Bibliometric Analysis of Research Contributing to Animal Health Risk Assessment

Council of Canadian Academies
Conseil des académies canadiennes

Science Advice in the Public Interest

Key Findings

Canada's scientific output in research contributing to animal health risk assessment compares reasonably well with the output of many of our international peers. Compared to other major agricultural producers, Canada generates a large volume of quality scientific literature relative to the size of its livestock industries. In general, however, the bibliometric data suggest that this research tends to be less intensive (as a proportion of total scientific output) and have less relative impact (measured by average relative citations) than that produced by leading countries such as the United Kingdom, the Netherlands, Denmark, and Belgium.

1. Background

Research capacity is an important contributor to knowledge production in animal health risk assessment. This bibliometric analysis examines the output of Canadian researchers in two key areas contributing to knowledge in animal health risk assessment: animal health risk assessment science (AHRAS) and the human health consequences of animal health events (HHCAHE). Its purpose is to provide a benchmark of where Canada ranks, relative to international peer countries. It does not examine the reasons behind the relative ranking, as this question was outside the scope of the project and would require further research on the nature of the literature produced in each country, the differences in research infrastructures across countries, and other such factors.[1]

This bibliometric analysis is a supplementary document produced in support of the Expert Panel on Approaches to Animal Health Risk Assessment report Healthy Animals, Healthy Canada. The bibliometric data was compiled by Science-Metrix; the analysis was conducted by Council staff with input from the Expert Panel on Approaches to Animal Health Risk Assessment.

2. Methodology

Bibliometrics is a method used to quantify academic research output in terms of peer-reviewed publications, using metrics such as research production, specialization, and impact. Despite some limitations in publication coverage and data results, this method has been commonly recognized as a useful approach for producing objective, consistent, and quantifiable indicators of research output (Picard-Aitken & Côté, 2010; European Commission, 2003; King, 1987).

[1] Available at www.scienceadvice.ca/en/animal-health.aspx

The two main bibliometric data sets used in this study — AHRAS and HHCAHE — were generated and validated in the following manner. For each of the two main data sets, the Panel defined six research areas as its subsets (see Table 1). A list of keywords relating to each subset was then generated and refined, combining input from the Panel, Council staff, and Science-Metrix. Based on these keywords, bibliometric data were drawn from Elsevier's Scopus database, in which 16.7 million records of "peer reviewed" documents for the period of 1996-2009 were examined (personal communication, Grégoire Côté; Science-Metrix Inc.). Following the data collection, Panel members and Council staff reviewed samples of the papers used in creating the data sets to verify data quality and assist in the interpretation of the results.

Since many of the papers in the HHCAHE dataset also relate to AHRAS, there is overlap between the two – with AHRAS being larger and more general. For this reason, AHRAS is used as the main measure of overall research output. What the HHCAHE subset shows is the research output more specifically directed toward the interface between animal and human health, which relates to two of the questions posed to the Panel:

- *What is the state and comprehensiveness of risk assessment techniques in animal health risk assessment science, specifically pertaining to risks which may impact human health?*
- *What, if any, gaps exist with regard to integrated animal-human health research that may have an impact on human health?*

Table 1
Subsets of AHRAS and HHCAHE

Animal Health Risk Assessment Science (AHRAS)	*Human Health Consequences of Animal Health Events (HHCAHE)*
• **DIAG** – Diagnostic test evaluation • **ECON** – Economic models of consequences • **FREQ** – Disease frequency • **NATH** – Epidemiology (natural history) of disease/pathogen • **RISK** – Epidemiology (risk factors) of disease/pathogen • **SURV** – Evaluation of surveillance systems for the disease/pathogen	• **DETC** – Detection of animal-human pathogens • **FPAT** – Frequency of zoonotic pathogens in animals and humans • **IMPH** – Animal diseases with human impact • **PSYC** – Psycho-social consequences of management of animal health events • **TRSM** – Animal-human disease transmission • **ZOON** – Zoonotic diseases (as identified by the Panel and/or Canadian Food Inspection Agency reportable diseases)

For detailed results from these two areas of research, see Figure 4.

Three main categories of indicators were used in measuring research output:

1. productivity (i.e., the number of papers produced and the growth rate in paper production);

2. impact (i.e., the number of citations per paper and the impact of the journals in which the papers were published); and
3. intensity (i.e., concentration of work in a particular area relative to the rest of the world).

(Picard-Aitken & Côté, 2010)

Further details on these indicators are provided in Box 1. Results for the indicators were generated for the period between 1996 and 2009. These results were further broken down into two five-year periods, 1996-2000 and 2004-2008, to highlight changes in research output and impact over time.

Countries selected for the analysis included the members of the Organisation for Economic Co-operation and Development (OECD) and the emerging economies of Brazil, Russia, India, and China (BRIC). For the purpose of comparison, Canadian performance was measured against overall OECD performance, top scientific producers, countries with similar sized livestock sectors and research output, and other comparator countries examined in the Panel's report.

Box 1 **Bibliometric Indicators**

The bibliometric indicators used in this analysis can be classified into three broad categories:

1. **Productivity Indicators**
   i. *Number of Papers* – the raw number of research papers produced in a particular field by researchers in a given country.

   ii. *Growth Rate*[2] – the rate of change in the production of papers over two periods of time, i.e., 1996-2000 and 2004-2008.

2. **Impact Indicators**
   i. *Average of Relative Citations (ARC)* – the *observed* scientific impact of papers produced in a given country based on the number of citations received divided by the average citation count of the papers in a given subfield in a given period. This adjusts for different citation patterns and quantities of papers produced across fields and subfields. An ARC value above 1.0 demonstrates that a country's papers are cited more frequently than the world average in this research area.

   ii. *Average Relative Impact Factor (ARIF)* – the *expected* scientific impact of papers produced in a particular country based on the impact (a measure of the number of citations a journal receives relative to the number of papers it publishes) of the journals in which the papers were published. As with ARC, ARIF is the average of its RIFs (Relative Impact Factor) which is obtained by dividing each papers impact factor by the average impact factor of the papers in that given subfield. An ARIF value above 1.0 implies that a country's papers have more impact than the world average in a given research area.

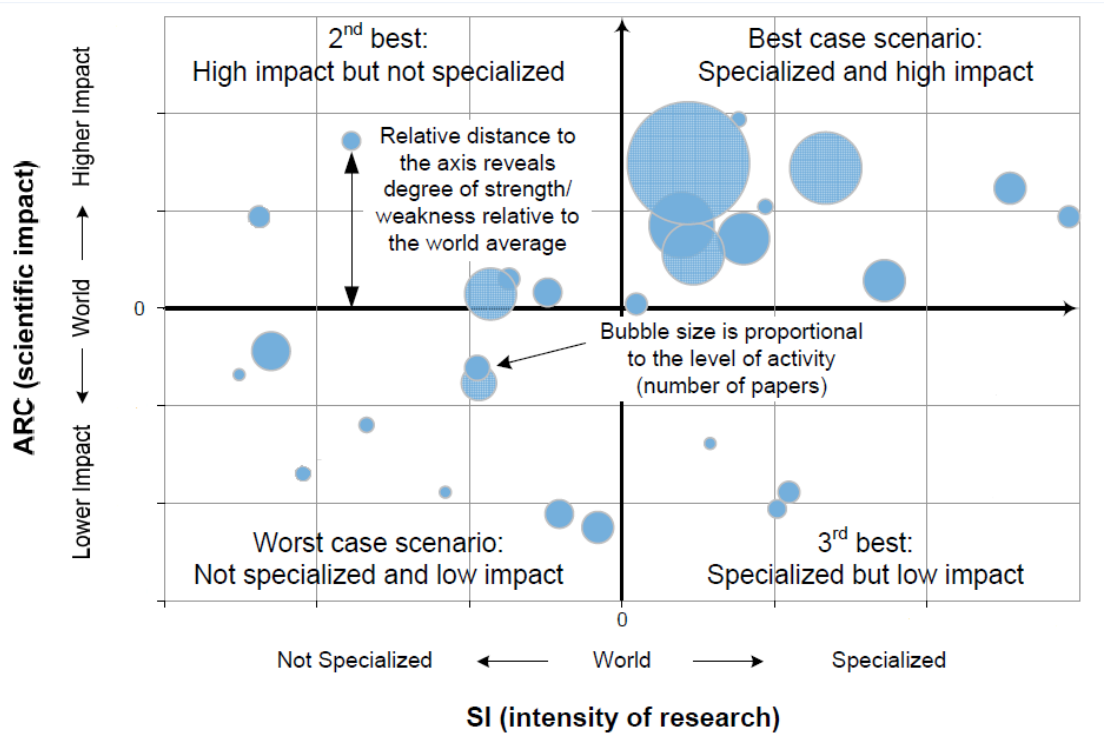
3. **Intensity Indicator**

[2] This is a Council metric, which was adapted from the Science-Metrix Inc. *growth index* indicator.

i. *Specialization Index (SI)* – the research intensity or concentration of a particular country for a given research area relative to the world. An SI value above 1.0 implies that a country is specialized relative to the world in a given area.

(Picard-Aitken & Côté, 2010)

The results of the bibliometric analysis for each data set (AHRAS and HHCAHE) are presented graphically. Figure 1 provides an example of how to interpret this information. The horizontal axis measures the Specialization Index (SI) and the vertical axis measures the Average of Relative Citations (ARC). The size of each circle represents a country's output, indicative of the relative production of research papers when compared with the circles of other countries. The upper right hand quadrant is deemed to be the most desirable, as it represents an area in which publications are more specialized and have a higher scientific impact. The least desirable quadrant is the lower left hand quadrant with a lower degree of specialization and lower impact.



(Adapted from: Picard-Aitken & Côté, 2010)

Figure 1
Example of a Positional Analysis Figure

3. Bibliometric Results

3.1 Animal Health Risk Assessment Science (AHRAS)

Productivity Indicators: Canada has produced a large and growing volume of research relative to other countries with similar livestock sectors in AHRAS in recent years. From 1996 to 2009, Canadian researchers produced 2,729 papers in areas related to AHRAS. This accounted for approximately six per cent of the global research output in this area, with Canada ranking fourth behind the United States (13,673), United Kingdom (5,180), and Germany (3,227). Canadian research output growth of about 84 per cent from 1996-2000 to 2004-2008 outstripped the world average (~73 per cent), and was higher than other countries with a similar level of paper production such as Germany (~72 per cent), France (~59 per cent), and Australia (~59 per cent) (see Table 2).

Compared to the relative size of its livestock industry, the volume of Canada's research output compares even more favourably to that of many other OECD countries. Canada produced 20.5 papers per $1 billion international dollars (INT$) of livestock production during 2004-2008, which, although well behind the United Kingdom (42.0), was significantly ahead of other major paper producers such as Germany (13.9), Australia (13.4), the United States (12.1) and France (10.8). Switzerland, with a relatively small livestock sector, also produced a high number of papers per INT$$1 billion[3] of livestock production (53.7) during this same period.

Impact Indicators: Canada's research impact in AHRAS is in the average range of comparator countries. Measured in terms of ARC, Canada's research impact in this field (1.2) is higher or about the same as that of countries with a similar volume of research output such as Germany (1.0), France (1.2), and Australia (1.2). Overall, however, Canada's ARC rating trails behind other countries such as the United Kingdom (1.5), the Netherlands (1.5), Denmark (1.4), and China (1.3) (see Table 2). Measured in terms of expected research impact based on journal importance and prominence, Canada falls in the low- to mid-range, with an Average Relative Impact Factor (ARIF) of 1.1, trailing countries such as China (1.5), the United Kingdom (1.4), the United States (1.3), France (1.2), and Australia (1.2), but similar to the Netherlands (1.1) and ahead of countries such as New Zealand (1.0) Japan (1.0), Germany (0.9), and India (0.4) (see Appendix A –Table A2).

[3] International dollars are a hypothetical currency generated to adjust for commodity price and exchange rate differences across countries and time periods, providing a more accurate description of the real dollar value of production in a given country and making for better cross country comparisons. For more information, see FAOSTAT, "Glossary (List)," available September 24, 2011 2011http://faostat.fao.org/site/375/default.aspx.

Intensity Indicators: In terms of concentration of research in areas related to AHRAS, Canada's SI value of 1.4 was equal to that of the United Kingdom and above that of the United States (1.0), Germany (0.9), France (0.9), Japan (0.4), and China (0.2) (see Table 2), but lower than countries such as New Zealand (3.5), Denmark (2.8), Brazil (2.0), Australia (1.6), the Netherlands (1.5), and India (1.5).

Table 2
Research Output versus Livestock Production

Country	1996-2009						1996-2000			2004-2008		
	AHRAS			HHCAHE			AHRAS			AHRAS		
	Total Papers	SI	ARC	Total Papers	SI	ARC	Total papers	Livestock production* (INT $ billion)	Papers/ Output**	Total papers	Livestock production* (INT $ billion)	Papers/ Output**
United States	13673	1.0	1.2	8770	1.0	1.4	3821	458.9	8.3	6019	497.3	12.1
United Kingdom	5180	1.4	1.5	3172	1.4	1.4	1334	58.2	22.9	2334	55.5	42.0
Germany	3227	0.9	1.0	1874	0.9	1.1	851	101.0	8.4	1462	105.3	13.9
Canada	**2729**	**1.4**	**1.2**	**1402**	**1.2**	**1.2**	**710**	**54.2**	**13.1**	**1305**	**63.8**	**20.5**
France	2358	0.9	1.2	2070	1.3	1.0	655	102.8	6.4	1057	98.2	10.8
Australia	1967	1.6	1.2	1035	1.3	1.3	547	61.5	8.9	872	65.1	13.4
India	1862	1.5	0.3	901	1.2	0.5	518	158.5	3.3	841	215.5	3.9
Netherlands	1638	1.6	1.5	926	1.4	1.7	530	44.7	11.9	665	43.1	15.4
Japan	1562	0.4	0.8	1079	0.5	0.9	435	49.4	8.8	673	48.8	13.8
Brazil	1506	2.0	0.6	1276	2.6	0.8	278	171.3	1.6	791	252.5	3.1
China	1207	0.2	1.3	1740	0.5	1.2	120	539.8	0.2	711	693.2	1.0
Denmark	1110	2.8	1.4	533	2.1	1.2	296	23.6	12.5	479	25.2	19.0
Switzerland	1079	1.4	1.2	772	1.6	1.5	252	9.2	27.4	505	9.4	53.7
New Zealand	841	3.5	1.1	285	1.9	1.2	221	34.2	6.5	382	42.1	9.1
World	**46205**	**1.0**	**1.0**	**29729**	**1.0**	**1.0**	**12143**	**2925.1**	**4.2**	**20995**	**3453.3**	**6.0**

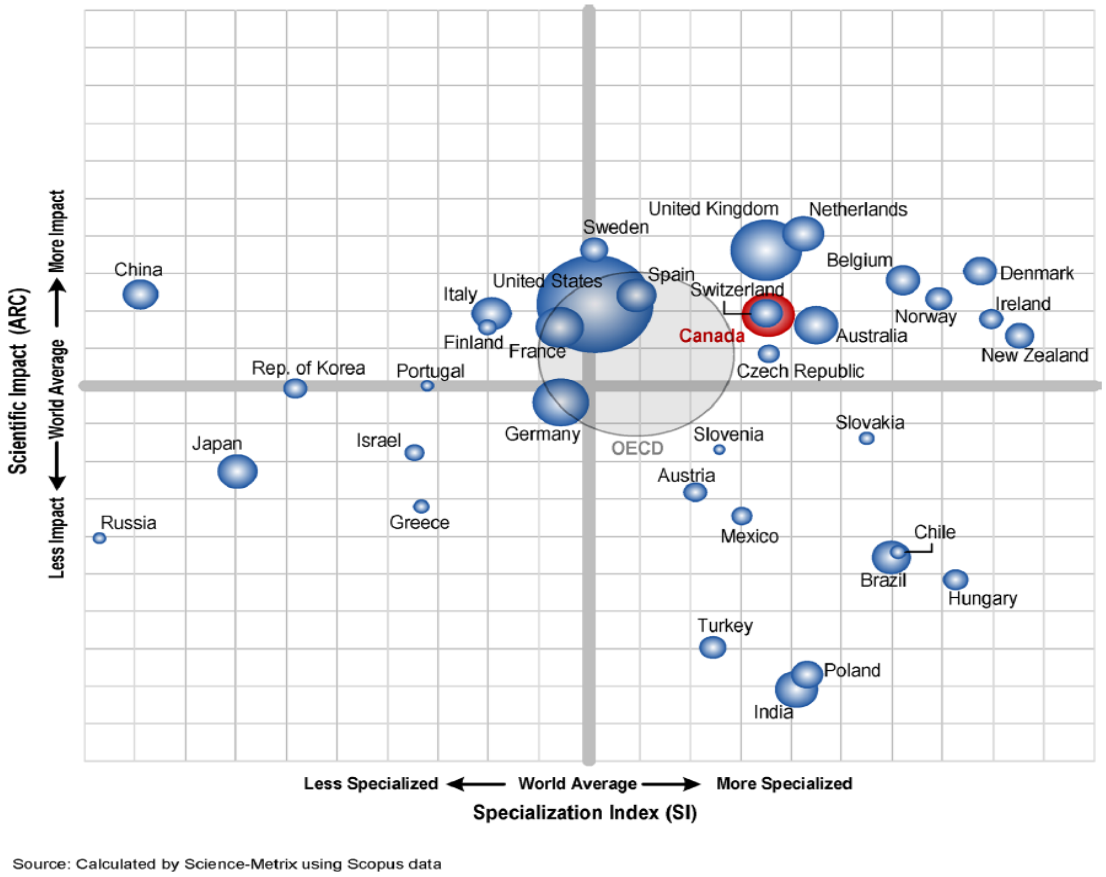
* Staff calculation based on *Food and Agriculture Organization Statistics Division* (FAOSTAT)data of livestock products of the 20 most important food and agricultural commodities in 1996-2000 and 2004-2008 for each country. Based on data available at FAOSTAT, as of September 2011:http://faostat.fao.org/site/339/default.aspx. Data may be subject to change over time as figures are updated FAOSTAT and the reporting countries.

** Total papers divided by livestock production for the same period, producing an average number of papers per INT$ $1 billion of livestock production.

This table shows the research output of comparator countries compared to the value of consumable livestock products. The measure of paper output per billion dollars of livestock production presented here is intended to provide an approximate means for gauging research output in relation to the wealth generated by consumable livestock products.

Calculations for consumable livestock products are drawn from data from the Food and Agriculture Organization (FAO) of the United Nations on the top 20 food and agricultural commodities for specific countries in 1996-2000 and 2004-2008. In some cases, countries had different consumable livestock products depending on the nature of their livestock production industry.

The table includes the top 10 countries by research output in AHRAS, plus other comparator countries of interest identified in the Panel's report.



Source: Calculated by Science-Metrix using Scopus data

Figure 2
Research Performance of OECD and BRIC countries in AHRAS

Canada's research output performance relative to all other OECD and BRIC countries is illustrated in Figure 2. The centre point of the grey circle represents the average for all OECD countries, and the area represents the total relative production of research papers. This figure, which plots the ARC against the SI, illustrates that Canada performs better than the OECD average and many other comparator countries, though falling into the upper end of the mid-range overall.

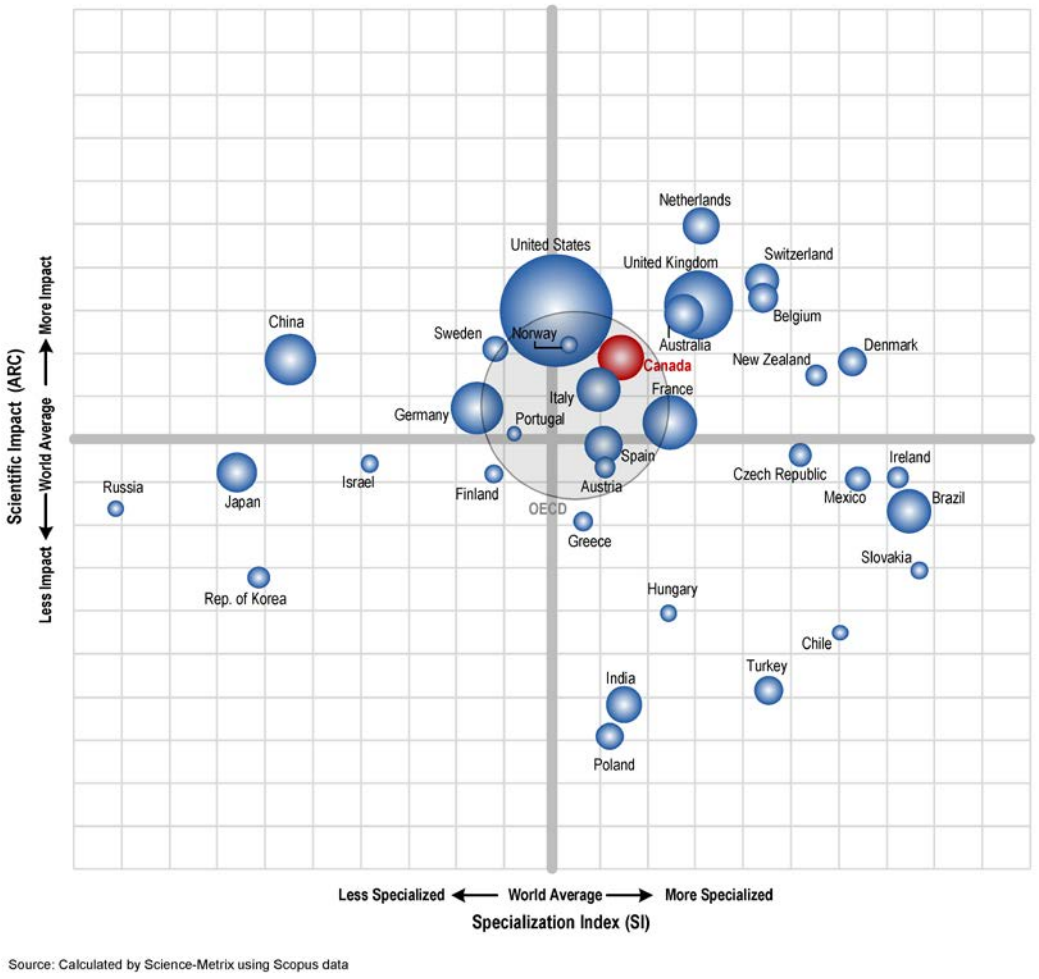
3.2 Human Health Consequences of Animal Health Events (HHCAHE)

Productivity Indicators: From 1996 to 2009, Canadian researchers produced 1,402 papers in areas related to HHCAHE. Canadian output accounted for approximately five per cent of the global research output in this area, placing Canada sixth in terms of research output behind the United States (8,770), the

United Kingdom (3,172), France (2,070), Germany (1,874), and China (1,740). The growth of approximately 230 per cent in papers produced in Canada from 1996-2000 to 2004-2008, however, vastly outstripped the world average (150 per cent) and was greater than some of the other countries with similar levels of paper outputs, ranking above Italy (207 per cent), Germany (131 per cent), and France (99 per cent), but behind Brazil (268 per cent). Albeit starting from a lower base than other countries, China had among the fastest growing research outputs of countries producing more than 1000 papers over the entire period, increasing by 978 per cent from 1996-2000 to 2004-2008.

Impact Indicators: Canada ranked in the upper end of the mid-range in research impact. With an ARC of 1.2, Canada's research impact rating in HHCAHE was below that of the Netherlands (1.7) and Australia (1.3); equal to China (1.2); and ahead of countries such as Germany (1.1), Italy (1.1), Spain (1.0), France (1.0), Japan (0.9), and Brazil (0.8) – among countries with similar levels of research output in this area. Overall, it also trailed the United States (1.4) and the United Kingdom (1.4) (Table A2). In terms of journal impact, Canada’s ARIF of 1.1 also placed it relatively well compared to countries with similar levels of research output, ahead of Germany (1.0), Japan (1.0), Spain (1.0), Italy (0.9), and Brazil (0.8); equal to France and the Netherlands; and below China (1.3) and Australia (1.2). Overall, it also lagged behind the United States (1.3) and the United Kingdom (1.3) in this area (Table A2).

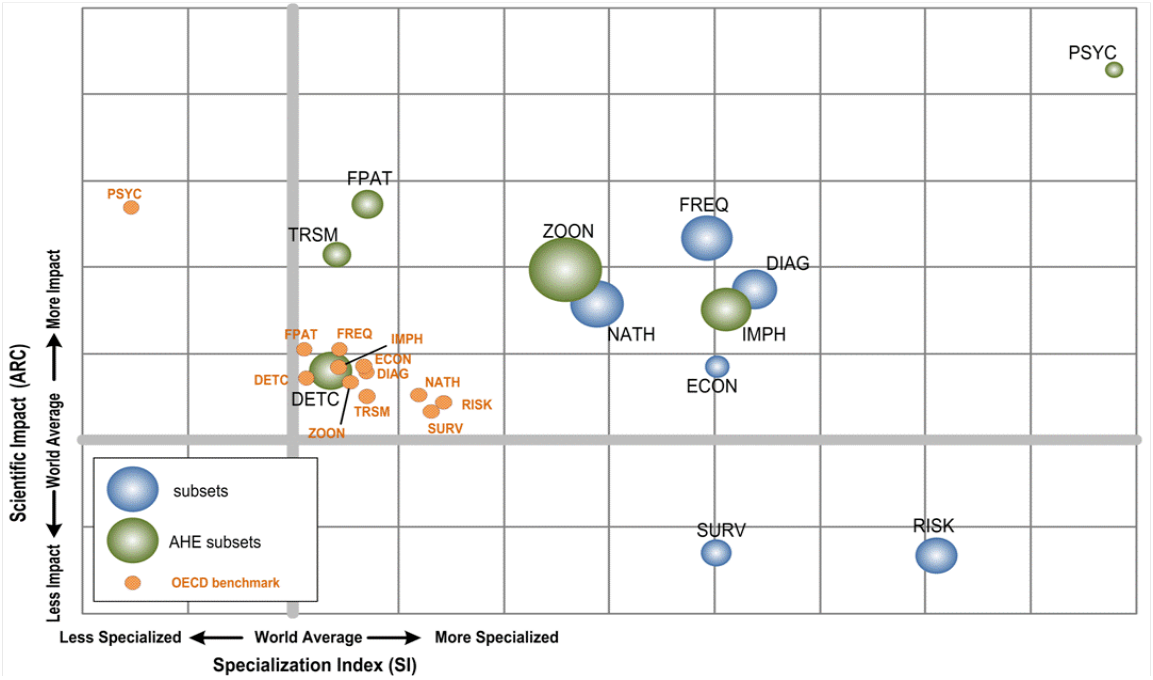
Intensity Indicators: In terms of concentration of research in areas related to HHCAHE, Canada’s SI value of 1.2 was equal to that of India and ahead of Italy (1.1), Spain (1.1), the United States (1.0), Germany (0.9), Japan (0.5), and China (0.5) (see Table A2), but behind countries such as Brazil (2.6), Denmark (2.1), New Zealand (1.9), Switzerland (1.6), the United Kingdom (1.4), the Netherlands (1.4), Australia (1.3) and France (1.3).



Source: Calculated by Science-Metrix using Scopus data

Figure 3
Research Performance of OECD and BRIC Countries in HHCAHE

Canada's research performance in HHCAHE relative to all other OECD and BRIC countries is illustrated in Figure 3. This figure shows that Canada performed slightly better than the OECD average (represented by the centre of the grey circle) and the world average (represented by the point of intersection of the two axes) in terms of both impact and specialization, though below several other major countries such as the United Kingdom, the Netherlands, and Australia (see Figure 3). Overall, Canada performed relatively better in AHRAS than in HHCAHE (compare Figures 2 and 3).



See Table 1 for abbreviations of terms comprising the subsets.

Figure 4
Positional analysis of Canadian in AHRAS and HHCAHE subsets, 1996-2009

Looking at research performance in the breakdown of two main sets of data provides some insight as to where Canada stands in the major subfields comprising AHRAS and HHCAHE. In Figure 4, each of the major subfields is graphed (with AHARS in blue and HHCAHE in green) in comparison with the world average (represented by the darker grey lines dividing the quadrants) and OECD benchmarks (shown as the orange dots).

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Appendix A
Detailed Bibliometric Results for AHRAS and HHCAHE

Table A1

Specialization Index (SI), Average of Relative Citations (ARC), and Average Relative Impact Factors (ARIF) in animal health risk assessment science (AHRAS), by leading countries, 1996-2009

Country	Papers	% of world	SI	ARC	ARIF
OECD	38,934	84.3	1.1	1.1	1.1
United States	13,673	29.6	1.0	1.2	1.3
United Kingdom	5,180	11.2	1.4	1.5	1.4
Germany	3,227	7.0	0.9	1.0	0.9
Canada	2,729	5.9	1.4	1.2	1.1
France	2,358	5.1	0.9	1.2	1.2
Australia	1,967	4.3	1.6	1.2	1.2
India	1,862	4.0	1.5	0.3	0.4
Netherlands	1,638	3.5	1.6	1.5	1.1
Japan	1,562	3.4	0.4	0.8	1.0
Brazil	1,506	3.3	2.0	0.6	0.7
Spain	1,495	3.2	1.1	1.3	1.2
Italy	1,492	3.2	0.8	1.2	1.1
China	1,207	2.6	0.2	1.3	1.5
Belgium	1,175	2.5	2.1	1.3	1.0
Denmark	1,110	2.4	2.8	1.4	1.1
Switzerland	1,079	2.3	1.4	1.2	1.2
Poland	1,038	2.2	1.6	0.4	0.3
New Zealand	841	1.8	3.5	1.1	1.0
Sweden	757	1.6	1.0	1.5	1.1
Norway	687	1.5	2.3	1.3	1.2
Turkey	675	1.5	1.3	0.4	0.5
South Africa	623	1.3	2.9	0.9	1.0
Argentina	594	1.3	2.6	0.8	1.0
Hungary	550	1.2	2.5	0.6	0.5

Ireland	534	1.2	3.0	1.2	1.0
Korea	521	1.1	0.5	1.0	1.1
Austria	482	1.0	1.2	0.7	0.9
Kenya	462	1.0	15.2	0.7	1.0
Czech Republic	430	0.9	1.4	1.1	0.8
Mexico	409	0.9	1.4	0.7	1.0
Iran	350	0.8	1.5	0.4	0.6
Israel	319	0.7	0.7	0.8	1.1
Finland	305	0.7	0.8	1.2	1.1
Thailand	301	0.7	2.3	1.4	1.3
Chile	238	0.5	2.0	0.6	0.7
Greece	234	0.5	0.7	0.7	1.1
Ethiopia	211	0.5	16.0	0.7	0.7
Slovakia	201	0.4	1.9	0.9	0.7
Tanzania	183	0.4	13.0	0.7	1.0
Nigeria	183	0.4	2.9	0.4	0.6
Egypt	183	0.4	1.2	1.0	1.0
Portugal	164	0.4	0.7	1.0	1.1
Croatia	152	0.3	1.6	0.7	0.6
Zimbabwe	146	0.3	13.1	0.7	0.8
Russia	140	0.3	0.1	0.7	0.9
Pakistan	131	0.3	1.6	0.4	0.8
Slovenia	118	0.3	1.3	0.8	0.9
Vietnam	114	0.2	4.8	2.5	2.0
Venezuela	113	0.2	2.2	0.8	0.9
Uganda	103	0.2	9.1	0.8	1.0
WORLD	**46,205**	**100**	**1.0**	**1.0**	**1.0**

Note: By definition, the SI, ARC and ARIF at the world level are equal to 1.0.

Source: Calculated by Science-Metrix using Scopus data

Table A2

Specialization Index (SI), Average of Relative Citations (ARC) and Average Relative Impact Factors (ARIF) in human health consequences of animal health events (HHCAE) by leading countries, 1996-2009

Country	Papers	% of world	SI	ARC	ARIF
OECD	24,204	81.4	1.0	1.1	1.1
United States	8,770	29.5	1.0	1.4	1.3
United Kingdom	3,172	10.7	1.4	1.4	1.3
France	2,070	7.0	1.3	1.0	1.1
Germany	1,874	6.3	0.9	1.1	1.0
China	1,740	5.9	0.5	1.2	1.3
Canada	1,402	4.7	1.2	1.2	1.1
Italy	1,287	4.3	1.1	1.1	0.9
Brazil	1,276	4.3	2.6	0.8	0.8
Japan	1,079	3.6	0.5	0.9	1.0
Australia	1,035	3.5	1.3	1.3	1.2
Spain	976	3.3	1.1	1.0	1.0
Netherlands	926	3.1	1.4	1.7	1.1
India	901	3.0	1.2	0.5	0.6
Switzerland	772	2.6	1.6	1.5	1.3
Belgium	587	2.0	1.6	1.4	1.0
Turkey	551	1.9	1.6	0.5	0.6
Denmark	533	1.8	2.1	1.2	1.1
Poland	475	1.6	1.1	0.4	0.4
Thailand	430	1.4	5.0	1.4	1.1
Sweden	428	1.4	0.9	1.2	1.3
Argentina	418	1.4	2.9	0.7	0.8
Mexico	411	1.4	2.1	0.9	0.9
Czech Republic	339	1.1	1.8	1.0	0.6
Iran	337	1.1	2.2	0.4	0.5
Korea	319	1.1	0.5	0.7	0.9
Ireland	289	1.0	2.5	0.9	1.0
New Zealand	285	1.0	1.9	1.2	1.0
Austria	280	0.9	1.1	0.9	0.9
Greece	227	0.8	1.1	0.8	0.9

Finland	213	0.7	0.9	0.9	1.2
Israel	197	0.7	0.7	0.9	1.2
South Africa	196	0.7	1.4	1.1	0.9
Norway	195	0.7	1.0	1.2	1.1
Slovakia	192	0.6	2.8	0.7	0.6
Hungary	181	0.6	1.3	0.7	0.7
Singapore	177	0.6	1.0	1.3	1.4
Russia	159	0.5	0.2	0.8	1.0
Chile	151	0.5	2.0	0.6	0.7
Vietnam	150	0.5	9.8	3.1	1.9
Croatia	138	0.5	2.2	0.5	0.4
Portugal	136	0.5	0.9	1.0	0.9
Egypt	132	0.4	1.4	1.0	1.0
Venezuela	130	0.4	3.9	0.7	0.6
Colombia	129	0.4	4.2	0.6	0.8
Malaysia	126	0.4	2.0	1.0	1.2
Peru	124	0.4	13.8	1.3	1.3
Nigeria	106	0.4	2.6	0.5	0.7
Kenya	102	0.3	5.2	0.8	0.9
Tunisia	89	0.3	2.4	0.6	0.7
Slovenia	88	0.3	1.5	0.9	0.8
WORLD	**29,729**	**100**	**1.0**	**1.0**	**1.0**

Note: By definition, the SI, ARC and ARIF at the world level are equal to 1.0.

Source: Calculated by Science-Metrix using Scopus data