

Science-Matrix

Bibliometric analysis of GRDI-funded researchers' international scientific collaboration





Introduction/Objectives

1- Overview of GRDI-funded scientists' international scientific collaboration: Trends in their papers co-authored with foreign partners in genomics and profiles of specialties (within genomics) in which they collaborate the most.

2- Breakdown of GRDI-funded scientists' collaboration by country: Countries with which they collaborate the most in genomics, and identification of specialties (within genomics) within which selected countries excel, to help guide the development of future partnerships.



Bibliometric indicators produced with the Web of Science (WoS)

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

Specialization index (SI): 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.

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

SI > 1 → Canada is Specialized in Genomics

SI < 1 → Canada is not Specialized in Genomics

Average of relative citations (ARC): 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



Bibliometric indicators (continued)

Number of International Collaborations: Number of papers co-authored with at least one foreign country, based on author addresses.

Collaboration rate: The relative intensity of collaboration of an entity at different aggregation levels (e.g., international, national, or institutional). The rate is calculated by dividing the number of papers co-authored with a collaborator by the entity's total number of papers.

$$\text{Int'l Collab. Rate of Canada} = \frac{\text{(Canadian Papers Co-Authored with Foreign Countries)}}{\text{(All Canadian Papers)}}$$

Share of GRDI-funded scientists' bilateral collaborations: Percentage of GRDI-funded scientists' bilateral collaborations by country. A paper co-authored by a GRDI-scientist, an Italian, and two American researchers is the result of three bilateral collaborations: one between the GRDI-scientist and Italy, one between the GRDI-scientist and the US, and one between Italy and the US. In this case, the GRDI-scientist would have one paper in international collaboration (int'l collab. rate of 100%, if only one paper was produced) and two bilateral collaborations. Italy and the US would each have a 50% share of the GRDI scientist's bilateral collaborations.



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Overview of GRDI-funded scientists' international scientific collaboration





GRDI-funded scientists do not collaborate more internationally when supported by the Initiative

International collaboration rates of GRDI-funded researchers among their genomics papers authored while receiving and not receiving funds from the Initiative, 1996-2007

Dataset	Number		Intl. Collabo. Rate
	Intl. Collaborations	Papers	
Non-supported papers	180	527	34%
Supported papers	247	773	32%
p-value			NS

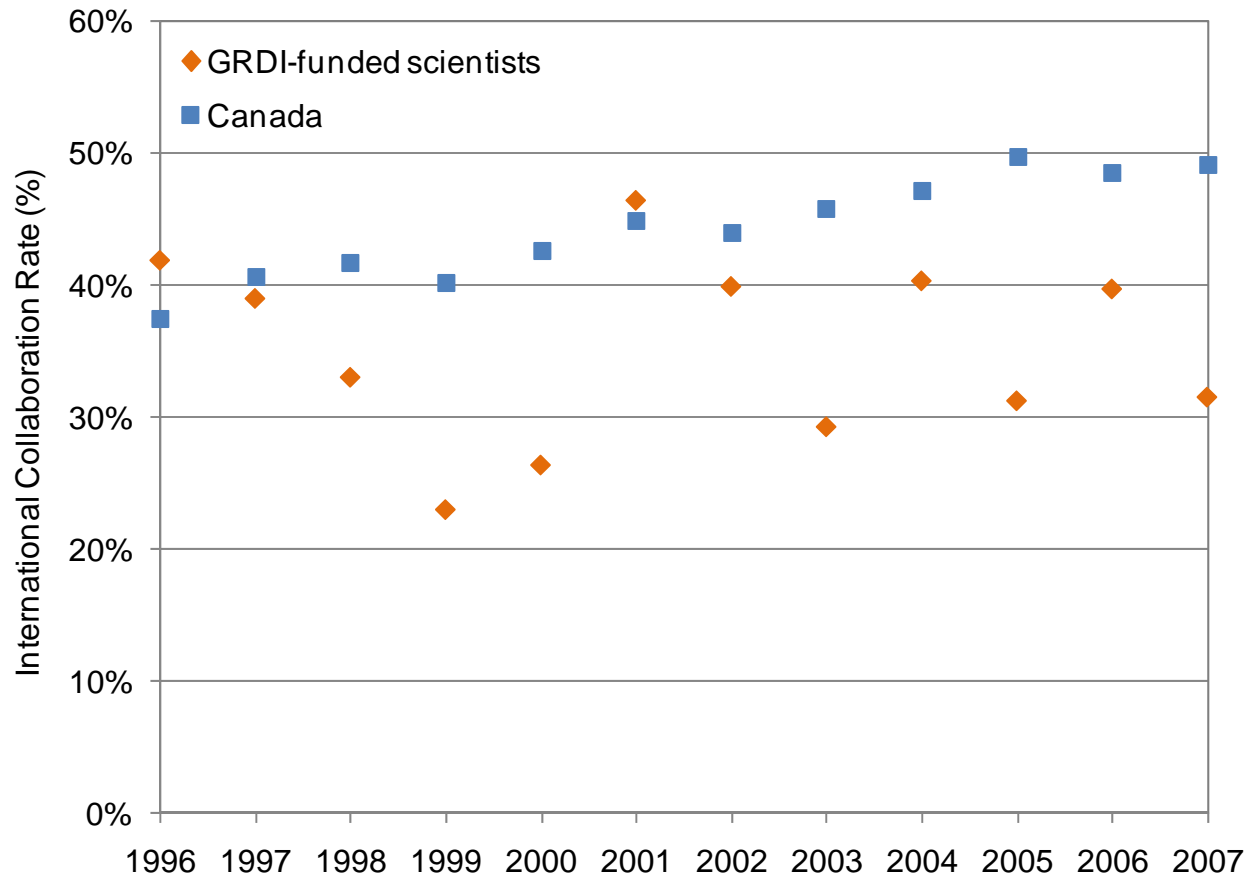
Note: Non-supported papers refer to papers authored while not receiving GRDI support and supported papers refer to papers authored while receiving GRDI support (these papers might include papers authored with other sources of financing). H_0 = The proportion of papers authored in international collaboration is not significantly different between supported and non-supported papers [Z-test for two proportions].

Source: Calculated by Science-Metrix using the WoS



From 1996 to 2007, the int'l collab. rate of GRDI-funded scientists fluctuated, while that of Canada rose steadily

International collaboration rates by year in genomics of GRDI-funded researchers compared to Canada, 1996-2007



- Over the whole period examined, 35% of genomics papers by GRDI-funded scientists were authored with at least one foreign partner.
- In Canada, 45% of genomics papers were authored with at least one author from another country.
- The int'l collab. rate of GRDI-funded scientists fluctuated between a low of 23% and a high of 46%.
- The int'l collab. rate of Canada rose from 37% in 1996 to 49% in 2007.

Source: Calculated by Science-Metrix using the WoS



GRDI-funded scientists collaborate the most internationally in Immunology and Genetics & Heredity

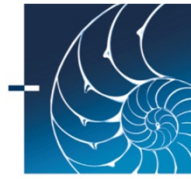
International collaboration rates by specialty in genomics of GRDI-funded researchers compared to Canada, 1996-2007

Specialty	GRDI-funded scientists			Canada		
	No. Intl. Collaboration	No. Papers	Intl. Collabo. Rate	No. Intl. Collaboration	No. Papers	Intl. Collabo. Rate
Immunology	31	68	46%	757	1,687	45%
Genetics & Heredity	92	227	41%	2,588	5,126	50%
Microbiology	68	191	36%	640	1,821	35%
Virology	26	75	35%	347	925	38%
Biochemistry & Molecular Biology	92	274	34%	2,616	6,374	41%
Neurology & Neurosurgery	17	54	31%	1,053	2,202	48%
Marine Biology & Hydrobiology	33	107	31%	150	390	38%
Botany	62	213	29%	488	1,513	32%
Entomology	4	40	10%	72	189	38%
Total	546	1,564	35%	15,964	35,762	45%

Note: Only specialties in which GRDI-funded scientists published more than 30 papers from 1996 to 2007 were considered.

Source: Calculated by Science-Metrix using the WoS

- GRDI-funded scientists collaborate more in genomics specialties related to biomedical research (i.e., Immunology, Genetics & Heredity, Microbiology, Virology, and Biochemistry & Molecular Biology) than in specialties related to biology (i.e., Marine Biology & Hydrobiology, Botany, and Entomology).
- GRDI-funded scientists collaborate less than Canada in most specialties, except in Immunology and Microbiology. Its int'l collab. rate is fairly low relative to Canada in Entomology and Neurology & Neurosurgery.



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Breakdown of GRDI-funded scientists' collaboration by country





GRDI-funded scientists' top three international partners in genomics are the US, the UK, and France

GRDI-funded researchers number of bilateral collaborations per country in genomics, 1996-2007

Country	Bilateral collaborations	Share of total bilateral collaborations
United States	261	34.7%
United Kingdom	88	11.7%
France	56	7.4%
Germany	48	6.4%
Japan	26	3.5%
Sweden	25	3.3%
Switzerland	25	3.3%
Netherlands	22	2.9%
China	18	2.4%
Australia	18	2.4%
Total bilateral collaborations	587	100%

Note: Only the top ten partners of GRDI-funded scientists were considered.

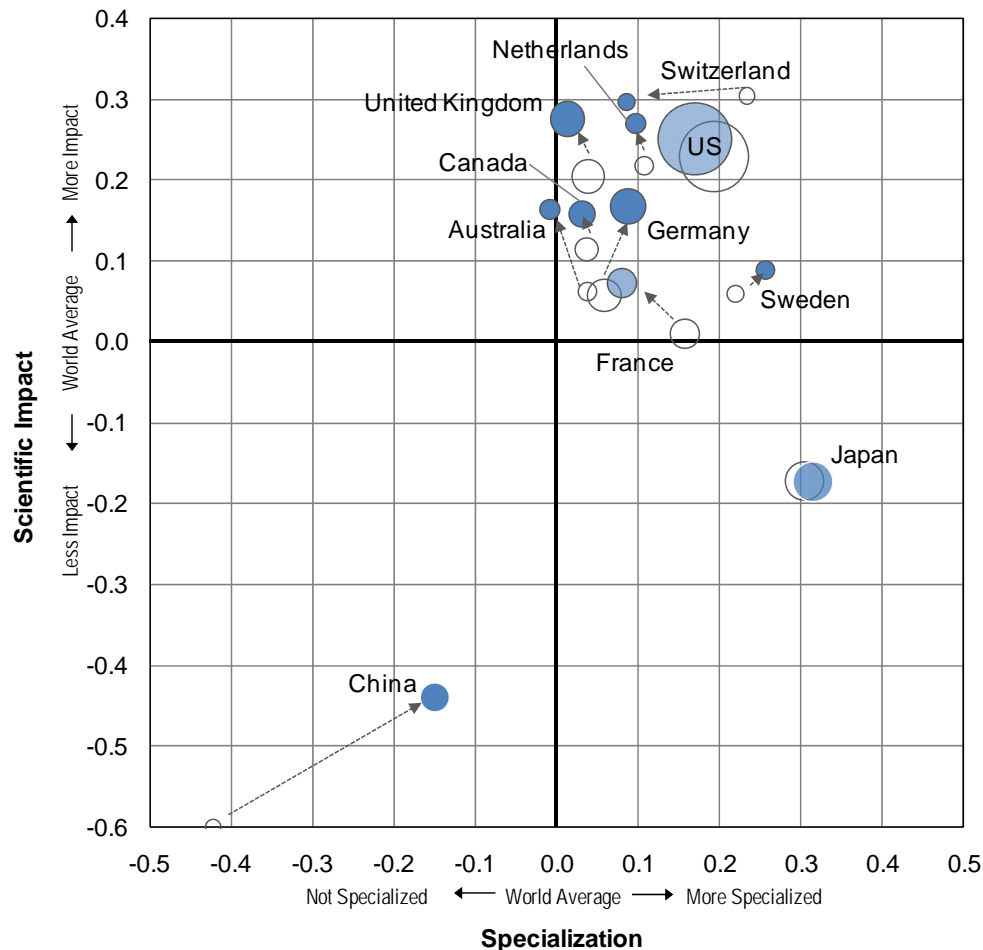
Source: Calculated by Science-Metrix using the WoS

- Altogether, GRDI-funded scientists' top three international partners account for over 50% of their collaborative links with a foreign country.
- GRDI-funded scientists' main international partners include countries from North America, Europe, and Asia. Among them, China is the most rapidly developing country in genomics as well as in many other scientific areas.



Canada is well positioned in genomics research, being specialized and having an impact above the world level

Evolution of selected countries' specialization and scientific impact in genomics over two periods, 1996-2001 and 2002-2007



- Among GRDI-funded scientists' top international partners are leading countries in genomics.
- The most remarkable of these, with the highest scientific impact among selected countries, is the US (1st place in a multicriteria ranking, performed by Science-Metrix for Genome Canada), Switzerland (2nd), the Netherlands (3rd), and the UK (4th).
- Japan is specialized but has a scientific impact below the world level.
- China is not specialized and has a low scientific impact relative to the world average. However, its performance improved greatly with respect to each of these two indicators over the last decade.



In the biochemistry & molecular biology specialty, the leaders are Switzerland, the UK, and the US

Number of publications, SI, and ARC of selected countries in genomics - biochemistry & molecular biology specialty, 1996-2007

Country	Papers	SI	ARC
Switzerland	2,995	1.27	1.33
United Kingdom	11,118	1.08	1.18
United States	60,000	1.32	1.16
Netherlands	2,701	0.86	1.11
Germany	11,703	1.15	1.02
France	9,991	1.29	0.94
Sweden	2,980	1.08	0.90
Australia	2,801	0.86	0.89
Japan	15,934	1.17	0.78
China	3,936	0.82	0.55
Canada	6,374	1.19	0.95
World	114,118	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, Switzerland, the UK, and the US are clear leaders, being specialized and having a scientific impact above the world level.
- The Netherlands, although not specialized in this specialty, is the only other country within the selection to have a scientific impact above the world average.
- As several studies by Science-Metrix have pointed out, papers authored in international collaboration usually have higher scientific impacts than other papers. As such, the GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.



In the botany specialty, the leaders are the UK, the Netherlands, and Germany

Number of publications, SI, and ARC of selected countries in genomics - botany specialty, 1996-2007

Country	Papers	SI	ARC
Switzerland	504	1.04	1.52
United Kingdom	2,425	1.15	1.29
Netherlands	798	1.24	1.28
Germany	2,713	1.30	1.21
United States	8,314	0.90	1.17
Sweden	625	1.11	1.08
France	2,062	1.30	1.06
Australia	1,454	2.18	0.96
Japan	3,793	1.36	0.90
China	2,491	2.55	0.46
Canada	1,513	1.39	0.88
World	23,335	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, the UK, the Netherlands, and Germany are clearly specialized and have a scientific impact above the world level.
- Switzerland does not have a high SI but is the country with the highest scientific impact.
- The US is not specialized but has the largest production in this area, with an impact above the world level.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.



In the entomology specialty, the leaders are Australia and the US

Number of publications, SI, and ARC of selected countries in genomics - entomology specialty, 1996-2007

Country	Papers	SI	ARC
Switzerland	48	0.70	1.48
Australia	220	2.34	1.20
United Kingdom	302	1.02	1.17
France	217	0.97	1.13
United States	1,842	1.41	1.10
Netherlands	59	0.65	1.05
China	178	1.29	0.94
Germany	193	0.65	0.92
Japan	410	1.04	0.78
Sweden	48	0.61	0.77
Canada	189	1.23	0.89
World	3,294	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, Australia and the US are highly specialized and have a scientific impact above the world level.
- In proportion to its total scientific output in genomics, Australia actually puts more than twice the world effort in this speciality.
- Other noticeable countries for their scientific impact above the world level include Switzerland, the UK, and France.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.



In the genetics & heredity specialty, the leaders are the UK, the Netherlands, the US, Switzerland and Sweden

Number of publications, SI, and ARC of selected countries in genomics - genetics & heredity specialty, 1996-2007

Country	Papers	SI	ARC
United Kingdom	10,790	1.64	1.22
Netherlands	3,334	1.66	1.20
United States	37,142	1.28	1.20
Switzerland	1,828	1.21	1.16
Sweden	2,347	1.34	1.12
Germany	7,973	1.22	1.06
France	7,565	1.53	1.04
Australia	3,303	1.59	0.95
Japan	8,754	1.00	0.77
China	2,339	0.77	0.62
Canada	5,126	1.51	1.08
World	72,771	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, the UK, the Netherlands, the US, Switzerland, and Sweden rank highest in scientific impact, and all are specialized in this area.
- All have a scientific impact above the Canadian average.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.



In the immunology specialty, the leaders are Switzerland, the US, and the Netherlands

Number of publications, SI, and ARC of selected countries in genomics - immunology specialty, 1996-2007

Country	Papers	SI	ARC
Switzerland	1,037	1.51	1.38
United States	16,850	1.28	1.17
Netherlands	1,380	1.52	1.08
United Kingdom	3,809	1.28	1.04
Germany	3,349	1.13	1.00
Australia	1,406	1.49	0.99
France	2,729	1.22	0.97
Japan	4,339	1.10	0.81
Sweden	1,328	1.67	0.78
China	920	0.67	0.51
Canada	1,687	1.09	1.06
World	33,013	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, Switzerland, the US, and the Netherlands are specialized and have a scientific impact above the Canadian and world average.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.



In the marine biology & hydrobiology specialty, Canada is the clear leader and will likely benefit other countries

Number of publications, SI, and ARC of selected countries in genomics - marine biology & hydrobiology specialty, 1996-2007

Country	Papers	SI	ARC
Netherlands	88	0.75	1.57
Switzerland	31	0.35	1.44
Germany	217	0.57	1.27
United Kingdom	428	1.11	1.10
United States	1,635	0.96	1.06
Sweden	95	0.92	1.06
France	319	1.10	1.01
Australia	332	2.71	0.96
China	382	2.13	0.76
Japan	844	1.65	0.71
Canada	390	1.95	1.53
World	4,280	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Other countries who excel in this area include the Netherlands, Switzerland, Germany, and the UK.
- However, contrary to Canada, these countries do not specialize in this area.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.
- Canadian researchers, particularly in this specialty, might help other countries to increase their scientific impact.



In the microbiology specialty, the leaders are the Netherlands, the US, and Switzerland

Number of publications, SI, and ARC of selected countries in genomics - microbiology specialty, 1996-2007

Country	Papers	SI	ARC
Netherlands	1,288	1.61	1.18
United States	12,516	1.09	1.14
Switzerland	806	1.34	1.14
Germany	3,735	1.44	1.09
United Kingdom	3,528	1.35	1.06
France	3,302	1.68	0.94
Sweden	801	1.15	0.92
Australia	1,225	1.48	0.89
Japan	2,914	0.84	0.82
China	964	0.79	0.56
Canada	1,821	1.34	0.92
World	29,000	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, Switzerland, the US, and the Netherlands are specialized and have a scientific impact above the world average.
- Other countries that are specialized with a scientific impact above the Canadian and world average include Germany and the UK.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.



In the neurology & neurosurgery specialty, the leaders are Switzerland, the US and the UK

Number of publications, SI, and ARC of selected countries in genomics - Neurology & Neurosurgery specialty, 1996-2007

Country	Papers	SI	ARC
Switzerland	955	1.40	1.18
United States	16,582	1.26	1.18
United Kingdom	3,569	1.20	1.14
Germany	4,026	1.36	1.04
Netherlands	969	1.07	1.03
Australia	1,000	1.06	0.95
Sweden	1,278	1.61	0.90
France	2,570	1.15	0.90
Japan	4,935	1.25	0.73
China	976	0.71	0.57
Canada	2,202	1.43	1.11
World	32,981	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, Switzerland, the US, and the UK lead in this area, being specialized and having a scientific impact above the world average.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.
- Canada is also a leading country in this specialty.



In the virology specialty, the leaders are Switzerland, the US, and the Netherlands

Number of publications, SI, and ARC of selected countries in genomics - Virology specialty, 1996-2007

Country	Papers	SI	ARC
Switzerland	339	0.97	1.18
United States	8,981	1.35	1.15
Netherlands	606	1.31	1.12
United Kingdom	1,913	1.26	0.98
France	1,351	1.18	0.97
Germany	1,746	1.16	0.95
Sweden	442	1.09	0.86
Australia	597	1.24	0.83
Japan	1,769	0.88	0.81
China	718	1.02	0.74
Canada	925	1.18	0.93
World	16,783	1.00	1.00

Source: Calculated by Science-Metrix using the WoS

- Among selected countries, Switzerland, the US, and the Netherlands lead in this area, being specialized and having a scientific impact above the world average.
- The GRDI could promote partnership with the aforementioned countries as a means to increase the scientific impact of the researchers it funds.



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Conclusion





Conclusion: Overview of GRDI-funded scientists' international scientific collaboration

- GRDI-funded scientists did not collaborate more internationally when receiving funds from the Initiative compared to the period when they were not supported by the GRDI.
- On average, GRDI-funded scientists (int'l collab. rate = 35%) did not collaborate as much as the average Canadian scientist (int'l collab. rate = 45%) internationally.
- While Canada's international collaboration rate increased steadily from 37% in 1996 to 49% in 2007, that of GRDI-funded scientists fluctuated between 23% and 46%.
- GRDI-funded scientists collaborates the most in the following genomics specialties: Immunology (46%), Genetics & Heredity (41%), Microbiology (36%), Virology (35%), and Biochemistry & Molecular Biology (34%), Neurology & Neurosurgery (31%), Marine Biology & Hydrobiology (31%), Botany (29%), and Entomology (10%).
- GRDI-funded scientists collaborates less than Canada in most specialties except in Immunology and Microbiology. Its international collaboration rate is fairly low relative to Canada in Entomology and Neurology & Neurosurgery.



Conclusion: Breakdown of GRDI-funded scientists' collaboration by country

- Altogether, GRDI-funded scientists' top three international partners, the US, the UK and France, account for over 50% of their collaborative links with a foreign country.
- GRDI-funded scientists' main international partners include countries from North America, Europe, and Asia. Among them, China is the most rapidly developing country in genomics as well as in many other scientific areas. In fact, although China is not specialized and has a low scientific impact relative to the world average, its performance improved greatly over the last decade.
- Of GRDI-funded scientists' top international partners, the most remarkable for their performance in genomics are the US (1st place in a multicriteria ranking performed by Science-Metrix for Genome Canada), Switzerland (2nd), the Netherlands (3rd), and the UK (4th).
- In fact, GRDI-funded scientists would most often benefit from collaborating with these four countries in selected genomics specialties.
- Unfortunately, GRDI-funded researchers do not collaborate intensely with Switzerland and the Netherlands.
- The GRDI could promote increased partnership with the US, the UK, and (especially) Switzerland and the Netherlands as a means to increase the scientific impact of the researchers it funds.
- Importantly though, the development of a collaboration strategy with a specific country should involve the identification of specific research groups from the foreign partners that excel in the targeted specialty. Bibliometrics, in combination with an environmental scan, can be used in the implementation of such a strategy.



Bibliometric analysis of GRDI-funded researchers' international scientific collaboration

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