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# *Changing patterns of international scientific collaboration*



Universiteit Leiden  
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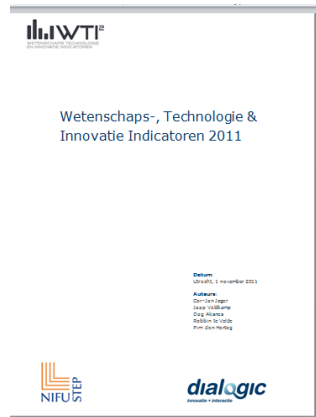
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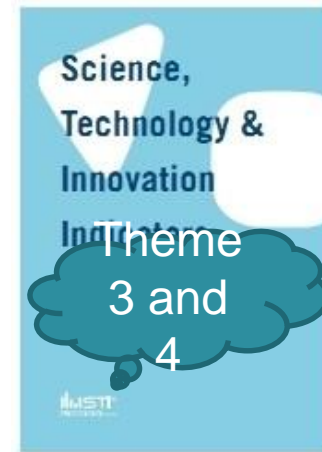


2012



2013

2014



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Olivier H. Beauchesne

**The increasing role of international collaboration is one of the most striking changes in the way science is carried out the recent decades**

**We will look at the global pattern of international collaboration measured through co-authorship and analyze trends for the 30-year period 1981 to 2011.**

## Understanding Patterns of International Scientific Collaboration

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*International scientific collaboration has increased both in volume and importance. In this article, the authors study the interpretation of macro-level data on international co-authorship collaboration. They address such questions as how one might explain country-to-country differences in the rates of international coauthorship, networks of international scientific collaboration among countries, and patterns of international collaboration in scientific fields. Attention is drawn to cognitive, social, historical, geopolitical, and economic factors as potential determinants of the observed patterns. They present a methodology that gives one a measure, independent of size, of countries' propensities to collaborate internationally.*

The first collaborative scientific paper was published in 1665,<sup>1</sup> and the number of collaborative papers has increased ever since, first slowly, then dramatically after the middle of the eighteenth century. Beaver and Rosen noted collaborative linkages across national borders as early as the nineteenth century.<sup>2</sup> These linkages increased toward the end of the century, and international collaboration has grown in importance throughout the present century.

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**Table 1. Percentage of Papers with International Institutional Coauthorships**

Subject Area	CHI 1973 Fixed Journal Set <sup>a</sup>		CHI 1981 Fixed Journal Set <sup>a</sup>
	1973	1983	1981-86
Earth and space	5.38	11.80	11.09
Mathematics	5.47	10.78	11.35
Physics	4.39	9.45	9.79
Biomedicine	3.51	6.93	7.22
Biology	3.01	5.84	5.77
Chemistry	2.42	5.37	5.68
Engineering and technology	2.04	5.16	5.69
Clinical medicine	2.47	4.77	4.98

## Data and methods

- Our study is based on the CWTS WoS database. The version of WoS applied includes the Science Citation Index Expanded, the Social Sciences Citation Index and Arts and Humanities Citation Index and covers the 30 years period 1981-2011. The database contains bibliometric data on individual journal articles (only regular journal articles, reviews and letters are included in the study).
- By definition a publication is co-authored if it has more than one author, internationally co-authored if it has authors from more than one country. International co-authorship is used as an indicator of international collaboration.

# RANDOMIZED TRIAL OF CHOLESTEROL-LOWERING IN 4444 PATIENTS WITH CORONARY-HEART-DISEASE SIMVASTATIN SURVIVAL STUDY (4S)

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LARSEN, ML (LARSEN, ML); HAASTRUP, B (HAASTRUP, B); HJAERE, I (HJAERE, I); THUROE, A (THUROE, A); LETH, A (LETH, A); M (WORCK, R); NIELSEN, B (NIELSEN, B); THORN, AG (THORN, AG); PEDERSENBJERGAARD, O (PEDERSENBJERGAARD, O); FOURNAISE, B (FOURNAISE, B); SIG (NIELSEN, H (NIELSEN, H); JACOBSEN, L (JACOBSEN, L); SVENDSEN, TL (SVENDSEN, TL); HOEGHOLM, A (HOEGHOLM, A); MUNTER, H (MUNTER, H); KAUFMAN (HAUNSO, S); GRANDE, P (GRANDE, P); ERIKSEN, C (ERIKSEN, C); NIELSEN, HH (NIELSEN, HH); JURLANDER, B (JURLANDER, B); PINBORG, T (PINBORG, T); (TOST, H); CHRISTIANSEN, BD (CHRISTIANSEN, BD); OPPENHAGEN, M (OPPENHAGEN, M); EGEDE, F (EGEDE, F); HVIDT, S (HVIDT, S); KJAERBY, T (KJAERBY, T) (KLAUSEN, I); MIETTINEN, TA (MIETTINEN, TA); VANHANEN, H (VANHANEN, H); STRANDBERG, TE (STRANDBERG, TE); HOLTTA, K (HOLTTA, K); LUOMANMAKI, H (L (VUORINEN, A (VUORINEN, A); PASTERNAK, A (PASTERNAK, A); OKSA, H (OKSA, H); SIITONEN, L (SIITONEN, L); RIMPI, R (RIMPI, R); KESANIEMI, YA (KESANIEMI (KORHONEN, T); RANTALA, A (RANTALA, A); RANTALA, M (RANTALA, M); SAVOLAINEN, M (SAVOLAINEN, M); UKKOLA, O (UKKOLA, O); LAINE, L (LAINE, L); VIRKKALA (MIETTINEN, H (MIETTINEN, H); SALOKANNEL, A (SALOKANNEL, A); RAISANEN, R (RAISANEN, R); HOGNASON, J (HOGNASON, J); KRISTJANSDOTTIR, H (KRISTJ (THORVALDSDOTTIR, G); SIGURDSSON, G (SIGURDSSON, G); SVERRISSON, JT (SVERRISSON, JT); HANSTEEN, V (HANSTEEN, V); KJELSBORG, F (KJELSBORG (PETTERSEN, R (PETTERSEN, R); BALTO, ER (BALTO, ER); HOLM, T (HOLM, T); GUNDERSEN, T (GUNDERSEN, T); ASLAKSEN, B (ASLAKSEN, B); ANDERSEN, EH (TORSVIK, H); FABER, A (FABER, A); INDREBO, T (INDREBO, T); OSE, A (OSE, A); ROTERUD, T (ROTTERUD, T); HOLSTLARSSEN, L (HOLSTLARSSEN, L); WAAGE, K (W (HOLSTLARSSEN, E); HAEREM, JW (HAEREM, JW); AUKRUST, P (AUKRUST, P); TORP, R (TORP, R); RISBERG, K (RISBERG, K); MAUSETH, K (MAUSETH, K); GERDT (NYGARD, O); HALLARAKER, A (HALLARAKER, A); GRADEK, G (GRADEK, G); VANGEN, EM (VANGEN, EM); SCHARTUMHANSEN, H (SCHARTUMHANSEN, H); REFS (LISTERUD, S); GUNDERSRUD, B (GUNDERSRUD, B); STENE, AM (STENE, AM); KLYKKEN, B (KLYKKEN, B); AAKERVIK, O (AAKERVIK, O); LORAAS, A (LORAAS, A) (A); THORESEN, L (THORESEN, L); DRIVENES, A (DRIVENES, A); LEM, P (LEM, P); GABRIELSEN, F (GABRIELSEN, F); HESTAD, S (HESTAD, S); RODE, R (RODE, R) (SKJELVAN, G); ELDORSEN, E (ELDORSEN, E); YTREARNE, K (YTREARNE, K); RASMUSSEN, K (RASMUSSEN, K); MYHRE, ESP (MYHRE, ESP); NERMOEN, I (NERMOEN (CHRISTIANSEN, L); KARLSEN, AS (KARLSEN, AS); WALBERG, K (WALBERG, K); TJONNDAL, HA (TJONNDAL, HA); KULSENG, B (KULSENG, B); ROKSETH, R (ROKSETH (TV); ROE, MO (ROE, MO); TENSTAD, O (TENSTAD, O); LOFSNES, IL (LOFSNES, IL); BERGSRUD, U (BERGSRUD, U); MELBERG, TH (MELBERG, TH); VONBRANDIS (BARVIK, S); WOIE, L (WOIE, L); ABRAHAMSEN, AM (ABRAHAMSEN, AM); AARSLAND, T (AARSLAND, T); SVANES, H (SVANES, H); NOER, G (NOER, G); NORDLIE, K (NORDLIE (HANEDALEN, AE); JOHANSEN, T (JOHANSEN, T); LARSEN, CB (LARSEN, CB); OSTHOLM, E (OSTHOLM, E); OVERSKEID, K (OVERSKEID, K); SANDVEI, P (SANDVEI (SOGNEN, E (SOGNEN, E); AARSKOG, D (AARSKOG, D); DALE, A (DALE, A); HEGRESTAD, S (HEGRESTAD, S); REIKVAM, A (REIKVAM, A); HAWKES, L (HAWKES, L); (TORJUSSEN, T); NORVIK, R (NORVIK, R); JORGENSEN, C (JORGENSEN, C); HJERMANN, I (HJERMANN, I); LEREN, P (LEREN, P); NARVESTAD, A (NARVESTAD, (GJESTVANG, FT); NORDLAND, B (NORDLAND, B); BRUNMARK, P (BRUNMARK, P); BIOKLUND, H (BIOKLUND, H); BIOKLUND, B (BIOKLUND, B); FORSBERG, H (FOR (BERGSTROM, B); LAAKSONEN, I (LAAKSONEN, I); VESTERMARK, MB (VESTERMARK, MB); MASCHER, G (MASCHER, G); HAMMARSTROM, E (HAMMARSTROM, E) (L (KARLSSON, L); HALLSTROM, L (HALLSTROM, L); STJERNA, A (STJERNA, A); SLETTE, MK (SLETTE, MK); DIDERHOLM, E (DIDERHOLM, E); PBERGLUND, K (PBERGLUND (AHLMARK, G (AHLMARK, G); SAETRE, H (SAETRE, H); AHLBERG, G (AHLBERG, G); SUNDKVIST, K (SUNDKVIST, K); GUSTAFSSON, PE (GUSTAFSSON, PE); GUST (A (NORRBY, A); JAUP, B (JAUP, B); SVENSSON, L (SVENSSON, L); WIKLUND, O (WIKLUND, O); LINDEN, T (LINDEN, T); BERGH, CH (BERGH, CH); JONSTEG, K (JON (LUNDIN, Y (LUNDIN, Y); ROMANUS, K (ROMANUS, K); 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# Background

- International collaboration is one particular kind of collaboration. In the broadest sense collaboration encompasses all research carried out by more than one person.
- In 1958 already, Smith observed an increase in the incidence of multi-authored papers (Smith, 1958), suggesting that this reflected an increasing importance of collaboration in science.
- This finding was later confirmed in many similar studies (Merton and Zuckerman, 1973; Price and Beaver, 1966).
- In recent decades this development has continued
- The single-author paper has, in fact, become an exception to the norm

**Proportion of the world production of articles that have more than author and more than one author-address by field, 1981 and 2011, per cent, selected fields**

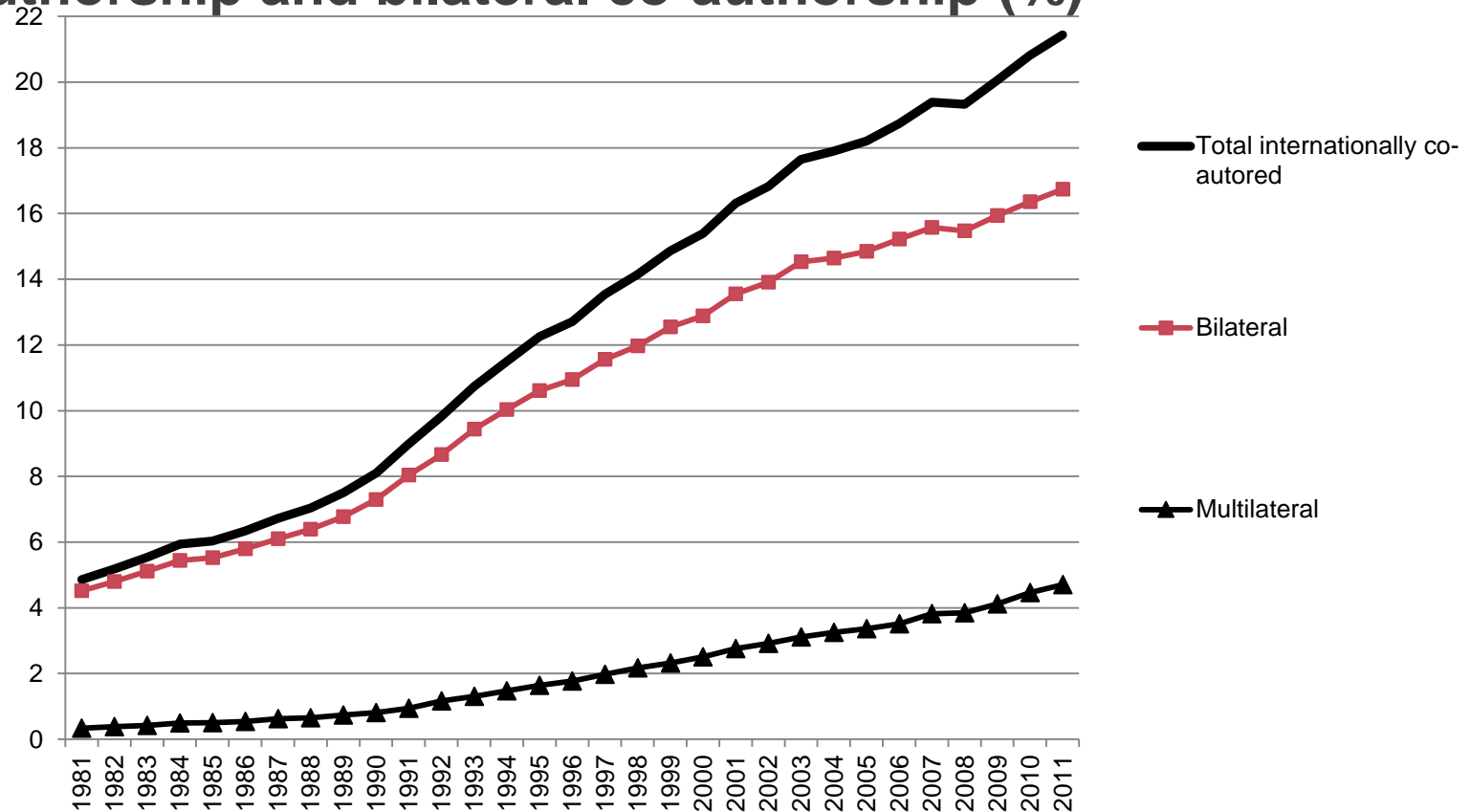
Field	Proportion of articles with more than one address		Proportion of articles with more than one author	
	1981	2011	1981	2011
BASIC MEDICAL SCIENCES	35	75	87	97
BIOMEDICAL SCIENCES	39	75	85	95
BIOLOGICAL SCIENCES	23	71	66	94
CLINICAL MEDICINE	37	73	75	94
PHYSICS AND MATERIALS SCIENCE	25	63	75	93
EARTH SCIENCES AND TECHNOLOGY	28	70	61	92
CIVIL ENGINEERING AND CONSTRUCTION	17	57	54	91
HEALTH SCIENCES	33	71	60	89
PSYCHOLOGY	26	62	57	87
ECONOMICS AND BUSINESS	21	57	32	71
MATHEMATICS	21	52	35	71
SOCIOLOGY AND ANTHROPOLOGY	21	43	33	55
POLITICAL SCIENCE AND PUBLIC ADMINIST	12	37	17	42
LANGUAGE AND LINGUISTICS	14	30	27	41
HISTORY, PHILOSOPHY AND RELIGION	6	21	8	22
CREATIVE ARTS, CULTURE AND MUSIC	5	15	6	15
LITERATURE	2	8	3	6



# International collaboration

- Beaver and Rosen (1978) identified collaborative linkages across national borders as early as the nineteenth century, and Frame and Carpenter (1979) found that the proportion of journal articles involving international co-authorship in 1973 varied from 1 to 4% in various fields of science.
- The relative number of papers with authors from more than one country has increased significantly over recent decades.
- Worldwide, the proportion of international co-authorship has risen from 4.9% in 1981 to 21.4% in 2011.

# Proportion of world production of articles involving international co-authorship, 1981-2011, multilateral co-authorship and bilateral co-authorship (%)

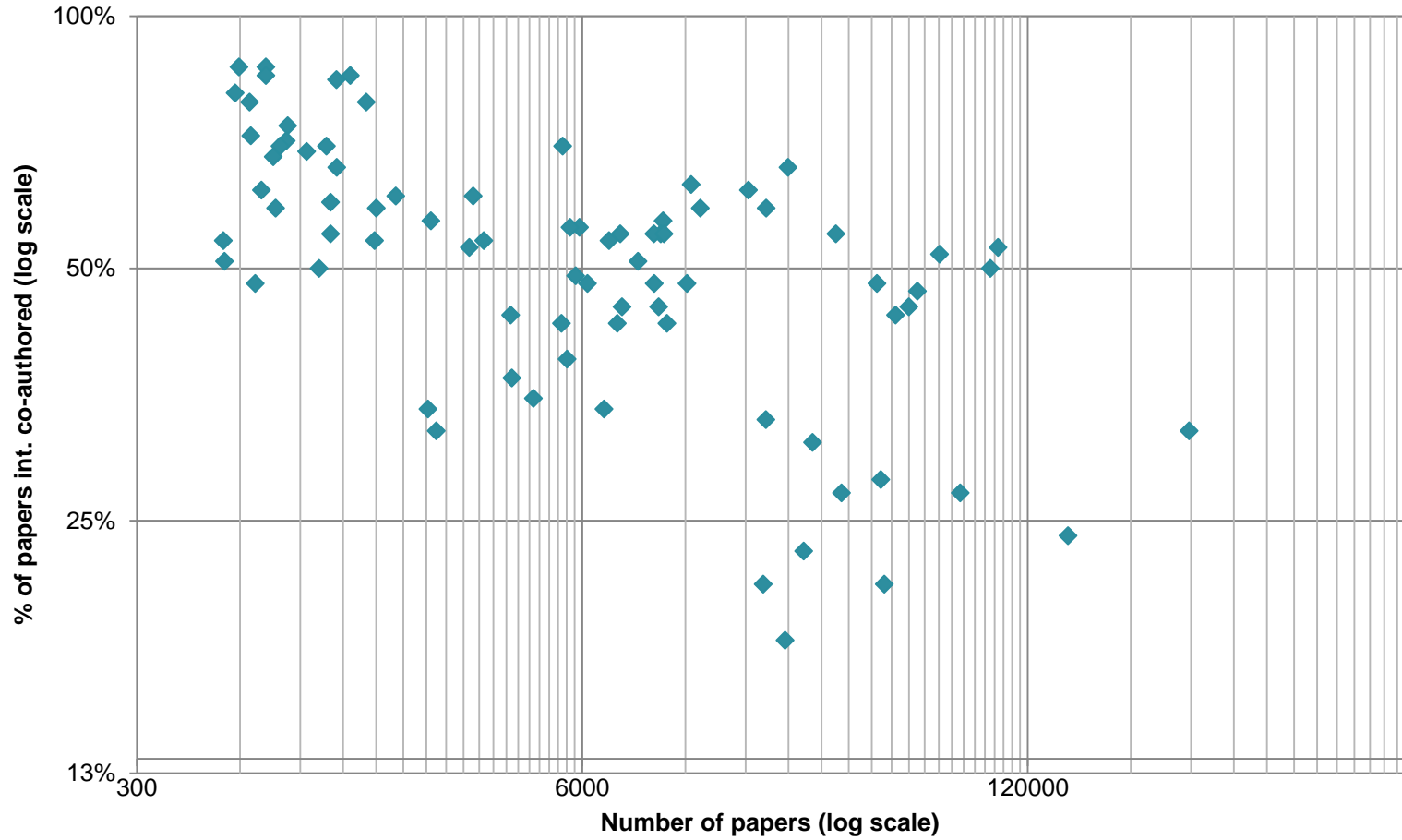


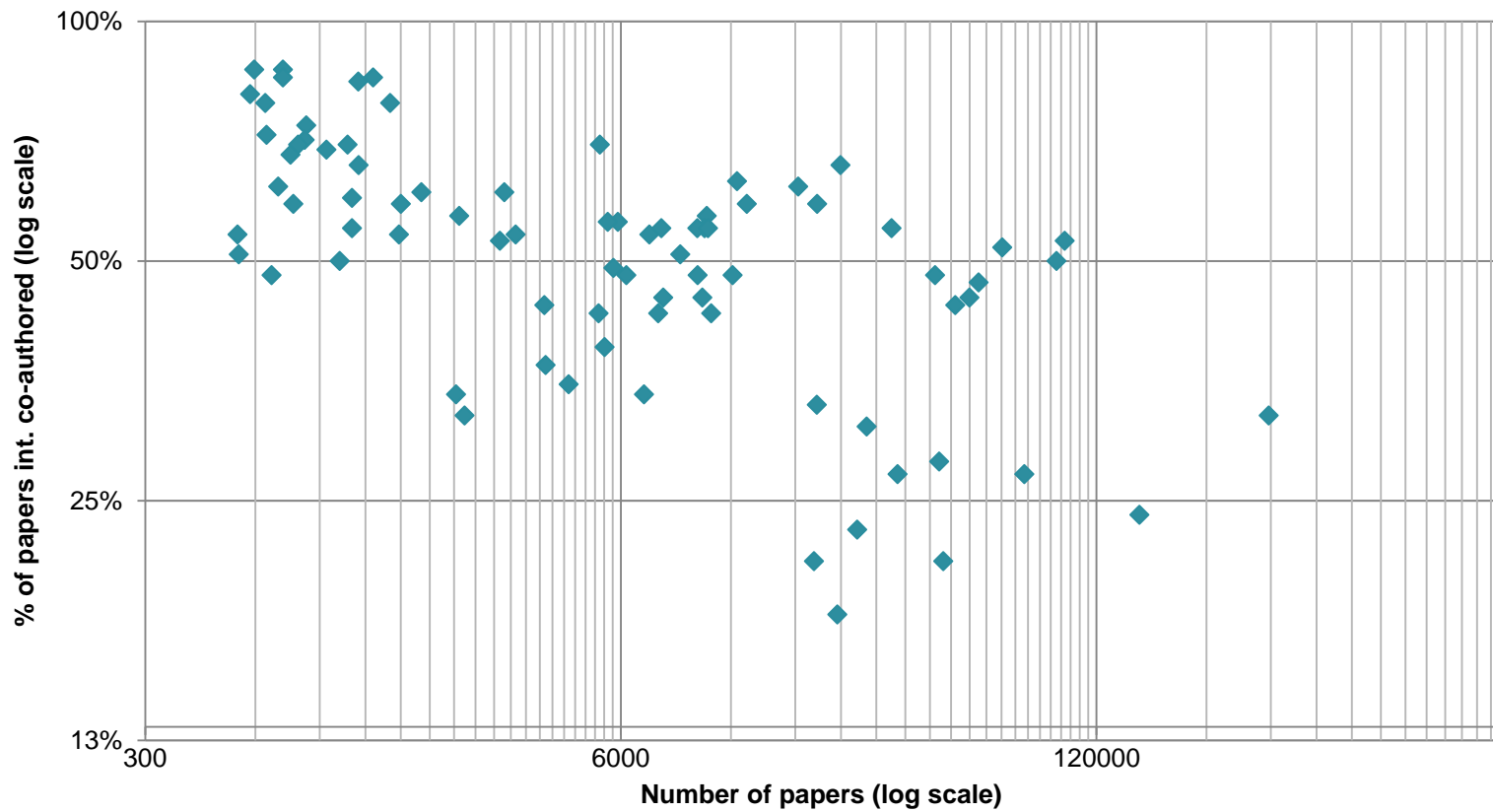
## Proportion of internationally co-authored papers by country\*, 2011.

Country	Prop	Country	Prop	Country	Prop
Tanzania	87 %	Denmark	59 %	Egypt	48 %
Uganda	87 %	Norway	57 %	Canada	47 %
Peru	85 %	Bulgaria	57 %	Italy	45 %
Kenya	85 %	Hungary	56 %	Mexico	45 %
Indonesia	84 %	Chile	56 %	Argentina	45 %
Cameroon	81 %	Netherlands	55 %	Slovenia	44 %
Luxembourg	79 %	New Zealand	55 %	Spain	44 %
Vietnam	79 %	Portugal	55 %	Greece	43 %
Iceland	74 %	Singapore	55 %	Malaysia	43 %
Ethiopia	72 %	Venezuela	55 %	Ukraine	43 %
Cuba	71 %	Finland	55 %	Pakistan	39 %
Saudi Arabia	70 %	Ireland	54 %	Croatia	37 %
Bangladesh	70 %	Slovakia	54 %	Serbia	35 %
Cyprus	70 %	Azerbaijan	54 %	Lithuania	34 %
Philippines	69 %	Estonia	54 %	Romania	34 %
Uruguay	68 %	Great Britain	53 %	Poland	33 %
Switzerland	66 %	Tunisia	53 %	Nigeria	32 %
U Arab Emirates	66 %	France	52 %	USA	32 %
Austria	63 %	Latvia	51 %	Russia	31 %
Armenia	62 %	South Africa	51 %	South Korea	28 %
Belgium	62 %	Jordan	50 %	Japan	27 %
Algeria	61 %	Germany	50 %	Brazil	27 %
Colombia	61 %	Thailand	49 %	China	24 %
Byelarus	60 %	Israel	48 %	Taiwan	23 %
Lebanon	59 %	Kuwait	48 %	India	21 %
Morocco	59 %	Australia	48 %	Iran	21 %
Sweden	59 %	Czech Republic	48 %	Turkey	18 %

\*) The 81 countries with a total of more than 500 articles in 2011.

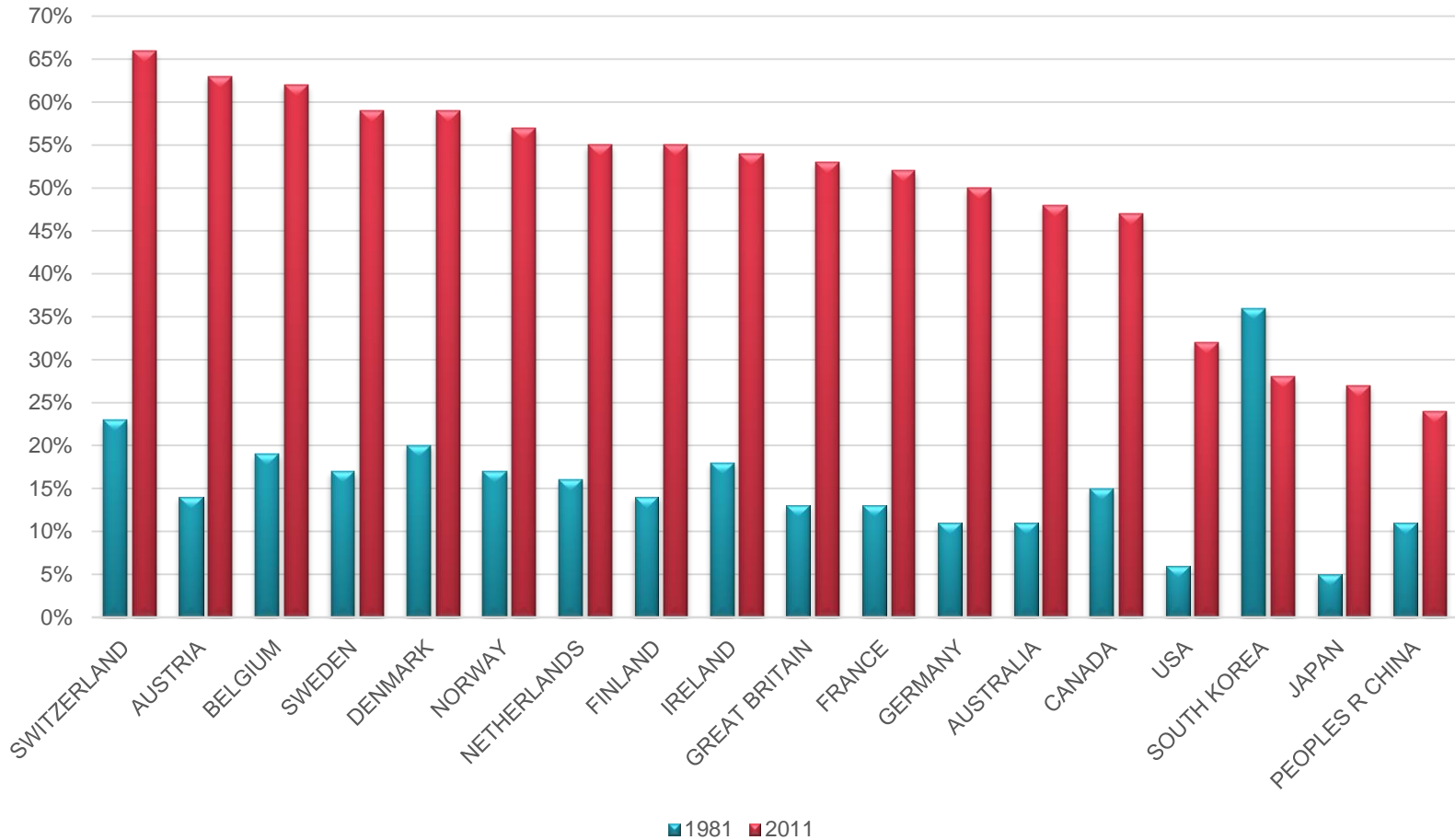
# Size and internationally co-authored papers by country, 2011



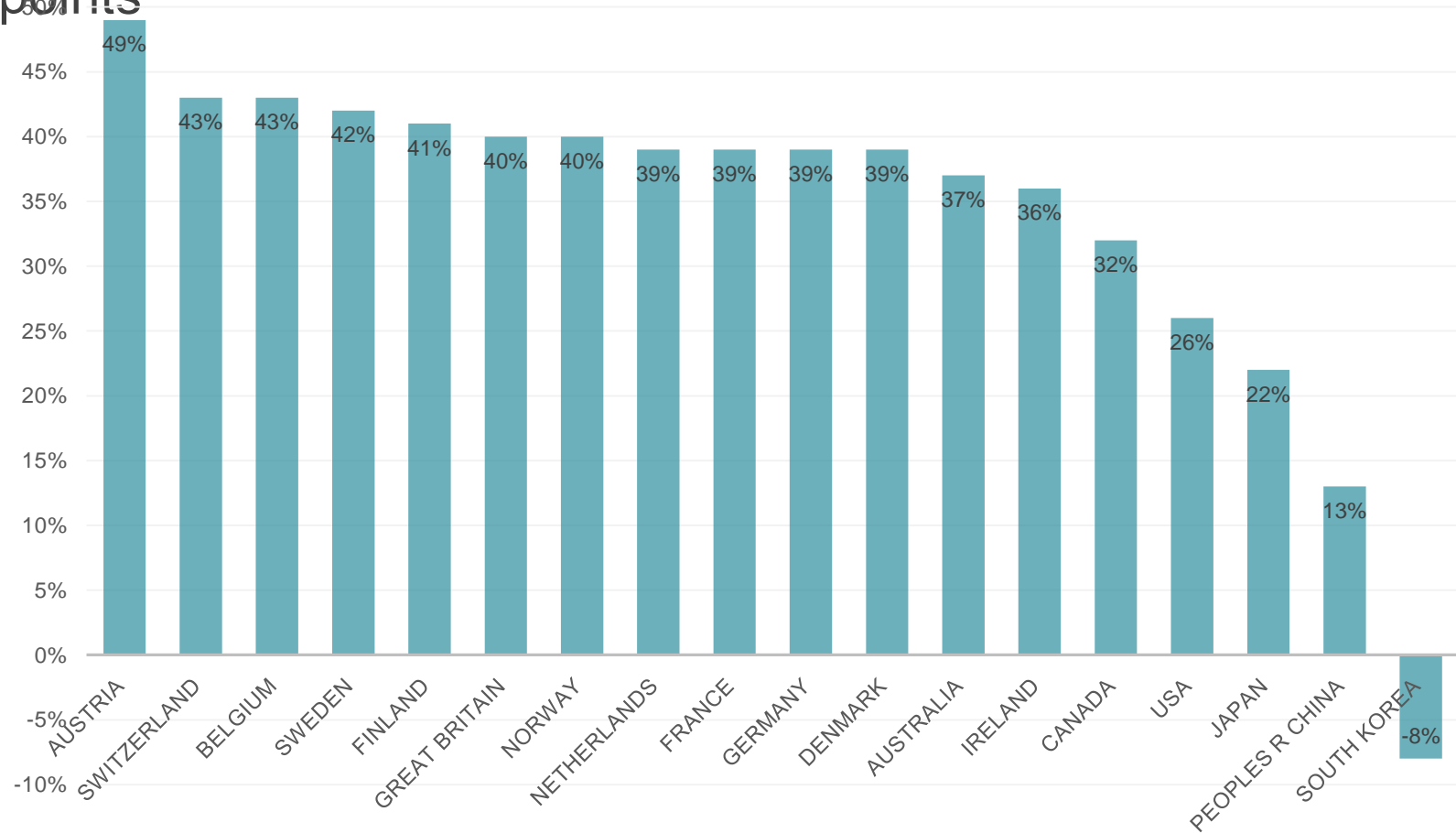


Sample	Regression	1981	1991	2001	2011
80 largest countries	Linear regression, $R^2$	0.08	0.09	0.11	0.13
80 largest countries	Logarithmic regression, $R^2$	0.43	0.41	0.36	0.42

# Proportion of the article production in 1981 and 2011 that involves international-co-authorship for selected countries.



# Increase/change in proportion of internationally co-authored articles from 1981 to 2011 for selected countries, percentage points



## Average increase in proportion of internationally co-authored paper (percentage point), by country size\* and 10 year periods.

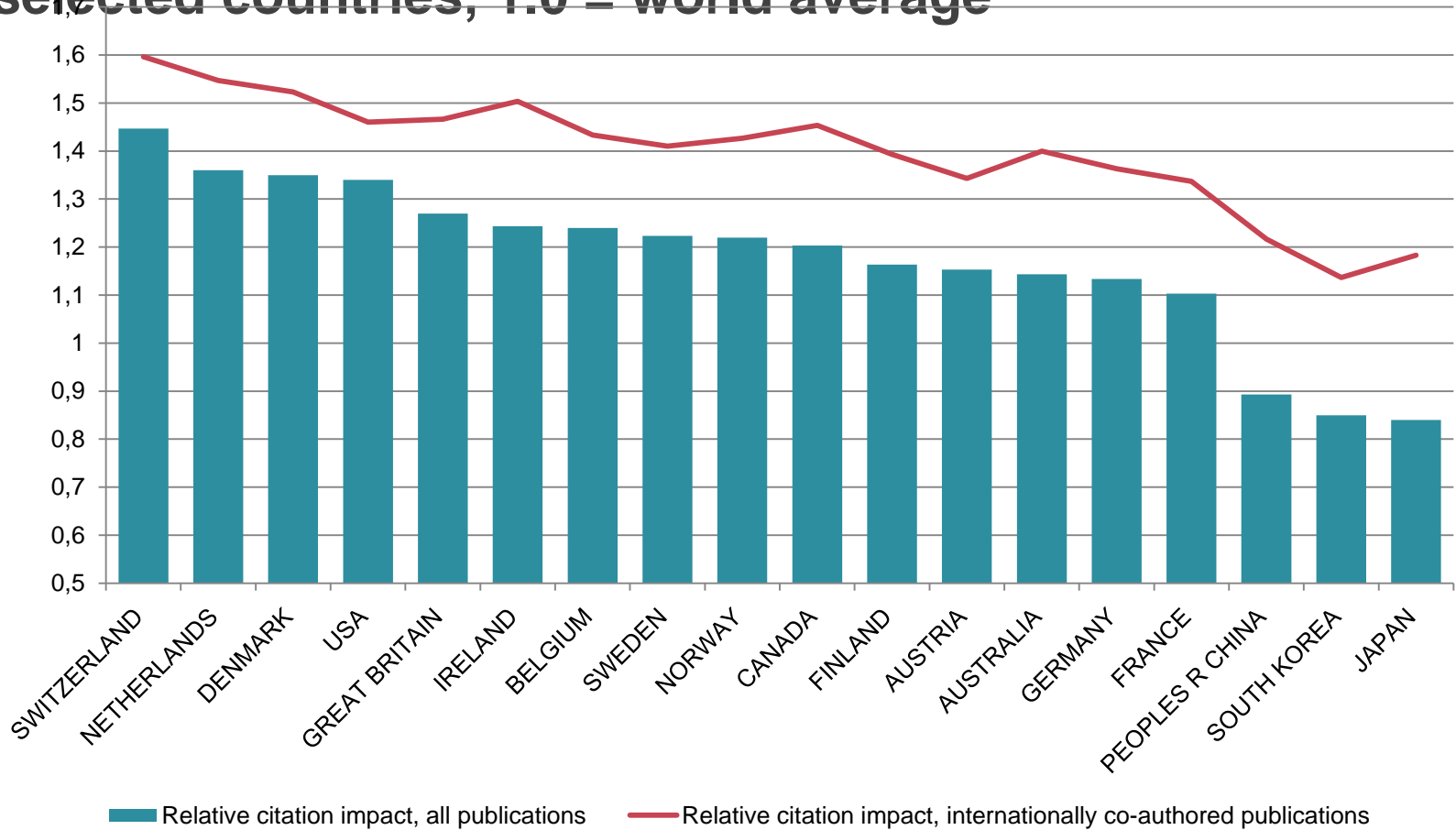
Size*, rank number	Proportion 1981	1981-1991	1991-2001	2001-2011	Total increase
1-10	9.9	7.5	13.5	9.1	30.1
11-20	15.6	12.0	11.3	6.9	30.2
21-40	15.2	10.2	11.4	9.6	31.2
41-80	27.5	10.6	13.6	7.7	31.9

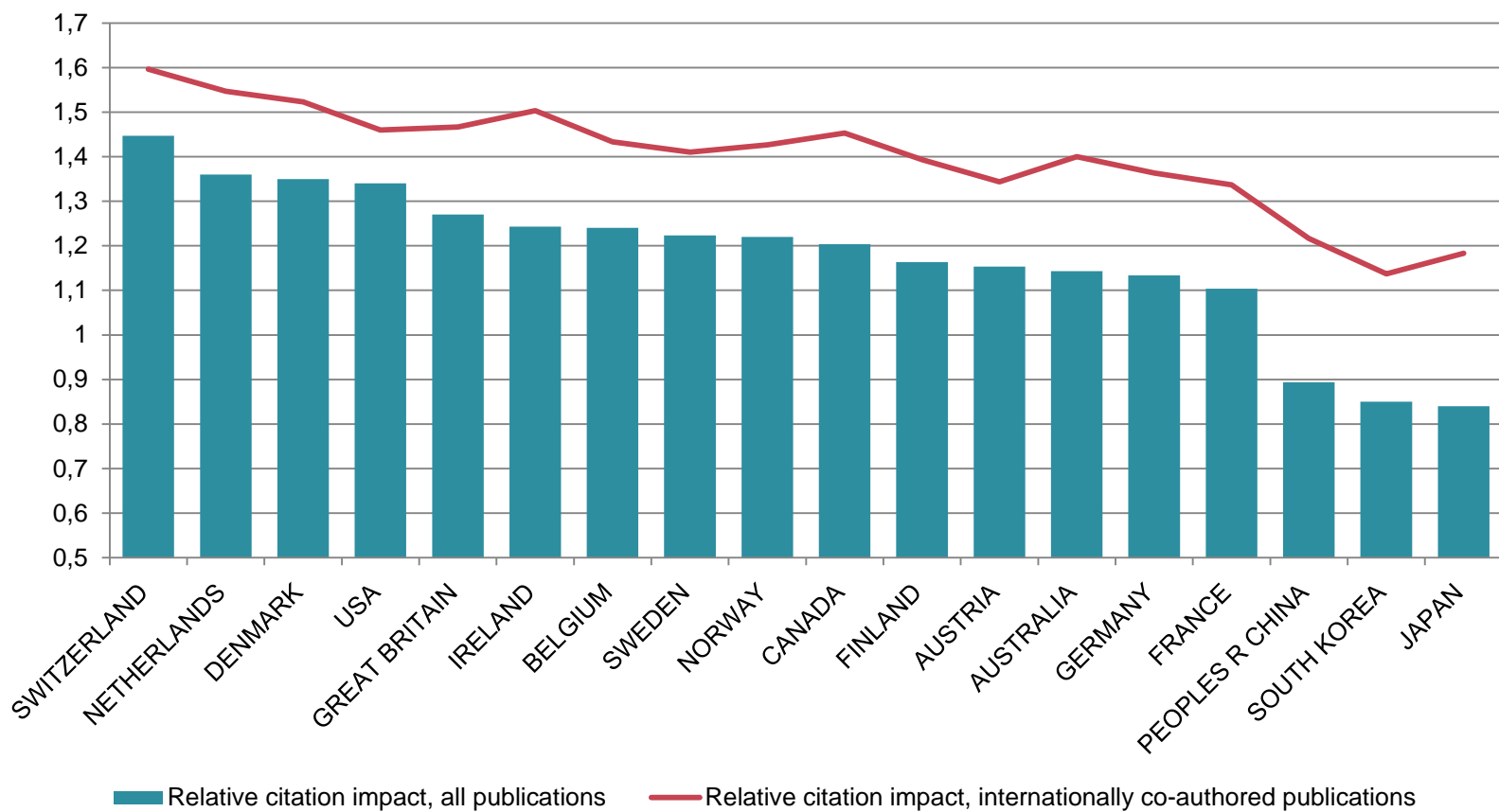


# Citation rates

- Collaboration also influences the impact of publications. Multi-authored papers are generally more highly cited than single-author papers and international co-authored publications more cited than purely domestic papers.

# Relative citation impact (field normalized) of all vs. internationally co-authored publications (2005-2007) for selected countries, 1.0 = world average





Various factors explain these higher citation rates:

- Quality of research may improve thanks to the involvement of more scientists with complementary competences, more technical resources and laboratory facilities.
- Some of the differences may be due to other effects, for example self-selection processes, in which the better, more widely-known and respected scientists are those who co-operate and author papers internationally

# Counting of publications – methodological issues

- The question of how to handle papers involving co-authorship in general and international co-authorship in particular has been a recurrent issue in the literature on the use of bibliometric indicators

Reduction in total number of publications due to fractionalization, selected countries (2012):

Country	Reduction
China	11%
Denmark	37%
Netherlands	35%
South Korea	14%
Sweden	38%
Switzerland	44%
United Kingdom	30%
United States	17%

Table 1. Reduction in total number of publications due to fr

# Conclusions

- The bibliometric analysis has provided evidence to the effect that there is a strong move towards internationalisation in science and that the research efforts of nations are becoming more and more entwined.
- It is clear that a significant structural change in the science system has taken place during a period of only 30 years.
- Collaboration with international colleagues has become a very common practice in research communities, particularly within the natural sciences, engineering and medicine.
- Large differences at the level of countries
- Large differences at the level of disciplines

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