial statements with countries with whom Canada seeks to pursue collaborative relationships in S&T (natural sciences and engineering)

Collaboration indicators

- Collaboration indicators used for each selected country
  - Bilateral collaborations (co-authored papers)
    - Number, share and trend over 12 years
  - Probabilistic affinity index (PAI)
    - Measures the intensity of scientific collaboration between country A and country B by comparing the observed number of bilateral collaborations between them with the number expected, given their individual share of the world's bilateral collaborations
    - PAI > 0 = positive affinity; PAI < 0 = negative affinity

DFAIT – Collaboration profile between Canada and the Netherlands

Trends in the Netherlands' Share of Canada's Bilateral Collaboration by Field in the Natural Sciences & Engineering, 1996-2007

Field	No.	Share	Share Trend	PAI
Clinical Medicine	2,169	3.1%		-0.33
Biomedical Research	928	2.4%		-0.35
Earth & Space	565	2.0%		-0.53
Physics	737	2.0%		-0.18
Biology	423	2.0%		-0.46
Chemistry	272	1.9%		-0.20
Mathematics	141	1.6%		-0.13
Engineering & Technology	331	1.4%		-0.50
Total	**5,566**	**2.3%**		**-0.32**

Source: Calculated by Science-Metrix using the Scopus Database

Performance indicators

Number of papers: Whole counting based on author addresses (e.g., countries and institutions)

Specialization index (SI): Measures the intensity of research of an entity (e.g., a country) in a given field relative to the intensity of the world in the same field.

$$SI = \frac{(X_F/X_T)}{(R_F/R_T)} = \frac{(\text{Canadian Papers in Biology}/\text{Canadian Papers in the Database})}{(\text{World Papers in Biology}/\text{World Papers in the Database})}$$

SI > 1 → Canada is Specialized in Biology

SI < 1 → Canada is not Specialized in Biology

Average of relative citations (ARC): Measures the impact of research conducted by an entity based on the average number of citations its papers received relative to the average number of citations received by world papers. Each paper's citation count is normalized to account for different citation patterns across subfields of science.

ARC > 1 → Canada's Research is More Cited than the Average World Research

ARC < 1 → Canada's Research is Less Cited than the Average World Research

DFAIT – Research areas for collaboration (by country)

- Presentation/combination of multiple indicators to identify areas of matching specialization (SI) and strengths, as per number of papers and average of relative citations (ARC)

Collaboration profile of Canada and the Netherlands and the positioning of their relative outputs in Earth & Space, 1996-2007

	Collaboration		Positionning of Scientific Output							
			Papers		SI		ARC		SI/ARC	
Field/Subfield	No.	PAI	NL	CA	NL	CA	NL	CA	NL	CA
Earth & Space	565		17,637	35,228	1.3	1.5	1.4	1.3		
Astronomy & Astrophysics	226		5,369	4,770	2.4	1.3	1.3	1.6		
Earth & Plantry Sciences	114		3,591	9,427	1.1	1.6	1.4	1.1		
Environmental Sciences	100		4,668	10,160	1.2	1.6	1.4	1.4		
Geology	62		2,127	6,918	0.8	1.6	1.6	1.4		
Meteorology & Atmospheric Sci.	41		845	2,065	1.0	1.5	1.6	1.2		
Oceanography & Limnology	22		1,037	1,888	1.5	1.6	1.4	1.3		

DFAIT – Collaboration policy summary example: the Netherlands and Canada

Subfields in which collaboration would benefit Canada's impact:

Botany, Materials Science, **Agriculture & Agri-Food**, General Chemistry, **Electrical Engineering & Electronics**, **Chemical Engineering**, **Earth & Planetary Sciences**, **Radiology & Nuclear Medicine**, Civil Engineering, Ecology, Mechanical Engineering, and Ophthalmology

Subfields in which collaboration would benefit the Netherlands' impact:

General & Internal Medicine, **Astronomy & Astrophysics**, **Nuclear Technology**, and **Applied Chemistry**

Subfields in which collaboration would be mutually beneficial:

Cardiovascular System, Respiratory System, **Environmental Sciences**, and **Oceanography & Limnology**

DFAIT – Uses and follow-up studies

- DFAIT successfully extended its funding for the International S&T Partnership Program (2010 Federal Budget)
- Follow-up study requested in 2010 to provide collaboration profiles and supporting data on matching areas of research for additional countries
- Continue to meet DFAIT's policy needs
  - *"The [2008] study was considered to be of high quality in articulating the structure and changing nature of Canada's international scientific participation."*

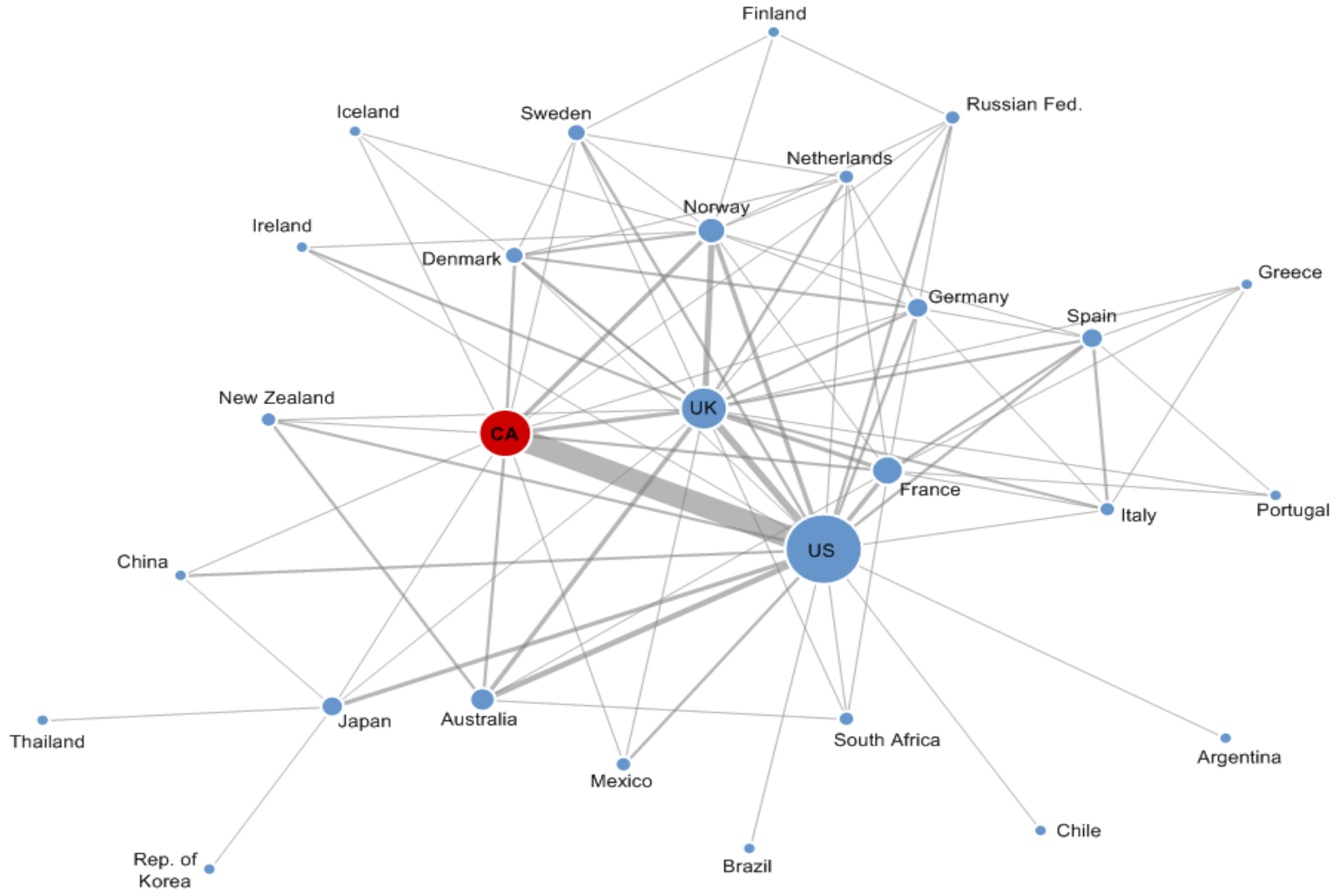
DFO Study – Description and Purpose

- **Description**: Bibliometric analysis to a) describe DFO's collaboration profile and b) identify leading countries in 12 priority research areas
  - 12 research areas were delineated using keyword searches in the titles, abstracts and author keywords of papers
- **Purpose**: Provide data to support DFO's International Science Strategy
  - Inform the negotiation and renewal of agreements (memorandum of understanding)
  - Performance measurement (past performance and baseline to measure effectiveness of strategy)

DFO – Indicators and approach

- Similar set of indicators as DFAIT studies:
  - Number of papers
  - Papers per capita
  - Specialisation index (SI)
  - Average of relative citations (ARC)
  - Probabilistic affinity index (PAI)
- The first four indicators were combined to produce a multi-criteria ranking (calculated as the average rank)
- Collaboration networks were drawn to illustrate existing linkages between countries
  - Based on co-publications, in NetDraw

DFO – Fish Populations: Collaboration network and multi-critera ranking, 1996-2007



Rank	Fish Pop.
1	Canada
2	Norway
3	Australia (3)
4	Denmark (3)
5	New Zealand
6	UK
7	United States
8	South Africa
9	Sweden
10	Finland
11	Spain
12	Netherlands
13	France
14	Ireland (14)
15	Portugal (14)
16	Germany
17	Japan
18	Chile
19	Greece
20	Mexico
21	Italy
22	Russian Fed.
23	Argentina
24	Brazil
25	China

Source: Calculated by Science-Metrix using the Scopus database

DFO – Communication and response to user needs

- Sustained communication with DFO to assess usability of data and ensure their presentation is adequate
  - Presentation for various uses and users:
    - *"We will be using it to back up new and renewed agreements with specific countries, so a lot of detail is good. What would also be good is a summary booklet that could be passed out to managers and others who don't have the capacity or patience for a lot of detail."*
  - Combination/presentation of indicators:
    - *"Would it be possible to have a table that ranked and compared existing international collaborations on each research area alongside the data that identifies countries for potential collaboration?"*

DFO – Revised approach

- In each area, countries identified as having high, medium or low potential for mutually beneficial collaboration based on multi-criteria ranking and adjusted for other factors
  - Established countries with high potential for collaboration have multiple and sustained research strengths in the research area
  - Countries with a medium potential for collaboration are rapidly increasing their output and impact (ARC), and may also be well-positioned in the collaboration network
    - Collaboration with these countries can be beneficial if it is targeted—for example, with leading-edge research programs, organizations and/or researchers that have been identified
- Presented alongside collaboration data (PAI) and number of co-authored papers

DFO – Potential for collaboration in Fish Populations

- 25 countries ranked for each priority research area
- Allows managers to see at a glance the potential for collaboration and existing collaboration practice

Rank	Country	PAI-DFO	No. Coll.
High Potential	Norway	↑	55
	Australia	↓	15
	Denmark	↑	26
	New Zealand	↓	7
	United Kingdom	↓	41
	United States	↑	245
	South Africa	↓	3
	Sweden	→	17
	Netherlands	↓	3
	France	↓	26
	Germany	↓	15
Medium Potential	Finland	↑	12
	Spain	↓	12
	Ireland		
	Portugal	↓	1
	Japan	→	19
	Chile	↓	3
	Greece	↓	5
	Italy	↓	3
	Argentina	↑	6
	Brazil	↓	2
	Iceland	↑	13
	Belgium	↓	4
	Estonia		
	Peru		
Low Potential	Mexico	↓	6
	Russian Fed.	↑	12
	China	↓	5
	Taiwan	↑	7
	Rep. of Korea	↑	4
	Israel	↑	3
	Thailand	↓	2
	Turkey	↓	1

PAI legend:

- ↑ DFO and country X collaborate more than expected (positive affinity)
- → DFO and country X collaborate as often as expected (neutral affinity)
- ↓ DFO and country X collaborate less than expected (negative affinity)

Lessons learned in supporting science policy planning

- The **usability** of the information is as important as the **quality** of the information
- Provide detailed/nuanced data *and* high-level summaries appropriate for various audiences, from scientific directors to policy-makers and management
- Work with users to understand their needs, tailor the study's approach, and offer practical/workable solutions
- Visuals (colours, arrows, mini-graphs, dashboards) work well to summarise information for rapid reference and comparisons

Next steps

- Refine and adapt the approach used to combine multiple indicators
  - For example:
    - Weigh indicators based on user's needs or focus in the multi-criteria ranking; Multidimensional Scaling Analysis
    - Graphically combine indicators to plot subfields/areas for potential collaboration (i.e., who to collaborate with and to what extent collaboration is already occurring)
- Follow-up with users to better understand what worked downstream – and what didn't! – to better support policy-based decision-making in subsequent projects

Thank you for your attention

Contact information:

Michelle Picard-Aitken

Senior Research Analyst

m.picard-aitken@science-metrix.com

David Campbell

Senior Research Analyst

David.campbell@science-metrix.com

Grégoire Côté

Vice-President, Bibliometrics

gregoire.cote@science-metrix.com