Bibliometric study of India's Scientific Publication outputs during 2001-10

Evidence for Changing Trends

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Contents

Acknowledgment

Changing trends in activities relating to scientific publications from India have now been analyzed based on the “Evidence” report commissioned to Thomson Reuters by the Department of Science and Technology in December 2011 and updated more recently by the company.

Some data relating to Full Time Equivalents of Research and Development personnel as well as Gross Expenditure on Research and Development (GERD) have been gathered from the UNESCO Global Science Report 2010. An attempt has been made to correlate inputs to outputs in this work.

Comments from India Vision prepared by the Scientific Advisory Council to the Prime Minister have been adopted in this analysis. Analysis of R&D outputs initiated by the Science Advisory Council to the Cabinet has provided some basis for this effort.

Main motivation of the analysis of changing trends in publication habits of the Indian scientific community is to inform and assist policy bodies and funding decisions in the country. Inputs sourced from various agencies in the preparation of this analysis report are gratefully acknowledged.

This is a culmination of an effort to analyze some changing trends in publication behaviour of India vis-à-vis other developed and emerging Nations and assist in evidence based policy building.

Executive Summary

Global landscape of Science, Technology and Innovation is changing. Indian Science Sector is also undergoing significant changes. Some efforts have been made to map changes in the landscape of Indian Science, Technology and Innovation. The Department of Science and Technology had commissioned third party study to gather evidence for changes, if any, in the scientific publication outputs emanating from India. Thomson Reuters have submitted an “Evidence” report. This has now been analyzed by the Department of Science and Technology.

The analysis of changing trends in outputs of scientific publications as assessed through 5-year moving averages indicate a growth rate of about 66% between 2006-10 relative to 2001-05 period. This amounts to average growth rate of about 13% per year. The study also reveals that Chemistry, Physics, Materials Science, Engineering and Clinical medicine are the active areas of research outputs from India during the study period.

The study also reveals that though the percentage papers remaining un-cited or non- cited is on the decline, there is a need to decrease the proportion from current levels of about 48% to less than 30% through various interventions.

Citation impact of papers emanating from India has increased from 0.35 in 1981-85 to about 0.68 in 2006-10. The relative global impact of Indian research publications require significant improvements during the next five years and target a value of 1 during 12th Plan.

Engineering research is making significant progress. There is a near quadrupling of number of Indian scientific publications on the top1% journals in the world. Citation impact of Indian scientific publications in the areas of Engineering, Physics and Materials Sciences are higher than 0.8 and Psychiatry /psychology is close to 0.99 of global ratios.

There is an 81% increase in the number of publications in top 1% impact making journals during 2006-10 relative to 2001-05 periods. The impact factor profile of scientific publications reveals a bimodal distribution. There is a call for the Indian Science Community for examining the best possible means for enhancing the quality parameters of scientific publications from India.

This report has presented changing trends in scientific publications activity and proposed some possible actions for improving Indian Science and Technology output indicators.

National Science and Engineering Research Board might want to plan some actions based on this evidence provided here.

Motivation for the Bibliometric study

Global competitiveness among comity of Nations in the emerging knowledge economy of the world is often assessed from the research outputs originating from the country. Prior to 1980, India was considered as one of the major sources of Research and Development outputs from among the developing and Third world countries. In the changing global landscape of Science and Technology, relative strength of India in research and development was eroding for more than two decades. Several reasons could be attributed to such erosion of global competitiveness. Measurement of S&T outputs from various countries had revealed the loss of competitiveness of India in the Research and Development Sector. Serious concerns had been expressed about the eroding competitiveness of India in Science, Technology and Innovation by various advisory groups[1,2]. Policy interventions for regaining the relative strength had been sought by the Indian Science Community. In response to such calls, India seeks to adopt evidence-based approaches for building national Research and Development policies and arrive at investments decisions.

Global share of publications in journals indexed by Science Citation Index has become one of the Science and Technology output indicators for assessing the competitiveness of National R&D systems. National commitment to strengthen R&D systems has been made by the successive Governments[3,4].

In order to develop evidence-based approaches to policy building, the Department of Science and Technology commissioned bibliometric studies from third party agencies. Gathering of Evidence as input for planning exercises is the motivating reason for commissioned studies. Informing policy bodies and decision making agencies about the changing trends is the objective of this report.

"Evidence" Report of Thomson Reuters

Thomson Reuters, one of the global agencies involved in gathering "Evidence" as a business have been commissioned to undertake an India-specific study. The "evidence "report has presented a large volume of data and trends in research outputs from India. The Report is appended in **Annexure 1,** which brings out the observations of Thomson Reuters.

The Thomson Reuters study is expected to document output indicators originating from India. It compares output data relevant to India with those of some select countries.

Analysis of Changing Trends in Indian Scientific Research outputs

The Department of Science and Technology, Government of India, in its capacity as a policy and funding body has undertaken a study to analyse the data and trends reported by Thomson Reuters in “Evidence” report. This analysis is to help Indian funding agencies in decision making. While third party studies form useful tools for measuring output indicators, output to input and outcome to input relations would require additional effort. This analysis report is an effort of the Department of Science and Technology for carrying out evidence-based approach for R&D funding and policy building.

Changing Trends: Observations from "Evidence Report"

Global Volume Share of Scientific publications from India

Evidence report Thomson Reuters has presented data on Global Share of India with respect to scientific publications as captured by SCI data bases. The report has also presented relative comparisons of India with respect to developed and some leading emerging economies of the world. The period of study is 1981 to 2010. Methodologies adopted by the company have been well articulated. Data collected and presented by Thomson Reuters Annexure-1 have been used in analyzing the changing trends in this report.

The changing trends in number and global share of scientific publications from SCI data base are presented in **Figure 1a and 1b,** respectively**.**

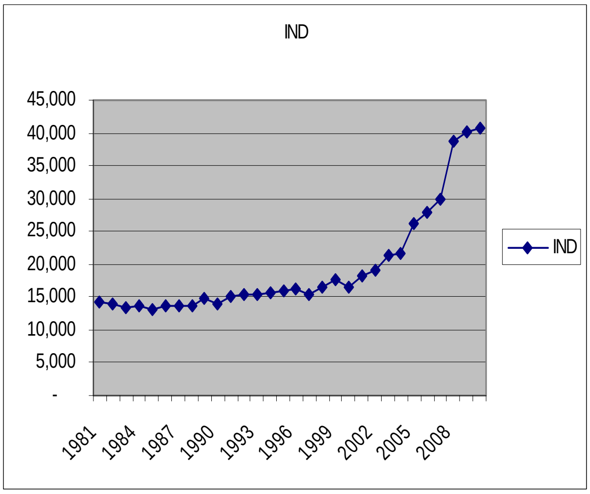


Figure 1a: Changing Trends in number of publications

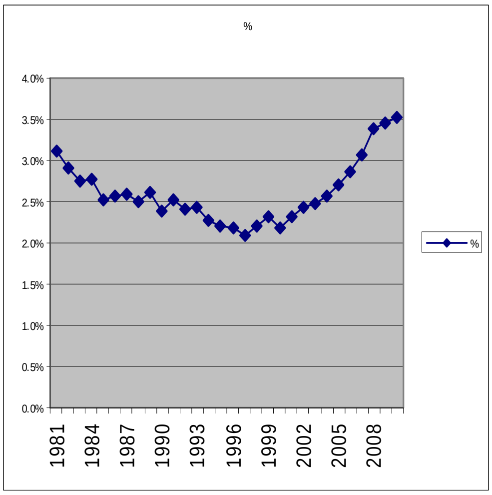


Figure 1b: changing Trends in global Share of publications

Source: Evidence report of Thomson Reuters December 2011

It is evident from trends presented in Figure 1a and 1b that India has started to regain the volume share of scientific publications lost during 1980's since 2002. The present global share of scientific publications is about 3.5%. Based on relative share, India ranks currently 9th in the world with respect to scientific publications in SCI journals. Based on the current trends, India could vie for a share of about 5% within the next five years. This would call for planned investments and concerted actions from all the stake holders.

1. Comparisons of publication outputs relative to Developed Economies

Comparisons of Indian performance with respect to SCI publications with respect to some developed countries (Australia, France, Germany, Israel, Italy, Japan, UK and USA) in global share are represented in **Figure 2.**

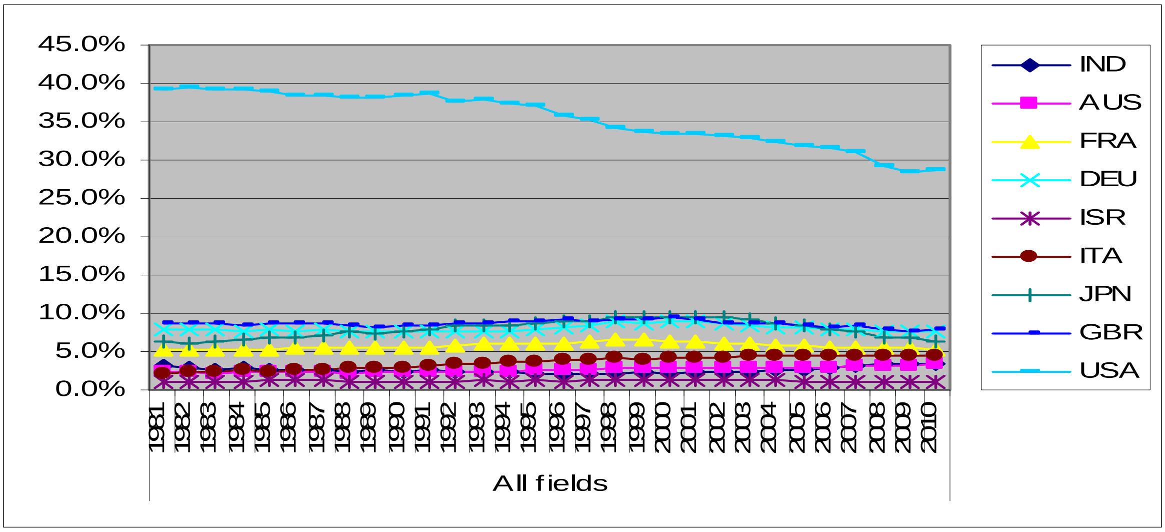


Figure 2: Comparative performance of India with respect to Developed countries

With the relative share around 3.5%, India does not compare favourably at present with respect to developed economies as evident from Figure 2. However, relative share of many developed countries in scientific publications is decreasing at this time. In the new geography of science, it is expected by the developed countries that India would emerge as one of the important powers during the next two decades.

Should the present trends continue and India improves its share, there is some likelihood for better positioning of India in relative ranking. It is predicted that relative position of India could improve to 5th or 6th in about 3-6 years time. A comparison is made among various developed countries and India with respect to investments and number of Full Time Equivalent of R&D professionals in the **Table 1.**

Table 1: Comparison of Input -Output Relations for a select group of Nations

S. No	Country	GERD (in parenthesis is percentage of GDP)	FTEs of R&D personnel(number of parenthesis is global rank in FTEs)	Relative ranking of Scientific outputs. SCI Publications (number of parenthesis is global rank)
1	Australia	15.36 (2.06)	87,140(14)	28313(12)
2	Canada	23.96 (1.84)	139,011(10)	43539(8)
3	France	42.89 (2.02)	215,755(8)	57133(6)
4	Germany	72.24(2.54)	290,853(5)	76368(3)
5	India	24.79 (0.9)	154,827(9)	36261(9)
6	Italy	22.12 (1.18)	96,303(13)	45273(7)
7	Japan	147.9 (3.44)	709,974(3)	74618(4)
8	Spain	19.34 (1.34)	130,896(12)	35739(10)
9	UK	41.04 (1.88)	261,406(6)	71,302(5)
10	USA	398 (2.82)	1425,550(1)	272,879 (1)

Publications Data relevant to 2008; GERD relevant to 2007; GERD in billion dollar adjusted to PPP
Source: UNESCO Global Science Report 2010

It is evident from data presented in Table 1 above that all countries with relative ranking better than India with respect to SCI publications invest more and with the exception of Italy, employ larger number of Full Time Equivalents of R&D professionals compared to India.

2. Comparisons relative to some Select Emerging Economies

Comparisons of Indian performance with respect to SCI publications with respect to some select emerging economies in global share are represented in **Figure 3**.

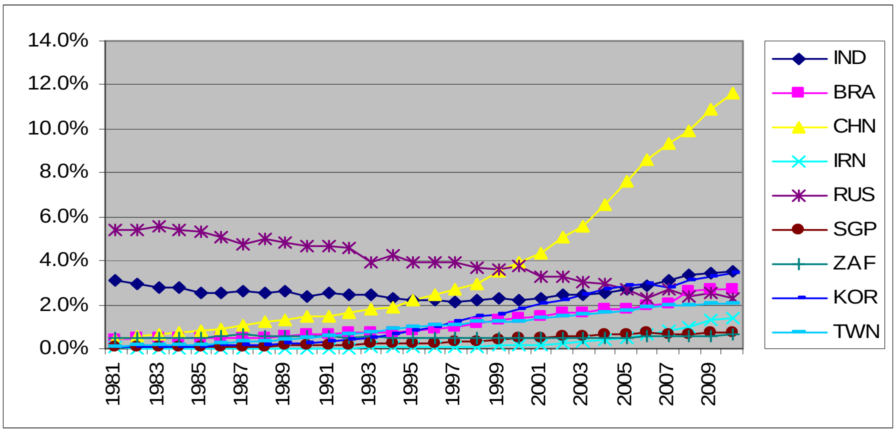


Figure 3: Comparative performance of India with respect to emerging economies

The current and relative global volume share of 3.5% of India compares favourably with many other emerging economies but not China as seen from the trends presented in **Figure 3**. However, countries like Korea and Brazil are growing their research outputs at high rates. They could outperform India in volume share in future, if India were to slacken the R&D effort and engagement. A comparison is made among various emerging countries and India with respect to investments and number of Full Time Equivalent of R&D professionals in the **Table 2.**

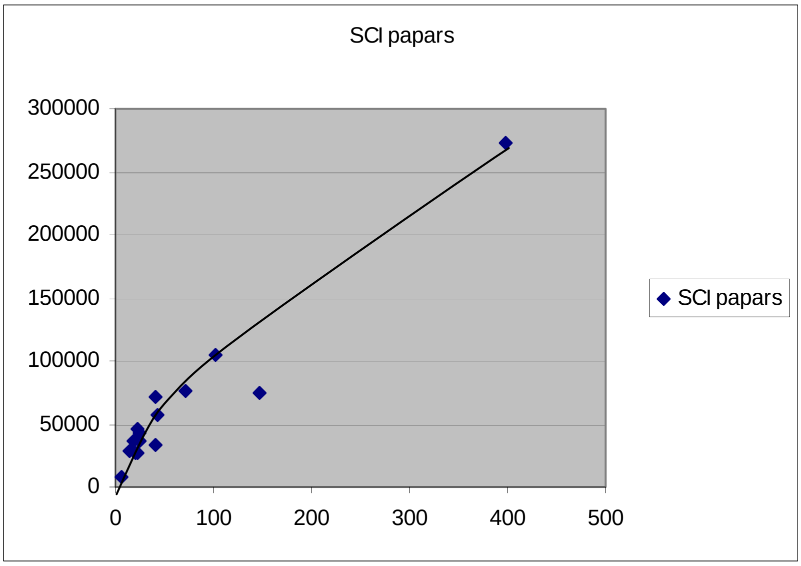
Table 2: Comparison of investments and number of Full Time Equivalent of R&D professionals for a select group of Nations

S. No	Country	GERD (number in parenthesis is %GERD to GDP)	FTEs of R&D personnel(number of parenthesis is global rank in FTEs)	Relative ranking of Scientific outputs. SCI Publications (number of parenthesis is global rank)
1	Brazil	20.2 (1.1)	133,266(11)	26482(14)
2	China	102.4 (1.49)	1423,380(2)	104968(2)
3	India	24.8 (0.9)	154,827(9)	36261(9)
4	Korea	41.3 (3.21)	221,928(7)	32781(11)
5	Mexico	55.9	37,930(16)	8262(16)
6	Russia	23.4 (1.03)	451,213(4)	27083(13)

Publications Data relevant to 2008; GERD relevant to 2007; GERD in billion dollar adjusted to PPP
Source: UNESCO Global Science Report 2010

It is evident from the data presented in **Table 2** that relative positioning of India with respect to China in scientific publications could be traced to among other reasons, levels of differences in inputs as well as policy derived causes. Emerging countries like Korea invest significantly into R&D. Their aspirations in relating knowledge to economic development are evident in their policy instruments. Brazil is aggressive in promoting Research and Development. India needs to adopt approaches which do not lead to erosion of strengths regained during the last few years.

Correlations of Gross Expenditure on R &D against SCI publications reveal that UK, Italy and India deviate from the mean line on positive side, while Korea, Russia and Japan on the negative side.



GERD Vs SCI publications of some major economies

3. India's growth Performance in SCI publications with respect to time

The relative performance of various sub sectors and disciplines of science with respect to SCI publications has been studied for 21 discipline areas listed here under.

- Clinical medicine
- Psychiatry and Psychology
- Neuroscience and Behaviour
- Immunology
- Pharmacology and Toxicology
- Molecular biology and Genomics
- Biology and Biochemistry
- Microbiology
- Plant and Animal Sciences
- Agricultural Sciences
- Environment and Ecology
- Geosciences
- Chemistry
- Physics
- Space Science
- Materials science
- Mathematics
- Computer science
- Engineering
- Economics and Business
- Social sciences

An approach to investigate performance of Indian S&T system through five-year moving averages rather than annual data has been preferred. Such a moving average offers an opportunity to avoid year-year aberrations; diminishing the value of trend analysis. Evidence report of Thomson Reuters has accordingly adopted the approach of evaluating five-year moving approaches.

The total number of publications from India has increased from 106,456 during 2001-05 to 177,208 in 2006-10. This amounts to an increase of about 66% during the five year period. If India could maintain such a growth rate, aggregated outputs of India during 2011-15 could be estimated at about 3,00,000.

4. Changing trends in Volume outputs of India: Discipline wise

Volume of scientific publication outputs emanating from India has been mapped 21 discipline areas listed above in "evidence" report of Thomson Reuters. The sub-classifications adopted by the company are the same as for other countries in the world. The data on the volume of outputs of scientific publications have been sourced from the Evidence report.

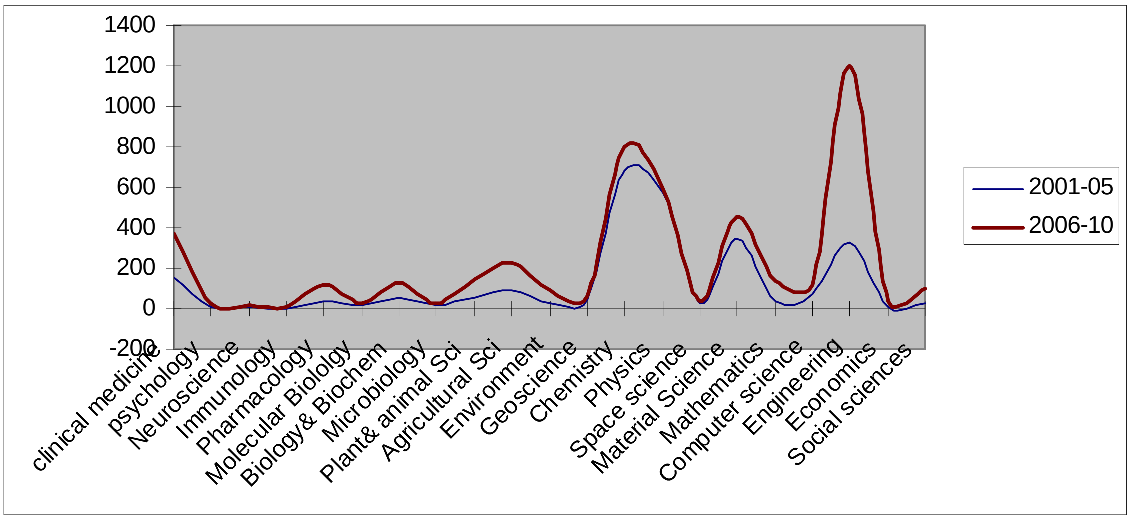
Outputs during the five year periods between 2001-05 as well as 2006-10 have been computed and presented in **Table 3**. The percentage changes in moving averages for each discipline have been worked out in this study. Such an analysis offers information on changing trends in discipline-wise manner.

Table 3: Volume of Indian Scientific Publication Outputs and changes in moving averages

S.No	Subject	SCI publications 2001-05	SCI publications 2006-10	% Change of moving average
1	Clinical medicine	10046	19273	92
2	Psychology	282	475	33
3	Neuroscience	1228	1720	41
4	Immunology	653	1181	80
5	Pharmacology	2518	5755	125
6	Molecular Biology	1367	2675	91
7	Biology& Biochem	5403	9722	82
8	Microbiology	1327	3736	180
9	Plant& animal Sci	8748	11591	33
10	Agricultural Sci	4514	7270	60
11	Environment	2737	4858	80

12	Geoscience	3566	5508	55
13	Chemistry	25719	38920	51
14	Physics	13490	20525	53
15	Space science	1381	2040	50
16	Materials Science	7987	14190	77
17	Mathematics	2071	3224	55
18	Computer science	1828	2703	48
19	Engineering	9605	18596	96
20	Economics	384	720	89
21	Social sciences	1036	1847	81
	Total outputs	**106,456**	**177,208**	**66**

Increasing trends in publications in terms of moving averages of the 21 discipline areas are represented in **Figure 4**



"Evidence" document reports an increase in the volume of outputs in all discipline areas of science during the 2006-10 relative to 2001-05. Some discipline areas have registered higher increases than the 66% overall average of India. Relative ranking of publication outputs are as shown in **Table 4.**

Table 4: Relative ranking in various discipline areas in terms of publication outputs

Relative rank in volume share		Subject	Number of Publications 2001-05	Number of Publications 2006-10	% Change of moving average	% global share
2010	**2005**					
1	1	Chemistry	25719	38920	51	6.5
2	2	Physics	13490	20525	53	4.6
3	3	Clinical medicine	10046	19273	92	1.9
4	4	Engineering	9605	18596	89	4.2
5	6	Materials Science	7987	14190	77	6.4
6	5	Plant& animal Sci	8748	11591	33	3.9
7	7	Biology& Biochem	5403	9722	82	3.8
8	8	Agricultural Sci	4514	7270	60	6.2
9	11	Pharmacology	2518	5755	125	6.1
10	9	Geoscience	3566	5508	55	3.2
11	10	Environment	2737	4858	80	3.5
12	16	Microbiology	1327	3736	180	4.9
13	12	Mathematics	2071	3224	55	~2
14	13	Computer science	1828	2703	48	2.4
15	15	Molecular Biology	1367	2675	91	2.1
16	14	Space science	1381	2040	50	3.4
17	18	Social sciences	1036	1847	81	~0.6
18	17	Neuroscience	1228	1720	41	1.4
19	19	Immunology	653	1181	80	1.8
20	20	Economics	384	720	89	~0.7
21	21	Psychology	282	475	33	~0.5

Publication activities in disciplines like microbiology, pharmacology and material science seem to have maintained high growth rates; gaining improvements in relative ranks. Many large density publication areas, however, represent conventional strength of the country. Relatively lower ranking of mathematics and computer sciences is an area of concern. Although in agriculture, scientific publication outputs and global share seem reasonable, it is a matter of concern that global share of India had been falling, which was at 7.4% during 1981 to 1995. Brazil enjoys 9.5% share ahead of even China. The need for serious efforts and special efforts to strengthen research in the area of mathematics and computer sciences is apparent from the data given in **Table 4.**

5. Changing Trends in Citation Impacts of India: Discipline wise

Citation impacts of scientific publications emanating from Indian research over two decades have been analyzed discipline wise. The observed trends have been summarized in **Table 5** for the 21 discipline areas. There is an overall improvement in citation impacts across the 21 discipline areas relative to the 1993-97 periods. However, there are some signals that merit attention. In case of some areas, improvements are limited to only recovering lost ground. This is the case for materials, agriculture and neuro-, immunology sciences.

Four discipline areas gaining considerable improvements in citation impacts are psychology, physics, engineering and social sciences. Improvements in R&D in engineering discipline are particularly noteworthy. It represents a case of high density and high impact. Citation impacts of publications in Physics and material science areas represent traditional strengths of the country. Chemistry is a case of border line, where the high density is starting to match also with high impact. Stagnancy of citation impact of research in immunology is disconcerting.

Table 5: Moving averages of Citation impacts of Indian scientific publications

Sl no	Discipline	Citation impact ratio 1981-85	Citation impact ratio 1993-97	Citation impact ratio 2006-10	Difference 2006-10 to 1993-97	Difference 2006-10 to 1981-85
1	Clinical medicine	0.34	0.42	0.58	0.16	0.24
2	Psychology	0.29	0.44	0.99	0.45	0.70
3	Neuroscience	0.31	0.25	0.55	0.30	0.24
4	Immunology	0.53	0.47	0.51	0.04	-0.02
5	Pharmacology	0.46	0.55	0.64	0.09	0.18
6	Molecular Biology	0.16	0.3	0.47	0.17	0.31
7	Biology& Biochem	0.19	0.28	0.55	0.27	0.36
8	Microbiology	0.24	0.38	0.62	0.24	0.38
9	Plant& animal Sci	0.23	0.29	0.46	0.17	0.23
10	Agricultural Sci	0.3	0.27	0.55	0.28	0.25
11	Environment	0.25	0.37	0.64	0.27	0.39
12	Geoscience	0.27	0.3	0.49	0.19	0.22
13	Chemistry	0.4	0.5	0.68	0.18	0.28
14	Physics	0.37	0.63	0.82	0.19	0.48
15	Space science	0.23	0.44	0.63	0.19	0.40
16	Materials Science	0.8	0.71	0.82	0.11	0.02
17	Mathematics	0.38	0.44	0.67	0.23	0.29
18	Computer science		0.65	0.81	0.16	--
19	Engineering	0.52	0.67	0.95	0.28	0.43

20	Economics	0.43	0.44	0.66	0.22	0.23
21	Social sciences	0.25	0.27	0.75	0.48	0.50
	Overall	**0.35**	**0.47**	**0.68**	**0.21**	**0.33**

Citation impacts of Indian scientific publications seem to be increasing since 1993-97 steadily. Near doubling of the citation impact of Indian publications since 1981-85 is evident from the data in **Table 5**.

In the area of chemistry, India has gained fifth rank globally with respect to number of publications. Strategic efforts to enhance the citation impact of Indian publications in chemistry would be in order. Research in engineering seems to have picked up momentum in recent years. The expansion in volume of publications in engineering seems to have been accomplished without loss of citation impact and quality of publications. India has exceeded Japan in citation impact of publications in the area of engineering. A more focussed effort to strengthen research outputs in engineering may be in order. International cooperation in the area of physics might benefit the country in terms of both volume and value impact, especially in areas of experimental physics. Moving averages of citation impacts of Indian publications have been ranked and presented in **Table 6.**

Table 6: Moving averages of citation impacts over five year cycles

Relative rank as of		Discipline	Citation impact ratio 1981-85	Citation impact ratio 1993-97	Citation impact ratio 2006-10
2010	**1997**				
1	8	Psychology	0.29	0.44	0.99
2	2	Engineering	0.52	0.67	0.95
3	4	Physics	0.37	0.63	0.82
4	1	Materials Science	0.8	0.71	0.82
5	3	Computer science		0.65	0.81
6	20	Social sciences	0.25	0.27	0.75
7	6	Chemistry	0.4	0.5	0.68
8	8	Mathematics	0.38	0.44	0.67
9	8	Economics	0.43	0.44	0.66
10	5	Pharmacology	0.46	0.55	0.64
11	14	Environment	0.25	0.37	0.64
12	8	Space science	0.23	0.44	0.63
13	13	Microbiology	0.24	0.38	0.62
14	12	Clinical medicine	0.34	0.42	0.58
15	21	Neuroscience	0.31	0.25	0.55
16	18	Biology& Biochem	0.19	0.28	0.55
17	19	Agricultural Science	0.3	0.27	0.55

18	7	Immunology	0.53	0.47	0.51
19	15	Geoscience	0.27	0.3	0.49
20	15	Molecular Biology	0.16	0.3	0.47
21	17	Plant& Animal Science	0.23	0.29	0.46

Of the 21 discipline areas, nearly one third have registered equal or higher citation impacts relative to National averages as per the data relevant to 2006-10. Among the seven discipline areas, namely, psychology, engineering, physics, material science computer science, social science and chemistry, four are grouped under the category of high density and high impact. Indian publications in the areas of psychology, computer science and social sciences need to increase the volume and density for making global impact.

The relatively lower citation impact in areas like plant and animal sciences, molecular biology and geosciences and moderate impact in areas like clinical medicine, biology, biochemistry and agricultural sciences calls for special attention from the national planners and the relevant scientific community.

6. Changing Trends in the Indian Share of Top 1% impact making Journals

The relatively low share of India in top 1% journals has been a matter of concern. It has been stated that the share of Indian publications in top 1% impact making journals has been as low as 0.54%[1] as of 2001. One of the parameters used for assessing the global impact of the national S&T system has been share in the top 1% of the impact making journals. Evidence report has specifically addressed this parameter for the period 2001-10.

It has been observed that the number of papers in top 1% impact making journals has increased from 2610 to 4723 for the reference periods. These represent only 2.5 to 2.7% of the publications of India.

Considerable improvements in these parameters are possible in future. This would call for strategies for specifically addressing the issue of increasing the global share of publications in top 1% journals.

Engineering discipline has gained the most during 2006-10. In terms of citation impact, India has surpassed China in case of scientific publications in engineering.

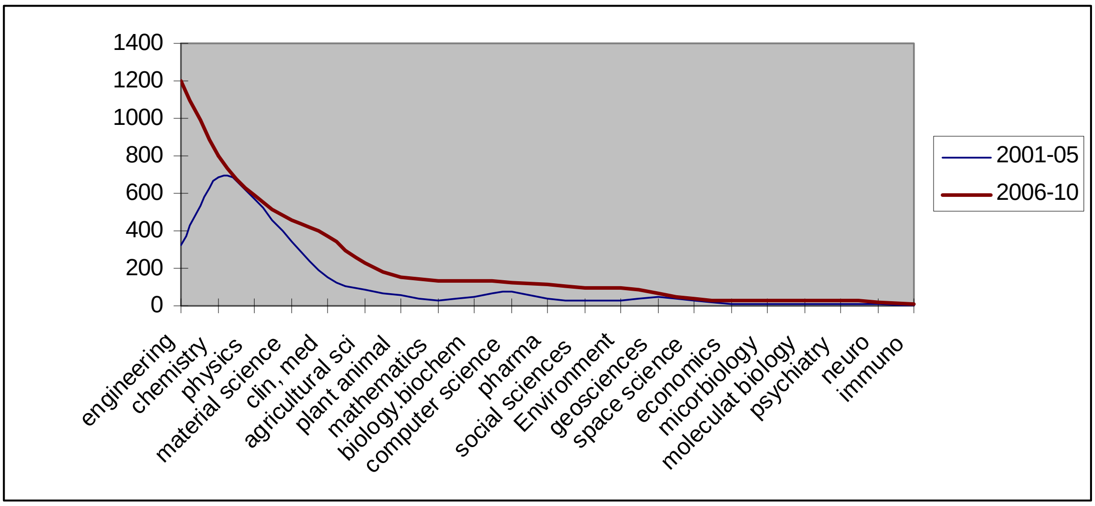
The relative ranking of scientific disciplines contributing to the scientific publications in the top 1% journals is presented in **Table 7.**

Table 7: Relative ranking of scientific disciplines contributing to the scientific publications in the top 1% journals

Relative rank		Discipline	Number of papers in top 1% impact journals 2001-05	Number of papers in top 1% impact journals 2006-10
2010	**2005**			
1	4	Engineering	324	1204
2	1	Chemistry	685	797
3	2	Physics	572	587
4	3	Materials science	340	454
5	5	Clinical medicine	155	369
6	6	Agricultural science	89	226
7	8	Plant & animal	58	148
8	12	Mathematics	33	133
9	9	Biology& Biochem.	51	130
10	7	Computer science	75	122
11	11	Pharmacology	39	117
12	14	Social sciences	26	100
13	13	Environment	31	94
14	10	Geosciences	48	63
15	15	Space science	25	36
16	20	Economics	7	32
17	16	Microbiology	14	31
18	19	Psychiatry	9	25
19	17	Molecular biology	14	25
20	18	Neurosciences	11	18
21	21	Immunology	3	8

More than 60% of the increase in the top 1% journals seems to have emanated from just four disciplines namely Engineering, Chemistry, Clinical medicine and Materials science. Changing trends in contributions to share in impact making scientific publications are depicted in **Figure 5** below.

Figure 5: Changing trends in contributions to share in impact making scientific publications



The trends indicate that Engineering has surpassed chemistry, physics and materials science in relative rankings during the study periods.

- ❖ The net gaining disciplines with respect to national ranking are engineering, plant and animal sciences, mathematics, social sciences and economics.
- ❖ A major loser in the relative ranking among disciplines is geosciences with respect to contributions in top 1% publications.

Special efforts for promoting research in centres of excellence in disciplines like geosciences, mathematics etc and fostering collaborations in clinical medicine as well as disease biology might offer significant benefits to the country at this stage of development. Mission mode efforts in areas like Geosciences might be considered.

7. Degree of non-cited-ness of publications emanating from India

The Evidence report of Thomson Reuters has shown that there is a decrease in the percentage of papers emanating from India which do not receive citations. Discipline wise analysis of non-cited-ness of publications has been made and presented in **Table 8**. Need for reducing the degree non-cited-ness of publications by at least factor of about two is stressed in this analysis. Degree of non-cited-ness of publications from developed countries is generally in the range of ~25%.

Table 8: **Data on non-cited-ness of Indian publications on various disciplines**

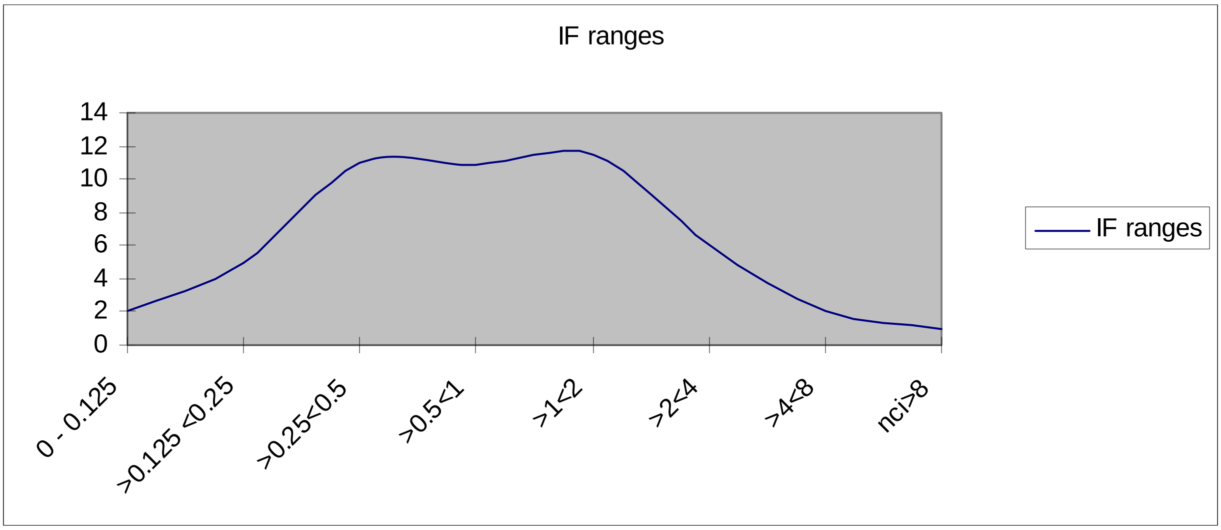
Relative rank		Discipline	% uncitedness	
2010	**2005**		**2001-05**	**2006-10**
1	1	Immunology	36.9	25.9
2	2	Molecular biology	36.9	33
3	7	Psychology	43.6	34.4
4	5	Space science	40.8	34.5
5	11	Neurosciences	48.1	35.8
6	4	Biology & Biochemistry	40.6	37.9
7	8	Chemistry	46.2	39.6
8	13	Environment	53.7	39.9
9	9	Physics	46.8	40.1
10	12	Materials science	51.3	41.4
11	6	Pharmacology	40.9	42.1
12	10	Clinical medicine	47.3	43.8
		Overall	**51.9**	**44.9**
13	3	Microbiology	36.9	45.9
14	14	Geoscience	55.6	48.3
15	15	Engineering	62.2	49.4
16	16	Economics	66.3	57.6
17	20	Computer science	69	58.4
18	17	Agricultural science	67.4	61
19	18	Plant & Animal Science	67.9	62.1
20	19	Social sciences	68	62.4
21	21	Mathematics	70.4	63.8

Microbiology and pharmacology are only two areas where the degree of non-cited-ness has increased during the study period. Sudden and rapid increase in the publication activity in these discipline areas might be one of the causes for the increase in non-cited-ness of publications. Although mathematics seems to have improved in degree of citations, urgent measures are needed to reduce the level of non-cited-ness. Given the global perception of strength India enjoys in this area, a large number of publications remaining non-cited does not augur well.

8. Evidence for Bimodal distribution of Journal Impact factor Distribution

Evidence report of Thomson Reuters brings out a unique feature among the impact factor distribution of publications emanating from India particularly during the reference periods. Whereas in case of most developed countries with a legacy of publishing in SCI journals, a normal distribution of impact factor profile of publications is expected. Evidence report for India presents a general feature of impact profile for most disciplines in a simulated distribution shown in **Figure 6**.

***Figure 6*: Impact profile for most disciplines**



Bimodal distribution of impact profile of publications may arise from a number of factors. Deeper analysis of probable causes and case studies for each discipline would be of value for policy development. Since in most cases the relative shift of the impact profile is towards the right, the general trend could be considered positive. At this time the following causes could be considered.

- Two categories of researchers one with early and the other with established publication habits
- New entrants dominating in the lower impact factor category
- The established schools and centres of excellence exploring into higher impact journals
- Expansion of doctoral research base without the attended strength of mentoring
- Entry of latent and hidden talent in R&D is into new publication habits
- Rejuvenation of research in university sector with early stage behaviour
- International cooperation promoting shift of impact profile towards the right
- Expansion of publication base is attended by submissions to lower impact journals due to precautionary habits

Deeper studies are necessary at this stage of development. It may be more rewarding to trigger the following habits among the Indian scientists at this time.

- Adding quality to doctoral training select areas and research centres
- Interconnecting research competencies among the new and established centres of excellence in India and abroad
- Leveraging international cooperation for increasing the impact profile of researchers in the university sector
- Introducing post doctoral schemes
- Positioning a well designed performance related incentive scheme for shifting the impact profile of Indian publications
- Introducing Grant mode of funding based on past track record

9. What is learnt from Evidence based analysis for shaping the future of Indian S&T landscape?

The study has provided evidence for some positive signals with respect to scientific publications. Increasing volume share of India for gaining global competitiveness has emerged a major priority at this stage.

- The study has opened up discussions for such efforts to increase the volume share of India in scientific publications.
- The study has also revealed a need to decrease rapidly the extent non-cited-ness of publications originating from India.
- Citation impact of publications from India is relatively low compared to many emerging economies.

Some emerging economies tend to increase the citation impact of their publications by attracting international talents and relocating established researchers. India is trying to increase the citation impact through several home grown techniques.

- New mechanisms may be essential for India to improve the citation impact levels to near 1 within the next five years from the current levels of 0.68. (or global averages)

10. Evidence based Lessons for India with respect to Volume Share in S&T

The changing global trends in volume share of publications indicate a scope for India gaining at least 5% global share by 2017. If India were to gain a global share of about 5%, the relative ranking could improve to five or six from the current 9th ranking based on current global trends. Therefore, it may be relevant for India to set for herself a national target of reaching 5% global share by the end of Twelfth plan period in 2017. This would require among many other policy based actions larger investments into R&D and expanding the Number of Full Time Equivalent R&D professionals. Case study of China indicates the need to increase the number of Full Time Equivalent R&D professionals and GERD as a percentage of GDP for gaining global competitiveness in volume of S&T outputs. Some possible actions for further consideration are

- Increasing the number of Full Time Equivalents of R&D professionals in a planned and urgent manner
- Increasing the PhD outputs with mechanisms for connecting national research institutions and university sector
- Joint appointments among university, research and industry sector wherever feasible
- Increasing the budget support per scientist and right sizing the project grants
- Positioning a measurement system for monitoring publication outputs from public funded research
- Positioning a methodology for relating project grant sizes to R&D output indicators
- R&D funding supported by empowerment systems for decision support

11. Evidence based lessons for India for decreasing the non-cited-ness of Publications

Although there is a gradual improvement in the citation impact of publications originating from India, efforts to reduce the degree of non-cited-ness to levels below 30% are required. This would call for two fold approaches. One approach is to discourage submissions to low impact factor journals. The other is to stimulate the submissions to higher impact making journals. Probability of citing is expected to increase by appropriate selection of journals for publications. A parallel effort to increase the citation profiles of national journals through various measures would be another valuable step.

India could explore strategic international cooperation as one of the pragmatic and quicker approaches to enhance the citation profiles and reduce the non-cited-ness of publications. A study of journal profiles of non-cited publications would enable advisories to authors in journal selection.

12. Evidence based lessons for India for increasing the impact profiles of Publications

Increasing the impact and citation profiles of emerging S&T systems is not easy and direct. Discovery science is a challenging proposition to several researchers. While discovering new facets of a science poses challenge of one dimension, selection and publishing in impact making journals is challenge of another dimension in modern world. It requires a combination of both creativity and right publishing habits. Comparisons of citation impacts of scientific publications from India with those for some other developed and emerging economies have been made and presented in **Annexure 2.**

Currently the moving average of publications in top 1% impact making journals is estimated at 4723 over a five year period. This is estimated to account for only 2.7% of Indian publications during 2006-10. Trebling the number of publications in top 1% journals may be considered as a target for the 2012-17 periods. India should develop strategic plans for gaining appropriate shares in the top and second quartile of impact making publications. Bottom-up approaches and governance models of the various institutions make setting up targets a challenging task. There are some valuable lessons for India to learn from emerging economies. Promoting excellence in university research is a way forward for India.

13. Some Next Best Steps for consideration of National Funding and Research Agencies

Evidence based approaches to policy building are emerging global trends. The report prepared by Thomson Reuters has provided some valuable data for analysis and development of national strategies. Some feasible national targets for strengthening scientific publication base of the country are

- Further increasing the R&D base
- Expanding the Full Time Equivalent R&D professionals
- Stimulate research in universities
- Enrol latent R&D professional strength in various entities
- Right size the project funding and grant sizes
- Introduce measurement and transparent reporting systems
- Position a well designed Performance Related Incentive System
- Invest into large number of established R&D professionals with proven track record
- Interconnect research competencies within India and abroad
- Interconnect research resources

- ❖ Position a transparent performance reward system
- ❖ Promote strategic international S&T cooperation in well chosen areas
- ❖ Promote academy research and academy industry linkages
- ❖ Institutionalize the measurement and reporting system for National S&T output indicators
- ❖ Position a Science Observatory

14. Concluding Remarks

An attempt has been made to analyze the data and observations contained in the “evidence” report prepared by Thomson Reuters for the Department of Science and Technology. Although the study provided data relating to several other economies for providing a relative assessment, this analysis is primarily related to what India should do in self interest of the country. While the country is planning for a science, technology, innovation policy, this analysis is expected to provide some useful inputs. National aspirations for emerging as one of the important knowledge powers and economy would require much more than broadening investments and creation of an enabling ambiance. Empowering knowledge institutions and universities in effective ways would emerge as critical steps forward. Attraction and supply chain management of talent for study of science and careers with research would emerge best next course for rise of India in the global landscape of science, technology and innovation.

There is early evidence for Indian science and technology machinery moving ahead with some credible pace. Tenth and Eleventh plan programmes seem to have delivered results for the science sector. The “Art of Possible” has been accomplished. Now is the time for exploring the “Art of the Impossible” or “Art of Improbable”. There is both aspiration and hope. Let the next best steps change the S&T landscape. Let us hope that the next report would present a discontinuity and conversion of positive signals into significant and sustainable progress.

References

1. Report of Science Advisory Council to the Prime Minister 2010.
2. Report of Science Advisory Council to the Cabinet 2006.
3. Science & Technology Policy 2003.
4. Science Congress Address by Honourable Prime Minister in 2010.

Annexure 1

evidence

A bibliometric study of India's research output and collaboration – Phase I

Thomson Reuters

A bibliometric study of India's research output and collaboration

Phase 1

December 2011

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1 Introduction

Evidence, Thomson Reuters has been commissioned by the Department of Science and Technology India (DST India) to show, through objective analysis, India's competitive strengths and weaknesses in science and technology, and key areas in which India is well-placed to leverage its strengths whilst tackling its weaknesses.

In this Phase I project, DST India wishes to understand India's volume of research activity, research quality and international collaboration in an internationally comparative context. The aim of this report is therefore to provide a high-level analysis of India's research and collaboration which can be used to inform a more focused analysis by identifying disciplinary or functional areas where further work may be beneficial.

The outcome of this will feed into the Indian Government's Science and Technology policy formulation and strategy for continued growth.

1.1 *Department of Science and Technology India (DST India)*

Science and Technology have come to be regarded as the most powerful instruments of economic growth and development, especially in the development of a competitive economy. The Department of Science and Technology India was established in May 1971 and co-ordinates, supports and oversees scientific activities and research in India. DST India plays a pivotal role in the promotion of science and technology in India, and has wide-ranging activities from promoting high-end basic research and development of cutting-edge technologies on the one hand, and on the other to service the technological requirements of the common man through the development of appropriate skills and technologies.[1]

DST India has responsibilities for specific projects and programmes, such as:

- The formulation of policies relating to science and technology
- Responsibility for matters relating to the Scientific Advisory Committee of the Cabinet (SACC)
- Promotion of new areas of science and technology with special emphasis on emerging areas
- Futurology
- Coordination and integration of areas of Science & Technology having cross-sectoral linkages in which a number of institutions and departments have interests and capabilities
- Undertaking or financially sponsoring scientific and technological surveys, research design and development
- Support and grants-in-aid to Scientific Research Institutions, Scientific Associations and Bodies
- All matters concerning:
    - The Science and Engineering Research Council
    - Technology Development Board and related Acts
    - National Council for Science and Technology Communication
    - National Science and Technology Entrepreneurship Development Board
    - International Science and Technology Cooperation
    - Autonomous Science and Technology Institutions
    - Professional Science Academies
    - The Survey of India and National Atlas and Thematic Mapping Organisation
    - National Spatial Data Infrastructure
    - National Innovation Foundation (Ahmedabad)

[1] www.dst.gov.in

- Matters commonly affecting scientific and technological departments, organisations and institutions (financial, personnel, purchase and import policies and practices)
- Management information systems for science and technology and coordination thereof
- Inter-agency/inter-departmental coordination for evolving science and technology missions
- Domestic technology and the commercialisation of technology with the Department of Scientific and Industrial Research
- The promotion of science and technology for the development and security of India
- Institutional science and technology capacity-building
- Grass-roots promotion of science and technology at the state, district and village levels
- Application of science and technology to weaker and disadvantaged sections of Indian society[2]

1.2 About Evidence

Evidence, a Thomson Reuters business, specialises in research performance analysis and interpretation. We have an extensive track record in delivering quantitative and analytical reports that provide a strong data-platform to enable improved management and decision-making at an institutional and system level.

The company was founded in 2000 and acquired by Thomson Reuters in January 2009, with which it already had a long-standing relationship on data and analytical development. The new relationship augments *Evidence's* global data access, enhances its capacity and provides a wide range of additional support and experience. Thomson Reuters maintains the *Web of Knowledge*[SM] the most complete and in-depth international data on research journal publications and their citations.

Evidence staff have experience in the higher education (HE) research environment such as in research institutions, university research management and administration, national policy development and in both private sector and charitable research organisations.

Evidence has particular expertise in the identification, development and testing of innovative research quality and activity indicators, reporting approaches and interpretative reports designed to support improved decision-making and research management. Our expertise in mapping between different types and sources of data (such as linking information on funding, people and outputs at subject category, discipline and national research evaluation categories) enables us to produce innovative but well-founded analyses.

Evidence works for government departments and agencies (including regional and national bodies) and for universities and other research-based organisations. We regularly work for overseas customers such as the Australian Research Council, the New Zealand Tertiary Education Council, the Singaporean National Medical Research Council, the Malaysian Office of Science Technology and Innovation, the Global Forum for Health Research, the Human Frontier Science Program, the Netherlands Cancer Research Institute and the Swedish Royal Institute of Technology. We have also worked with FAPESP – the research agency for the São Paulo region of Brazil. *Evidence* recently produced a report for Research Councils UK analysing the Indian research base.[3]

We produce informative and evidence-based reports to our clients' specifications and which are tailored to their requirements. Within this portfolio, many clients have commissioned multiple studies over several years, attesting to the value they have found in the work *Evidence* produces and the confidence they have gained in its approach. Clients particularly emphasise the accessible nature of the reports, their high information content and the close level of support which is provided to enable them to make the fullest use of the work.[4]

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[2] www.dst.gov.in/about_us/intro_DST.htm

[3] www.rcuk.ac.uk/international/Offices/OfficeinIndia/landscape/Pages/Collaboration.aspx

[4] science.thomsonreuters.com/evidence

2 Executive summary

On 24 November 2011, following India's Higher Education Summit, organised by the Federation of Indian Chambers of Commerce and Industry (FICCI) in New Delhi on 11 and 12 November 2011, an article was published by *Evidence's* Director and Thomson Reuters' Director of Research Evaluation, Dr Jonathan Adams, in the Times Higher Education Supplement.[5]

India has been the 'sleeping giant' of Asia. Research in the university sector, stagnant for at least two decades is now accelerating, but it will be a long haul to restore India as an Asian knowledge hub. Indian higher education is faced with powerful dilemmas and difficult choices: public/private, access/equity, uncertain regulation, different teaching standards and contested research quality. India – with 1.2 billion people, 8-10 per cent annual growth and barely a 10 per cent higher education age participation rate – needs a massive expansion in tertiary education and a sharper, stronger research base. The present economy cannot afford these, and the future economy cannot do without either.

The question is what sort of research base does India need? There are fundamental questions about resource distribution, subject balance, institute versus university, research training and the management of excellence. The conclusion was that India needed a well-rounded system, that used multiple indicators, balanced across universities' missions and normalised across faculties. External analysts, including ourselves, can only skim the Indian surface.

The FICCI conference indicated that the consensus, the ambition and the leadership to start on research assessment for India are there. Our hope in producing this report, is that we can begin a journey with DST India, to understand India's historical research base, to bring in a contemporary view, and ultimately to take that view forward into pragmatic analysis that informs and enables researchers and policy-makers in India. We can collectively identify the strengths and weaknesses of the Indian research system, informed by multiple indicators across different research areas, so that our analysis is helpful to and understood by Indian researchers and policy-makers to accelerate the transformation of the Indian research base.

2.1 Key findings

India's share of world research output: India's share of world research output was tracked for 1981-1995 and 1996-2010. India's share of world research output declined between 1981 and 1995. By 1996, China's growth surpassed India's and by 2010 its share of world research output ranked 2nd to the USA. India's share started to rise after 2000, regaining its 1981 share (3.1% of world) by 2007 rising to 3.5% by 2010. In 1981, India's largest shares of world research output by field were in Agricultural Sciences (7.8%), Plant & Animal Science (6.1%), Chemistry (5.1%), Engineering (4.3%), Environment/Ecology (4.1%) and Geosciences (4.0%). By 2010, India's largest world shares of output by field were in Chemistry (6.5%), Materials Science (6.4%), Agricultural Sciences (6.2%), Pharmacology & Toxicology (6.1%) and Microbiology (4.9%), Physics (4.6%) and Engineering (4.2%), reflecting a shift in the Indian research base. The most significant expansions were in Pharmacology & Toxicology (+4.2%), Microbiology (+3.2%) and Materials Science (+3.1%). The biggest declines by volume were in Plant & Animal Science (-2.2%) and Agricultural Sciences (-1.6%). The detail is set out in Section 5.

India's citation impact: India's citation impact improved between 1981-1985 (0.35 compared to world average of 1.0) and 2006-2010 (0.68). India is relatively low among the highly competitive countries in these analyses but the gap in citation impact between India and the established research economies is narrowing. Singapore stands out as an example of an emerging research economy which has made great impact gains. By 2006-2010, India's citation impact was highest in Psychiatry/Psychology (0.99 – close to world average), Engineering (0.95), Physics (0.82), Materials Science (0.82) and Computer Science (0.81). The greatest increases in citation impact between 1981-1985 and 2006-2010 were in Psychiatry/Psychology (+0.70), Social Sciences (+0.50), Physics (+0.46) and Engineering (+0.43). The detail is set out in Section 5.

India's Impact Profile®: The distribution (rather than average) of citation impact for India's research was compared for 2001-2005 and 2006-2010. Relatively high levels of uncitedness characterise the Indian research profile, due to the slower citation rates of emerging research economies compared to established research economies. Uncitedness (44.9% in 2006-2010) has fallen by 7% compared to 2001-2005. The Indian research profile is skewed towards the part of the distribution where citation impact is below world average. For

[5] http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=418186&c=1

example, in 2006-2010, 35% of papers received fewer than world average number of citations compared to 20% receiving above world average citations. Changes in distribution (there is typically a greater increase in the percentage of research cited above world average - +3.9% - rather than below world average - +3.1%) are pulling the curve upwards. In some fields (such as Chemistry and Physics) bimodality in impact may be emerging: this is unusual and warrants further investigation. These findings are set out in Section 6.

India's highly-cited papers analysis: We identified the more highly-cited research, where papers are cited at least four times the world average for field and year. About 2.7% of India's papers met this highly-cited threshold in 2006-2010 (equivalent for UK = 8.6%). Engineering had the highest percentage of highly-cited papers in 2006-2010 (6.5%) with the greatest increase (+3.1%) on 2001-2005. The volume of highly-cited papers decreased between 2001-2005 and 2006-2010 in Chemistry (from 2.7% to 2.1%, -0.6%), Physics (from 4.3% to 2.9%, -1.4%) and Materials Science (from 4.3% to 3.2%, -1.1%). The drivers behind these falls warrant further investigation. Biomedical fields are also comparatively weak but fields such as Computer Science, Social Sciences and Psychiatry/Psychology, whilst small, have relatively high and increasing percentages of highly-cited papers. These findings are set out in Section 7 of this report.

India's international collaboration analysis: India's international collaboration in 2001-2005 and 2006-2010 was compared. Collaboration is less frequent than for many established economies. In some fields, growth in collaboration has not kept pace with growth in volume. In 2001-2005, 18.8% of Indian research publications were internationally co-authored and this increased marginally to 19.5% by 2006-2010. Overall, collaboration in 2006-2010 is highest in Space Science (47.1%), Economics & Business (38.4%), Psychiatry/Psychology (34.9%) and Mathematics (34.3%) and Physics (29.3%). The USA is India's most frequent collaborating partner, on 6.6% of India's total research output in 2006-2010 (a slight fall since 2001-2005, -0.3%). Germany is the 2nd most frequent collaborator and the UK is 3rd. Collaboration with South Korea increased by +0.6% between 2001-2005 and 2006-2010, but with China by only 0.1%. Citation impact for internationally co-authored work is often higher than the domestic average for established economies: there would be value in exploring the impact gain for selected partner countries.[6] These findings are set out in Section 8 of this report.

India's journal impact factor analysis: We have assessed the percentage of papers published in journals that were in the top quartile, top two quartiles and top three quartiles of global journals indexed by Journal Impact Factor (JIF) for 2001-2005 and 2006-2010. Journals in the upper quartiles by Journal Impact Factor not only have higher average citation impact but also tend to publish a greater average volume of papers each year. Thomson Reuters *Web of Knowledge*SM has expanded its regional journal coverage with the effect, for India, of decreasing the relative volume of papers in the upper journal quartiles. There may also be journal choices at play, for example between national, regional and international journals which merit further investigation. Fields with a high percentage of papers in the top journal quartile in 2006-2010 included Materials Science (49.2%), Psychiatry/Psychology (46.0%), Computer Science (42.0%) and Immunology (41.2%). Microbiology (14.1%), Plant & Animal Science (18.7%) and Neuroscience & Behaviour (19.3%) had far smaller percentages. These findings are set out in Section 9 of this report.

2.2 Visualisations of India's research performance

2.2.1 Detailed indicators

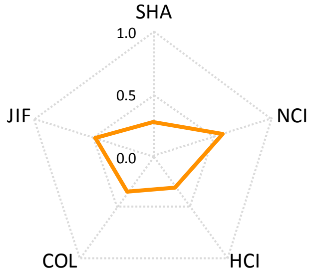
The following Figures summarise India's research performance by the indicators which are used in this report for the most recent period, 2006-2010. These data are scaled to the maximum value by field, which is equal to 1, thereby transforming data to the scale where 1 is high (i.e. the maximum) and 0 is low. This allows a visual interpretation of a number of indicators simultaneously. The Figures show;

- the share of world research output (**SHA**) where the maximum is Chemistry (6.2%)
- normalised citation impact (**NCI**) where the maximum is Psychiatry/Psychology (0.99)
- the percentage of highly-cited papers, cited at least four times or more than the world average for the field and year of publication (**HCI**) where the maximum is Engineering (6.5%)
- the percentage of international collaboration (**COL**) where the maximum is Space Science (47.1%)
- the percentage of papers in the top quartile of journals by Journal Impact Factor (**JIF**) where the maximum is Materials Science (49.2%)

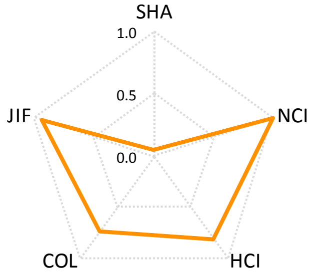
[6] **Patterns of international collaboration for the UK and leading partners** (2007), Adams J, *et al.*

World share of research output, normalised citation impact, highly-cited papers, international collaboration and research in the top quartile by Journal Impact Factor, ESI fields, India
Time period: 2006-2010, Source: NSI-ESI 2010 and NCR India 2010

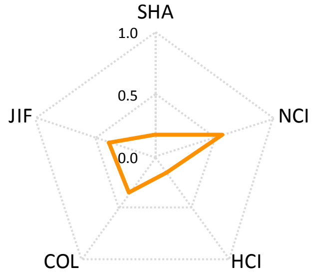
Clinical Medicine



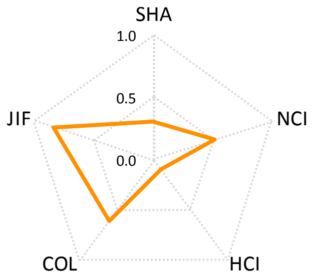
Psychiatry/Psychology



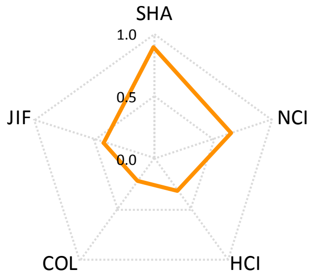
Neuroscience & Behaviour



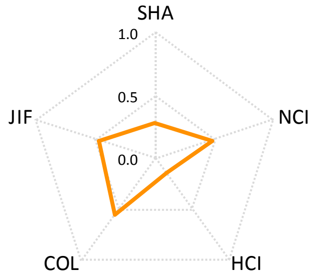
Immunology



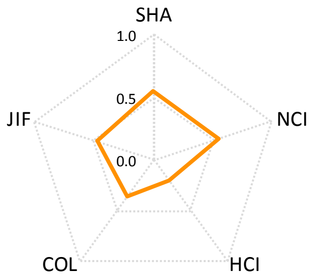
Pharmacology & Toxicology



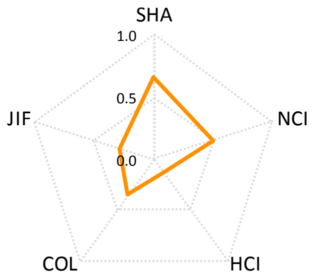
Molecular Biology & Genetics



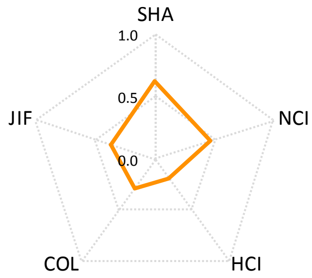
Biology & Biochemistry



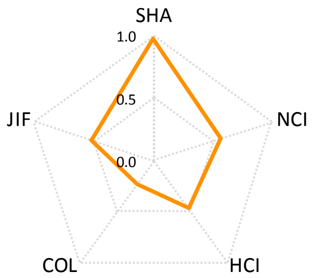
Microbiology



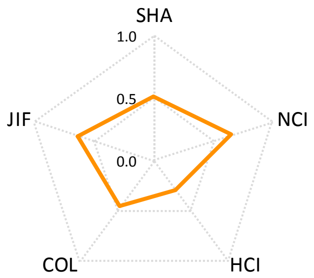
Plant & Animal Science



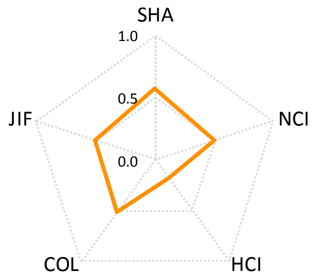
Agricultural Sciences



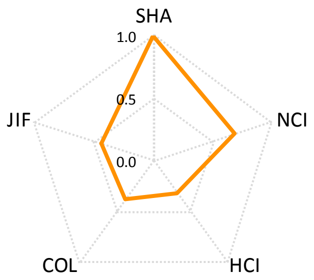
Environment/Ecology



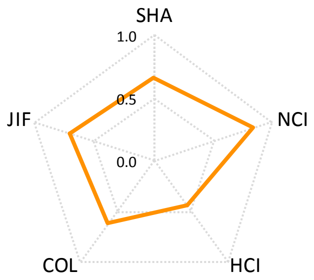
Geosciences



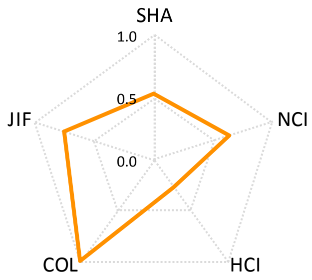
Chemistry



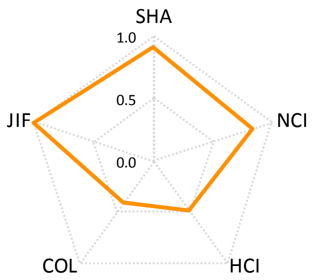
Physics



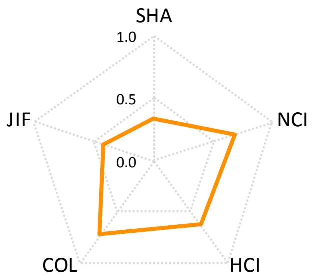
Space Science



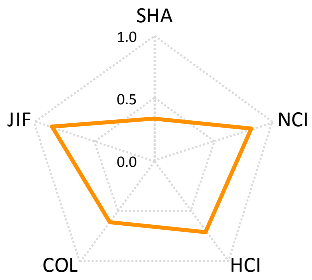
Materials Science



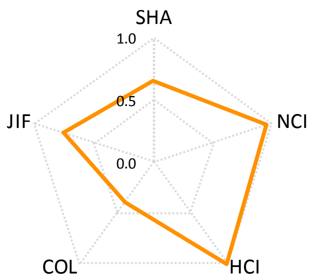
Mathematics



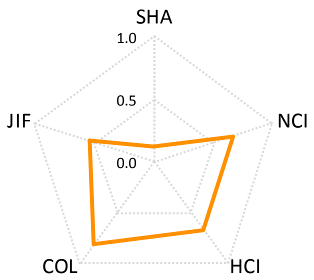
Computer Science



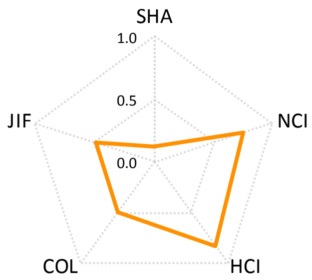
Engineering



Economics & Business



Social Sciences

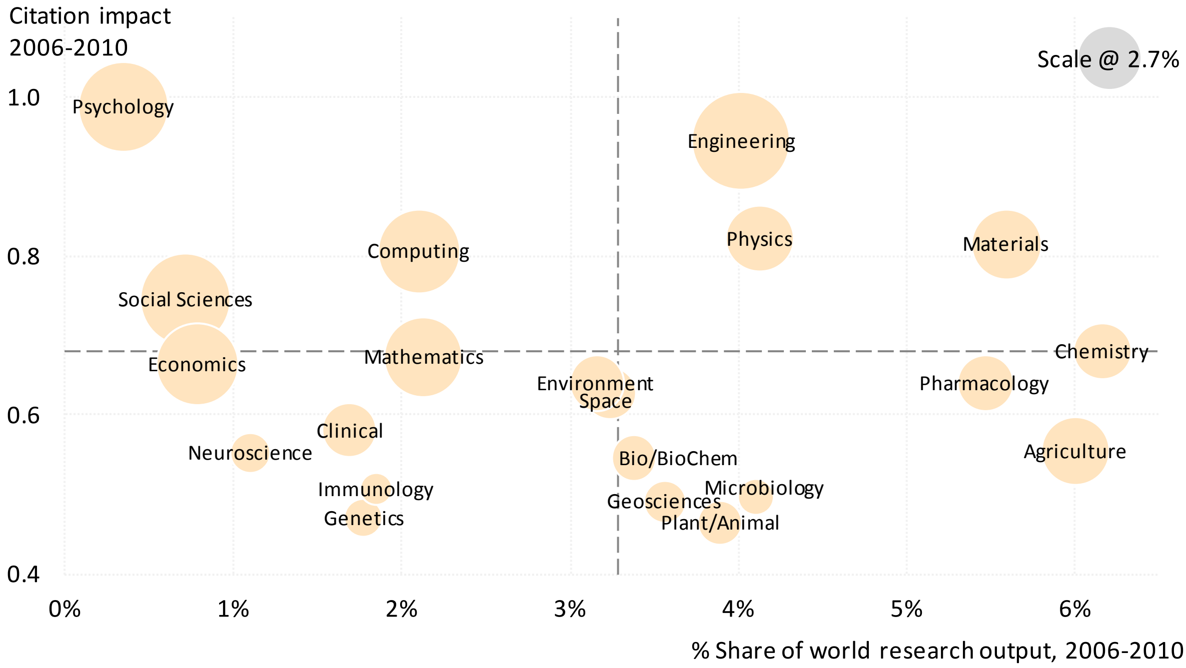


2.2.2 Selected indicators

The following Figure summarises key elements of India's current research performance. It shows:

- India's percentage world share of output over 2006-2010 (x-axis). The intercept is at 3.3% reflecting India's overall world share.
- India's citation impact over 2006-2010 (y-axis). The intercept is at 0.68 reflecting India's average overall citation impact during this period.
- The relative bubble area reflects India's percentage of highly-cited papers, with a scale in the top right-hand corner to indicate the percentage of highly-cited papers for Indian research overall (2.7%).

Share of world research output, normalised citation impact and highly-cited papers, ESI fields, India
Time period: 2006-2010, Source: NSI-ESI 2010 and NCR India 2010



The data are divided into four quadrants:

- **High share/high impact**: Those fields where India has a higher world share compared to its world share overall, and a higher citation impact compared to its citation impact overall. These fields are Engineering, Physics and Materials Science. Chemistry is on the margin of this group.
- **Low share/high impact:** Those fields where India has a lower world share compared to its world share overall, but a higher citation impact compared to its citation impact overall. These fields are Psychiatry/Psychology, Computer Science and Social Sciences.
- **High share/low impact:** Those fields where India has a higher world share compared to its world share overall, but a lower citation impact compared to its citation impact overall. These fields are (in order of ascending citation impact): Plant & Animal Science, Geosciences, Microbiology, Biology & Biochemistry, Agricultural Sciences and Pharmacology & Toxicology.
- **Low share/low impact:** Those fields where India has a lower world share compared to its world share overall, and a lower citation impact compared to its citation impact overall. These fields include (in order of ascending citation impact): Molecular Biology & Genetics, Immunology, Neuroscience & Behaviour, Clinical Medicine, Space Science, Environment/Ecology, Economics & Business and Mathematics.

2.3 Areas for further analysis

This analysis has identified where further research may be beneficial and which could potentially feed into Phase II of this work. The principal recommendations for follow-up analysis from Phase I of this research include:

- Identify the underlying drivers in Impact Profiles® where there have been falls in the proportion of highly-cited papers or where there is emerging bimodality.
- Analyse the additional citation impact gained through collaboration with international partners.
- Analyse whether changes in usage of national, regional and international journals may explain changes in the spread of Indian research across journals by Impact Factor.

We would also explore and disaggregate Indian research performance below the state level, at the regional and institutional levels which we recommended as the principal area of follow-up for Phase II analysis. Furthermore, focused analyses of particular fields of strategic importance at a more detailed categorisation (for example at the *Web of Science*^{SM} journal category level) could also potentially extend this initial study. We would be happy to explore these options with DST India to achieve a brief that would most usefully inform their policy formulation and strategy for continued growth.

3 The background to Indian research performance

3.1 Global Research Report India

In October 2009, *Evidence* produced the 'Global Research Report: India, Research and collaboration in the new geography of science'. It is part of a series launched by Thomson Reuters to inform policy-makers on the changing landscape and dynamics of the global research base.[7]

The report focused on India in the context of a series of reports about the 'BRIC' group: India, which like Brazil, and fellow BRIC members Russia and China, is building on its vast resources and potential in becoming a lead economic power. Underpinning the realisation of that economic potential will be a significant expansion in its ability to generate and exploit its knowledge resources through research and the related skills of its workforce.

Science and technology have been central to India's development efforts since the country achieved independence in 1947. Since then, via government directives such as the Scientific Policy Resolution (1958), the Technology Policy Statement (1983) and Science and Technology Policy (2003), India has achieved notable scientific successes. These include self-sufficiency in food grain production; a space program that has enabled satellite launches and a moon mission; an autonomic energy program; indigenously developed missiles and aircraft; and exports in biotechnology, pharmaceuticals and information-technology services.

Despite these achievements, recent years have seen a growing realisation among scholars, policy-makers and other observers that India lags behind other key countries and some of its BRIC partners in research investment and output. As *Nature* reported in 2009, government spending on science research accounts for roughly 0.9% of Gross Domestic Product (GDP); by 2012, the figure is expected to rise to 1.2%. A nagging problem – paradoxically for the second-most populous country on earth – is a current lack of human resources: the availability of qualified researchers has not kept pace with the increased funding.

India's recent increase in world research output is striking: rising sharply in contrast to the other countries' largely static changes in growth since 2000, and what many observers note is the change in the trajectory for India. References have been made in the science policy literature to India as a 'sleeping giant'. Compared to other countries with a major research base, India somewhat 'slumbered' – deeply through the 1980s - and only starting to awaken in the 1990s, but it has caught up with other countries in a strikingly brief period.

India has a long and distinguished history as a country of knowledge, learning and innovation. India is a huge part of and a vital source of influence on the future global economy. In the recent past, however, it has failed to realise its undoubted potential as a home for world-class research. There are signs that there is now a change in trajectory that will bring India up to the level where it can begin to realise its potential, to the benefit of its own population and economy, as well as contributing to global knowledge networks.

During the 1980s and early 1990s, the output of India's research base was almost static, while other countries grew rapidly, particularly other countries in Asia. China expanded with an intensity and drive that led it rapidly to overtake leading European countries in the volume of its research publications. India is just beginning on that gradient, and has only now got back to the relative position it held thirty years ago. The possibility is that the new geography of research may see not just new leading countries, but a change in regional balances.

With its diversity and capacity, it seems a surprise that India does not collaborate more. The collaborative network does now seem to be expanding, and it is expanding eastwards towards other new and emerging research economies and not to the traditional trans-Atlantic research axis, although these countries account currently for a greater proportion of India's current collaborative research. We have shown that China has increased its relative collaboration alongside a massive expansion in volume which may reflect a whole-scale commitment to engagement with the international research community.[8]

With unprecedented domestic growth and exceptional rates of change, this is a time of opportunity and activity for Indian research and Indian researchers. The conventional frames of reference, for activity, growth and impact are adjusting to these new dynamics.

[7] researchanalytics.thomsonreuters.com/grr

[8] http://image.guardian.co.uk/sys-files/Education/documents/2007/07/13/OSICollaborationSummaryRepo.pdf

3.2 Headline economic indicators

India is the seventh largest country in the world, with territories encompassing 3,287 thousand square kilometres. It has the second largest population in the world 1,198.0 million in 2009 (approximately 17% of total world population), and second only to China (1,345.8 million) (with approximately 20% of the world population) just under four times greater than that of the USA (314.7 million - with approximately 5% of the world population). The Economist forecasts that India will have the largest world population by 2050: 1,614 million. Cities such as Delhi (24.2 million), Mumbai (21.8 million), Kolkata (16.9 million) are forecast to be amongst the top ten largest cities in the world by population in millions in 2015. In 2009, its economy was valued at 1,377 billion USD ranking tenth in the world, but 3,808 billion USD PPP 2009, ranking fourth in the world by purchasing power. India's average annual percentage increase in real GDP between 1999 and 2009 was 6.9%: China's was 10.3%. The equivalent figures for the USA and UK were 1.8% and 1.7% respectively.[9]

3.3 Key R&D information

The UNESCO Institute for Statistics 'Global Investments in R&D' Statistical Bulletin July 2011 presents the latest internationally comparable indicators to monitor resources devoted to R&D worldwide including data for India.[10]

3.3.1 R&D spending

In terms of shares of world R&D expenditure by principal geographic regions and countries in 2002 and 2007 (% measured by Gross Domestic Expenditure on R&D, GERD), there are several key observations. India increased its percentage share of world global R&D spending from 1.6% in 2002 (12.9 billion USD PPP) to 2.2% (24.8 billion USD PPP) by 2007. The equivalent figures for China were 5.0% (39.2 billion USD PPP) in 2002 and 8.9% (102.4 billion USD PPP) by 2007. By way of contrast, the USA's share of world R&D expenditure fell from 35.1% (277.1 billion USD PPP) in 2002 to 32.6% (373.1 billion USD PPP) in 2007; the European Union's share fell from 26.1% (206.2 billion USD PPP) to 23.1% (264.9 billion USD PPP) over the same period.

In terms of which regions were the most R&D intensive, measured by gross domestic expenditure on R&D as a percentage of GDP in 2007, the figure for the USA was 2.7% in both 2002 and 2007 (no change), the figure for the European Union was 1.8% in both 2002 and 2007 (no change), but the figures for China were 1.1% in 2002 and 1.4% by 2007, and the figures for India were 0.7% in 2002 and 0.8% in 2007. This is indicative of improvement, but a substantial gap in terms of R&D intensity remains to be narrowed. These differences are more apparent when analysing GERD per capita (in USD PPP). In the USA, GERD per capita was 942.4 in 2002 and 1,208.7 in 2007; in the European Union 425.8 in 2002 and 537.0 in 2007; but in China it was 30.5 in 2002 and 77.1 in 2007, and India it was 12.0 in 2002 and 21.3 in 2007.

R&D Spending (Gross Expenditure on R&D), Selected Countries
Time period: 2002 and 2007, Source: UNESCO Institute for Statistics July 2011

	GERD (in billions PPP$)		% world GERD		GERD as % of GDP		GERD per capita (in PPP$)	
	2002	2007	2002	2007	2002	2007	2002	2007
India	12.9	24.8	1.6%	2.2%	0.7%	0.8%	12.0	21.3
China	39.2	102.4	5.0%	8.9%	1.1%	1.4%	30.5	77.1
USA	277.1	373.1	35.1%	32.6%	2.7%	2.7%	942.4	1208.7
EU	206.2	264.9	26.1%	23.1%	1.8%	1.8%	425.8	537.0

[9] The Economist Pocket World in Figures 2012 Edition

[10] http://www.uis.unesco.org/FactSheets/Documents/fs15_2011-investments-en.pdf

3.3.2 Researchers

Research potential ultimately rests in human capacity and human potential. The USA had 23.1% of the world's researchers in 2002 (1342.5 thousand researchers) and this share fell to 20.0% by 2007 though the number of researchers increased (1425.6 thousand researchers). The EU had 20.6% of the world's researchers in 2002 (1197.9 thousand) and this share fell to 20.1% (1448.3 thousand researchers). China's increase in researchers moved its share of world researchers from 13.9% in 2002 (810.5 thousand researchers) to 19.7% of world researchers by 2007 (1423.4 thousand researchers, and not far short of the USA). India's world share of researchers actually fell from 2.3% of world share in 2002 (115.9 thousand) to 2.2% of world share in 2007 (154.8 thousand). Given China and India's large and growing populations, their percentage share of the world's researchers as their economic development trajectories normalise over the long-run should, in principle at least, increase. Given these dynamics, it is conceivable that shares of world research now may not be the shares of world research another thirty years from now.

In terms of researchers per million inhabitants, it is evident that a substantial gap still remains between India and China vis-à-vis the USA and the European Union. The USA had 4566.0 researchers per million inhabitants in 2002 and 4663.3 per million by 2007. The EU had 2473.9 researchers per million inhabitants in 2002 and 2936.4 per million by 2007. China has rapidly expanded the number of researchers per million inhabitants from 630.3 in 2002 to 1070.9 in 2007. India's levels, and increase, were more than modest in comparison: 111.2 researchers per million inhabitants in 2002 and 136.9 by 2007. India's GERD per researcher, however, is higher than China's: 102.6 thousand USD PPP in 2002 and 126.7 thousand USD PPP by 2007 compared to figures of 48.4 thousand USD PPP for China in 2002 and 72.0 thousand USD PPP by 2007, suggesting that there are greater R&D financial resources for researchers in India compared to China, although they are around half of the GERD per researcher in the USA (206.4 in 2002 and 243.9 in 2007).

Researchers, Selected Countries
Time period: 2002 and 2007, Source: UNESCO Institute for Statistics July 2011[11]

	Researchers ('000s)		% world researchers		Researchers per million inhabitants		GERD per researcher ('000s PPP$)	
	2002	2007	2002	2007	2002	2007	2002	2007
India	115.9	154.8	2.3%	2.2%	111.2	136.9	102.6	126.7
China	810.5	1423.4	13.9%	19.7%	630.3	1070.9	48.4	72.0
USA	1342.5	1425.6	23.1%	20.0%	4566.0	4663.3	206.4	243.9
EU	1197.9	1448.3	20.6%	20.1%	2473.9	2936.4	172.1	182.9

[11] Data for India in this Table refer to years which are two years prior to the displayed data (-2). This is for the indicators Researchers ('000s), Researchers per million inhabitants and GERD per researcher ('000s PPP$). Data for the indicator % world researchers are UIS estimates based on extrapolation or interpolation. Data for the USA in 2007 is based on data which is one year prior to the displayed data (-1). Therefore, the derived indicator for the % world researchers is a UIS estimate based on extrapolation or interpolation.

4 Methodology

This Section outlines key concepts and methodology. A description of bibliometric methodology used by *Evidence* is provided in Annex 1. This report is based upon analysis of indicators for whole-country and disaggregated by the fields used in Thomson Reuters *Essential Science Indicators®*.

- **Comparative international analysis of India's world share of output and citation impact** (Section 5). This looks at India's changing annual share of world output over a 30-year time frame (1981-2010) split into an historical period (1981-1995) and a contemporary period (1996-2010). India is compared with a selection of established research economies (Australia, France, Germany, Israel, Italy, Japan, the UK and the USA) and emerging research economies (Brazil, China, Iran, Russia, Singapore, South Africa, Korea and Taiwan). India's citation impact is evaluated over the same time-frame, but aggregated by five-year moving averages rather than annual data. Data are sourced from Thomson Reuters National Science Indicators Database 2010 (ESI edition).
- **Impact Profile® analysis** (Section 6). This details the distribution of citation impact in the Indian research base, rather than the average. Impact Profiles® reveal uncitedness, breakdown the research profile into impact categories, and indicate the percentage of research which is below and above world average citation impact. These Impact Profiles® consider change between 2001-2005 and 2006-2010. Data are sourced from a customised National Citation Report for India to December 2010.
- **Highly-cited papers analysis** (Section 7). This flows from the Impact Profile® analysis (Section 6) and assesses the percentage of research which falls into the two most highly-cited impact categories of the Impact Profile® distribution, where citation impact is at least four times world average. This analysis considers the change between 2001-2005 and 2006-2010. Data are sourced from a customised National Citation Report for India to December 2010.
- **International collaboration analysis** (Section 8). This analyses the percentages of Indian research which are internationally co-authored and the countries that are India's most frequent international partners. The selection focuses on the most frequent ten countries for 2006-2010, and analyses how the shares of international co-authorship have changed since 2001-2005. Data are sourced from a customised National Citation Report for India to December 2010.
- **Journal analysis** (Section 9). This analyses the percentages of Indian research which are authored in journals linked to the *Journal Citation Report®*, and the quartiles into which Indian research falls by Journal Impact Factor: the top quartile (top 25% of journals by impact), the top two quartiles (top 50%) and the top three quartiles (top 75%). This is split into two time-frames, 2001-2006 and 2006-2010. Data are sourced from a customised National Citation Report for India to December 2010.

4.1 Bibliometric data and citation analysis

Research evaluation increasingly makes use of bibliometric data and analyses. Bibliometrics is the analysis of data derived from publications and their citations. Publication of research outcomes is an integral part of the research process and is a universal activity. Consequently, bibliometric data have a currency across subjects, time and location that is found in few other sources of research-relevant data. The use of bibliometric analysis, allied to informed review by experts, increases the objectivity of and confidence in evaluation.

Research publications accumulate citation counts when they are referred to by more recent publications. Citations to prior work are a normal part of publication, and reflect the value placed on a work by later researchers. Some papers get cited frequently and many remain uncited. Highly-cited work is recognised as having a greater impact and *Evidence*, Thomson Reuters has shown that high citation rates are correlated with other qualitative evaluations of research performance, such as peer review.[12] This relationship holds across most science and technology areas and, to a limited extent, in social sciences and even in some humanities subjects.

Indicators derived from publication and citation data should always be used with caution. Some fields publish at faster rates than others and citation rates also vary. Citation counts must be carefully normalised to account

[12] **Maintaining Research Excellence and Volume: A report by Evidence Ltd to the Higher Education Funding Councils for England, Scotland and Wales and to Universities UK** (2002), Adams J, *et al*.

for such variations by field. Because citation counts naturally grow over time it is essential to account for growth by year. Normalisation is usually done by reference to the relevant global average for the field and for the year of publication.

Bibliometric indicators have been found to be more informative for core natural sciences, especially for basic science, than they are for applied and professional areas and for social sciences. In professional areas the range of publication modes used by leading researchers is likely to be diverse as they target a diverse, non-academic audience. In social sciences there is also a diversity of publication modes and citation rates are typically much lower than in natural sciences.

Bibliometrics work best with large data samples. As the data are disaggregated, so the relationship weakens. Average indicator values (e.g. of citation impact) for small numbers of publications can be skewed by single outlier values. At a finer scale, when analysing the specific outcome for individual departments, the statistical relationship is rarely a sufficient guide by itself. For this reason, bibliometrics are best used in support of, but not as a substitute for, expert decision processes. Well-founded analyses can enable conclusions to be reached more rapidly and with greater certainty, and are therefore an aid to management and to increased confidence among stakeholders, but they cannot substitute for review by well-informed and experienced peers.

4.2 Data source

For this evaluation, bibliometric data will be sourced from Thomson Reuters databases underlying the *Web of Knowledge*^{SM}, which gives access to conference proceedings, patents, websites, and chemical structures, compounds and reactions in addition to journals. It has a unified structure that integrates all data and search terms together and therefore provides a level of comparability not found in other databases. It is widely acknowledged to be the world's leading source of citation and bibliometric data. The *Web of Science*^{SM} is part of the *Web of Knowledge*^{SM}, and focuses on research published in journals and conferences in science, medicine, arts, humanities and social sciences. The authoritative, multidisciplinary content covers over 11,500 of the highest impact journals worldwide, including Open Access journals and over 110,000 conference proceedings. Coverage is both current and retrospective in the sciences, social sciences, arts and humanities, in some cases back to 1900. Within the research community these data are often still referred to by the acronym 'ISI'.

Granularity of analysis is an important issue. Unduly fine analysis at the level of research groups provides little comparability or connectedness, while coarse analysis may miss spikes of excellence in key areas.

Journals are mapped to one or more subject categories, and every article within that journal is subsequently assigned to that category. *Evidence* uses these subject categories as the basis for bibliometric analysis because they are well-established and informed by extensive work with the research community since inception. Papers from prestigious, 'multidisciplinary' and general 'biomedical' journals such as Nature, Science, BMJ, The Lancet, New England Journal of Medicine and the Proceedings of the National Academy of Sciences (PNAS) are assigned to specific categories based on the journal categories of the citing and cited references in each article. Further information about the journals included in the citation databases and how they are selected is available here: http://scientific.thomsonreuters.com/mjl/.

Annex 1 provides the standard methodology and data definitions used in bibliometric and citation analyses. A brief summary of key citation data definitions is also given Section 4.3.

The bibliometric analyses presented in this report will not cover conference proceedings, meeting abstracts, books, chapters in books or grey literature such as reports (with the exception of Section 8 regarding international collaboration analysis). It therefore captures only a specific part of the total output of India's research output over the period, but this part is usually recognised as describing the most direct contribution to the research base.

4.2.1 Location

In order to benchmark India's performance to other countries, Section 5 comprises analyses comparing India's research performance to two comparator groups, selected by DST India. The first group is termed the 'established research economies', which includes the G7 countries with the exception of Canada. The second group is termed the 'emerging research economies' which includes the so-called BRICK countries (India plus Brazil, Russia, China and (South) Korea) as well as the Asian 'tiger' economies of Taiwan and Singapore.

In order to simplify the visual presentation of this information, 3-letter UN abbreviations[13] have been used in this report. India (IND) is compared to both groups and compared within both sets of Figures.

Established research economies

Code	Country
AUS	Australia
FRA	France
DEU	Germany
IND	India
ISR	Israel
ITA	Italy
JPN	Japan
GBR	United Kingdom
USA	United States of America

Emerging research economies

Code	Country
BRA	Brazil
CHN	China
IND	India
IRN	Iran
RUS	Russia
SGP	Singapore
ZAF	South Africa
KOR	South Korea
TWN	Taiwan

In addition to this competitive benchmarking, Section 8 of the report outlines analysis of international collaboration with countries. These countries are selected on the basis of the top ten collaborating countries with India in the most recent five-year period (2006-2010), which may differ from the countries listed above.

[13] http://unstats.un.org/unsd/methods/m49/m49alpha.htm

4.2.2 Time

Several time periods are used in this report. Section 5 relies on long-term time-frames, from 1981 to 2010, split into two periods of 1981-1995 (a historical 15-year period) and 1996-2010 (a contemporary 15-year period). Other Sections of this report use two time frames over the past decade: 2001-2005 and 2006-2010.

It is important to note that for the Sections on Impact Profiles® (Section 6) and Highly-Cited Papers (Section 7), in order to enable meaningful comparisons between the two time periods, we have counted the citations accrued by papers published in each time period up to the end of that time period. This means that the data shown for the time period 2001-2005 relate to citations accrued up to the end of 2005 by papers published between 2001 and 2005. Likewise, data shown for the time period 2006-2010 relate to citations accrued up to the end of 2010 by papers published between 2006 and 2010.

4.2.3 Research fields

Standard bibliometric methodology uses journal categories as a proxy for research fields or areas. We have used one such mapping scheme in this report to associate published research with research areas. These are the *Essential Science Indicators®* (ESI) fields, which aggregate data at a higher level than the *Web of Science*SM journal categories.[14] The *Essential Science Indicators®* fields and *Web of Science*SM journal categories do not map directly but complement each other to provide both a high-level and detailed analysis of research.

There are 22 ESI fields compared to 254 *Web of Science*SM journal categories. Analyses using ESI fields are useful to gain a headline understanding of the strengths and weaknesses of a research system, whereas analyses using *Web of Science*SM journal categories are useful to identify strengths and weaknesses in more specific research areas. ESI fields are defined by a unique grouping of journals with no journal being assigned to more than one field. Articles in journals such as *Science* and *Nature*, are assigned to Multidisciplinary field on the basis of an article-level classification. Therefore, the category 'Multidisciplinary' does not describe research that is inter-disciplinary in nature, but refers to research work which appears in multidisciplinary journals. We have excluded the Multidisciplinary category in this report due to its errant citation behaviour owing to changing methodological definitions meaning that it is not comparable over time.

[14] thomsonreuters.com/products_services/science/science_products/a-z/essential_science_indicators

Essential Science Indicators® fields

Standard sequence	ESI code	ESI field
1	n/a	All fields
2	00004	Clinical medicine
3	00020	Psychiatry/psychology
4	00016	Neuroscience & behaviour
5	00010	Immunology
6	00017	Pharmacology & toxicology
7	00014	Molecular biology & genetics
8	00002	Biology & biochemistry
9	00013	Microbiology
10	00019	Plant & animal science
11	00001	Agricultural sciences
12	00008	Environment/ecology
13	00009	Geosciences
14	00003	Chemistry
15	00018	Physics
16	00022	Space science
17	00011	Materials science
18	00012	Mathematics
19	00005	Computer science
20	00007	Engineering
21	00006	Economics & business
22	00021	Social sciences

In order to produce world output and citation impact by comparator country (Section 5), we have used the pre-aggregated National Science Indicators (NSI) database (NSI-ESI 2010). By contrast, in order to produce the more detailed analyses on India for Sections 6, Section 7, Section 8 and Section 9, we have produced a National Citation Report for all publications where the address is affiliated to India (NCR India 2010).

4.3 Key definitions

Papers/publications: Thomson Reuters abstracts publications including editorials, meeting abstracts and book reviews as well as research journal articles. The terms 'paper' and 'publication' are often used interchangeably to refer to printed and electronic outputs of many types. In these analyses the term 'paper' has been used exclusively to refer to substantive journal articles, reviews and some proceedings papers and excludes editorials, meeting abstracts or other types of publication. **Papers** are the subset of publications for which citation data are most informative and which are used in calculations of citation impact. **Publications** refer to all document types. Note that 'Publications' are used in Section 8 on International Collaboration.

Output and world share: Research papers are not the only output of the research process and some fields publish fewer research papers than others; nevertheless, they are universally important. The volume of research papers produced by an individual, research organisation or country can, therefore, be used as an indicator of research activity. Because publication behaviour differs between fields, the share of world output is a more useful indicator for comparing across disciplines.

Citations: The citation count is the number of times that a citation has been recorded for a given publication since it was published. Not all citations are necessarily recorded since not all publications are indexed. The material indexed by Thomson Reuters is estimated to attract about 95% of global citations.

Citation impact: 'Citations per paper' is an index of academic or research impact (as compared with economic or social impact). It is calculated by dividing the sum of citations by the total number of papers in any given dataset (so, for a single paper, raw impact is the same as its citation count). Impact can be calculated for papers within a specific research field such as Clinical Neurology, or for a specific institution or group of institutions, or a specific country. Citation count declines in the most recent years of any time-period as papers have had less time to accumulate citations (papers published in 2007 will typically have more citations than papers published in 2010).

Normalised citation impact (nci): Citation rates vary between research fields and with time, consequently, analyses must take both field and year into account. In addition, the type of publication will influence the citation count. For this reason, only citation counts of articles and reviews are used in calculations of citation impact. The standard normalisation factor is the world average citations per paper for the year and journal category in which the paper was published. This normalisation is also referred to as 'rebasing' the citation count.

Highly-cited papers: Citation data are highly skewed; relatively large number of papers receiving none or very few citations and very few papers receiving many citations. There is no theoretical limit on the number of citations a paper could receive. Therefore, very highly-cited papers do occur and these can strongly affect average citation impact statistics. This effect is particularly exaggerated for fields that publish relatively small numbers of papers or countries with relative low outputs of research papers.

Impact Profiles®: Indicators based on average citation counts are useful for understanding overall performance but do not describe the distribution of citations within a body of work. Therefore, Impact Profile® methodology[15] was developed to allow a visual comparison of the percentages of output relative to the world average and relative to comparator profiles. This provides much more information about the basis and structure of research performance than conventionally reported averages. An Impact Profile® shows the percentage of papers that are uncited and the percentage that are in each of eight categories of relative citation rates, normalised to world average (which becomes 1.0). Normalised citation rates above 1.0 indicate papers cited more often than the world average in the relevant journal category and year of publication. Information is derived from the percentage of uncited papers, the percentage of cited papers either side of world average, the location of the most common (modal) group near the centre, and the percentage of papers in the most highly-cited categories ≱ 4 x world, ≥ 8 x world). A full guide to the interpretation of Impact Profiles® is given in Annex 1.

Research field: Standard bibliometric methodology uses journal category as a proxy for research field. Journals are assigned to one or more categories, and every article within that journal is subsequently assigned to that category. Papers from prestigious, 'multidisciplinary' and general medical journals such as Nature, Science, The Lancet, BMJ, The New England Journal of Medicine and the Proceedings of the National Academy of Sciences (PNAS) are assigned to specific categories based on the journal categories of the references cited in the article.

[15] **Profiling citation impact: A new methodology**, (2007), Adams J, *et al.*

The selection procedures for the journals included in the citation databases are documented here http://scientific.thomsonreuters.com/mjl/.

4.4 Interpretation of data and analyses

Papers: The minimum number of papers suitable as a sample for quantitative research evaluation is a subject of widespread discussion. Larger samples are always more reliable, but a very high minimum may defeat the scope and specificity of analysis. Experience has indicated that a threshold between 20 and 50 papers can generally be deemed appropriate. For work that is likely to be published with little contextual information, the upper boundary (≥ 50) is a desirable starting point. For work that will be used primarily by an expert, in-house group then the lower boundary (≥ 20) may be approached. Because comparisons for in-house evaluation often involve smaller, more specific research groups (compared to broad institutional comparisons) a high volume threshold is self-defeating. Smaller samples may be used but outcomes must be interpreted with caution and expert review should draw on multiple information sources before reaching any conclusions.

In this report, small paper numbers (<50) are highlighted in the analyses. This is particularly relevant for the paper numbers of the emerging research economies (and also the citation impact) in the period 1981-1995 used in Section 5 of this report.

Normalised citation impact: nci values for individual papers vary widely and it is more useful to consider the mean nci. This average can be at several granularities: field (either journal category or field), annual and overall (total output under consideration). When considering such mean nci data points, care must be taken to understand that these data are highly skewed and the average can be driven by a single, highly-cited paper (this would be highlighted in accompanying text though not apparent from Tables & Figures). The world average is 1.0, so any nci value higher than this indicates a paper, or set of papers, which are cited more than average for similar research worldwide. For research management purposes, experience suggests that nci values between 1.0 and 2.0 should be considered to be indicative of research which is influential at a national level whilst that cited more than twice the world average has international recognition.

Research field: A problem frequently encountered in the analysis of data about the research process is that of 'mapping'. For example, a funding body allocates money for chemistry but this goes to researchers in biology and engineering as well as to chemistry departments. Clinicians publish in mathematics and education journals. Publications in environmental journals come from a diversity of disciplines. This creates a problem when we try to define, for example, 'Physics research'. Is this the work funded under Physics programmes, the work of researchers in Physics units or the work published in Physics journals? For the first two options we need to track individual grants and researchers to their outputs, which is feasible but not within the scope of this study nor for every comparator institution. Therefore, to create a simple and transparent dataset of equal validity across time and geography, we rely on the set of journals associated with Physics as a proxy for the body of research reflecting the field.

Indicator values:

Indicator	Threshold
Number of publications (all output types)	No threshold, although publication numbers (<50) are highlighted in the analyses.
Number of papers (articles and reviews)	Citation impact based on fewer than 20 papers at any particular aggregation, *e.g.* year or field are not reliable. Paper numbers (<50) are highlighted in the analyses.
Normalised citation impact data (an indication of paper quality within the field)	Values > 1.0 indicate better performance than world average.
Percentage of highly-cited papers (those which received ≥4 world average citations)	Benchmark varies between subjects (and average varies between countries). In 2006-2010: 8.6% of UK papers were highly-cited compared to 2.7% for India.

4.5 Journal impact factors

In the same way that citation impact can be used as an index of research quality, the average number of citations per paper can be used to indicate the impact and/or importance of a journal. The Impact Factor for a journal (JIF) is calculated using data for a three-year period. For example, the 2010 Impact Factor for a given journal is calculated is calculated by Thomson Reuters as the average number of times which articles from the journal published in the past two years (2008 and 2009) were cited in 2010. Thus, a JIF of 2.0 means that, on average, the articles published in 2008 or 2009 have been cited twice. Citing articles may be from the same journal; however, most citing articles are from other journals.

For the journal *Applied Physics Letters*, the 2010 Journal Impact Factor would be calculated as follows:

Cites in 2010 to items published in 2009 =	15,761	Number of items published in 2009 =	4,677
Cites in 2010 to items published in 2008 =	23,137	Number of items published in 2008 =	5,449
Total	**38,898**		**10,126**

$$\frac{\text{Number of citations}}{\text{Number of items}} = \frac{38{,}898}{10{,}126} = \mathbf{3.841}$$

The calculation of the Journal Impact Factor is fully described on the Thomson Reuters website at: thomsonreuters.com/products_services/science/free/essays/impact_factor.

When looking at Journal Impact Factor data it is important to remember that, as citation rates vary between research fields publication type, these will affect the JIF. That is a JIF of 3.841 ranks the journal *Applied Physics Letters* 14th out of 116 journals in the Applied Physics journal category and therefore in the top quartile. However, the journal *Analytical and Bioanalytical Chemistry* with the same JIF of 3.841 is ranked in the second quartile (19th out of 70 journals) in the journal category Biochemical Research Methods.

4.6 Data presentation

4.6.1 Data descriptions and rounding

All Figure titles are fully described with:

- Indicator name
- Field
- Country/countries
- Time period
- Data source
- Special notes (if applicable) on ordering or methodology

Data are rounded to 1 decimal place for percentages, and to 2 decimal places for indices of citation impact.

4.6.2 Presentation of data on share of world research output

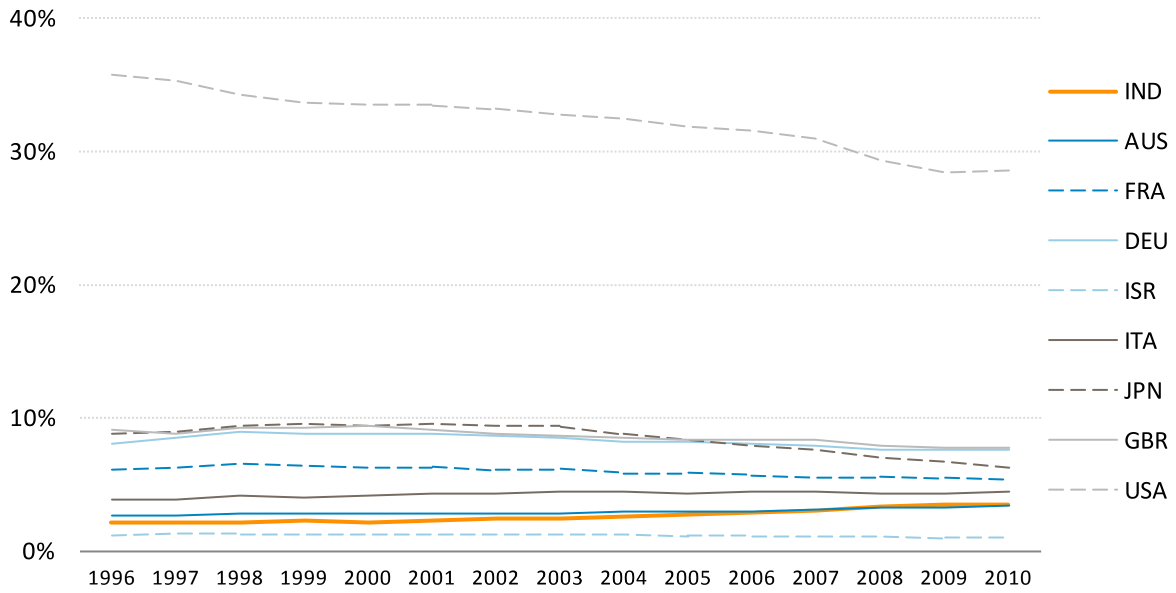
Data in Section 5 of this report are displayed as line graphs. In these Figures, data for India are indicated by a broad orange line. Data for other countries are indicated by narrower lines of different colours which are used consistently throughout the report. Countries are indicated in the Figures by the corresponding three-letter UN standard ISO ALPHA-3 codes (see Section 4.2.1).

Two major adjustments have been made to aid visual interpretation. These affect the USA and China.

The USA produces a much larger volume of papers than other research economies. Showing data for all G7 countries on the same Figure would therefore means that the other countries would be crowded in a narrow band at the bottom of the graph, making it difficult to differentiate between them.

The Figure below reproduces that from Section 5.1a.ii with the USA shown to illustrate this effect.

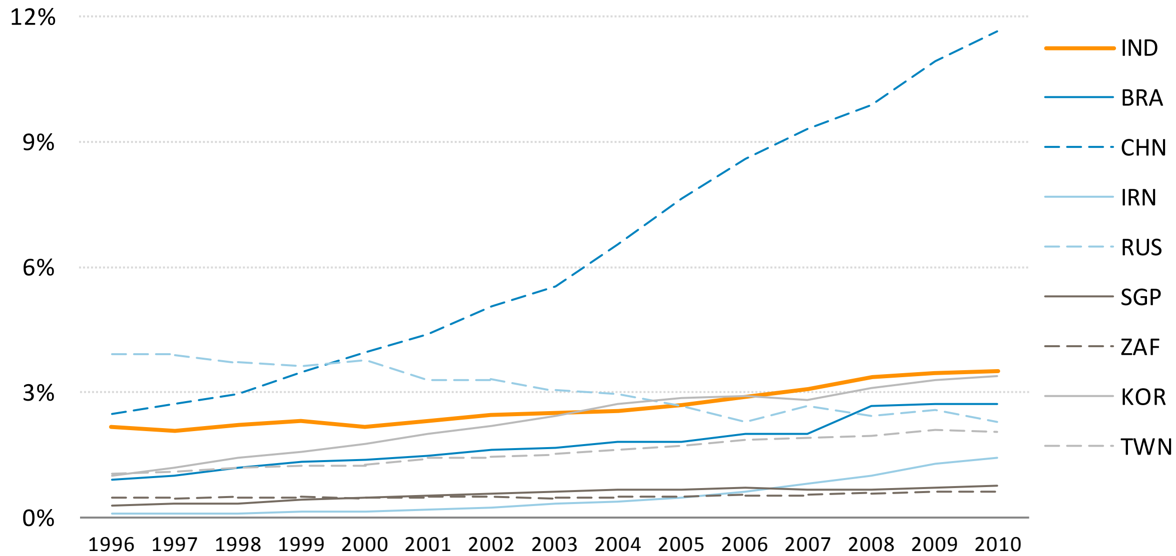
Share of world research output, All fields, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010 (includes the USA)



China has grown exceptionally rapidly compared to other emerging research economies. This means that it has a similar 'crowding effect' to the USA, but only in the later part of the period analysed. China's trajectory is allowed to leave the graphical analysis where its final volume would distort the visual interpretation of the research performance of other emerging research economies. Usually, this occurs in 1995-2010.

The Figure below reproduces the Figure from Section 5.1a.iv in a version that includes all China data to illustrate the crowding effect.

Share of world research output, All fields, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010 (China not cut-off)



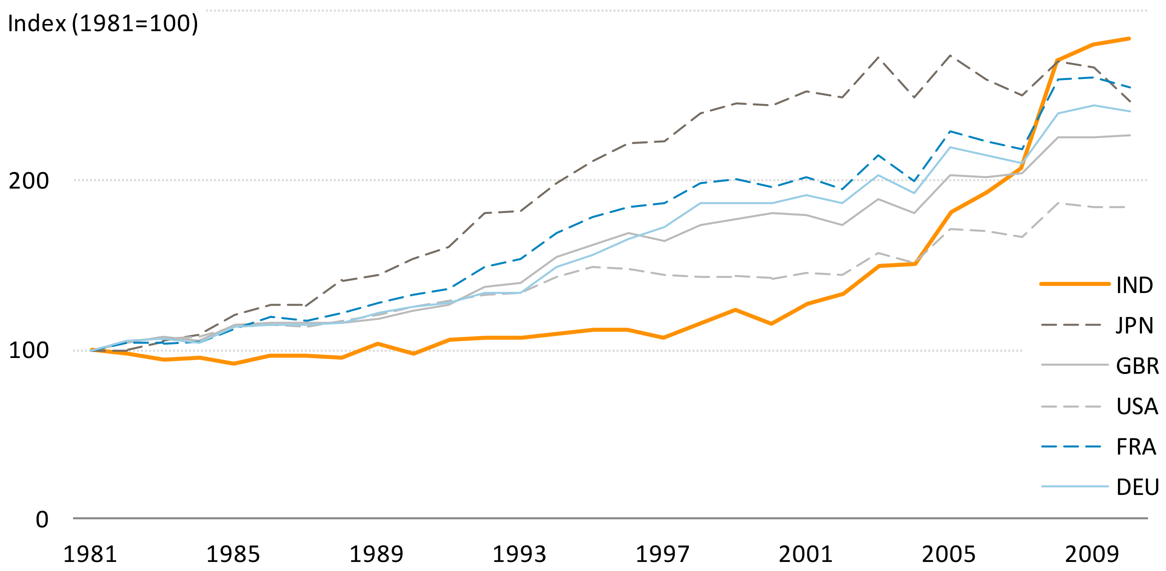
Wherever China and the USA are omitted from graphs, in whole or in part, full commentary is made of the changing share of world research output as these changes form a fundamental dynamic of the changing global research landscape.

Expanding global output has consequences for our interpretation of relative volumes of research activity. The most significant feature observed in studies of world research output over the past thirty years has been the very different growth of some countries. The growth in output of established research economies has been relatively steady, whilst the growth of emerging research economies has dramatically accelerated. The effect of this is two-fold.

- Some countries have increased their absolute output of research papers but lost world share.
- An observed decrease in share of world output does not necessarily mean that research capacity has decreased for that country.

The relative growth of India over the thirty year period is shown in the following Figure

World research output indexed to 1981, All fields, Selected research economies
Time period: 1981-2010, Source: NSI-ESI 2010



4.6.3 Presentation of data on citation impact

Citation impact data are shown as five-year moving averages. The reason for this is that output in specific fields may be relatively low for some countries. This introduces apparently erratic annual variation into the Figures making the visualisation and interpretation of annual trends more difficult to discern.

4.6.4 Presentation of axes and scaling of Figures

Axes may be set at different scales for the established economies and for the emerging economies, to reflect their different shares of world output. These axes are held constant between the two groups of countries for the early (1981-1995) and late periods (1996-2010) to assist a comparison of world shares.

5 Comparative international analysis of India's world share of output and citation impact

The aim of this Section is to analyse research paper output and citation impact:

- For India and a set of comparator countries (established and emerging research economies);
- Over a thirty-year time frame, split into two periods: 1981-1995 (historical) and 1996-2010 (contemporary);
- Disaggregated by the research fields used in *Essential Science Indicators®*.

Each analysis is presented as two double-paged spreads: one for output and one for citation impact, each comprising four Figures and two interpretative commentaries.

- **Share of world research output**: percentage share of world research output for each country. This is appropriate because the total world volume has grown over the period and database coverage has expanded to reflect this.
- **Normalised citation impact**: citation impact for each country relative to the world average (1.0). This is appropriate because citations accumulate over time and citation rates differ between fields.

Summary – Share of world research output

India lost a marginal share of its world output between 1981 and 1995, but at this time, it broadly ranked second to Russia within the emerging research economies group. By 1995, India and China had about equal world shares, but from 1996 onwards, China's world share exceeded that of India. India started to increase its share of world output over the last decade, but it had been surpassed by China from 1996 onwards. Indeed, China's rise was so dramatic, that its world share came second to that of the USA (albeit with a sizeable margin) and other established research economies saw their world shares decline. India regained its second position to China amongst the emerging economies research group as Russia declined although its relative position has been challenged by Korea over the past decade. India's share in 1981 was 3.1% and this fell to 2.1% by 1997 and its 1981 share was not regained until 2007. In 2010, it stands at 3.5%.

This summary of India's changing world share of output overall highlights several key themes:

- **Decline** of India's world share of output in the 1980s and 1990s.
- China **passing** India in terms of research activity.
- **Rise** of India's world share of output in the late 2000s.
- **Regaining** by India of its earlier world share.

Summary - Citation Impact

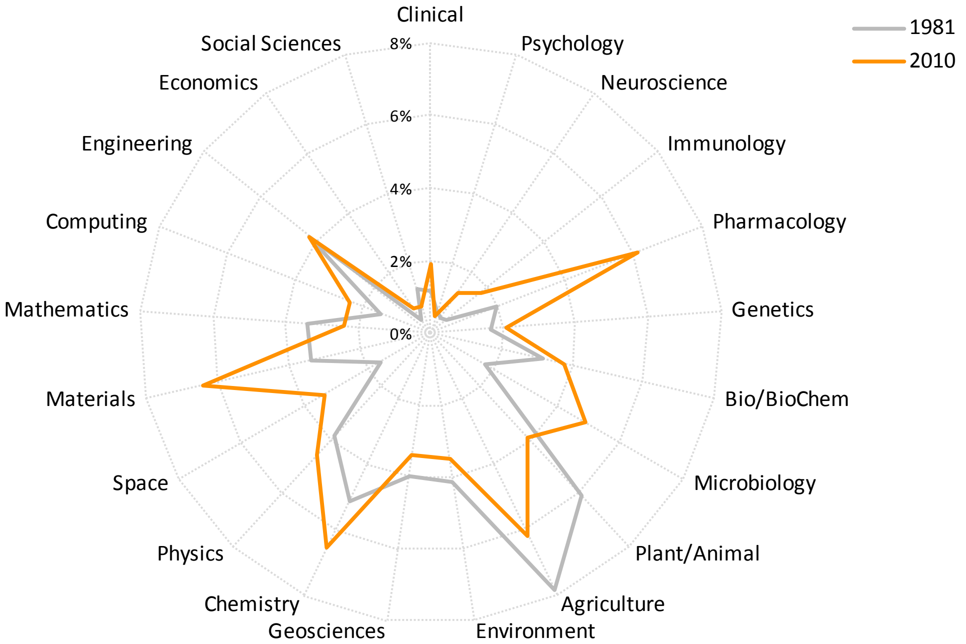
India's citation impact in the earlier period was low, though it improved. Its citation impact increased from 0.35 in 1981-1985 to 0.47 by 1993-1997, although this latter level was less than half of the world average (1.0). India ranked the lowest in the comparator group, with a sizeable gap between itself and the established research economies. India was also second lowest of the emerging research economies to Russia. It must be noted that these are comparisons to the selected comparator groups. There are other emerging research economies with lower citation impact than India internationally. Singapore stands out as the emerging research economy who has made the greatest gains when measured by citation impact. In the latter period (1994-1998 to 2006-2010), India's relative rank compared to other research economies remained unchanged, although its citation impact improved from 0.50 in 1994-1998 to 0.68 by 2006-2010.

This underlying pattern of India's citation impact highlights several key themes:

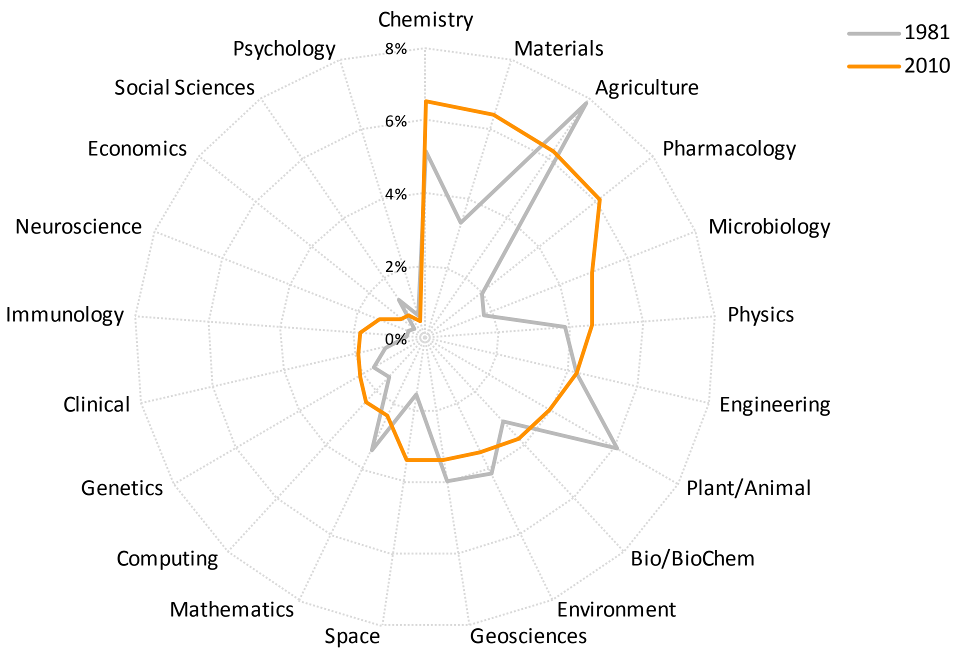
- Relatively **low citation impact** of India's research
- Associated **low ranking** of Indian research when compared to established research economies
- **Marked improvement** between 1981-1985 and 2006-2010
- **Narrowing gap** between citation impact for India and established economies

Summary Figures – Share of world research output

Share of world research output, ESI fields, India, 1981 and 2010, Source: NSI-ESI 2010
Ordered by standard sequence

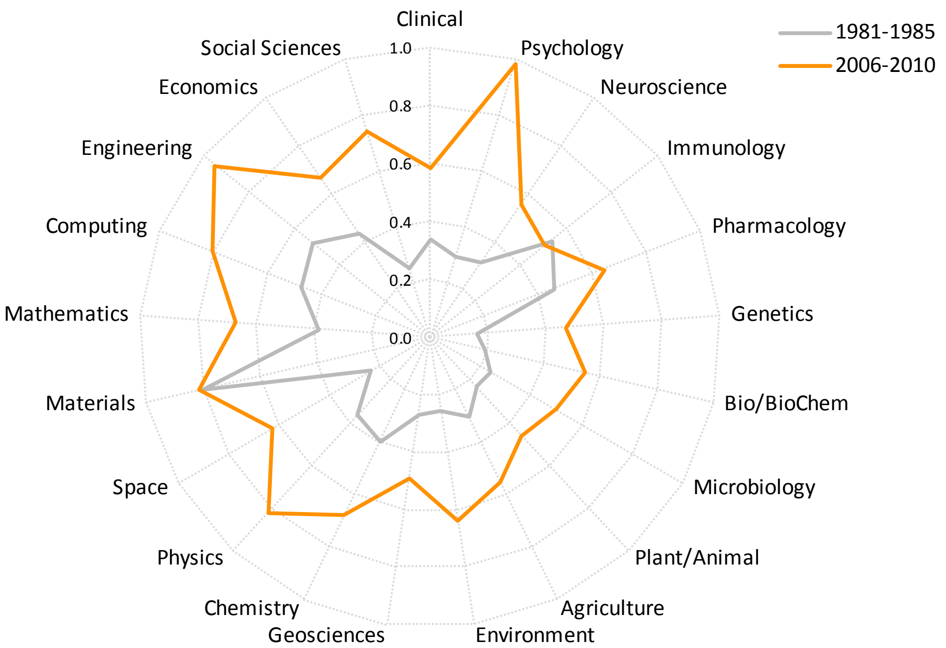


Share of world research output, ESI fields, India, 1981 and 2010, Source: NSI-ESI 2010
Ordered by share of world research output 2010

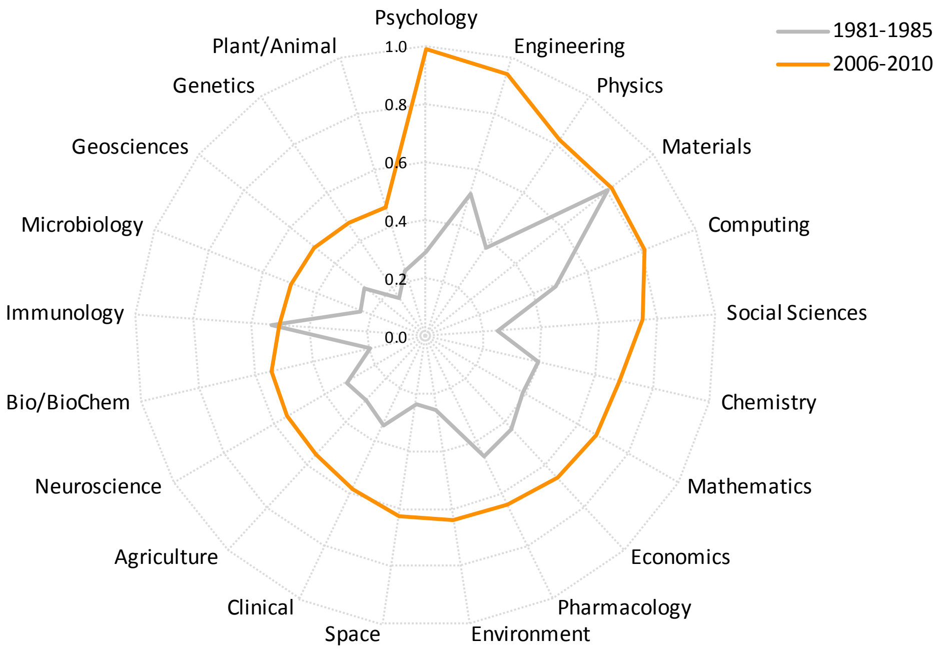


Summary Figures – Normalised citation impact

Normalised citation impact, ESI fields, India; 1981-1985 and 2006-2010, Source: NSI-ESI 2010
Ordered by standard sequence



Normalised citation impact, ESI fields, India; 1981-1985 and 2006-2010, Source: NSI-ESI 2010
Ordered by normalised citation impact 2006-2010



Summary by field – World share of output

- **Clinical Medicine**: India's share of world research output was less than 1% between 1981 and 1995. It increased to 1.9% by 2010. China, Korea and Brazil have greater shares than India, although the established research economies shares have not declined as dramatically as in other fields.
- **Psychiatry/Psychology**: India's share of world research output was less than 0.5%, but this field was largely dominated by the USA and the UK, with little or no challenge from other research economies.
- **Neuroscience & Behaviour**: India's share of world research output averaged less than 0.5% in the earlier period, but it rose to 1.4% by 2010.
- **Immunology**: India's share of world research output only rose marginally in Immunology from 0.5% in 1981 to 0.8% by 1995 but it grew to 1.8% by 2010.
- **Pharmacology & Toxicology**: India's share in Pharmacology & Toxicology fell between 1981 and 1995, but it rose dramatically to 6.1% by 2010, more or less converging with the shares of the UK and Germany by 2009.
- **Molecular Biology & Genetics**: India's share in Molecular Biology & Genetics fell between 1981 (1.7%) and 1995 (0.9%), but it rose to 2.1% by 2010, although China, Korea and Brazil had greater shares by 2010. The rising shares of the established research economies levelled.
- **Biology & Biochemistry**: India's share in Biology & Biochemistry fell from 3.2% in 1981 to 1.6% by 1995, but it recovered its share to 3.8% by 2010 with a drive upwards from approximately 2004 onwards.
- **Microbiology**: India's share in Microbiology, though negligible in the 1980s and 1990s, leapt in 2008 to a 4.9% share by 2010. This moved India's rank up vis-à-vis the established research economies and made it second to China amongst the emerging research economies.
- **Plant & Animal Science**: India had quite a large world share in Plant & Animal Science in the 1980s; although it fell markedly from 6.1% in 1981 to 3.9% by 1995 (it was 3.9% by 2010). Its share was superseded by both China and Brazil.
- **Agricultural Sciences**: India had a large world share in Agricultural Sciences, which broadly averaged 7.4% over the 1981 to 1995 period, well ahead of other emerging research economies. Its share fell to 6.2% by 2010. What is notable about this particular field is the leap in Brazil's share: 9.6% by 2010, which exceeded the share of China.
- **Environment/Ecology**: India's world share in this field fell from 4.1% in 1981 to 2.4% by 1995, but rose again to 3.5% by 2010.
- **Geosciences**: India's world share in this field averaged around 3.5% in the earlier period and around 3.2% in the later period.
- **Chemistry**: India's share of world output fell over the earlier period (from 5.1% in 1981 to 3.8% by 1990) and China's increase in world share of Chemistry research output was notable at quite an early stage. India's share of world output in Chemistry increased from 4.1% in 1996 to 6.5% by 2010, with the UK and France falling in rank to India's rise. China, however, quadrupled its output in Chemistry research to 20.7% by 2010, overtaking the USA in 2007.
- **Physics**: India's world share in Physics fell over the earlier period from 3.9% in 1981 to 2.9% by 1995, but rose to 4.6% by 2010. China's output quadrupled during this period to 18.6% of world share by 2010.
- **Space Science**: India's share of world output in Space Science rose and fell over the earlier period: it was 2.1% by 1995, but rose to 3.4% by 2010. European countries saw their research output in this field increase, possibly due to European collaboration in this area.
- **Materials Science**: India's share of world output in Materials Science broadly averaged 4.0% during the earlier period, and China's increases in world share in Materials Science was notable at quite an early stage. India's share grew between 1996 and 2010 to 6.4% by 2010, but China's output quintupled from 5.1% in 1996 to an astounding 25.3% by 2010, surpassing the USA in 2005.
- **Mathematics**: India's share of world output fell from 3% to 2% by 1995 and was broadly maintained at these levels. China's rise in Mathematics was notable in this earlier period. China trebled its Mathematics output over this period to 16.7% of world share by 2010.

- **Computer Science**: India's share of world output in Computer Science only marginally increased over this period. It was 2.4% by 2010, up from 1.5% in 1981. World share moved to three emerging research economies by 2010: China (14.5%), Korea (6.3%) and Taiwan (5.7%).
- **Engineering**: India's share of world output in Engineering fell from 4.3% in 1981 to 2.2% by 1995. China's rise was notable over this period. In the later period, however, India regained its lost share: 4.2% by 2010. India was overtaken by other emerging research economies by 2010, namely China (16.4%), Korea (5.4%) and Taiwan (4.4%).
- **Economics & Business**: India's share of world research output in Economics & Business averaged 0.5% in the earlier period and 0.7% in the later period.
- **Social Sciences**: India's world share of output in Social Sciences averaged 1.0% over the earlier period, and 0.6% over the later period.

Summary by field – Citation impact

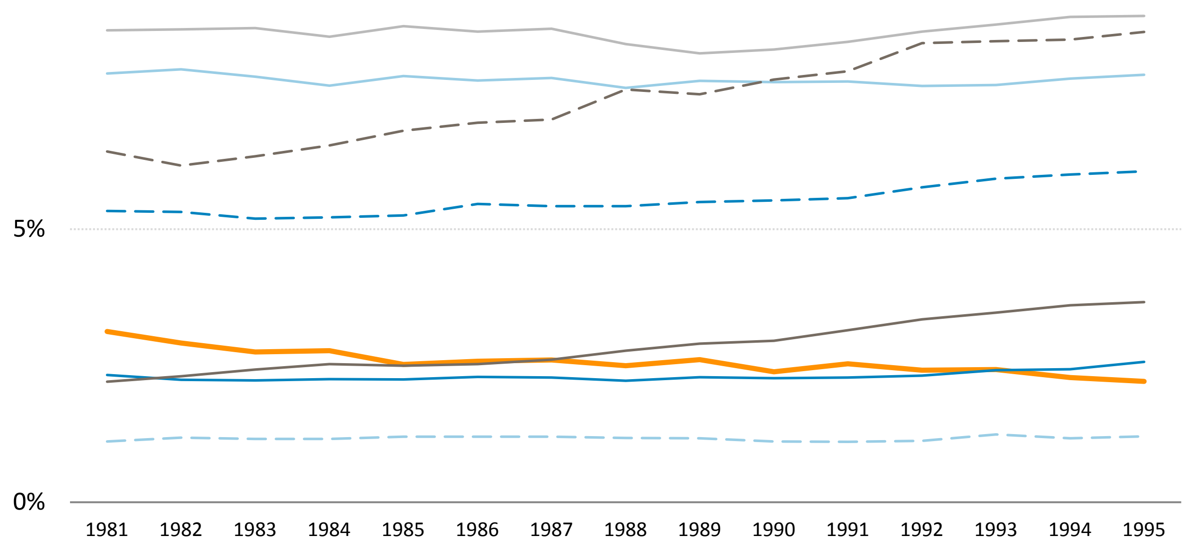
- **Clinical Medicine**: India's citation impact in Clinical Medicine improved from 0.34 in 1981-1985 to 0.42 in 1993-1997, to 0.58 by 2006-2010, but this was below the figure for Indian research as a whole (0.68 in 2006-2010).
- **Psychiatry/Psychology**: India's citation impact in Psychiatry/Psychology improved from a low 0.29 in 1981-1985 to 0.44 by 1993-1997; but by 2006-2010, India's citation impact was 0.99, the highest amongst all fields and just short of world average levels (1.0), and the highest citation impact of emerging research economies by this point. This needs to be qualified by the capacity of the field which is comparatively small.
- **Neuroscience & Behaviour**: India's citation impact in Neuroscience & Behaviour fell from 0.31 in 1981-1985 to 0.25 in 1993-1997, but rose to 0.55 by 2006-2010.
- **Immunology**: India's citation impact in Immunology fell from 0.53 in 1981-1985 to a low of 0.31 in 1988-1992 but rose to 0.47 by 1993-1997. The citation impact of Indian Immunology research only marginally increased in the later period, from 0.45 in 1994-1998 to 0.51 by 2006-2010, which was a slight fall on its 1981-1985 level.
- **Pharmacology & Toxicology**: India's citation impact in Pharmacology & Toxicology improved from 0.46 in 1981-1985 to 0.55 by 1993-1997, to 0.64 by 2006-2010, although this was a fall from a high of 0.76 in the early part of the 2000s.
- **Molecular Biology & Genetics**: This was India's lowest citation impact in any field: 0.16 in 1981-1985 to 0.30 by 1993-1997. It improved to 0.47 by 2006-2010 but it was the second lowest citation impact by field in this period.
- **Biology & Biochemistry**: India's citation impact was low: 0.19 in 1981-1985 and 0.28 by 1993-1997. It increased substantially to 0.55 by 2006-2010, although this is below the Indian average for research overall (0.68 in 2006-2010).
- **Microbiology**: India's citation impact is this field was low: 0.24 in 1981-1985 but it improved to 0.38 by 1993-1997. Its citation impact increased to a high of 0.62 in 2003-2007, but it fell back to 0.50 by 2006-2010, which coincided with the expansion in Indian Microbiology papers.
- **Plant & Animal Science**: India's citation impact was well below world average – 0.23 in 1981-1985 and 0.29 by 1993-1997. Whilst its citation impact increased to 0.46 by 2006-2010, this was the lowest citation impact by field in this period.
- **Agricultural Sciences**: India's citation impact was 0.30 in 1981-1985 and 0.27 by 1993-1997. It improved to 0.55 by 2006-2010.
- **Environment/Ecology**: India's citation impact was 0.25 in 1981-1985, 0.37 by 1993-1997, but its citation impact increased dramatically in the 2000s to 0.64 by 2006-2010. This was just below the background figure for Indian research as a whole.
- **Geosciences**: India's citation impact was 0.27 in 1981-1985 and 0.30 by 1993-1997. By 2006-2010, it was 0.49: the third lowest citation impact by field in this period.
- **Chemistry**: Indian citation impact was 0.40 in 1981-1985 and 0.50 by 1993-1997 and it rose to 0.68 by 2006-2010.
- **Physics**: Indian citation impact rose quite dramatically over the earlier period, from 0.37 in 1981-1985 to 0.63 by 1993-1997, and it rose to 0.82 by 2006-2010 making it the field with the third highest

citation impact by 2006-2010. This move significantly narrowed the gap between India and the established research economies.

- **Space Science**: India's citation impact increased from a low 0.23 in 1981-1985 to 0.44 by 1993-1997. It increased to 0.63 by 2006-2010, but below the background citation impact figure for Indian research overall.
- **Materials Science**: India's citation impact fell from a high value in 1981-1985 of 0.80 to 0.71 by 1993-1997. This citation impact was regained by 2006-2010: 0.82. This is well above the background citation impact figure for Indian research, narrowing the gap between India and the established research economies.
- **Mathematics**: India's citation impact was relatively low in Mathematics: 0.38 in 1981-1985 and 0.44 by 1993-1997. India's citation impact improved in the later period and was 0.67 by 2006-2010.
- **Computer Science**: India's citation impact was 0.65 by 1993-1997. It rose to 0.81 by 2006-2010.
- **Engineering**: India's citation impact improved from 0.52 in 1981-1985 to 0.67 by 1993-1997. India's citation impact particularly improved over the later period: it was 0.95 by 2006-2010 slightly down from a high of 0.98 in 2005-2009. This made Engineering the field with India's second highest citation impact, that was also greater than Japan's citation impact in the 2000s.
- **Economics & Business:** India had a negligible improvement in citation impact in the earlier period: 0.43 in 1981-1985 and 0.44 by 1993-1997. However, by 2006-2010, it had increased to 0.66.
- **Social Sciences**: India had a negligible improvement in citation impact in the earlier period: 0.25 in 1981-1985 and 0.27 by 1993-1997. However, all research economies (except the USA and the UK) had below world average citation impact in this field. In the later period, India's citation impact in Social Sciences more or less doubled from 0.37 in 1994-1998 to 0.75 by 2006-2010.

Section 5.1.a: Share of world research output, All fields

5.1.a.i: Share of world research output, All fields, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

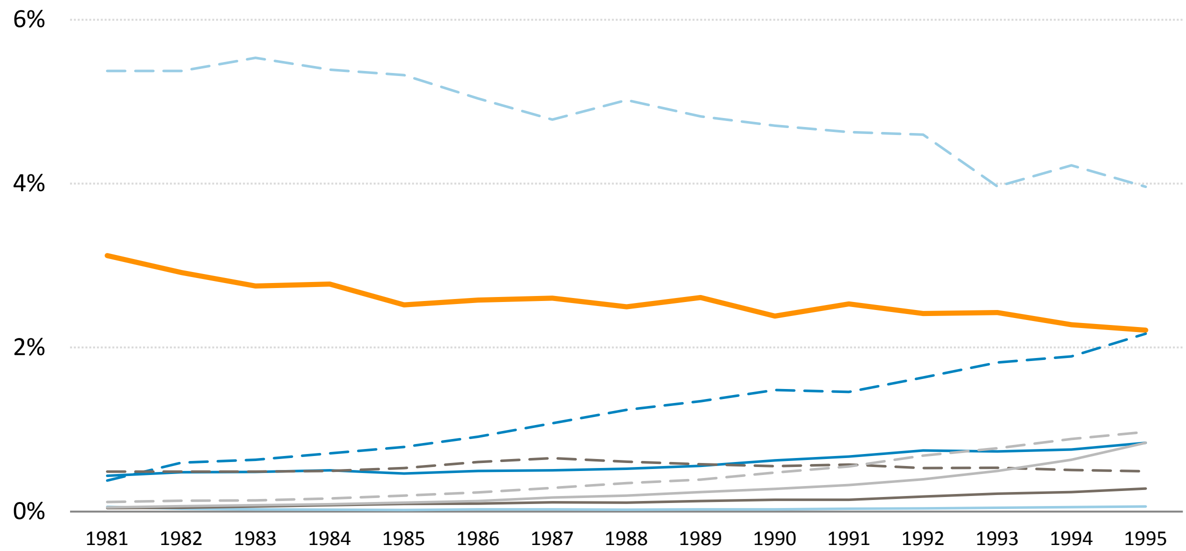


Amongst the established research economies, the USA (not shown due to the visually dwarfing effect of its scale) was clearly the dominant player. It had an average over this 15-year period of a 38.4% share, although its share declined from 39.1% in 1981 to 37.0% in 1995. The USA was followed by the UK and Germany, though Japan overtook Germany in the early 1990s.

India's percentage world share broadly declined by 0.9% over the same period although it is notable that it ranked second to Russia within the emerging research economies group. Amongst this group, two trends are evident. The first is the decline of Russia, and the second is the beginning of the rise of China from 0.4% in 1981 to 2.2% by 1995.

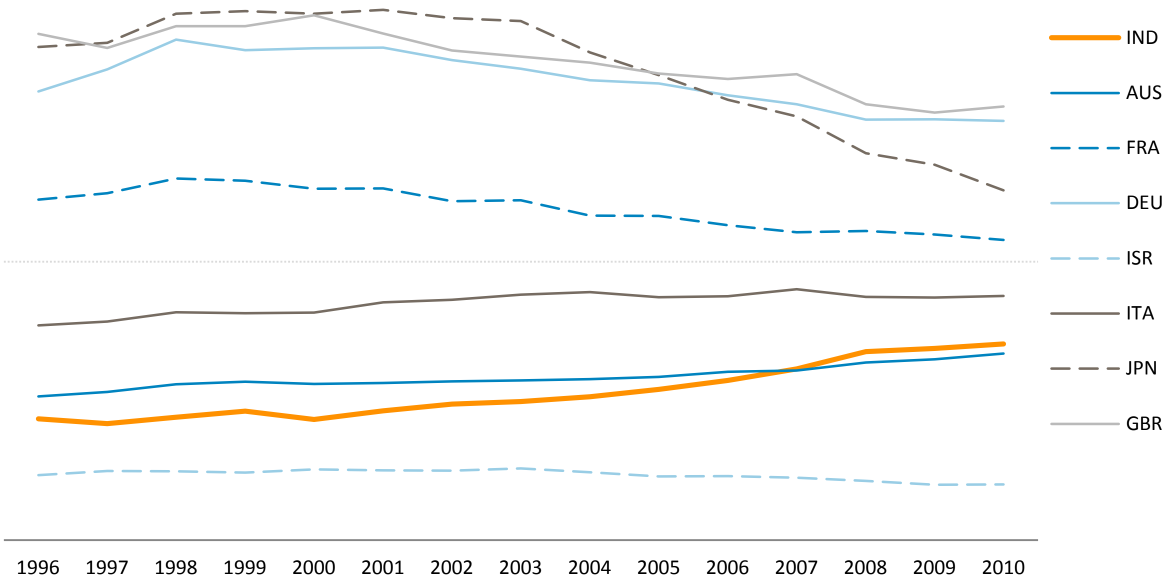
Note that the axes for established and emerging research economies are set at different scales. This reflects their different shares of world output.

5.1.a.iii: Share of world research output, All fields, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.1.a: Share of world research output, All fields

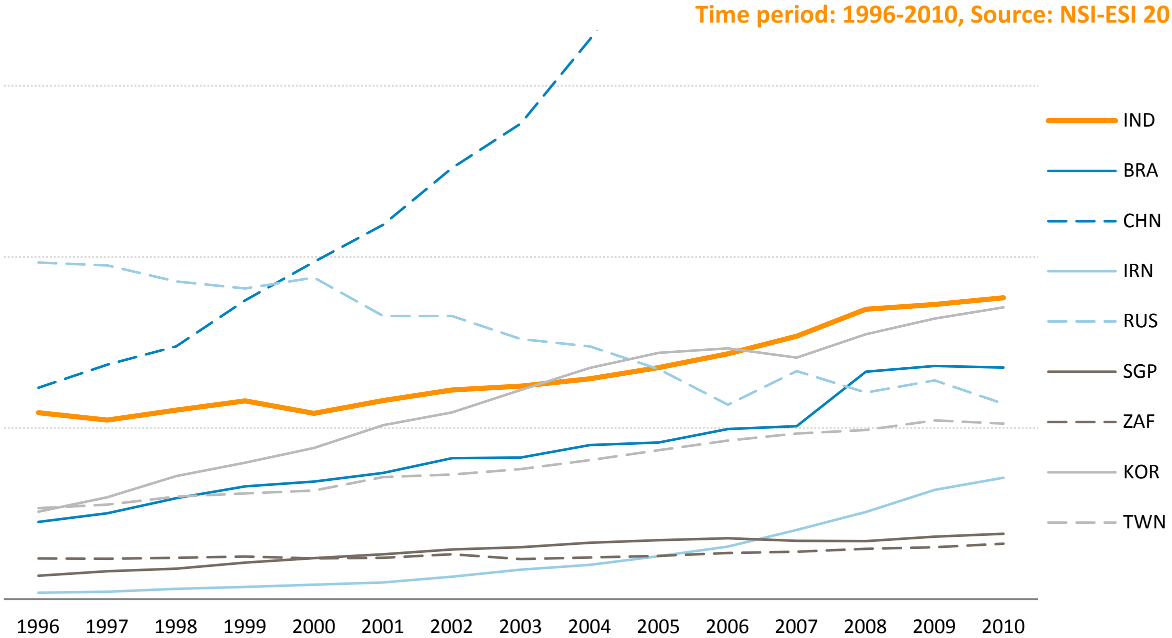
5.1.a.ii: Share of world research output, All fields, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010



In this later period, the decline in world share amongst some of the major established research economies became more apparent. The USA (not shown) lost around 7.2% of world share over this period, falling from 35.8% in 1996 to 28.6% by 2010. Japan's world share (which had briefly overtaken that of the UK and Germany in the late 1990s) declined from around 2002/2003, with the UK and Germany coming second and third respectively to the USA. Italy and Australia increased their world shares over this period.

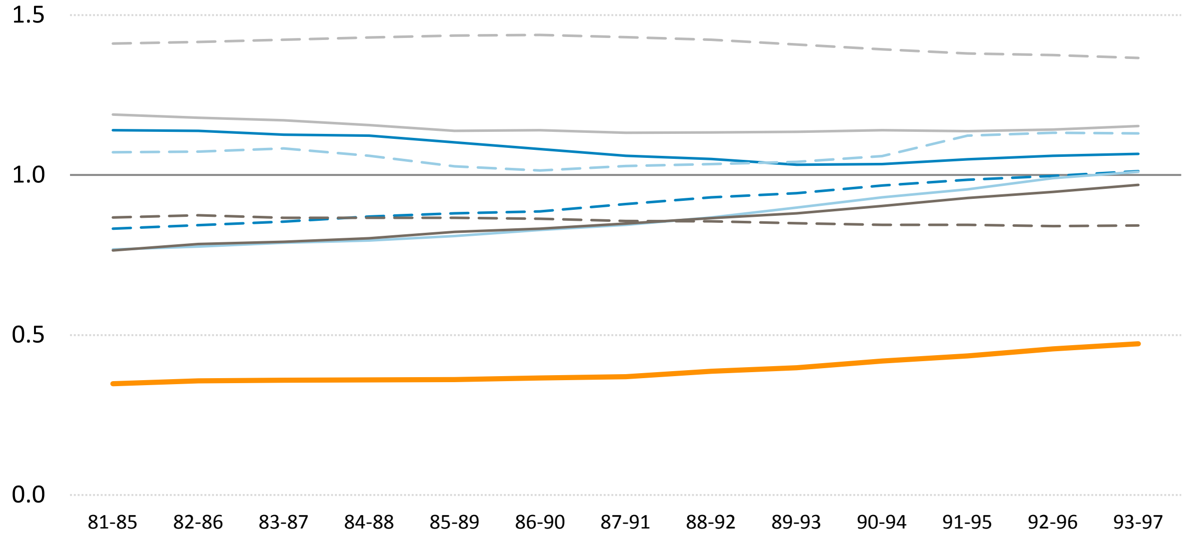
India increased its world share from 2.2% in 1996 to 3.5% by 2010, ranking second within the emerging research economies group. However, it is evident that the gap between India and Korea is narrowing (Korea briefly overtook India between 2004 and 2006). China increased its world share dramatically from 2.5% in 1996 to 11.7% by 2010. The growth over this period of other emerging research economies such as Korea, Brazil and Taiwan is also remarkable.

5.1.a.iv: Share of world research output, All fields, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.1.b: Normalised citation impact, All fields

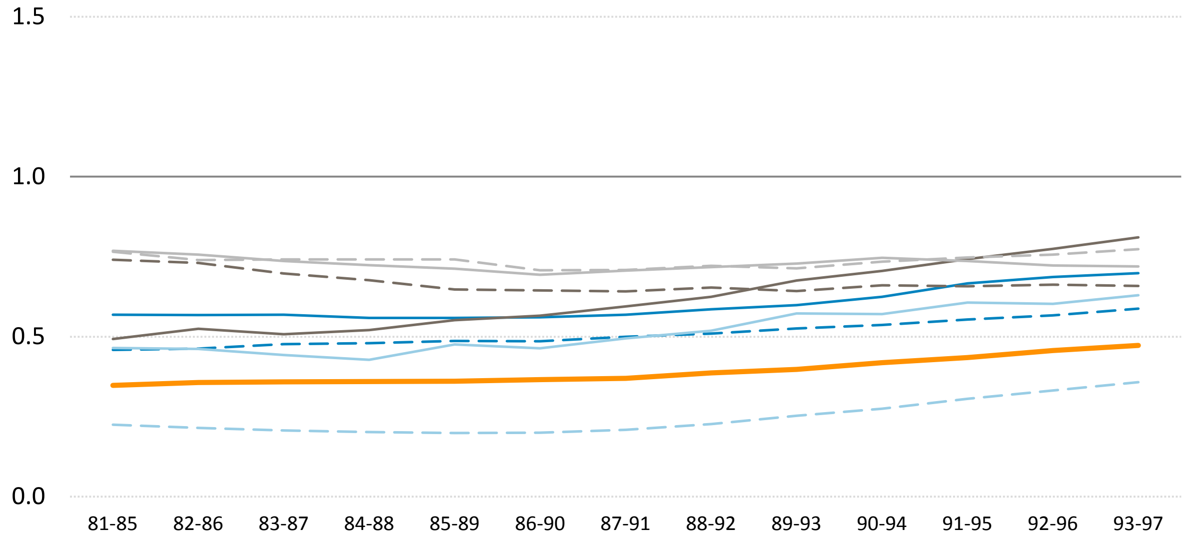
5.1.b.i: Normalised citation impact, All fields, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



By 1993-1997, India's citation impact was clearly and significantly below the levels of the established research economies, although it improved from 0.35 to 0.47. The USA had the highest citation impact over this period, although it began to fall in the later part of it from 1.41 to 1.37. The UK was second by rank, with Australia third by rank in the earlier period until overtaken by Israel.

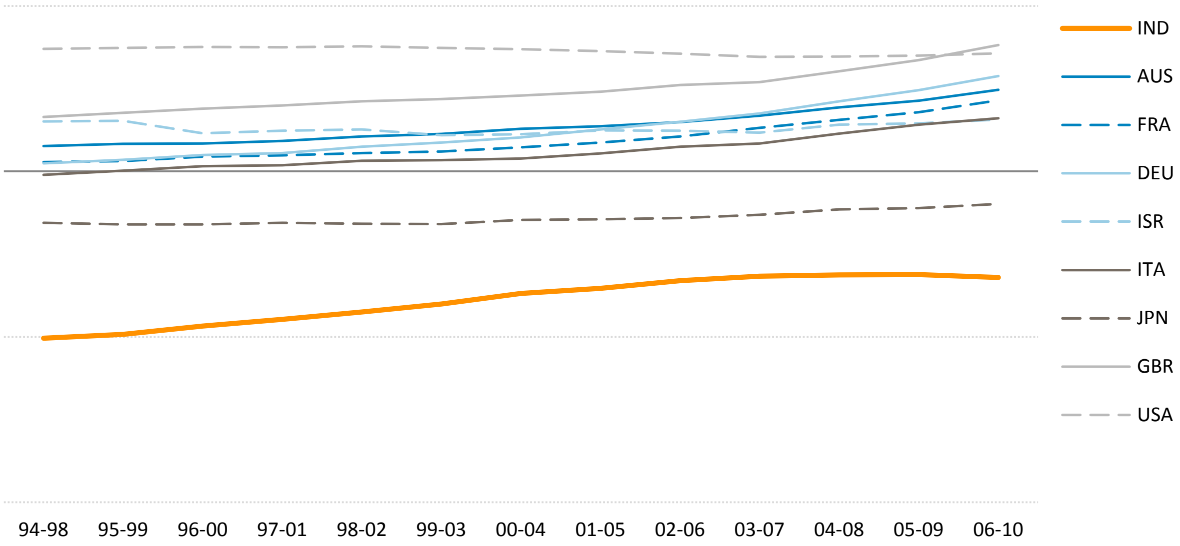
Amongst the emerging research economies, India ranked second lowest to Russia. That said, all the emerging research economies at this stage are well below world average levels of impact (1.0 in the graph), but it is evident that Singapore's trend of improving citation impact begins in this period, rising from 0.49 (1981-1985) to 0.81 (1993-1997).

5.1.b.iii: Normalised citation impact, All fields, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.1.b: Normalised citation impact, All fields

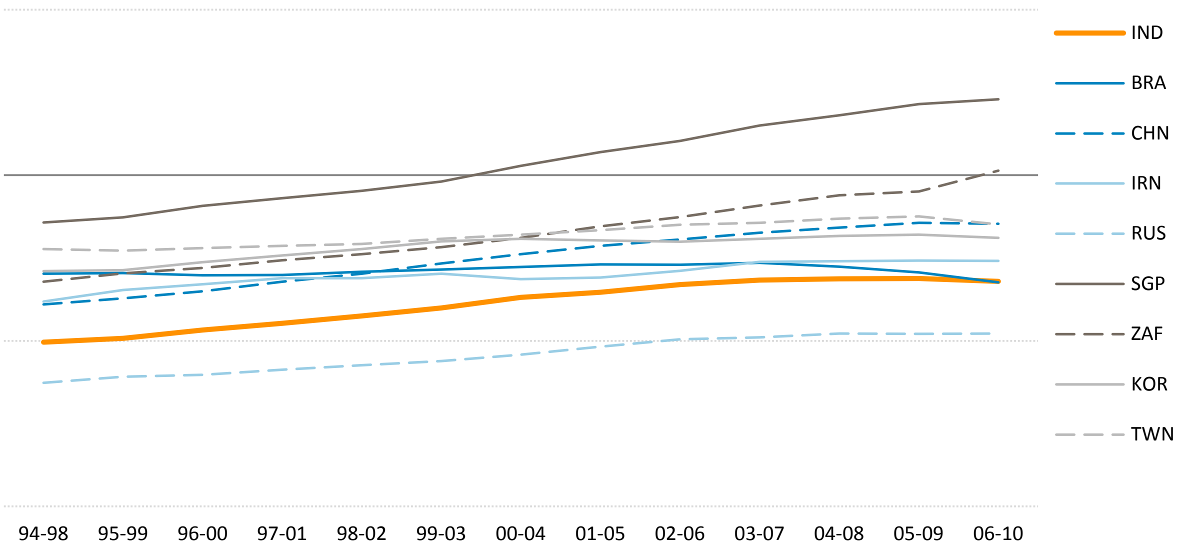
5.1.b.ii: Normalised citation impact, All fields, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



In this later period, it is evident that all of the established research economies increased their citation impact (USA levels were more or less stable, though on the downside). The UK marginally overtakes the USA by 2010 (from 1.16 in 1994-1998 to 1.38 by 2006-2010). India over this period improved its citation impact from 0.50 in 1994-1998 to 0.68 in 2006-2010. It still remains lowest in this group by rank but the gap has narrowed.

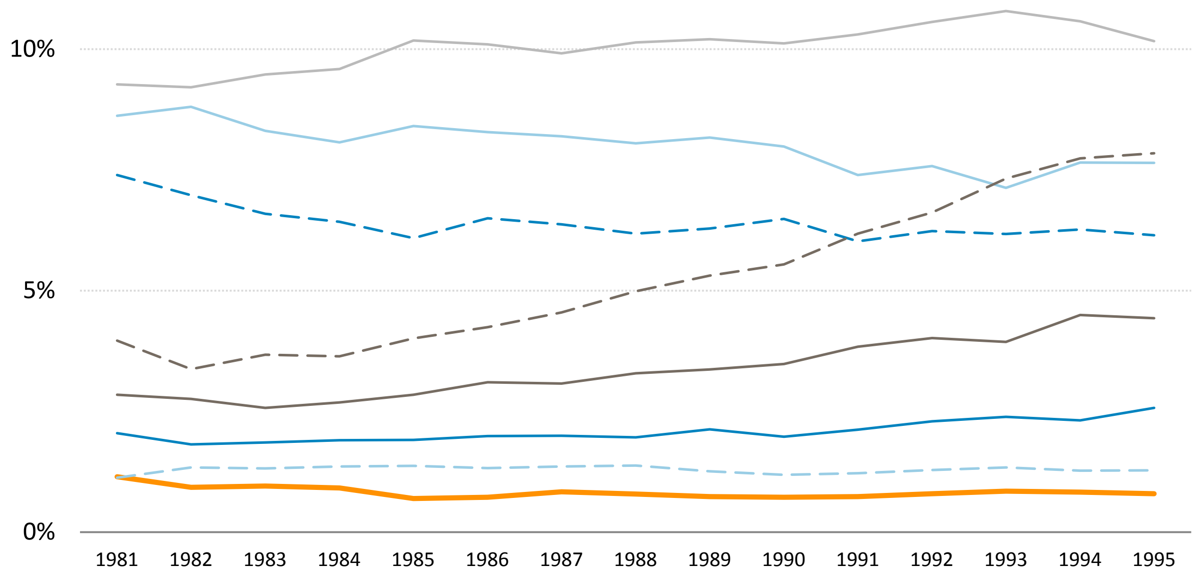
Amongst the emerging research economies, the trend witnessed in the earlier period is still apparent, in that India is second lowest to Russia, but also that the improvement in citation impact amongst the emerging research economies is quite distinct. Singapore notably improves its citation impact from 0.86 (1994-1998) to 1.23 (2006-2010). South Africa also crosses the world average threshold by 2006-2010.

5.1.b.iv: Normalised citation impact, All fields, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.2.a: Share of world research output, Clinical medicine

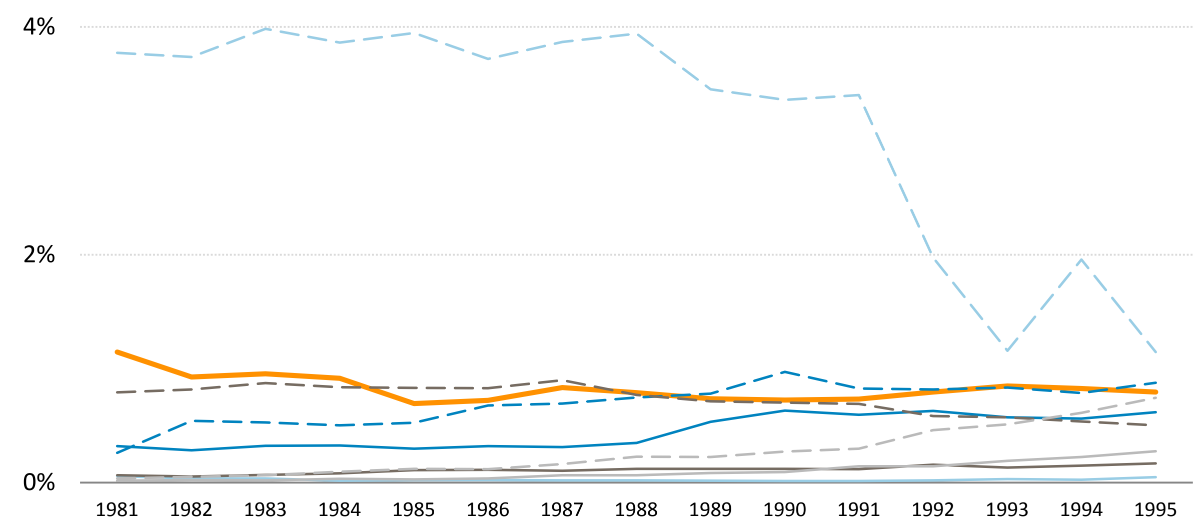
5.2.a.i: Share of world research output, Clinical medicine, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010



India's share of world output in Clinical Medicine was less than 1%. It had the lowest rank amongst the established research economies. Amongst the emerging research economies, its rank was more mixed: sometimes second and sometimes third relative to South Africa in the earlier part of this period, and relative to China in the later part of this period. Russia's decline in this field was clearly precipitous, from 3.8% of world share in 1981 to 1.1% of world share by 1995 (and ultimately 0.5% of world share by 2010).

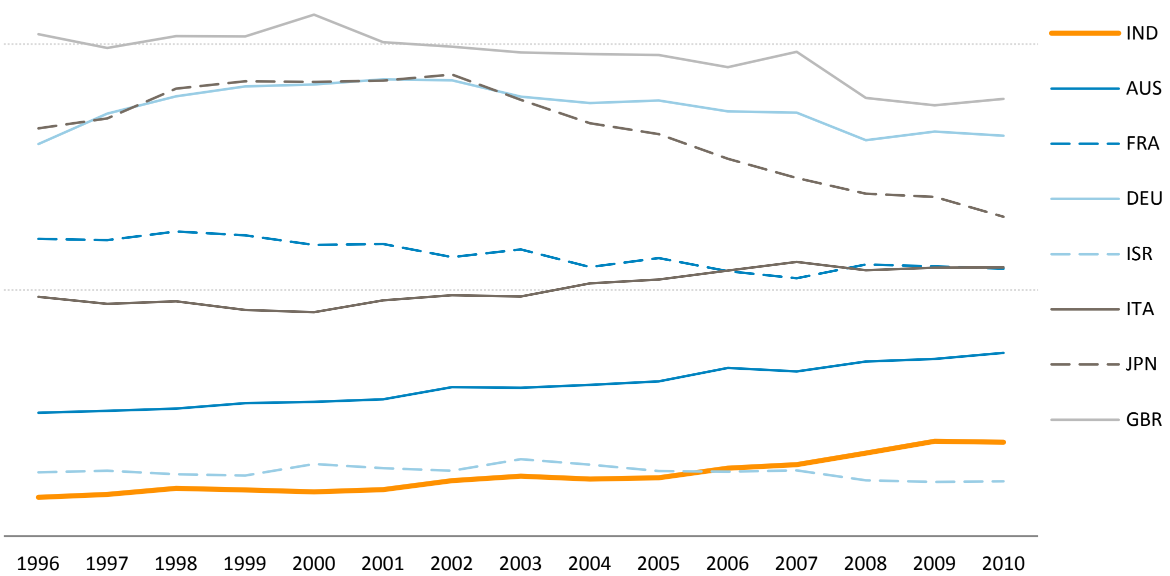
The USA (not shown) maintained its world share over this period, averaging 39.3%. Second to the USA was the UK whose share broadly rose from 9.3% in 1981 to 10.2% by 1995 (with a high of 10.8% in 1993). Germany and France's shares broadly declined (-1.0% and -1.3%) whilst the world shares of Japan (+3.9%), Italy (+1.6%) and Australia rose (+0.5%).

5.2.a.iii: Share of world research output, Clinical medicine, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.2.a: Share of world research output, Clinical medicine

5.2.a.ii: Share of world research output, Clinical medicine, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

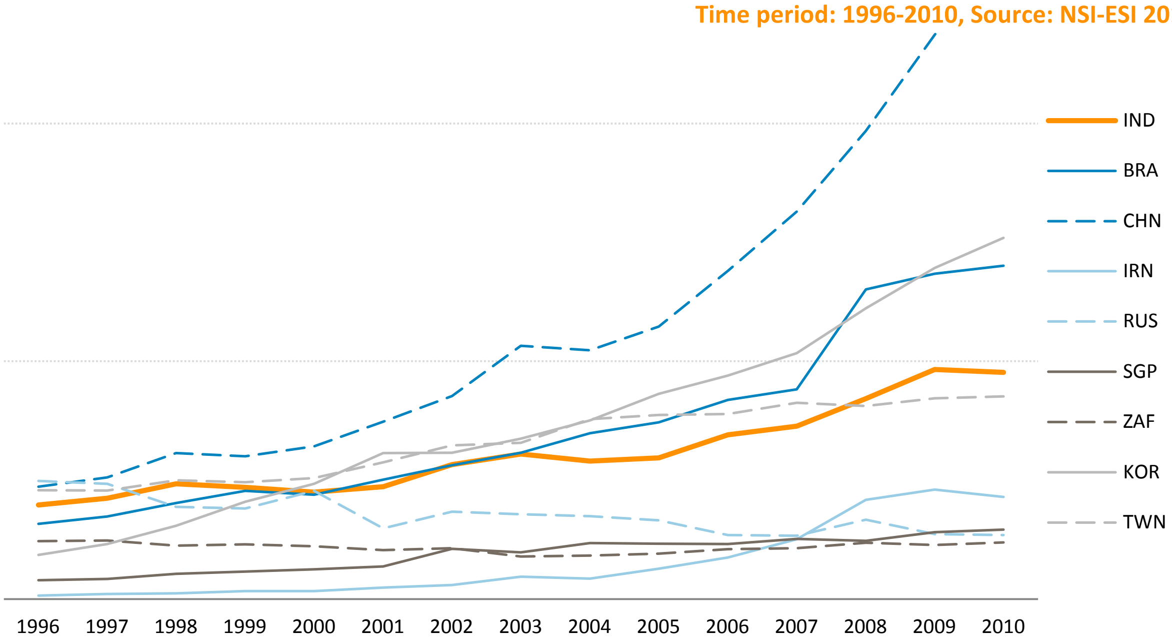


India's share of world output in Clinical Medicine increased from 0.8% to 1.9% (+1.1%). Its rank improved from last to eighth amongst the established research economies as it overtook Israel in 2006. China's gains in this field were more marked, rising from 0.9% in 1996 to 5.5% by 2010.

China's general rise was less marked in this field so the fall in share of the USA (not shown) and other established research economies was not as marked (the USA's share fell from 37.9% to 34.1%) compared to other fields. Some established research economies lost share, such as the UK (-1.3%) and Japan (-1.8%), and others gained, such as Australia (+1.2%) and Italy (+0.6%). France's share had declined from 7.4% in 1981 to 5.4% by 2010 whilst Germany's world share varied over the period.

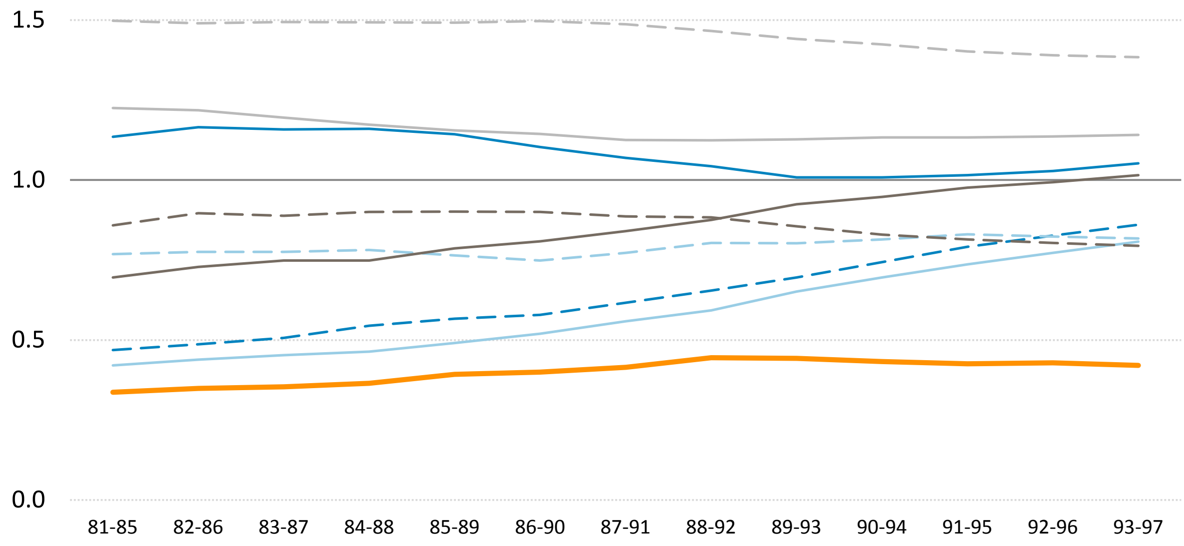
Korea and Brazil have overtaken India in Clinical Medicine. Korea's world share rose from 0.4% in 1996 to 3.0% by 2010; Brazil's from 0.6% to 2.8%. Taiwan has broadly around the same share as India.

5.2.a.iv: Share of world research output, Clinical medicine, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.2.b: Normalised citation impact, Clinical medicine

5.2.b.i: Normalised citation impact, Clinical medicine, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

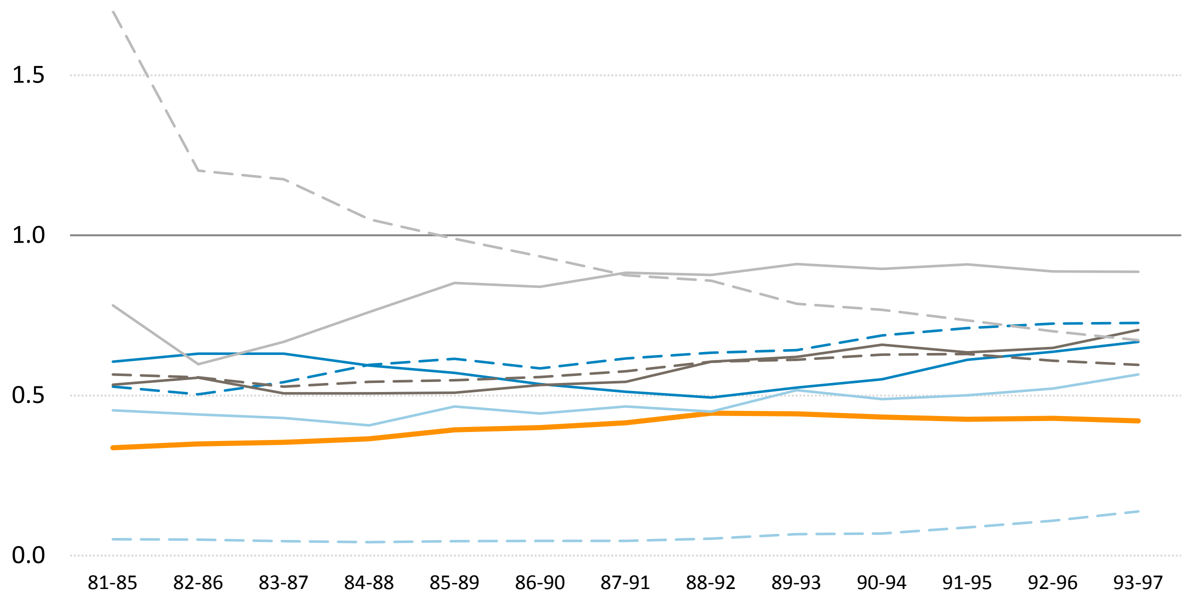


India's citation impact improved somewhat from 0.34 in 1981-1985 to 0.42 by 1993-1997. However, these levels are well below world average and it ranked the lowest amongst the established research economies and was second lowest to Russia amongst the emerging research economies.

The USA had the highest citation impact, although it fell over the period from 1.50 in 1981-1985 to 1.38 by 1993-1997. The UK had the second highest citation impact, but this fell from 1.23 in 1981-1985 to 1.14 by 1993-1997. Australia's citation impact varied over the period: from a high of 1.17 in 1982-1986, to 1.05 by 1993-1997. All other established research economies were below world average, although big improvements were made by Italy (+0.32), France and Germany (both +0.39).

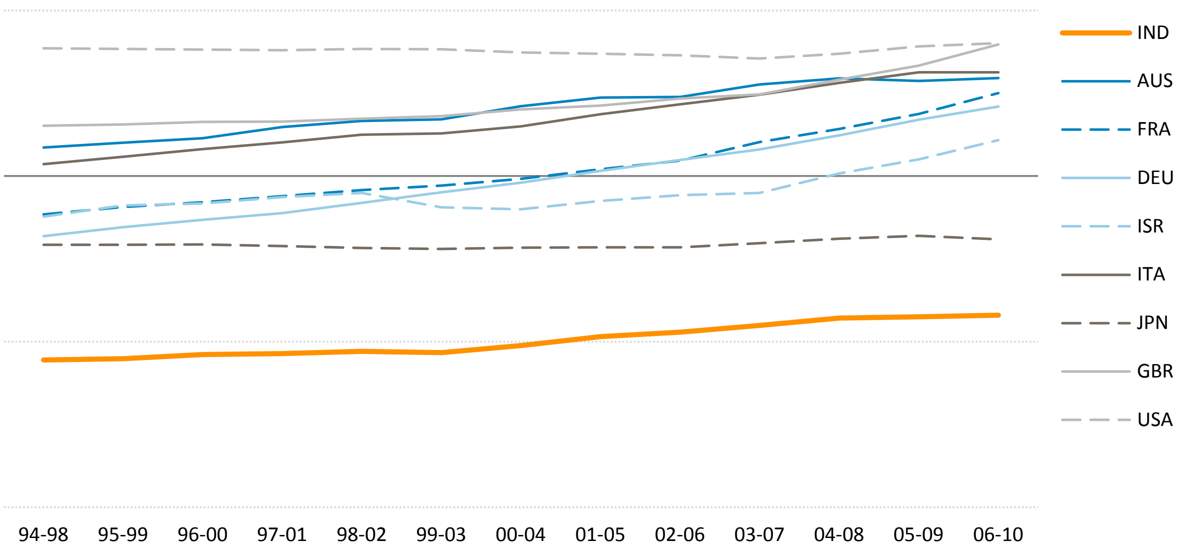
Amongst the emerging research economies, Taiwan had a period in the early 1980s when its citation impact was well above world average (1.70 in 1981-1985) and Korea made gains from 0.60 in 1982-1986 to 0.89 by 1993-1997.

5.2.b.iii: Normalised citation impact, Clinical medicine, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.2.b: Normalised citation impact, Clinical medicine

5.2.b.ii: Normalised citation impact, Clinical medicine, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

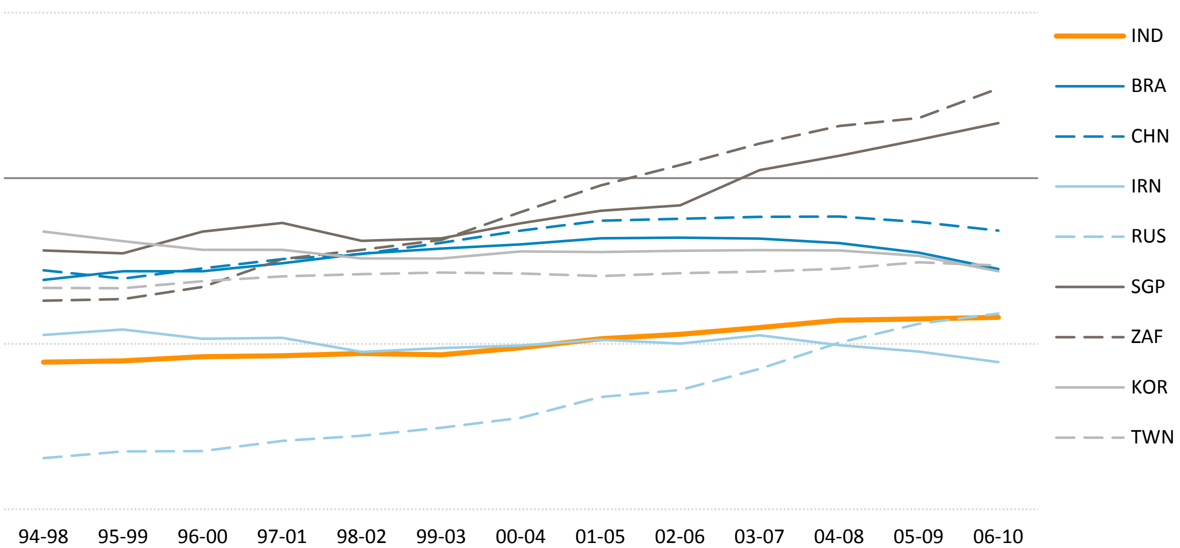


India's citation impact improved from 0.44 in 1994-1998 to 0.58 by 2006-2010, but it was still well below the world average, and it ranked the lowest amongst the established research economies and varied in rank between seventh and eighth amongst the emerging research economies vis-à-vis Russia and Iran.

Amongst the established research economies, the USA remained top but by 2006-2010 its citation impact was equal to that of the UK (1.40). Italy had come to rank third (1.31), Australia fourth (1.30) and France fifth (1.25). Japan's citation impact was well below world average (0.81).

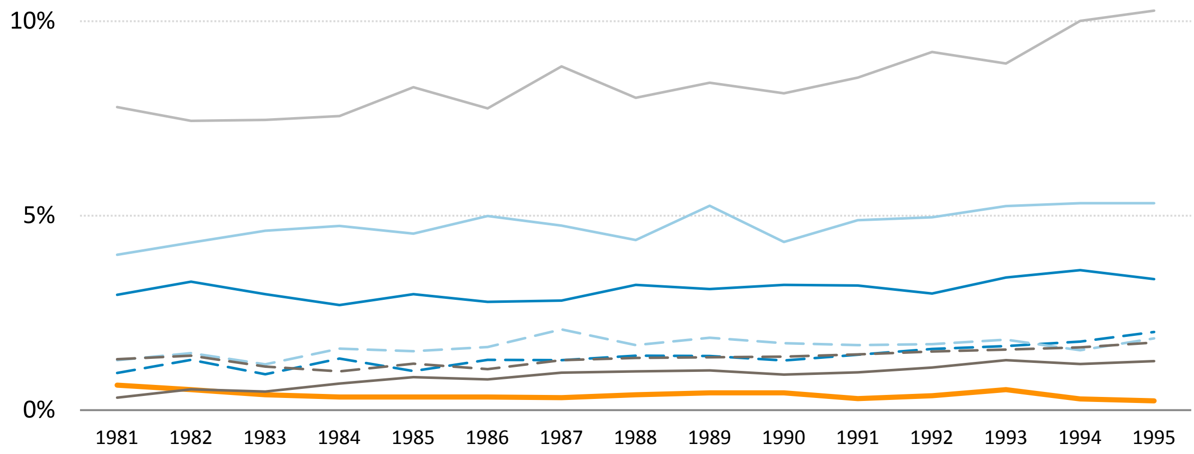
Amongst the emerging research economies, South Africa and Singapore achieved above world average levels of citation impact and it was indicative of substantial improvements in citation impact (+0.64 and +0.38) respectively. China's citation impact by the end of the period was 0.84, and Russia's citation impact improved significantly from 0.15 in 1994-1998 to 0.59 by 2006-2010.

5.2.b.iv: Normalised citation impact, Clinical medicine, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.3.a: Share of world research output, Psychiatry/psychology

5.3.a.i: Share of world research output, Psychiatry/psychology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

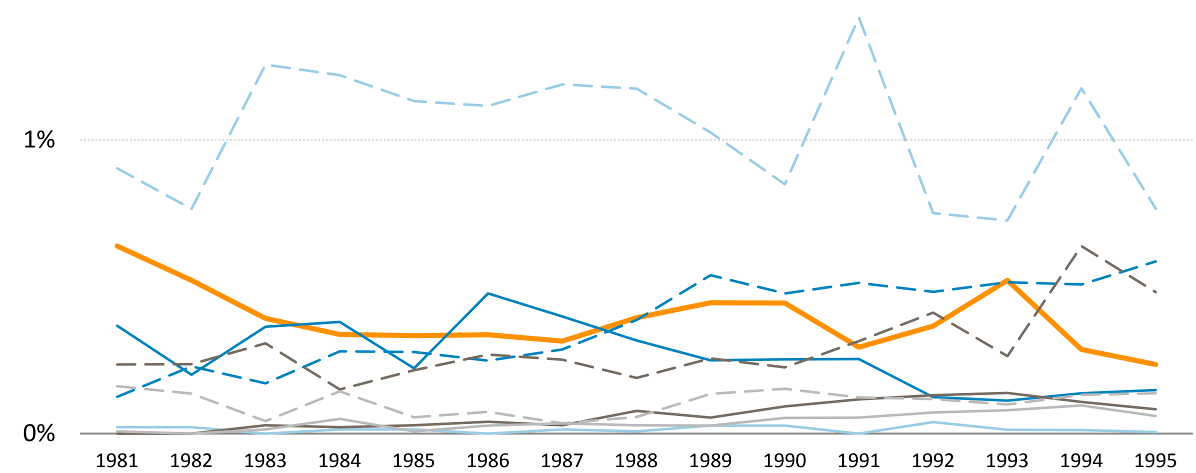


India's share of world output in Psychiatry/Psychology averaged less than 0.5%, falling from 0.6% in 1981 to 0.2% by 1995. India ranked the lowest amongst the established research economies in this field (apart from in 1981). Amongst the emerging research economies, its rank varied over the period, but its rank broadly moved from second to Russia in 1981 to fourth by 1995.

The USA (not shown) had an astounding 67.3% of world share in Psychiatry/Psychology in 1981 which fell to 59.0% by 1995. The UK ranked second with a share that increased from 7.8% in 1981 to 10.3% by 1995. Germany ranked third and its share increased from 4.0% to 5.3% over this period. Australia ranked fourth.

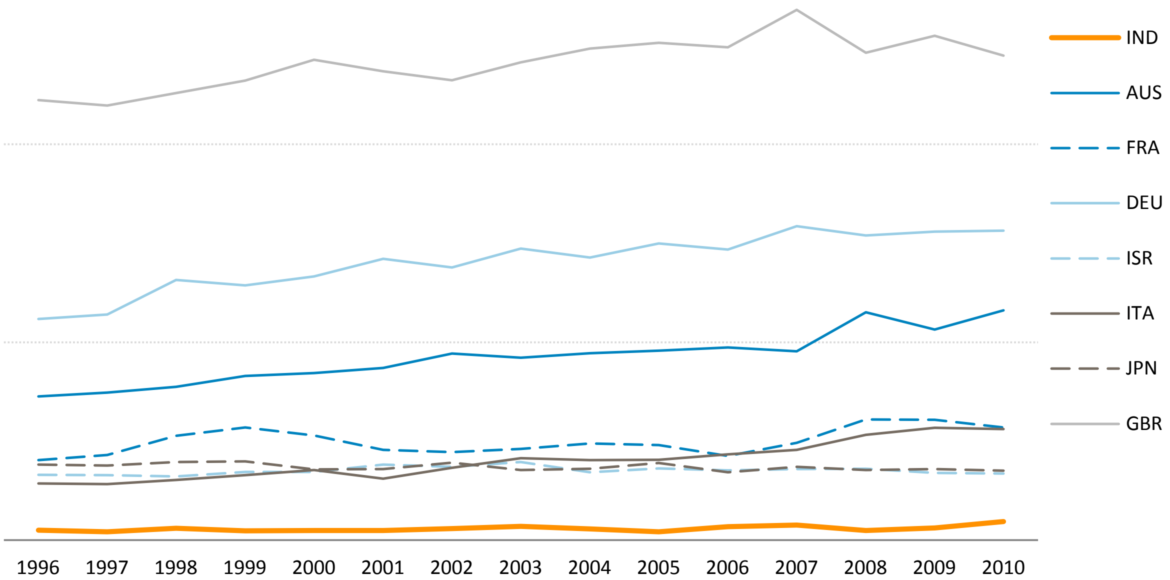
The emerging research economies' shares were exceptionally small. Even Russia which ranked first in this group, averaged around a 1% share over the period, so the variations are due more to the scale at which the axis are set rather than indicative of substantive variation.

5.3.a.iii: Share of world research output, Psychiatry/psychology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.3.a: Share of world research output, Psychiatry/psychology

5.3.a.ii: Share of world research output, Psychiatry/psychology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

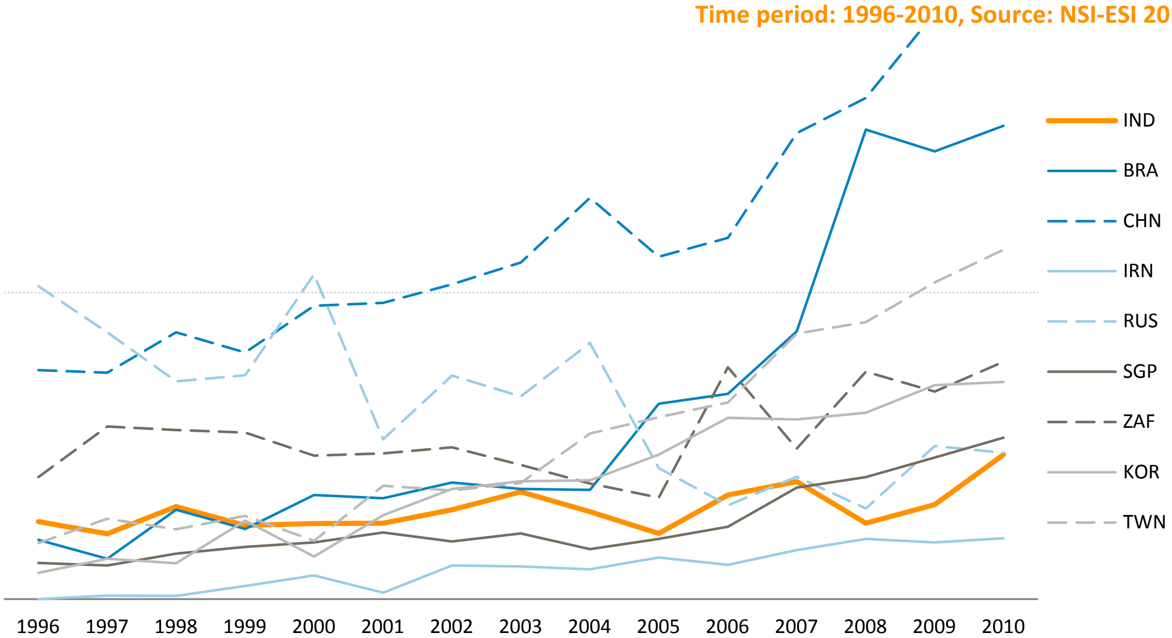


In this later period, India's share of world output in Psychiatry/Psychology averaged less than 0.5%. It ranked the lowest amongst the established research economies and its rank moved from fourth in 1996 to eighth by 2010 amongst the emerging research economies.

Whilst the USA's world share fell from 57.1% in 1996 to 47.6% in 2010 (not shown), it was clearly still the dominant player in this field. The UK continued to acquire greater world share in this field (+1.1% between 1996 and 2010) as did Germany (+2.2%) and Australia (+2.2%).

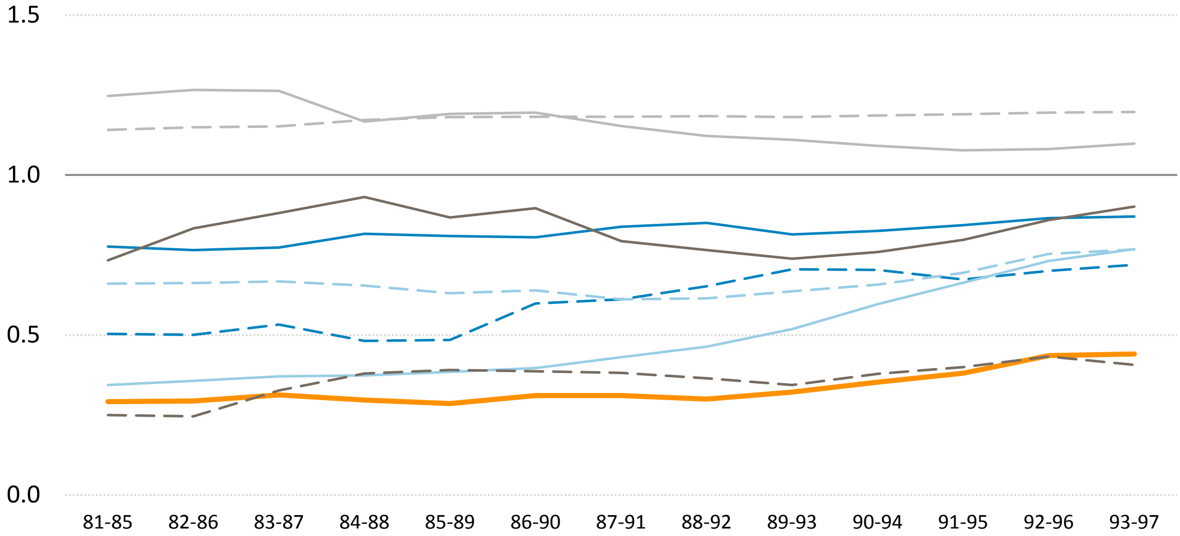
Amongst the emerging research economies, China's share increased from 0.7% to 2.2% and Brazil's increased from 0.2% to 1.5% between 1996 and 2010. However, it can broadly be said, that this may not be a priority field for emerging research economies, hence the very low levels of world share and changes in the percentage of world share relative to other fields.

5.3.a.iv: Share of world research output, Psychiatry/psychology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.3.b: Normalised citation impact, Psychiatry/psychology

5.3.b.i: Normalised citation impact, Psychiatry/psychology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

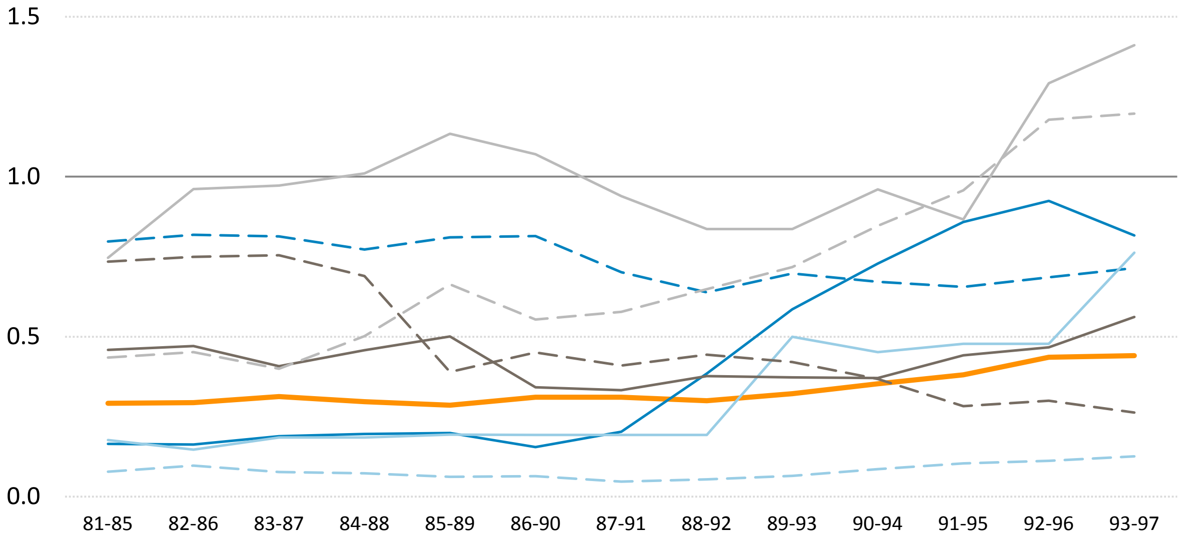


India's citation impact improved over this earlier period from 0.29 in 1981-1985 to 0.44 by 1993-1997. These levels are well below world average, and India ranked more or less the lowest over the period vis-à-vis the established research economies.

Whilst the UK had the highest citation impact at the start of the period (1.25 in 1981-1985) by the end of the period the USA had the highest citation impact (1.20). All other established research economies had citation impacts which were well below world average, although there were big improvements in citation impact amongst Germany (+0.42) and France (+0.22); and Italy had an citation impact in 1993-1997 of 0.90 and Australia (same period) of 0.87.

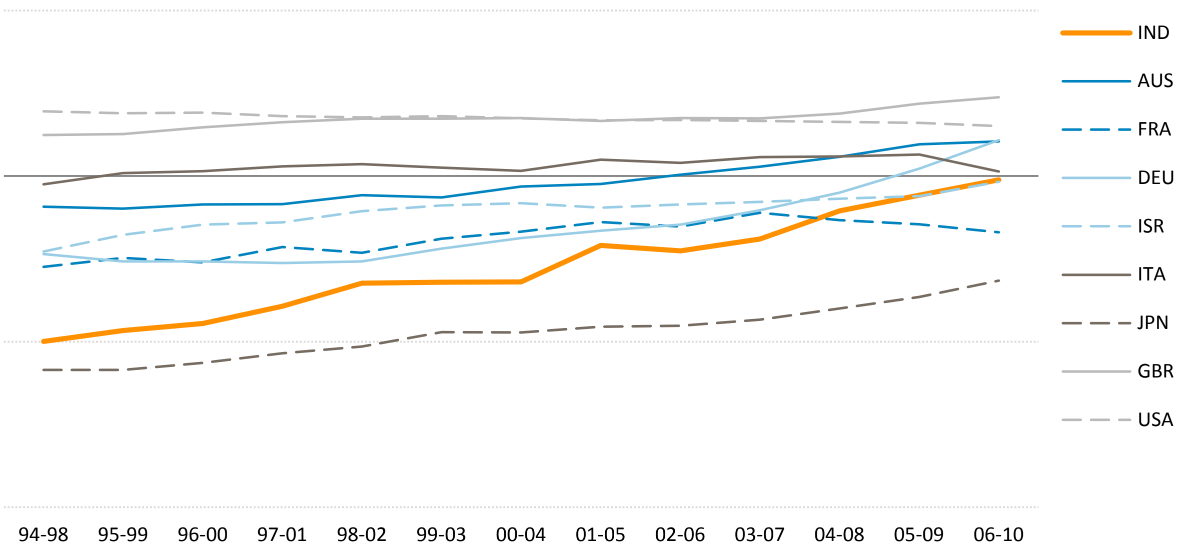
Several emerging economies have citation impact based on paper numbers which are too small to be reliably analysed. Excluding these, it is Brazil which shows the most remarkable change in citation impact rising from 0.16 in 1981-1985 to 0.82 by 1993-1997.

5.3.b.iii: Normalised citation impact, Psychiatry/psychology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.3.b: Normalised citation impact, Psychiatry/psychology

5.3.b.ii: Normalised citation impact, Psychiatry/psychology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

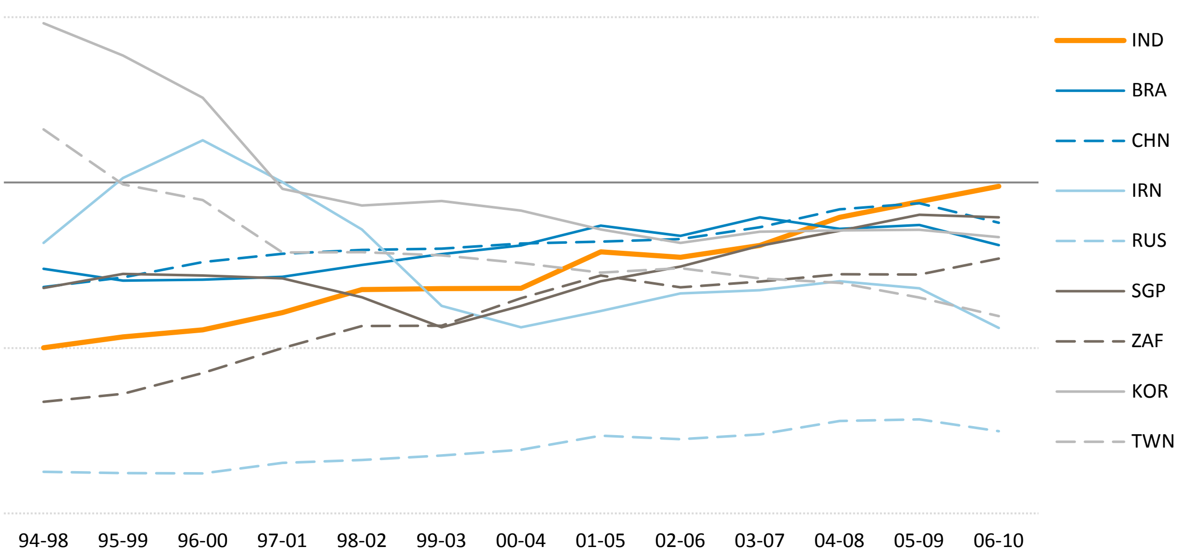


In the later period, it is notable that India made substantial improvements in its citation impact relative to other fields, rising from 0.50 in 1994-1998 to 0.99 by 2006-2010 - i.e. just short of world average levels and surpassing the citation impact of both France and Japan in this field. It also had the highest citation impact of the emerging research economies in this field by 2006-2010.

The UK superseded the citation impact of the USA from 2002-2006 onwards ending at 1.24 versus 1.15 for the USA. Italy's citation impact was over the world average from 1995-1999 onwards. Germany and Australia crossed the line of the world average by 2006-2010 with finishing citation impacts of 1.11 and 1.10 respectively.

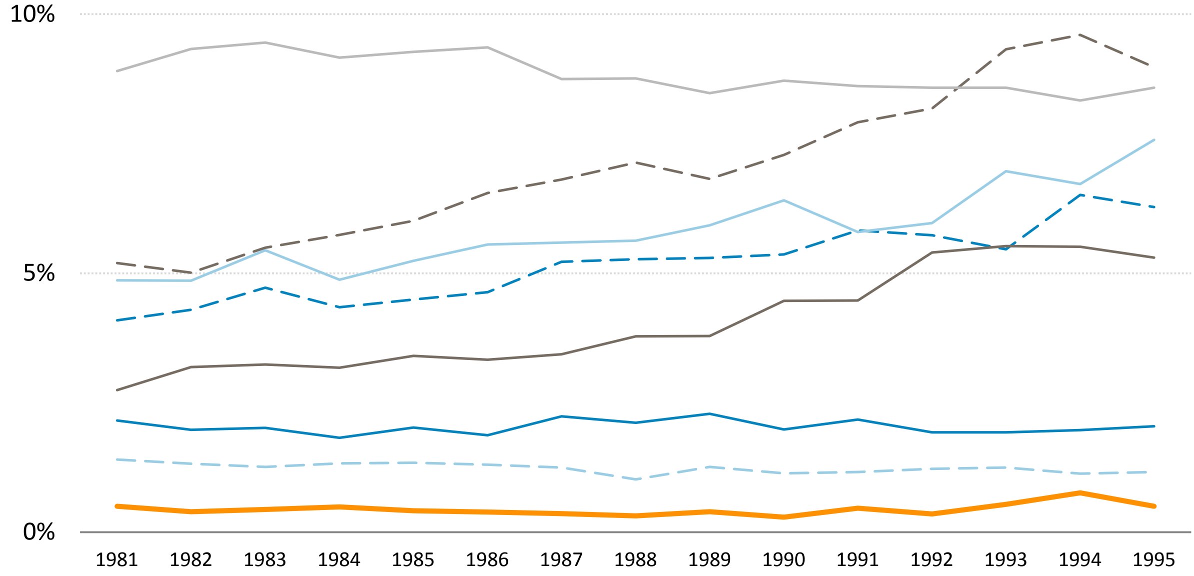
Whilst it appears that Korea, Taiwan and Iran attained above world average levels of citation impact, these values are in fact based on small paper numbers. This effect aside, all emerging research economies were otherwise below the line of the world average.

5.3.b.iv: Normalised citation impact, Psychiatry/psychology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.4.a: Share of world research output, Neuroscience & behaviour

5.4.a.i: Share of world research output, Neuroscience & behaviour, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

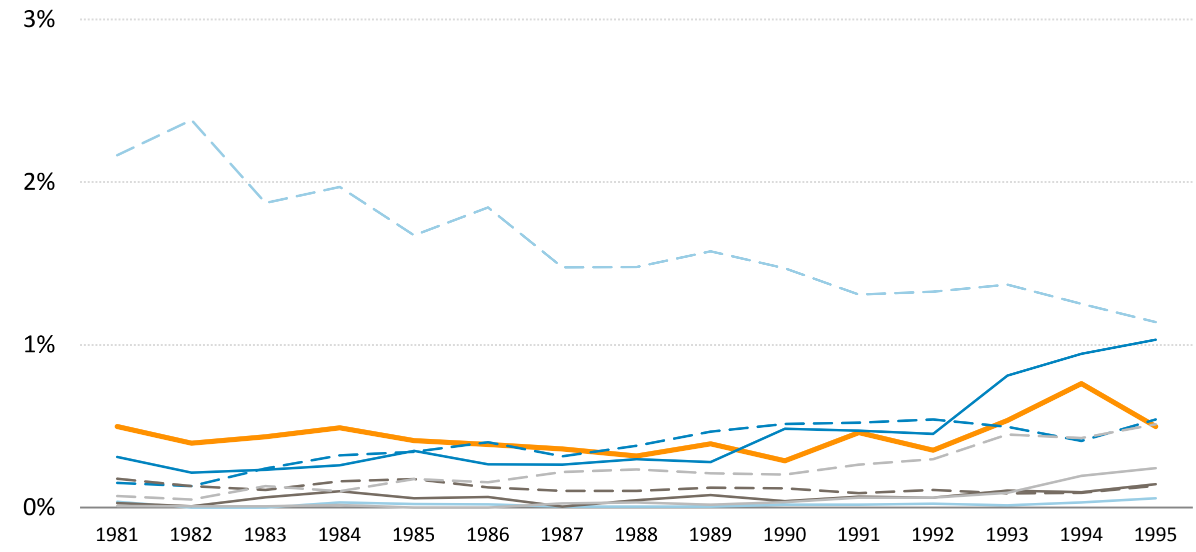


India's share of world output in Neuroscience & Behaviour averaged less than 0.5% over this period. It ranked the lowest amongst the established research economies in this field and its rank amongst the emerging research economies varied, moving from second in 1981 to fifth by 1995.

Amongst the established research economies, the USA (not shown) was clearly the dominant player, though its share fell from 51.4% in 1981 to 44.6% by 1995. The UK was second to the USA in the earlier part of the period, with a share averaging 8.9% although its rank fell to Japan by 1993, whose world share rose from 5.2% in 1981 to a high of 9.6% by 1994. Other established research economies also increased their shares over this period: Germany (+2.7%), France (+2.2%) and notably Italy (+2.6%).

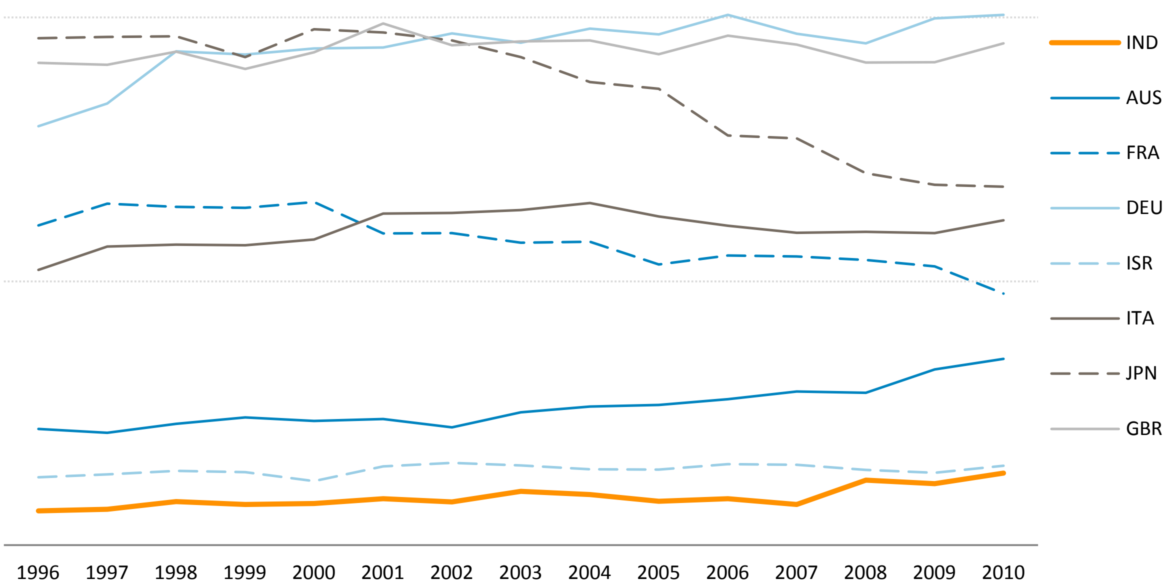
In terms of the emerging research economies, Russia's share declined from 2.2% in 1981 to 1.1% by 1995. The emergence of Brazil in this field is also apparent from 1993 onwards.

5.4.a.iii: Share of world research output, Neuroscience & behaviour, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.4.a: Share of world research output, Neuroscience & behaviour

5.4.a.ii: Share of world research output, Neuroscience & behaviour, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

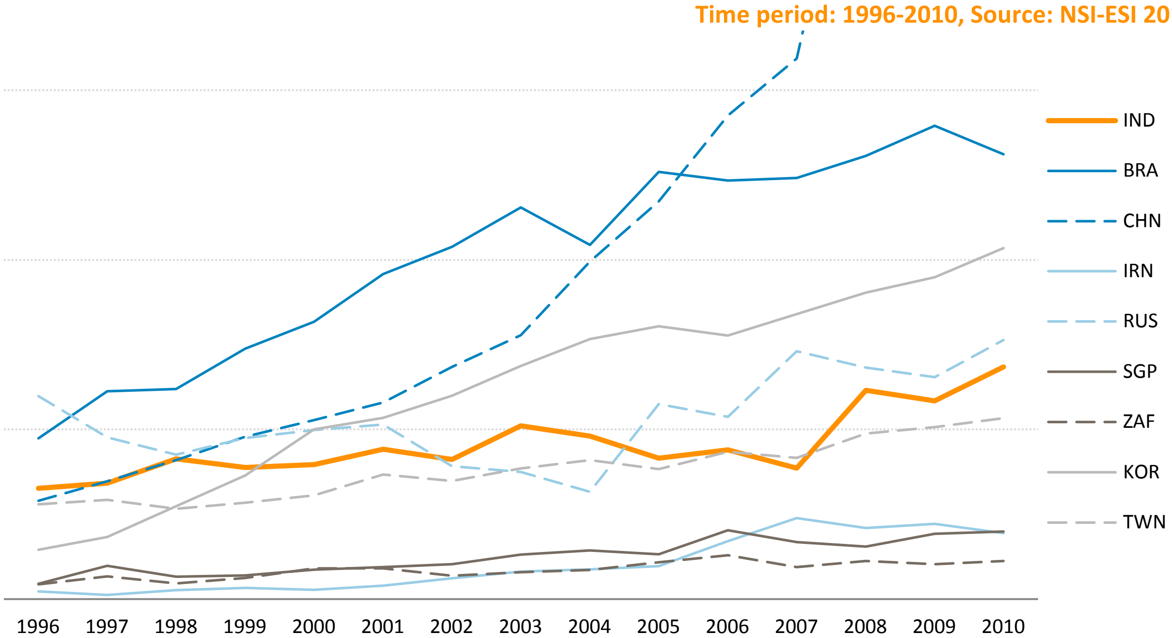


In this later period, whilst India's share increased from 0.7% in 1996 to 1.4% by 2010, it still ranked the lowest amongst the established research economies and was surpassed by China, Brazil, Korea and latterly Russia amongst the emerging research economies.

The USA's share in this field (not shown) fell from 44.4% in 1996 to 39.8% in 2010. This fall is share in not as marked as in some other fields. Japan's rise and fall is quite marked: its world share fell from 9.6% in 1996 to 6.8% by 2010. Meanwhile the UK's position was challenged by Germany's rise. Germany increased its share from 7.9% in 1996 to 10.0% by 2010. The UK broadly maintained its levels of research in Neuroscience & Behaviour averaging 9.4% over the period.

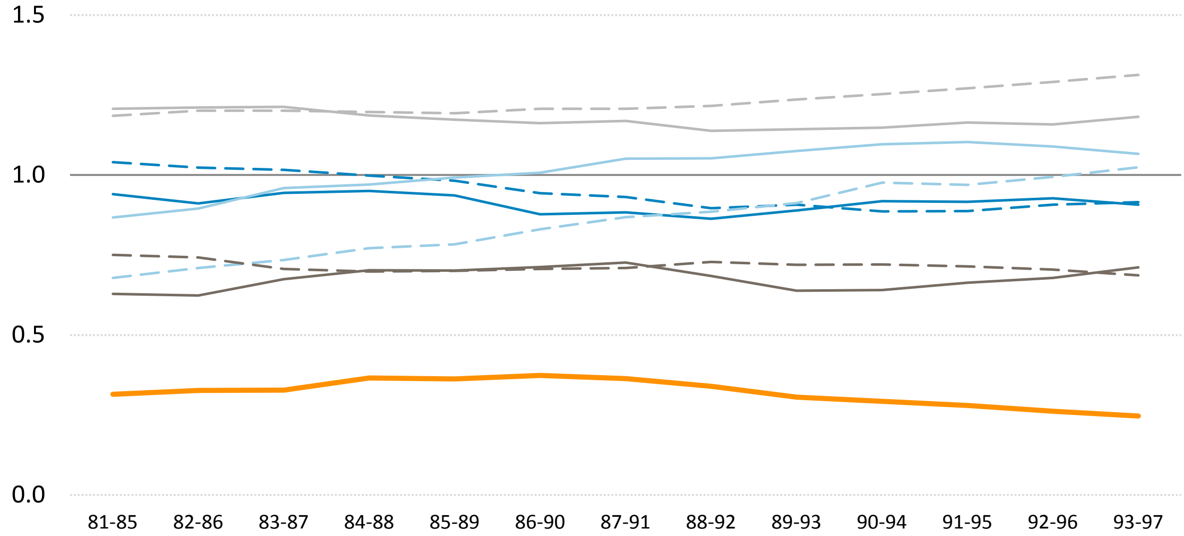
China increased its share from 0.6% in 1996 to 6.1% by 2010, overtaking Brazil in 2006, whose growth plateaued after this point in comparison. Korea increased its share from 0.3% in 1996 to 2.1% in 2010, overtaking India in 2000.

5.4.a.iv: Share of world research output, Neuroscience & behaviour, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.4.b: Normalised citation impact, Neuroscience & behaviour

5.4.b.i: Normalised citation impact, Neuroscience & behaviour, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

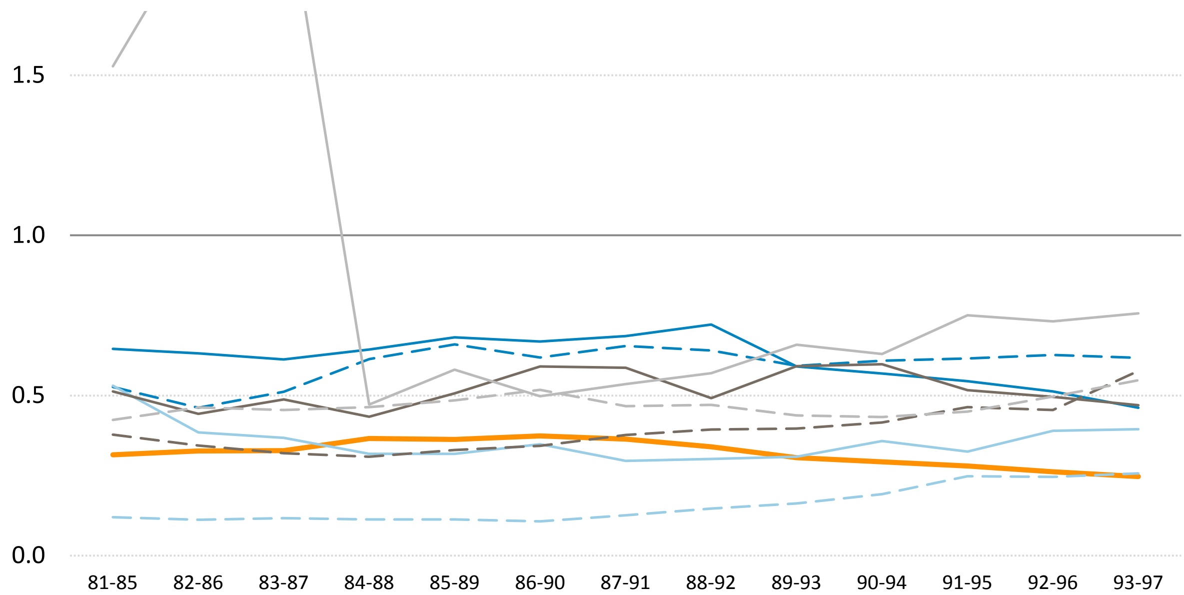


India's citation impact in Neuroscience & Behaviour rose and fell over this period: from 0.31 (1981-1985) to 0.37 (1986-1990) down to 0.25 (1993-1997). These are extremely low levels of citation impact. India ranked the lowest amongst the established economies research group and amongst the emerging research economies, whilst its rank varied, it was generally near to the lower end of the group.

Amongst the established research economies, the USA had the highest citation impact which increased over the period (from 1.18 in 1981-1985 to 1.31 by 1993-1997) whilst the citation impact of the UK broadly fell (from 1.21 in 1981-1985 to 1.18 by 1993-1997). Germany's citation impact was above world average after 1986-1990.

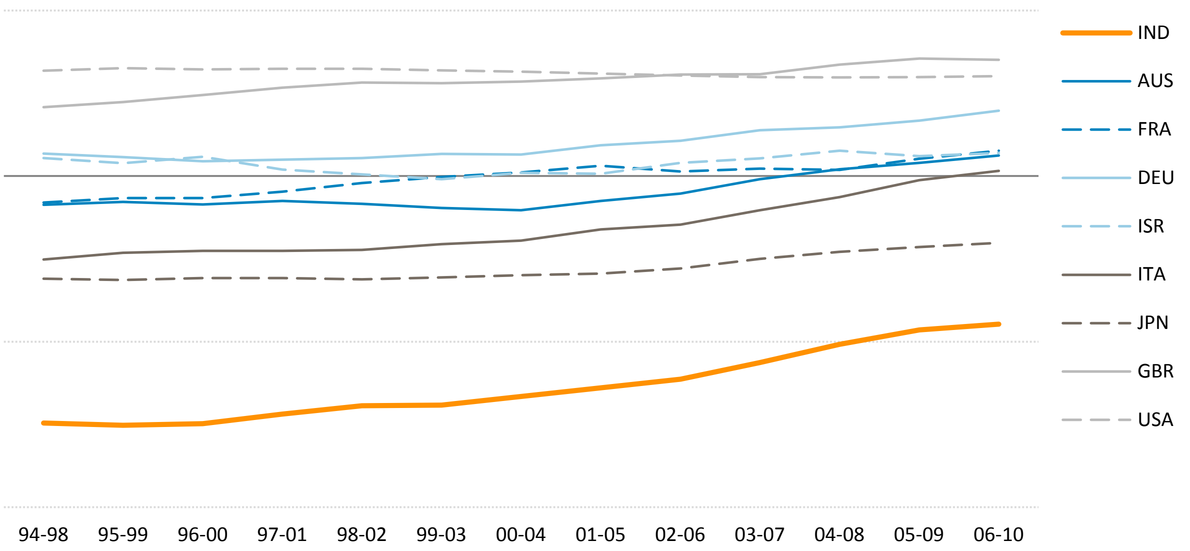
Amongst the emerging research economies, all were below world average. The spike for Korea is based on a very small number of papers (less than 10) and some other countries have quite low paper numbers (less than 100) during this period (Iran, Singapore, South Africa, Taiwan), particularly during the earlier part.

5.4.b.iii: Normalised citation impact, Neuroscience & behaviour, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.4.b: Normalised citation impact, Neuroscience & behaviour

5.4.b.ii: Normalised citation impact, Neuroscience & behaviour, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

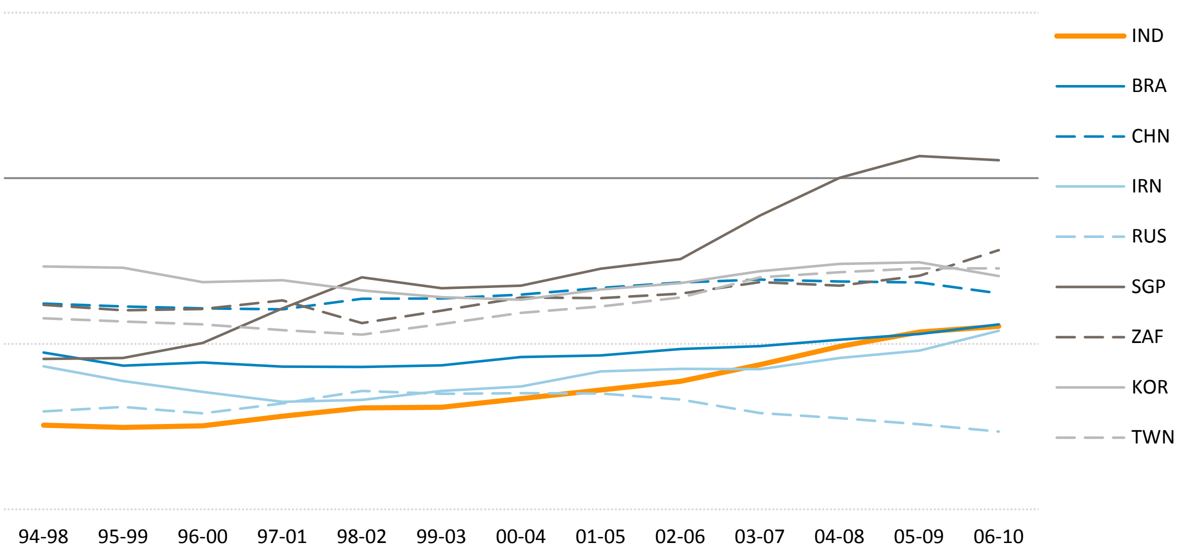


India's citation impact in Neuroscience & Behaviour more than doubled from 0.25 in 1994-1998 to 0.55 by 2006-2010, indicative of a strong improvement in the citation impact of its research, but the 2006-2010 level was still just under half of the world average. It ranked the lowest amongst the established economies research group, but it certainly narrowed the gap. The improvement in Indian citation impact in this field meant that India moved from being the lowest amongst the emerging research economies to being ahead of Iran and Russia, and about equal to Brazil.

The UK improved its citation impact over that of the USA: its citation impact was 1.35 by 2006-2010 versus 1.30 for the USA. Germany's citation impact also increased from 1.07 to 1.20. All countries other than Japan crossed the world average threshold by the end of the period.

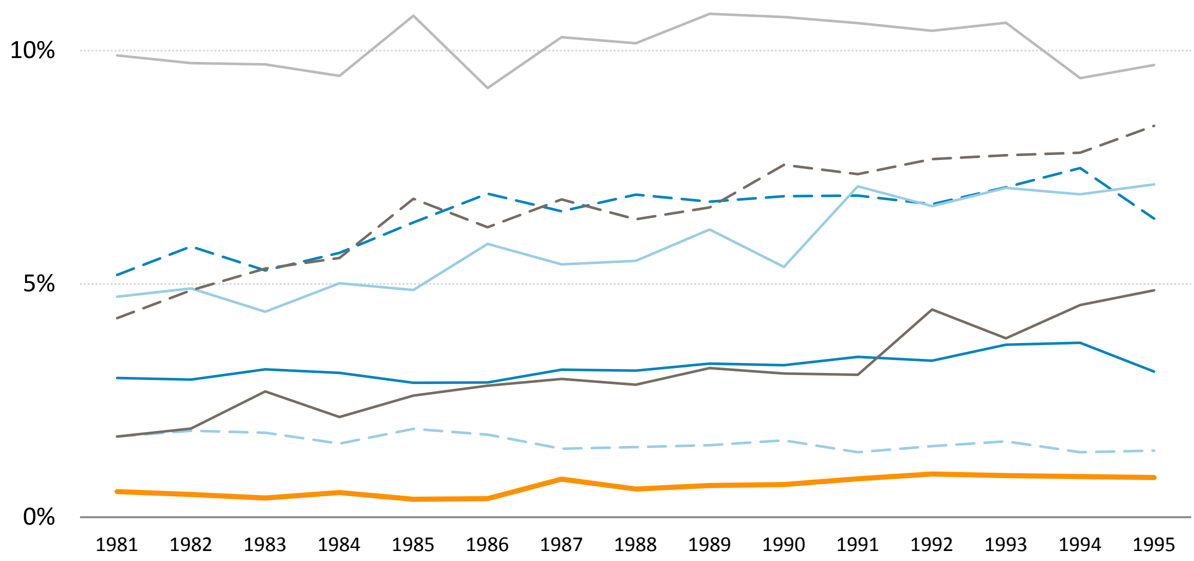
Amongst the emerging research economies, Singapore dramatically increased its citation impact from 0.45 in 1994-1998 to 1.05 by 2006-2010. The other countries were all well below world average.

5.4.b.iv: Normalised citation impact, Neuroscience & behaviour, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.5.a: Share of world research output, Immunology

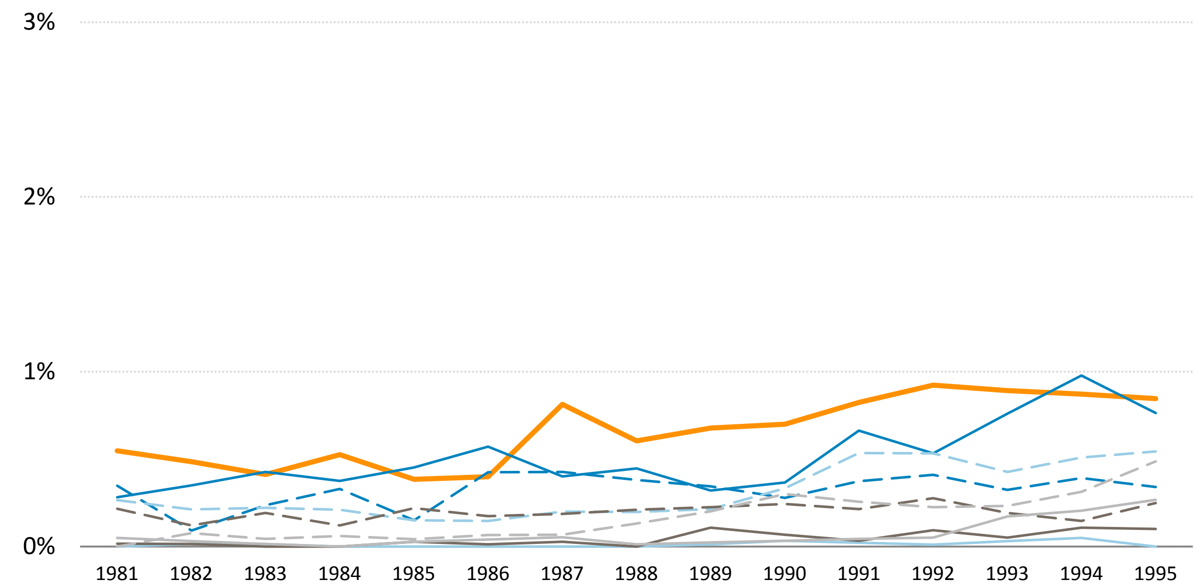
5.5.a.i: Share of world research output, Immunology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010



In this earlier period, India's share of world output in Immunology rose, but only marginally, from 0.5% in 1981 to 0.8% by 1995. Amongst the established research economies, India's rank by share was the lowest. Amongst the emerging research economies, India ranked first at the start and the end of the period, but this rank was challenged by Brazil as its output rose from 0.3% in 1981 to a 1.0% by 1994. However, it is important to note that all emerging research economies had a world share of less than 1% during this period. At this stage, the established research economies were clearly pre-eminent in this field.

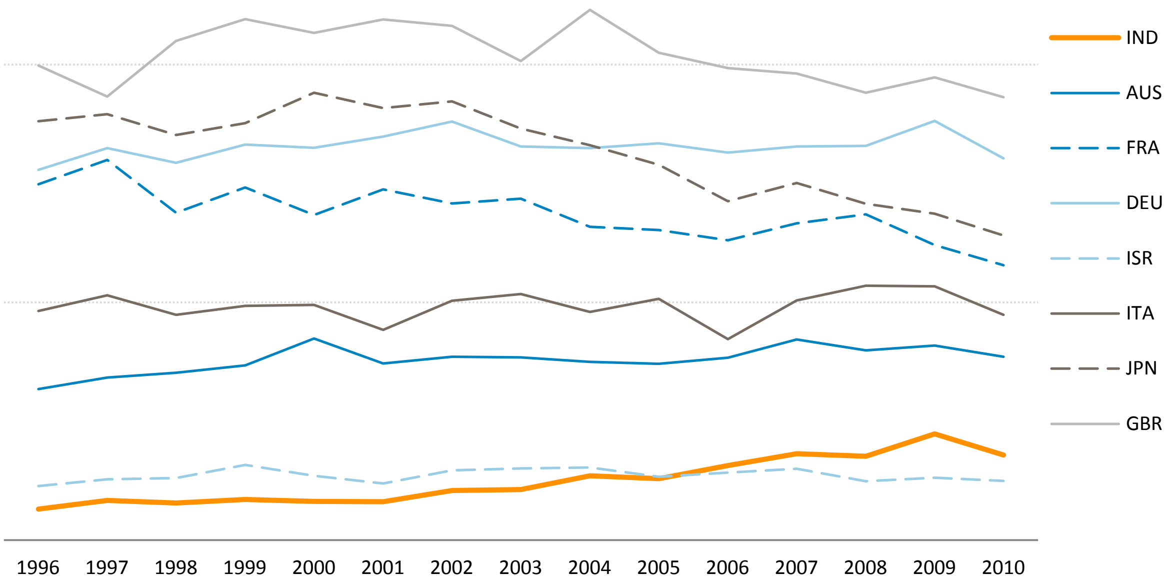
Amongst the established research economies, the USA (not shown) had a substantial share of world output, but it fell from 50.9% in 1981 to 45.8% by 1995. The UK had the second largest world share during this time: averaging just above 10% of world output over the period. Japan's share increased from 4.3% in 1981 to 8.4% by 1995 and France's share increased from 5.2% in 1981 to 7.5% by 1994, before dipping to 6.4% by 1995. Germany's share increased from 4.7% in 1981 to 7.1% by 1995. Italy's share also increased (+3.1%).

5.5.a.iii: Share of world research output, Immunology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.5.a: Share of world research output, Immunology

5.5.a.ii: Share of world research output, Immunology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

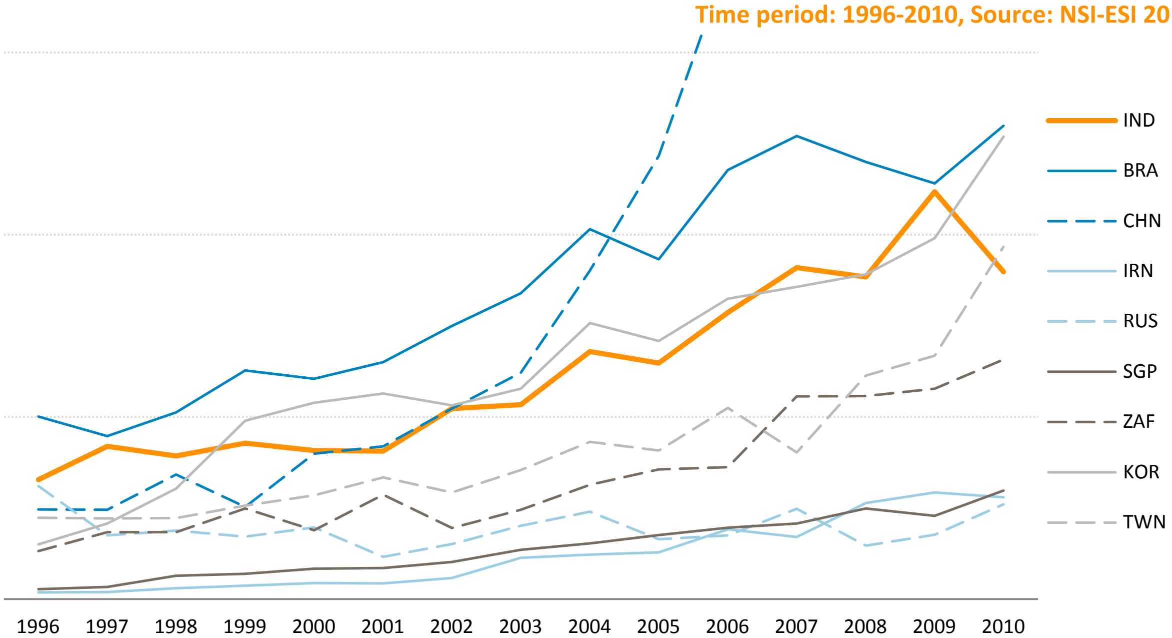


India's world share of output in Immunology rose from 0.7% in 1996 to a high of 2.2% by 2009, dropping back slightly to 1.8% by 2010. Its rank amongst the established research economies moved from ninth to eighth as it overtook Israel in 2006. Amongst the emerging research economies, India's rank varied, but it broadly moved downwards as India was surpassed firstly by Brazil (1996) then by China (2003) and challenged by Korea.

The USA (not shown) saw its world share of output fall from 44.7% in 1996 to 41.9% by 2010. This was ultimately a 9.0% decline on its 1981 world share. The UK's world share broadly averaged just over 10% during this period; Japan's world share declined (-2.4%) as did France's (-1.7%) and Germany's share broadly averaged 8.3% and Italy's share levelled (averaging 4.9%).

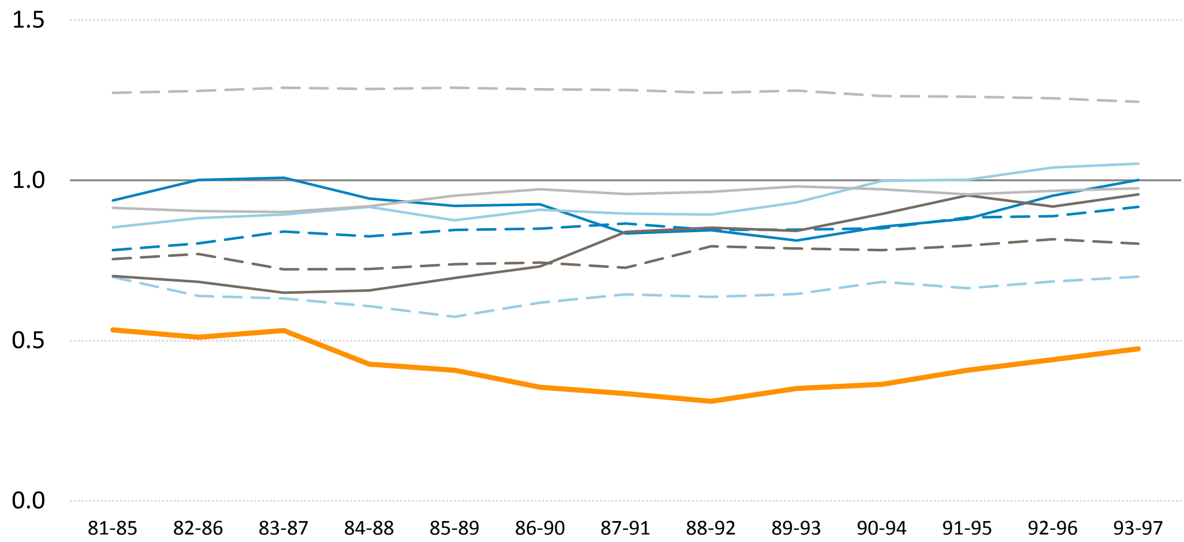
China's share rose from 0.5% in 1996 to 7.5% by 2010. Brazil's share from 1.0% to 2.6% and Korea's share rose from 0.3% to 2.5% over the same period.

5.5.a.iv: Share of world research output, Immunology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.5.b: Normalised citation impact, Immunology

5.5.b.i: Normalised citation impact, Immunology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

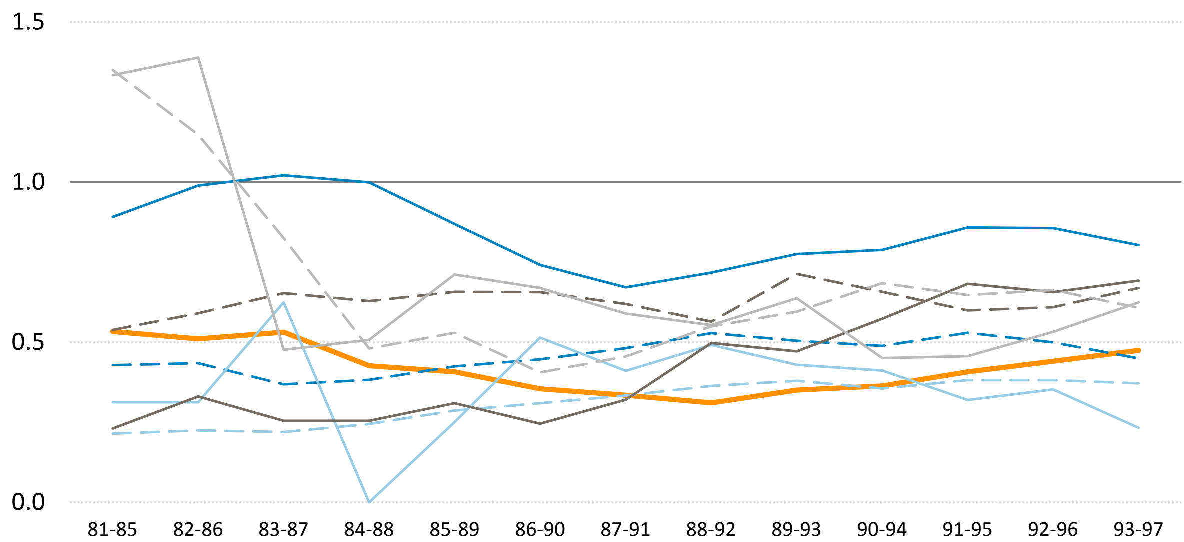


The citation impact of India in Immunology fell from 0.53 in 1981-1985 to a low of 0.31 in 1988-1992, but rose to 0.47 by 1993-1997. It ranked the lowest amongst the established research economies, but its rank was more mixed amongst the emerging research economies primarily due to low paper numbers (<50), but accounting for these, China surpassed India, within India ranking towards the lower end of the group.

Amongst the established research economies, it is notable during this period that only the USA had a higher than world average citation impact, averaging 1.27. Germany's citation impact rose above world average from 1991-1995 onwards, and Australia's citation impact was 1.00 by 1993-1997, though its citation impact had fallen to 0.81 by 1989-1993. Italy's citation impact improved by +0.25.

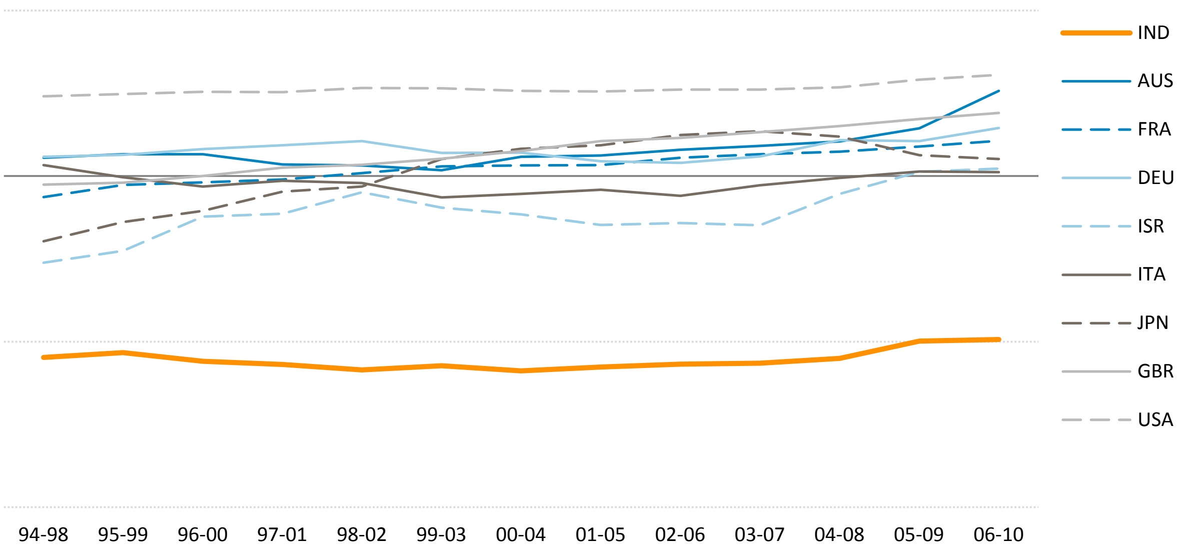
Brazil's citation impact was the highest amongst the emerging research economies, although it varied from 0.89 in 1981-1985 and 0.80 in 1993-1997, with a high of 1.02 in 1983-1987. South Africa's citation impact ranked broadly second.

5.5.b.iii: Normalised citation impact, Immunology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.5.b: Normalised citation impact, Immunology

5.5.b.ii: Normalised citation impact, Immunology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

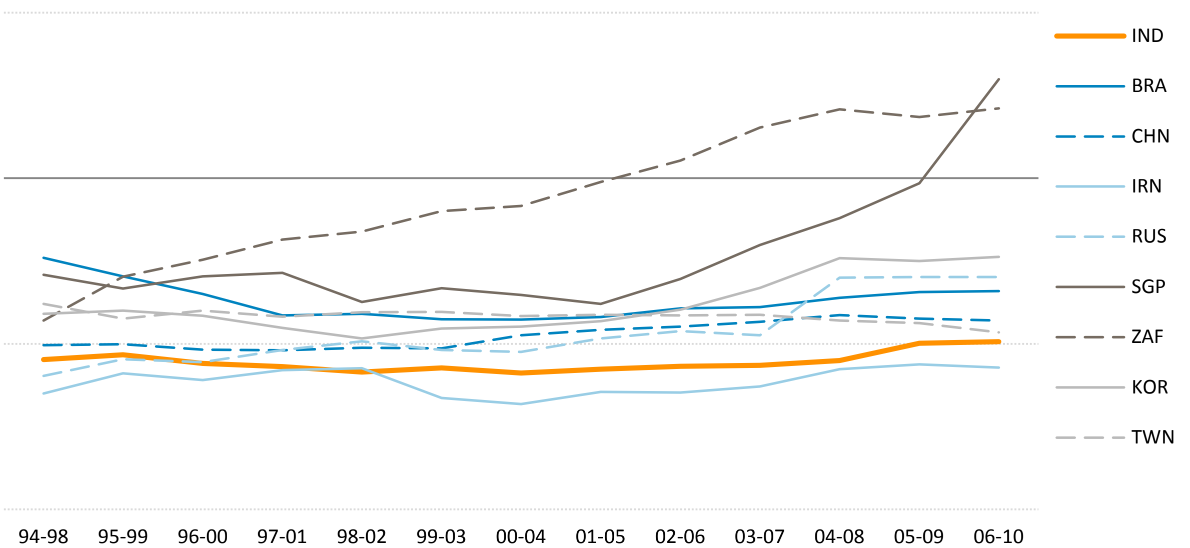


The citation impact of India in Immunology only marginally increased from 0.45 in 1994-1998 to 0.51 by 2006-2010, leaving a large gap between India and the established research economies. India's rank amongst the established research economies, moved from seventh in 1994-1998 to eighth by 2006-2010.

Amongst the established research economies, the USA's citation impact increased (from 1.24 in 1994-1998 to 1.31 by 2006-2010), Australia's citation impact shot up from 1.06 at the start of the period to 1.26 by the end of it. The UK increased its citation impact from 0.97 in 1994-1998 to 1.19 by 2006-2010. Germany and France also achieved above world average levels of citation impact (1.14 and 1.11 by 2006-2010 respectively).

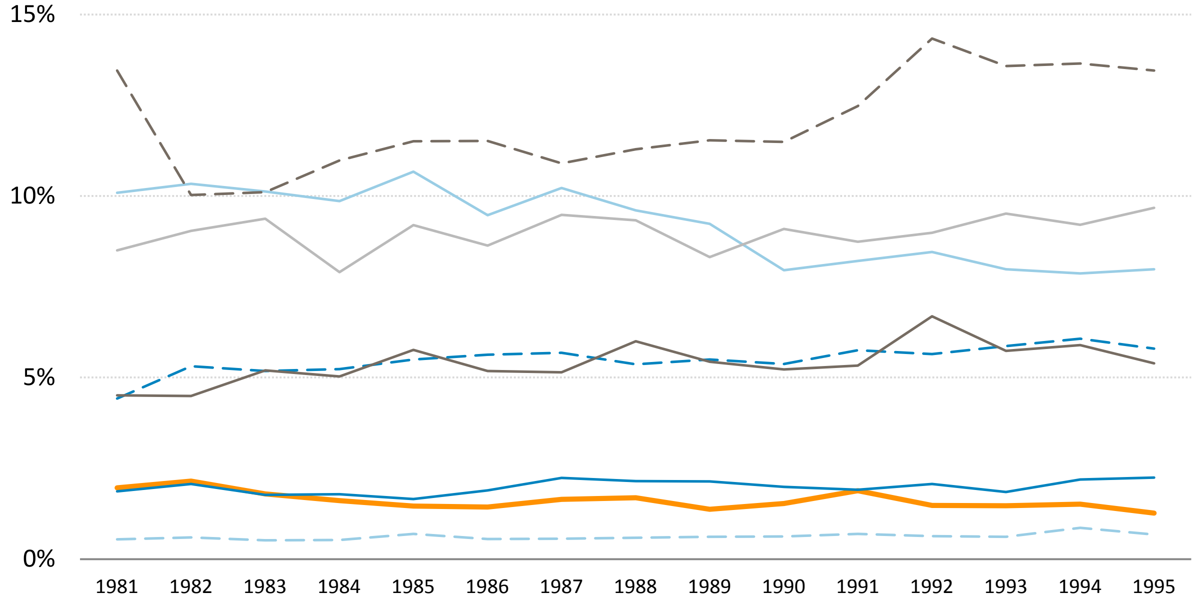
South Africa's citation impact shot up from 0.57 in 1994-1998 to 1.21 by 2006-2010, Singapore's citation impact too rose rapidly from 0.71 in 1994-1998 to 1.30 by 2006-2010. Russia's citation impact surprisingly rose from 0.40 in 1994-1998 to 0.70 by 2006-2010. Brazil's citation impact broadly fell from 0.76 in 1994-1998 to 0.66 by 2006-2010.

5.5.b.iv: Normalised citation impact, Immunology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.6.a: Share of world research output, Pharmacology & toxicology

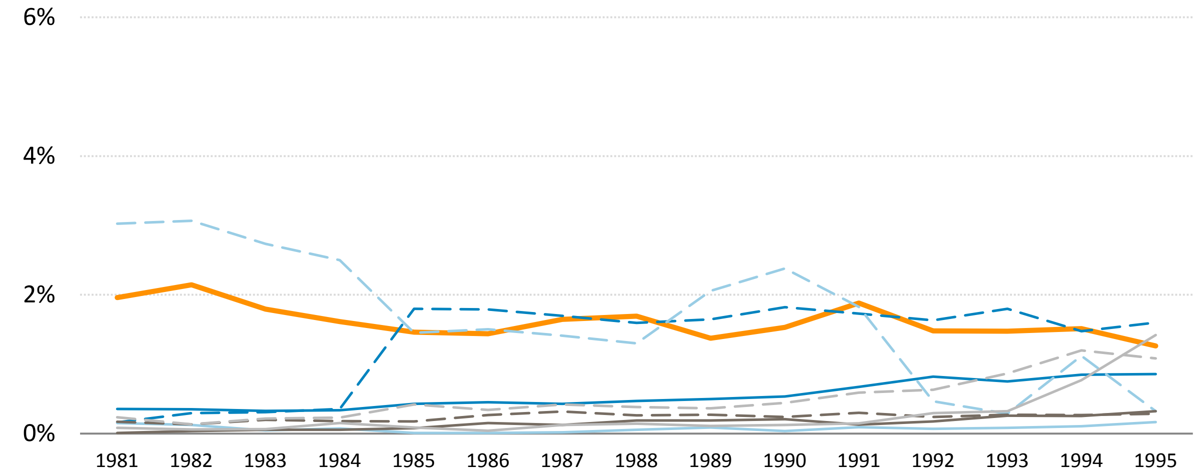
5.6.a.i: Share of world research output, Pharmacology & toxicology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010



In this earlier period, in Pharmacology & Toxicology, India had a percentage share of world output of 2.0% in 1981 which (though it varied somewhat over the period) fell to 1.3% by 1995. India ranked broadly eighth amongst the established research economies (with Israel ranking ninth); and broadly second amongst the emerging research economies although this rank varied due to Russia's share falling from 3.0% in 1981 to 0.3% by 1995, and China's share rising from 0.2% in 1981 to 1.6% by 1995 (with a leap from 0.4% in 1984 to 1.8% by 1985).

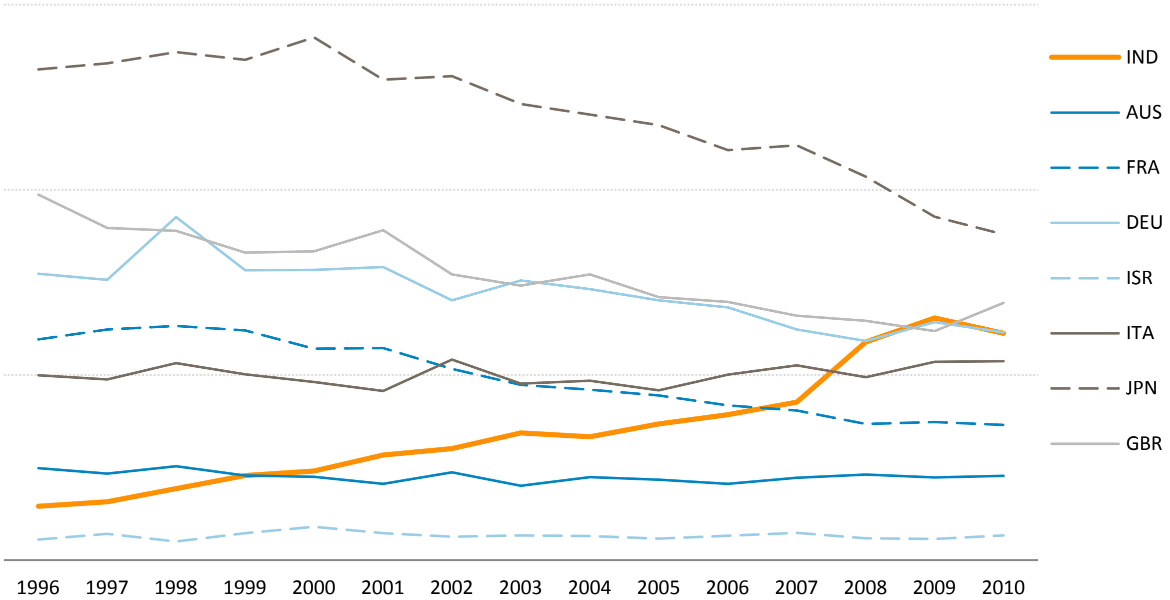
Amongst the established research economies, the USA (not shown) increased its share of world output from 29.3% in 1981 to 33.1% by 1995. Japan as well, after an initial dip from 13.5% in 1981 to 10.0% in 1982 regained a 13.5% share by 1995. Germany's share fell over this period (from 10.1% in 1981 to 8.0%) whilst the UK's marginally increased from 8.5% in 1981 to 9.7% by 1995.

5.6.a.iii: Share of world research output, Pharmacology & toxicology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.6.a: Share of world research output, Pharmacology & toxicology

5.6.a.ii: Share of world research output, Pharmacology & toxicology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

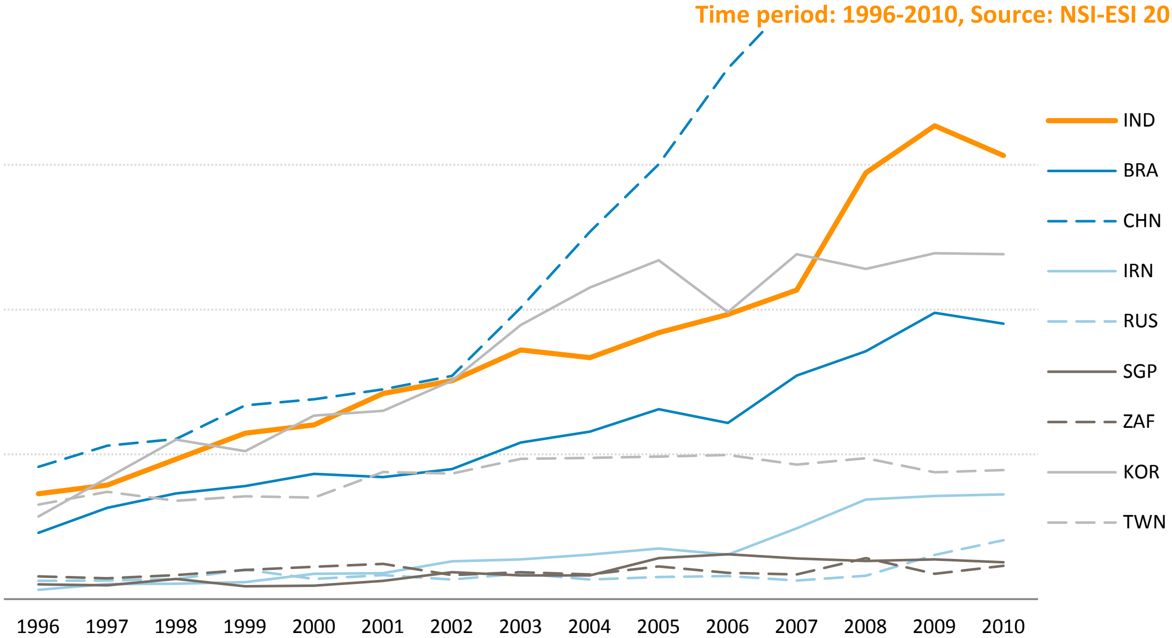


In this later period, India clearly acquired greater world share in Pharmacology & Toxicology, increasing its world share from 1.5% in 1996 to 6.1% by 2010. This is a notable rise.

The share of the USA (not shown) fell over this period, but not as sharply as in comparison with other fields (-6.0%) from 32.6% to 26.6%. Other established research economies also lost share: Japan (-4.4%), the UK (-2.9%) and Germany (-1.6%). Indeed, India's share converged with that of the UK and Germany by 2009.

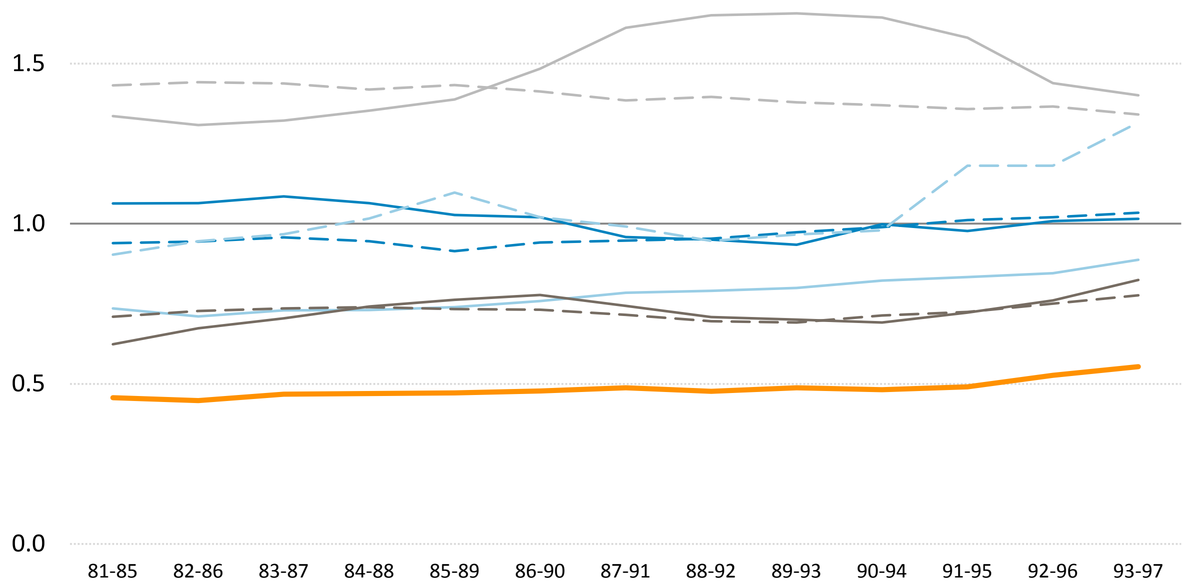
Amongst the emerging research economies, China increased its world share from 1.8% in 1996 to 11.3% by 2010 (+9.5%). India and Korea were next in rank: Korea increased its world share from 1.1% to 4.8%, but was superseded by India from 2008 onwards. Brazil and Taiwan increased their shares over this period, but Brazil's rise was more marked (+2.9%) and Taiwan's initial acquisition of world share plateaued.

5.6.a.iv: Share of world research output, Pharmacology & toxicology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.6.b: Normalised citation impact, Pharmacology & toxicology

5.6.b.i: Normalised citation impact, Pharmacology & toxicology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

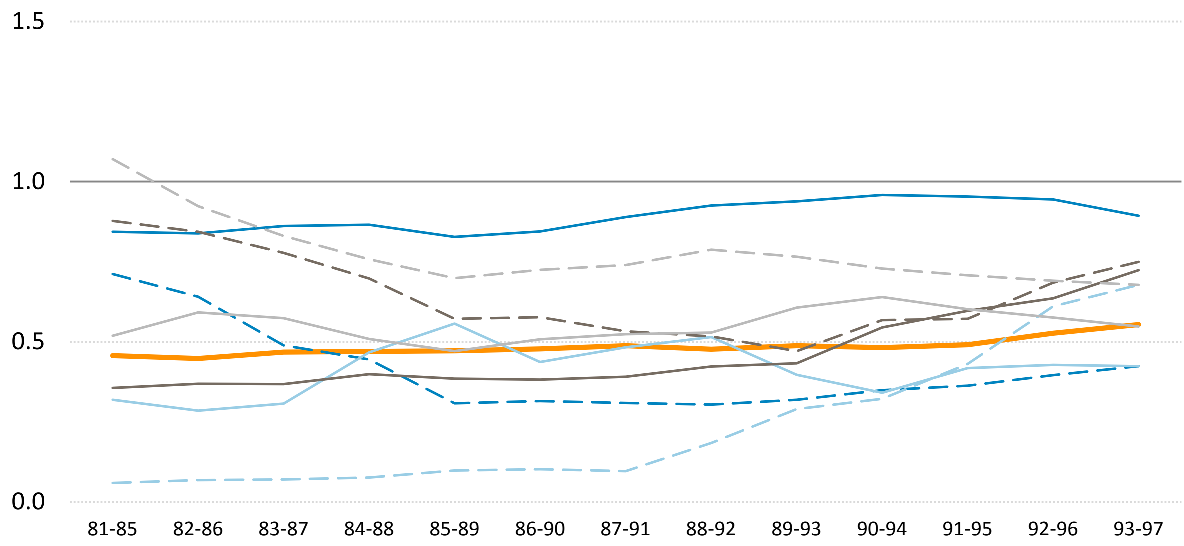


India's citation impact in Pharmacology & Toxicology improved from 0.46 in 1981-1985 to 0.55 by 1993-1997, but this was a relatively modest improvement. It ranked the lowest amongst the established research economies, but its rank was more mixed amongst the emerging research economies.

Amongst the established research economies, the UK superseded the USA from 1986-1990 in terms of citation impact: a position which it maintained over the rest of this period, although its citation impact rose to 1.66 in 1989-1993 and fell to 1.40 by 1993-1997. The USA's citation impact fell from 1.43 in 1981-1985 to 1.34 by 1993-1997.

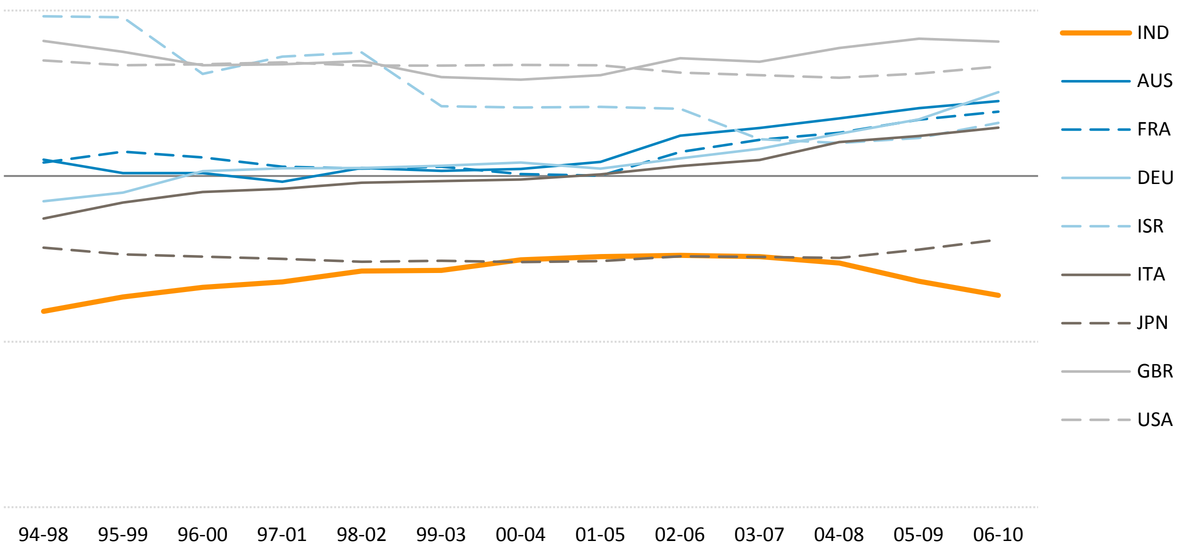
Amongst the emerging research economies, whilst all were below world average (with the exception of Taiwan achieving an citation impact of 1.07 in 1981-1985, something of a 'one-off' during this period), Brazil's citation impact was ahead of the others during this period rising from 0.84 in 1981-1985 to 0.89 by 1993-1997 with a peak of 0.96 by 1990-1994.

5.6.b.iii: Normalised citation impact, Pharmacology & toxicology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.6.b: Normalised citation impact, Pharmacology & toxicology

5.6.b.ii: Normalised citation impact, Pharmacology & toxicology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

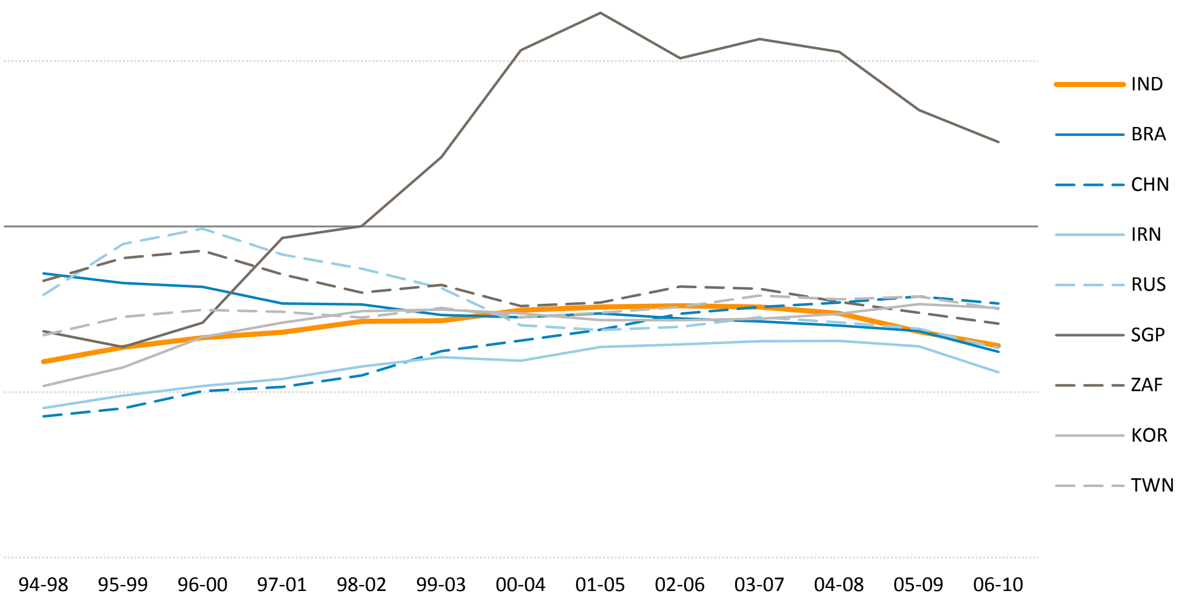


Indian citation impact improved from 0.59 in 1994-1998 to 0.64 by 2006-2010, however the latter figure was a fall from a high of 0.76 in the periods 2001-2005 - 2003-2007 (inclusive). It ranked the lowest amongst the established research economies, although it converged with Japan during the periods 2000-2004 - 2003-2007 (inclusive).

Amongst the established research economies, the citation impact of Israel, which was briefly the highest at the beginning of this period, fell. The US and the UK resumed their respective positions, with the UK's citation impact finishing at 1.41 and the USA's citation impact at 1.33 by 2006-2010. Other economies improved their citation impact over this period, notably Germany (+0.33), Australia (+0.18) and Italy (+0.27).

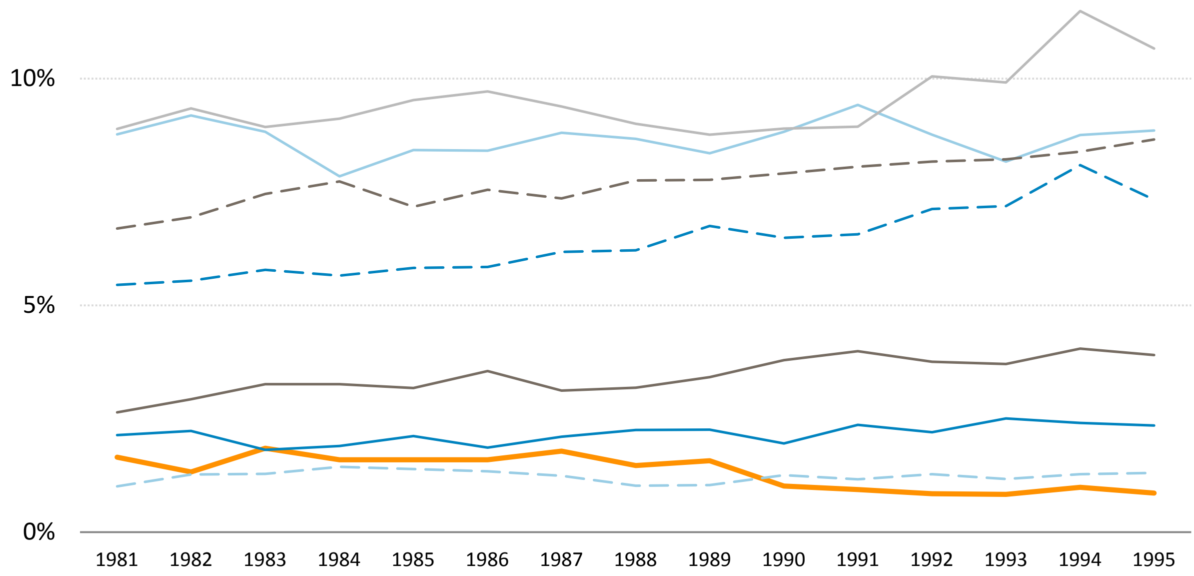
Singapore's citation impact leapt from 0.68 in 1994-1998 to a high of 1.65 by 2001-2005, from which it fell to 1.26 by 2006-2010, superseding the citation impact of the USA and the UK between the periods 2000-2004 - 2004-2008. The citation impact of the other emerging research economies converged from 2000-2004.

5.6.b.iv: Normalised citation impact, Pharmacology & toxicology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.7.a: Share of world research output, Molecular biology & genetics

5.7.a.i: Share of world research output, Molecular biology & genetics, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

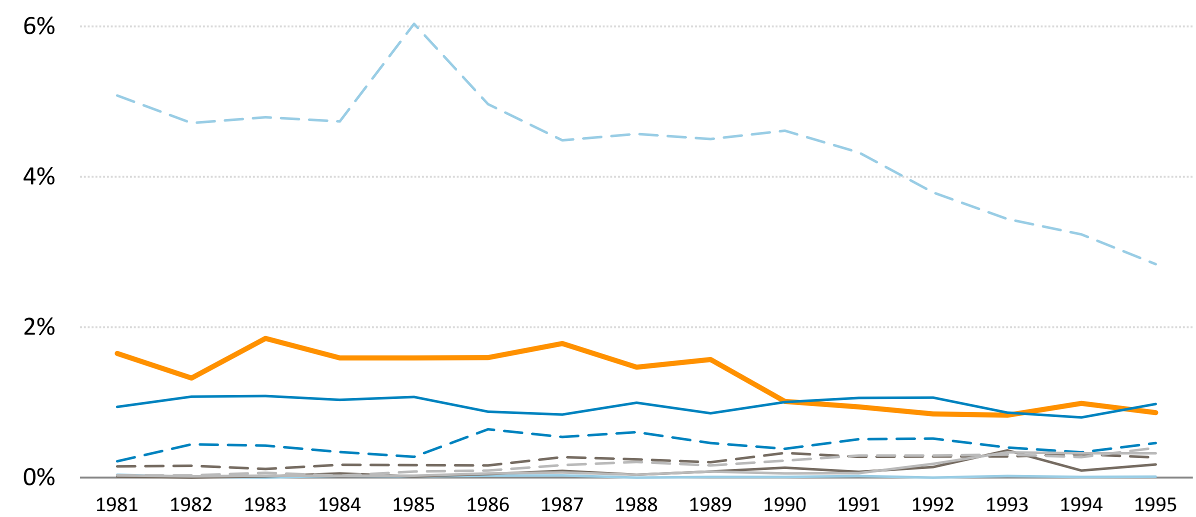


India's world share in Molecular Biology & Genetics fell from 1.7% in 1981 to 0.9% by 1995. Amongst the established research economies, India's rank fell from eighth to ninth as Israel surpassed India in 1990. Amongst the emerging research economies, India's ranked second to Russia until it was overtaken by Brazil more or less from 1991 onwards (though their world shares were broadly comparable from 1990 onwards).

All the world shares of the established research economies increased. The USA's share (not shown) increased from 42.6% in 1981 to 47.4% by 1995. The UK ranked second to the USA, with its share increasing from 8.9% in 1981 to a high of 11.5% by 1994, dipping slightly to 10.7% by 1995. Germany's share averaged 8.7% and the world shares of Japan and France increased (+2.0% and +1.9% respectively).

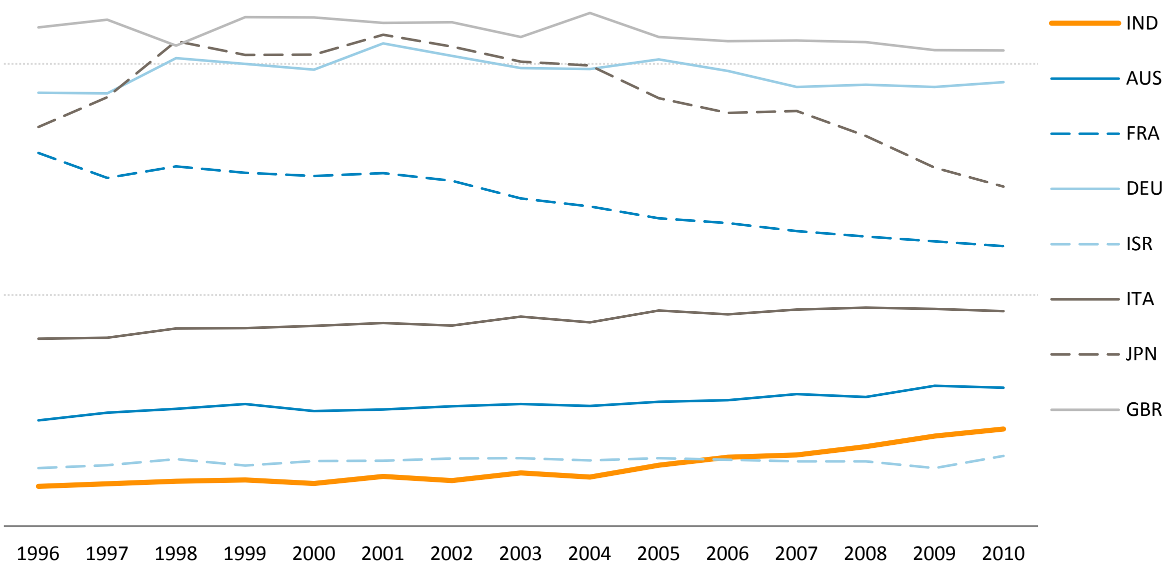
Russia's share declined from a high of 6.0% in 1985 to 2.8% by 1995. Brazil's share averaged 1.0% over this period. All the other emerging research economies had less than 0.5% of world output in this field (with the occasional exception of China whose share averaged 0.4% over this period).

5.7.a.iii: Share of world research output, Molecular biology & genetics, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.7.a: Share of world research output, Molecular biology & genetics

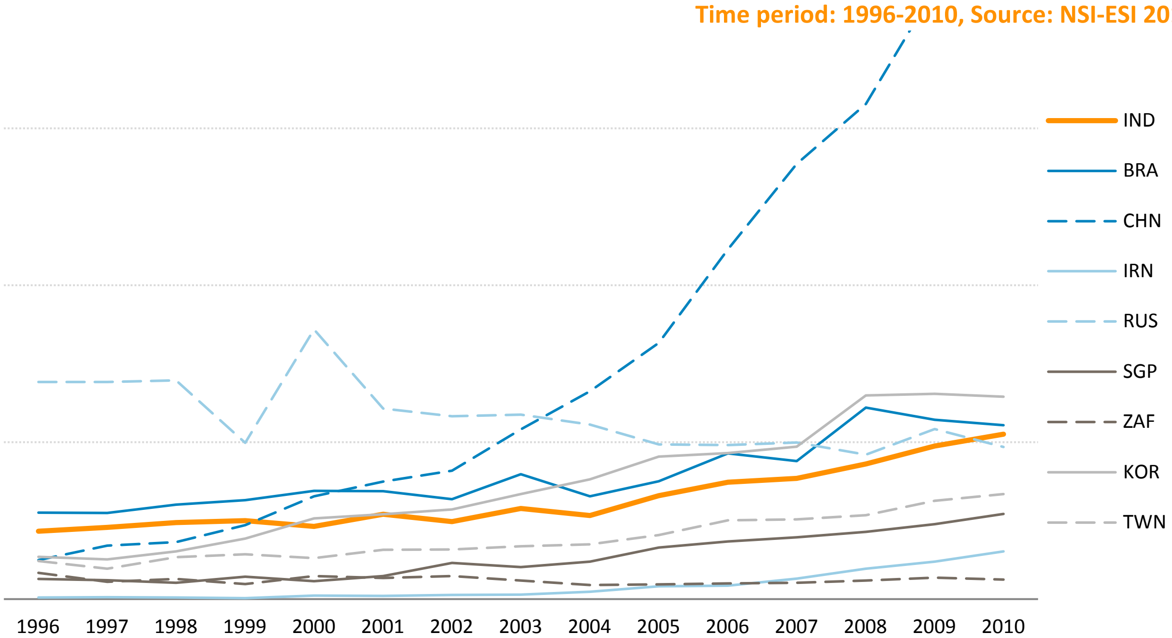
5.7.a.ii: Share of world research output, Molecular biology & genetics, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010



India's share in Molecular Biology & Genetics increased from 0.9% in 1996 to 2.1% by 2010. It ranked last amongst the established research economies, until its share exceeded that of Israel's in 2006. Amongst the emerging research economies, India's rank broadly moved down from third in 1996 to fifth by 2002, and up to fourth by 2010 (as its share increased marginally relative to Russia's). But by this stage, India had been overtaken by China (2000), Korea (2002) in addition to Brazil. The dynamics here were Russia's continued decline (its share fell from 2.8% in 1996 to 1.9% by 2010) and China's rise (its share increased from 0.5% to 9.2% surpassing Russia in 2004). Korea's share rose from 0.5% to 2.6%; Brazil's from 1.1% to 2.2% between 1996 and 2010.

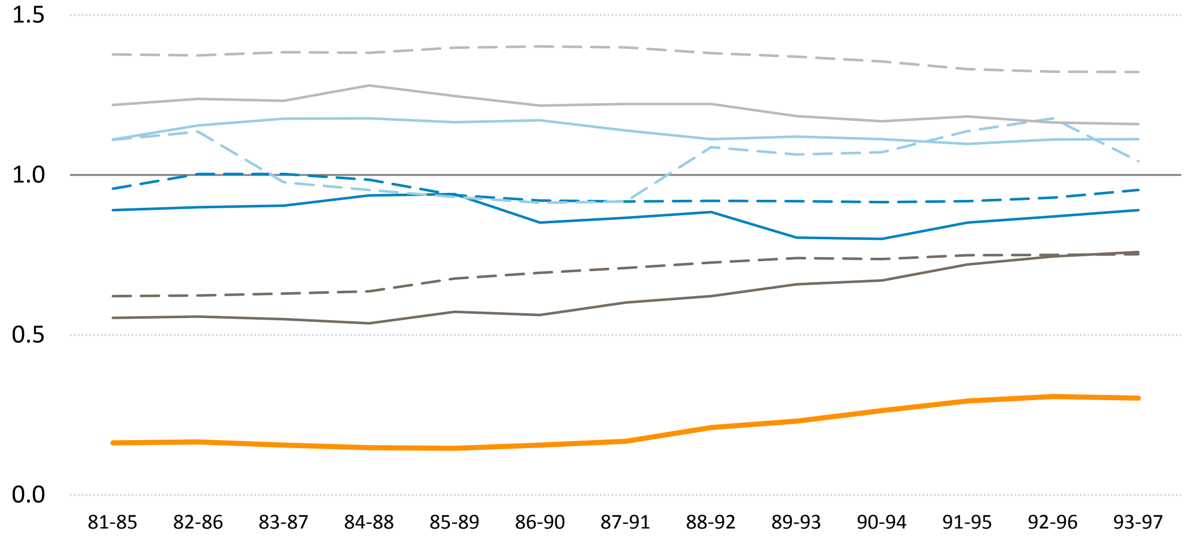
The USA's share (not shown) fell from 46.0% in 1996 to 40.9% by 2010. The rising shares of the UK, Germany, Japan and France were halted. The share of the UK fell slightly over this period (-0.5%), but broadly remained stable (10.7%). Germany's share averaged 9.8% (up on the previous period). Japan's share rose to 10.6% by 2001, but fell to 7.3% by 2010. France's share fell by -2.0%.

5.7.a.iv: Share of world research output, Molecular biology & genetics, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.7.b: Normalised citation impact, Molecular biology & genetics

5.7.b.i: Normalised citation impact, Molecular biology & genetics, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

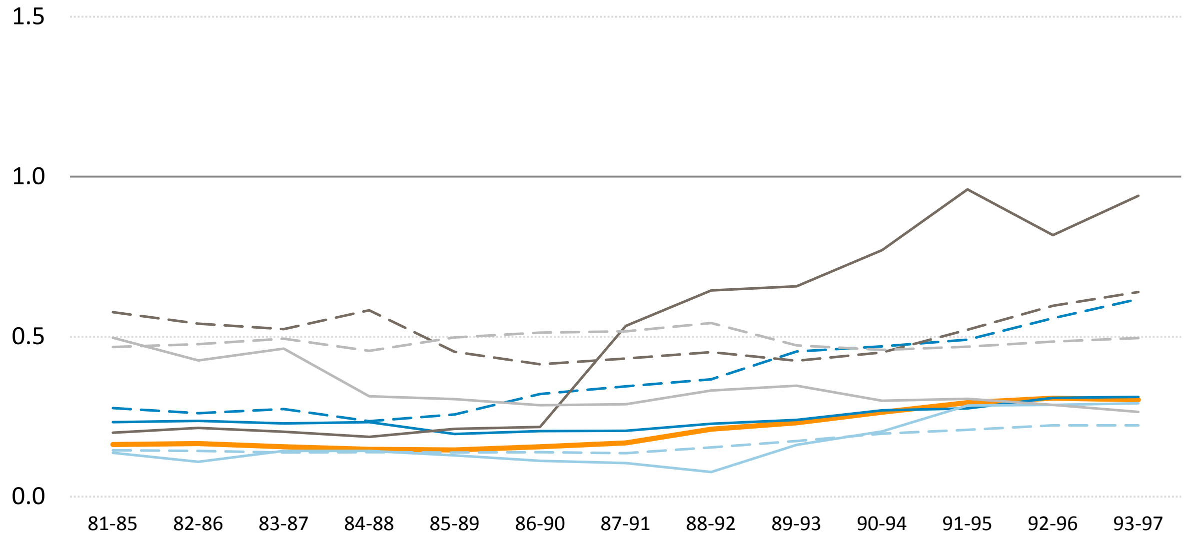


India's citation impact in Molecular Biology & Genetics was well below world average. In fact, during the 1980s, it was India's lowest citation impact in any field, although it did improve from 0.16 in 1981-1985 to 0.30 by 1993-1997. It ranked the lowest amongst the established research economies. When adjusting for countries with low paper numbers, India's rank was second to Russia for the most part of the period, but slightly ahead of Korea (though not Brazil) by the end of the period.

The USA had the highest citation impact although this fell from 1.38 in 1981-1985 to 1.32 by 1993-1997. The UK was second to the USA, but its citation impact also fell over the period from a high of 1.28 in 1984-1988 to 1.16 by 1993-1997. Germany's citation impact was 1.11 at the beginning and end of this period and Israel's citation impact varied.

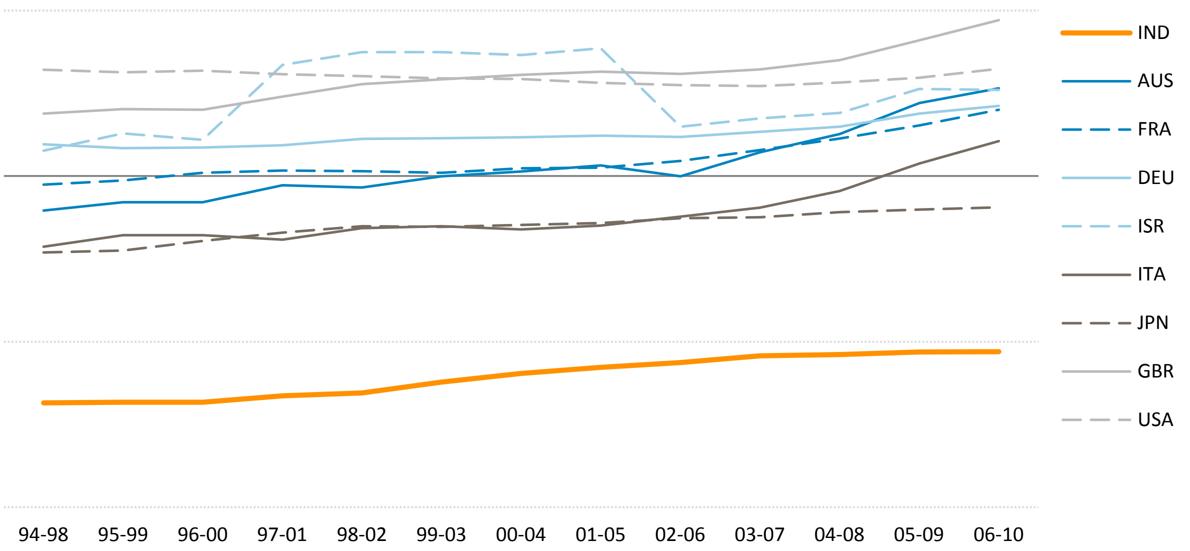
Singapore's citation impact leapt to 0.94 in 1993-1997 (its paper numbers were small in the 1980s) and South Africa's citation impact was 0.64. China's citation impact rose from 0.28 in 1981-1985 to 0.62 by 1993-1997.

5.7.b.iii: Normalised citation impact, Molecular biology & genetics, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.7.b: Normalised citation impact, Molecular biology & genetics

5.7.b.ii: Normalised citation impact, Molecular biology & genetics, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

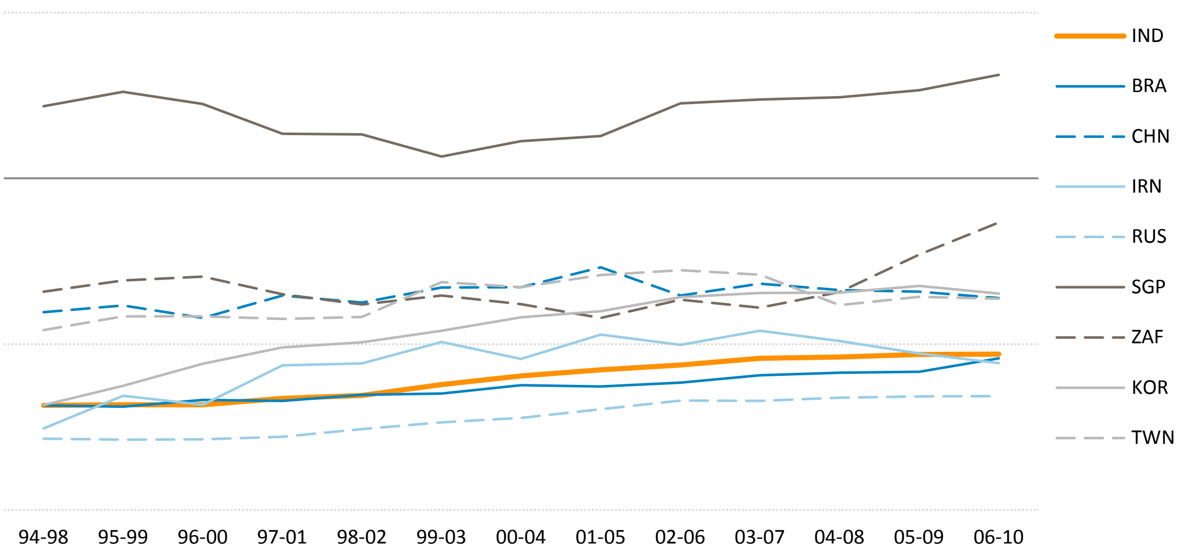


India's citation impact improved in Molecular Biology & Genetics, from 0.31 in 1994-1998 to 0.47 by 2006-2010. However, a substantial gap still remained between India and the established research economies, and whilst its rank varied amongst the emerging research economies, it was firmly on the lower end.

The USA's citation impact averaged 1.30 over this period, and Israel's citation impact peaked in 1997-2001 to 2001-2005, it is notable that the UK's citation impact rose from 1.19 in 1994-1998 to 1.47 by 2006-2010, overtaking the USA from 2000-2004 onwards. The citation impact of all the established research economies improved over this period: Australia (+0.37), Italy (+0.32) and France (+0.23) in particular. Only Japan's citation impact remained below world average at the end of the period (0.91).

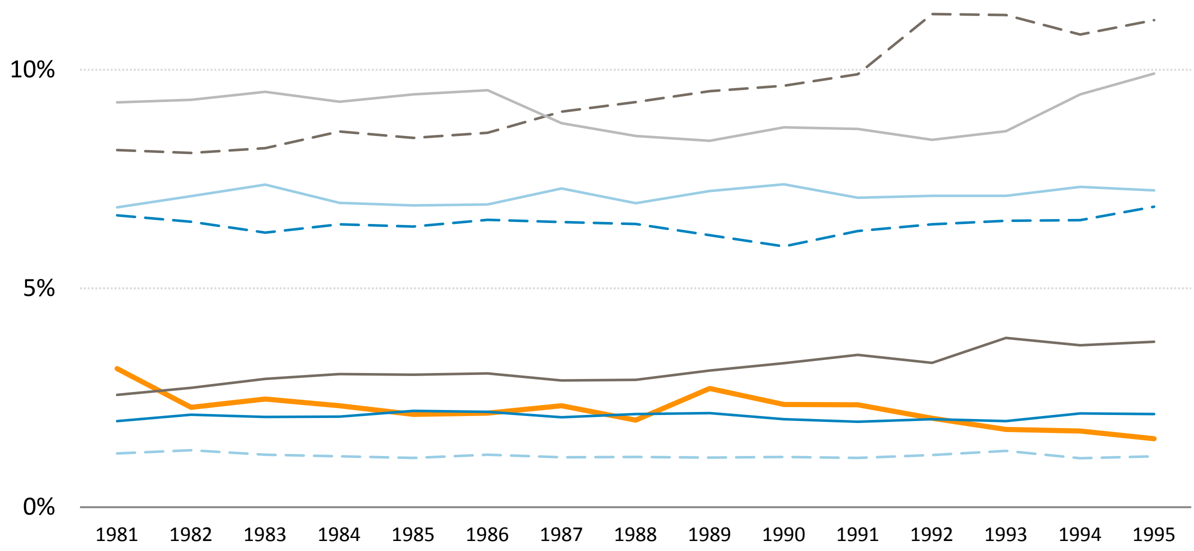
Singapore's citation impact was high over this period: 1.22 in 1994-1998 and 1.31 by 2006-2010 (an citation impact similar to the USA: 1.32). South Africa's citation impact was 0.87 by 2006-2010 and Korea had made significant improvements in citation impact, from 0.32 in 1994-1998 to 0.65 by 2006-2010 (+0.34).

5.7.b.iv: Normalised citation impact, Molecular biology & genetics, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.8.a: Share of world research output, Biology & biochemistry

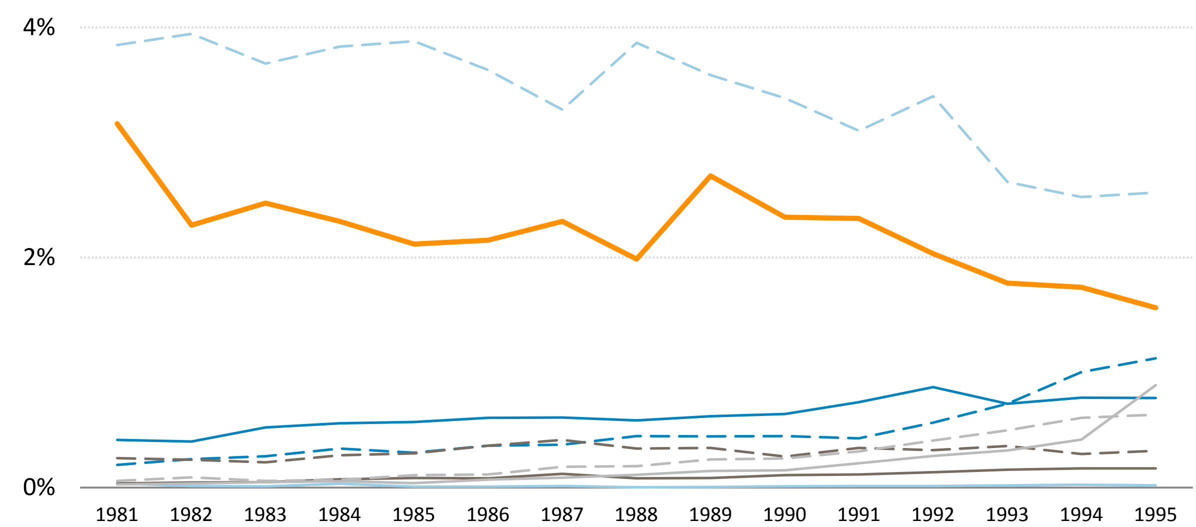
5.8.a.i: Share of world research output, Biology & biochemistry, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010



India's world share of output in Biology & Biochemistry fell from 3.2% in 1981 to 1.6% by 1995. Amongst the established research economies, India ranked from sixth in 1981 to eighth by 1995 as Italy surpassed India's output in 1982, and Australia surpassed it by 1993. Amongst the emerging research economies India ranked second to Russia, whose share also broadly declined over the period from 3.8% in 1981 to 2.6% by 1995. All the other emerging research economies had shares of less than 1%, with the exception of China from 1994 onwards. This field was clearly the domain of the established research economies, but it is notable that small increases in the shares of Brazil, Taiwan and Korea were apparent at this stage.

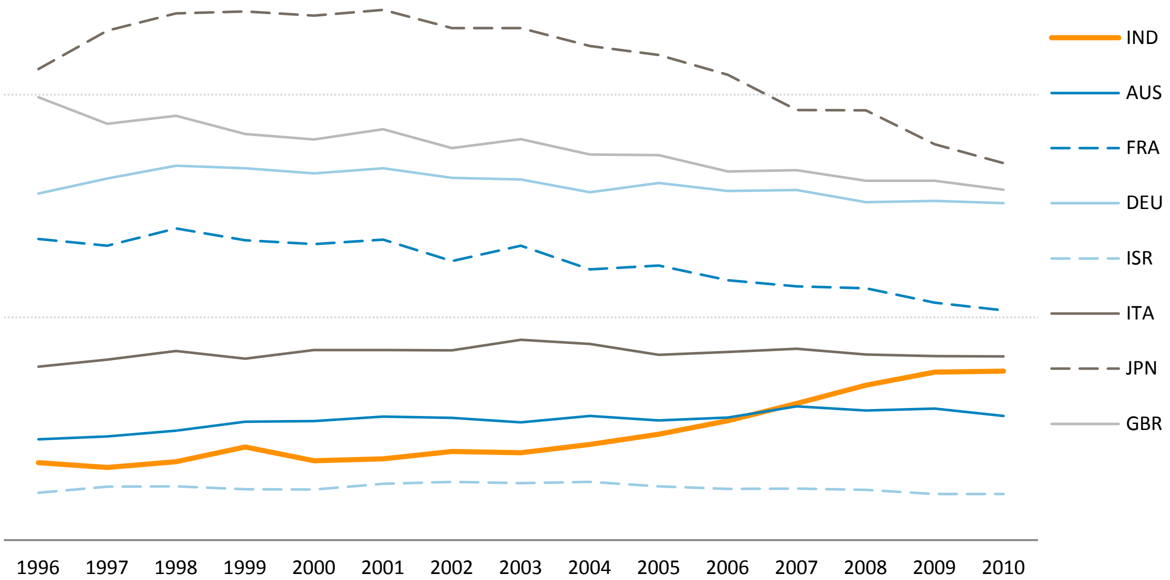
The share of the USA (not shown) marginally increased over this period, and averaged just short of 40%. Japan overtook the UK in 1987 to be second to the USA: its share increased from 8.2% in 1981 to 11.1% by 1995. The UK's share averaged 9.0% of world output over this period; the averaged shares of Germany and France over the same period were 7.1% and 6.5% respectively.

5.8.a.iii: Share of world research output, Biology & biochemistry, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.8.a: Share of world research output, Biology & biochemistry

5.8.a.ii: Share of world research output, Biology & biochemistry, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

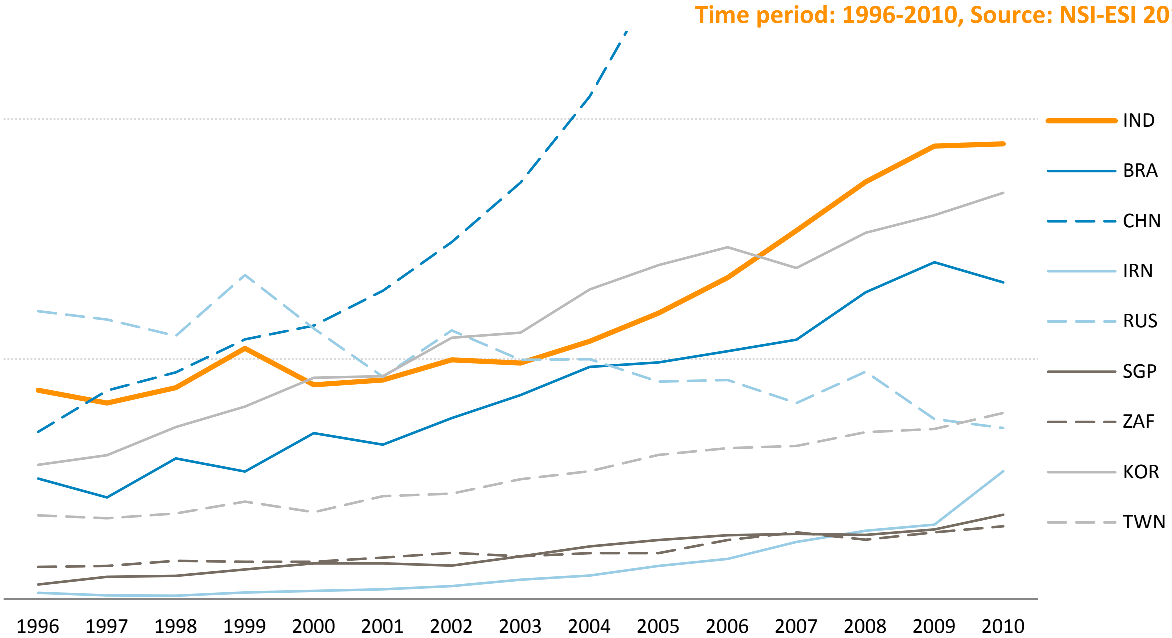


India recovered its lost share of world output in Biology & Biochemistry: it rose from 1.7% in 1996 to 3.8% by 2010. Its rank moved from eighth to seventh amongst the established research economies, as its share surpassed Australia's in 2007 and whilst its rank moved from second to fourth in the first half of this period, it rose back to second to China after India surpassed Korea in 2007.

The share of the USA (not shown) fell by -7.5% in this period, from 39.2% in 1996 to 31.7% by 2010. Japan's share which had peaked at 11.9% in 2001, then fell to 8.5% by 2010. The share of the UK fell from 9.9% in 1996 to 7.9% by 2010, and Germany's broadly averaged 8.0% (up on the earlier period). France's share fell from 6.8% in 1996 to 5.2% by 2010.

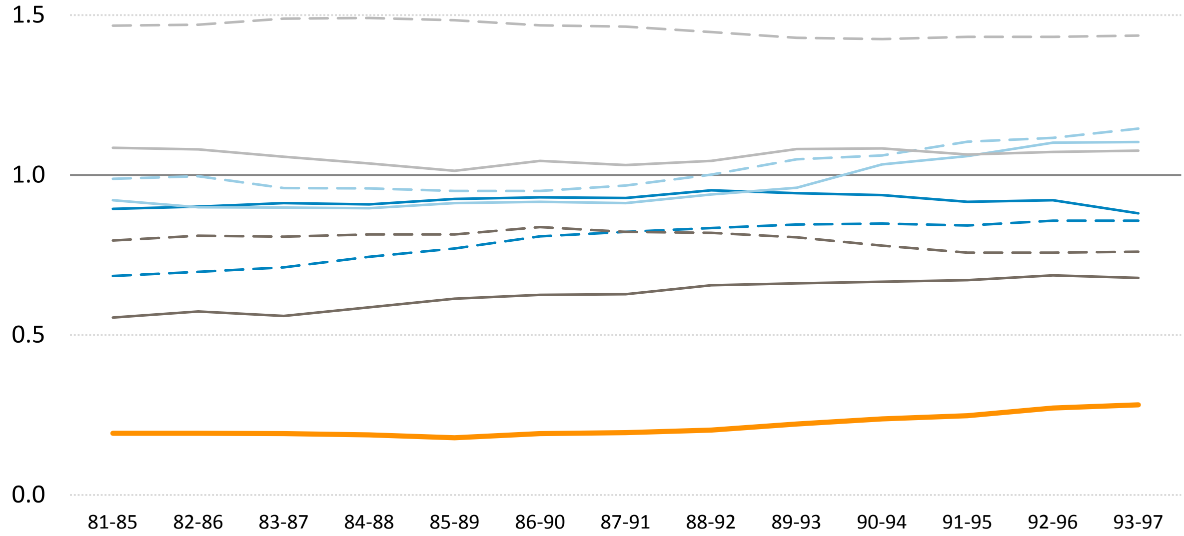
China's world share rose from 1.4% in 1996 to 9.9% by 2010, surpassing Japan's share of world output. As Russia's share fell from 2.4% in 1996 to 1.4% by 2010, Korea's share rose from 1.1% to 3.4% and Brazil's from 1.0% to 2.6%. Taiwan's share increased by +0.9%.

5.8.a.iv: Share of world research output, Biology & biochemistry, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.8.b: Normalised citation impact, Biology & biochemistry

5.8.b.i: Normalised citation impact, Biology & biochemistry, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

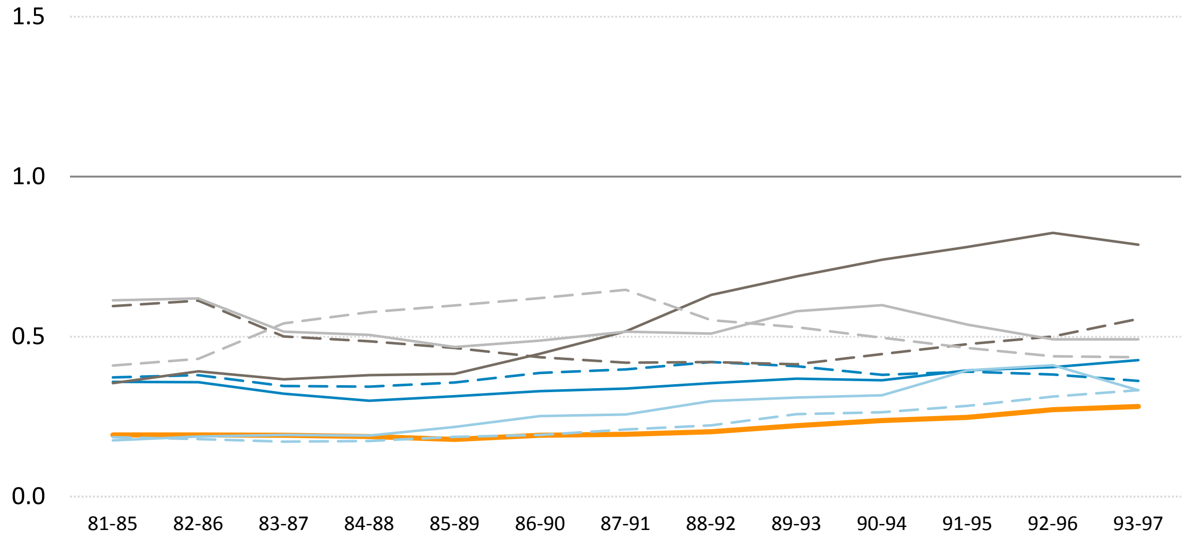


India's citation impact in Biology & Biochemistry was low during this earlier period: 0.19 in 1981-1985 and 0.28 by 1993-1997, which was a modest improvement. It ranked the lowest amongst the established research economies, and its rank moved from seventh to ninth amongst the emerging research economies.

The USA had the highest citation impact in this field, but it fell marginally from 1.47 in 1981-1985 to 1.44 by 1993-1997. The UK had the second highest citation impact for the best part of this period, but Israel and Germany surpassed it during the early 1990s. Their final citation impact for 1993-1997 was 1.08 (UK), 1.15 (Israel) and 1.10 (Germany). Surprisingly, given Japan's share, its citation impact fell from 0.80 in 1981-1985 to 0.76 by 1993-1997.

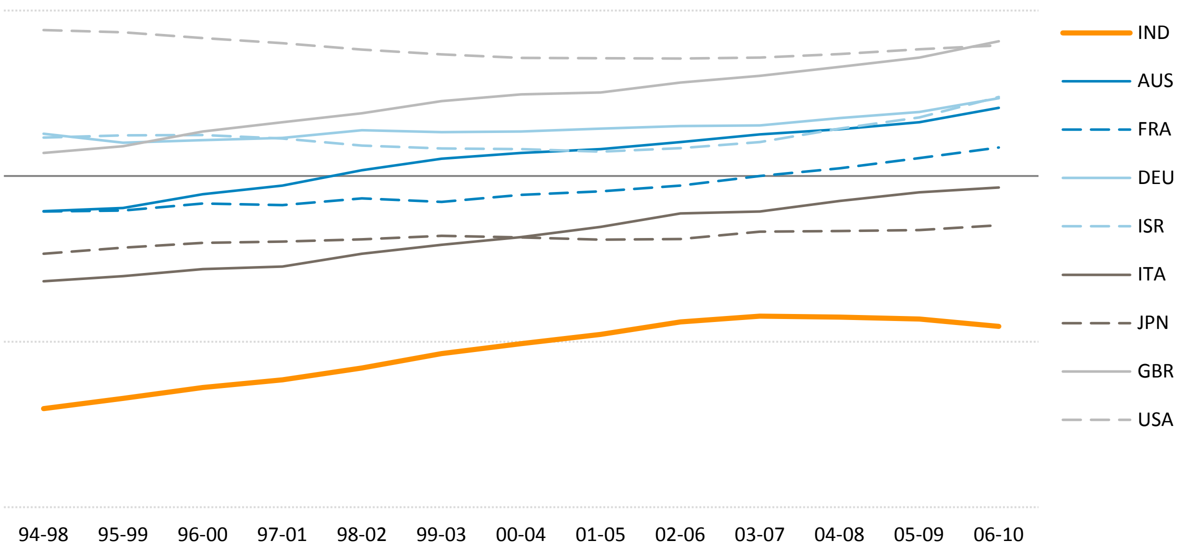
Singapore's citation impact grew strongly over this period: from 0.36 in 1981-1985 to 0.79 by 1993-1997 (+0.43). The other emerging research economies were all well below world average in this field, most less than 0.50 with the occasional exceptions of South Africa, Korea and Taiwan.

5.8.b.iii: Normalised citation impact, Biology & biochemistry, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.8.b: Normalised citation impact, Biology & biochemistry

5.8.b.ii: Normalised citation impact, Biology & biochemistry, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

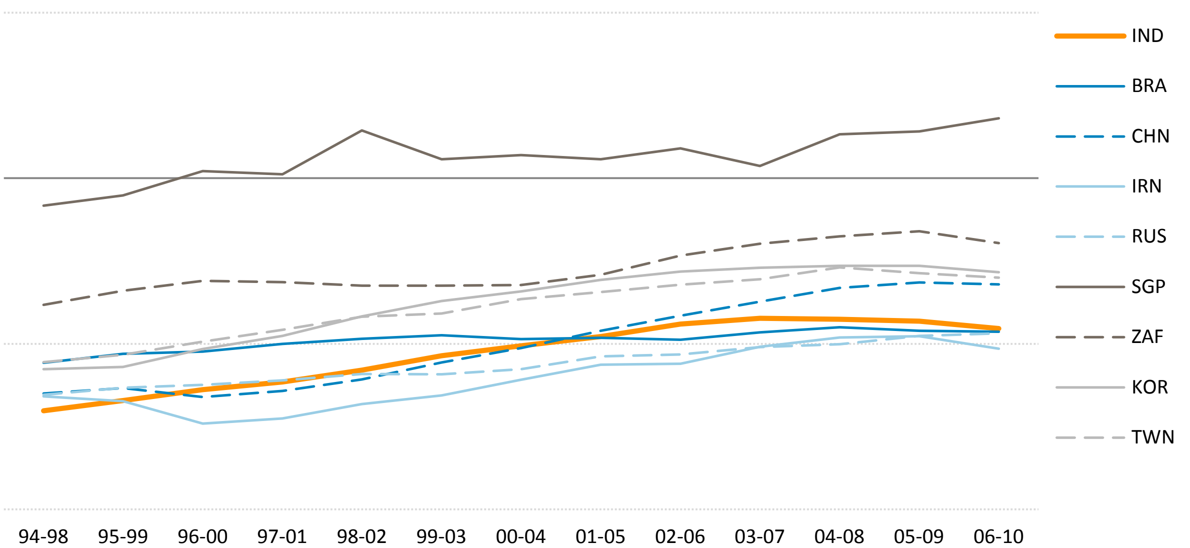


India's citation impact in Biology & Biochemistry increased from 0.30 in 1994-1998 to 0.55 by 2006-2010. This improvement somewhat narrowed the gap between India and the established research economies, although their citation impact improved over this period (with the exception of the USA). Amongst the emerging research economies, India's rank improved from last to sixth: ahead of Iran, Russia and Brazil.

The UK surpassed the citation impact of the USA in 2006-2010 (1.41 versus 1.39). The citation impact of Germany and Israel were 1.24 by 2006-2010. Australia's citation impact shot up from 0.89 in 1994-1998 to 1.21 by 2006-2010. The citation impact of France and Italy improved (+0.19 and +0.28 respectively). Japan's citation impact was quite low, but it rose from 0.77 in 1994-1998 to 0.85 by 2006-2010.

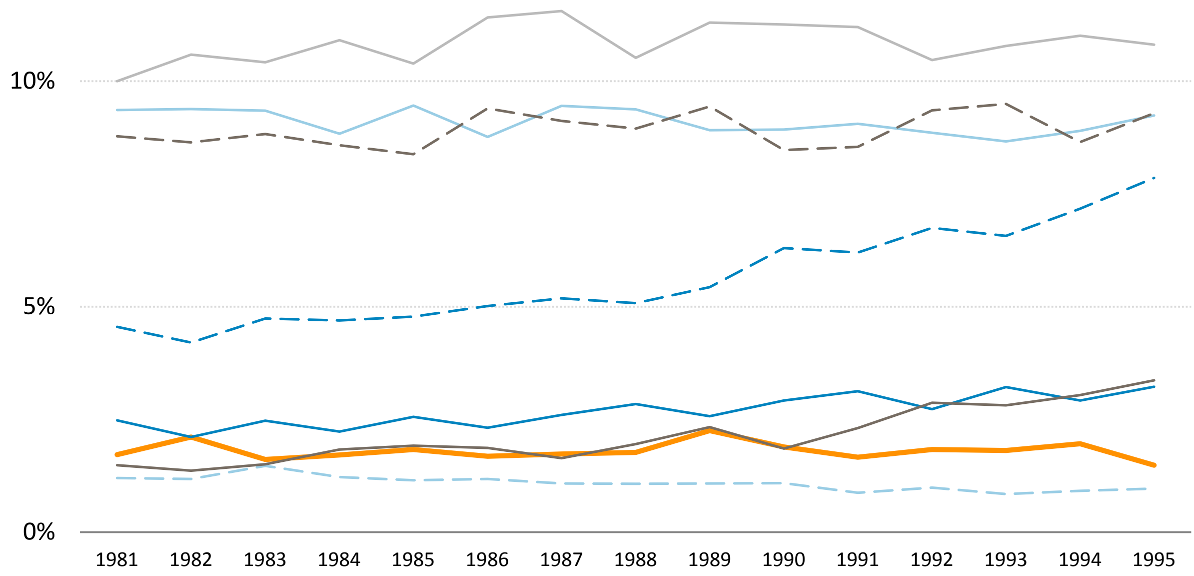
Singapore's citation impact increased from 0.92 to 1.18. All the other emerging research economies were well below average in this field, but all improved. South Africa ranked second to Singapore, followed by Korea and Taiwan. The improvement in Chinese citation impact was the highest (+0.33).

5.8.b.iv: Normalised citation impact, Biology & biochemistry, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.9.a: Share of world research output, Microbiology

5.9.a.i: Share of world research output, Microbiology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

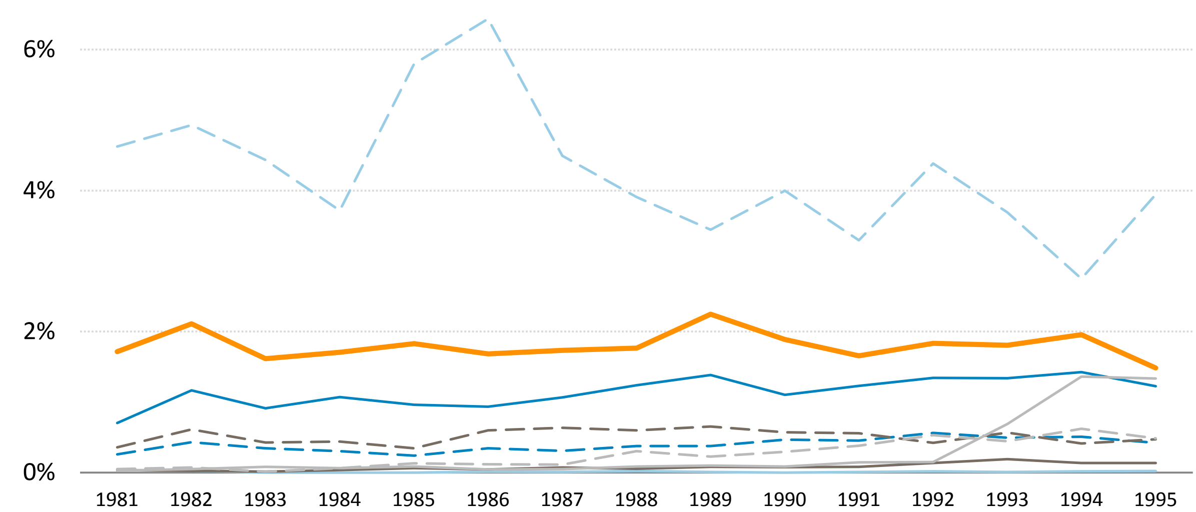


India's world share in Microbiology broadly averaged 1.8% over the period. Its rank varied amongst the established research economies (mainly due to Italy's changing share) but by 1991, Italy had surpassed India's world share, so India ranked eighth in the group above Israel. Amongst the emerging research economies, India ranked second to Russia.

The share of the USA (not shown) was broadly stable although on the downside, in that it fell from 37.5% in 1981 to 34.8% by 1995. The UK was second to the USA, with a share averaging 10.8%. Germany and Japan's shares were broadly equal: Germany's averaged 9.1% and Japan's averaged 8.9%. France's share increased over this period by +3.3% and Italy's share increased by +1.9%.

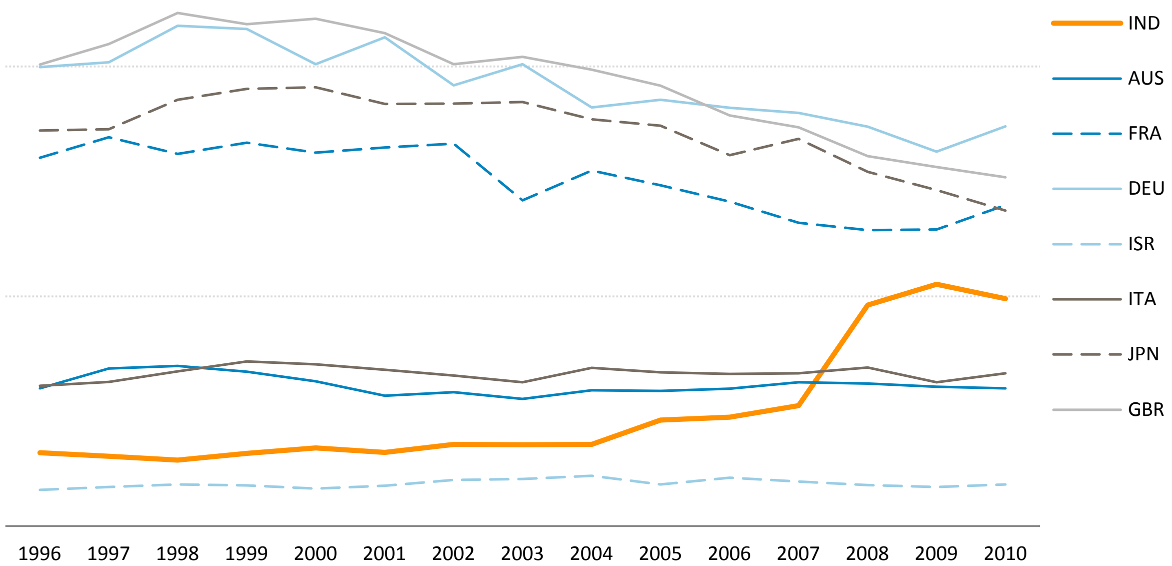
Russia's share varied over the period, but fell from a high of 6.4% in 1986 to a low of 2.8% by 1994. Brazil's share rose from 0.7% in 1981 to 1.2% by 1995 and Korea's share (which was unremarkable in the 1980s less than 0.1%) jumped in 1994 (1.4%) and was 1.3% by 1995.

5.9.a.iii: Share of world research output, Microbiology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.9.a: Share of world research output, Microbiology

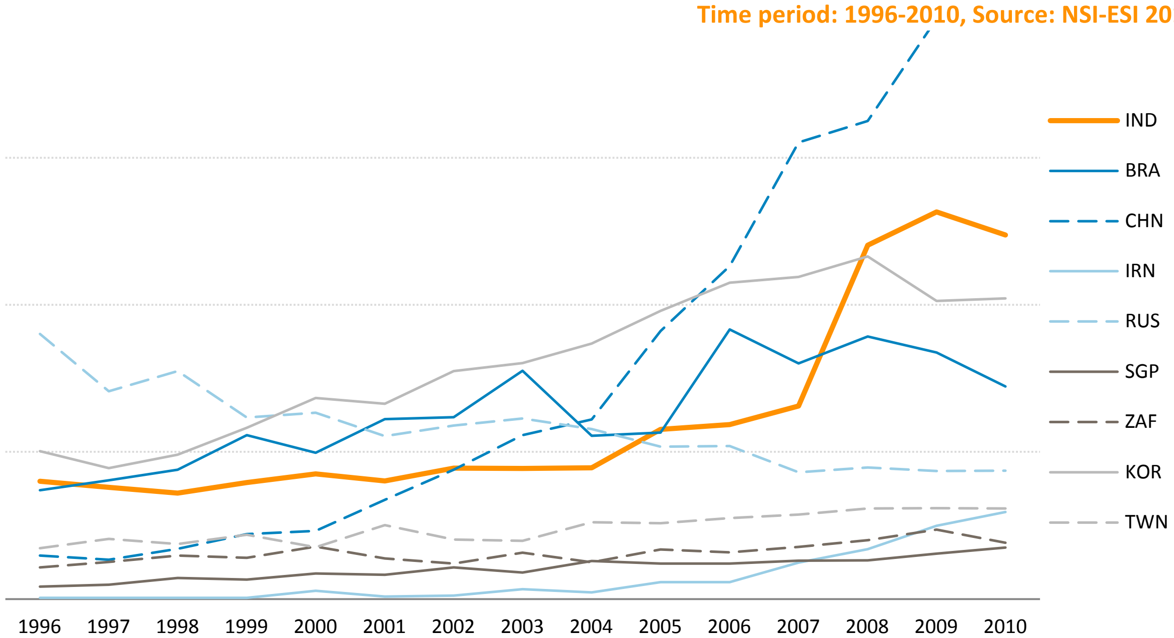
5.9.a.ii: Share of world research output, Microbiology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010



There was a 'leap' in India's share in Microbiology in this period. Whilst it was 1.6% in 1996, and increased to 2.3% by 2005, it was notable that from a share of 2.6% in 2007, it short of doubled to 4.8% in 2008 with 4.9% of share by 2010. This leap meant that India surpassed the shares of both Australia and Italy to rank sixth in the established research economies group by 2010. Amongst the emerging research economies, this leap meant that India surpassed the world shares of Brazil and Korea to rank second to China from 2008 onwards. Meanwhile, China's share had shot up from 0.6% in 1996 to 9.0% by 2010; Korea's share doubled from 2.0% to 4.1% over the same period. Brazil's share reached a high of 3.7% in 2006, but fell to 2.9% by 2010.

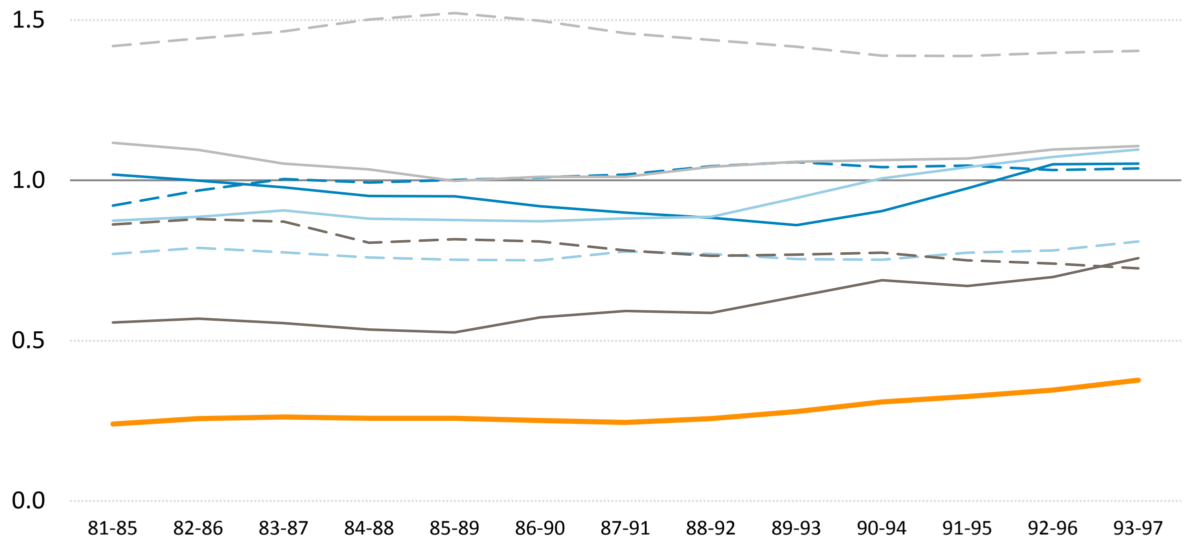
The USA's share (not shown) declined from 35.9% in 1996 to 29.3% by 2010. The UK's share declined from a high of 11.2% in 1998 to 7.6% by 2010. Germany's share also fell, but was higher than the UK's share by the end of the period (8.7%). Japan's share fell from a high of 9.6% in 2000 to 6.9% by 2010. France's share fell from 8.0% in 1996 to 7.0% by 2010.

5.9.a.iv: Share of world research output, Microbiology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.9.b: Normalised citation impact, Microbiology

5.9.b.i: Normalised citation impact, Microbiology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

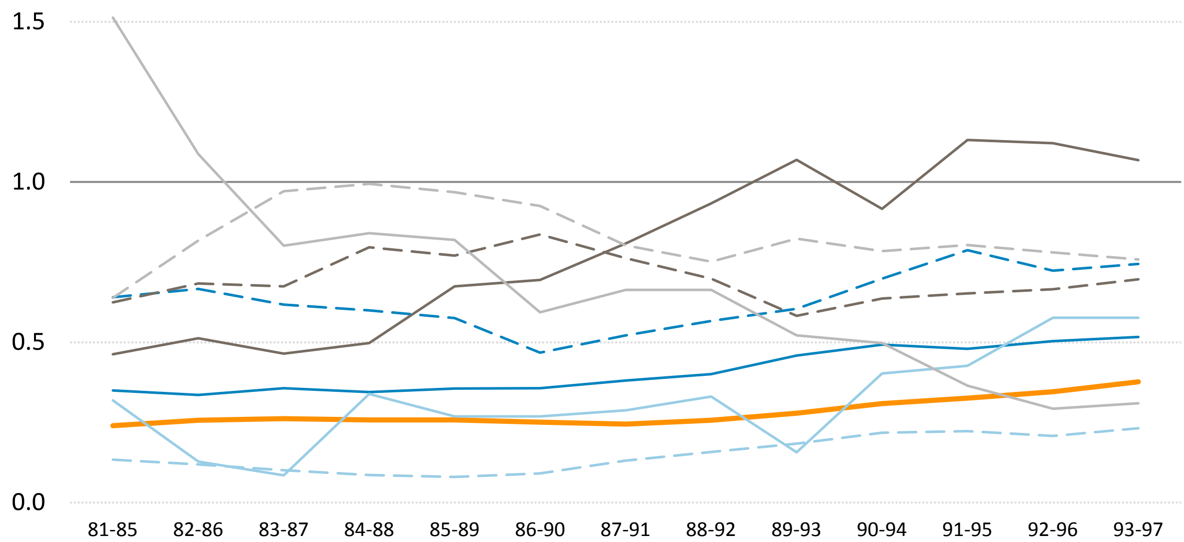


India's citation impact in Microbiology was very low, but it did improve: from 0.24 in 1981-1985 to 0.38 by 1993-1997. It ranked the lowest amongst the established research economies, and factoring out countries with small paper numbers (namely Iran) it ranked second lowest to Russia until Korea fell below India in 1992-1996 and 1993-1997.

The USA had the highest citation impact: 1.42 in 1981-1985 and 1.40 by 1993-1997, with a high of 1.52 in 1985-1989. The UK also had an above world average citation impact for the period: 1.12 in 1981-1985 and 1.11 by 1993-1997. Other established research economies whose citation increased to above world average by 1993-1997 were France (1.04), Germany (1.10) and Australia (1.05).

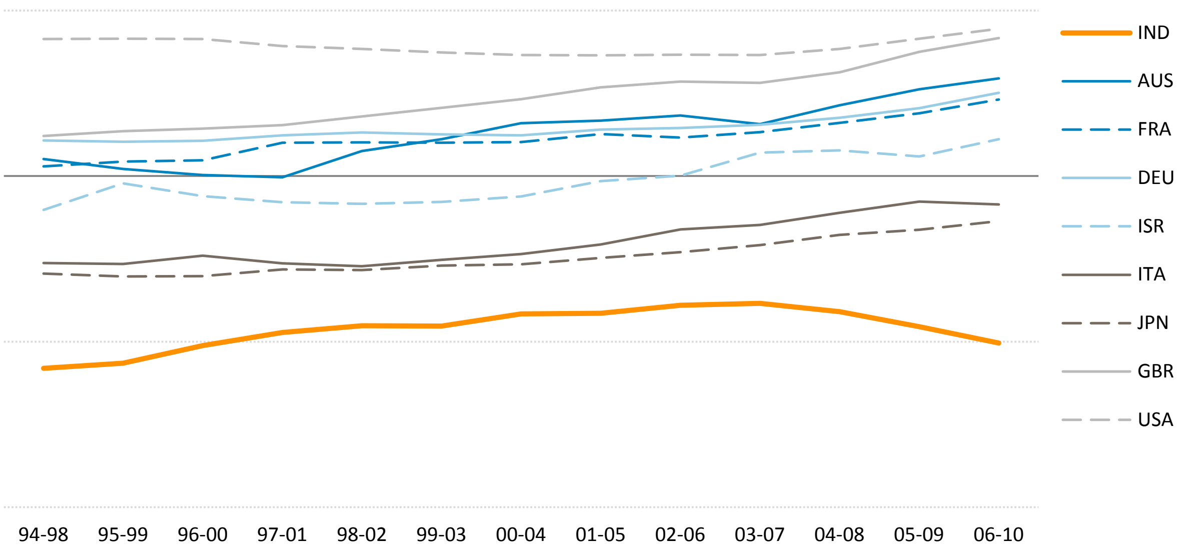
With the caveat of small paper numbers (<50), it is notable that Singapore achieved an above world average citation impact (it was 1.07 by 1993-1997). Taiwan's citation impact declined during the early 1990s, South Africa's citation impact rose and fell, and China and Brazil's citation impact broadly rose.

5.9.b.iii: Normalised citation impact, Microbiology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.9.b: Normalised citation impact, Microbiology

5.9.b.ii: Normalised citation impact, Microbiology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

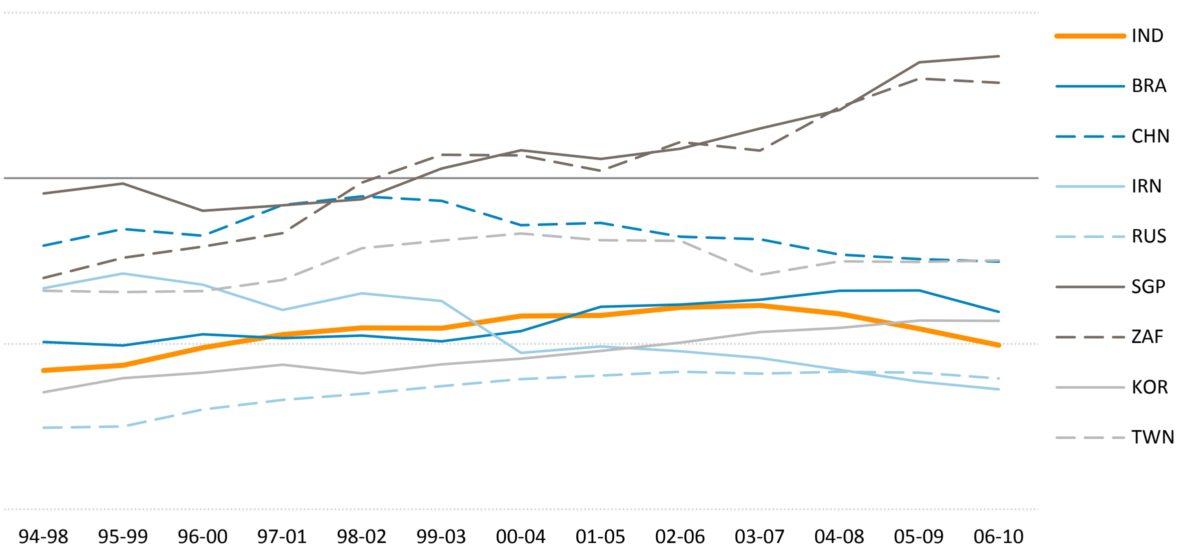


India's citation impact increased from 0.42 in 1994-1998 to 0.62 by 2003-2007, but then fell again to 0.50 by 2006-2010. This coincided with the expansion of Indian Microbiology papers. India narrowed the gap between itself and the established research economies (although still ranking lowest by citation impact). Amongst the emerging research economies, India's rank by citation impact varied.

The citation impact of all established research economies increased. The USA's citation impact was 1.41 in 1994-1998 and 1.44 by 2006-2010, although it dipped during most of the 2000s. Meanwhile, the UK's citation impact rose up from 1.12 in 1994-1998 to 1.42 by 2006-2010. Australia's citation impact too rose from 1.05 in 1994-1998 to 1.29 by 2006-2010. Germany's citation impact was 1.25 by 2006-2010 (+0.14) and France's citation impact was 1.23 by 2006-2010 (+0.20).

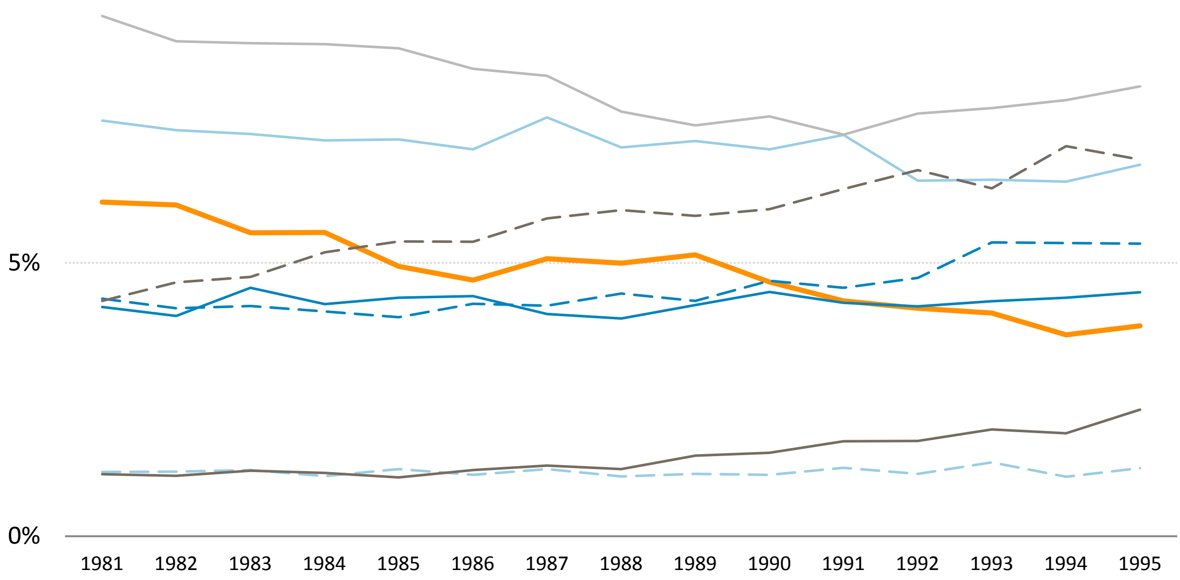
Singapore and South Africa's citation impact crossed the line of the world average from 1999-2003 onwards with 2006-2010 citation impact of 1.37 and 1.29 respectively.

5.9.b.iv: Normalised citation impact, Microbiology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.10.a: Share of world research output, Plant & animal science

5.10.a.i: Share of world research output, Plant & animal science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

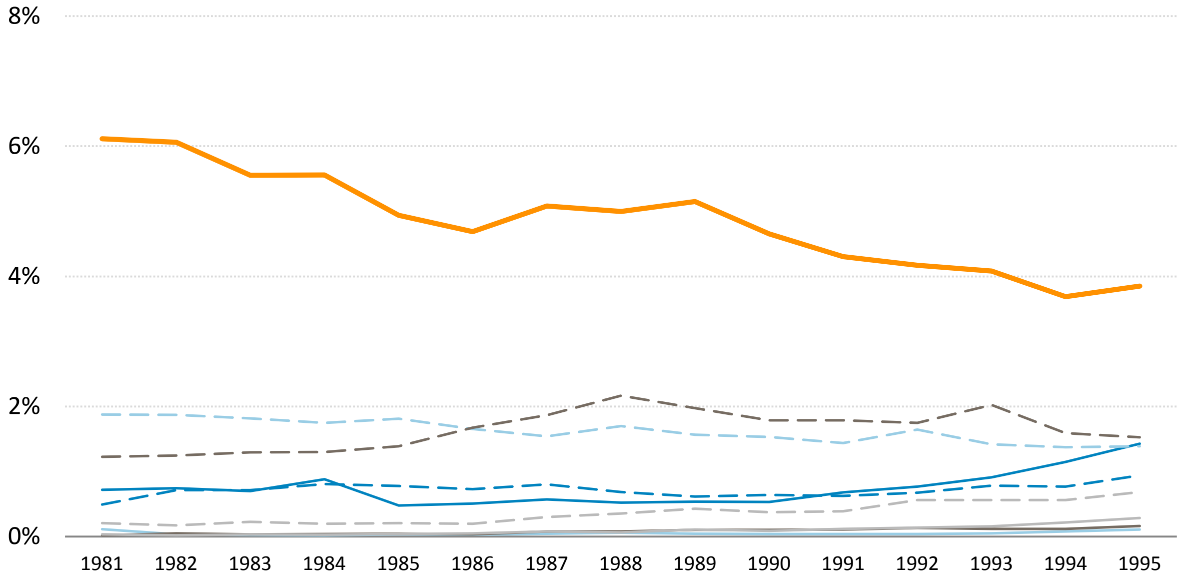


In this earlier period, India's percentage world share of research in Plant & Animal Science declined from 6.1% in 1981 to 3.9% by 1995, a fall of around a third.

The USA (not shown) had the highest share over the period, but it fell from 36.2% in 1981 to 32.4% in 1995. The UK ranked second, but its share also fell from 9.5% in 1981 to 8.2% in 1995, with Germany ranking third over the period until overtaken by Japan from around 1992 onwards. In the earlier part of the period, India ranked fourth within this group, but this position fell to Japan (whose share rose from 4.3% in 1981 to 6.9% by 1995) and latterly to France and Australia.

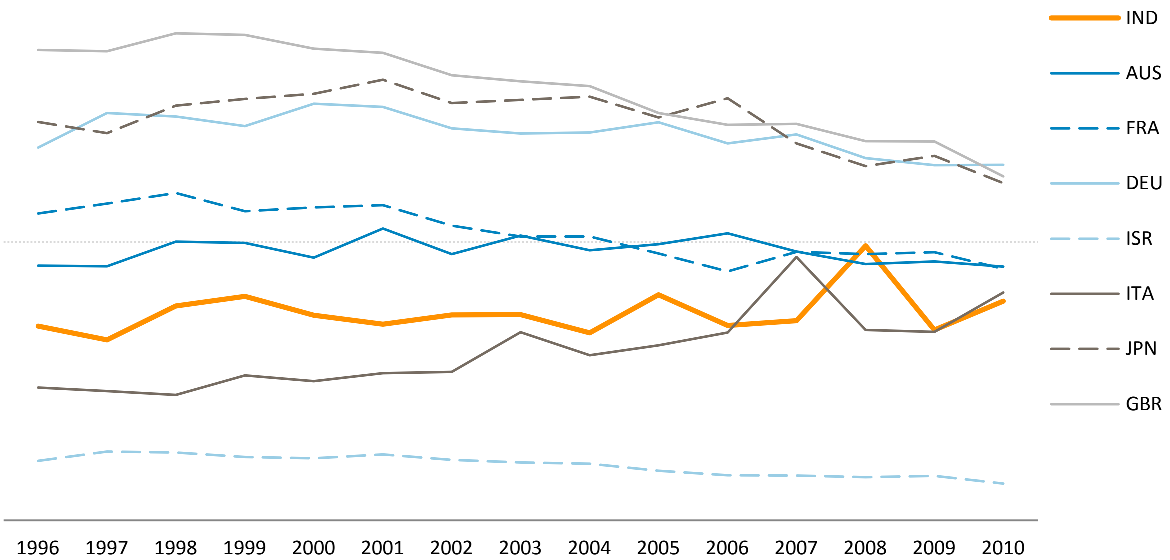
Regarding the emerging research economies, whilst India ranked first over the period, its share visibly declined. Russia initially ranked second, although this rank fell to South Africa from 1987 onwards. The emergence of Brazil becomes apparent from 1993 onwards with a share of 1.4% by the end of 1995.

5.10.a.iii: Share of world research output, Plant & animal science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.10.a: Share of world research output, Plant & animal science

5.10.a.ii: Share of world research output, Plant & animal science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

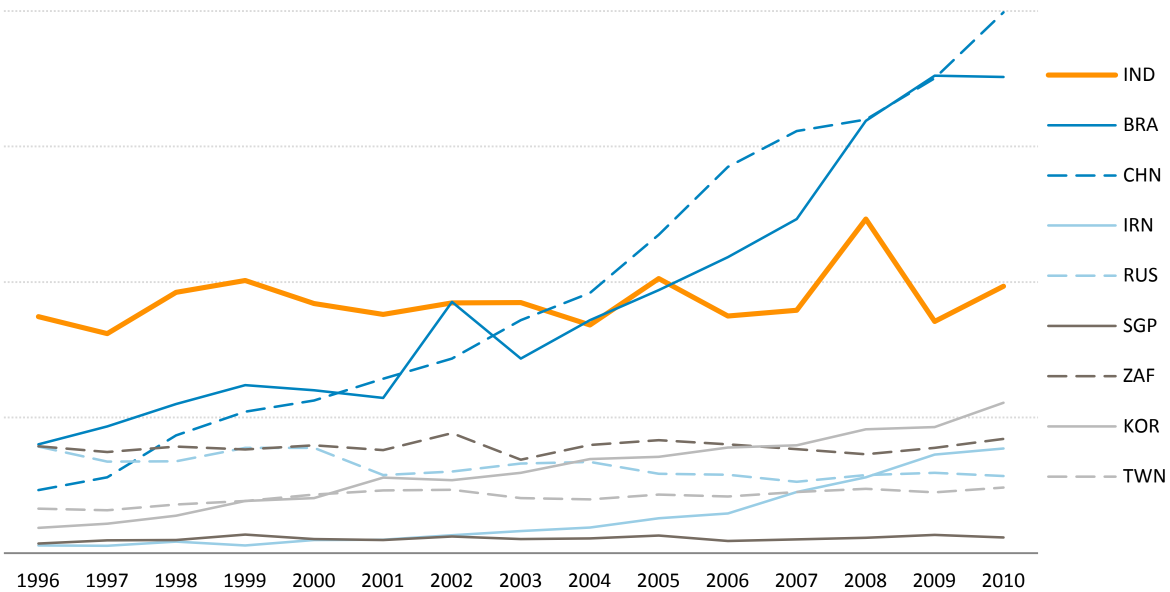


In this later period, India's percentage share of world output varied somewhat from 3.5% in 1996 to 3.9% by 2010, with a high of 4.9% in 2008.

The USA's percentage world share (not shown) fell further from 31.8% in 1996 to 24.2% by 2010 (-7.6% fall), as did that of the UK (-2.3%) and Japan (-1.1%). Australia's share of world Plant & Animal Science research broadly remained stable whilst Italy's increased (+1.7% over this period).

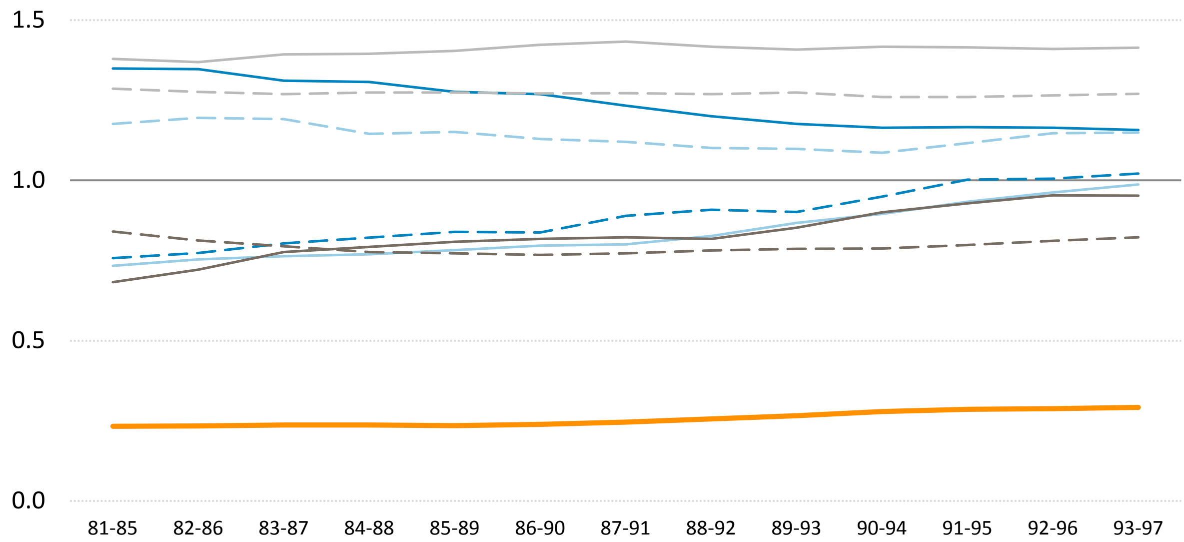
The changes amongst the emerging research economies in this field are even more dramatic. India certainly lost its first in rank position to China and Brazil. This position was lost to China in 2004 and to Brazil by 2006. The growth in share of world output of these two countries is remarkable: China rose from 0.9% in 1996 to 8.0% by 2010; whilst Brazil rose from 1.6% to 7.0% over the same period.

5.10.a.iv: Share of world research output, Plant & animal science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.10.b: Normalised citation impact, Plant & animal science

5.10.b.i: Normalised citation impact, Plant & animal science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

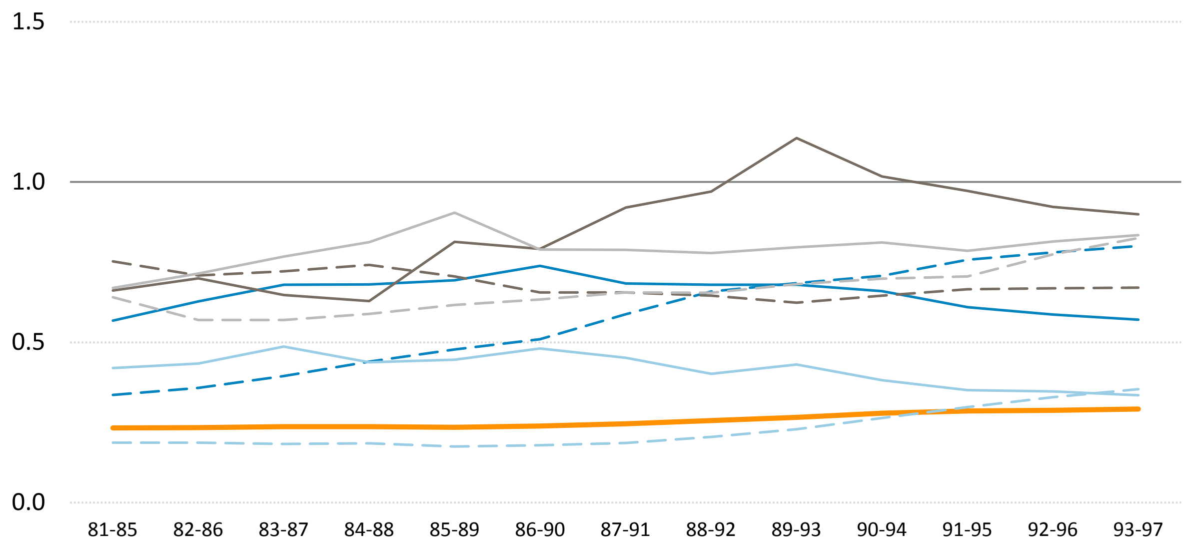


The citation impact of India's Plant & Animal Science research was well below world average in the earlier period, 0.23 in 1981-1985 and rising to 0.29 in 1993-1997.

Amongst the established research economies, the UK had the leading citation impact in Plant & Animal Science research over this period (1.41 in 1993-1997), with Australia's citation impact falling from 1.35 to 1.16, and the USA overtaking Australia to rank second from 1987-1991 onwards. Israel ranked fourth.

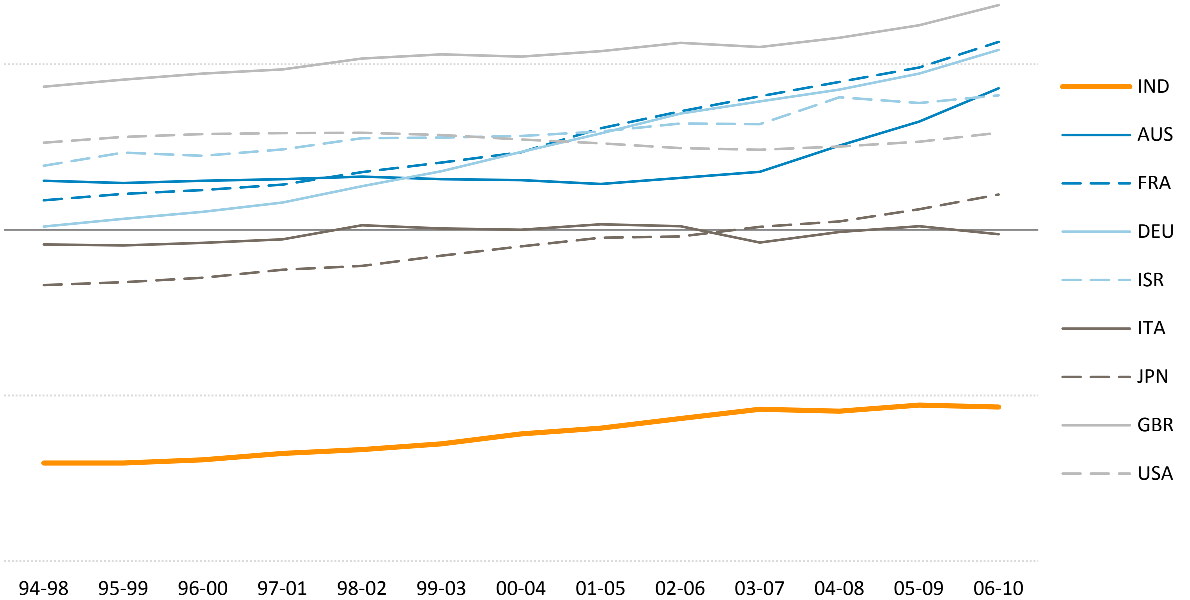
Amongst the emerging research economies, India was second lowest to Russia until the periods from 1991-1995 onwards, after which it ranked the lowest.

5.10.b.iii: Normalised citation impact, Plant & animal science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.10.b: Normalised citation impact, Plant & animal science

5.10.b.ii: Normalised citation impact, Plant & animal science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

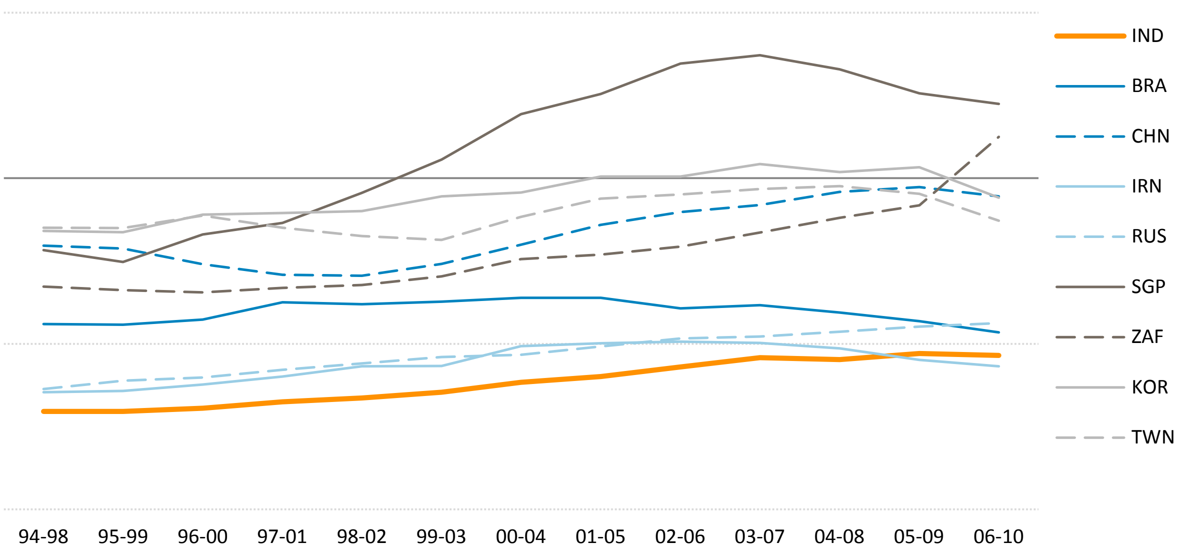


The citation impact of India's research in Plant & Animal Science over this period was still well below world average, both compared to the established research economies and the emerging research economies. Whilst its citation impact improved from 0.30 in 1994-1998 to 0.46 by 2006-2010 this didn't narrow the gap, and it more or less ranked the lowest amongst the two groups.

Amongst the established research economies, the UK was clearly the leader in terms of citation impact (1.68 by 2006-2010) but it is notable that France improved its citation impact substantially in this field (from 1.09 over the 1994-1998 period to 1.57 by 2006-2010). Germany's citation impact improved from 1.01 to 1.54 and Australia's improved from 1.15 to 1.43.

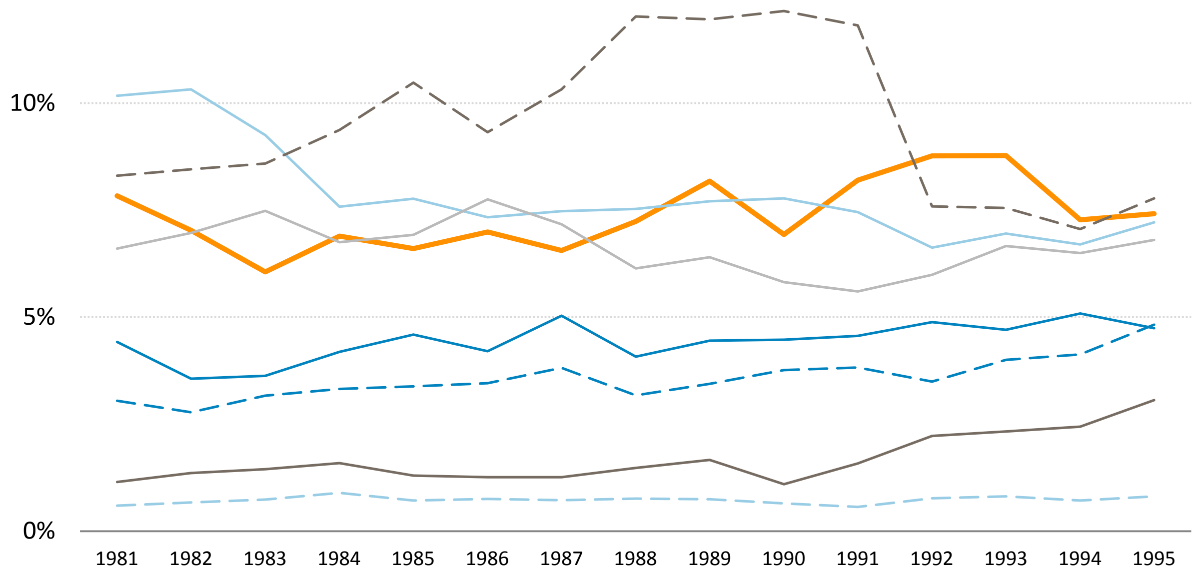
Amongst the emerging research economies, Singapore's citation impact increased from 0.78 in 1994-1998 to 1.22 by 2006-2010 with a high of 1.37 in 2003-2007. South Africa's citation impact also improved (+0.45). China's citation impact improved from 0.80 to 0.95, but Brazil's citation impact remained broadly unchanged.

5.10.b.iv: Normalised citation impact, Plant & animal science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.11.a: Share of world research output, Agricultural sciences

5.11.a.i: Share of world research output, Agricultural sciences, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

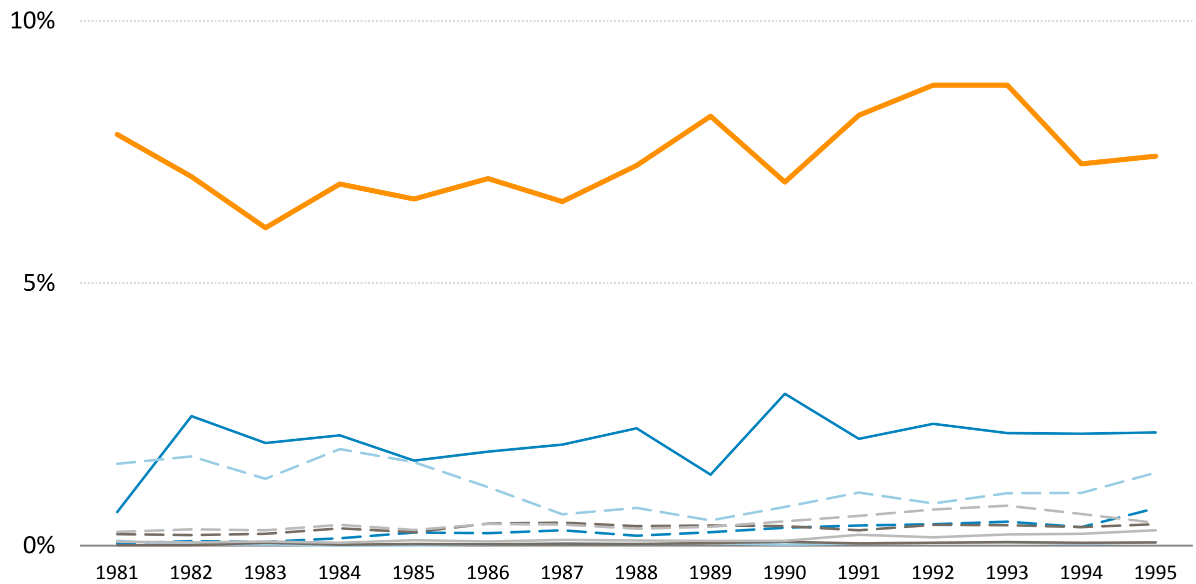


In 1981, India had a 7.8% world share in Agricultural Sciences. This share varied but broadly averaged 7.4%. Amongst the established research economies, India's rank varied in this field, but amongst the emerging research economies, it ranked far and away number one with Brazil a significant margin behind.

The USA (not shown) had the largest world share, but this fell from 34.1% in 1981 to 27.1% by 1995. Japan's world share rose from 8.3% in 1981 to a high of 12.2% in 1990, but its share then fell to 7.8% by 1995 (similar to India's world share). Germany's world share fell from 10.2% in 1981 to 7.2% by 1995. The UK's world share varied over the period, but averaged 6.6%. Australia's world share averaged 4.4% and France's world share broadly increased from 3.0% in 1981 to 4.8% by 1995.

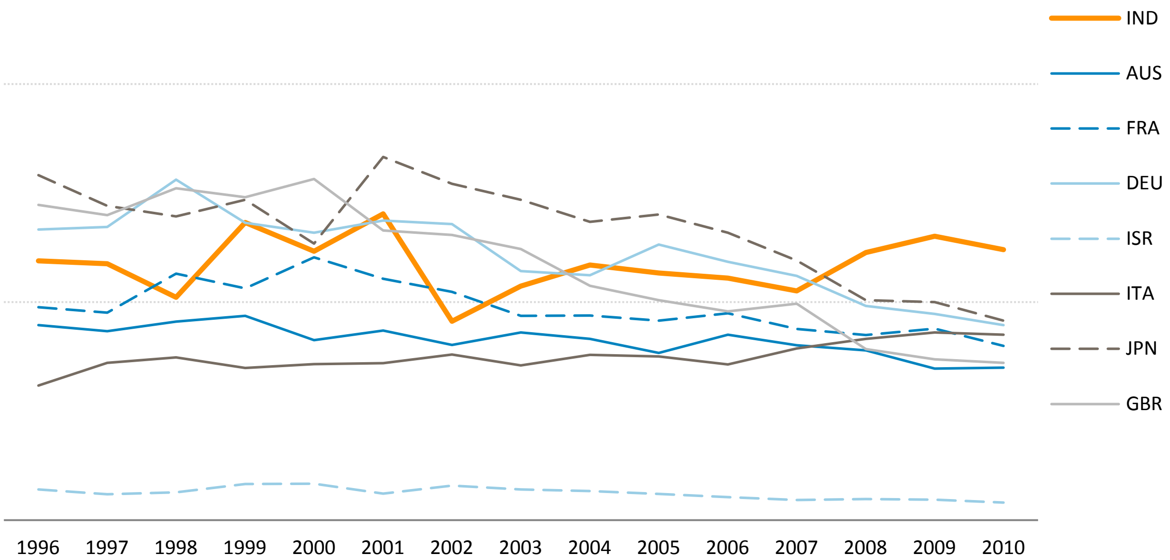
Brazil's share increased from 0.6% in 1981 to 2.2% by 1995. Russia's share decreased over the same period from 1.6% to 1.4% (with a low of 0.5% in 1989). The other countries had less than a 1% share.

5.11.a.iii: Share of world research output, Agricultural sciences, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.11.a: Share of world research output, Agricultural sciences

5.11.a.ii: Share of world research output, Agricultural sciences, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

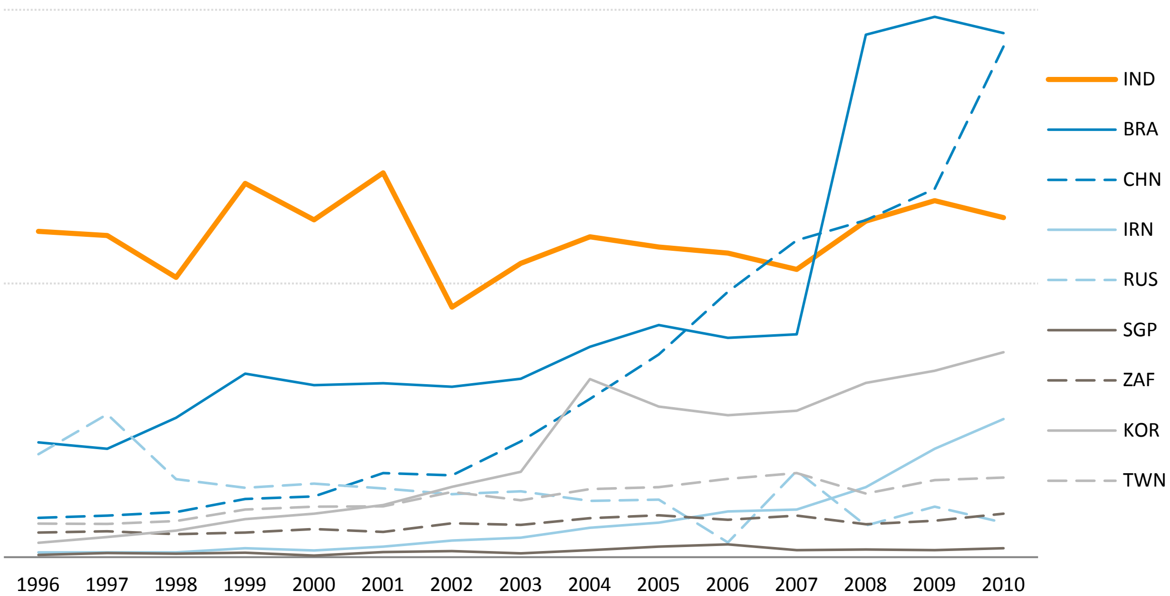


India's share in Agricultural Sciences varied, but broadly fell on its share in the earlier period: its world share averaged 5.9%, although it was 6.2% in 2010. Its rank moved from fifth to second to the USA amongst the established research economies. Its first rank amongst the emerging research economies was surpassed by the rise of China (2007) and Brazil (2008) moving its rank to third.

The USA's world share (not shown) of Agricultural Sciences declined further during this period, from 26.4% in 1996 to 17.0% by 2010, a 17.2% fall on its 1981 world share. Japan's share fell from a high of 8.3% in 2001 to 4.6% by 2010. The UK's share fell from 7.2% in 1996 to 3.6% by 2010. Germany's share fell from 7.8% in 1998 to 4.5% by 2010.

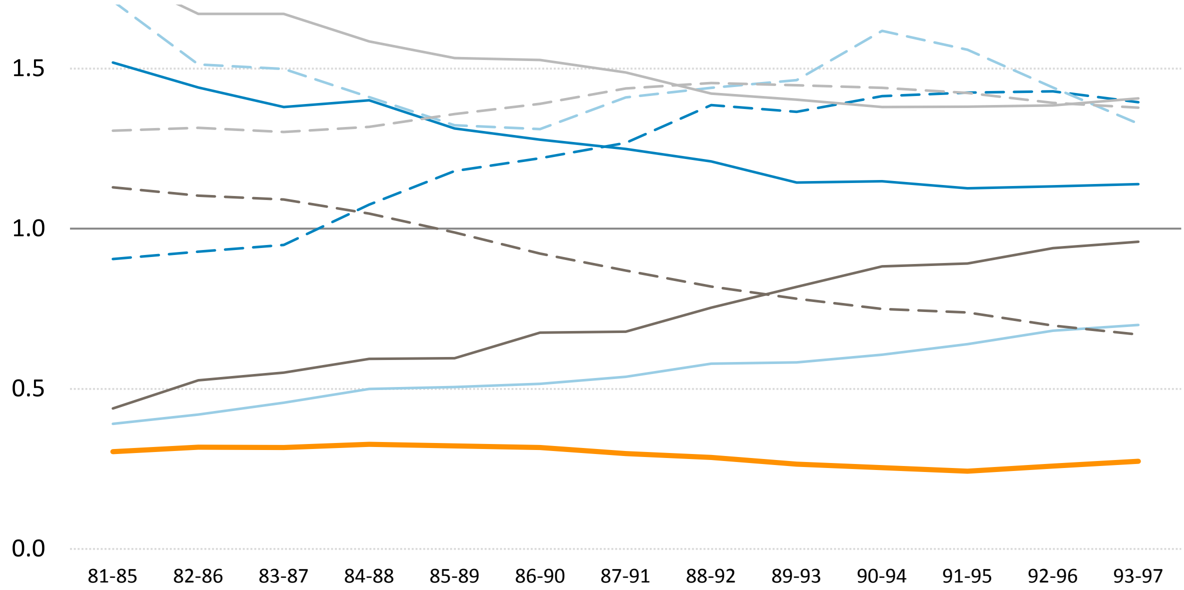
It is notable that Brazil's world share leapt during this period. It rose from 2.1% in 1996 to 4.1% by 2007 which then over doubled in 2008 finishing on 9.6% of world share by 2010. China's share also notably rose from 0.7% in 1996 to 9.3% to 2010.

5.11.a.iv: Share of world research output, Agricultural sciences, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.11.b: Normalised citation impact, Agricultural sciences

5.11.b.i: Normalised citation impact, Agricultural sciences, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

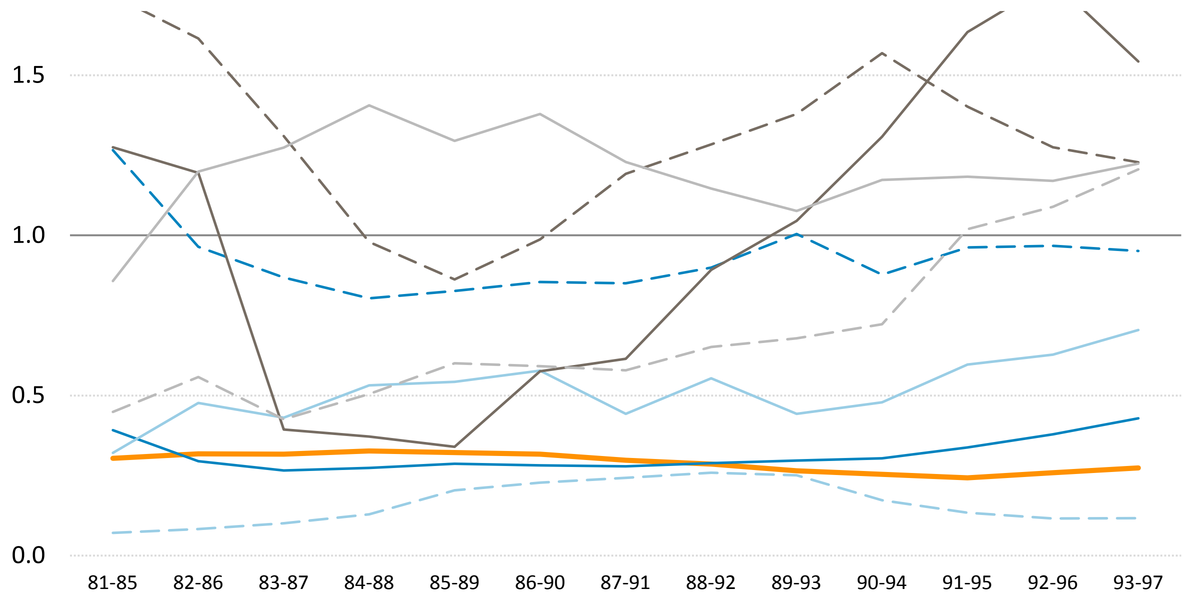


India's citation impact in Agricultural Sciences was well below world average and marginally fell over this period period: from 0.30 in 1981-1985 to 0.27 in 1993-1997. It ranked the lowest amongst the established research economies, and its rank was second lowest amongst the emerging research economies, apart from a period where Brazil had a lower citation impact than India in this field for most of the 1980s.

The UK's citation impact was the highest amongst the established research economies: 1.80 in 1981-1985 although this fell to 1.41 by 1993-1997. Israel's citation impact varied over this period and Australia's citation impact fell from 1.52 to 1.14. The USA's citation impact rose from 1.31 in 1981-1985 to 1.38 by 1993-1997. France's citation impact climbed over this period from 0.90 in 1981-1985 to 1.40 by 1993-1997.

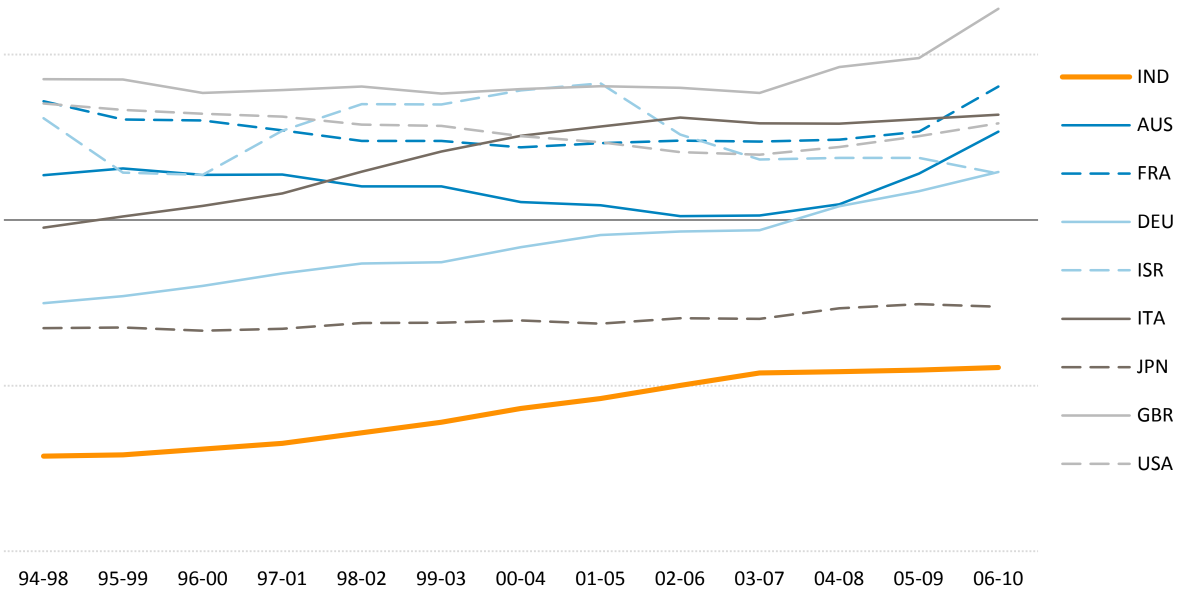
South Africa's citation impact varied but it was generally above world average: it was 1.75 in 1981-1985 but 1.23 by 1993-1997. China's citation impact averaged 0.93 and Taiwan made strong gains from 0.45 in 1981-1985 to 1.21 by 1993-1997. Singapore's citation impact is based on small paper numbers (<50).

5.11.b.iii: Normalised citation impact, Agricultural sciences, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.11.b: Normalised citation impact, Agricultural sciences

5.11.b.ii: Normalised citation impact, Agricultural sciences, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

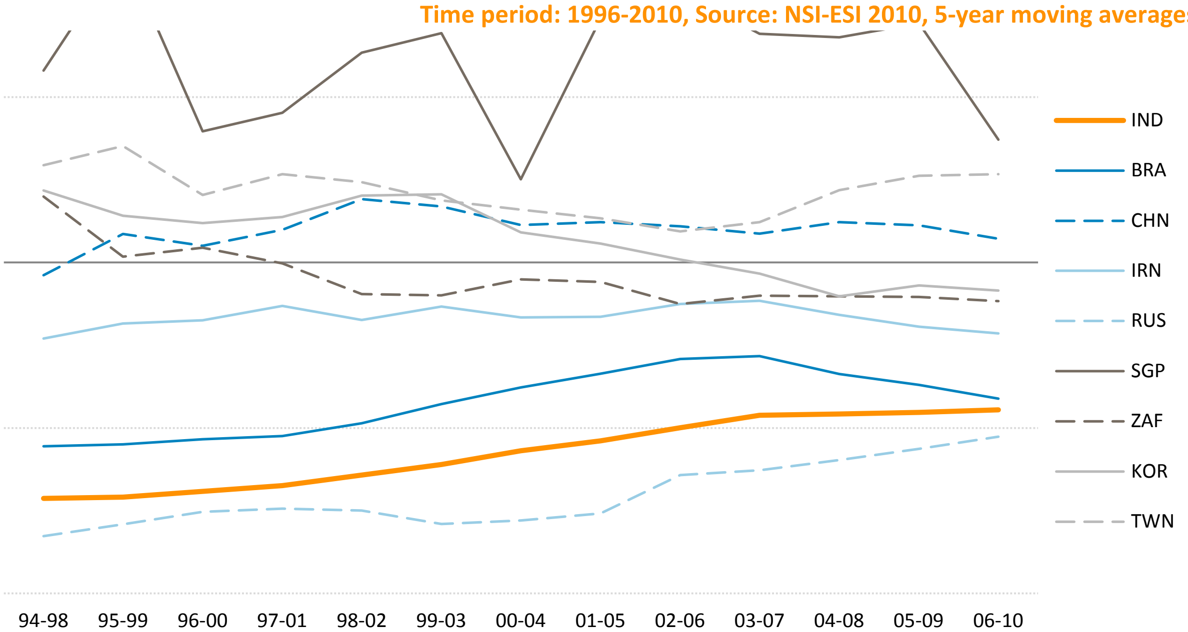


Indian citation impact increased from 0.29 in 1994-1998 to 0.55 in 2006-2010. This was an improvement, and narrowed the gap between India and the established research economies, although India still ranked the lowest amongst them. Amongst the emerging research economies, India's citation impact ranked second lowest from Russia as Brazil's citation impact rose relative to India's.

The UK had the highest citation impact which increased substantially over the period, from 1.43 in 1994-1998 to 1.64 by 2006-2010. The USA's citation impact fell and rose from 1.35 in 1994-1998 to 1.20 by 2003-2007 and it was overtaken by France in 2002-2006 whose citation impact in 2006-2010 was 1.40. Italy's citation impact also rose substantially from 0.98 in 1994-1998 to 1.32 by 2006-2010.

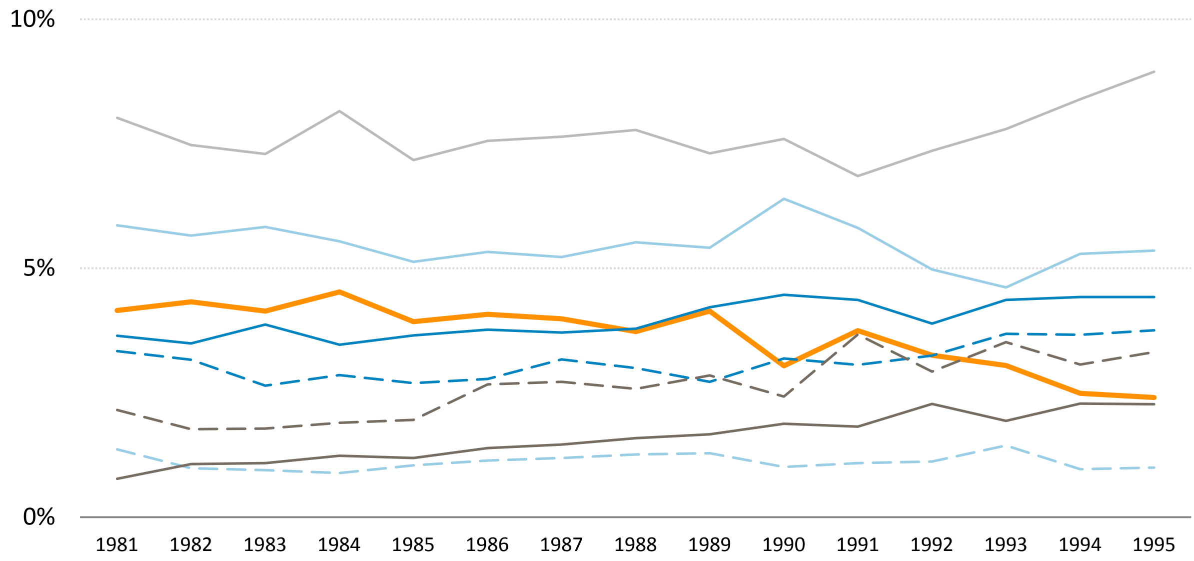
Singapore's citation impact was high, although based on small paper numbers. Taiwan's citation impact was above world average and it was 1.27 by 2006-2010. China's citation impact was above world average from 1995-1999 and 1.07 by 2006-2010. Korea's citation impact fell to below world average (0.92) by 2006-2010.

5.11.b.iv: Normalised citation impact, Agricultural sciences, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.12.a: Share of world research output, Environment/ecology

5.12.a.i: Share of world research output, Environment/ecology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

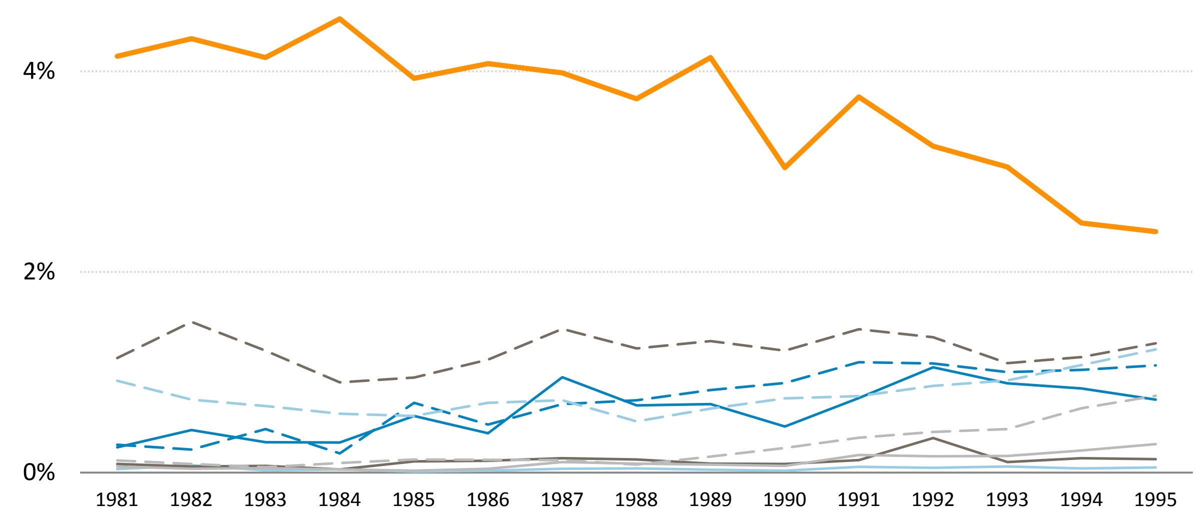


In this earlier period, India had a 4.1% share of world research output in Environment/Ecology in 1981. This fell to 2.4% by 1995. It ranked first amongst the emerging research economies during this period, but its rank amongst the established research economies fell from fourth in 1981 to seventh by 1995, as India was superseded by Australia in 1988, and then by France and Japan by 1993.

The USA (not shown) had the pre-eminent world share in this field during this period, but it fell from 48.4% in 1981 to 38.0% by 1995, a 10.4% fall. The UK was second to the USA amongst this group, and its share, which was 8.0% in 1981, fell to 6.9% in 1991, before rising to 8.9% by 1995. Germany's share averaged 5.5% over this period.

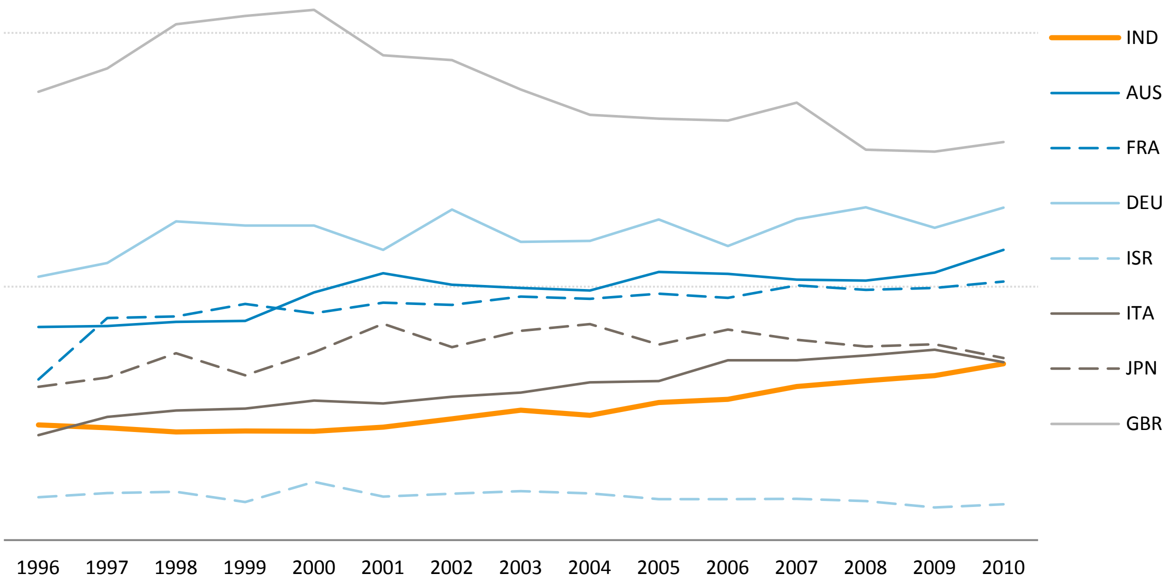
Amongst the emerging research economies, South Africa was second to India, but the emergence of China and Brazil began in this period. China increased its share from 0.3% in 1981 to 1.1% by 1995. Brazil increased its share from 0.3% in 1981 to 0.7% by 1995.

5.12.a.iii: Share of world research output, Environment/ecology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.12.a: Share of world research output, Environment/ecology

5.12.a.ii: Share of world research output, Environment/ecology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

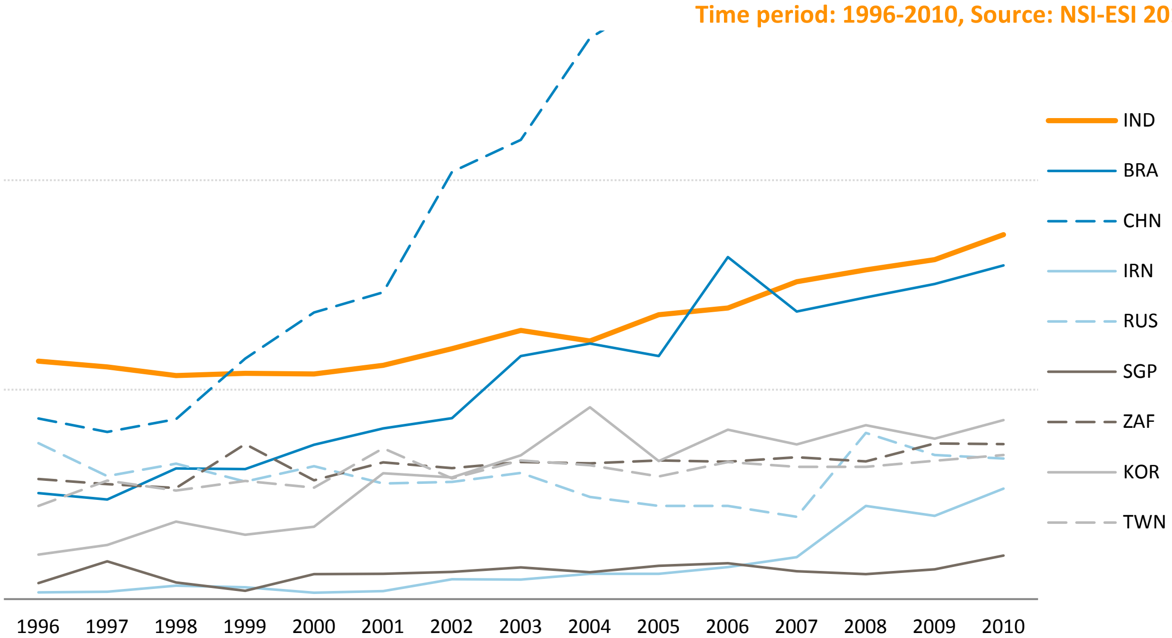


India's world share rose from 2.3% in 1996 to 3.5% by 2010, but it wasn't as high as it had been in the 1980s where India had averaged just over 4% of world output. Amongst the established research economies, India's rank fell to eighth as it was superseded by Italy in 1997. Amongst the emerging research economies, China rose from having a 1.7% share in 1996 to a 10.4% of world share by 2010, overtaking India in 1999, with India's rank falling to second.

The USA's share fell further (not shown), from 38.0% in 1996 to 28.6% by 2010, a 9.5% fall, but ultimately a 20% decline on its 1981 share. The UK's share rose further from 8.8% in 1996 to 10.5% by 2000, but it fell to 7.8% by 2010. Other established research economies increased their shares: Germany (+1.4%), Australia (+1.5%), France (+1.9%), Japan (+0.6%) and Italy (+1.4%).

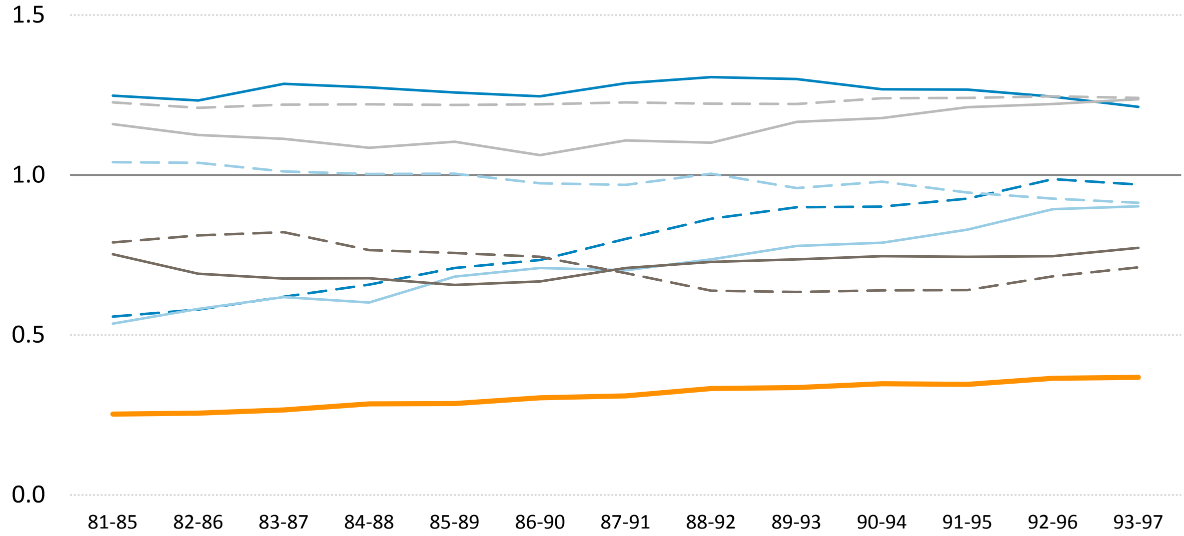
Brazil's world share challenged India's and superseded it briefly in 2006, but over the long-term it had risen from 0.3% (India 4.1%) in 1981 to 3.2% (India 3.5%) by 2010.

5.12.a.iv: Share of world research output, Environment/ecology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.12.b: Normalised citation impact, Environment/ecology

5.12.b.i: Normalised citation impact, Environment/ecology, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

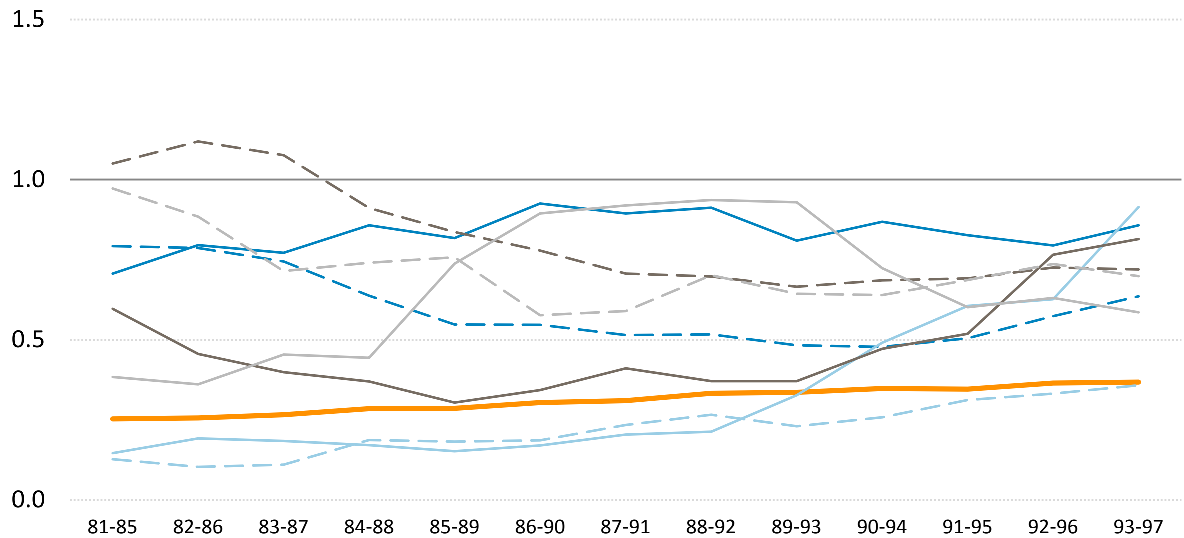


India's citation impact in Environment/Ecology increased over this period from 0.25 in 1981-1985 to 0.37 by 1993-1997, but these levels were below world average. India ranked the lowest amongst the established research economies in terms of citation impact and its rank was seventh, falling to eighth amongst the emerging research economies (though Iran's citation impact was based on small paper numbers).

Australia's citation impact was the highest over this period averaging 1.26. The USA ranked second with an citation impact averaging 1.23. The UK's citation impact rose from 1.16 in 1981-1985 to 1.24 by 1993-1997. Israel's citation impact fell below the world average, and France's citation impact increased from 0.56 in 1981-1985 to 0.97 by 1993-1997. Germany, Italy, Japan had citation impact below the world average.

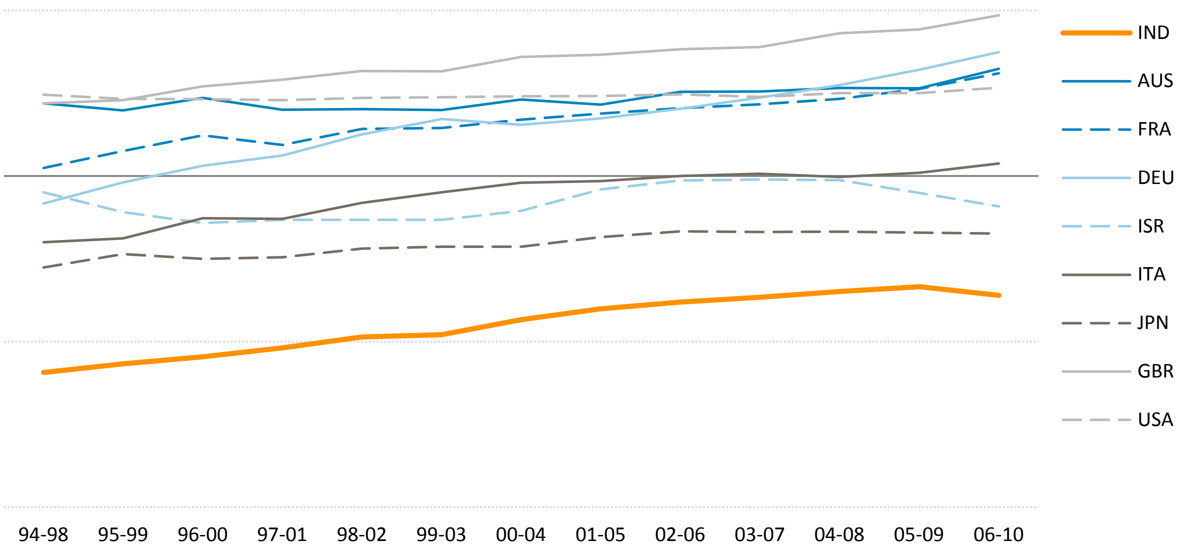
Brazil's citation impact increased, from 0.71 in 1981-1985 to 0.86 by 1993-1997. South Africa's citation impact decreased over the period from a high of 1.12 in 1982-1986 to 0.72 by 1993-1997. China's citation impact fell from 0.79 in 1981-1985 to 0.48 (1989-1993 and 1990-1994) and then rose to 0.64 by 1993-1997.

5.12.b.iii: Normalised citation impact, Environment/ecology, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.12.b: Normalised citation impact, Environment/ecology

5.12.b.ii: Normalised citation impact, Environment/ecology, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

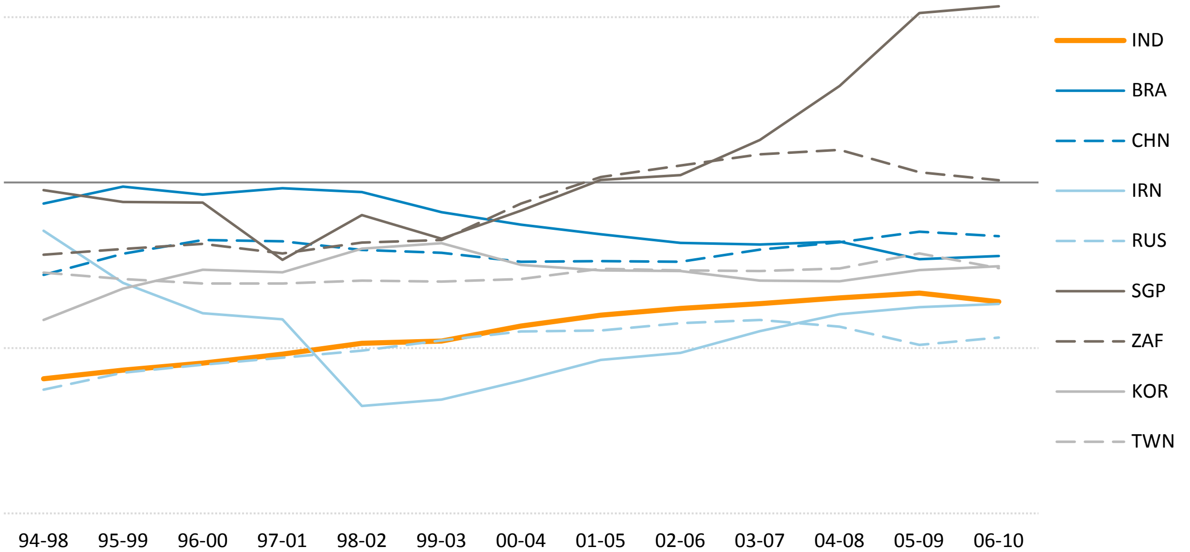


India's citation impact increased over this period from 0.41 in 1994-1998 to 0.64 by 2006-2010, with a high of 0.67 in 2005-2009. It ranked the lowest amongst the established research economies, but it narrowed the gap. Amongst the emerging research economies, its citation impact ranked eighth in 1994-1998 but rose to seventh by 2006-2010.

The UK's citation impact increased from 1.22 in 1994-1998 to 1.49 by 2006-2010. The USA's citation impact had risen to 1.27 by 2006-2010, with Germany, Australia and France superseding its citation impact. Italy achieved above world average citation impact in the last decade; Israel and Japan did not.

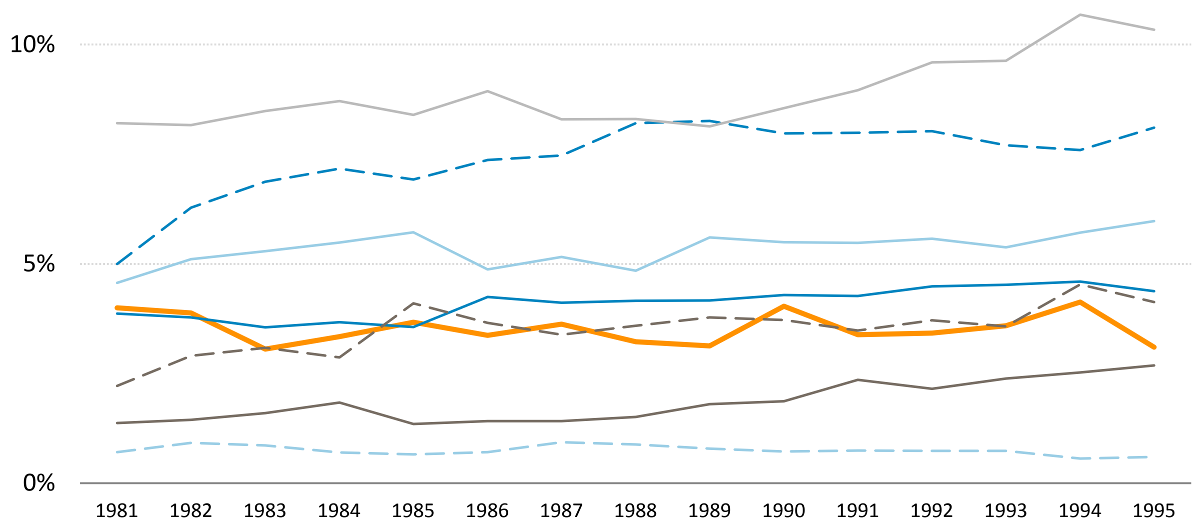
Singapore's citation impact increased from 0.98 in 1994-1998 to 1.53 by 2006-2010, and South Africa's citation impact increased from 0.78 to 1.01 over the same period with a high of 1.10 in 2004-2008. Brazil's citation impact had fallen from 0.99 in 1995-1999 to 0.78 by 2006-2010. Singapore's citation impact had therefore been the highest amongst all countries in Environment/Ecology, higher than that of the UK.

5.12.b.iv: Normalised citation impact, Environment/ecology, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.13.a: Share of world research output, Geosciences

5.13.a.i: Share of world research output, Geosciences, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

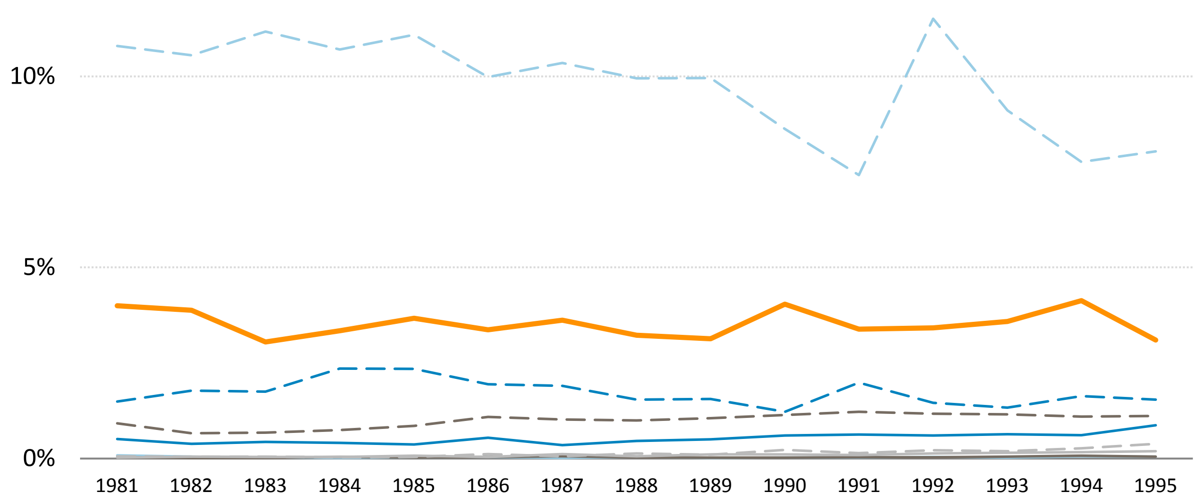


Between 1981 and 1995, India's world share of Geosciences research output varied over this period between 3% to 4% of world share (averaging 3.5%). Amongst the established research economies, India's rank varied between fifth, sixth and seventh, but its world share was broadly comparable to that of Japan. Amongst the emerging research economies, India's rank was second to that of Russia, with China ranking third.

The USA's share (not shown) varied over the period, but it was 41.9% in 1981 and 40.2% by 1995. The UK's world share increased from 8.2% in 1981 to 10.3% by 1995 (+2.1%). France's world share also increased from 5.0% in 1981 to 8.1% in 1995 (+3.1%).

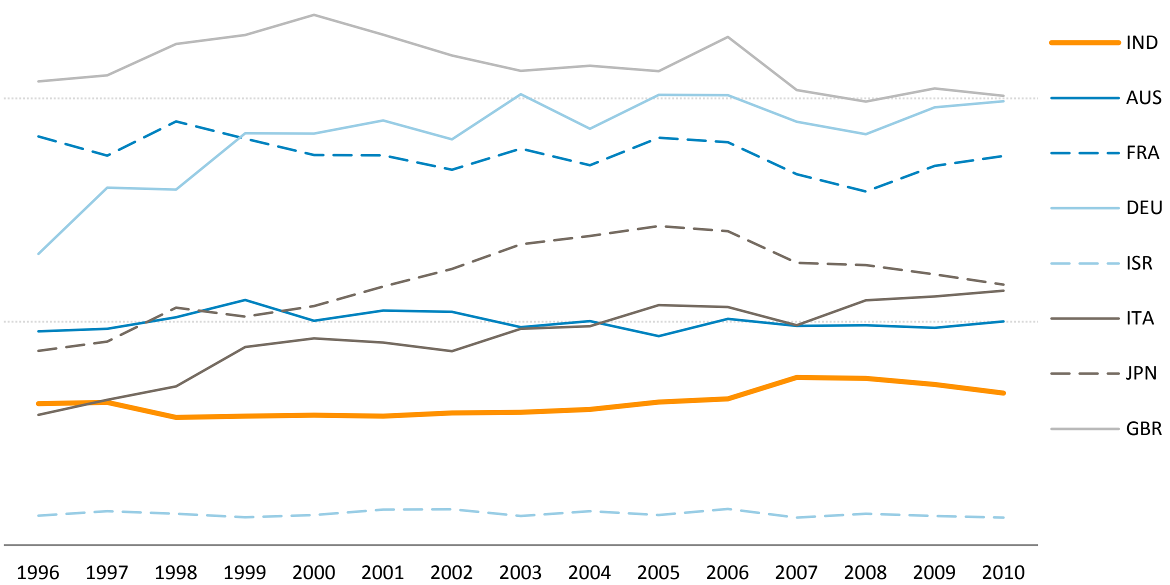
Amongst the emerging research economies, Russia had the largest world share but it varied substantially over the period, but broadly declined from 10.8% in 1981 to 8.0% by 1995. China's world output also varied over the period, but averaged 1.7% over the period.

5.13.a.iii: Share of world research output, Geosciences, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.13.a: Share of world research output, Geosciences

5.13.a.ii: Share of world research output, Geosciences, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

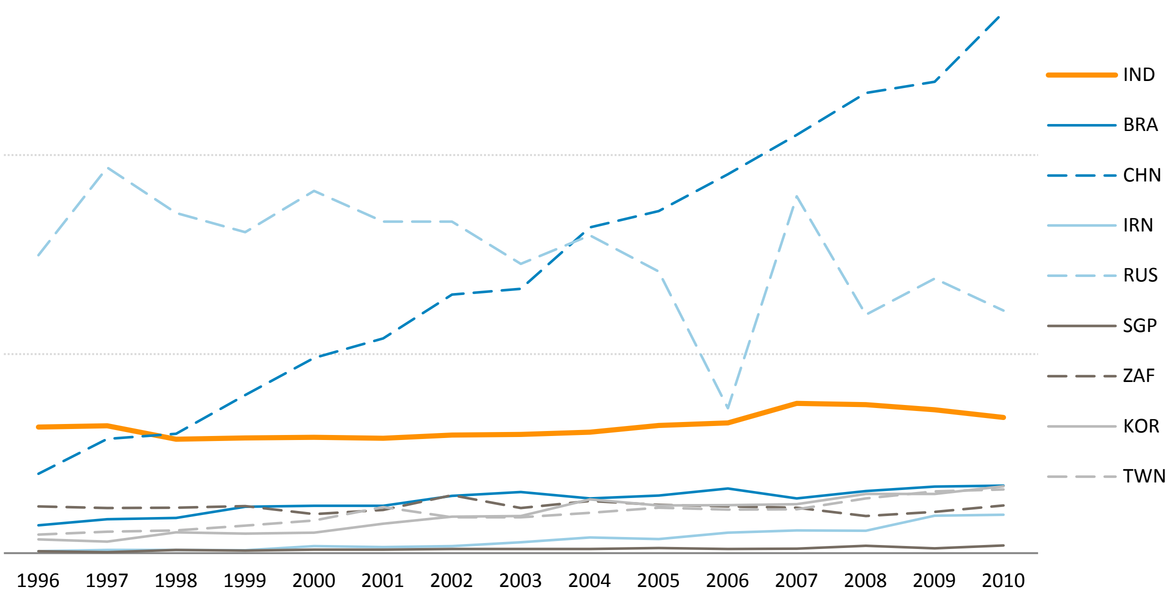


India's world share of world output remained broadly the same as in the earlier period albeit slightly lower, averaging 3.2% of world share. Its rank amongst the established research economies fell as it was superseded by Japan from 1994 and Italy from 1997 onwards. India's rank amongst the emerging research economies fell from second to third, after China overtook India in 1998.

The USA (not shown) had a much sharper decline in world share in this period, falling from 38.1% in 1996 to 30.3% by 2010 (-7.8% fall). The UK initially rose further to a height of 11.9% of world share in 2000, but its world share fell to 10.1% by 2010. France's rank passed to Germany whose world share grew by 3.4% between 1996 and 2010. Japan's share rose and fell.

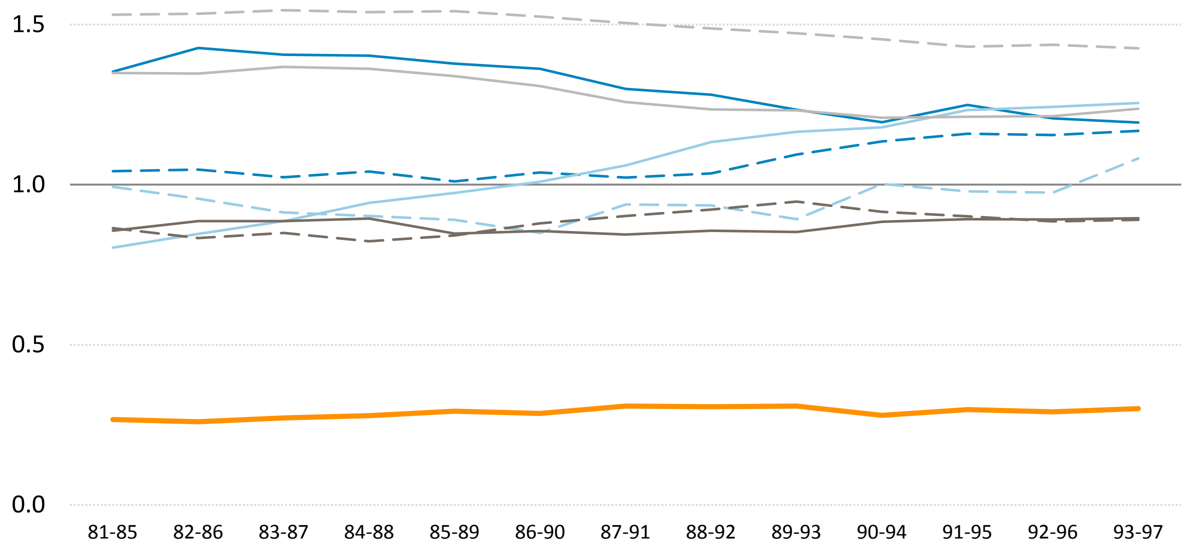
China acquired world share which rose from 2% in 1996 to 13.6% in 2010, superseding Russia in 2004 and the UK in 2007. Russia's world share varied over the period with a low of 3.6% in 2006 and finishing at 6.1% by 2010.

5.13.a.iv: Share of world research output, Geosciences, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.13.b: Normalised citation impact, Geosciences

5.13.b.i: Normalised citation impact, Geosciences, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

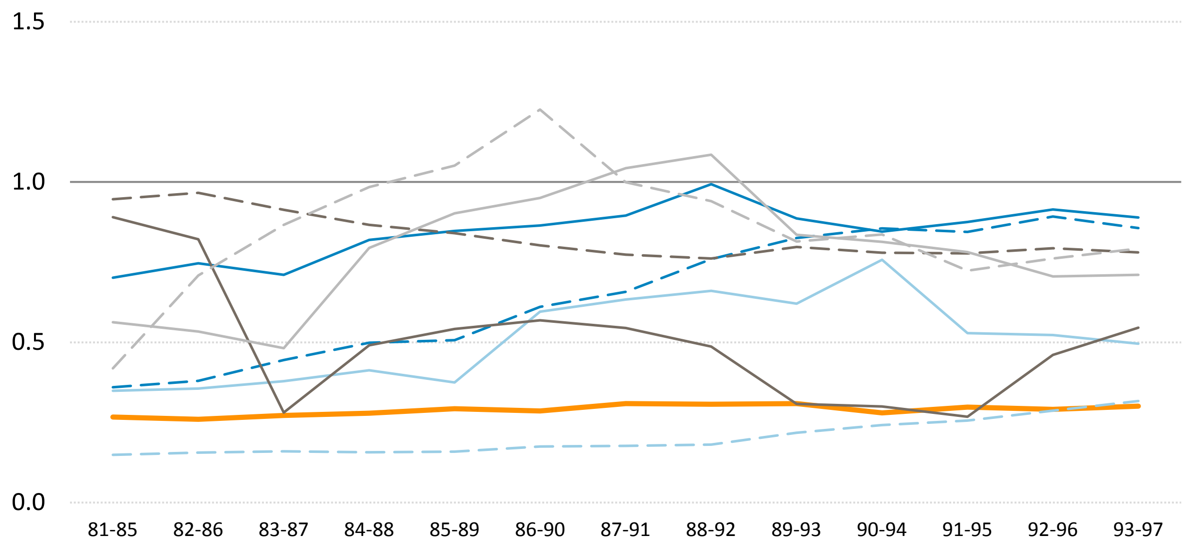


In this earlier period, India's citation impact was well below world average and that of the established research economies: 0.27 in 1981-1985 rising to 0.30 by 1993-1997. It was second lowest to Russia.

Amongst the established research economies, the USA had the highest citation impact over this period: 1.53 in 1981-1985 and falling to 1.43 by 1993-1997. Australia had the second highest citation impact over this period, though this also fell from 1.35 in 1981-1985 to 1.19 by 1993-1997. The UK had the third highest citation impact over this period, although this also fell broadly over the period from 1.35 in 1981-1985 to 1.24 by 1993-1997. Germany had a notable rise in citation impact over this period from 0.80 in 81-83 to 1.26 by 1993-1997 (+0.45).

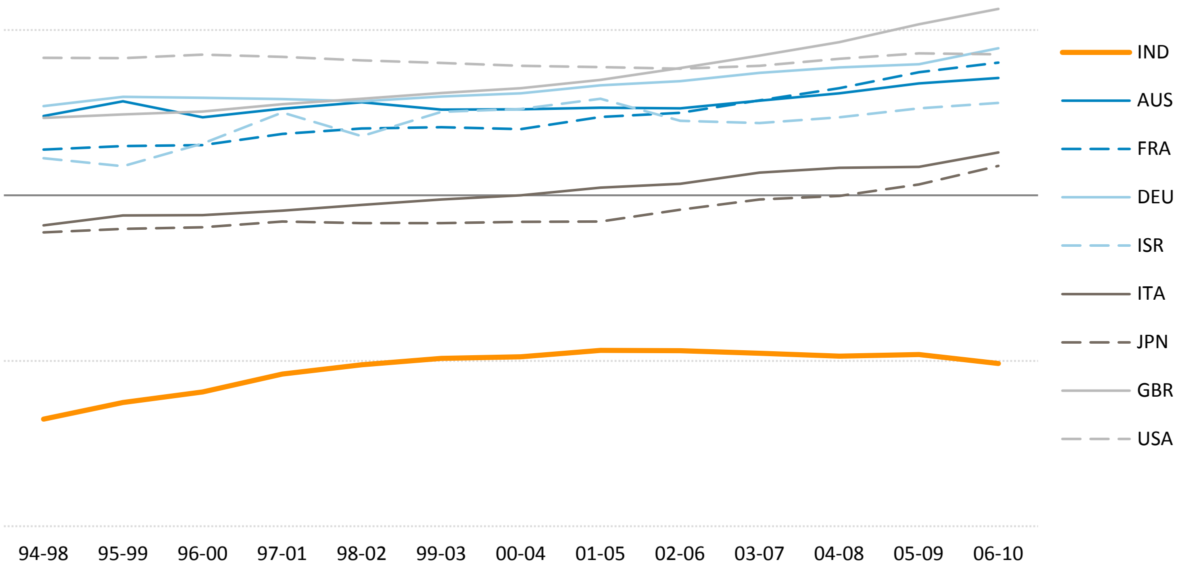
Amongst the emerging research economies, most were generally below world average for the entire period in Geosciences research. Taiwan had a peak in 1986-1990 (1.23) and Korea in 1988-1992 (1.08).

5.13.b.iii: Normalised citation impact, Geosciences, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.13.b: Normalised citation impact, Geosciences

5.13.b.ii: Normalised citation impact, Geosciences, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

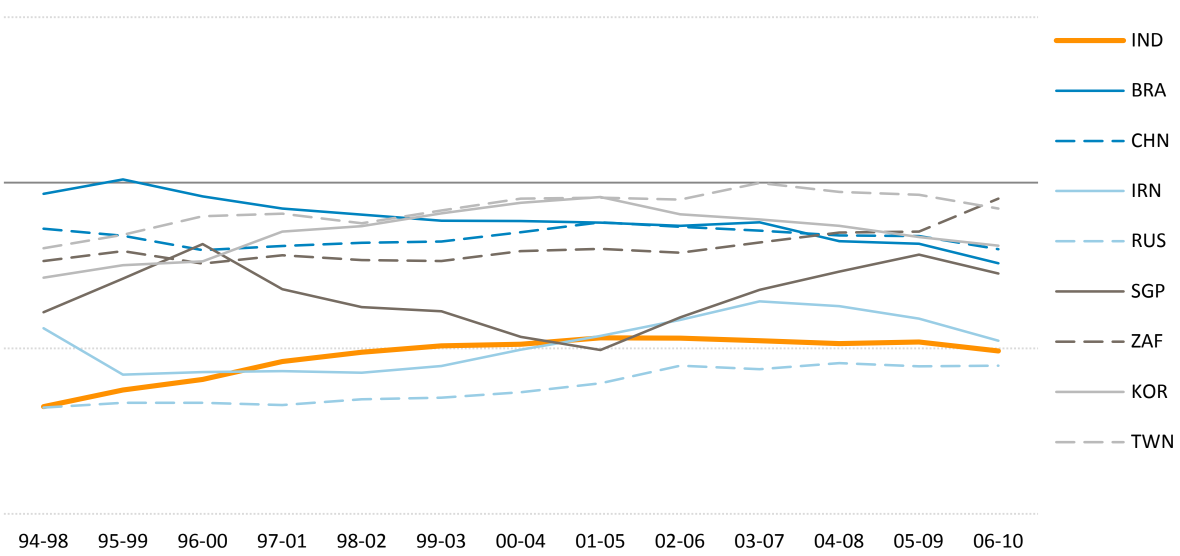


In this later period, India's citation impact rose from 0.32 in 1994-1998 to 0.49 by 2006-2010, with a high of 0.53 in 2001-2005 and 2002-2006. However, these levels were well below world average, and whilst the gap was narrowed between India and the established research economies, a significant gap remains. It still broadly remained second lowest in rank to Russia amongst the emerging research economies, with a period where it was seventh in rank amongst the group (1997-2001 to 2001-2005 inclusive).

The pre-eminence of the USA in Geosciences research was challenged by the UK from 2003-2007 onwards. The final citation impact of the UK in 2006-2010 was 1.56 and for the USA it was 1.43.

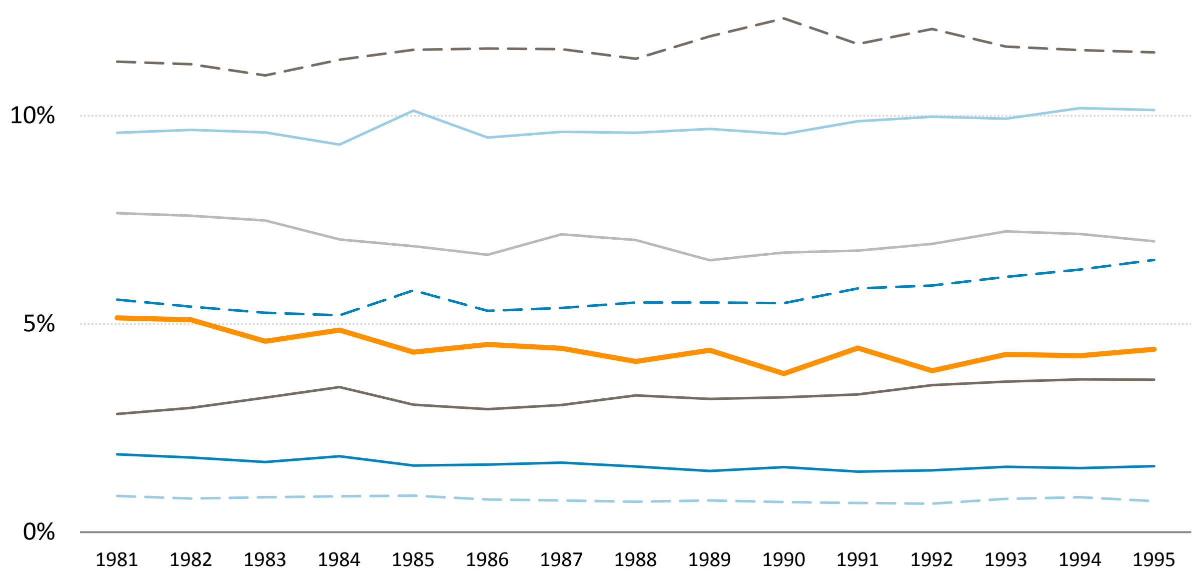
Amongst the emerging research economies during this period, only Brazil achieved an over world average level of citation impact in 1995-1999.

5.13.b.iv: Normalised citation impact, Geosciences, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.14.a: Share of world research output, Chemistry

5.14.a.i: Share of world research output, Chemistry, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

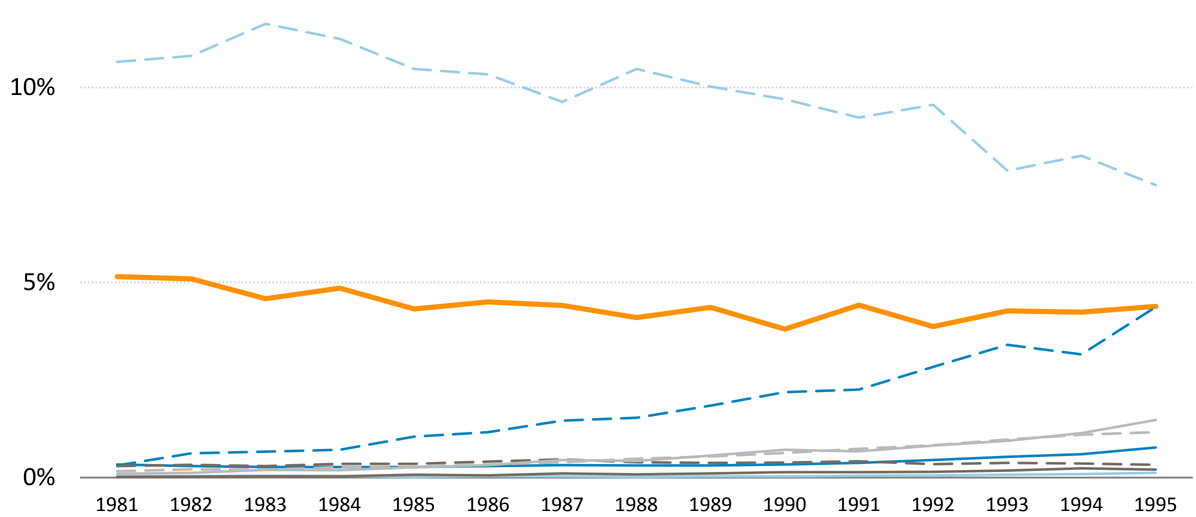


In this earlier period, India's percentage share of world output broadly fell from 5.1% in 1981 to 3.8% in 1990, and it rose again slightly to 4.4% by 1995.

The USA (not shown) maintained around one quarter of world output (24.6%) over this period. Japan's output averaged around 11.6% over this period, and Germany ranked third with an average output of just under 10%. The UK's output was broadly around 7% during this period. Italy's output increased from 2.8% in 1981 to 3.7% by 1995. India ranked sixth within this group over the period.

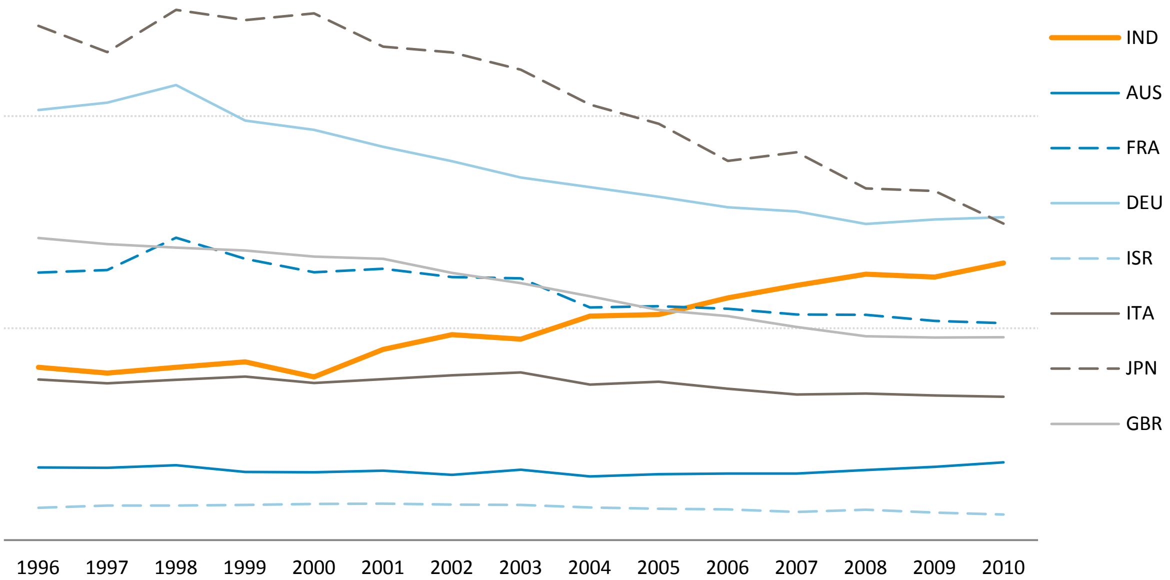
Russia's decline in share of world output in Chemistry in this period was very marked, falling from a high of 11.6% in 1983 to 7.5% by 1995. Ultimately, its share fell to 4.1% by 2010. The rise of China is notable in Chemistry at a much earlier stage in this analysis: rising from 0.3% in 1981 to 4.4% by the end of 1995, at which point its world share was equal to India's, which had until that point ranked second to Russia.

5.14.a.iii: Share of world research output, Chemistry, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.14.a: Share of world research output, Chemistry

5.14.a.ii: Share of world research output, Chemistry, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

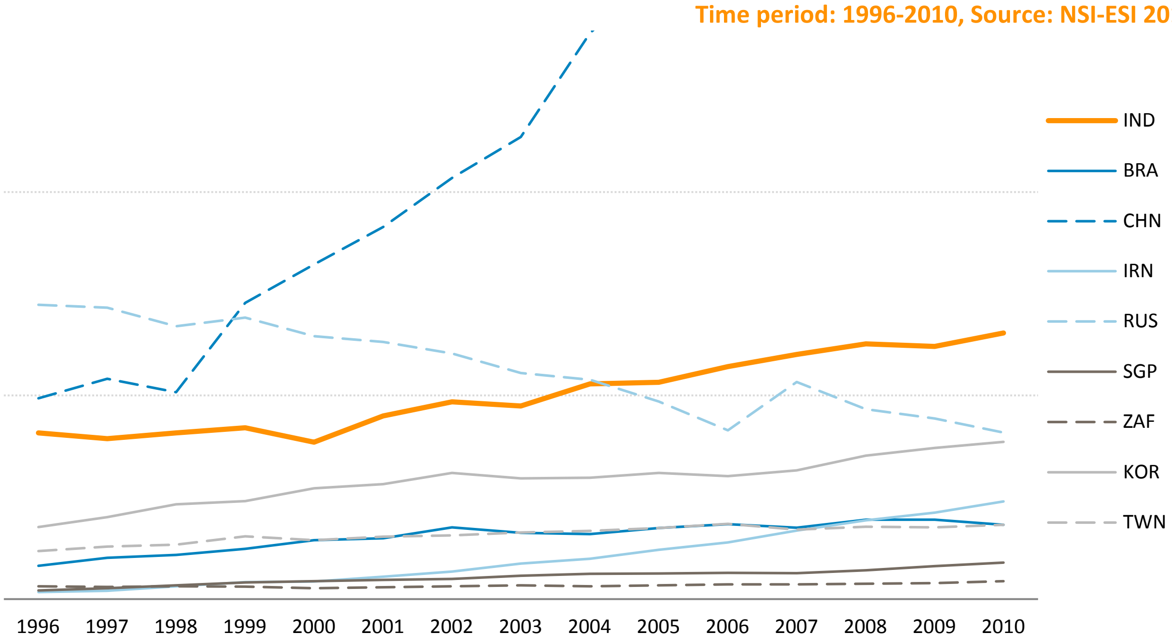


In this later period, India's world share in Chemistry research rose from 4.1% to 6.5%, switching its rank from sixth position to fourth position amongst the established research economies, as France and the UK fell in rank to India's rise.

The world share of the USA (not shown) fell further from 22.9% in 1996 to 17.8% by 2010. The world share of Japan also fell sharply over this period (12.1% to 7.5%), as did the world share of Germany (from 10.1% to 7.6%), the UK (7.1% to 4.8%) and France (6.3% to 5.1%).

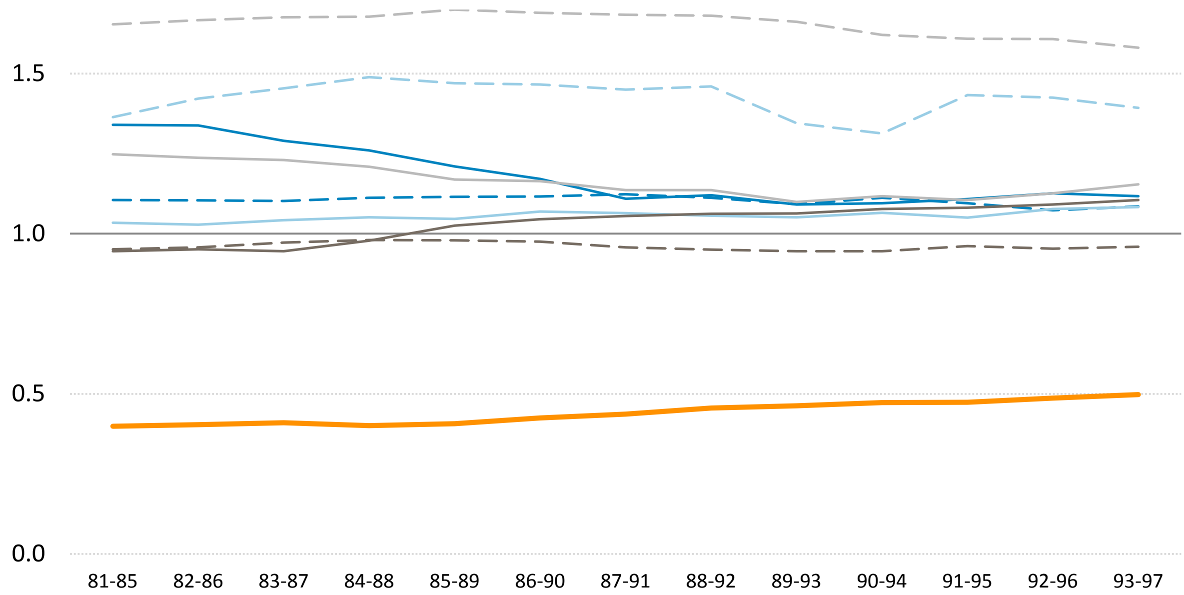
China's rise was dramatic. It quadrupled its world share in Chemistry from 4.9% in 1996 to 20.7% by 2010, overtaking Russia in 1999, Japan in 2003 and the USA in 2007. India rose to second place amongst the emerging research economies, as Russia fell to third. Korea increased its world share from 1.8% in 1996 to 3.9% by 2010.

5.14.a.iv: Share of world research output, Chemistry, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.14.b: Normalised citation impact, Chemistry

5.14.b.i: Normalised citation impact, Chemistry, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

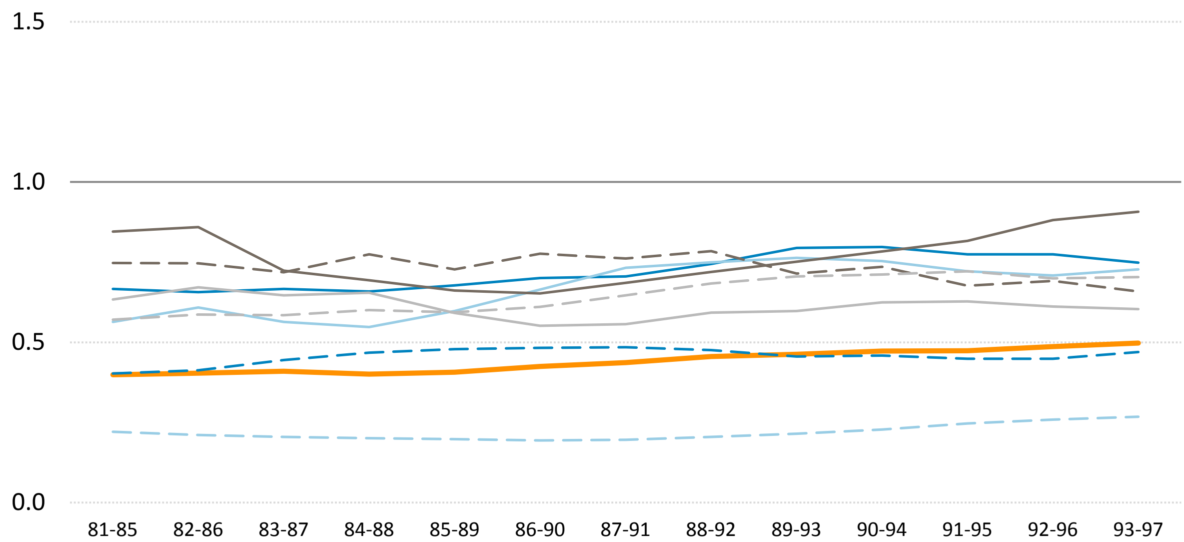


In the earlier period, India's citation impact was well below world average in Chemistry research, but rose from 0.40 in 1981-1985 to 0.50 by 1993-1997.

The USA's citation impact fell over this period from 1.65 to 1.58, and Israel which ranked second in the established economies research group, varied over the period from 1.36 in 1981-1985 to a high of 1.49 in 1984-1988, ending at 1.39 by 1993-1997. Australia's citation impact fell over this period from 1.34 (1981-1985) to 1.12 (1993-1997).

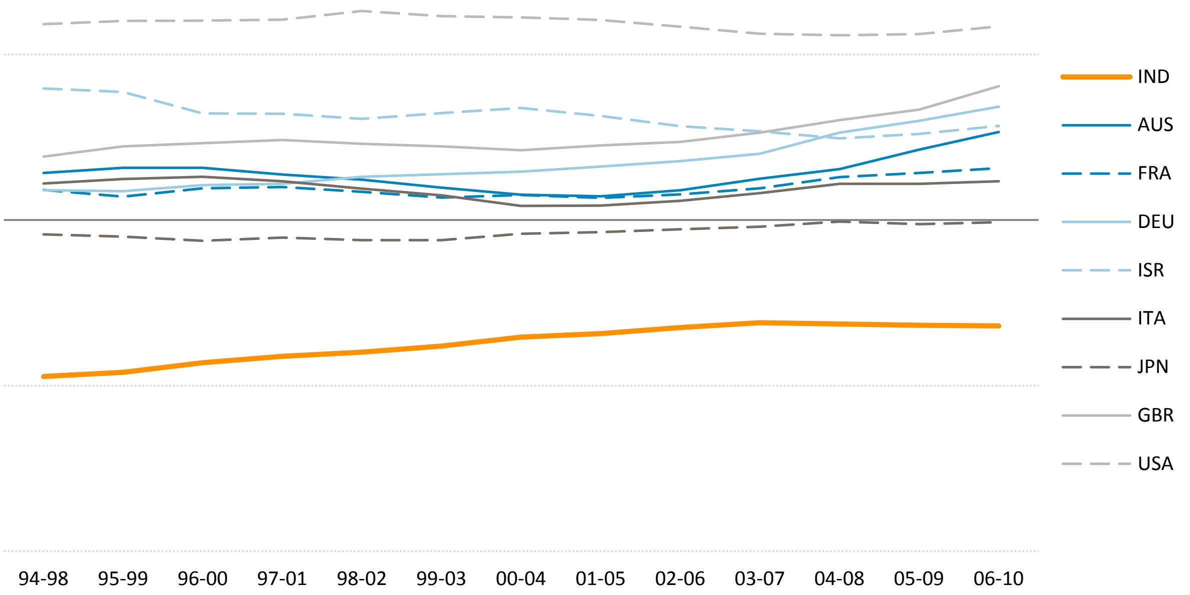
Amongst the emerging research economies, India ranked in the earlier part of the period second lowest to Russia, broadly equal with China until overtaking it by 1989-1993. Singapore's emergence to lead the group commenced in the early part of the 1990s when it overtook Brazil.

5.14.b.iii: Normalised citation impact, Chemistry, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.14.b: Normalised citation impact, Chemistry

5.14.b.ii: Normalised citation impact, Chemistry, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

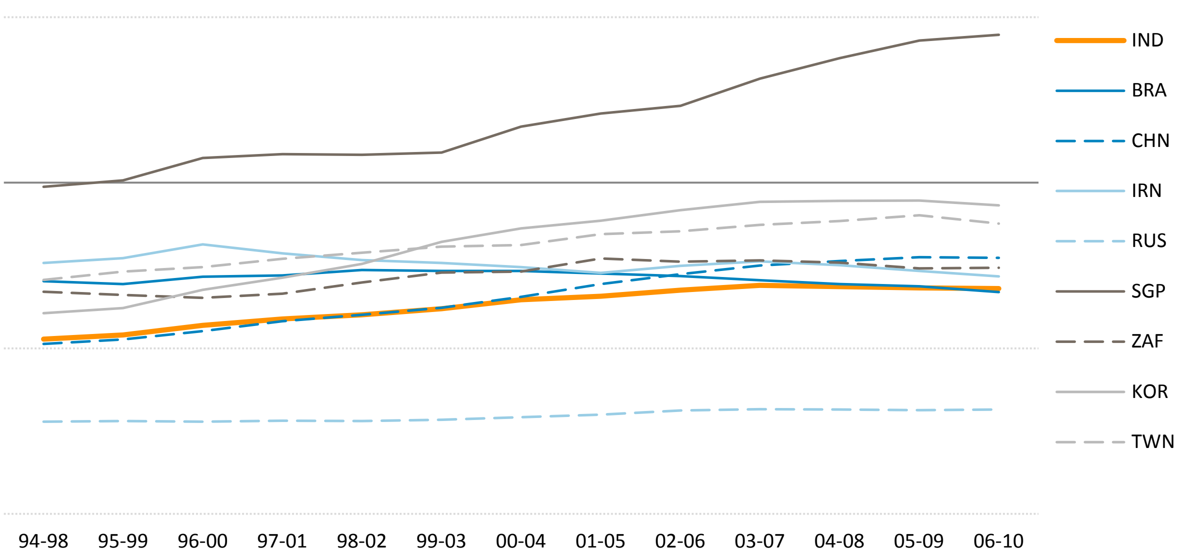


India's citation impact improved further over this period, rising from 0.53 in 1994-1998 to 0.68 by 2006-2010, somewhat narrowing the gap with the emerging research economies. Whilst it improved on its citation impact relative to Russia, it more or less remained on a par with China until China overtook India in 2000-2004.

Amongst the established research economies, the USA maintained its leading position in terms of citation impact (1.58 in 2006-2010) whilst Israel's position fell from 1.40 (1994-1998) to 1.28 (2006-2010), superseded by the UK (with an citation impact of 1.40 by 2006-2010) and Germany (1.34 by 2006-2010).

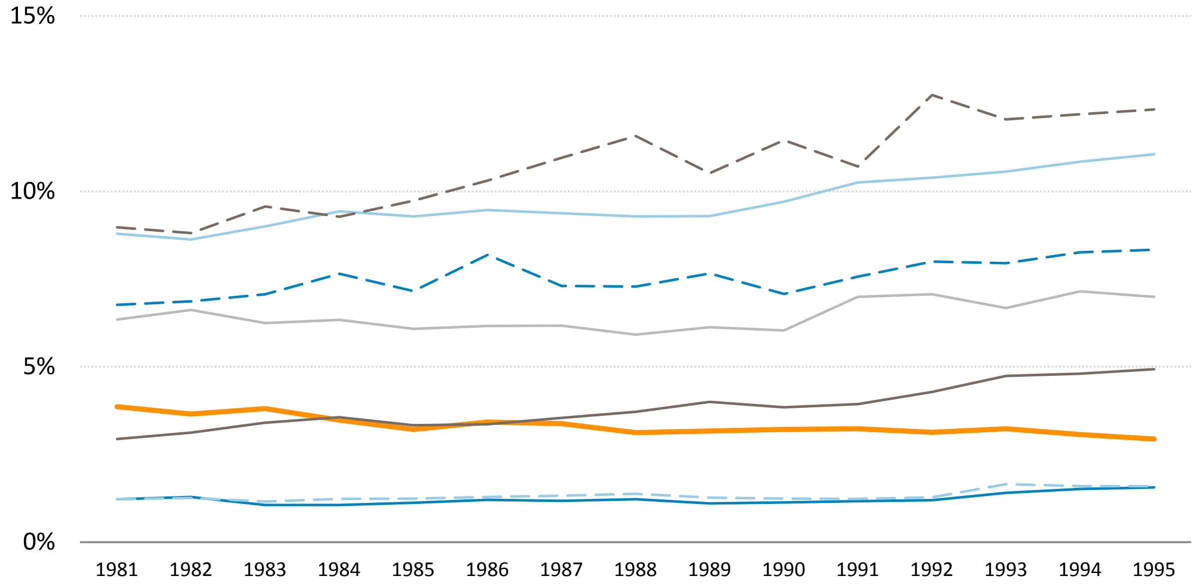
Amongst the emerging research economies, Singapore took off: its citation impact rose from 0.99 in 1994-1998 to 1.45 by 2006-2010, i.e. it had a higher than the UK. Korea also increased its citation impact to a peak of 0.95 in 2005-2009 which dropped slightly to 0.93 by 2006-2010, followed by Taiwan (0.88 in 2006-2010).

5.14.b.iv: Normalised citation impact, Chemistry, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.15.a: Share of world research output, Physics

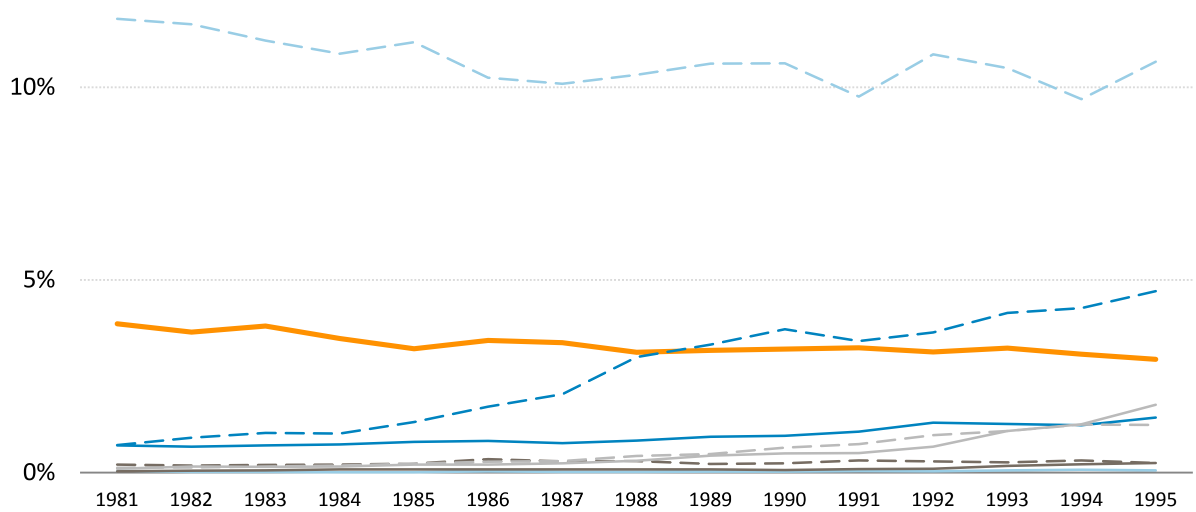
5.15.a.i: Share of world research output, Physics, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010



In this earlier period, amongst the established research economies, the USA's share in world research output in Physics (not shown) broadly fell over the period from 30.9% to 27.6%, whilst that of Japan rose from 9.0% to 12.3% with Germany ranking third rising from 8.8% to 11.1%. India's world share of output in Physics research fell over this period from 3.9% to 2.9%.

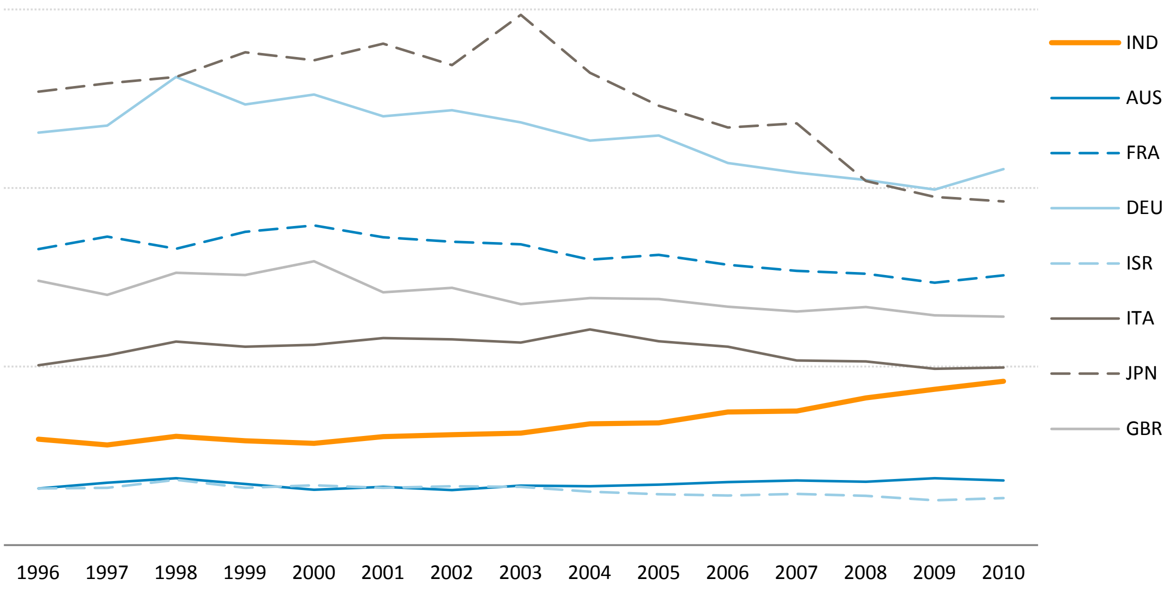
Russia's output over this period faltered and fell, but it was clearly the world leader amongst the emerging research economies with India ranking second until overtaken by China in 1989. The start of the emergence of Korea, Brazil and Taiwan are also visible from around 1993 onwards.

5.15.a.iii: Share of world research output, Physics, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.15.a: Share of world research output, Physics

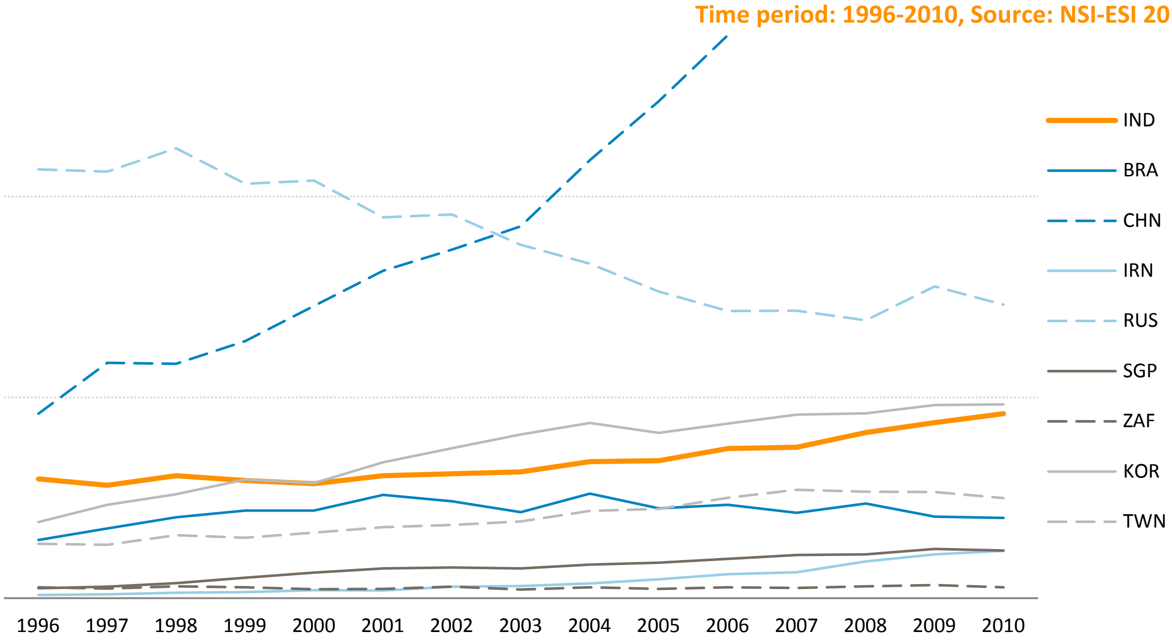
5.15.a.ii: Share of world research output, Physics, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010



In this later period, the USA's share declined further (not shown), from 27.0% to 22.0% and that of Japan's which after a strong rise to 14.9% by 2003, then fell to 9.6% by 2010. Germany's share also fell from a high of 13.1% in 1998 to 10.5% by 2010. India's share of world output in Physics research increased over this period from 3.0% to 4.6%.

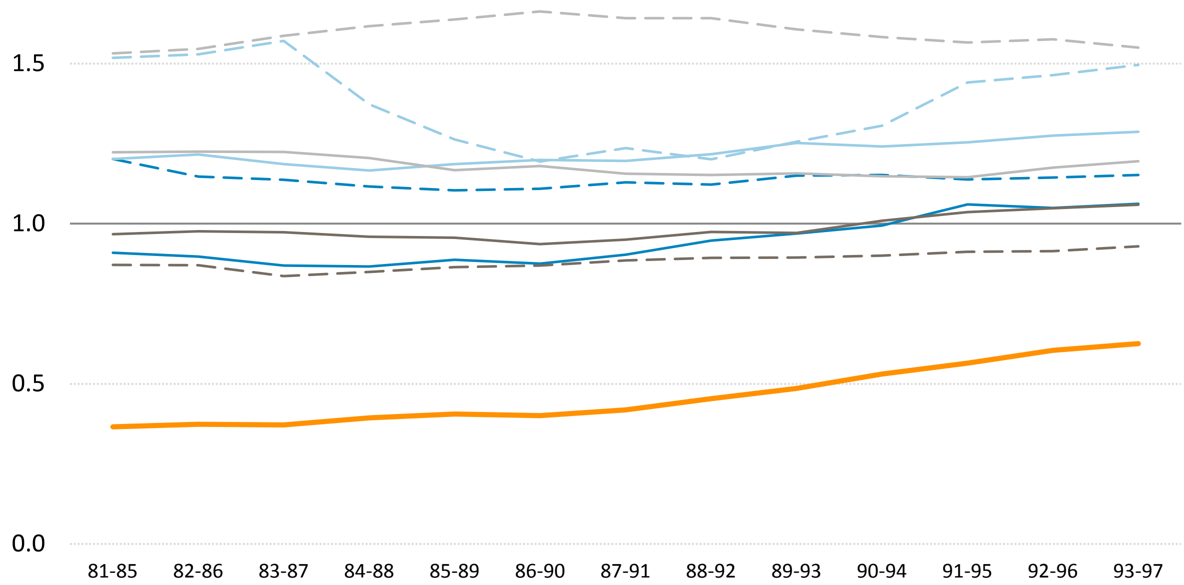
Amongst the established research economies, common to trends seen elsewhere, Russia's share of world output in Physics research declined further from 10.7% in 1996 to 7.3% by 2010. Meanwhile, China's research output more than quadrupled from 4.6% in 1996 to 18.6% by 2010. Korea overtook India in 2001 in terms of world share of Physics output and has maintained this. Taiwan has also overtaken Brazil from 2006 onwards.

5.15.a.iv: Share of world research output, Physics, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.15.b: Normalised citation impact, Physics

5.15.b.i: Normalised citation impact, Physics, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

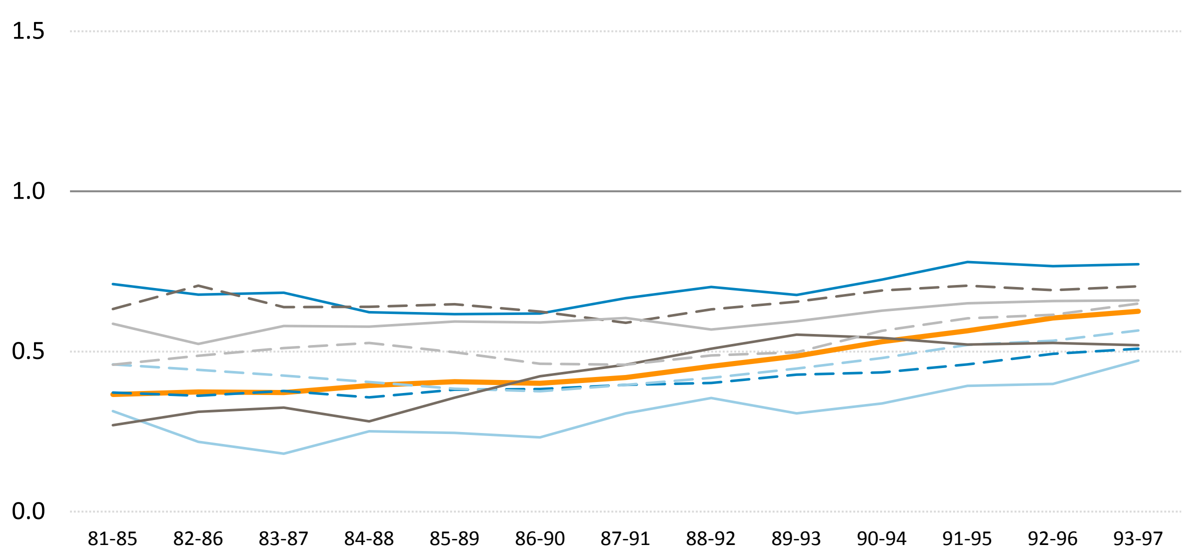


In the earlier period, India was significantly below the world average in terms of citation impact in its Physics research, although it improved over the period from 0.37 to 0.63.

Amongst the established research economies, the USA was the leader in terms of citation impact (1.55 in 1993-1997), with Israel ranking second within the group (although its citation impact varied substantially over the period with a figure of 1.50 in 1993-1997), with Germany ranking third (1.29).

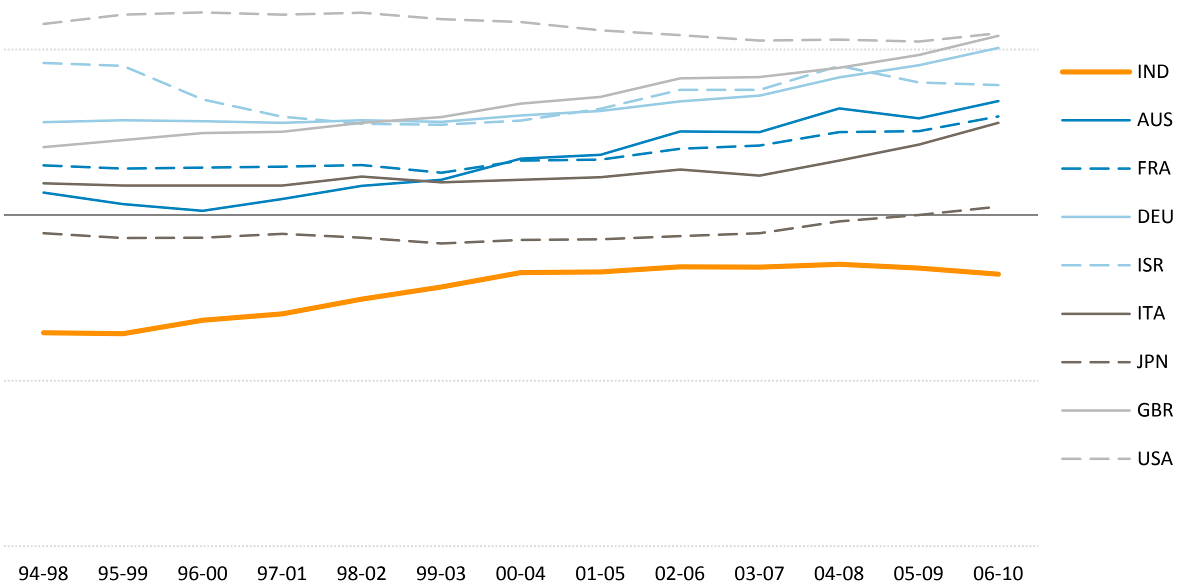
In terms of the emerging research economies, Brazil led the group in terms of citation impact from the 1987-1991 period onwards with South Africa ranking second and Korea third, with 1993-1997 figures of 0.77, 0.70 and 0.66 respectively (these figures are all well below world average). It is significant though that there generally seems to be an improvement of citation impact amongst the emerging research economies, and India's improvement is more marked relative to others (+0.26 over the period).

5.15.b.iii: Normalised citation impact, Physics, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.15.b: Normalised citation impact, Physics

5.15.b.ii: Normalised citation impact, Physics, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

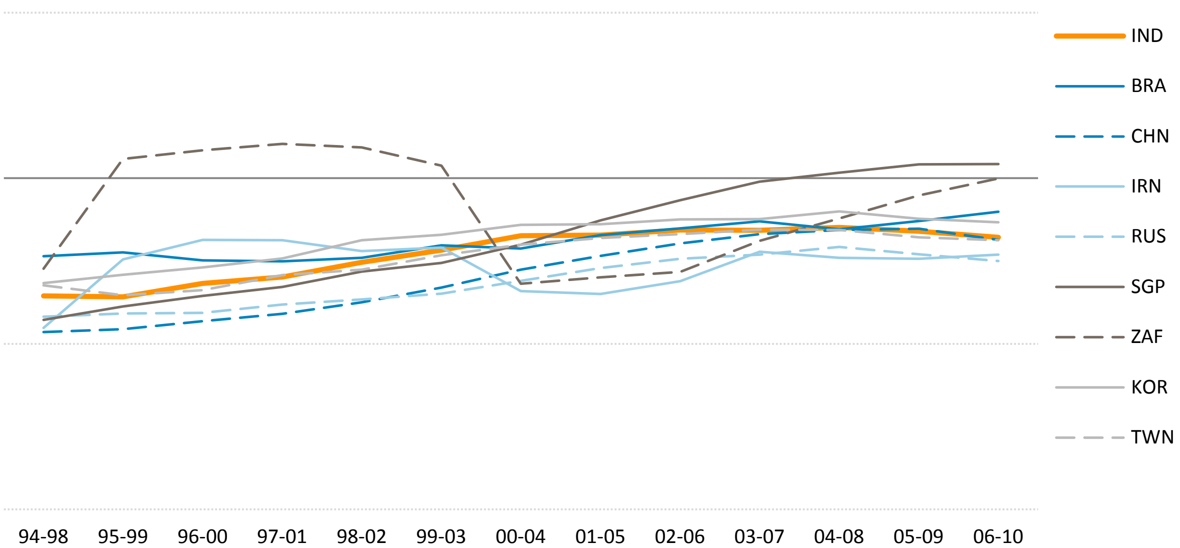


In this later period, India, whilst below world average, showed a notable improvement in the citation impact of its Physics research which rose from 0.64 to 0.82 and narrowed the gap in its citation impact relative to the established research economies.

In terms of the established research economies, the USA was the clear leader, with Israel's lead falling to the UK and Germany. It is notable that the UK's Physics research by the 202006-2010 period came close to that of the USA (1.54 to 1.55). Australia also showed a substantial improvement in its citation impact which rose from 1.07 to 1.34 (+0.28).

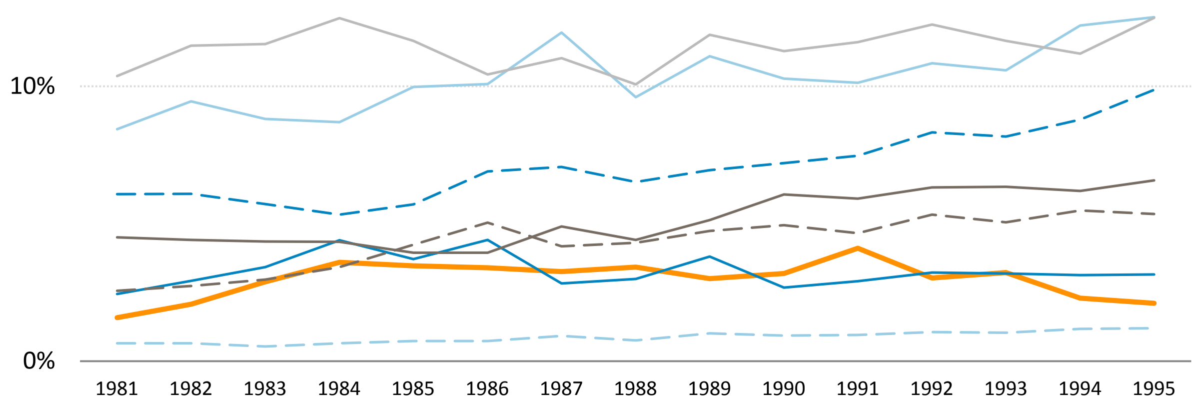
In terms of the emerging research economies, South Africa had a notable leap in the earlier part of this period, but similar to trends seen elsewhere, the citation impact of Singapore's Physics research rose to over the world average by the 2004-2008 period from 0.57 in 1994-1998 to 1.04 by 2006-2010 (+0.47).

5.15.b.iv: Normalised citation impact, Physics, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.16.a: Share of world research output, Space science

5.16.a.i: Share of world research output, Space science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

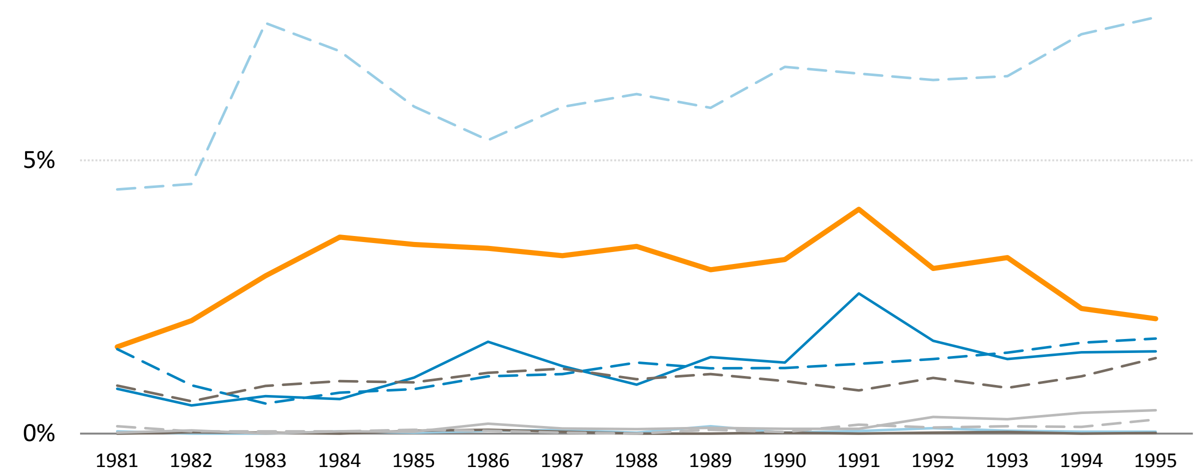


India's share of world output in Space Science increased from 1.6% in 1981 to 4.1% by 1991 before falling back to 2.1% by 1995. Amongst the established research economies, India's rank varied between seventh and eighth vis-à-vis Australia. Amongst the emerging research economies, India's rank was a clear second to Russia.

The USA (not shown) had a world share of 53.4% in 1981 which fell to 47.3% by 1995. The UK ranked second to the USA, and its world share broadly increased from 10.4% in 1981 to 12.5% by 1995. Germany's share was generally lower than that of the UK, but challenged it on several occasions. The world shares of Italy and Japan increased (2.1% and 2.8% respectively).

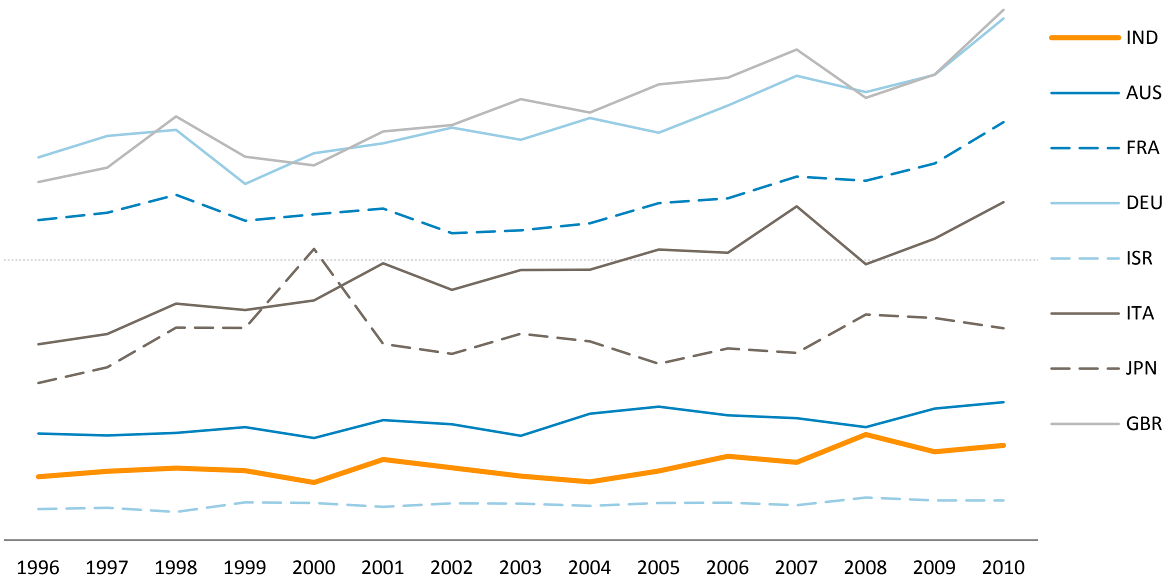
Russia's world share varied, but it was the clear leader amongst the emerging research economies. It's share rose from 4.5% in 1981 to 7.5% by 1983, it fell to 5.4% by 1986 and rose to 7.6% by 1995. After India, Brazil, China and South Africa were also players with broadly increasing shares.

5.16.a.iii: Share of world research output, Space science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.16.a: Share of world research output, Space science

5.16.a.ii: Share of world research output, Space science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

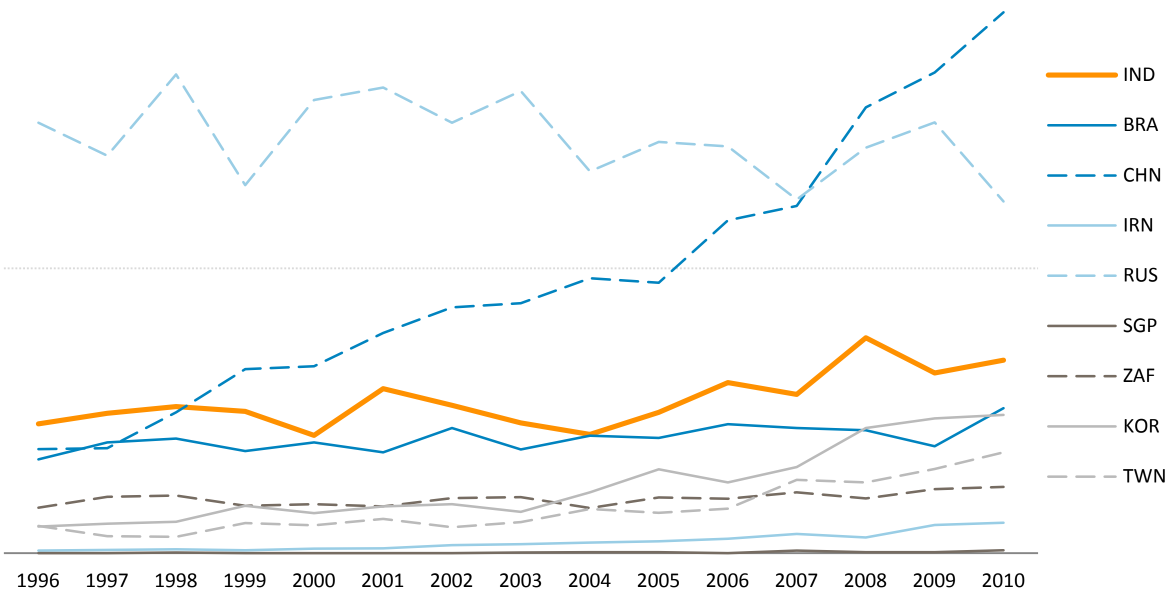


India's share of world output in Space Science increased from 2.3% in 1996 to 3.4% by 2010, but these shares were generally lower than the shares India had in the earlier period, suggesting lost ground. India firmly ranked eighth amongst the established research economies (above Israel) as Australia gained share and its rank fell from second to third amongst the emerging research economies as it was overtaken by China in 1999.

The USA (not shown) maintained its share which averaged 46.8%. The UK and Germany increased their shares (+6.2% and +5.0%) as did France and Italy (+3.5% and 5.1%). This may be due to increasing European collaboration in this field. Japan's share increased from 5.6% in 1996 to 10.4% in 2000, but it fell back to 7.6% by 2010 (although this was an increase from 2.6% in 1981).

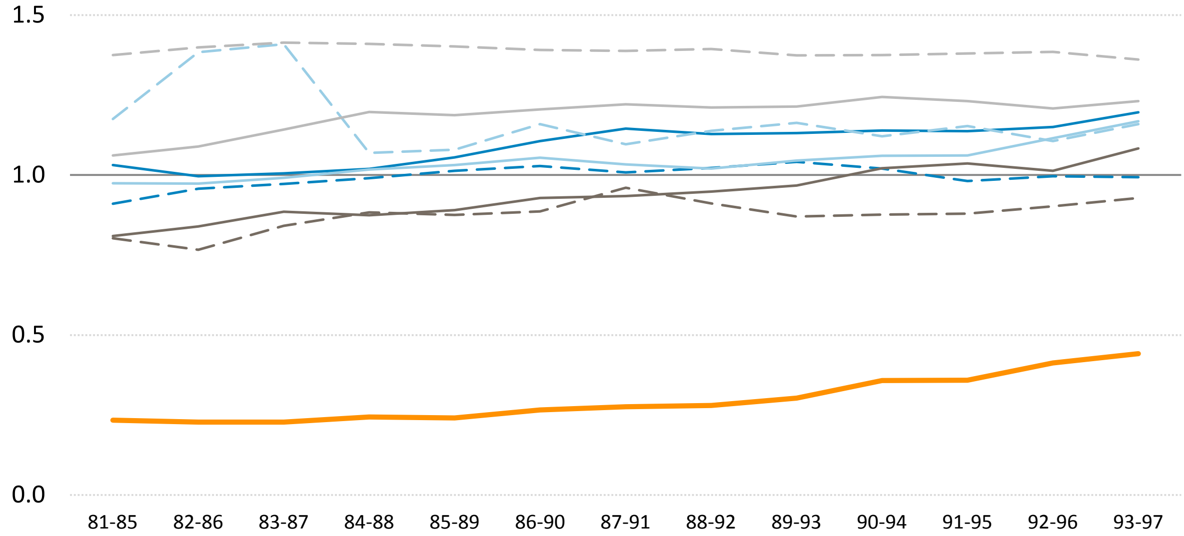
Russia's world share varied, but broadly increased on its 1981 levels. China overtook Russia in 2008: its world share has increased from 1.8% in 1996 to 9.5% by 2010.

5.16.a.iv: Share of world research output, Space science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.16.b: Normalised citation impact, Space science

5.16.b.i: Normalised citation impact, Space science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

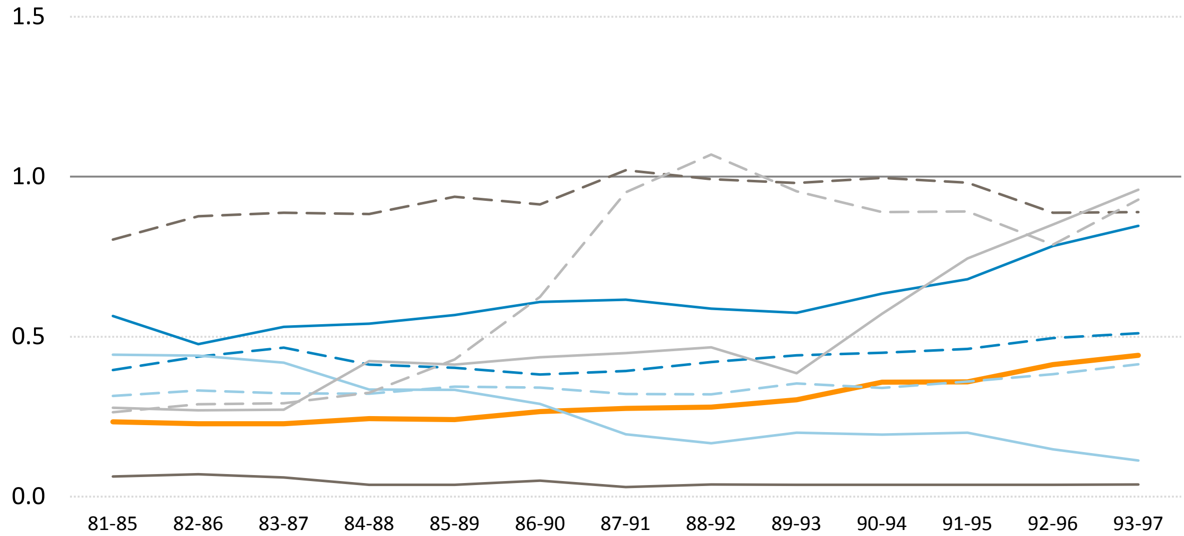


India's citation impact improved from 0.23 in 1981-1985 to 0.44 by 1993-1997, although this was below world average leaving a gap between India and the established research economies. India's citation impact was also below other emerging research economies. Excluding Iran, Singapore, Korea and Taiwan (with low paper numbers) India ranked the lowest, but its citation impact compared to Russia was greater in the 1990s.

The USA had the highest citation impact averaging 1.39. Israel's citation impact peaked in 1983-1987 (1.41) but fell back, and the UK more or less ranked second to the USA with its citation impact increasing from 1.06 in 1981-1985 to 1.23 by 1993-1997. Australia's citation impact increased from 1.03 in 1981-1985 to 1.20 by 1993-1997. The citation impact of Germany (+0.19), France (+0.08) and Italy (+0.27) increased.

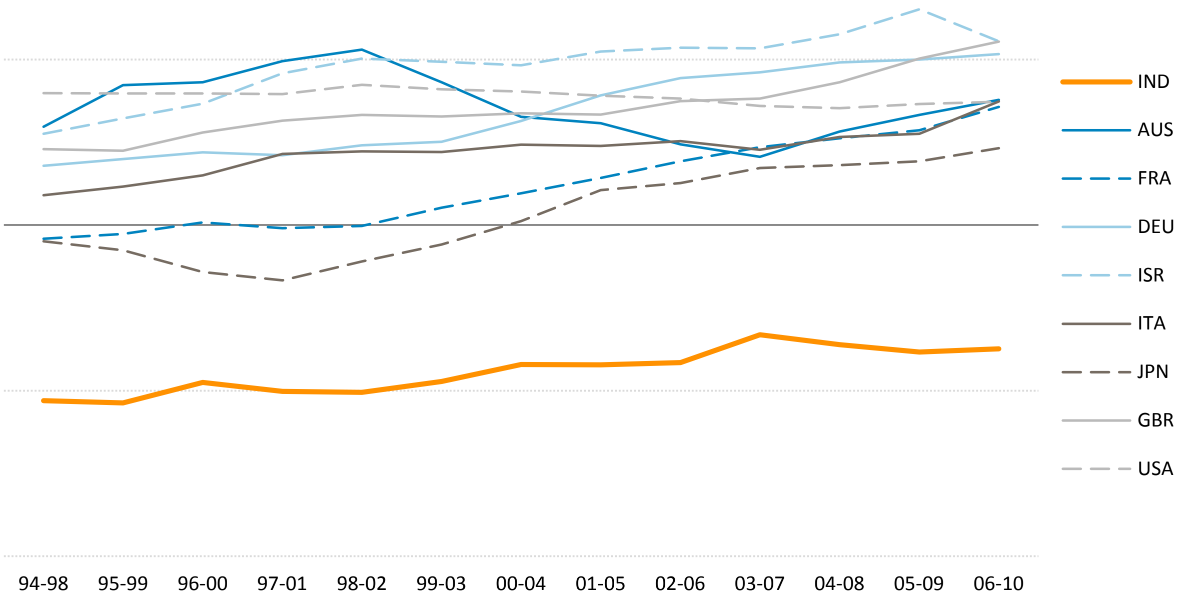
South Africa had the highest citation impact amongst the emerging research economies, with a peak of 1.02 in 1987-1991. Korea's citation impact was the highest by the end of this period (0.96). Brazil made strong gains (+0.28) and China's citation impact was around half the world average by 1993-1997.

5.16.b.iii: Normalised citation impact, Space science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.16.b: Normalised citation impact, Space science

5.16.b.ii: Normalised citation impact, Space science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

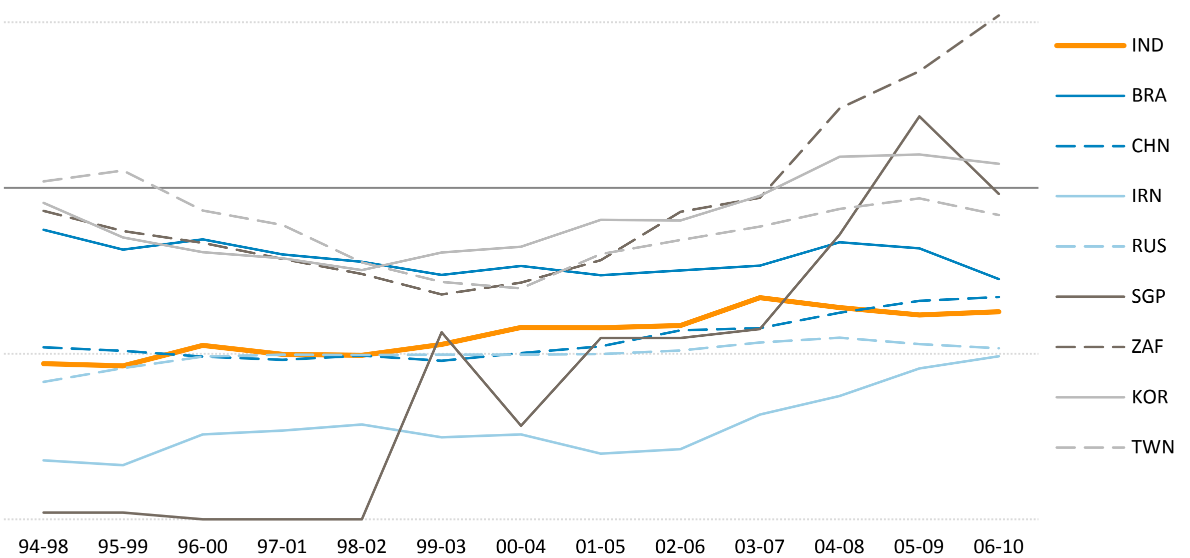


India's citation impact improved from 0.47 in 1994-1998 to 0.63 by 2006-2010. A larger gap emerged between India and the established research economies, as most increased their citation impact (except the USA). Amongst the emerging research economies, and excluding those with low paper numbers (Singapore and Iran), India's position was broadly comparable to China's and greater than Russia's.

Israel's citation impact increased from 1.28 in 1994-1998 to 1.56 by 2006-2010. Australia's citation impact rose to 1.53 in 1998-2002 and fell to 1.21 in 2003-2007 rising up to 1.38 by 2006-2010. The USA's citation impact averaged 1.39, whilst the UK's citation impact increased from 1.23 in 1994-1998 to 1.55 by 2006-2010 where it ranked second to Israel. Germany's citation impact rose from 1.18 in 1994-1998 to 1.52 by 2006-2010.

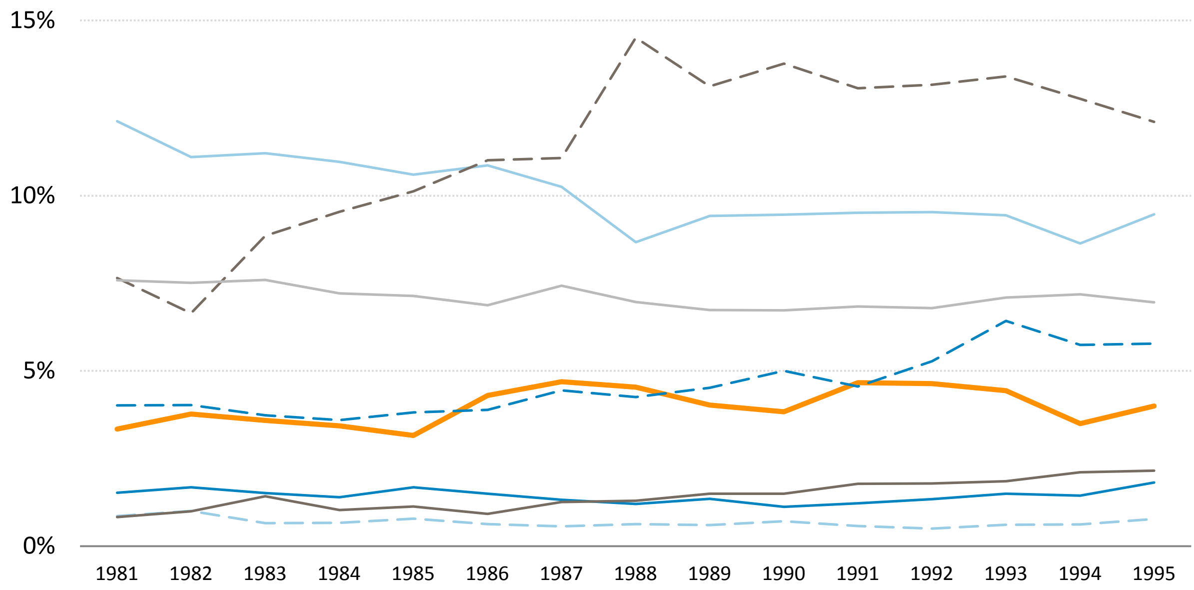
Amongst the emerging research economies, South Africa's citation impact was the highest by 2006-2010 (1.52) followed by Korea (1.07) and Taiwan (0.92). Brazil's citation impact fell over this period from 0.87 in 1994-1998 to 0.73 by 2006-2010.

5.16.b.iv: Normalised citation impact, Space science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.17.a: Share of world research output, Materials science

5.17.a.i: Share of world research output, Materials science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

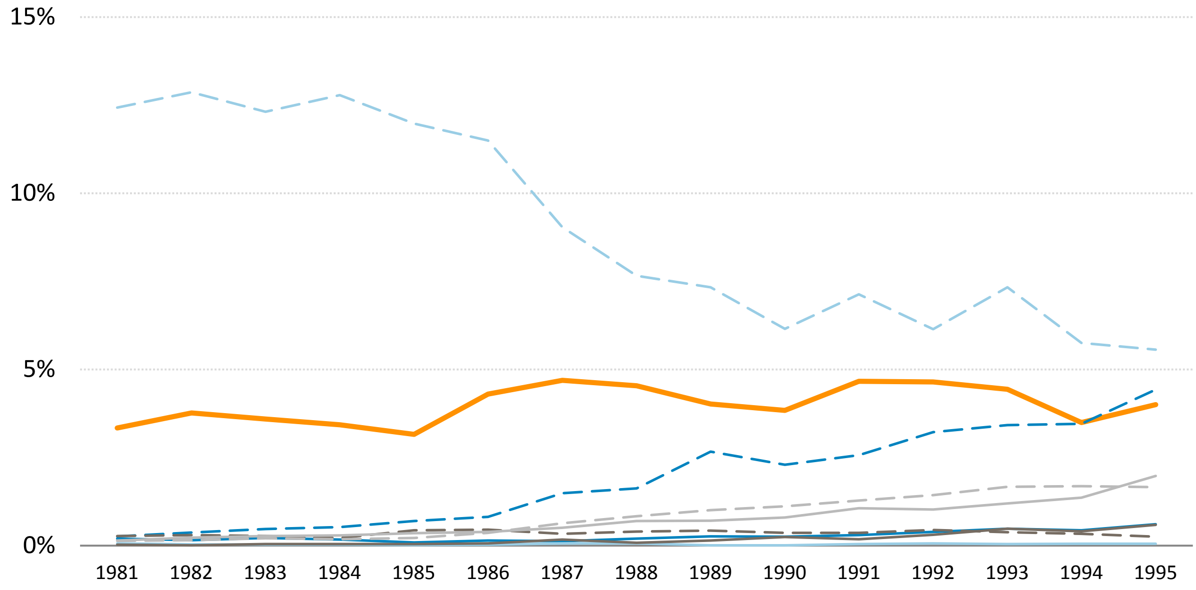


India's world share of Materials Science broadly averaged around 4.0% of world output during this earlier period. It ranked broadly sixth amongst the established research economies (higher than Italy, Australia and Israel), and ranked second to Russia amongst the emerging research economies until its share was overtaken by China in 1995.

The share of the USA (not shown) was 28.1% in 1981 and fell to 24.7% in 1986, and rose to 28.5% by 1995. Japan overtook Germany in 1986: its share rose from 7.6% in 1981 to a high of 14.5% in 1988, before it fell to 12.1% in 1995. Germany's share decreased from 12.1% in 1981 to 9.5% by 1995. The UK's share averaged around 7.1% over this period. France increased its share by 1.8%.

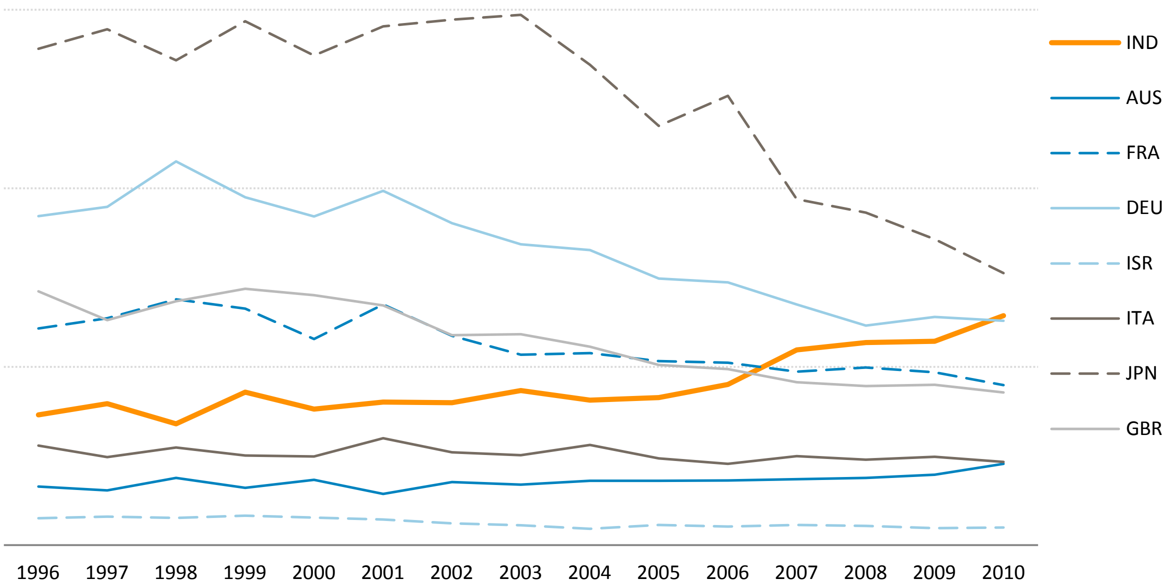
Russia's world share in Materials Science halved over this period, from 12.4% in 1981 to 5.6% by 1995. China's share increased over this period from 0.3% of world output in 1981 to 4.4% by 1995. Taiwan and Korea also increased their world share over this period (+1.5% and +1.8% respectively).

5.17.a.iii: Share of world research output, Materials science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.17.a: Share of world research output, Materials science

5.17.a.ii: Share of world research output, Materials science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

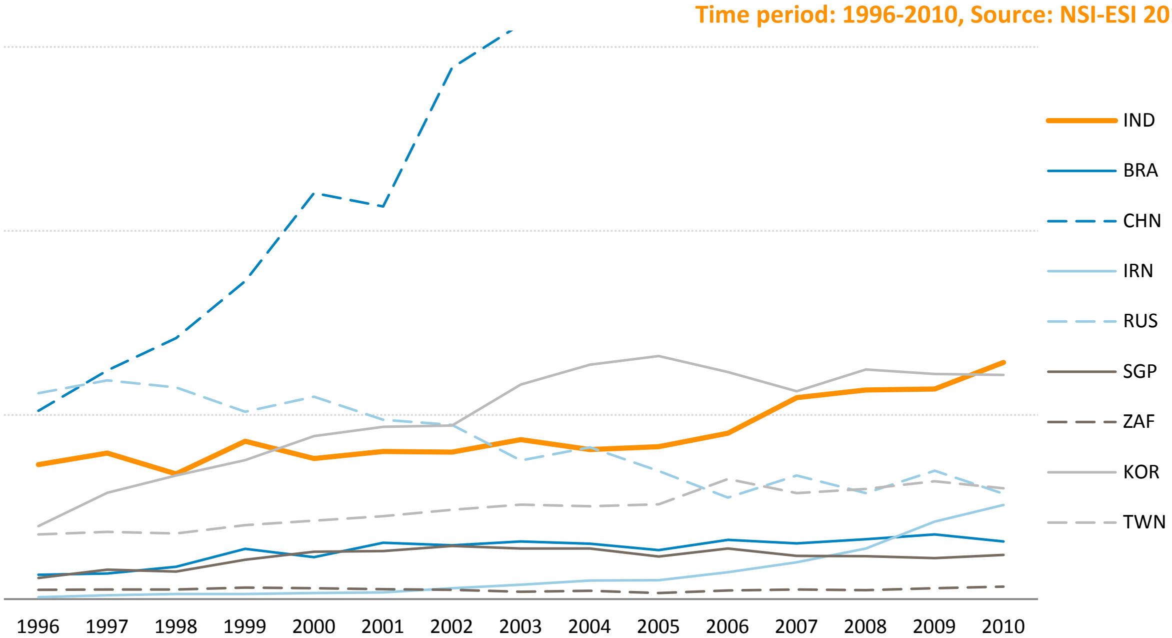


India's world share of Materials Science research about doubled from 3.6% in 1996 to 6.4% by 2010. It improved its rank among the established research economies, surpassing the UK and France in 2007 and Germany in 2010. India was overtaken by China as China quintupled its research output from 5.1% in 1996 to 25.3% by 2010, the highest world share China holds in any field, and in which it surpassed the USA in 2005.

The share of the USA (not shown) in Materials Science fell to very low levels by the standards of the USA: from 26.7% of world output in 1996 to 14.9% of world output by 2010. Japan's world share halved from a high of 14.9% in 2003 to 7.6% by 2010. Germany's share declined from a high of 10.7% in 1998 to 6.3% by 2010. France's share fell (-1.6%) as did the share of the UK (-2.8%).

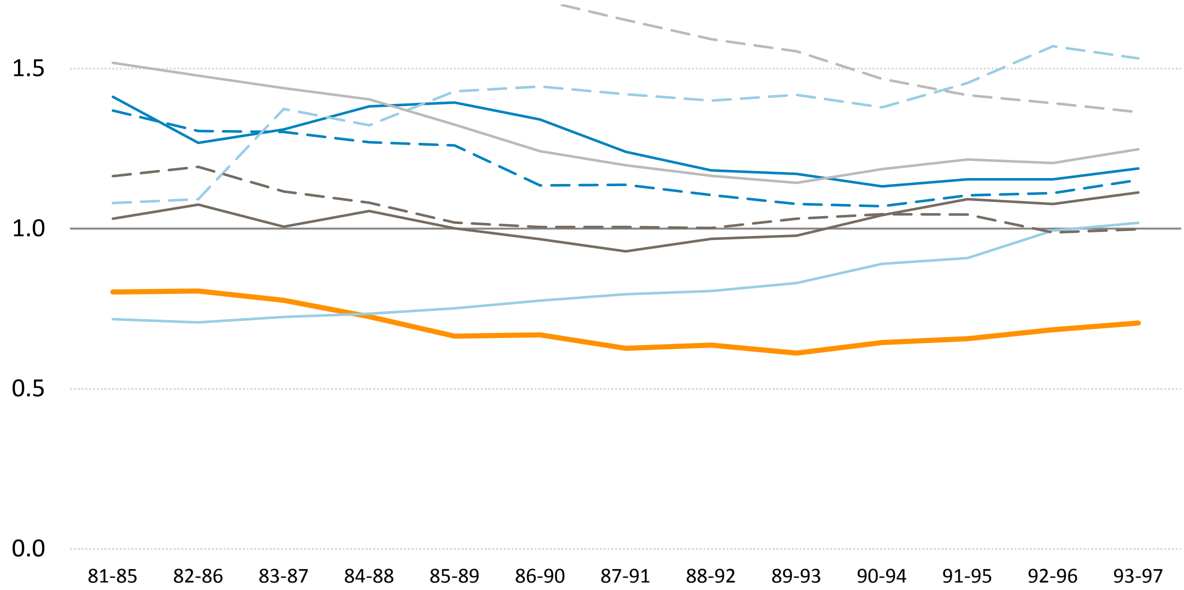
As Russia's share fell from 5.6% to 2.9%, Korea's share rose from 2.0% in 1996 to 6.1% in 2010, surpassing India's share from 2000, but in 2010, it is just short of it. Taiwan's share has also increased (+1.3%).

5.17.a.iv: Share of world research output, Materials science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.17.b: Normalised citation impact, Materials science

5.17.b.i: Normalised citation impact, Materials science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

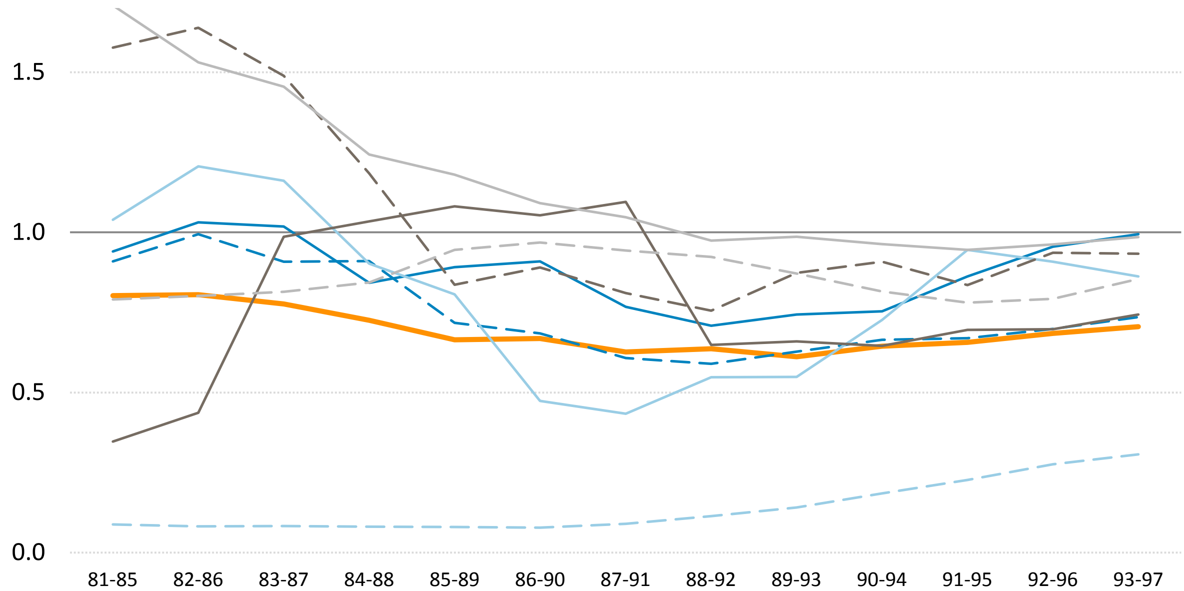


India's citation impact in Materials Science was the highest for any field during this period. However, its citation impact actually fell during this period from 0.80 in 1981-1985 to 0.71 by 1993-1997. Amongst the established research economies, India ranked more highly than Germany for the periods between 1981-1985 and 1983-1987, before it ranked the lowest. Amongst the emerging research economies, India's rank by citation impact varied, but moved from sixth in 1981-1985 to eighth by 1993-1997.

The USA's citation impact fell from 1.72 in 1981-1985 to 1.36 by 1993-1997. Israel's citation impact rose from 1.08 to 1.53 over the same period. The UK's citation impact fell from 1.52 in 1981-1985 to a low of 1.14 in 1989-1993 before rising to 1.25 by 1993-1997. Australia and France's citation impact fell (-0.22), Japan's citation impact was above world average over this period, but fell (-0.17). Germany's citation impact rose from 0.72 to 1.02 this period (+0.30).

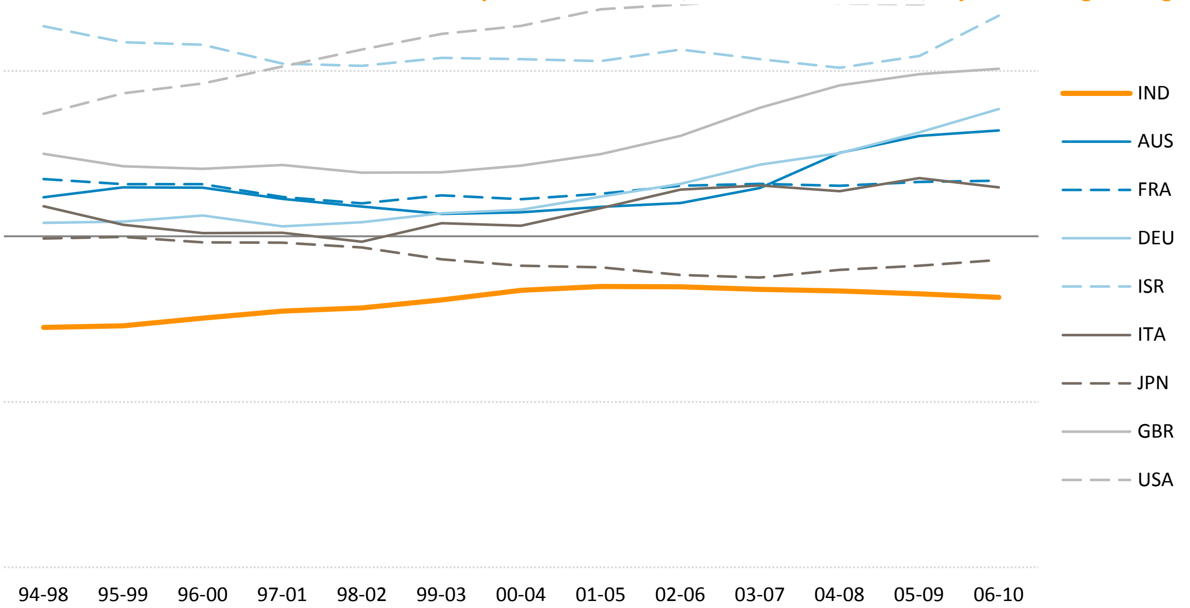
Korea's citation impact fell from 1.71 in 1981-1985 to 0.99 by 1993-1997, as did South Africa's (1.58 to 0.93).

5.17.b.iii: Normalised citation impact, Materials science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.17.b: Normalised citation impact, Materials science

5.17.b.ii: Normalised citation impact, Materials science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

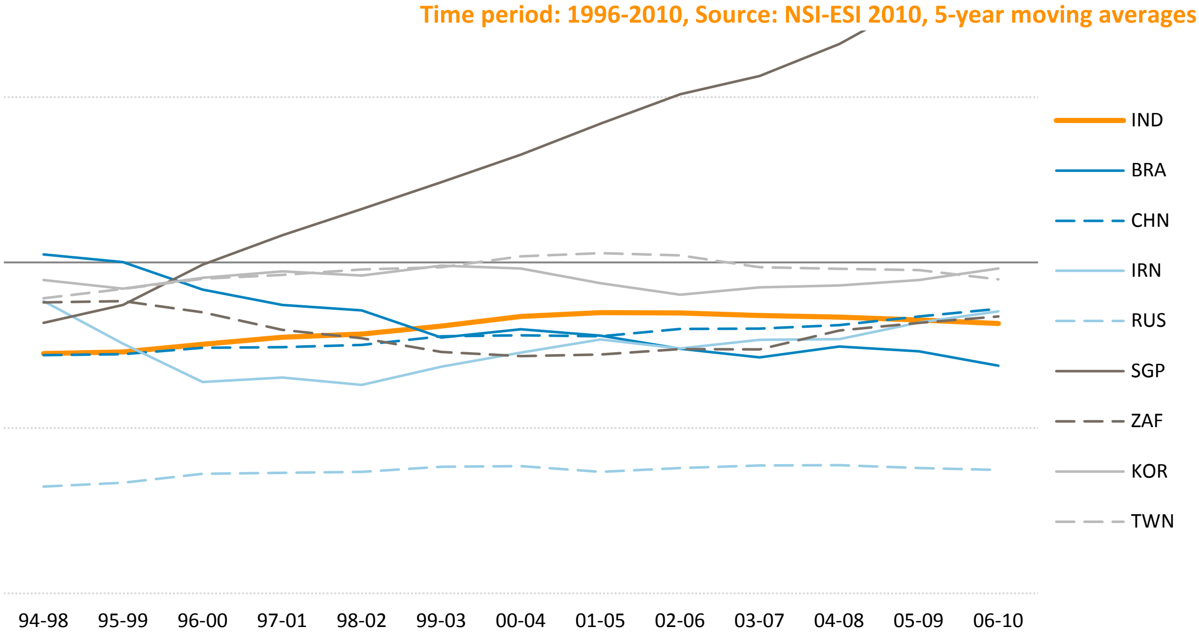


In this later period, India's citation impact improved from 0.73 in 1994-1998 to 0.82 by 2006-2010, significantly narrowing the gap between it and the established research economies.

The USA's citation impact increased from 1.37 in 1994-1998 to 1.72 by 2006-2010 over this period, and Israel's citation impact was also very high: it had reached 1.67 by 2006-2010 from 1.08 in 1981-1985, indicative of a long-term rise. After the UK's fall during the earlier period, it is notable that its citation impact rose from 1.25 in 1994-1998 to 1.51 by 2006-2010. Germany's citation impact increased substantially on the earlier period, rising from 1.04 in 1994-1998 to 1.39 by 2006-2010. Japan's citation impact fell further over this period (-0.06).

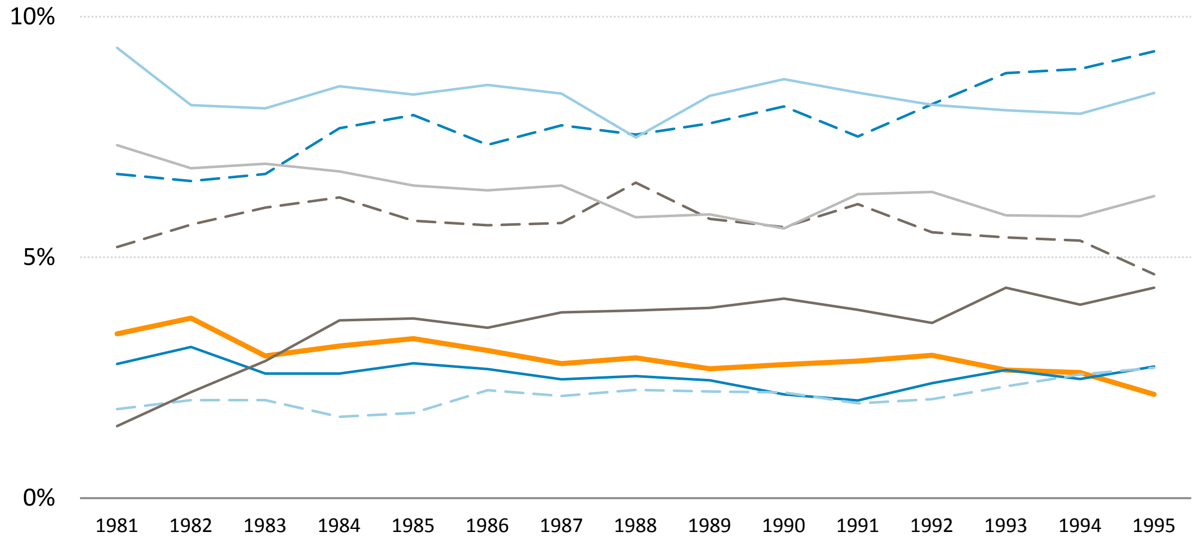
Singapore's citation impact was the highest of any country during this period: rising from 0.82 in 1994-1998 to 1.90 by 2006-2010. Taiwan's citation impact rose to above world average levels and fell again (0.95 in 2006-2010).

5.17.b.iv: Normalised citation impact, Materials science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.18.a: Share of world research output, Mathematics

5.18.a.i: Share of world research output, Mathematics, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

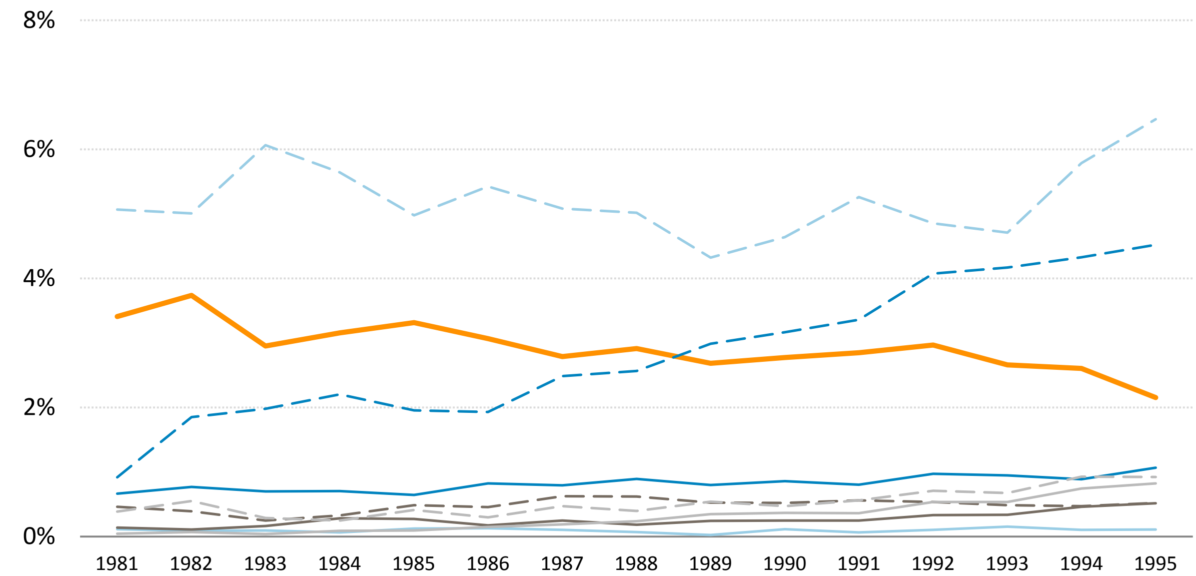


India's percentage share of world output fell from over 3% in the early part of this period to just over 2% by 1995.

In the earlier period, the USA (not shown) clearly dominated in terms of its percentage world share of Mathematics research output, although this share declined substantially over the period (from 40.9% in 1981 to 34.4% in 1995). It was followed by Germany in the earlier part of this period, until Germany was overtaken by France from 1993 onwards. The UK's share fell (from 7.3% in 1981 to 6.3% in 1995) and Japan's share also fell. Italy's share increased from 1.5% in 1981 to 4.4% by 1995.

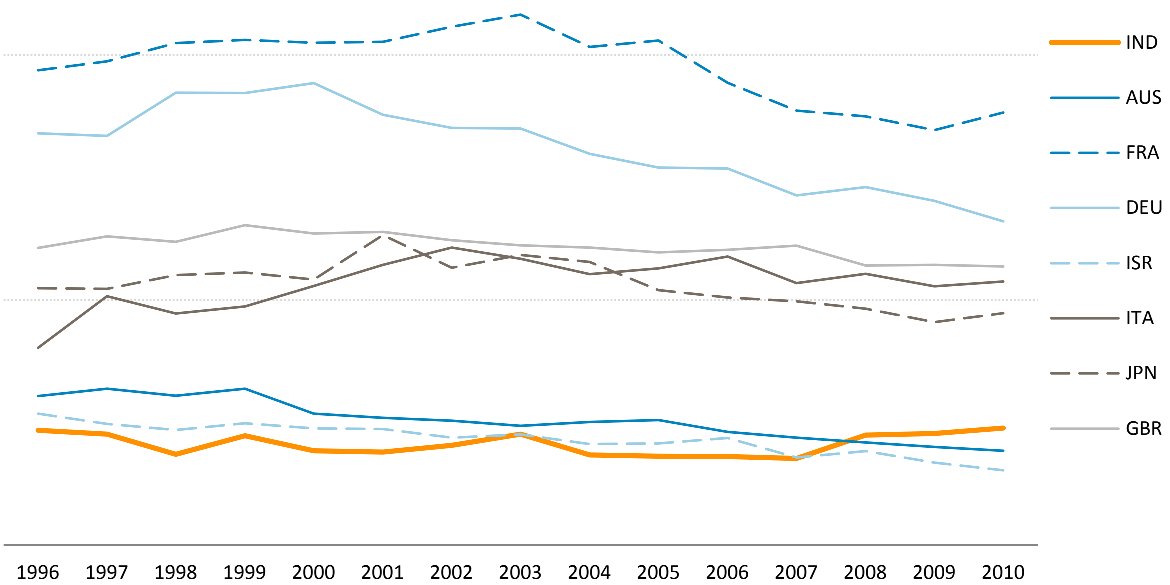
China's rise in Mathematics research began in this period, rising from 0.9% in 1981 to 4.5% by 1995, overtaking India in 1989 and displacing India as second in rank to Russia. Russia's share varied between from above 4% to just above 6% over this period.

5.18.a.iii: Share of world research output, Mathematics, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.18.a: Share of world research output, Mathematics

5.18.a.ii: Share of world research output, Mathematics, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

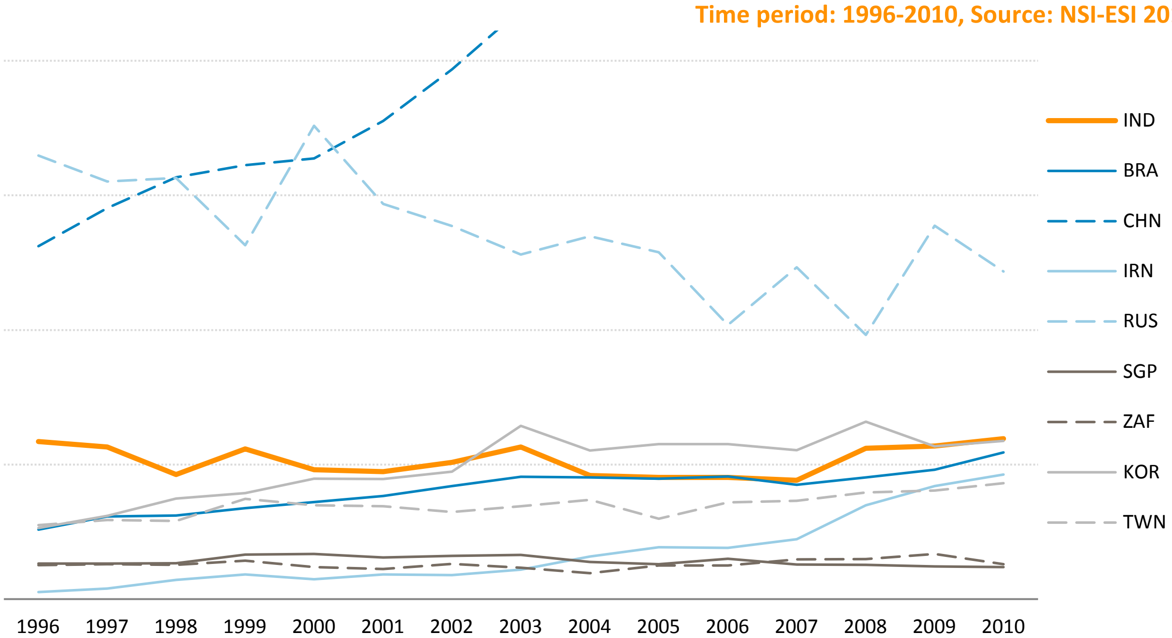


India's share of world Mathematics research output was around 2% over this period, and was broadly maintained at these levels.

In this later period, the USA's share of world Mathematics research output (not shown) was further eroded from 32.9% in 1996 to 23.6%, ultimately a fall of 17.3% (nearly half) on its 1981 level. France reached a share of 10.8% in 2003, but this fell to 8.8% by 2010. Germany's share also fell from a height of 9.4% in 2000 to 6.6% by 2010. Italy's share continued to rise from its 1981 levels overtaking Japan in 2005.

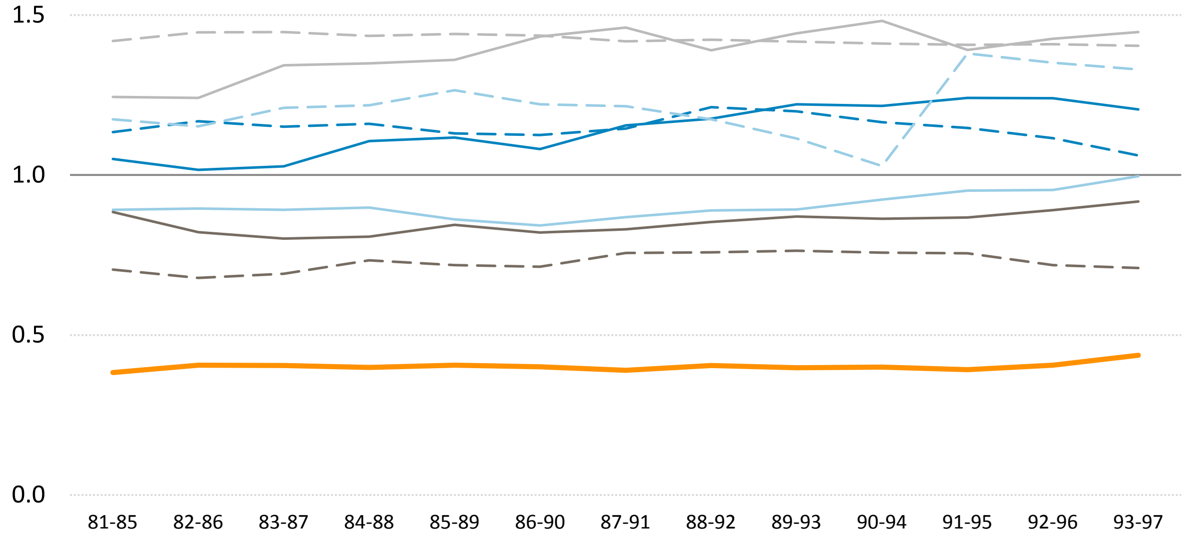
China in effect trebled its percentage world share of Mathematics research output, from 5.2% in 1996 to 16.7% by 2010. Korea began to overtake India from around 2003 onwards, although by 2009/2010, their world share was equal (2.4% by 2010). Brazil, Taiwan and also notably Iran increased their world share over this period too.

5.18.a.iv: Share of world research output, Mathematics, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.18.b: Normalised citation impact, Mathematics

5.18.b.i: Normalised citation impact, Mathematics, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

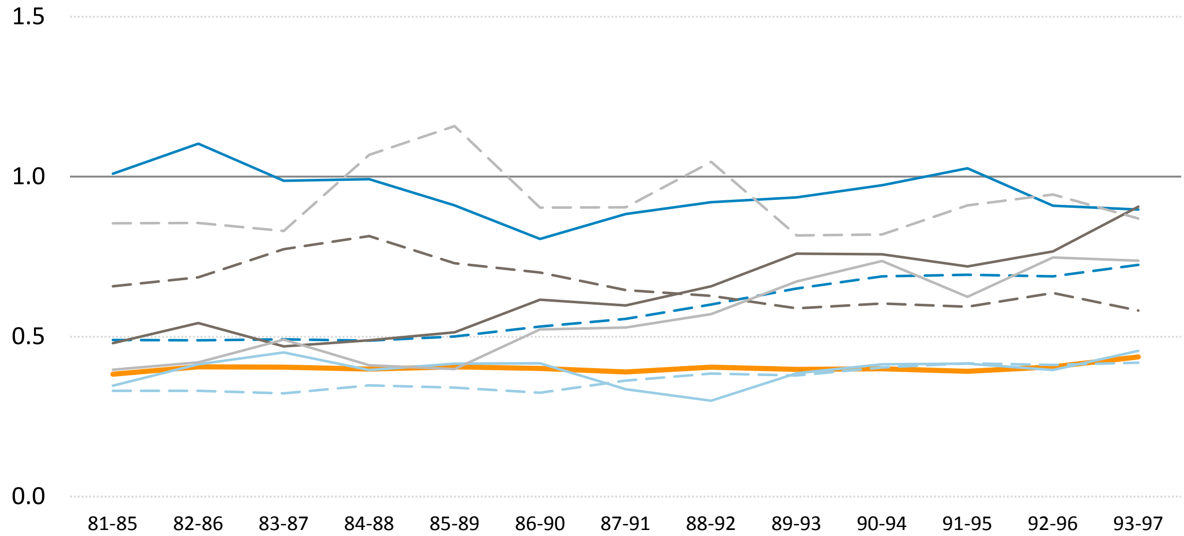


India's citation impact marginally improved over this period (from 0.38 in 1981-1985 to 0.44 by 1993-1997) but these gains are comparatively small, and these levels are well below world average.

Amongst the established research economies, the dominance of the citation impact of US Mathematics research was challenged by the UK whose citation impact rose over this period (from 1.24 in 1981-1985 to 1.45 by 1993-1997). Israel had a period where the citation impact of its Mathematics research surged during the early 1990s (continued on the page opposite). The citation impact of Australia's Mathematics research also improved (1.05 in 1981-1985 to 1.21 by 1993-1997).

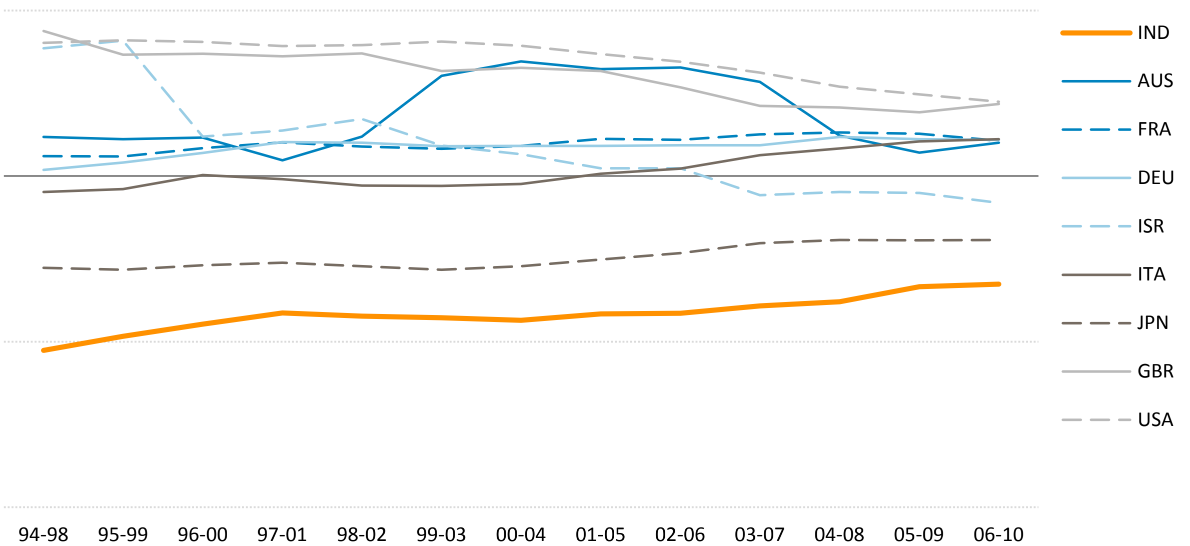
The citation impact of Mathematics research in Taiwan and Brazil occasionally increased to over world average levels. Singapore made notable improvements (from 0.48 in 1981-1985 to 0.91 by 1993-1997). India's citation impact ranked within the lowest three, and was broadly comparable to that of Iran.

5.18.b.iii: Normalised citation impact, Mathematics, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.18.b: Normalised citation impact, Mathematics

5.18.b.ii: Normalised citation impact, Mathematics, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

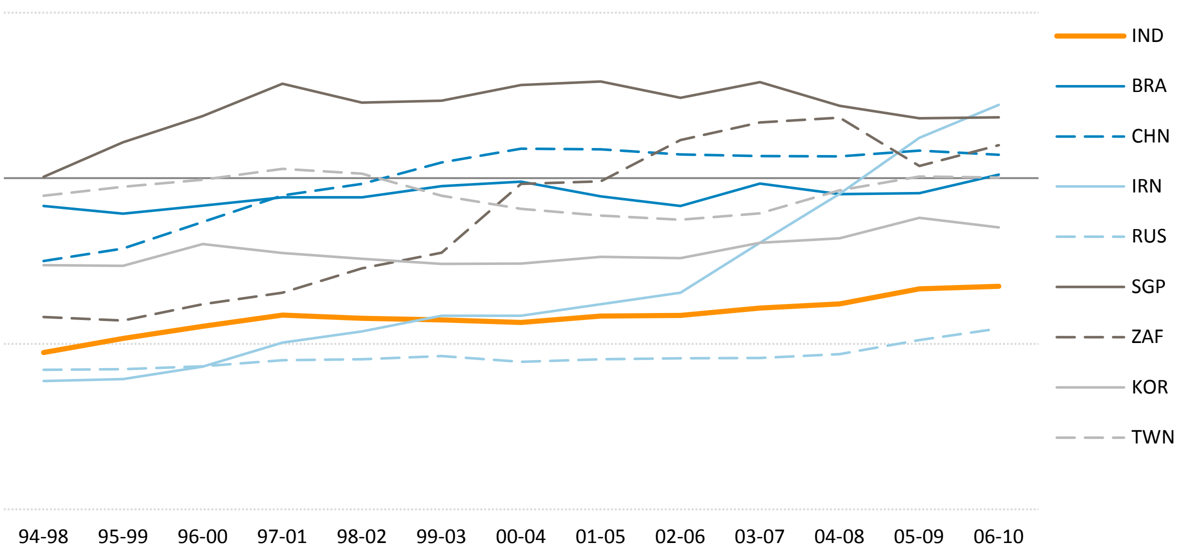


India's citation impact did improve over this period (+0.20) narrowing the gap with the established research economies, but it was still below world average. India was overtaken by Iran in 1999-2003.

Amongst the established research economies, the citation impact of the USA decreased over this period (from 1.40 to 1.22) as did that of the UK (from 1.44 to 1.22) and Israel (from 1.39 to 0.92). Australia's Mathematics research surged over the moving five-year periods from 1999 up to 2007. Italy made steady gains increasing its citation impact from 0.95 in 1994-1998 and 1.11 by 2006-2010. The citation impact of Japan's Mathematics research was also well below world average.

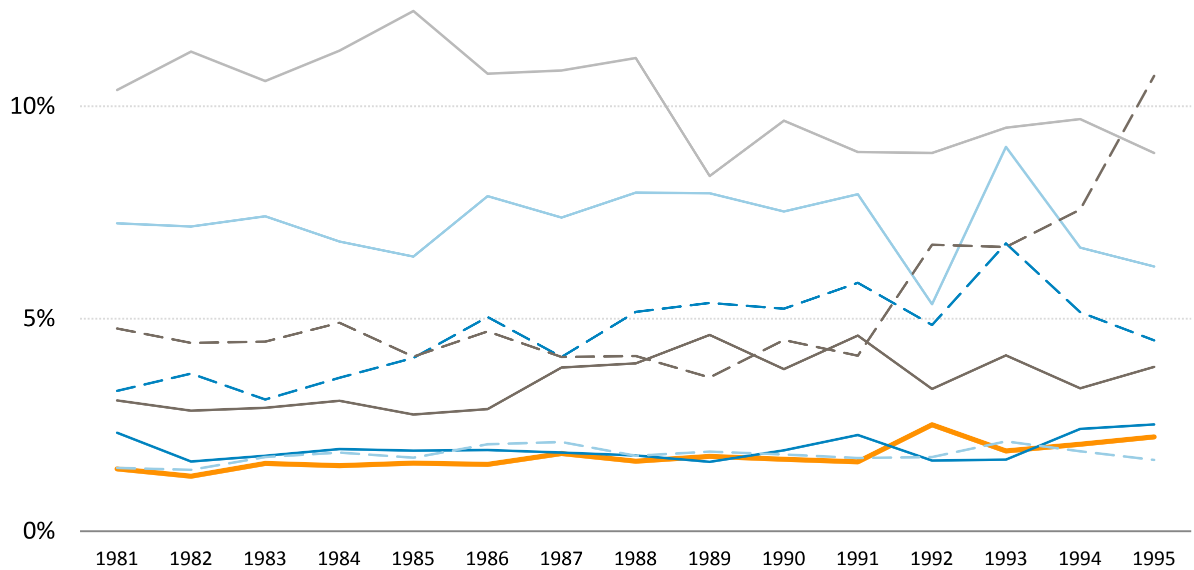
Several emerging research economies crossed the line of the world average (Singapore, China, South Africa, Iran, Taiwan and by 2010 Brazil also). Singapore increased its citation impact from 1.00 in 1994-1998 to 1.18 by 2006-2010 with highs of 1.29 in several periods. Iran increased its citation impact from being the lowest in this group in 1994-1998 (0.39) to being the highest by 2006-2010 (1.22).

5.18.b.iv: Normalised citation impact, Mathematics, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.19.a: Share of world research output, Computer science

5.19.a.i: Share of world research output, Computer science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

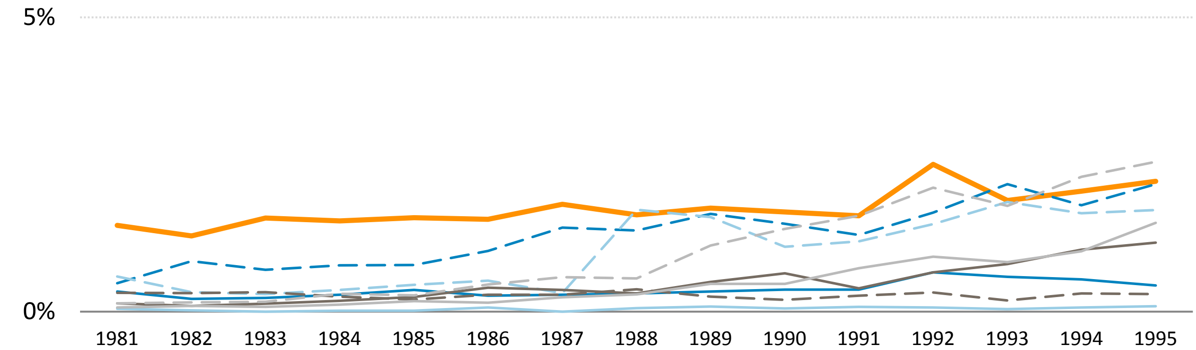


In this earlier period, India's world share of Computer Science research rose from 1.5% in 1981 to 2.2% by 1995, with a high of 2.5% in 1992. Amongst the established research economies, Indian levels were broadly comparable to those of Israel and Australia. Amongst the emerging research economies, India was the clear leader until the early 1990s when Taiwan overtook India in 1994, and China attained an equal world share in 1995 (2.2%).

The world share of the USA (not shown) fell from 50.8% in 1981 to 41.0% in 1995. The world share of the UK rose from 10.4% in 1981 to 12.2% in 1985 but fell to 8.9% by 1995. The world share of Germany somewhat varied over the period but rose to 9.0% in 1993. Japan's rise was dramatic: from 4.8% in 1981 to 10.7% in 1995, just over doubling its world share and overtaking both Germany and the UK.

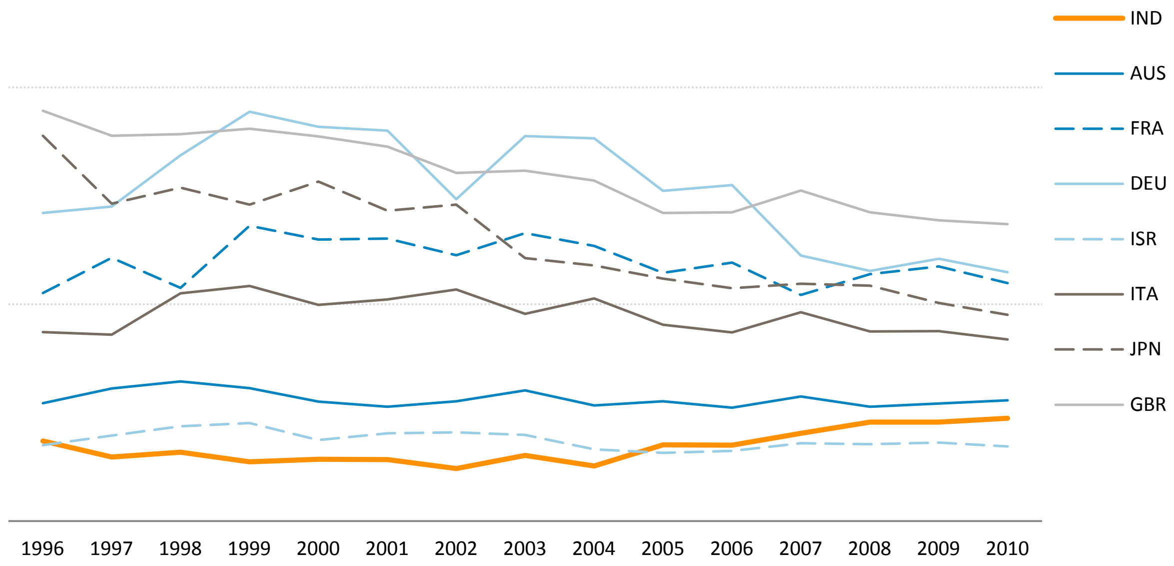
China's world share rose from 0.5% in 1981 to 2.2% in 1995. That of Taiwan rose from 0.1% to 2.5%. Interestingly, Russia's world share also rose over this period, from 0.6% in 1981 to 1.7% by 1995.

5.19.a.iii: Share of world research output, Computer science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.19.a: Share of world research output, Computer science

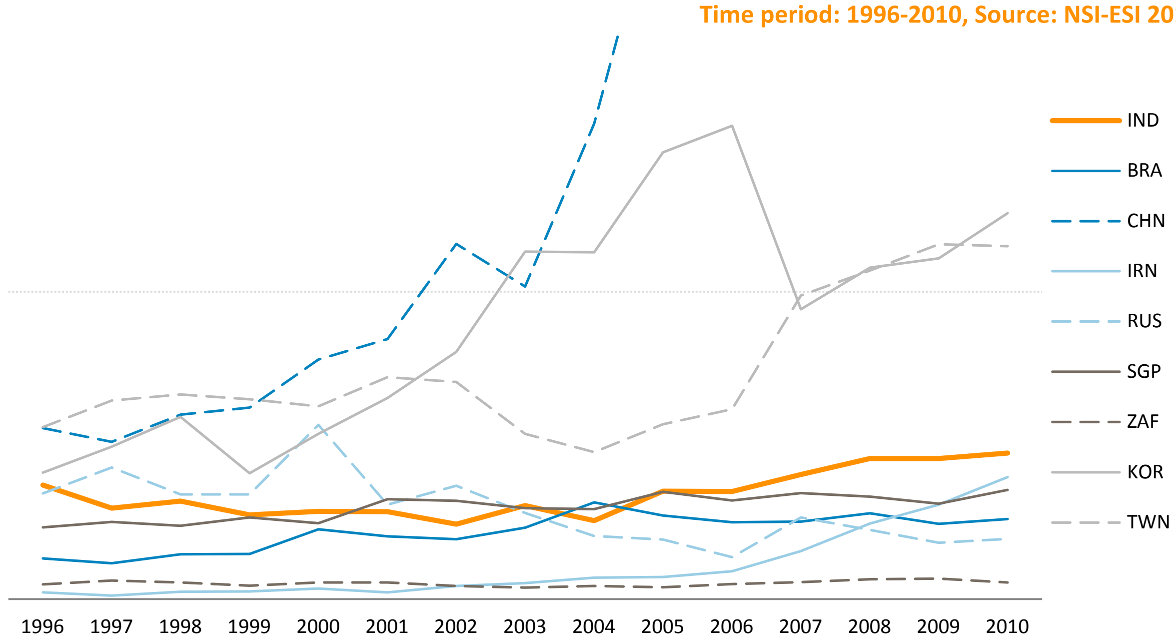
5.19.a.ii: Share of world research output, Computer science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010



In this later period, the USA's world share of Computer Science fell even further (not shown), from 38.1% in 1996 to 26.7% in 2010, i.e. a near halving of its 1981 world share. The UK's world share was challenged by Germany, but both countries share of world output in Computer Science fell over this period (-2.6% and -1.4% respectively). Japan's world share fell more deeply (-4.1%).

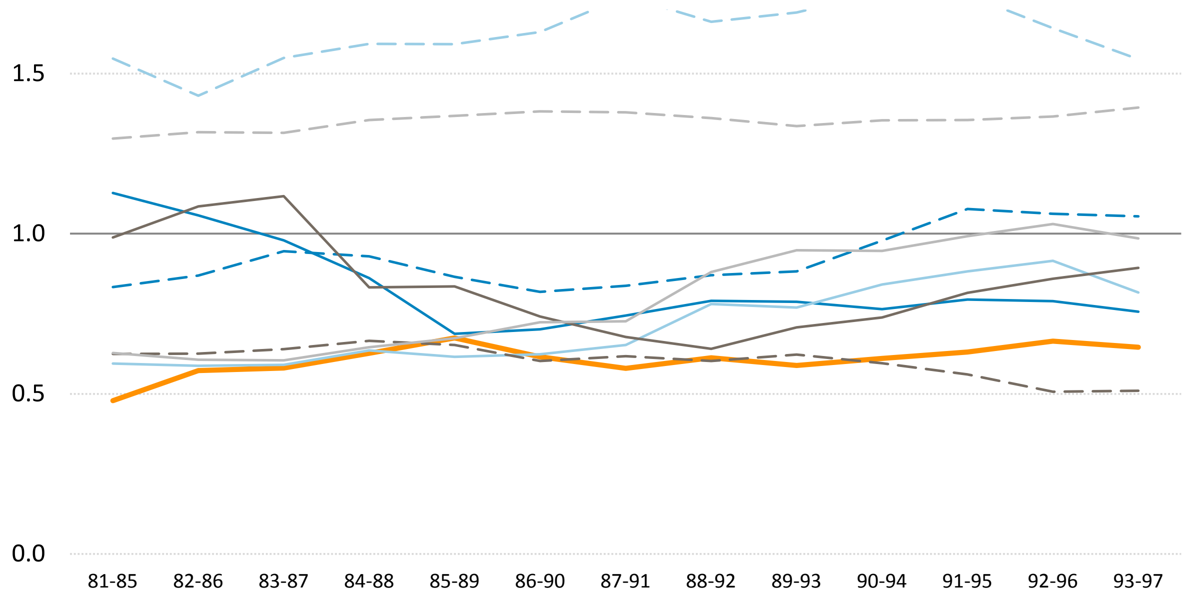
World share clearly moved to three emerging research economies in Computer Science. China increased its world share from 2.8% in 1996 (when it overtook India) to 14.5% by 2010. World share was also gained by Korea whose share increased from 2.1% in 1996, to a high of 7.7% in 2006 before it fell in 2007 and then rose to 6.3% in 2010. Taiwan broadly equalled Korea's rank from 2007 onwards following this fall. So whilst India's world share of Computer Science research increased from 1.9% in 1996 to 2.4% by 2010, it lost its pre-eminence amongst the emerging research economies to China and the 'tiger' economies of Korea and Taiwan.

5.19.a.iv: Share of world research output, Computer science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.19.b: Normalised citation impact, Computer science

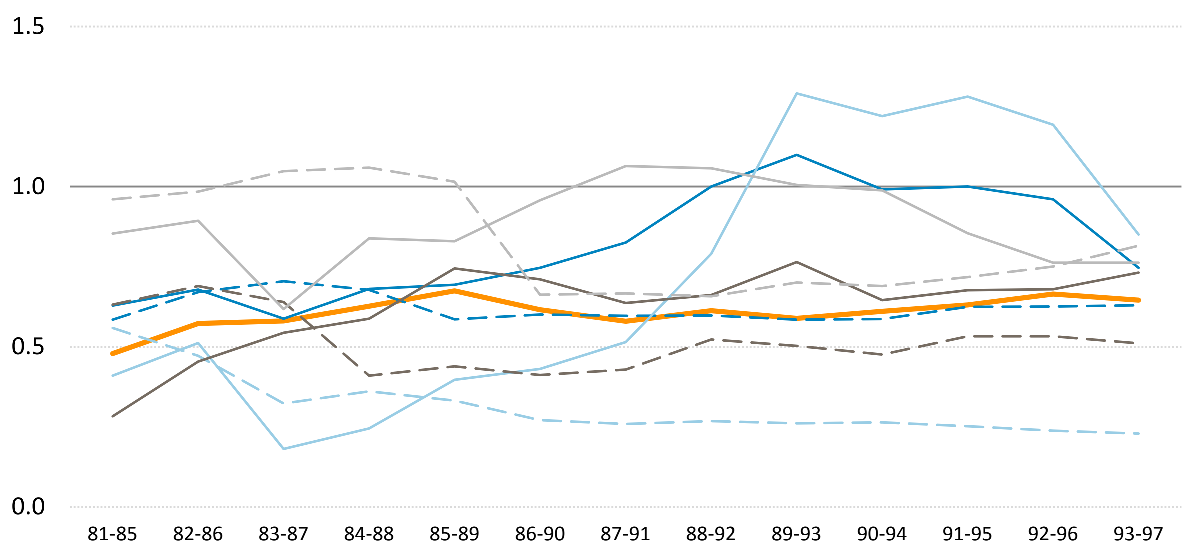
5.19.b.i: Normalised citation impact, Computer science, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



India's citation impact rose from 0.48 to 0.65 (+0.17). It ranked more or less the lowest amongst the established research economies, and its citation impact was broadly similar to Japan's, which fell below that of India's in the early 1990s. Israel had the leading citation impact over this earlier period, which reached a high of 1.76 in 1990-1994 but was 1.55 at the beginning and at the end of the period. The USA's citation impact increased from 1.30 in 1981-1985 to 1.39 by 1993-1997. Most other established research economies were below world average at this stage.

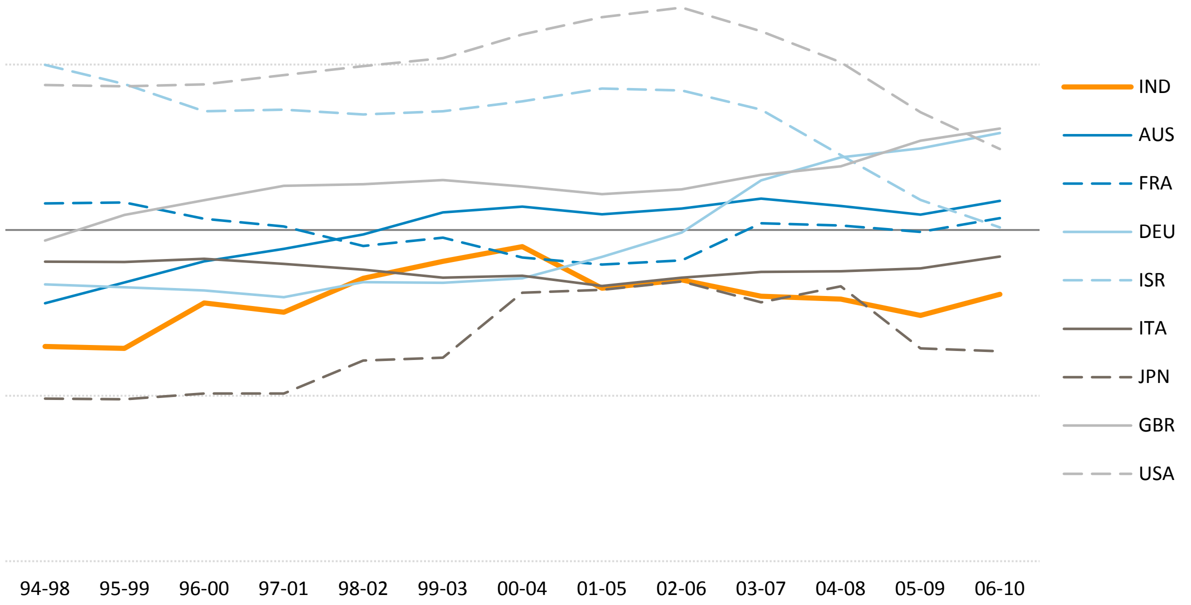
India's rank amongst the emerging research economies varied over the period, but it moved from seventh in 1981-1985 to sixth by 1993-1997. The apparent rise of Iran is based on citation impact where the paper numbers are less than 50 and so should be treated cautiously.

5.19.b.iii: Normalised citation impact, Computer science, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.19.b: Normalised citation impact, Computer science

5.19.b.ii: Normalised citation impact, Computer science, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

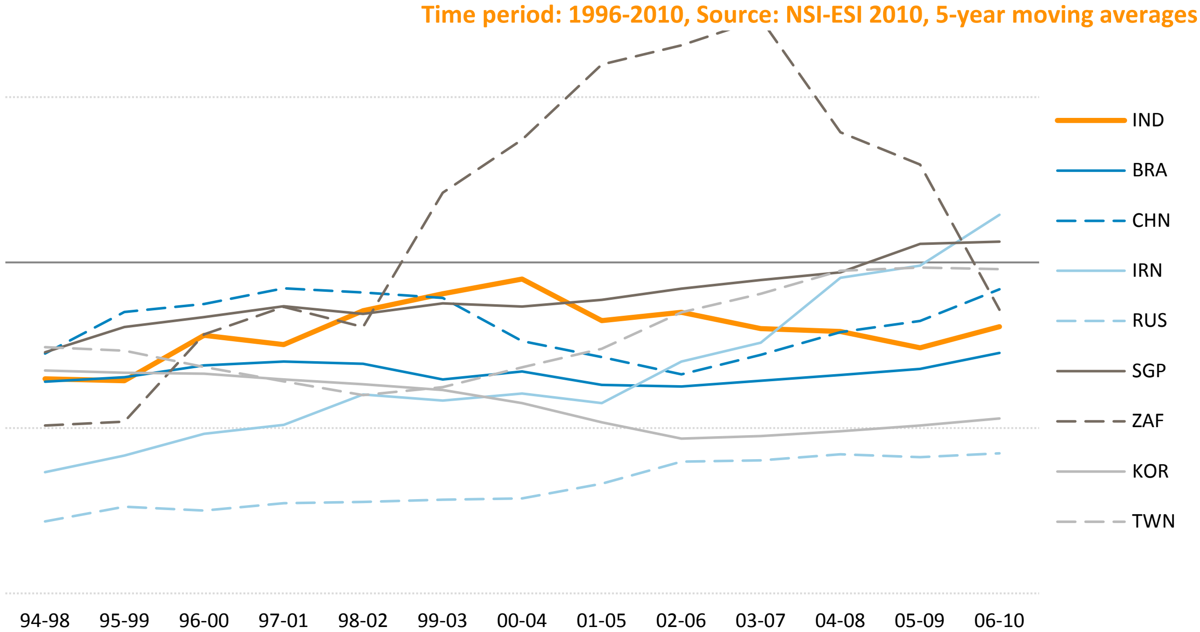


India's citation impact rose from 0.65 to 0.81. Though its rank varied within the established economies research group for a brief period (1998-2002 and 2000-2004), it was generally ahead of Japan.

The USA overtook Israel in 1996-2000 and its citation impact rose to 1.67 in 2002-2006 before falling to 1.24 by 2006-2010. Israel's citation impact fell over this period from 1.50 in 1994-1998 to 1.01 by 2006-2010. Meanwhile, the UK's citation impact rose from 0.97 in 1994-1998 to 1.31 by 2006-2010 - the highest within the group at the end of this period. Germany's citation impact also rose from 0.84 to 1.29.

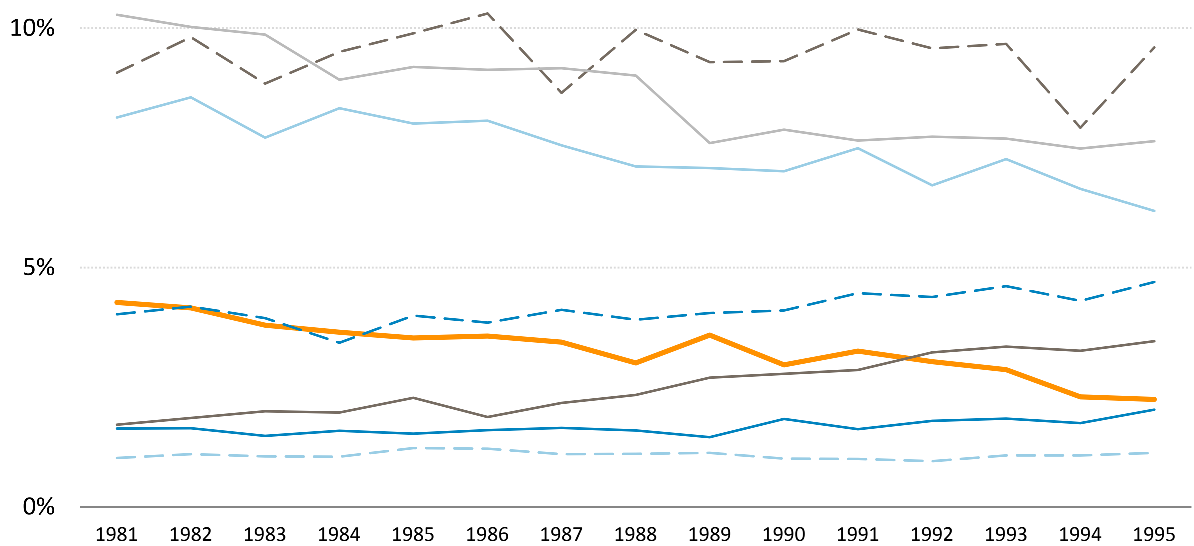
South Africa peaked in the periods from 1999-2003 to 2005-2009 (rising to 1.74 by 2003-2007), but fell back to an citation impact of 0.86 by 2006-2010. India's rank relative to other emerging research economies varied substantially, occasionally rising to second (1998-2002 to 2000-2004) but falling back to rank sixth by 2006-2010. Singapore and Iran by 2006-2010 had crossed the world average threshold (1.06 and 1.14 respectively).

5.19.b.iv: Normalised citation impact, Computer science, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.20.a: Share of world research output, Engineering

5.20.a.i: Share of world research output, Engineering, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

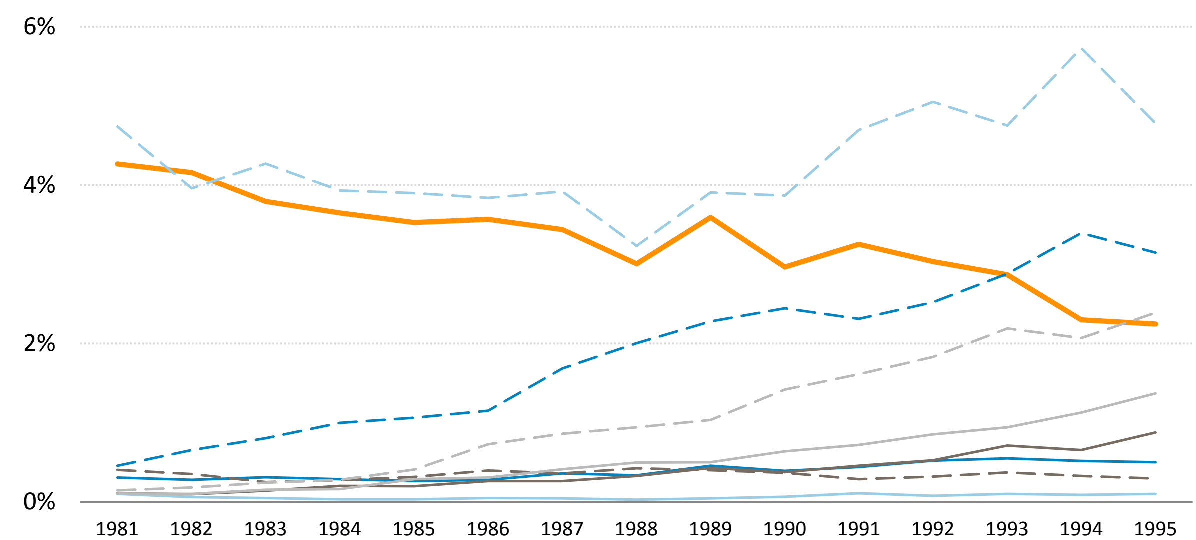


In this earlier period, India's percentage share of world output in Engineering fell from 4.3% in 1981 to 2.2% by 1995. Amongst the established research economies, India initially ranked fifth but its rank fell as it was superseded by France from 1985 onwards and Italy from 1992 onwards. Amongst the emerging research economies, India was a close second to Russia, but its rank fell to third as its share was surpassed by China in 1993 and then to fourth as it was surpassed by Taiwan.

Amongst the established research economies, the share of the USA (not shown) averaged 38.5% over this period, and was not particularly challenged. Japan's share averaged 9.4% and the UK's share declined from 10.3% in 1981 to 7.6% by 1995. Germany's share also fell from 8.1% in 1981 to 6.2% by 1995. Italy's share increased by 1.7% over the period.

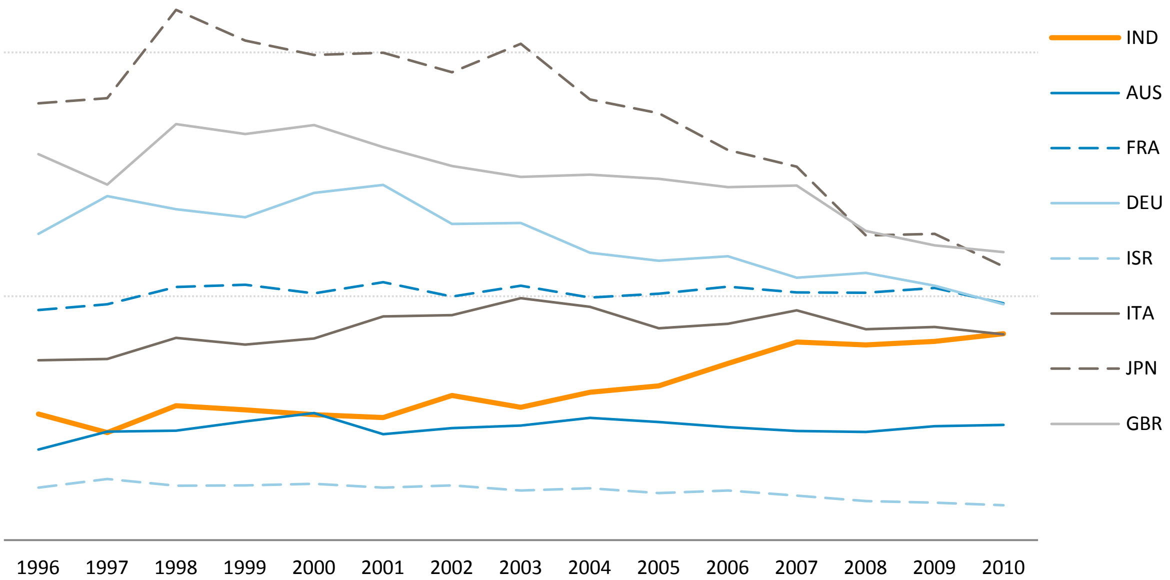
Amongst the emerging research economies, Russia's share fell from 4.7% in 1981 to 3.2% in 1988, but rose again to a high of 5.7% by 1994. The rise of China (+2.7%), Taiwan (+2.2%) and Korea (+1.3%) was apparent.

5.20.a.iii: Share of world research output, Engineering, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.20.a: Share of world research output, Engineering

5.20.a.ii: Share of world research output, Engineering, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

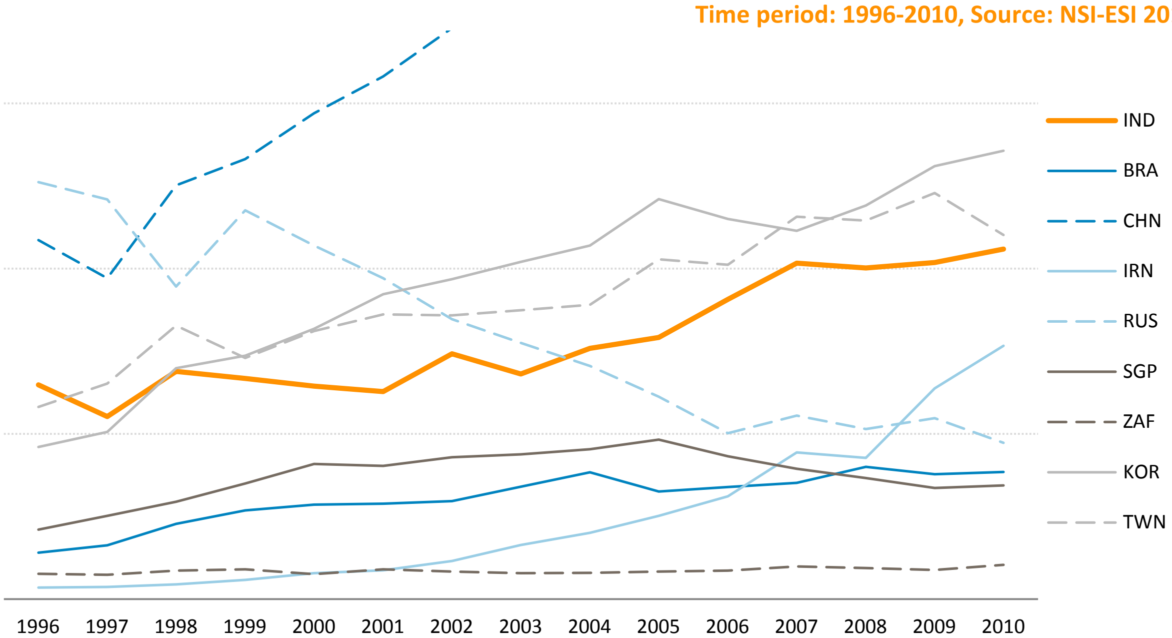


In this later period, India somewhat regained the share it had lost. Its share increased from 2.6% in 1996 to 4.2% by 2010 - nearly a return to its 1981 levels of world share. However, its rank had fallen to the other emerging research economies: it share was also surpassed by Korea in this period, ranking fourth by 2010 after Russia's fall in share from 2004 onwards.

Amongst the established research economies, the USA's world share (not shown) more or less halved from its levels during the previous period: by 2010, the USA held 20.8% of world share in Engineering. China's rise from 4.3% in 1996 to 16.4% of world output in Engineering in 2010 was undeniably linked. Japan's share fell from a high of 10.9% in 1998 to 5.6% by 2010. The shares of the UK and Germany fell (-2.0% and -1.4%).

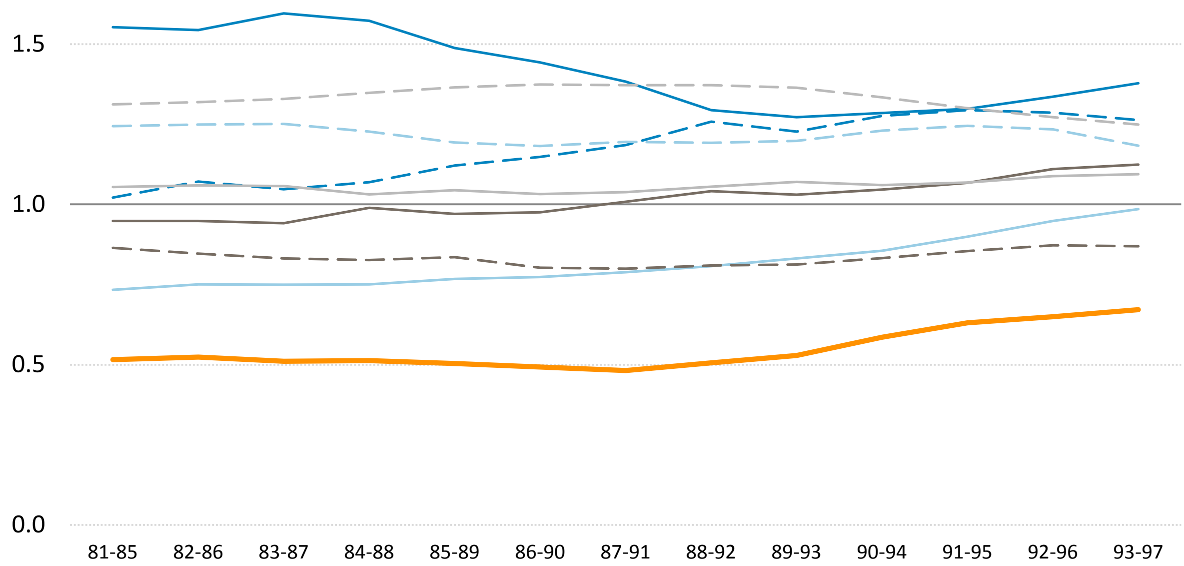
As Russia's world share in Engineering plummeted (-3.2% over the period), Korea increased its share from 1.8% in 1996 to 5.4% by 2010. Taiwan also increased its share from 2.3% in 1996 to 4.4% by 2010, although India is narrowing the difference. Iran has notably gone from a 0.1% share in 1996 to a 3.1% share by 2010.

5.20.a.iv: Share of world research output, Engineering, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.20.b: Normalised citation impact, Engineering

5.20.b.i: Normalised citation impact, Engineering, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

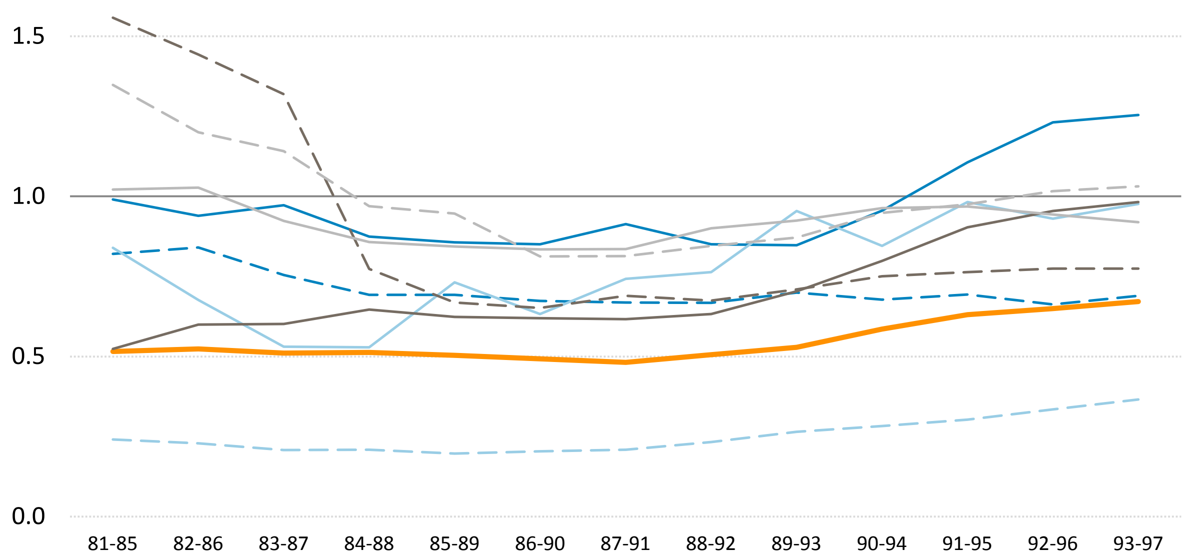


Although India ranked the lowest amongst the established research economies, and second lowest amongst the emerging research economies, India's citation impact increased over this period from 0.52 in 1981-1985 to 0.67 by 1993-1997, which was a strong improvement.

Amongst the established research economies, Australia initially ranked first, and its rank fell to the USA in the late 1980s/early 1990s although this rank was regained at the end of the period. France's citation impact increased from 1.02 in 1981-1985 to 1.26 by 1993-1997. Israel ranked quite highly, although its rank fell from third to fourth within the group.

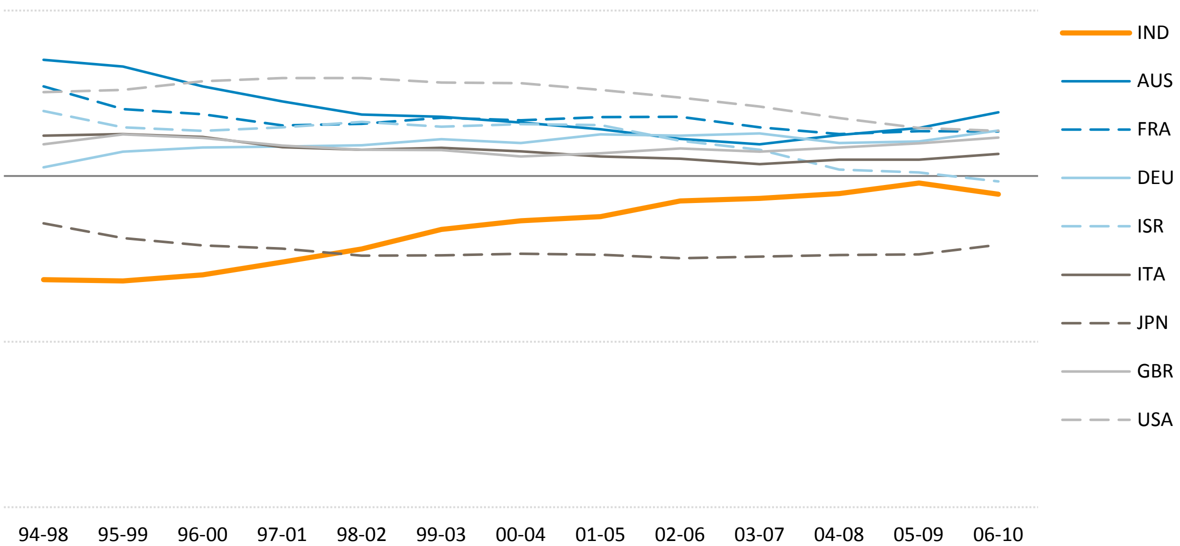
South Africa's citation impact was very high at the start, though it fell to 0.77 by 1984-1988 which was the citation impact it had in 1993-1997. Taiwan's citation impact was also very high: 1.35 at the start, and although it fell to below world average levels, it was 1.03 by 1993-1997. Brazil's citation impact rose from 0.99 in 1981-1985 to 1.25 by 1993-1997. Singapore's citation impact doubled from 0.52 to 0.98.

5.20.b.iii: Normalised citation impact, Engineering, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.20.b: Normalised citation impact, Engineering

5.20.b.ii: Normalised citation impact, Engineering, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

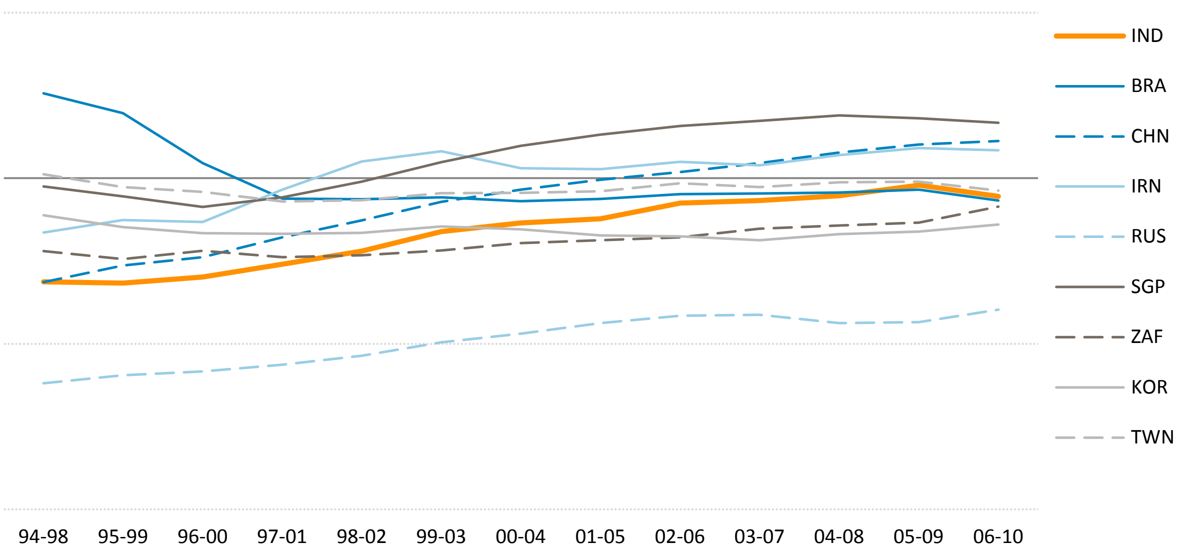


In this later period, India made major improvements in its citation impact in Engineering: its citation impact rose from 0.69 in 1994-1998 to 0.95 by 2006-2010 with a high of 0.98 in 2005-2009. It also had a higher citation impact than Japan from 1998-2002 onwards. Amongst the emerging research economies, India's rank moved from seventh in 1994-1998 to fifth by 2006-2010.

Amongst the established research economies, Australia again regained its top rank at the beginning and the end of the period. The USA's citation impact rose from 1.25 in 1994-1998 to 1.30 by 1997-2001 and 1998-2002 but fell to 1.14 by 2006-2010. France's citation impact fell from 1.27 in 1994-1998 to 1.13 by 2006-2010, and Israel's fell from 1.20 in 1994-1998 to 0.98 by 2006-2010.

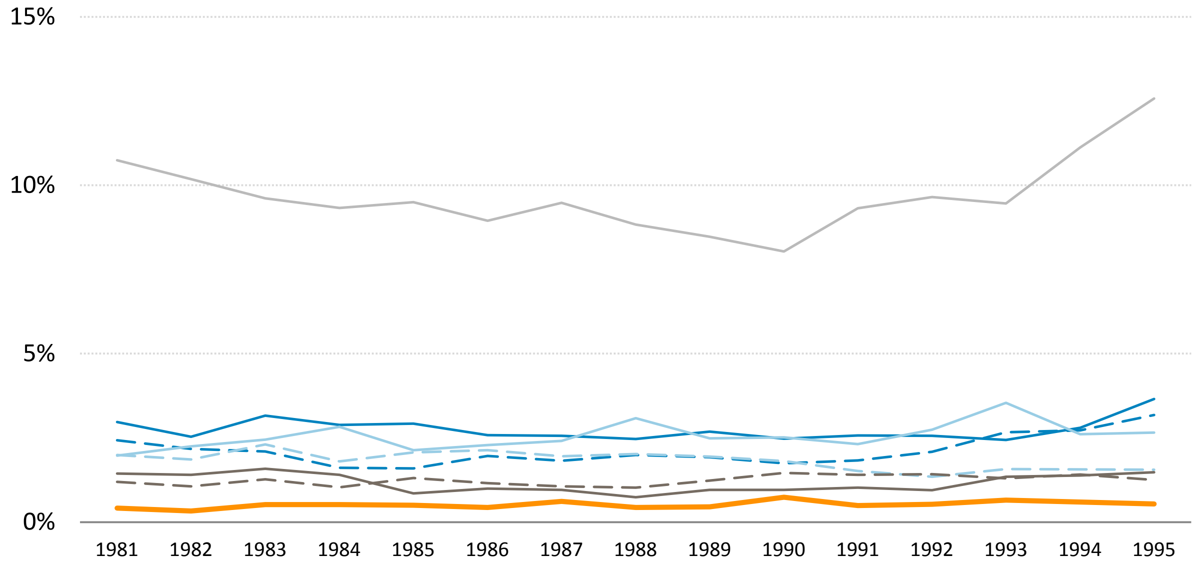
Amongst the emerging research economies, Singapore's citation impact increased from 0.98 in 1994-1998 to 1.17 - not far short of Australia's citation impact (1.19) at the same time. Iran's citation impact also increased to 1.08 by 2006-2010. China's citation impact rose from 0.69 in 1994-1998 to 1.11 by 2006-2010.

5.20.b.iv: Normalised citation impact, Engineering, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.21.a: Share of world research output, Economics & business

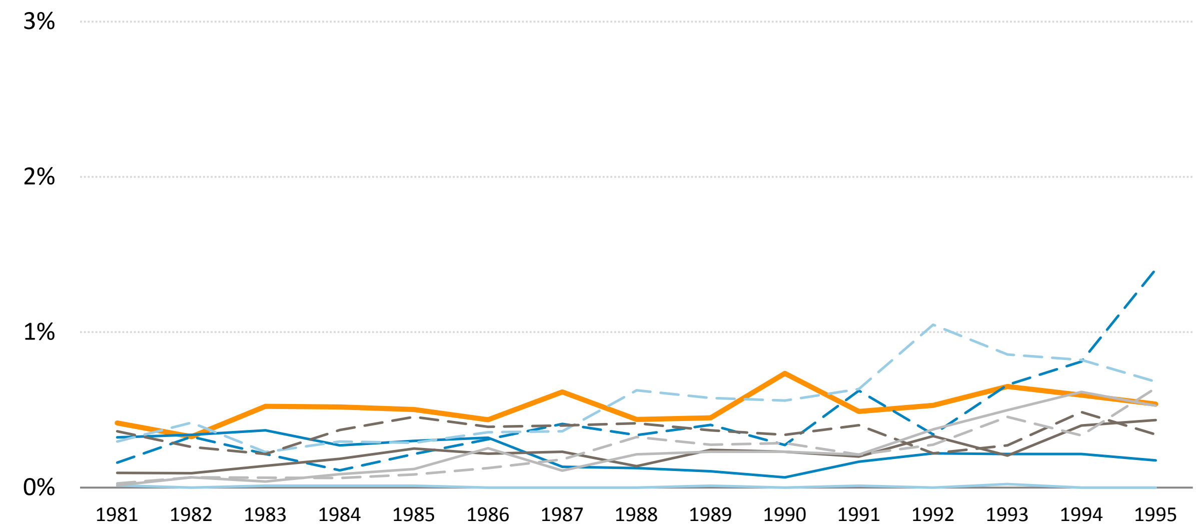
5.21.a.i: Share of world research output, Economics & business, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010



In this earlier period, India's world share of output in Economics and business averaged 0.5%. It ranked the lowest amongst the established research economies in this field, and its rank varied amongst the emerging research economies, although their shares in this area of research are so small (all less than 1%) with the exception of China, whose share rose to 1.4% by 1995, and Russia whose output in 1992 was 1.0%.

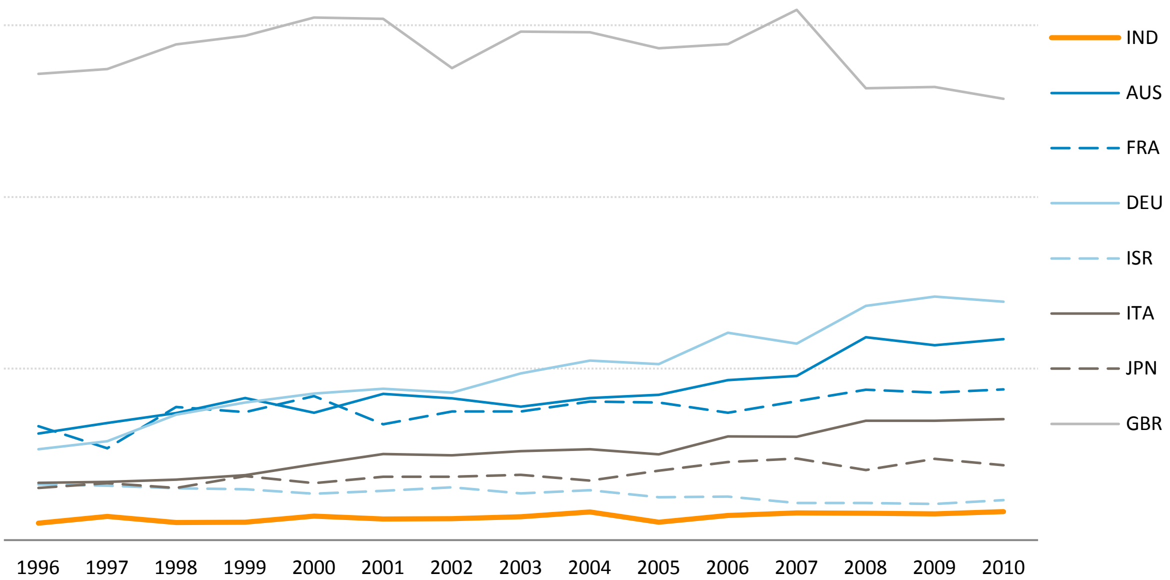
This is a field in which the USA (not shown) clearly dominates, although its share has somewhat fallen. In 1981, the USA had a world share in Economics and business of 65.9% and this rose to a high of 68.2% in 1990. However, by 1995, this share had fallen to 60.8%. The UK was the second largest player in this field, with a world share of 10.7% in 1981, which fell to 8.0% in 1990, but rose to 12.6% by 1995. The other established research economies had shares which were typically less than 3%. That said, Australia's world share in this field rose to 3.7% by 1995 and Germany's share over the period averaged 2.6%.

5.21.a.iii: Share of world research output, Economics & business, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.21.a: Share of world research output, Economics & business

5.21.a.ii: Share of world research output, Economics & business, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

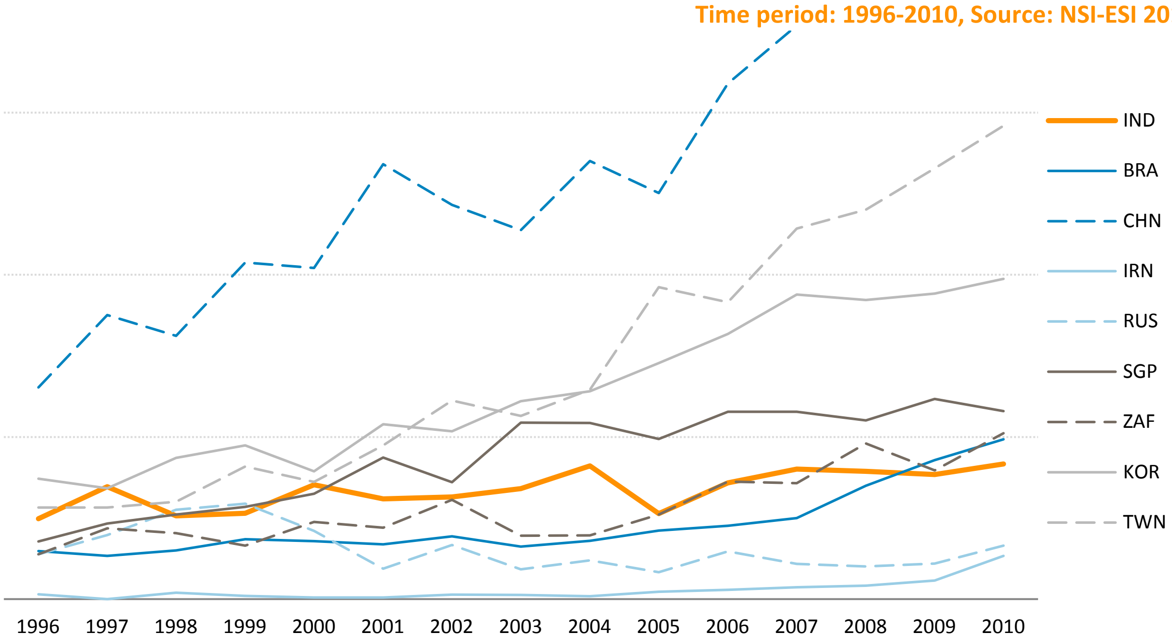


India's world share of output in Economics and business averaged 0.7%, a slight rise on the earlier period. It ranked the lowest amongst the established research economies, and its rank varied amongst the emerging research economies, though it broadly moved from fourth to seventh, as its world share was superseded by China (1993), Korea and Taiwan (1998), Singapore (2001), and latterly South Africa (2008) and Brazil (2009).

The USA's share (not shown) fell from 59.3% in 1996 to 39.3% by 2010 - a fall of 20.0%. The UK's share rose from 13.6% in 1996 to a high of 15.5% by 2007 although its share fell to 12.9% by 2010. The gains made by emerging research economies in this field are remarkable compared to other fields. Germany increased its share from 2.7% in 1996 to 6.9% by 2010 (+4.3%), as did Australia (+2.8%), France (+1.1%) and Italy (+1.9%).

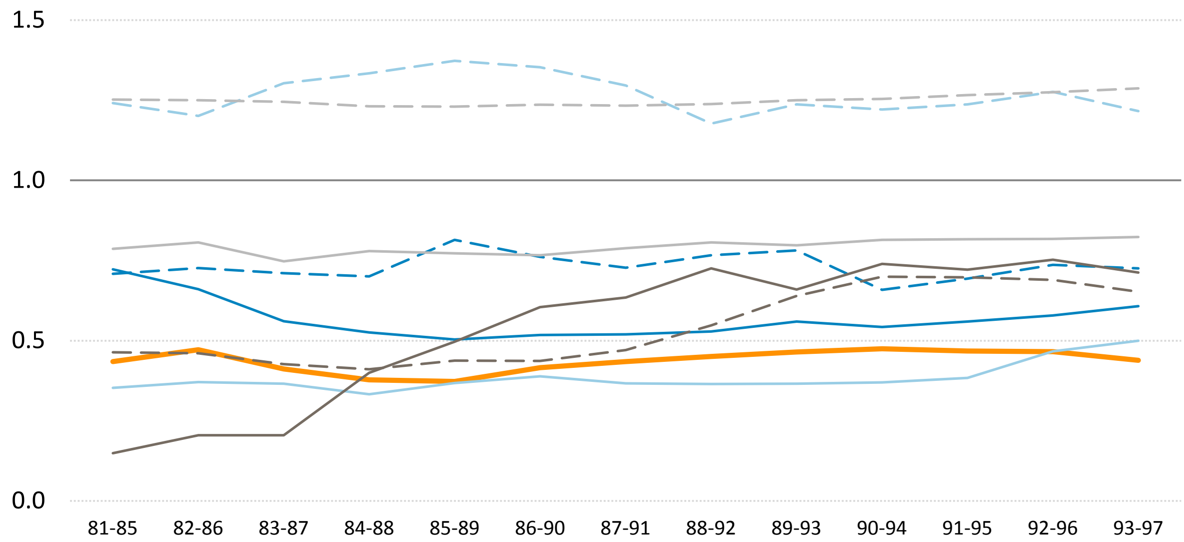
China's share increased from 1.3% in 1996 to 4.7% by 2010. Over the same time periods, Taiwan's share increased from 0.6% to 2.9%; Korea's from 0.7% to 2.0%; and Singapore's from 0.4% to 1.2%.

5.21.a.iv: Share of world research output, Economics & business, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.21.b: Normalised citation impact, Economics & business

5.21.b.i: Normalised citation impact, Economics & business, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

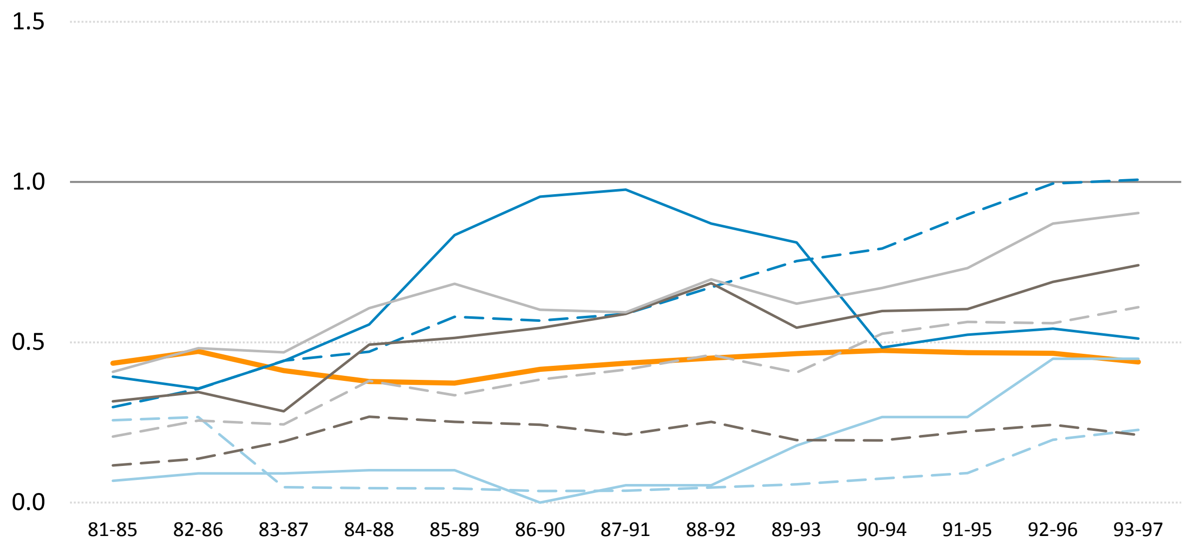


India's citation impact in Economics & Business was well below world average. It was 0.43 in 1981-1985 and by 1993-1997 it was 0.44. This is a negligible improvement. India's rank moved from seventh (ahead of Germany and Italy) to last by the end of the period.

Israel and the USA had the highest citation impact in this field. Israel's citation impact was 1.24 in 1981-1985 and 1.22 by 1993-1997; and the USA's citation impact rose from 1.25 in 1981-1985 to 1.29 by 1993-1997. All other established research economies were below world average, including (surprisingly given its world share in Economics & Business) the UK which averaged 0.79 over this period.

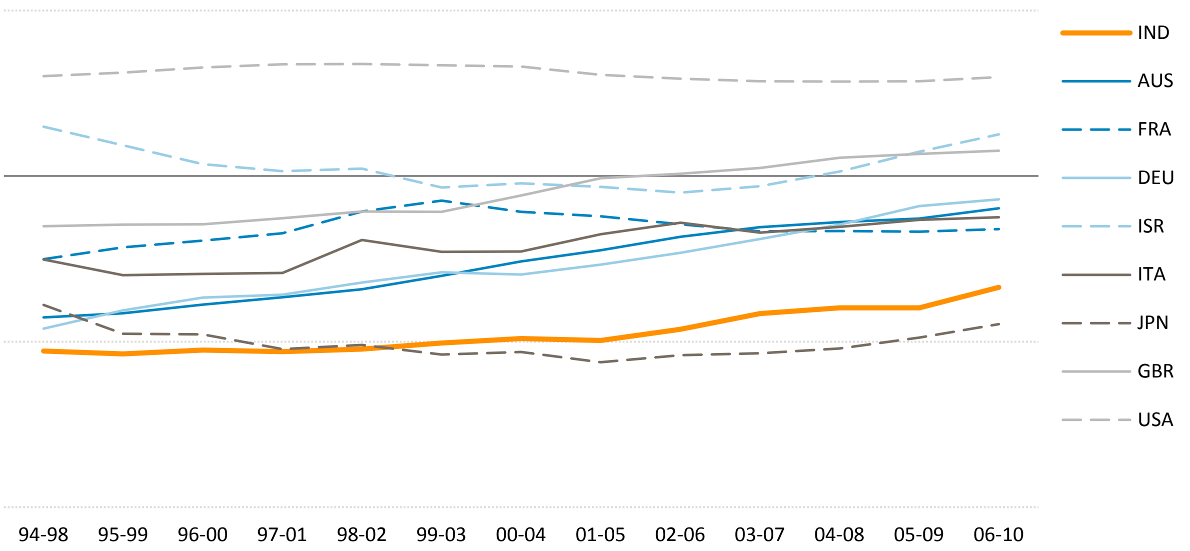
Excluding the countries with low paper numbers, China made the greatest improvements in citation impact in Economics & Business, with its citation impact rising from 0.30 in 1981-1985 to 1.01 (over world average) by 1993-1997. Korea's citation impact improved from 0.41 in 1981-1985 and 0.90 by 1993-1997 and Singapore's citation impact increased from 0.32 in 1981-1985 to 0.74 by 1993-1997.

5.21.b.iii: Normalised citation impact, Economics & business, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.21.b: Normalised citation impact, Economics & business

5.21.b.ii: Normalised citation impact, Economics & business, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

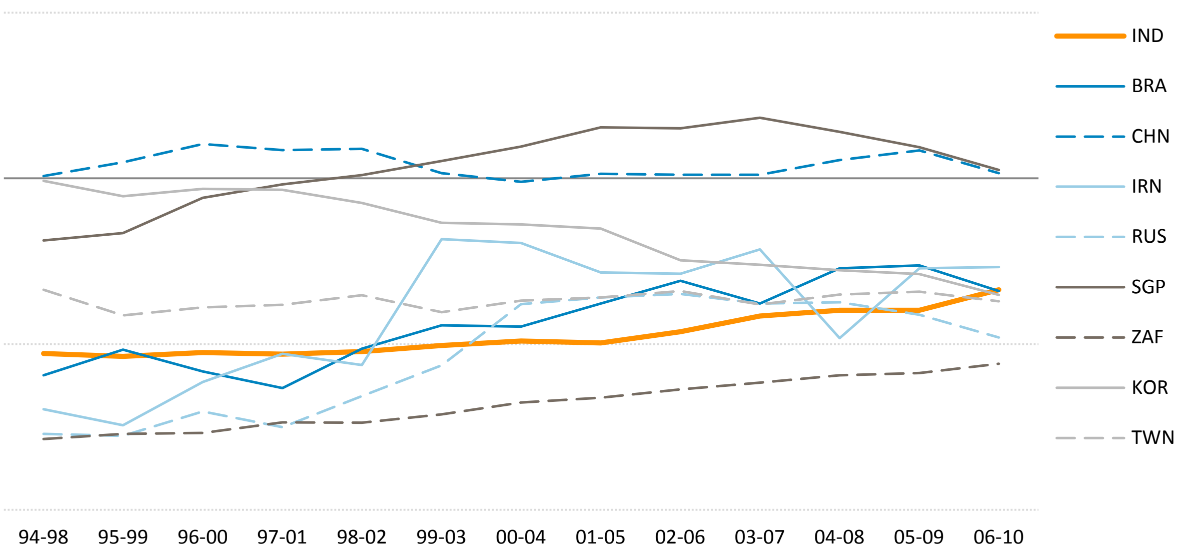


In this later period, India's citation impact improved from 0.47 in 1994-1998 to 0.66 by 2006-2010. Amongst the established research economies, its rank moved from ninth to eighth as it overtook Japan from 1999-2003 onwards. Amongst the emerging research economics, its rank moved from fifth in 1994-1998 to eighth by 2000-2004, but its rank was fourth by 2006-2010 as it converged with Brazil and Korea.

The USA had a clear lead on citation impact, which averaged 1.31 over the period. Israel's citation impact fell over the period from 1.15 in 1994-1998 to a low of 0.95 by 2002-2006 before it rose to 1.13 by 2006-2010. The UK's citation impact rose from being below world average (0.85 in 1994-1998) to above world average (1.08 in 2006-2010).

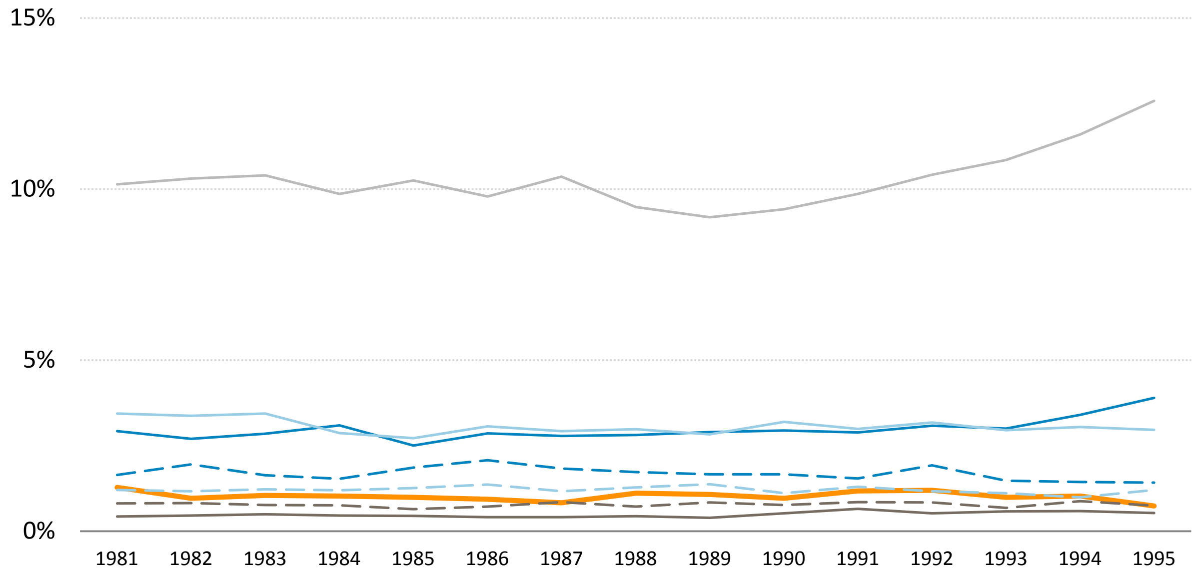
Singapore's citation impact rose from 0.81 in 1994-1998 to a high of 1.18 by 2003-2007. Interestingly, China's citation impact was also above world average for the majority of this period (1.02 by the end of the period), but Korea's citation impact decreased (from 0.99 in 1994-1998 to 0.65 by 2006-2010).

5.21.b.iv: Normalised citation impact, Economics & business, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



Section 5.22.a: Share of world research output, Social sciences

5.22.a.i: Share of world research output, Social sciences, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010

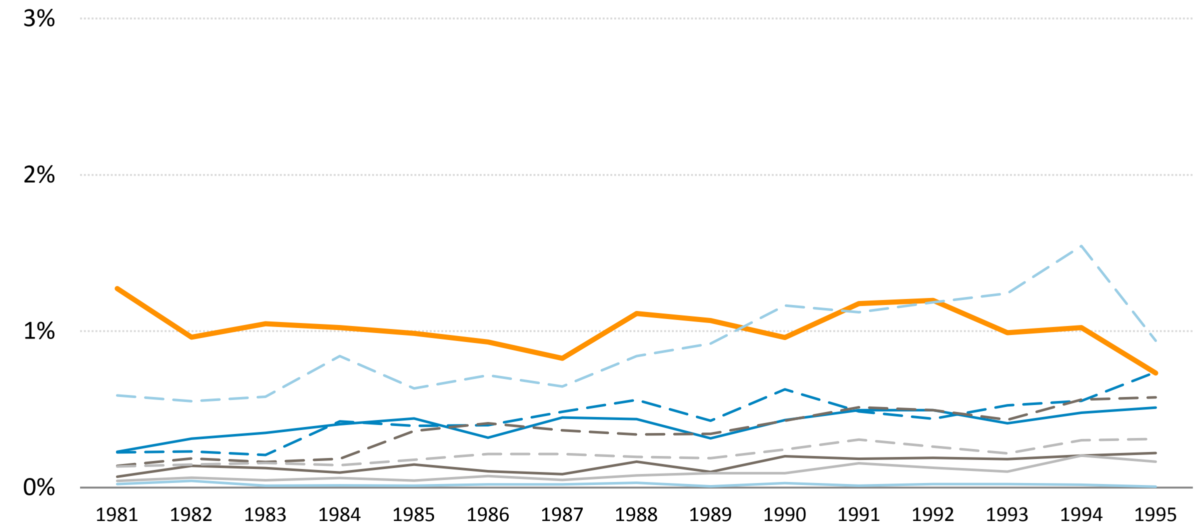


India's share of world output in Social Sciences was 1.3% in 1981, and this fell to 0.7% by 1995 averaging 1.0% of output over the period. Amongst the established research economies, India's rank varied in this field. However, it was first amongst the emerging research economies until India was overtaken by Russia in 1993 and China in 1995. With the exception of India and Russia, most emerging research economies had less than a 1% share in this field.

The USA (not shown) clearly dominated this field, with a 65.3% share in 1981 which fell to 61.3% by 1995. The UK was second to the USA in this field: its share rose from 10.1% in 1981 to 12.6% by 1995. Other established research economies had less than a 4% share in this field, although Australia's share rose from 2.9% in 1981 to 3.9% by 1995 and Germany share broadly averaged 3.1%.

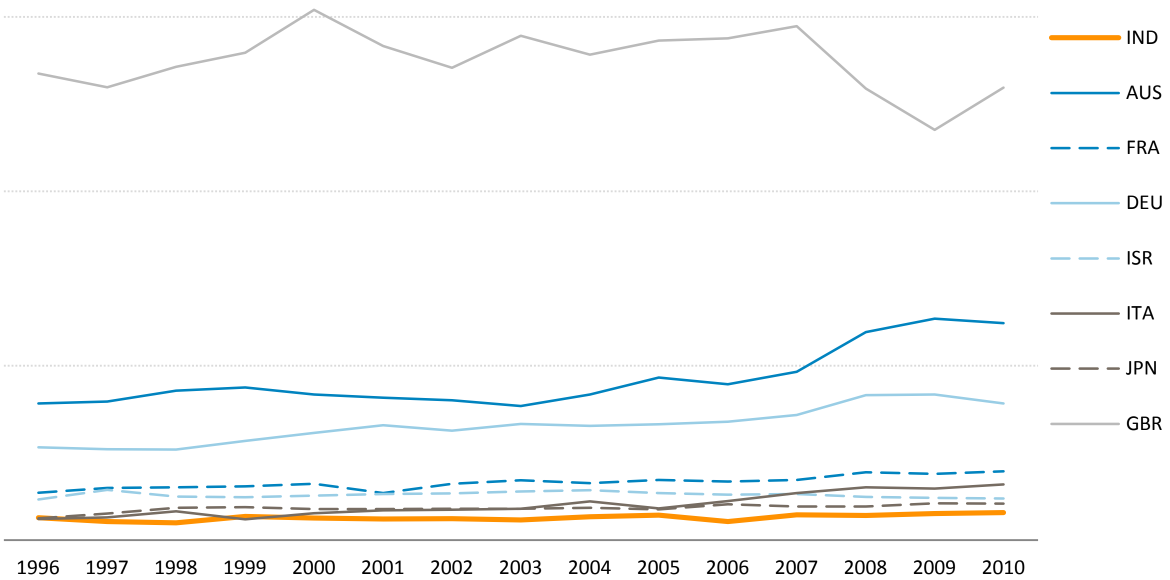
Russia's share rose from 0.6% in 1981 to a high of 1.5% in 1994, but fell again to 0.9% by 1995. China's share increased from 0.2% in 1981 to 0.7% by 1995.

5.22.a.iii: Share of world research output, Social sciences, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010



Section 5.22.a: Share of world research output, Social sciences

5.22.a.ii: Share of world research output, Social sciences, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010

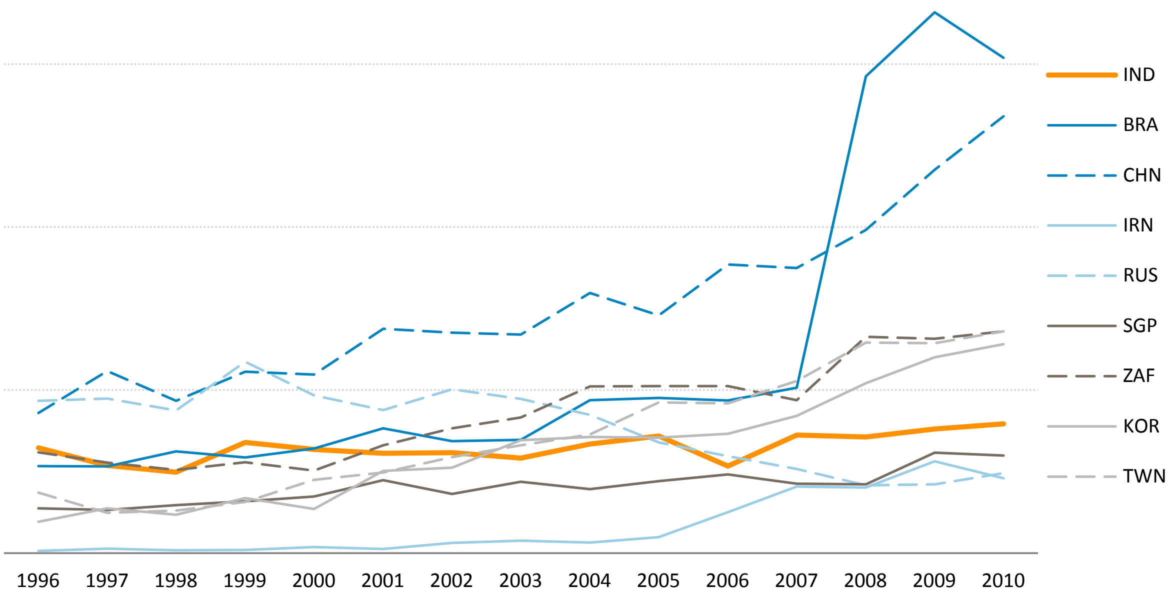


India's share of world output in Social Sciences research was 0.6% in 1996 and 0.8% by 2010 averaging 0.6% over the period. Amongst the established research economies, India's rank moved to last in this field by 2010. India's rank moved from having been first in the 1980s to being sixth among the emerging research economies by 2010.

The USA (not shown) saw its world share in Social Sciences research fall from 60.1% in 1996 to 40.9% by 2010, a fall of 19.2%. The UK saw its share rise from 13.4% in 1996 to a high of 15.2% by 2000, but it was 13.0% by 2010. Australia's share rose further in this period: from 3.9% in 1996 to 6.2% by 2010 (over doubling of its 1981 share). Germany's share also rose from 2.7% in 1996 to 3.9% by 2010. Other countries had less than a 2% share in this field.

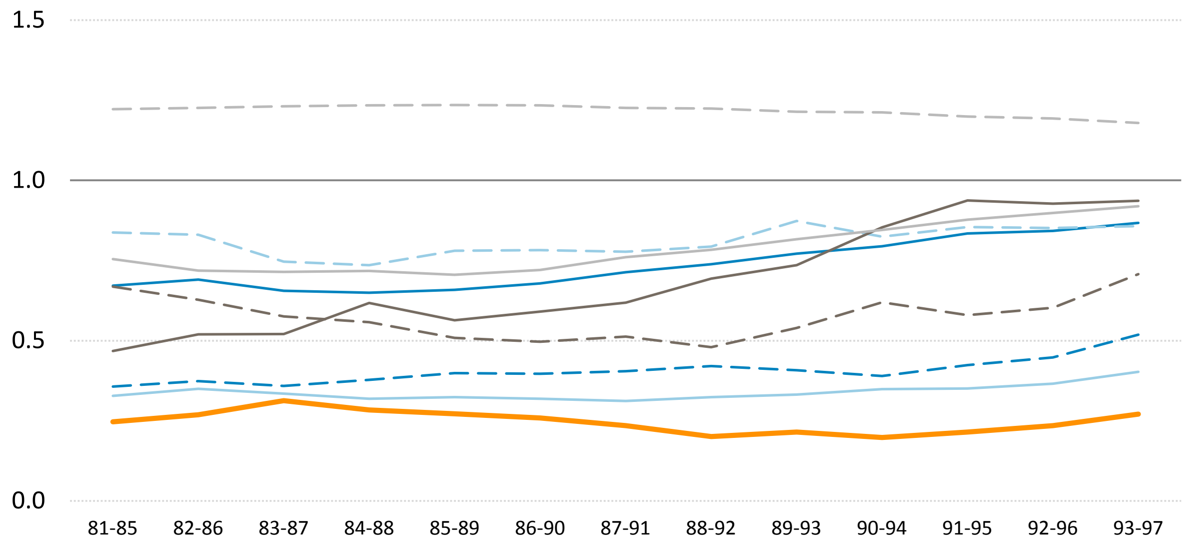
China's output in Social Sciences increased from 0.9% in 1996 to 2.7% by 2010, but it was overtaken by Brazil in 2008, whose share rose from 0.5% to 3.0% by 2010. Other countries had less than a 2% share.

5.22.a.iv: Share of world research output, Social sciences, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010



Section 5.22.b: Normalised citation impact, Social sciences

5.22.b.i: Normalised citation impact, Social sciences, Established research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages

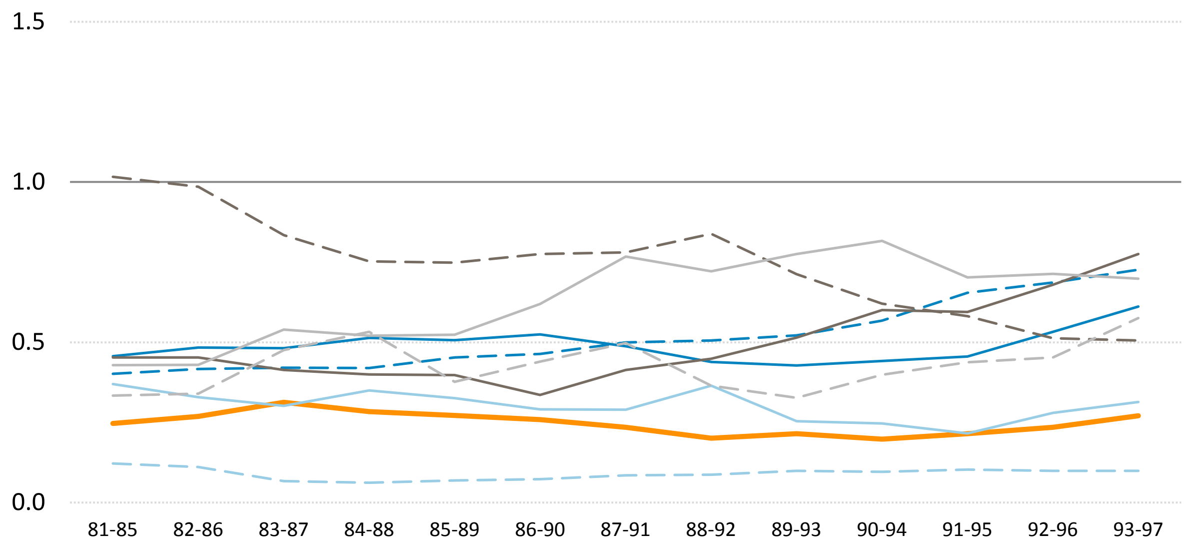


In Social Sciences, India's citation impact was 0.25 in 1981 rising to 0.27 by 1993-1997. These levels are well below world average, and the improvement is negligible. It is important to note however, that all the established and emerging research economies with the exception of the USA are 'below the line' of the world average on this indicator. That said, India ranked the lowest amongst the established research economies, and was second lowest to Russia amongst the emerging research economies in terms of citation impact.

The USA's citation impact was the highest over the period, averaging 1.22. It is again surprising that the UK's impact is below average (as in Economics & Business): its citation impact rose from 0.75 in 1981-1985 to 0.92 by 1993-1997. Italy's citation impact improved dramatically (+0.47) as did Australia's (+0.20). Israel's citation impact averaged 0.81.

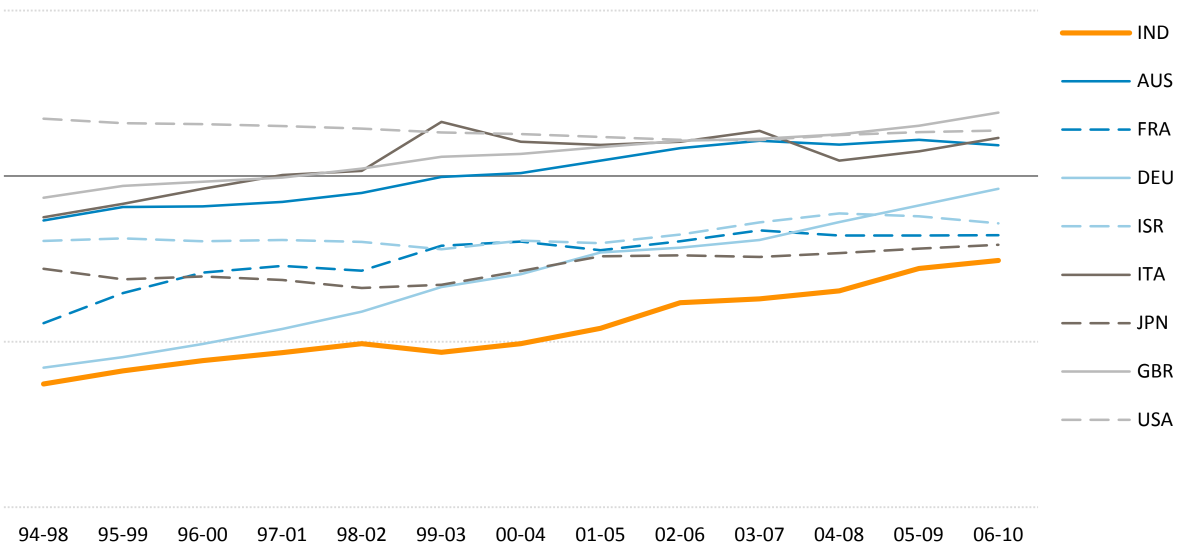
Amongst the emerging research economies, Singapore and China's citation impact improved (both +0.32), as did Korea's (+0.27). South Africa's citation impact fell (-0.51).

5.22.b.iii: Normalised citation impact, Social sciences, Emerging research economies
Time period: 1981-1995, Source: NSI-ESI 2010, 5-year moving averages



Section 5.22.b: Normalised citation impact, Social sciences

5.22.b.ii: Normalised citation impact, Social sciences, Established research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages

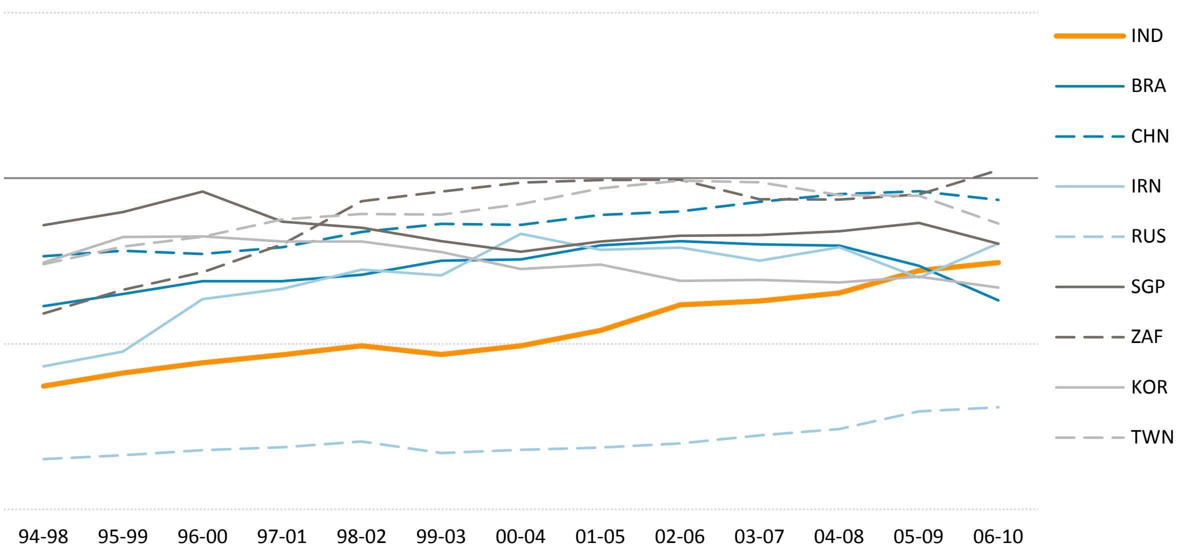


In this later period, India's citation impact improved dramatically in Social Sciences, just over doubling from 0.37 in 1994-1998 to 0.75 by 2006-2010. It still ranked the lowest amongst the established research economies, but its rank improved from eighth to sixth amongst the emerging research economies.

The USA's citation impact was 1.17 in 1994-1998 and broadly fell over the period to 1.14 by 2006-2010. In fact, the UK overtook the USA in terms of citation impact from 2003-2007 onwards, rising from an citation impact of 0.93 in 1994-1998 to 1.19 by 2006-2010. Italy also improved its citation impact from 0.88 in 1994-1998 to 1.12 by 2006-2010, as did Australia (from 0.87 to 1.09 over the same time period).

Amongst the emerging research economies, only South Africa crossed the line of the world average by 2010, and the rest were otherwise below world average. That said, there were improvements in Chinese citation impact (+0.17) and Taiwanese citation impact (+0.12).

5.22.b.iv: Normalised citation impact, Social sciences, Emerging research economies
Time period: 1996-2010, Source: NSI-ESI 2010, 5-year moving averages



6 Impact Profile® analysis

Whilst average normalised citation impact is useful for comparing the relative academic quality of groups of research papers, the distribution of citations is inherently skewed (there are many less frequently cited papers and fewer more frequently cited papers). *Evidence* has developed the Impact Profile® as a way of overcoming this problem of skewed data in order to allow the distribution of citations to be visualised.

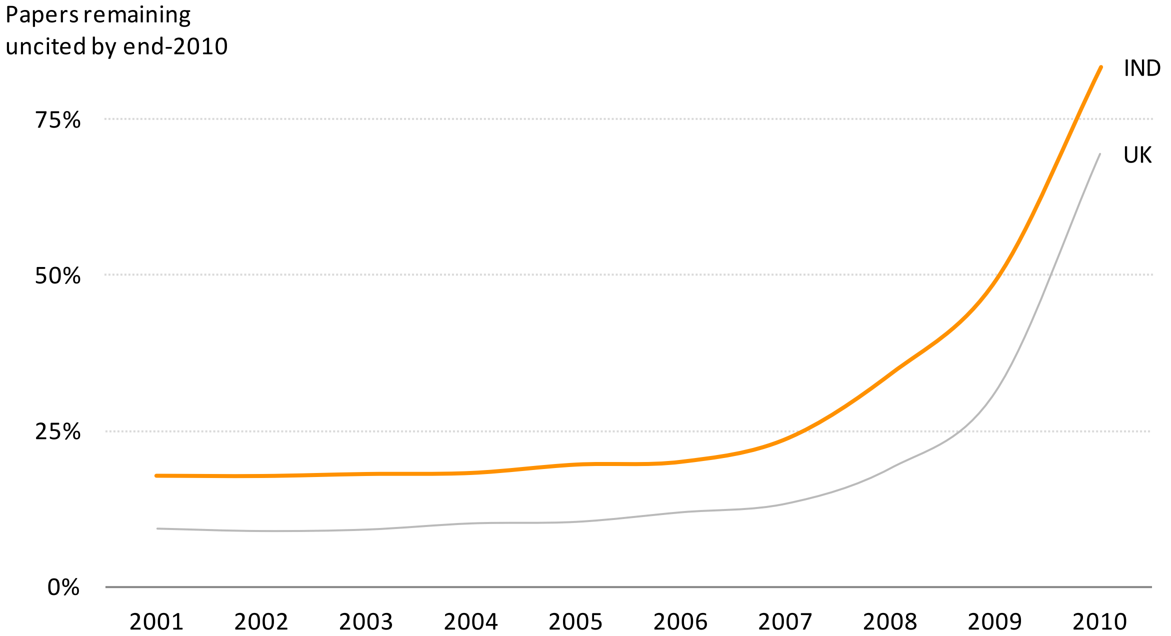
Here, we evaluate the distribution of citation impact for Indian research as whole, and also disaggregated by the *Essential Science Indicators®* fields. We compare the distribution of normalised citation counts for papers published during the periods 2001-2005 and 2006-2010, with end-2005 and end-2010 citation counts respectively. This analysis allows changes in citation impact over time to be understood in detail.

Each Impact Profile® is provided on a single page with interpretative commentary. Impact Profiles® contain a great deal of important information and data about the distribution of citation impact of a research area. Therefore, the analysis is structured to tackle the individual components of the Impact Profiles® and how these may have changed over time. The elements which are tackled include:

- The percentage of research which is uncited
- The percentage of research which receives less than the world average number of citations
- The percentage of research which receives more than the world average number of citations
- The modal (most frequent) impact category
- The percentage of highly-cited papers (cited at least four times or more than the world average)

A special methodological note which needs to be made on the Impact Profiles® in this report are the relatively high levels of uncitedness which characterise the Indian research profile. India (as an emerging research economy) has a slower citation rate than established research economies (for example the UK) and relatively more papers remain uncited in each year post publication. In addition, higher levels of uncitedness are to be expected over shorter time frames, such as the five-year time frames which are used in this analysis.

Papers remaining uncited at end-2010, All fields, India and UK
Time period: 2001-2010, Source: NCR India 2010 and NCR UK 2010, Citations to end-2010



Summary

The Impact Profile® for Indian research as a whole reveals several features which are common to most (though not all) fields. The percentage of Indian papers which were uncited was relatively high compared to the equivalent levels in established research economies such as the UK: 44.9% v 29.9% in 2006-2010. However, there was a fall in the percentage of uncited research (-7.0%) meaning that there was a rising percentage of cited research (by definition equal to the fall in uncited research). By 2006-2010, Indian papers which had received less than the world average number of citations (nci >0 and <1) was 35.1% (an increase of +3.1% on 2001-2005); the percentage of Indian research papers which had received more than the world average number of citations (nci≥1) was 20.0% (an increase of +3.9% on 2001-2005). This accounts for the general skew of the curves leftwards towards the lower categories of citation impact, but also the pull of the curve rightwards towards the higher categories of citation impact in 2006-2010. The percentage of Indian research which was highly-cited (cited at least four times or more than the world average) in 2006-2010 was 2.7% an increase of +0.2%. The equivalent figure for the percentage of highly-cited papers in the UK was 8.6% in 2006-2010, indicative of the substantial gap in citation impact which remains to be narrowed.

However, this is a story of improvement. The basic pattern of India's Impact Profiles® highlights several key themes in these analyses:

- A relatively high level of uncitedness
- Falls in uncitedness and therefore rises in citedness
- Proportionately more research falls into impact categories where citation impact is below rather than above world average (the **distributions are skewed leftwards**), but there is typically a greater change in impact categories which are above rather than below world average (**distributions are moving rightwards**) between 2001-2005 and 2006-2010, which is indicative of **improvement**
- **Low proportions of highly-cited papers** compared to established research economies
- In some fields, **bimodality** is evident, i.e. there are two most frequent impact categories

However, there are variations by field.

- **Clinical Medicine**: A smaller fall in uncitedness (-3.6%) compared to the Indian background. Whilst papers are strongly skewed towards citations which are below world average (40.2% in 2006-2010), there has been an increase in papers with citations that are above world average (+4.4%). There has been a particular lift in the impact category (nci ≥1 and <2) of +4.8%, which may be indicative of emerging bimodality. Highly-cited papers were relatively small: 1.9% by 2006-2010 (an increase of +0.4% on 2001-2005).
- **Psychiatry/Psychology**: Paper numbers are small. There was quite a substantial fall in uncitedness (-9.2%). Papers with above world average citations (nci≥1) accounted mostly for this fall: +8.0%, which was the second highest rise in papers with above world average citations across the fields. The impact category (nci ≥2 and <4) rose by +7.9%, which may be indicative of emerging bimodality. The percentage of highly-cited papers was comparatively high by 2006-2010: 5.3% of papers (+2.1% on 2001-2005).
- **Neuroscience & Behaviour**: Quite a large fall in uncitedness (-12.3%). Whilst papers were strongly skewed towards the impact categories which were below world average (46.5% in 2006-2010), there was a +9.0% increased in papers which citations that are above world average. There was a notable fall in the impact category (nci ≥0.125 and <0.25). The percentage of highly-cited papers was quite negligible: 1.0% by 2006-2010 (+0.2% on 2001-2005).
- **Immunology**: The highest percentage of research which was cited below the world average (59.3% in 2006-2010), and a small percentage of research which was cited above world average (14.8% in 2006-2010), although a greater increase has occurred here (+6.2%). Highly-cited papers were infrequent: 0.7% by 2006-2010 (+0.2% on 2001-2005).
- **Pharmacology & Toxicology**: Uncitedness increased by a small amount in this field, and this also happened in Microbiology which also experienced large growth research paper output. The shape of the curve changed only slightly, with a slight drop in the percentage of papers that were cited below the world average, and a slight increase in the percentage of papers that were cited above the world average, although the distribution is strongly skewed leftwards. The percentage of highly-cited papers was small: 2.0% in 2006-2010 (+0.5% increase on 2001-2005).

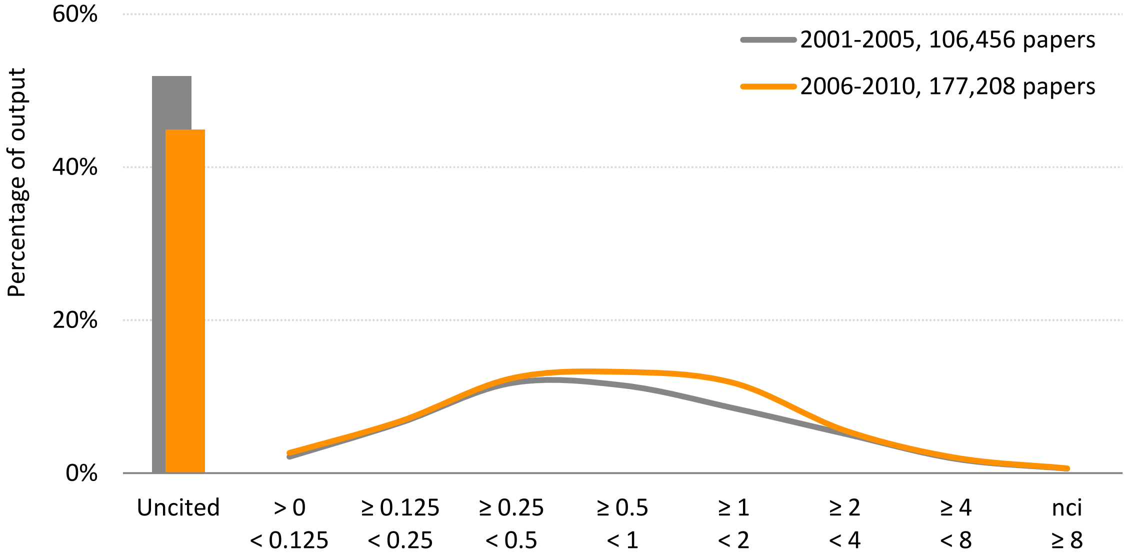
- **Molecular Biology & Genetics**: Levels of uncitedness were below the background figures for Indian research as a whole (33.0% by 2006-2010). However, papers are strongly skewed towards impact categories which are below world average (56.5% in 2006-2010) than those above world average (10.5% by 2006-2010) – the lowest percentage in all fields. The percentage of highly-cited papers in 2006-2010 was 0.9%, a fall on 2001-2005 (-0.1%).
- **Biology & Biochemistry**: A relatively small fall in uncitedness (-2.7%). Citation impact was strongly skewed towards the impact categories which are below world average (45.7% in 2006-2010), and there was an increase in papers which received citations above the world average (+4.1%). The percentage of highly-cited papers was small: 1.3% by 2006-2010 (+0.4% increase on 2001-2005).
- **Microbiology**: Paper numbers almost tripled (181.5%) but uncitedness increased substantially (+8.9%) probably in part due to such rapid growth. The balance of the distribution of citation impact was strongly skewed leftwards (40.5% by 2006-2010) compared to the right-hand side of the distribution (13.6% in 2006-2010). The percentage of highly-cited papers was 0.8% by 2006-2010, a small percentage and a -0.2% fall on 2001-2005.
- **Plant & Animal Science**: This field is characterised by comparatively high levels of uncitedness (62.1% in 2006-2010). It had the second lowest percentage of papers with citations above the world average (12.2% in 2006-2010) across the fields. The percentage of highly-cited papers was small: 1.3% by 2006-2010 but an increase on 2001-2005 (+0.6%).
- **Agricultural Sciences**: Uncitedness was comparatively high in this field (61.0% in 2006-2010). There was a lift in the curve from in the impact categories where (nci ≥0.5). The percentage of highly-cited papers increased to 3.1% by 2006-2010 (+1.1%).
- **Environment/Ecology**: This field had the largest fall in uncitedness across the fields (-13.8%). This resulted in an increase in papers which received below the world average number of citations (+8.3%) compared to those papers which received above the world average number of citations (+5.6%). The percentage of highly-cited papers was relatively small: 1.9% by 2006-2010 (an increase of +0.8% on 2001-2005).
- **Geosciences**: Uncitedness was comparatively higher than the Indian background (48.3% by 2006-2010). There was a 6.8% increase in the percentage of papers with below the world average number of citations compared to a 0.5% increase in the percentage of papers which above the world average number of citations, which can be observed in the leftwards shift of the curve. The percentage of highly-cited papers fell to 1.1% by 2006-2010 (-0.2%).
- **Chemistry**: There was a -6.6% fall in uncitedness, accounted for by a +3.1% increase in the percentage of papers which received below the world average number of citations versus +3.4% increase in the percentage of papers which received above the world average number of citations. The most notable lift in the curve occurred in the impact category (nci ≥1 and <2) +5.2% which shifted the modal impact category of papers upwards from (nci≥0.25 and <0.5). It may be indicative of emerging bimodality in Indian Chemistry research. The percentage of highly-cited papers fell to 2.1% by 2006-2010 (-0.6%).
- **Physics**: There was a -6.7% fall in uncitedness, with a greater increase in the percentage of papers which received below the world average number of citations (+4.6%) versus the percentage of papers which received above the world average number of citations (+2.1%). There is an emerging bimodality evident in the change in the impact category (nci ≥1 and <2) of +4.9%. The percentage of highly-cited papers fell to 2.9% by 2006-2010 (a fall of -1.4%) and is quite a substantial decrease.
- **Space Science**: In 2006-2010, 50.0% of papers received below the world average number of citations, which is comparatively high. So the distribution is strongly skewed leftward. There was a greater change in the percentage of papers which received less than the world average number of citations (+4.9%) versus more than the world average number of citations (+1.5%) with bimodality emerging in the lower impact categories. There was no change in the percentage of Space Science research which was highly-cited: 1.8% in both 2001-2005 and 2006-2010.
- **Materials Science**: There was quite a large fall in uncitedness (-10.0%) 26.7% of papers in 2006-2010 had more than the world average number of citations, an increase of +6.6% versus a 3.3% increase at the lower end of the distribution. There was a particular lift in the impact categories where (nci ≥1 and <4) but there was a fall in the percentage of highly-cited papers to 3.2% by 2006-2010 (-1.1%). This is quite a significant fall, but the percentage of highly-cited papers is relatively high.
- **Mathematics**: Uncitedness was at its highest in this field compared to other fields: 70.4% in 2001-2005 and 63.8% in 2006-2010. However, with this fall in uncitedness (-6.6%) this was accounted for by a -

0.5% decrease in the percentage of papers with below world average citations compared to a +7.2% increase in the percentage of papers with above world average citations, so Mathematics had relatively more papers cited above than below world average by 2006-2010 (20.4% v 15.8%) with the caveat that levels of uncitedness were high. There was quite a substantial increase in the percentage of highly-cited papers: 4.1% by 2006-2010 (an increase of 2.5%).

- **Computer Science**: Uncitedness was comparatively high (60.9% in 2001-2005 and 58.4% by 2006-2010). Whilst there was no change in the percentage of papers with above world average citations, there was a substantial increase in papers with below world average citations which was equal to the fall in uncitedness. This change pulled the 2006-2010 curve leftward. Computer Science had quite a high percentage of highly-cited papers: 4.5% by 2006-2010 (an increase of +0.4%).
- **Engineering**: Uncitedness was comparatively high in 2001-2005 (62.2%) but fell to 49.4% by 2006-2010, a fall of -12.8%. This was a large fall in uncitedness. This was accounted for by a +8.2% increase in the percentage of papers which were cited below the world average versus a +4.6% increase in papers which were cited above the world average, lifting the curve on both sides of the distribution, but relatively more on the lower end. Engineering had the highest percentage of highly-cited papers: 6.5% by 2006-2010, an increase of +3.1%. This is notable improvement for such a critical field.
- **Economics & Business**: Uncitedness was quite high (57.6% in 2006-2010), with a fall of -8.8% on 2001-2005. This was accounted for by an increase of +8.9% on papers which received below the world average number of citations, versus a -0.2% decrease on papers which received above the world average number of citations. This strongly pulled the curve leftwards, although this may reflect the typically low average number of citations in this field. However, highly-cited papers increased: 4.4% by 2006-2010, an increase of +2.6%.
- **Social Sciences**: Uncitedness was comparatively high in this field (62.4% in 2006-2010) a fall of -5.6% on 2001-2005. By 2006-2010, more papers were cited above the world average (20.8%) than below the world average (16.8%). The percentage of highly-cited papers was comparatively high in 2006-2010: 5.3%, an increase of +2.8%.

Section 6.1: Impact Profile®, All fields

6.1: Impact Profile®, All fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for all Indian research papers in the periods 2001-2005 and 2006-2010.

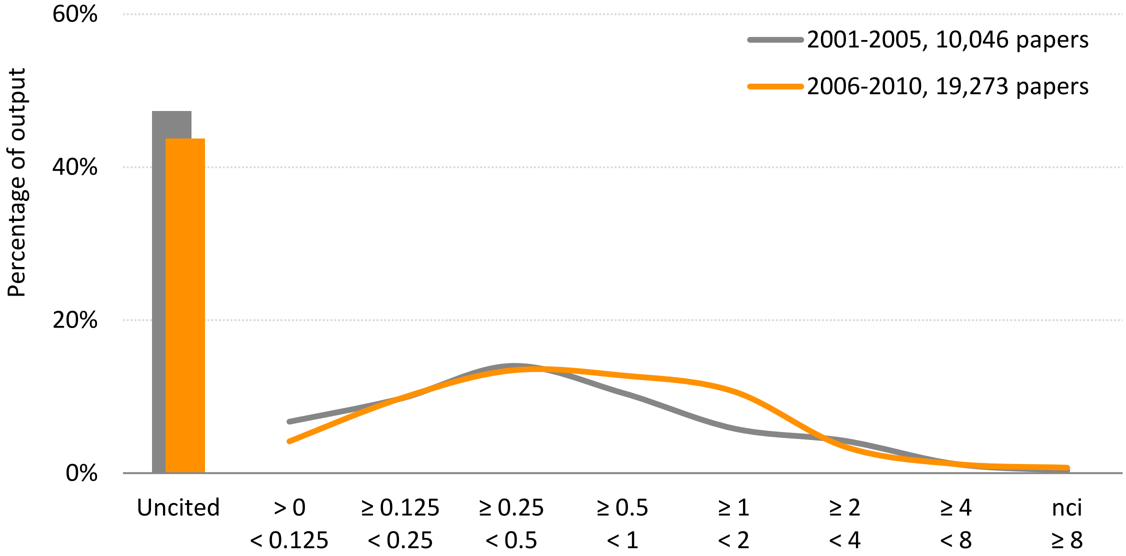
The percentage of Indian research papers which were uncited in 2001-2005 was 51.9% and by 2006-2010, this was 44.9%, a fall of -7.0%. This was the modal impact category of Indian research papers in both periods. These are high levels of uncitedness compared to established research economies. The equivalent figure for the UK in the 2006-2010 period was 29.9%. However, it is notable that there was a -7.0% fall in the percentage of Indian research papers which were uncited, as this means (by definition) that more Indian research papers are being cited in percentage terms. This is consistent with the trend of India's rising citation impact.

The percentage of Indian research papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 32.0%. By 2006-2010, this had increased to 35.1% (an increase of +3.1%). The percentage of Indian research papers which received more than the world average number of citations (nci ≥1) was 16.1% in 2001-2005 and 20.0% by 2006-2010, an increase of +3.9%. This shows two things. Firstly, that the balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1) than in the impact categories which are above world average for both time periods. However, a greater increase (+3.9%) has occurred in impact categories which are above world average (nci ≥1). This can be observed in the rightwards lift in the curve in the 2006-2010 period owing to change in the impact categories (nci ≥0.5 and <1: +1.8%) and (nci ≥1 and <2: +3.3%). The modal impact category of cited papers shifted from (nci ≥0.25 and <0.5) in 2001-2005 to (nci ≥0.5 and <1) by 2006-2010.

The percentage of Indian research papers which were highly-cited (nci ≥4) in 2001-2005 was 2.5%. By 2006-2010, this had increased to 2.7%, a 0.2% increase. The equivalent figure for UK research in the 2006-2010 period was 8.6%, so there is a significant gap.

Section 6.2: Impact Profile®, Clinical medicine

6.2: Impact Profile®, Clinical medicine, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Clinical Medicine papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Clinical Medicine papers which were uncited in 2001-2005 was 47.3% and this fell to 43.8% by 2006-2010, a fall of -3.6%. This was the modal impact category of Indian Clinical Medicine papers in both periods. This was a smaller fall in the percentage of uncited papers compared to the Indian background.

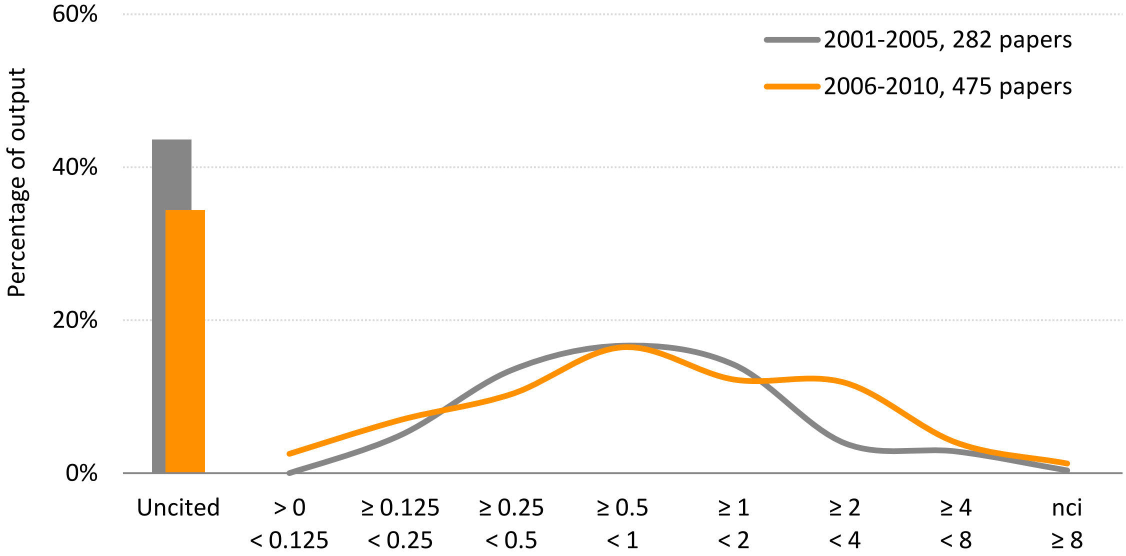
The percentage of Indian Clinical Medicine papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 41.0%. By 2006-2010, this had fallen slightly to 40.2% (-0.9%). The percentage of Indian Clinical Medicine papers which received more than the world average number of citations (nci ≥1) was 11.6% in 2001-2005 and 16.1% by 2006-2010, an increase of +4.4%. This shows two things. Firstly, that the balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1) than in the impact categories that are above world average for both time periods. However, a greater increase has occurred (+4.4%) in the impact categories which are above world average (nci ≥ 1). This can be observed in the rightwards lift in the curve in the 2006-2010 period owing to change in the impact categories (nci ≥0.5 and <1: +2.3%) and (nci ≥1 and <2: +4.8%). The modal impact category of cited papers in both periods was (nci ≥0.25 and <0.5).

The percentage of Indian Clinical Medicine papers which were highly-cited (nci ≥4) in 2001-2005 was 1.5% and by 2006-2010 this had increased to 1.9%, an increase of 0.4%.

These trends are consistent with India's low but improving nci in Clinical Medicine research.

Section 6.3: Impact Profile®, Psychiatry/psychology

6.3: Impact Profile®, Psychiatry/psychology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Psychiatry/Psychology papers in the periods 2001-2005 and 2006-2010.

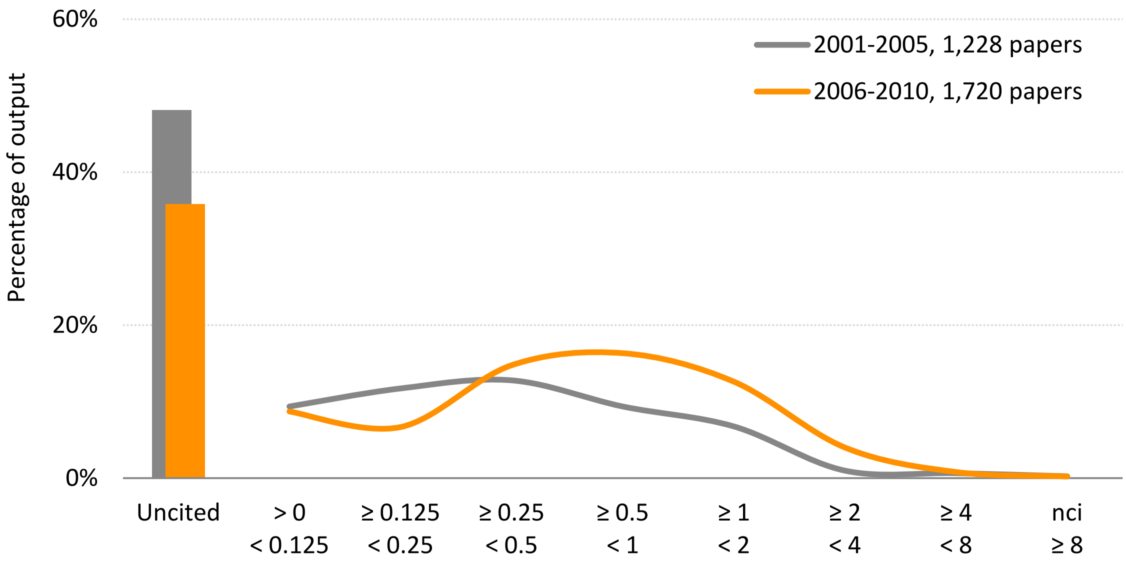
The percentage of Indian Psychiatry/Psychology papers which were uncited in 2001-2005 was 43.6% and this fell to 34.4%, a -9.2% decrease. This was the modal impact category of Indian Psychiatry/Psychology papers in both periods, but the fall was greater than the background figure for Indian research as a whole.

The percentage of Indian Psychiatry/Psychology papers which were cited but received received less than the world average number of citations (nci >0 and <1) was 35.1% in 2001-2005 and this increased slightly to 36.3% by 2006-2010, an increase of +1.2%. The percentage of Indian Psychiatry/Psychology papers which received more than the world average number of citations (nci ≥1) was 21.3% in 2001-2005 and 29.3% (the highest figures across all fields), an increase of 8.0%. This was the second largest increase across the fields in the percentage of papers receiving more than the world average number of citations. However, the balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1) than in the impact categories that are above world average for both time periods. However, a greater increase has occurred (+8.0%) in the impact categories which are above world average (nci ≥1). This can be observed in the rightwards shift in the curve in the 2006-2010 period owing to change in the impact category (nci ≥2 and <4: +7.9%). The modal impact category of cited papers in both periods was (nci ≥0.5 and <1).

The percentage of Indian Psychiatry/Psychology papers which were highly-cited (nci ≥4) in 2001-2005 was 3.2% and by 2006-2010, this had increased to 5.3%, an increase of 2.1%. The percentages for highly-cited papers are greater than the Indian background in both time periods, and the change is greater (with the caveat that it is based on small paper numbers). These trends are consistent with India's relatively high nci in this field, and also its increase.

Section 6.4: Impact Profile®, Neuroscience & behaviour

6.4: Impact Profile®, Neuroscience & behaviour, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Neuroscience & Behaviour papers in the periods 2001-2005 and 2006-2010.

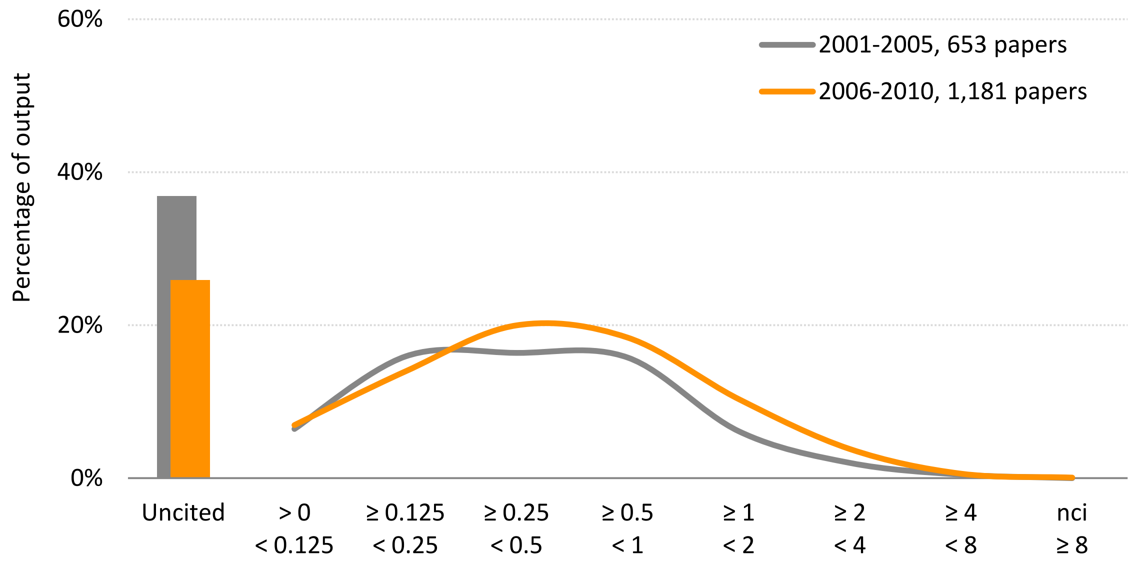
The percentage of Indian Neuroscience & Behaviour papers which were uncited in 2001-2005 was 48.1% and this fell to 35.8% by 2006-2010, a fall of -12.3%. This was the modal impact category of Indian Neuroscience & Behaviour papers in both periods. This was the third largest fall in uncited papers across all fields.

The percentage of Indian Neuroscience & Behaviour papers which were cited but received less than the world average number of citations (nci >0 and <1) was 43.2% in 2001-2005. By 2006-2010, this had increased to 46.5%, an increase of +3.3%. The percentage of Indian Neuroscience & Behaviour papers which received more than the world average number of citations (nci ≥1) was 8.6% in 2001-2005 and this increased to 17.7% by 2006-2010, an increase of 9.0%. The balance of the distribution of citation impact is strongly skewed towards the impact categories which are below world average (nci >0 and <1) than the impact categories which are above world average (nci ≥1) for both time periods. However, a greater increase has occurred (+9.0%) in the impact categories which are above world average (nci ≥1) which is the largest change across the fields. This can be observed in the rightward shift of the curve in the 2006-2010 period, owing to the change in the impact categories (nci ≥0.5 and <1: +7.0%) and (nci ≥1 and <2: 5.9%). The modal impact category of cited papers in 2001-2005 was (nci ≥0.25 and <0.5) and this changed to (nci ≥0.5 and <1) by 2006-2010. These trends are consistent with India's increasing nci in this field and also its improvement, although nci is relatively low.

The percentage of Indian Neuroscience & Behaviour papers which were highly-cited (nci ≥4) in 2001-2005 was 0.9%. This increased to 1.0% by 2006-2010, an increase of 0.2%. These percentages of highly-cited papers are small, and the change is negligible.

Section 6.5: Impact Profile®, Immunology

6.5: Impact Profile®, Immunology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Immunology papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Immunology papers which were uncited in 2001-2005 was 36.9% and this fell to 25.9% by 2006-2010, a fall of -11.0%. This was the modal impact category of Indian Immunology papers in both periods and was one of the larger falls in uncitedness across the fields.

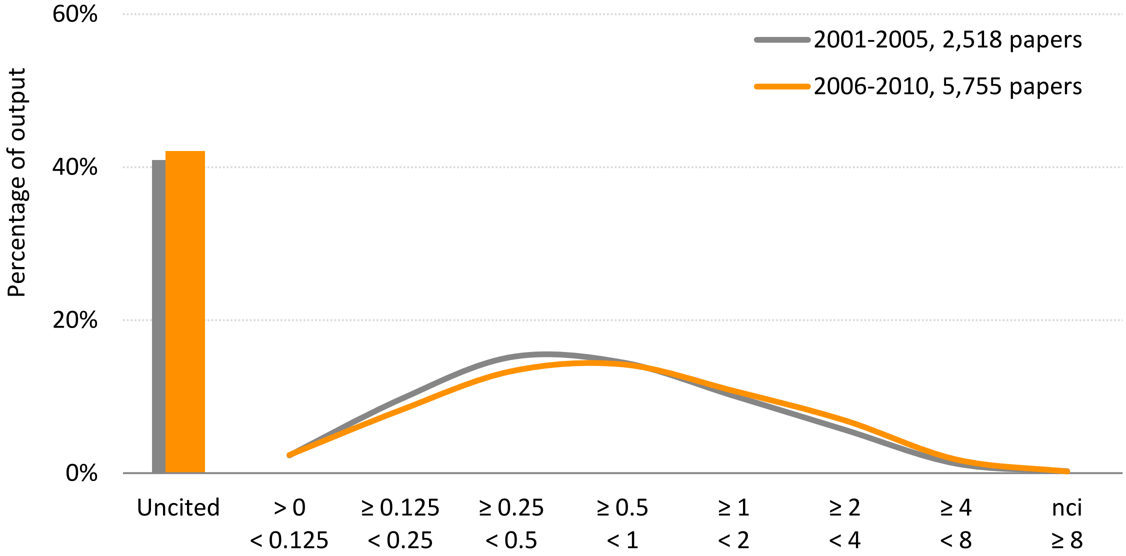
The percentage of Indian Immunology papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 54.5%. By 2006-2010, this had increased to 59.3% (an increase of +4.8%). The percentage of Indian Immunology papers which received more than the world average number of citations (nci ≥1) was 8.6% in 2001-2005 and 14.8% by 2006-2010, an increase of +6.2%. For 2006-2010, this was the largest percentage of papers across all fields which were cited below world average, strongly skewing the distribution leftwards. However, a greater increase (+6.2%) has occurred in the impact categories which are above world average (nci ≥1). This can be observed in the rightwards shift of the curve. The lift in the curve occurs across three impact categories: (nci ≥0.25 and <0.5: +3.6%), (nci ≥0.5 and <1: +2.6%) and (nci ≥1 and <2: +4.2%). The modal impact category of cited papers in both periods was (nci ≥0.25 and <0.5).

The percentage of Indian Immunology papers which were highly-cited (nci ≥4) in 2001-2005 was 0.5% and this increased marginally to 0.7%, an increase of +0.2%. This is the lowest percentage of highly-cited papers across the fields for both time periods.

These trends are consistent with India's relatively low but improving nci in Immunology research.

Section 6.6: Impact Profile®, Pharmacology & toxicology

6.6: Impact Profile®, Pharmacology & toxicology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Pharmacology & Toxicology papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Pharmacology & Toxicology papers which were uncited in 2001-2005 was 40.9% and by 2006-2010 this increased to 42.1%. This was one of two fields in which a rise in uncitedness happened (the other was Microbiology, also a field with rapid growth: 181.5%).

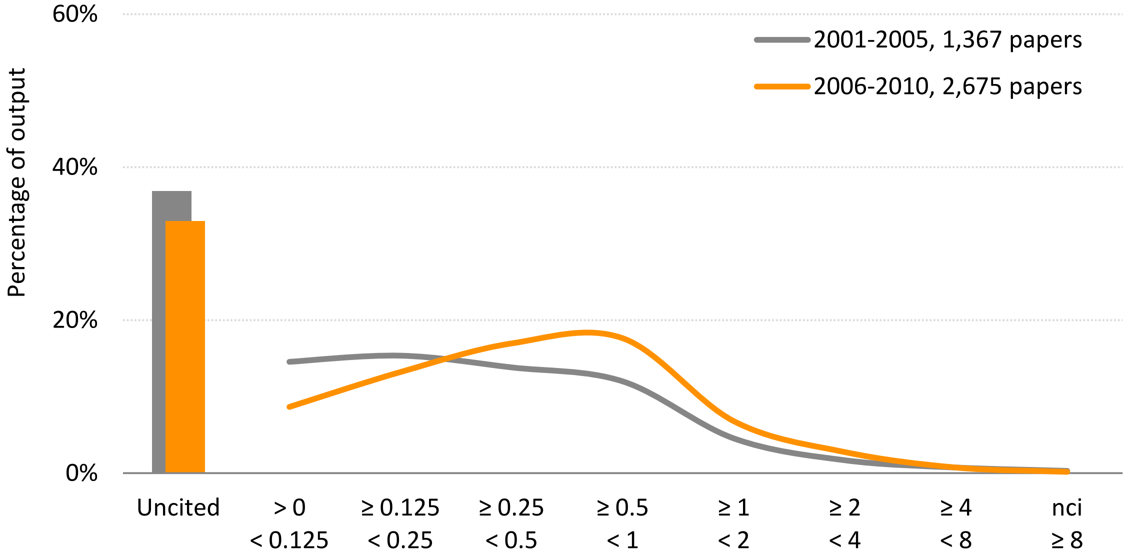
The percentage of Indian Pharmacology & Toxicology papers which were cited but received less than the world average number of citations (nci >0 and <1) was 41.7% in 2001-2005. This fell to 38.2% by 2006-2010, a fall of -3.6%. The percentage of Indian Pharmacology & Toxicology papers which were cited above world average (nci ≥ 1) was 17.4% in 2001-2005 and this increased to 19.7% by 2006-2010, an increase of +2.3%. This indicates that whilst the balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1), a slightly greater increase (+2.3%) has occurred in the impact categories which are above world average (nci ≥1). These changes are relatively small, but are nevertheless visible in the slight push of the 2006-2010 curve downwards in the impact categories which are below world average, and the slight lift in the impact categories which are above world average. The modal impact category of cited papers in 2001-2005 was (nci ≥0.25 and <0.5) and this changed to (nci ≥0.5 and <1) by 2006-2010.

The percentage of Indian Pharmacology & Toxicology papers which were highly-cited (nci ≥4) in 2001-2005 was 1.5% and by 2006-2010 this increased to 2.0%, an increase of 0.5%. These percentages are lower than for Indian research as a whole.

These trends are consistent with India's moderate but improving nci in Pharmacology & Toxicology.

Section 6.7: Impact Profile®, Molecular biology & genetics

6.7: Impact Profile®, Molecular biology & genetics, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Molecular Biology & Genetics papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Molecular Biology & Genetics papers which were uncited in 2001-2005 was 36.9% and by 2006-2010 it had fallen to 33.0%, a fall of -4.0%. This was the modal impact category of Indian Molecular Biology & Genetics papers in both periods. These levels of uncitedness are well below the background figure for Indian research as a whole, although the fall was smaller.

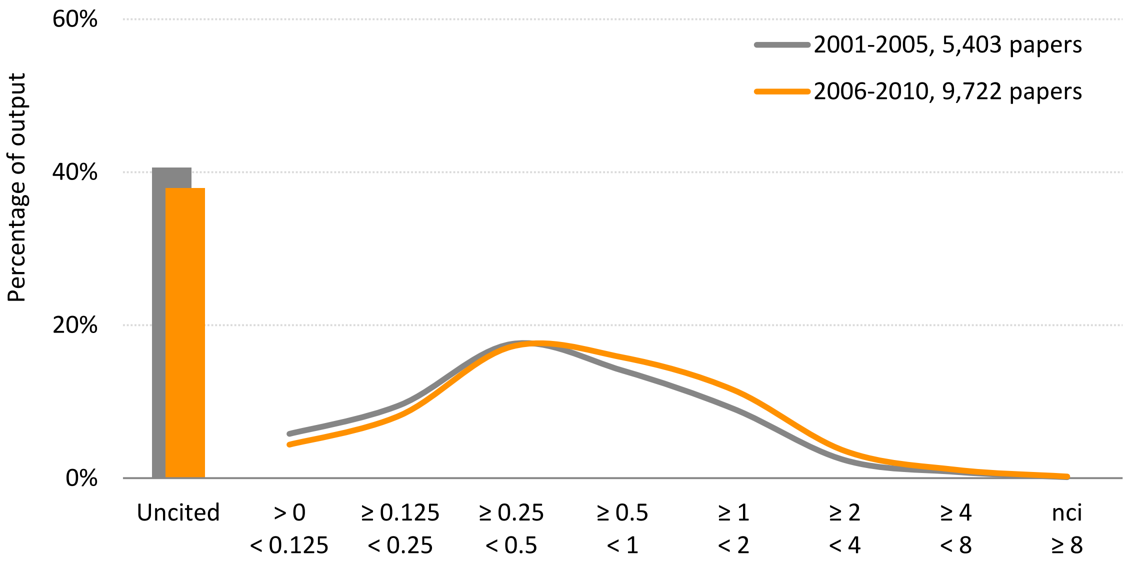
The percentage of Indian Molecular Biology & Genetics papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 55.8%, and by 2006-2010, this had increased to 56.5% (an increase of +0.7%). The former percentage is the highest amongst the fields in 2001-2005; and the latter percentage is the second highest amongst the fields in 2006-2010. The percentage of Indian Molecular Biology & Genetics papers which received more than the world average number of citations (nci ≥1) was 7.3% in 2001-2005 and 10.5% by 2006-2010, an increase of +3.3%. These were the lowest percentages for both time periods across the fields. This meant that the balance of the distribution of citation impact was strongly skewed towards the impact categories which were below world average (nci >0 and <1) than towards the impact categories which were above world average (nci ≥1) for both time periods. However, it is notable that the predominant changes in the curve are the fall in the impact category (nci >0 and <0.125: -5.9%) and the rise in the impact category (nci ≥0.5 and <1: +5.6%) between the two periods (and the modal impact categories for these respective periods).

The percentage of Indian Molecular Biology & Genetics research papers which were highly-cited (nci ≥4) in 2001-2005 was 1.0% and by 2006-2010 this had fallen slightly to 0.9% (-0.1%). In 2006-2010, this was the third smallest percentage of highly-cited papers across the fields.

These trends are consistent with India's low nci in this field.

Section 6.8: Impact Profile®, Biology & biochemistry

6.8: Impact Profile®, Biology & biochemistry, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Biology & Biochemistry papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Biology & Biochemistry papers which were uncited in 2001-2005 was 40.6% and by 2006-2010, this had fallen slightly to 37.9%, a fall of -2.7%. This was the modal impact category of Indian Biology & Biochemistry papers in both periods.

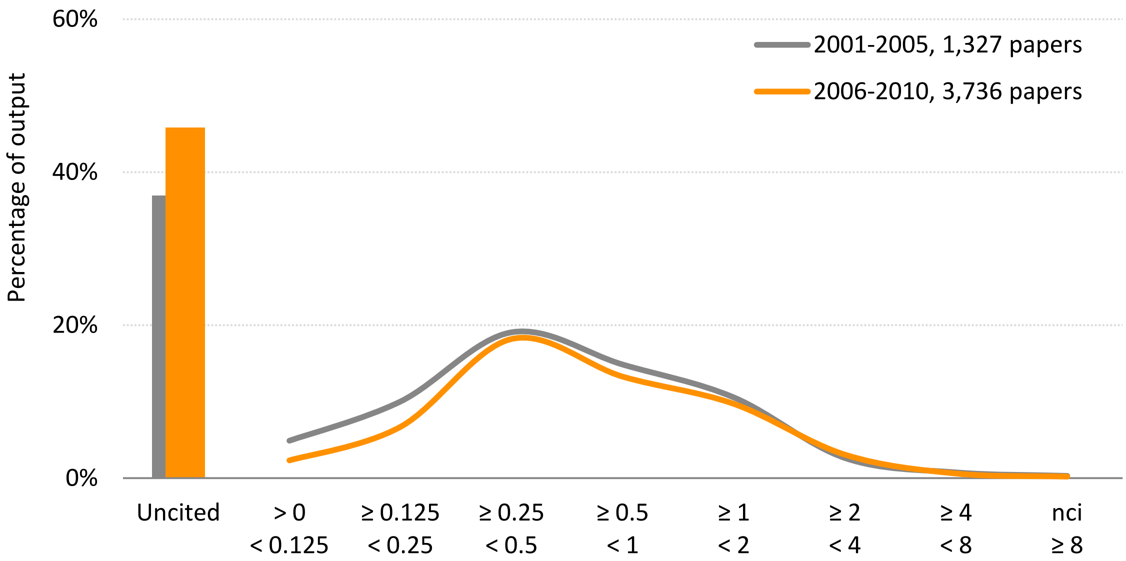
The percentage of Indian Biology & Biochemistry papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 47.0%, and by 2006-2010 this had fallen slightly to 45.7% (a fall of -1.4%). The percentage of Indian Biology & Biochemistry papers which received more than the world average number of citations (nci ≥1) was 12.4% in 2001-2005 and 16.4% by 2006-2010, an increase of +4.1%. The balance of the distribution of citation impact is strongly skewed to the impact categories which are below world average (nci >0 and <1) for both time periods. The modal impact category for papers in both periods was (nci ≥0.25 and <0.5). However, a greater increase (+4.1%) has occurred in the impact categories which are above world average (nci ≥1). This can be observed in the slight shift in the curve, with the slight fall in the impact categories (nci >0 and <0.5) and the rise in the impact categories (nci ≥0.5).

The percentage of Indian Biology & Biochemistry papers which were highly-cited (nci ≥4) in 2001-2005 was 0.9% and this increased to 1.3% by 2006-2010 (+0.4%). These are comparatively low percentages of highly-cited papers compared to the Indian background.

These trends are consistent with India's low but improving nci in this field.

Section 6.9: Impact Profile®, Microbiology

6.9: Impact Profile®, Microbiology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Microbiology papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Microbiology papers which were uncited in 2001-2005 was 36.9% and this actually increased to 45.9% by 2006-2010 (+8.9%). Microbiology is therefore one of two fields in which a rise in uncitedness occurred (the other is Pharmacology & Toxicology) and this may well be due to rapid growth.

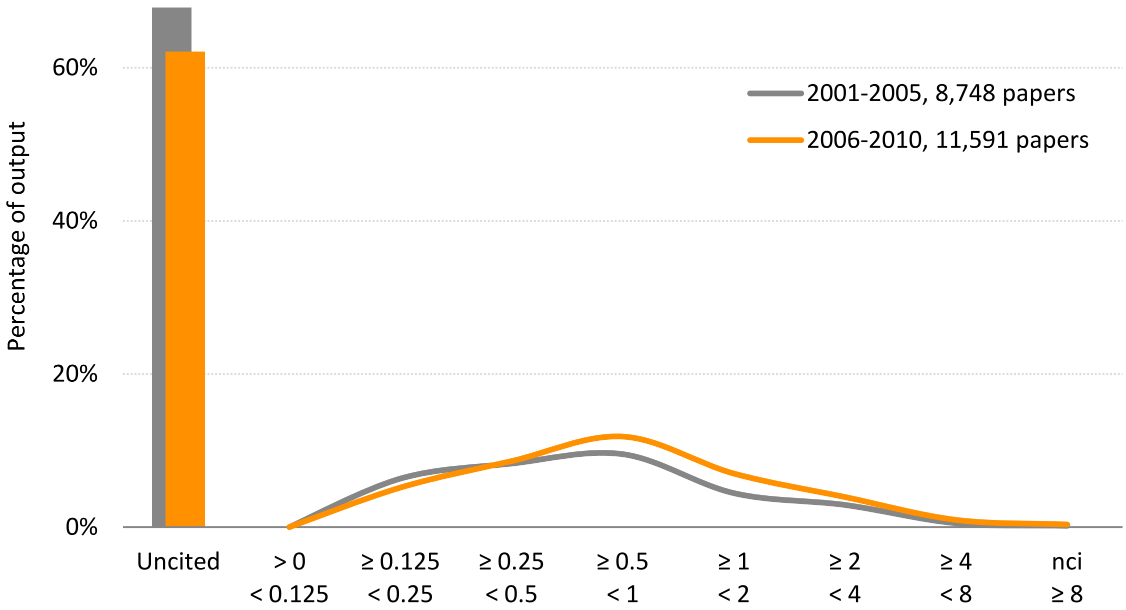
The percentage of Indian Microbiology papers which were cited but received less than the world average number of citations (nci >0 and <1) was 48.8% in 2001-2005 and 40.5% by 2006-2010, a fall of -8.3% (this fall mirrors the rise in uncitedness). The percentage of Indian Microbiology papers which received more than the world average number of citations (nci ≥1) was 14.2% in 2001-2005 and 13.6% by 2006-2010, a slight decrease of -0.6%. The balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1). The modal impact category of cited papers in both periods was (nci ≥0.25 and <0.5).

The percentage of Indian Microbiology papers which were highly-cited (nci ≥4) in 2001-2005 was 1.1% and by 2006-2010, this had fallen to 0.8% (a -0.2% fall). By 2006-2010, this was the second smallest percentage of highly-cited papers across the fields.

These trends are consistent with the fall in India's nci in Microbiology between the two periods 2001-2005 and 2006-2010, which may well be due to its recent rapid expansion in this field.

Section 6.10: Impact Profile®, Plant & animal science

6.10: Impact Profile®, Plant & animal science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Plant & Animal Science papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Plant & Animal Science papers which were uncited in 2001-2005 was 67.9% and this fell to 62.1% by 2006-2010, a fall of -5.7%. This was the modal impact category of Indian Plant & Animal Science papers in both periods. These are comparatively high levels of uncitedness compared to the background figures for Indian research as a whole, and the fall in uncitedness is also smaller.

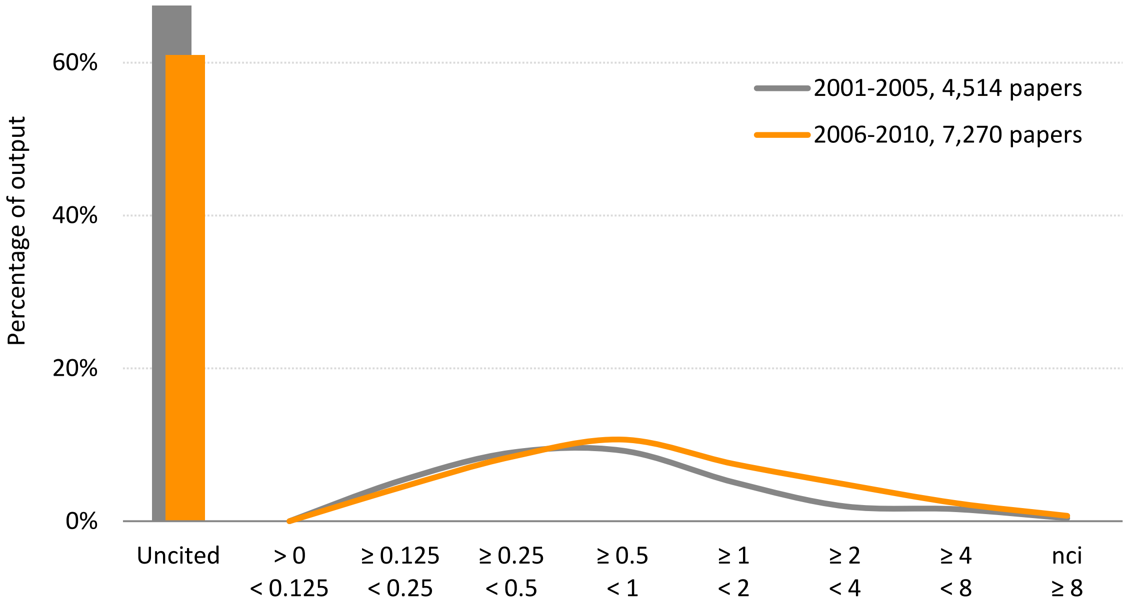
The percentage of Indian Plant & Animal Science papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 24.2% and by 2006-2010, this figure was 25.7%, an increase of 1.5%. The percentage of Indian Plant & Animal Science papers which received more than the world average number of citations (nci ≥1) was 8.0% in 2001-2005 and 12.2% by 2006-2010, an increase of +4.2%. These were the second lowest percentages of papers with above the world average number of citations (nci ≥1) across the fields in both periods. The balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1) for both time periods. However, a greater increase (+4.2%) has occurred in the impact categories which are above world average (nci ≥1). This can be observed in the slight rightwards shift in the curve and the lift in the curve in the impact categories (nci ≥0.5 and <1: +2.3%) and (nci ≥1 and <2: +2.6%). The modal impact category of cited papers in both periods was (nci ≥0.5 and <1).

The percentage of Indian Plant & Animal Science papers which were highly-cited (nci ≥4) in 2001-2005 was 0.7% and this increased to 1.3% by 2006-2010, an increase of +0.6%. These are comparatively low levels of highly-cited papers.

These trends are consistent with the low nci of Indian Plant & Animal Science research which was the lowest amongst the fields in the 2006-2010 period.

Section 6.11: Impact Profile®, Agricultural sciences

6.11: Impact Profile®, Agricultural sciences, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Agricultural Sciences papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Agricultural Sciences papers which were uncited in 2001-2005 was 67.4% and by 2006-2010 this was 61.0%, a fall of -6.4%. These levels of uncitedness were much higher than the equivalent figures for Indian research overall and the fall in uncitedness was smaller. This was also the modal impact category of Indian Agricultural Sciences papers in both time periods.

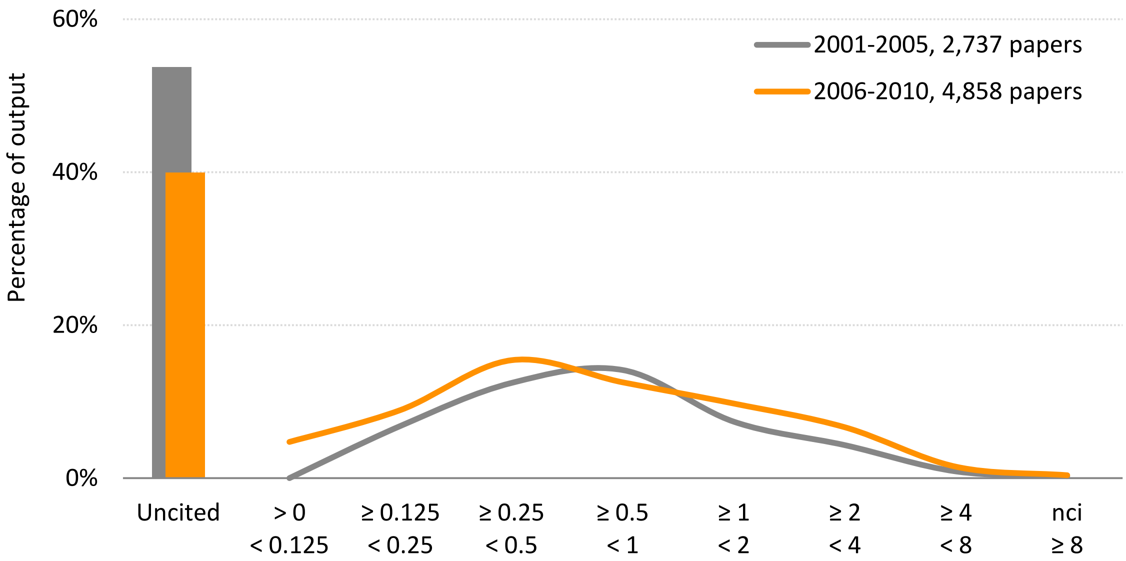
The percentage of Indian Agricultural Sciences papers which were cited but received less than the world average number of citations (nci >0 and <1) was 23.6% in 2001-2005 and by 2006-2010, this figure was the same (no change). The percentage of Indian Agricultural Sciences papers which received more than the world average number of citations (nci ≥1) was 9.0% in 2001-2005 and this increased to 15.4% by 2006-2010, an increase of +6.4%. This shows that the balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1) but with the fall in uncitedness, a greater increase has occurred in impact categories which are above world average (+6.4%). This can be observed in the 'lift' of the curve from (nci ≥0.5) onwards. The modal impact category of cited papers in both periods was (nci ≥0.5 and <1).

The percentage of Indian Agricultural Sciences papers which were highly-cited (nci ≥4) in 2001-2005 was 2.0% and by 2006-2010 it was 3.1%, an increase of +1.1%. The figure for 2006-2010 was above the background figure for highly-cited research across India's papers as a whole.

These trends are consistent with India's low nci in this field (which is well below world average and the equivalent figures for Indian research as a whole), but which improved.

Section 6.12: Impact Profile®, Environment/ecology

6.12: Impact Profile®, Environment/ecology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Environment/Ecology papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Environment/Ecology papers which were uncited in 2001-2005 was 53.7% and this fell to 39.9% by 2006-2010, a fall of -13.8% (this was the biggest fall in uncitedness across the fields). This was the modal impact category of Indian research papers in both periods.

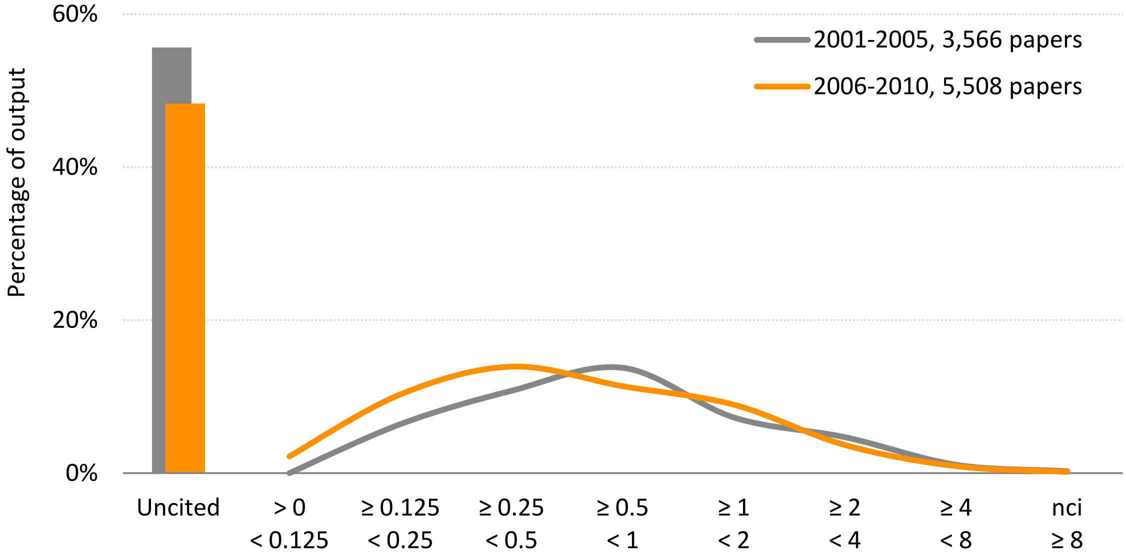
The percentage of Indian Environment/Ecology papers which were cited but received less than the world average number of citations (nci >0 and <1) was 33.4% in 2001-2005 and 41.7% by 2006-2010, an increase of +8.3%. The percentage of Indian Environment/Ecology papers which received more than the world average number of citations (nci ≥1) was 12.8% in 2001-2005 and 18.4% by 2006-2010, an increase of +5.6%. This shows that the balance of the distribution is predominantly in the impact categories which are below world average (nci >0 and <1) and that a greater increase occurred in those impact categories (+8.3%) compared to the impact categories which are above world average (+5.6%). These changes can be observed in the 'lift' in the curve across the impact categories where (nci > 0 and <0.5) and the 'lift' in the impact categories where (nci ≥1). The modal impact category of cited papers shifted from (nci ≥0.5 and <1) in 2001-2005 to (nci ≥0.25 and <0.5) by 2006-2010, which can be observed given the slight fall in the impact category (nci ≥0.5 and <1).

The percentage of Indian Environment/Ecology papers which were highly-cited (nci ≥4) in 2001-2005 was 1.1% and this increased to 1.9% by 2006-2010, an increase of +0.8%. These are lower percentages of highly-cited papers compared to the background figures for Indian research as a whole, but the improvement is greater than the equivalent figure (+0.8% v 0.2%).

These trends are consistent with India's below world average but improving nci in this field.

Section 6.13: Impact Profile®, Geosciences

6.13: Impact Profile®, Geosciences, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Geosciences papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Geosciences papers which were uncited in 2001-2005 was 55.6% and by 2006-2010 it was 48.3%, a fall of -7.3%. This was the modal impact category of Indian Geosciences papers in both periods. These levels of uncitedness are higher than the Indian background, but the fall was slightly greater (-7.3% v -7.0%).

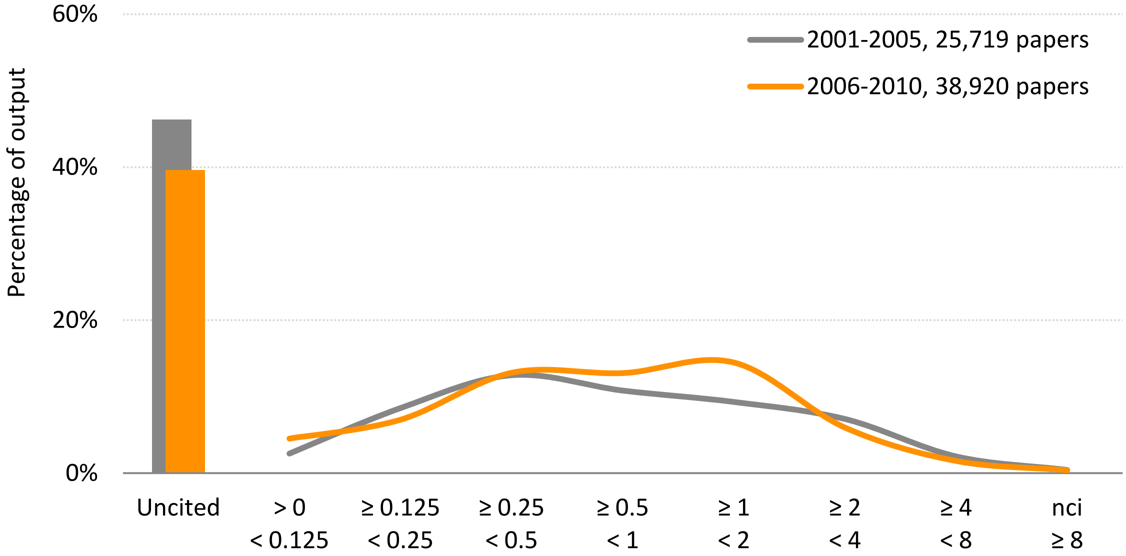
The percentage of Indian Geosciences papers which were cited but received less than the world average number of citations (nci >0 and <1) was 31.0% in 2001-2005 and 37.9% by 2006-2010, an increase of +6.8%. The percentage of Indian Geosciences papers which received more than the world average number of citations (nci ≥1) was 13.3% in 2001-2005 and 13.8% by 2006-2010, an increase of +0.5%. This shows that the balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1) for both time periods, and that a greater increase has occurred at this end of the distribution (+6.8%). This can be seen in the leftwards lift of the curve where (nci >0 and <0.5). The modal impact category of cited papers shifted from (nci ≥0.5 and <1) in 2001-2005 to (nci ≥0.25 and <5).

The percentage of Indian Geosciences papers which were highly-cited (nci ≥4) was 1.3% in 2001-2005 and 1.1% by 2006-2010, a fall of -0.2%. These levels are below the background figures for Indian research as a whole, and the direction is negative.

This Impact Profile® is consistent with India's relatively low nci in Geosciences, which has shown little improvement over the 2001-2005 and 2006-2010 periods.

Section 6.14: Impact Profile®, Chemistry

6.14: Impact Profile®, Chemistry, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Chemistry papers in the periods 2001-2005 and 2006-2010.

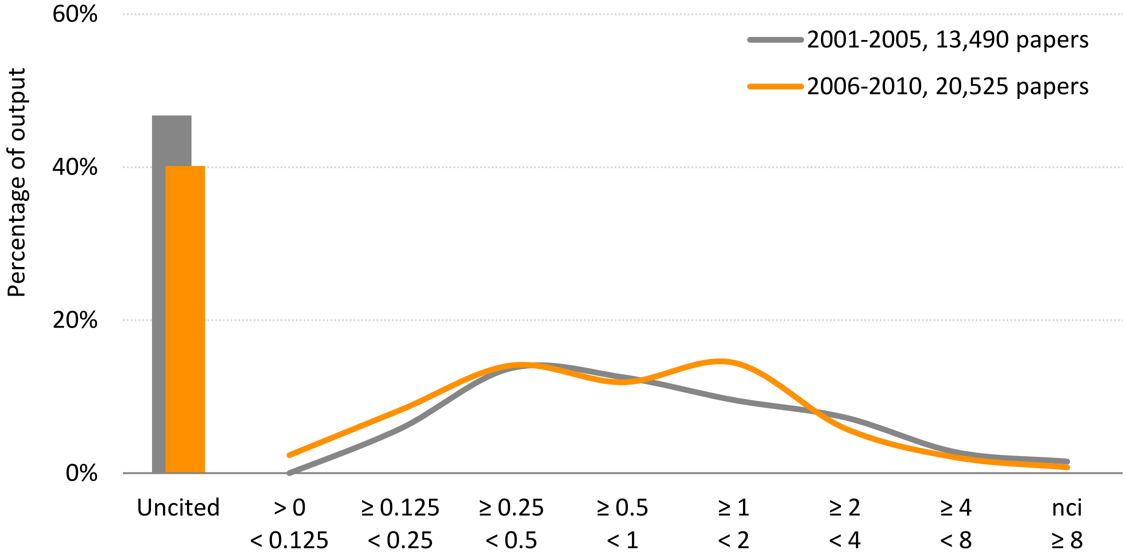
The percentage of Indian Chemistry papers which were uncited in 2001-2005 was 46.2% and by 2006-2010, this had fallen to 39.6%, fall of -6.6%. This was the modal impact category for Indian Chemistry papers in both periods. These levels of uncitedness are lower than for the Indian background, and the fall is slightly smaller.

The percentage of Indian Chemistry papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 34.7% and this increased to 37.8% by 2006-2010, an increase of +3.1%. The percentage of Indian Chemistry papers which received more than the world average number of citations (nci ≥1) was 19.1% in 2001-2005 and 22.5%, an increase of 3.4%. This shows that the balance of the distribution of citation impact over both periods was predominantly in the impact categories which are below world average and that a broadly similar increase occurred in impact categories which were below world average as those which were above world average, albeit that in the latter grouping, it was marginally higher (3.4% v 3.1%). However, it is notable that the biggest increase across the impact categories occurred where (nci ≥1 and <2: +5.2%), visualised in the lift of the curve at this point. This had the effect of changing the modal impact category of cited papers from (nci ≥0.25 and <5) in 2001-2005 to (nci ≥1 and <2) by 2006-2010.

The percentage of Indian Chemistry papers which were highly-cited (nci ≥4) was 2.7% in 2001-2005 and this fell to 2.1% by 2006-2010, a fall of -0.6%. This was the third largest decrease in highly-cited papers across the fields. Indian nci was higher than the Indian background figure during this period but the improvement was modest.

Section 6.15: Impact Profile®, Physics

6.15: Impact Profile®, Physics, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Physics papers in the periods 2001-2005 and 2006-2010.

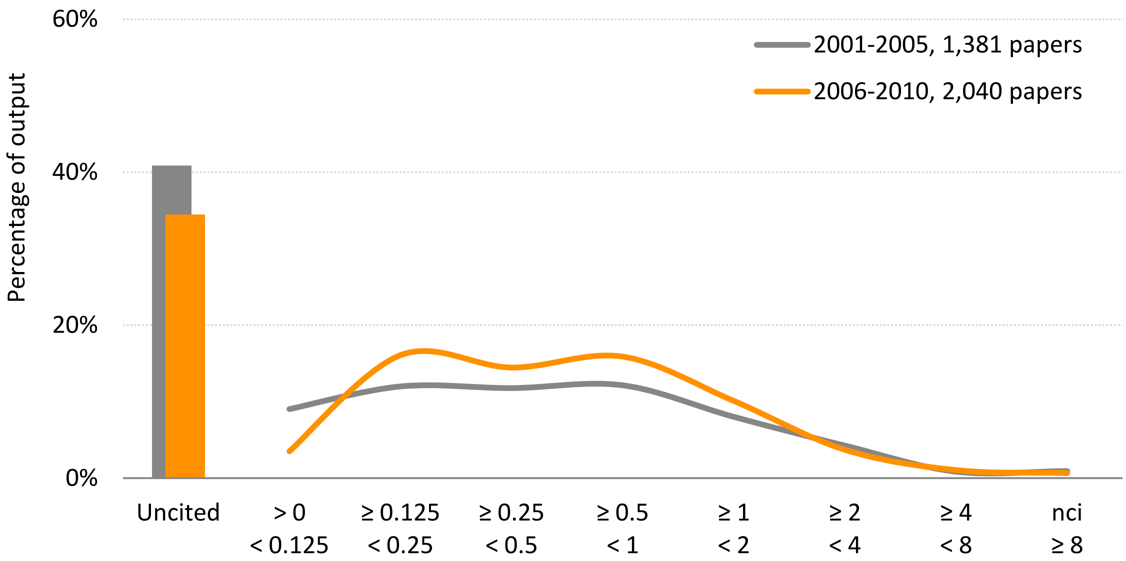
The percentage of Indian Physics papers which were uncited in 2001-2005 was 46.8% and by 2006-2010, it was 40.1%, a fall of -6.7%. This was the modal impact category of Indian research papers in both periods. These figures were also lower than the background figures for Indian research as a whole, but the fall in uncitedness was slightly smaller.

The percentage of Indian Physics papers which were cited but received less than the world average number of citations (nci >0 and <1) was 32.1% in 2001-2005 and this increased to 36.7% by 2006-2010, an increase of +4.6%. The percentage of Indian Physics papers which received more than the world average number of citations (nci ≥1) was 21.1% in 2001-2005 and 23.2% by 2006-2010, an increase of +2.1%. These percentages of papers where (nci ≥1) were amongst the highest across the fields. The balance of the distribution of citation impact is predominantly in the impact categories which are below world average (nci >0 and <1) for both time periods, and a greater increase has occurred in these impact categories (+4.6% v +2.1%). What is notable about the curves is the changing modal impact category of Indian Physics papers, from (nci ≥0.25 and <0.5) to (nci ≥1 and <2), driven by the increase in the latter (+4.9%). There appears to be less of a leap, and more of an emerging bimodality in the 2006-2010 curve within these same groups (nci ≥0.25 and <0.5: 14.1%) and (nci ≥1 and <2: 14.5%). This is unusual and warrants further investigation.

The percentage of Indian Physics papers which were highly-cited (nci ≥4) in 2001-2005 was 4.3% and by 2006-2010 it was 2.9%, a fall of -1.4%. This is quite a dramatic decrease: moving Physics from the second from top field by highly-cited papers in 2001-2005 (after Materials Science) to just above the equivalent background figure for Indian research as a whole by 2006-2010.

Section 6.16: Impact Profile®, Space science

6.16: Impact Profile®, Space science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Space Science papers in the periods 2001-2005 and 2006-2010.

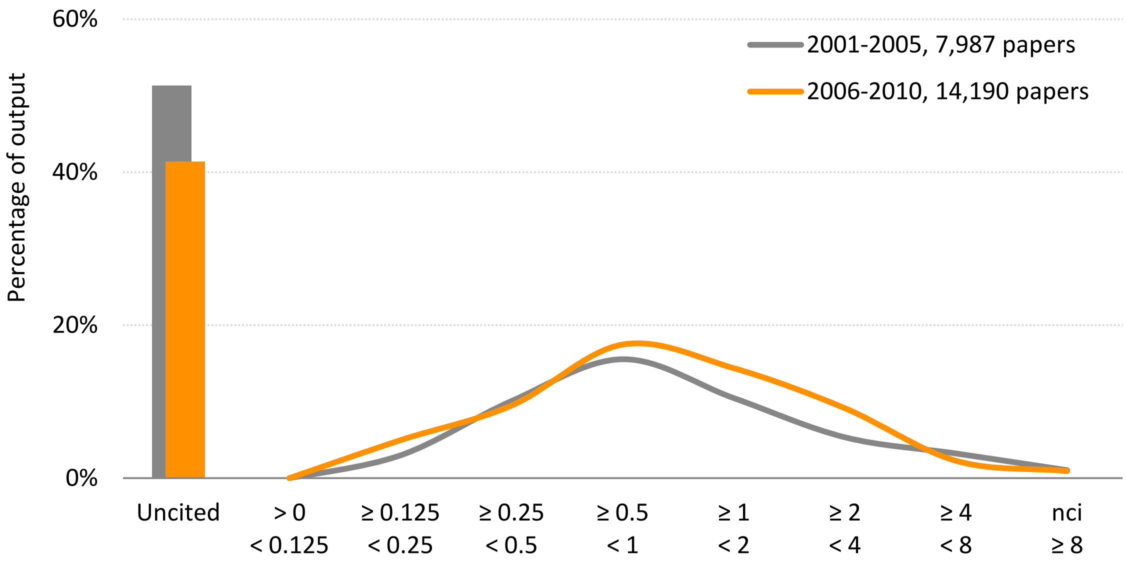
The percentage of Indian Space Science papers which were uncited in 2001-2005 was 40.8% and this fell to 34.5% by 2006-2010, a fall of -6.4%. This was the modal impact category of Indian Space Science papers in both periods. These levels of uncitedness were much lower than for the equivalent background figures for Indian research overall, and the fall was smaller.

The percentage of Indian Space Science papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 45.0% and by 2006-2010, this figure was 50.0% (the third highest percentage across the fields), an increase of +4.9%. The percentage of Indian Space Science papers which received more than the world average number of citations (nci ≥1) was 14.1% in 2001-2005 and 15.6% by 2006-2010, an increase of +1.5%. This shows that the balance of the distribution of citation impact is strongly skewed towards the impact categories which are below world average (nci >0 and <1) and furthermore, a greater increase occurred in impact categories which were below world average (+4.9%). Looking at the curve, whilst there was a fall in the percentage of papers in the lowest impact category (nci >0 and <0.125: -5.5%) there was a rise in all the other impact categories (nci ≥0.125 and <2) visible in the lift of this curve along these points. The biggest increase occurred in the impact category (nci ≥0.125 and <0.25: +4.1%). This had the effect of shifting the modal impact category from (nci ≥0.5 and <1) in 2001-2005 to (nci ≥0.125 <0.25), making the 2006-2010 curve more or less bimodal in these impact categories (15.9% and 16.1% respectively).

The percentage of Indian Space Science papers which were highly-cited (nci ≥4) was 1.8% in both 2001-2005 and 2006-2010 (i.e. no change). These figures are below the equivalent figures for Indian research as a whole.

Section 6.17: Impact Profile®, Materials science

6.17: Impact Profile®, Materials science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Materials Science papers in the periods 2001-2005 and 2006-2010.

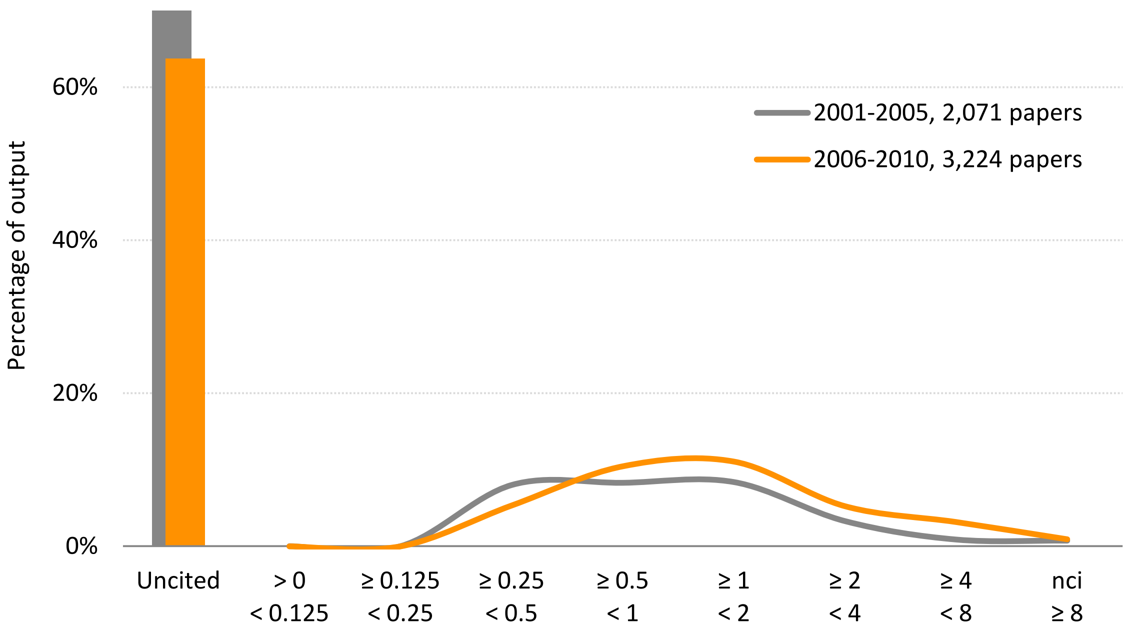
The percentage of Indian Materials Science papers which were uncited in 2001-2005 was 51.3% and this fell to 41.4% by 2006-2010, a fall of -10.0%. This was the modal impact category of Indian Materials Science papers in both periods, and these levels of uncitedness were lower than the equivalent figures for Indian research overall, and the fall in uncitedness was greater.

The percentage of Indian Materials Science papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 28.6% and by 2006-2010, it was 31.9%, an increase of +3.3%. The percentage of Indian Materials Science papers which received more than the world average number of citations (nci ≥1) was 20.1% in 2001-2005 and 26.7% by 2006-2010, an increase of +6.6%. By 2006-2010, this was the second largest percentage of papers with above the world average number of citations by field, narrowing the gap between papers with below and above world average citations (though still slightly negatively skewed in the distribution). The fact that there was a greater increase in the percentage of papers which achieved above world average citations (+6.6%) is visible in the upward lift in the curve, particularly where (nci ≥1 and <4). The modal impact category of cited papers for both periods was (nci ≥0.5 and <1).

The percentage of Indian Materials Science papers which were highly-cited (nci ≥4) in 2001-2005 was 4.3%. This was the highest percentage of highly-cited papers across the fields at this point in time. However, this percentage fell to 3.2%, a fall of -1.1%. This was quite a significant fall and the second largest amongst the fields (after Physics). This warrants further investigation.

Section 6.18: Impact Profile®, Mathematics

6.18: Impact Profile®, Mathematics, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Mathematics papers in the periods 2001-2005 and 2006-2010.

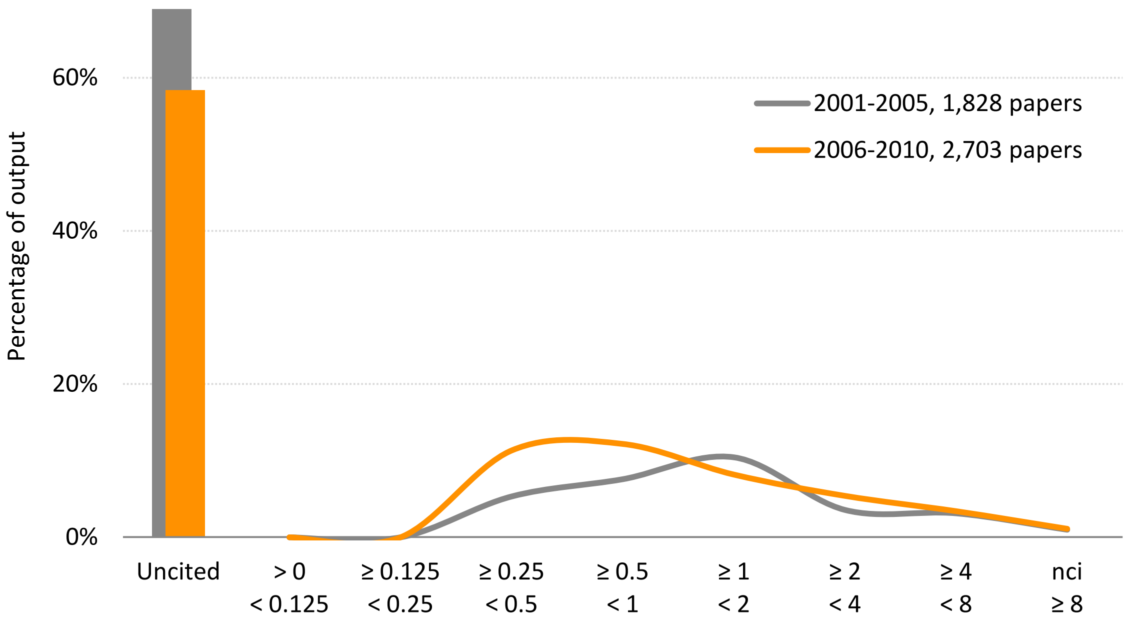
The percentage of Indian Mathematics papers which were uncited in 2001-2005 was 70.4% and by 2006-2010, this had fallen to 63.8%, a fall of -6.6%. These were the highest levels of uncitedness (for both periods) across the fields, and the fall was less than the equivalent figure for Indian research.

The percentage of Indian Mathematics papers which were cited but received less than the world average number of citations (nci >0 and <1) was 16.3% in 2001-2005 and 15.8% by 2006-2010, a decrease of -0.5%. The percentage of Indian Mathematics papers which received more than the world average number of citations (nci ≥1) was 13.3% in 2001-2005 and 20.4% by 2006-2010, an increase of +7.2%. This shows that amongst cited papers, by 2006-2010, Indian Mathematics papers had more papers being cited above the world average (nci ≥1) than below the world average (nci >0 and <1) i.e. 20.4% versus 15.8%. This can be observed in the rightwards shift and lift of the curve along theimpact categories where (nci ≥0.5). The modal impact category of cited papers was (nci ≥1 and <2) in both periods.

The percentage of Indian Mathematics papers which were highly-cited (nci ≥4) in 2001-2005 was 1.6%. This increased to 4.1% by 2006-2010, an increase of 2.5%. This was quite a substantial increase in the percentage of highly-cited papers.

Section 6.19: Impact Profile®, Computer science

6.19: Impact Profile®, Computer science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Computer Science papers in the periods 2001-2005 and 2006-2010.

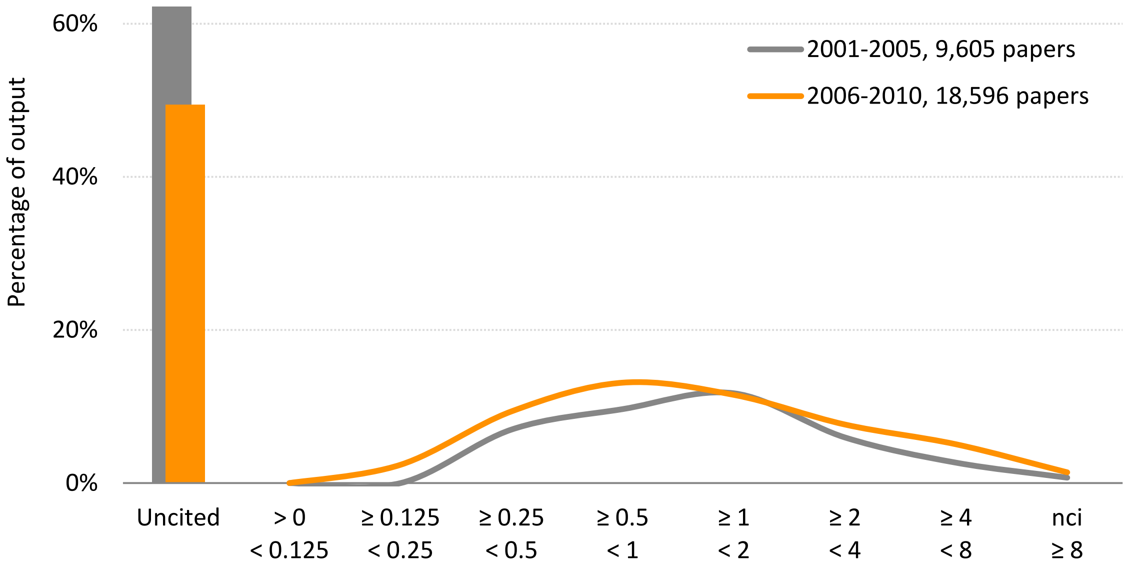
The percentage of Indian Computer Science papers which were uncited in 2001-2005 was 69.0% and 58.4% by 2006-2010, a decrease of -10.6%. In 2001-2005, this was the second highest percentage of uncited papers across all fields (second to Mathematics). This was the modal impact category of Indian Computer Science papers in both periods and constitutes comparatively high levels of uncitedness.

The percentage of Indian Computer Science papers which were cited but received less than the world average number of citations (nci >0 and <1) was 12.9% in 2001-2005 and 23.5% by 2006-2010, an increase of +10.6%. This was the biggest change across the fields. The percentage of Indian Computer Science papers which received more than the world average number of citations (nci ≥1) was 18.1% in 2001-2005 and 2006-2010 (i.e. no change). These factors led to the pull of the 2006-2010 curve leftwards and a change of the modal impact category from (nci ≥ 1 and <2) in 2001-2005 to (nci ≥0.5 and <1) by 2006-2010.

The percentage of Indian Computer Science papers which were highly-cited (nci ≥4) was 4.1% in 2001-2005 and 4.5% by 2006-2010, an increase of +0.4%. These were respectively the third and fourth largest percentage of highly-cited papers over the fields.

Section 6.20: Impact Profile®, Engineering

6.20: Impact Profile®, Engineering, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Engineering papers in the periods 2001-2005 and 2006-2010.

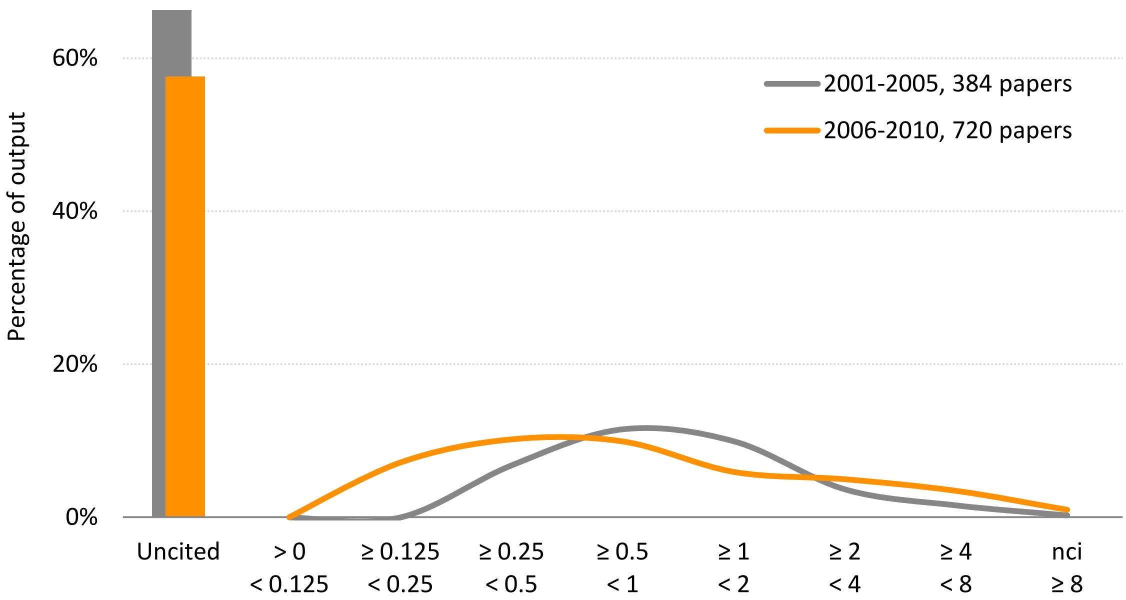
The percentage of Indian Engineering papers which were uncited in 2001-2005 was 62.2% and this fell to 49.4% by 2006-2010, a fall of -12.8%. This was the second largest fall in uncitedness across the fields, but these levels of uncitedness are higher than the equivalent figures for the Indian background.

The percentage of Indian Engineering papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 16.7% and this increased to 24.9% by 2006-2010, an increase of +8.2%. The percentage of Indian Engineering papers which were cited above world average (nci ≥1) was 21.1% in 2001-2005 and 25.7% by 2006-2010, an increase of +4.6%. This suggests several things. Firstly, by 2006-2010, the balance between papers which were cited below and cited above world average were broadly equal (24.9% and 25.7% respectively), with a slightly positive balance towards papers which were cited above world average (+0.8%) accounting for a lift in the curve on the right-hand side. However, the large rise in papers which were cited below world average (+8.2%) accounted for the largest fall in uncitedness and the lift in the curve on the left-hand side. The modal impact category of papers shifted from (nci ≥1 and <2) in 2001-2005 to (nci ≥0.5 and <1) by 2006-2010. There was more or less an increase in 'citedness' in a general sense across the distribution.

The percentage of Indian Engineering papers which were highly-cited (nci ≥4) in 2001-2005 was 3.4% and by 2006-2010 this had increased to 6.5%, an increase of +3.1%. By 2006-2010, this was the highest percentage of highly-cited papers amongst all fields, and it was also the largest increase. This parallels India's high nci in this field by 2006-2010.

Section 6.21: Impact Profile®, Economics & business

6.21: Impact Profile®, Economics & business, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Economics & Business papers in the periods 2001-2005 and 2006-2010.

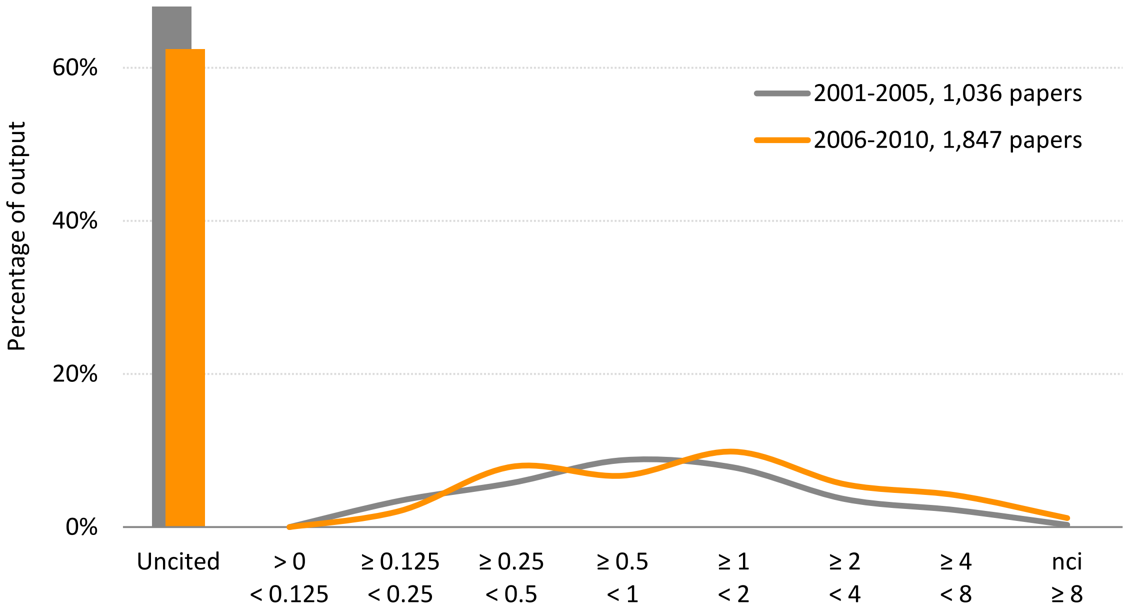
The percentage of Indian Economics & Business papers which were uncited in 2001-2005 was 66.3% and by 2006-2010 it was 57.6%, a fall of -8.8%. This was the modal impact category of Indian Economics & Business papers in both periods. These levels of uncitedness are higher than the background figures for Indian research as a whole, but the fall is greater.

The percentage of Indian Economics & Business papers which were cited but received less than the world average number of citations (nci >0 and <1) was 18.3% in 2001-2005 and 27.2% by 2006-2010, an increase of +8.9%. The percentage of Indian Economics & Business papers which received more than the world average number of citations (nci ≥1) was 15.4% in 2001-2005 and 15.2% by 2006-2010, a slight decrease of -0.2%. This altered the balance of the distribution of citation impact between the two periods. In 2001-2005, the difference between papers which were cited below (nci >0 and <1) versus papers that were cited above (nci ≥1) the world average, was negatively skewed towards papers which were cited below the world average (18.3% v 15.4%), but by 2006-2010, this difference had increased substantially (27.2% v 15.2%), pulling the 2006-2010 curve leftwards. This changed the modal impact category from (nci ≥0.5 and <1) in 2001-2005 to (nci ≥0.25 and <0.5) by 2006-2010. This drag was mainly caused by the rise in the percentage of papers in the impact category (nci ≥0.125 and <0.25: +7.1%) which is related to the relatively low average number of citations in this field.

The percentage of Indian Economics & Business papers which were highly-cited (nci ≥4) in 2001-2005 was 1.8%. By 2006-2010, this had increased to 4.4% (an increase of +2.6%). This was the third largest increase across the fields, with the caveat that it relates to small paper numbers.

Section 6.22: Impact Profile®, Social sciences

6.22: Impact Profile®, Social sciences, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010



This Impact Profile® shows the distribution of citation impact for Indian Social Sciences papers in the periods 2001-2005 and 2006-2010.

The percentage of Indian Social Sciences papers which were uncited in 2001-2005 was 68.0% and by 2006-2010, it had fallen to 62.4%, a fall of -5.6%. This was the modal impact category of Indian Social Sciences papers in both periods. These are comparatively high levels of uncitedness, and represented (respectively) the third largest and then the second largest levels of uncitedness across the fields between the two periods. The fall in uncitedness was also smaller compared to the background figure for Indian research as a whole.

The percentage of Indian Social Sciences papers which were cited but received less than the world average number of citations (nci >0 and <1) in 2001-2005 was 18.0% and by 2006-2010, this fell to 16.8%, a decrease of -1.3%. The percentage of Indian Social Sciences papers which received more than the world average number of citations (nci ≥1) was 14.0% in 2001-2005 and 20.8% by 2006-2010, an increase of +6.8%. These changes meant that in 2006-2010, there were more papers which were cited above world average (20.8%) than below world average (16.8%). This had the effect of shifting the modal impact category of cited papers from (nci ≥0.5 and <1) in 2001-2005 to (nci ≥1 and <2) by 2006-2010. These changes are visible in the lift of the curve on the right-hand side (nci ≥1) in 2006-2010 although there may be emerging bimodality where (nci ≥0.25 and <0.5).

The percentage of Indian Social Sciences papers which were highly-cited (nci ≥4) was 2.5% in 2001-2005 and 5.3% by 2006-2010, an increase of +2.8%. The figure for 2006-2010, was the second highest percentage of highly-cited papers across the fields, and also the second highest increase (after Engineering).

7 Highly-cited papers analysis

This analysis flows from Section 6 (Impact Profile® analysis) as highly-cited papers are in effect, a sub-component of the Impact Profile®. Thomson Reuters generally uses the term 'highly-cited' to refer to the most frequently cited 1% of the world's papers. In practice, for many countries, this refers to very few papers at the level of individual fields and *Evidence* prefers to use the classification of highly-cited papers as those which are cited at least four times or more than the world average for field and year (nci ≥4).

We have determined the volume of India's research output which is highly-cited, and the proportion of Indian research output that this represents. We have compared the percentage of research that is highly-cited for papers published between 2001-2005 and 2006-2010. This is broken down by the *Essential Science Indicators®* fields. These analyses are presented in tabular form with an associated interpretive commentary.

Summary

The Table shows the number and percentage of highly-cited papers (where nci ≥4 times the world average) for the periods 2001-2005 and 2006-2010. The final two columns (∆) refer to the change between these two periods. The information contained in this Table has been covered in detail by field in the Impact Profiles® so only headline information is covered here. It is also important to note that the percentage of highly-cited papers can differ by field, and so therefore analysis should be focused on change within fields rather than comparisons between fields (although the percentages for Indian research overall are used for comparison).

For Indian research as a whole, the percentage of highly-cited papers has increased, from 2.5% in 2001-2005 to 2.7% by 2006-2010, an increase of +0.2% equating to 2,113 papers. This is a notable improvement; however, it is important to note that this is a relatively low level of highly-cited papers and the equivalent figure for UK research over the 2006-2010 period was 8.6%.

Engineering emerges as a field with a largest number of highly-cited papers by 2006-2010 (1,204), combined with the highest percentage of highly-cited papers by this point (6.5%) with the greatest percentage change (+3.1%). For the next three largest fields by highly-cited papers in 2006-2010, all saw their percentage of highly-cited papers decrease between 2001-2005 and 2006-2010. These were Chemistry (from 2.7% to 2.1%, -0.6%), Physics (from 4.3% to 2.9%, -1.4%) and Materials Science (from 4.3% to 3.2%, -1.1%). Materials Science and Physics had the largest percentage of highly-cited papers in 2001-2005. For such significant fields within India's research base, the drivers behind these falls warrant further investigation.

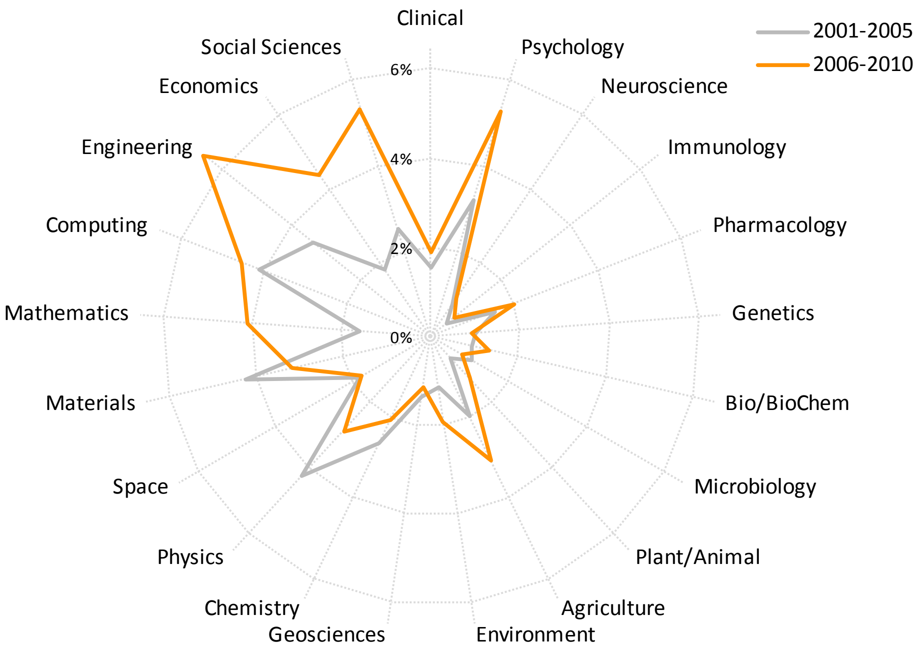
In terms of the fields which had the 'virtuous circle' of a greater percentage of highly-cited papers than the overall Indian figures in 2001-2005 and 2006-2010, combined with an increase between these two time periods, these are (in order of paper numbers in 2006-2010 and in addition to Engineering): Computer Science (from 4.1% to 4.5%, +0.4%), Social Sciences (from 2.5% to 5.3%, +2.8%), Psychiatry/Psychology (from 3.2% to 5.3%, +2.1%).

In terms of biomedical fields, the percentages of highly-cited papers were all below the equivalent figures for the Indian research base as a whole between 2001-2005 and 2006-2010, however, there were improvements in (by order of improvement) Pharmacology & Toxicology (+0.5%), Biology & Biochemistry (+0.4%), Clinical Medicine (+0.4%), Immunology (+0.2%) and Neuroscience & Behaviour (+0.2%). The percentage of highly-cited papers marginally decreased in Molecular Biology & Genetics (-0.1%) and Microbiology (-0.2%).

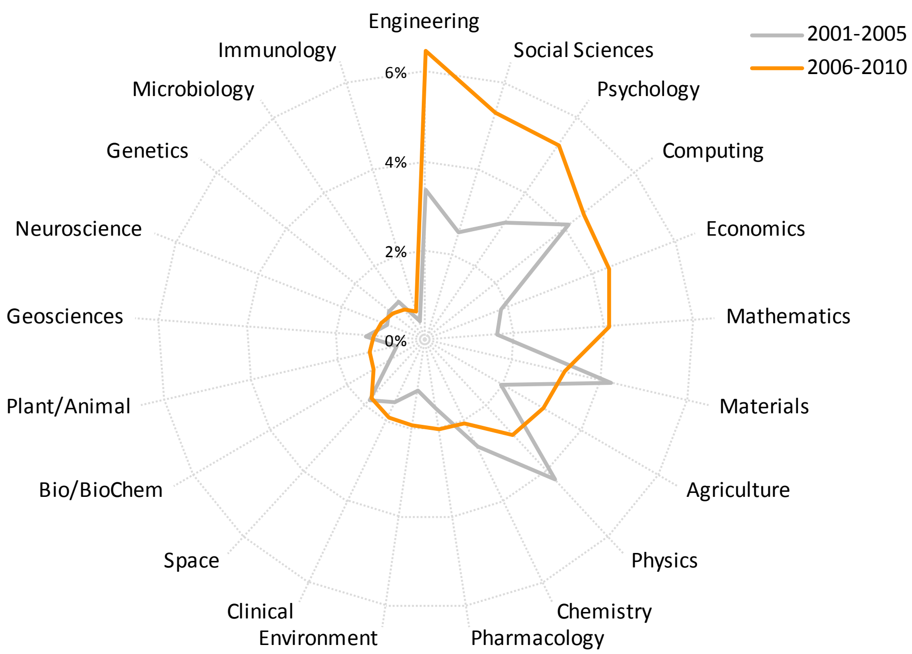
Elsewhere (and in order of improvement) Economics & Business and Mathematics both improved (+2.6% and +2.5% respectively). Agricultural Sciences improved (+1.1%) as did Environment/Ecology (+0.8%) and Plant & Animal Science (+0.6%), although for the latter two fields, their percentages of highly-cited papers were below the figures for the Indian research base overall. Space Science saw no improvement (0.0%) and Geosciences decreased (-0.2%).

Summary Figures – Highly-cited papers analysis

Highly-cited papers, ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, (nci ≥4 times world average), Ordered by standard sequence



Highly-cited papers, ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, (nci ≥4 times world average), Ordered by highly-cited papers 2006-2010



Section 7.1: Highly-cited papers, ESI fields

7.1: Highly-cited papers, ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, (nci ≥ 4 times world average)

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
All fields	**2,610**	**2.5%**	**4,723**	**2.7%**	**2,113**	**0.2%**
Clinical medicine	155	1.5%	369	1.9%	214	0.4%
Psychiatry/psychology	9	3.2%	25	5.3%	16	2.1%
Neuroscience & behaviour	11	0.9%	18	1.0%	7	0.2%
Immunology	3	0.5%	8	0.7%	5	0.2%
Pharmacology & toxicology	39	1.5%	117	2.0%	78	0.5%
Molecular biology & genetics	14	1.0%	25	0.9%	11	-0.1%
Biology & biochemistry	51	0.9%	130	1.3%	79	0.4%
Microbiology	14	1.1%	31	0.8%	17	-0.2%
Plant & animal science	58	0.7%	148	1.3%	90	0.6%
Agricultural sciences	89	2.0%	226	3.1%	137	1.1%
Environment/ecology	31	1.1%	94	1.9%	63	0.8%
Geosciences	48	1.3%	63	1.1%	15	-0.2%
Chemistry	685	2.7%	797	2.1%	112	-0.6%
Physics	572	4.3%	587	2.9%	15	-1.4%
Space science	25	1.8%	36	1.8%	11	0.0%
Materials science	340	4.3%	454	3.2%	114	-1.1%
Mathematics	33	1.6%	133	4.1%	100	2.5%
Computer science	75	4.1%	122	4.5%	47	0.4%
Engineering	324	3.4%	1,204	6.5%	880	3.1%
Economics & business	7	1.8%	32	4.4%	25	2.6%
Social sciences	26	2.5%	100	5.3%	74	2.8%

8 International collaboration analysis

The volume of publications which are internationally co-authored can be used as an indicator of the level of collaborative research between countries. Here we have determined the top ten countries with which India collaborates most frequently in 2006-2010 and determined the proportion of research which is collaborative with these partners, and compared this to the 2001-2005 period. The top ten partners are not necessarily the same comparator countries listed in earlier analyses. We do this for Indian research overall and disaggregated by the *Essential Science Indicators®* fields. Data are displayed in both absolute and percentage terms. Note that the base of Indian research differs in this analysis from elsewhere in the report, as it refers to 'publications' and not to 'papers'. These Tables are accompanied by an interpretive commentary indicating how collaborative research activity has changed between the two periods.

Summary

In 2001-2005, 18.8% of Indian research publications were internationally co-authored, and this increased to 19.5% in the 2006-2010 period (an increase of +0.6%). By way of an international comparison, the same figures for the UK were 33.5% (2001-2005) and 40.9% (2006-2010), an increase of +7.4%. Whilst international collaboration varies substantially by country and by field (the USA and China like India have much lower levels of international collaboration compared to the UK due to their larger internal geographies), *Evidence* has shown in previous reports that the average citation impact of internationally co-authored work is significantly higher than the overall average.[16] There could be value in exploring the citation impact gain of collaboration for India with selected partner countries in follow-up analyses to this report.

The USA was India's most frequent collaborating country in the 2006-2010 period, representing 6.6% of India's total research output, but it was a slight fall when expressed as an overall percentage contribution to India's research output compared to the 2001-2005 period (-0.3%). Germany was the second from most frequent collaborating country with India in the 2006-2010 period (2.5%) and the UK the third (2.3%), but collaboration with Germany has fallen slightly when expressed as an overall percentage contribution to India's research output on 2001-2005 (-0.3%) and increased slightly with the UK (+0.1%). Collaboration has proportionately decreased with Japan (-0.4%). By contrast, collaboration has proportionately increased with France (+0.1%), South Korea (+0.6%), Canada (0.1%), China (+0.1%), Australia (+0.2%) and remained more or less stable with Italy (0.0%). However, there have been major increases in volume terms when expressed as the number of publications. The USA standards apart in terms of its frequency of co-authorship with India-based institutions. However, the level of collaboration – as a fraction of national domestic output – is lower for India than it is for other emerging research economies such as Brazil, and much lower than for established G8 partnerships. India thus appears to have been less well connected to international networks than some other countries, but it therefore also retains a significant capacity to expand its collaborative links.

This reveals features which are common to most (though not all) fields and highlights several key themes in these analyses:

- In **volume terms, collaboration is increasing**
- Collaboration generally represents an **increasing contribution to India's research output**
- The **USA is India's most frequent collaborating partner** in all fields, often by a significant margin, although collaboration is proportionately decreasing
- The **UK and Germany are often in India's top three most frequent collaborating** partners
- There is often **higher growth in collaboration with emerging research economies** notably **South Korea** but there may be **unexploited collaboration with China**
- There is often **decreasing or static growth in collaboration with established research** economies
- There is **capacity for further international collaboration** particularly in certain high-growth fields

However, there are variations by field, which we discuss here.

[16] **Patterns of international collaboration for the UK and leading partners** (2007), Adams J, *et al.*

- **Clinical Medicine**: Collaboration in Clinical Medicine is proportionately less than in other fields (16.6% of publications in 2006-2010), but it has grown by 115.6% in volume terms. The USA and the UK are India's most frequent collaborating partners in this field. Collaboration increased notably with Canada (+0.7%).
- **Psychiatry/Psychology**: Collaboration in Psychiatry/Psychology is relatively high compared to other fields: 34.9%, the third highest level of collaboration by field in 2006-2010, and an increase of +9.0% on 2001-2005 (with the caveat of relatively small publication numbers). The USA and the UK are India's most frequent collaborating partners in this field.
- **Neuroscience & Behaviour**: Collaboration in Neuroscience & Behaviour is relatively low compared to other fields: 16.3% in 2006-2010, with only a small increase (+1.7%) on 2001-2005 levels of collaboration. The USA and the UK are India's most frequent collaborating partners in this field.
- **Immunology**: Collaboration in Immunology is relatively high compared to other fields: 28.7% in 2006-2010, an increase of +4.9% on 2001-2005. The USA and the UK are India's most frequent collaborating partners in this field, and there was a notable increase in collaboration with France (+2.8%) with the caveat that this is based on small publication numbers.
- **Pharmacology & Toxicology**: Collaboration in Pharmacology & Toxicology was the lowest amongst all research fields under analysis in this study: 10.6% in 2006-2010, and a fall of -0.7% on its 2001-2005 level. The USA and the UK are India's most frequent collaborating partners in this field, but there was a notable proportionate decrease in collaboration with the USA (-1.6%).
- **Molecular Biology & Genetics**: Collaboration in Molecular Biology & Genetics was 25.9% in 2006-2010, a slight fall of -0.1% on 2001-2005. The USA, Germany and the UK are India's most frequent collaborating partners in this field.
- **Biology & Biochemistry**: Collaboration in Biology & Biochemistry was 17.1% in 2006-2010, a drop of -0.9% on 2001-2005. The USA was the most significant collaborating partner, although collaboration with the USA fell proportionately (-2.0%).
- **Microbiology**: Collaboration in Microbiology was 16.3% in 2006-2010, a fall of -7.8% on 2001-2005, the largest fall in collaboration across the fields. This may be because growth in collaborative publications (117.8%) did not keep pace with the growth in publications in this field overall (221.7%). The USA, Germany and Japan were India's most frequent collaborating partners in this field.
- **Plant & Animal Science**: Levels of collaboration were significantly lower than the Indian background (the third lowest across the fields) at 13.3% by 2006-2010, an increase of 1.5% on 2001-2005 levels. The USA, Germany and the UK were India's most frequent collaborating partners in this field, although collaboration increased proportionately the most with South Korea (+0.5%).
- **Agricultural Sciences**: Levels of collaboration were the second lowest across the fields: 10.9% of India's research output in 2006-2010, an increase of 1.5% on 2001-2005 levels. The USA was India's most frequent collaborating partner in this field, and also had the greatest increase in collaboration (+0.8%).
- **Environment/Ecology**: Levels of collaboration in this field were above the background figures for Indian research overall, 21.3% by 2006-2010, an increase of 3.7% on 2001-2005 levels. There was substantial volume growth in terms of international collaboration. The USA, UK and Germany were India's most frequent collaborating partners, but collaboration with South Korea increased notably.
- **Geosciences**: Levels of collaboration in this field were above the background figures for Indian research overall, 24.0% in 2006-2010, an increase of +1.2%. The USA, Japan and Germany were India's most frequent collaborating partners, but collaboration with France increased notably.
- **Chemistry**: Levels of collaboration in this field were below the figures for Indian research overall: 18.0% in 2006-2010, an increase of +1.9%. The USA and Germany were India's most frequent collaborating partners, but collaboration increased significantly with Malaysia (+0.8%) and South Korea (+0.7%).
- **Physics**: Levels of collaboration in this field were quite high: 29.3% in 2006-2010, but a fall on 2006-2010, -1.3%. Collaboration was substantial for all countries, but the USA, Germany and France were India's most frequent collaborating partners, and collaboration increased substantially with South Korea (+1.0%) and the UK (+0.7%).
- **Space Science**: Levels of collaboration in this field were the highest across all fields: 47.1% (just short of half India's total publication output) in 2006-2010, an increase of +1.9% on 2001-2005 levels of

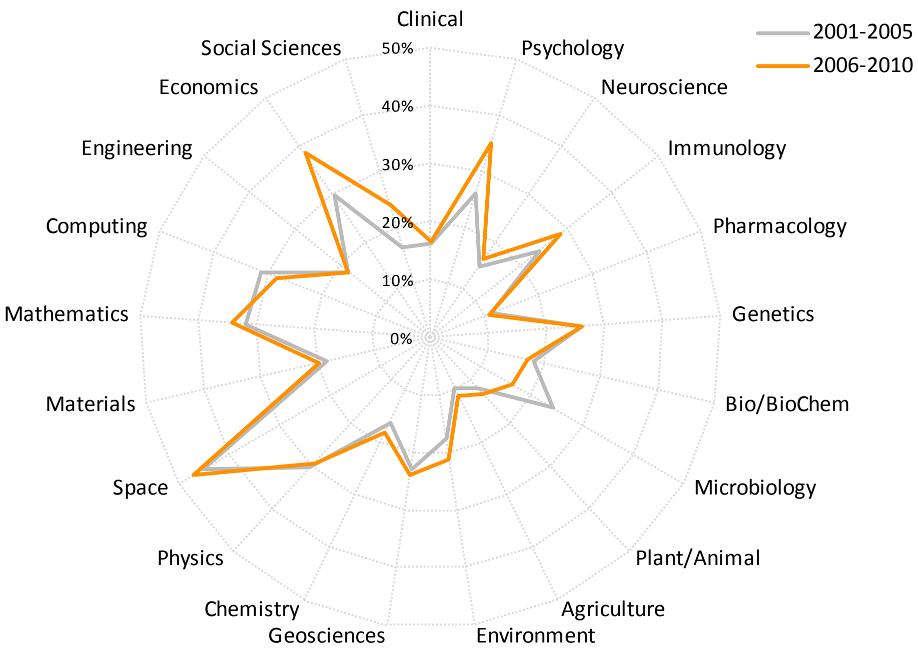
collaboration. Collaboration was high with the USA (22.3% of India's research output in 2006-2010), France, the UK and Germany.

- **Materials Science**: Levels of collaboration in this field were around the background levels for Indian research as a whole: 19.6% in 2006-2010, an increase of 1.2% on 2001-2005 levels. The USA and South Korea were India's most frequent collaborating partners, and collaboration increased notably with South Korea (+2.1%).
- **Mathematics**: By 2006-2010, levels of collaboration had reached 34.3%, an increase of +2.3% on 2001-2005 levels of collaboration. These are comparatively high levels of collaboration. The USA was India's most frequent collaborating partner, but collaboration increased notably with China (+1.0%).
- **Computer Science**: By 2006-2010, levels of collaboration in Computer Science had reached 28.4%, though this was a fall of -2.8% on India's 2001-2005 levels of collaboration. The USA was India's most frequent collaborating partner.
- **Engineering**: By 2006-2010, levels of collaboration in Engineering were 18.2%, an increase of +0.2% on 2001-2005 levels. These levels of collaboration were below the background figures for Indian research overall, and the increase was smaller. The USA, the UK and Germany were India's most frequent collaborating partners: however, collaboration proportionately decreased with these countries. Collaboration notably increased with South Korea (+0.7%).
- **Economics & Business**: 38.4% of India's Economics & Business research output was internationally co-authored in 2006-2010, the second highest levels of international co-authorship across the fields, and the second largest increase in international co-authorship on 2001-2005 levels (+8.8%). However, publication numbers are quite small. The USA was India's most frequent collaborating partner, although collaboration increased with the UK (+4.3%) - India's second most frequent collaborating partner.
- **Social Sciences**: 23.8% of India's Social Sciences research output was internationally co-authored, and this was an increase of +7.6% on its 2001-2005 levels, the third highest increase across the fields. However, publication numbers are quite small. The USA and the UK were India's most frequent collaborating partners, and collaboration increased substantially with the USA (+3.9%).

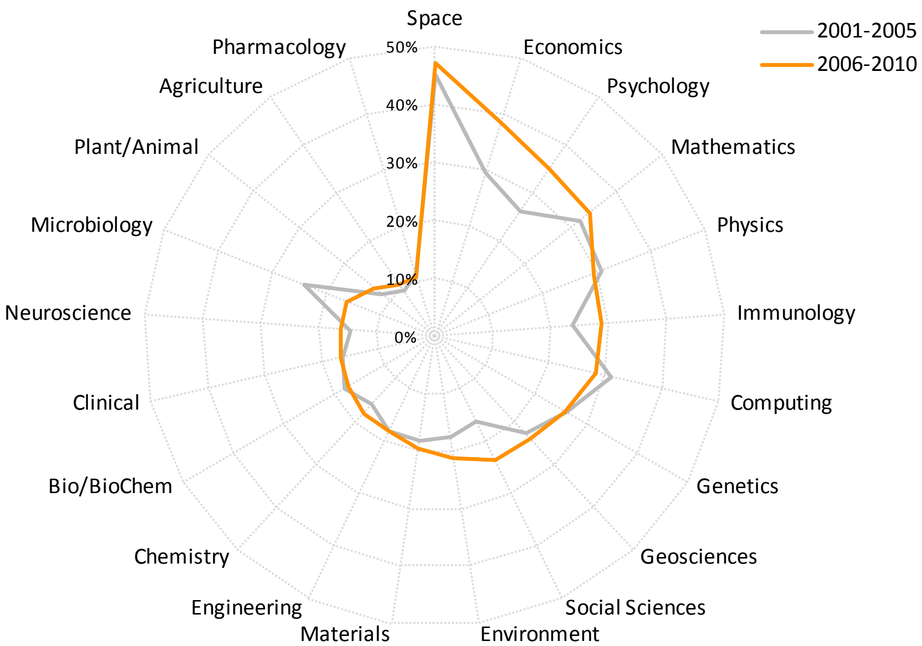
These changes are visualised in the Figures below.

Summary figures – International collaboration analysis

International collaboration, ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by standard sequence



International collaboration, ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by international collaboration 2006-2010



Section 8.1: International collaboration, All fields

8.1: International collaboration, All fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	8,054	6.9%	13,173	6.6%	5,119	-0.3%
Germany	3,310	2.8%	4,996	2.5%	1,686	-0.3%
UK	2,598	2.2%	4,555	2.3%	1,957	0.1%
Japan	2,399	2.0%	3,368	1.7%	969	-0.4%
France	1,678	1.4%	3,110	1.6%	1,432	0.1%
South Korea	994	0.8%	2,974	1.5%	1,980	0.6%
Canada	1,120	1.0%	2,186	1.1%	1,066	0.1%
China	999	0.9%	2,009	1.0%	1,010	0.1%
Australia	870	0.7%	1,815	0.9%	945	0.2%
Italy	984	0.8%	1,751	0.9%	767	0.0%

By way of background, in the 2001-2005 period, 18.8% of Indian research publications were internationally collaborative, and this increased to 19.5% in the 2006-2010 period (a small increase of 0.6%). The same figures for the UK were 33.5% in 2001-2005 and 40.9% by 2006-2010 (an increase of 7.4%). Whilst international collaboration varies substantially by country and by field (the USA and China like India have much lower levels of international collaboration compared to the UK due their larger geographies), Evidence has shown that for the UK, the 'impact gain on collaboration with all partner countries is often substantial'. UK collaboration with long-term partners such as the USA, Germany and France produces papers the impact of which are 50% higher than the UK research base average (Evidence report for the Department of Business Innovation and Skills, 'International comparative performance of the UK research base', September 2009).

The USA was the most frequent collaborating country with India in the 2006-2010 period, with 13,173 research publications co-authored between researchers based in the USA and researchers based in India. This represented 6.6% of India's research output. It was a volume increase of 5,119 on the 2001-2005 period, but a slight fall when expressed as an overall percentage contribution to India's research output (-0.3%).

Germany was the second most frequent collaborating country with India and the UK the third with 4,996 and 4,555 publications co-authored respectively with researchers in India (2.5% and 2.3% of total Indian research output in 2006-2010). This is around a third of USA levels of cooperation with India. It appears as though collaboration with Germany, whilst it has increased in volume terms since 2001-2005 (1,686), it represents a small fall when expressed as an overall percentage of India's research output (-0.3%). Publications co-authored with researchers in the UK have increased marginally as a percentage of India's overall research output (0.1%).

Collaboration as a percentage share of India's overall research output has increased with South Korea (0.6%), and Australia (0.2%) and decreased with Japan (-0.4%), otherwise it has remained broadly static with other countries, although across the board there are major increases in volume terms.

Section 8.2: International collaboration, Clinical medicine

8.2: International collaboration, Clinical medicine, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	1,118	7.7%	2,437	7.9%	1,319	0.3%
UK	505	3.5%	1,001	3.3%	496	-0.2%
Canada	118	0.8%	464	1.5%	346	0.7%
Australia	150	1.0%	416	1.4%	266	0.3%
Germany	153	1.0%	349	1.1%	196	0.1%
France	169	1.2%	317	1.0%	148	-0.1%
Switzerland	104	0.7%	276	0.9%	172	0.2%
China	90	0.6%	267	0.9%	177	0.3%
Japan	125	0.9%	266	0.9%	141	0.0%
Italy	83	0.6%	245	0.8%	162	0.2%

This Table shows the number and percentage of Indian research publications in Clinical Medicine which are internationally collaborative over the periods 2001-2005 and 2006-2010.

In the 2001-2005 period, 2,378 publications were internationally collaborative and this increased to 5,126 by 2006-2010. This represents a growth of 115.6% (over double) in pure volume terms. As a percentage of contribution to the India's Clinical Medicine research base, 16.3% of publications were internationally collaborative in 2001-2005 and this increased to 16.6% by 2006-2010 (+0.4%). These figures are below the Indian background figures for international collaboration.

The USA was India's most frequent collaborating partner in Clinical Medicine, with 2,437 publications co-authored between researchers in India and researchers in the USA in 2006-2010, representing 7.9% of India's total research output in Clinical Medicine. This was an increase of 0.3% on the 2001-2005 period. The UK was India's second most frequent collaborating partner, co-authoring less than half that of the USA: 1,001 publications in 2006-2010 which was 3.3% of India's total research output in Clinical Medicine, but a -0.2% fall on its contribution in relative terms on the 2001-2005 period. India's third most frequent collaborating partner in this field was Canada, which co-authored less than half the publications of the UK: 464 in 2006-2010, or 1.5% of India's total research output in Clinical Medicine. However, this was a 0.7% increase on its contribution in the 2001-2005 period.

Whilst collaboration increased with all partner countries in volume terms (see Change N), as a relative contribution to India's Clinical Medicine research output, it decreased with France (-0.1%), remained stable with Japan (0.0%). It increased with Australia (+0.3%), China (+0.3%), Italy (+0.2%) and Switzerland (+0.2%) and Germany (+0.1%).

Section 8.3: International collaboration, Psychiatry/psychology

8.3: International collaboration, Psychiatry/psychology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	64	11.0%	164	17.4%	100	6.4%
UK	57	9.8%	101	10.7%	44	0.9%
Australia	20	3.4%	54	5.7%	34	2.3%
Canada	15	2.6%	32	3.4%	17	0.8%
Germany	16	2.7%	25	2.6%	9	-0.1%
Brazil	12	2.1%	23	2.4%	11	0.4%
China	19	3.3%	23	2.4%	4	-0.8%
Switzerland	15	2.6%	19	2.0%	4	-0.6%
Japan	11	1.9%	16	1.7%	5	-0.2%
Mexico	3	0.5%	15	1.6%	12	1.1%
Netherlands	8	1.4%	15	1.6%	7	0.2%

This Table shows the number and percentage of Indian research publications in Psychiatry/Psychology which are internationally collaborative over the 2001-2005 and 2006-2010 periods.

By way of background, 151 internationally collaborative publications were published in the 2001-2005 period, and this increased to 330 by 2006-2010, a 118.5% growth (but note that this is growth on a small base). Overall, international collaboration contributed some 25.9% of India's total research output in Psychiatry/Psychology in 2001-2005 and this increased to 34.9% by 2006-2010 - an increase of 9.0%. This makes it the third ranking field for India in terms of international collaboration.

The USA was India's most frequent collaborating partner in 2006-2010, co-authoring 164 publications, or 17.4% of India's research output in Psychiatry/Psychology. This was an increase of +6.4% on its contribution in 2001-2005 (+100 publications). The UK was the second most frequent partner for India in terms of collaboration in this field accounting for 10.7% of India's research output in this field (101 publications). This was a 0.9% increase on the 2001-2005 period. Australia was the third most frequent partner for India in terms of collaboration, contributing to 5.7% of India's total research output in this field (54 publications).

Given the relatively low publication numbers for this field generally, and for some international collaborators in particular, it is probably not too meaningful to comment in great detail on the contents of this Table, save to say that India's most frequent partners are also those countries with large shares of Psychiatry/Psychology research (but note that Canada is not a country analysed in this report).

Section 8.4: International collaboration, Neuroscience & behaviour

8.4: International collaboration, Neuroscience & behaviour, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	177	9.8%	279	9.9%	102	0.1%
UK	39	2.2%	70	2.5%	31	0.3%
Germany	16	0.9%	41	1.5%	25	0.6%
Japan	10	0.6%	31	1.1%	21	0.5%
Canada	9	0.5%	27	1.0%	18	0.5%
Australia	5	0.3%	22	0.8%	17	0.5%
Sweden	2	0.1%	17	0.6%	15	0.5%
Italy	6	0.3%	13	0.5%	7	0.1%
China	5	0.3%	12	0.4%	7	0.1%
France	6	0.3%	12	0.4%	6	0.1%
Malaysia	3	0.2%	12	0.4%	9	0.3%

This Table shows the number and percentage of Indian research publications in Neuroscience & Behaviour which were internationally collaborative in the periods 2001-2005 and 2006-2010.

Over the 2001-2005 period, 266 publications were internationally co-authored and this increased to 461 by 2006-2010. This was an increase of 73.3% in raw volume growth terms. 14.7% of India's Neuroscience & Behaviour publications were internationally co-authored in 2001-2005 and this increased to 16.3% by 2006-2010 (a +1.7% increase). These levels of international collaboration are lower than the Indian background figures for internationally collaborative research overall (18.8% and 19.5% over the two periods respectively).

The USA was the most frequent collaborating partner country with India in Neuroscience & Behaviour, with authors in the USA co-authoring 279 publications with Indian researchers, or 9.9% (just short of a tenth) of India's total research output in this field. This was a slight relative increase on its 2001-2005 levels (+0.1%). The UK was the second most frequent collaborating partner country with the USA, co-authoring 70 publications with Indian researchers, or 2.5% of India's total research output (around a quarter of the contribution of the USA). This increased by 0.3% on the 2001-2005 period. Researchers in Germany co-authored 41 publications with Indian researchers, or 1.5% of India's total research output, an increase of 0.6%.

Publication numbers were generally quite small with other partners, but it is notable that across the board, there has been a relative increase in contribution from all countries which parallels the rise in research collaboration in Neuroscience & Behaviour research in India.

Section 8.5: International collaboration, Immunology

8.5: International collaboration, Immunology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	109	14.5%	231	16.7%	122	2.2%
UK	33	4.4%	53	3.8%	20	-0.6%
France	6	0.8%	50	3.6%	44	2.8%
China	3	0.4%	30	2.2%	27	1.8%
Canada	7	0.9%	25	1.8%	18	0.9%
Germany	6	0.8%	24	1.7%	18	0.9%
Japan	12	1.6%	23	1.7%	11	0.1%
Switzerland	4	0.5%	23	1.7%	19	1.1%
Australia	4	0.5%	21	1.5%	17	1.0%
Thailand	6	0.8%	15	1.1%	9	0.3%

This Table shows the number and percentage of Indian research publications in Immunology which are internationally collaborative over the periods 2001-2005 and 2006-2010.

In the 2001-2005 period, 178 publications were internationally collaborative (23.7% of India's total research output in this field) and by 2006-2010, 396 publications were internationally collaborative (28.7% of India's total research output in this field). Internationally collaborative publications had increased by 122.5%, and this accounted for a 4.9% rise in the percentage of India's Immunology research output which was internationally collaborative, the fourth highest change amongst the fields.

The USA was India's most frequent collaborating partner in this field, accounting for 231 publications, or 16.7% of India's total output in Immunology. This was an increase of +2.2% on its 2001-2005 level of contribution. The UK was India's second most frequent collaborating partner, with researchers in the UK co-authoring 53 publications with researchers in India, or 3.8% of India's total research output in Immunology. This is less than a quarter of the contribution of the USA. This was a relative decrease on its 2001-2005 levels of contribution (-0.6%). France was India's third most frequent collaborating partner, accounting for 3.6% of India's total collaborative output (50 publications) which was a +2.8% increase on its 2001-2005 levels of contribution.

Publication numbers are otherwise small for countries, but it is notable that collaboration increased as a percentage of India's total research output with all countries (with the exception of the UK), and that raw volume growth was high for all countries, with the caveat that these are increases on comparatively small bases.

Section 8.6: International collaboration, Pharmacology & toxicology

8.6: International collaboration, Pharmacology & toxicology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	154	5.7%	300	4.1%	146	-1.6%
UK	23	0.9%	88	1.2%	65	0.4%
Germany	24	0.9%	44	0.6%	20	-0.3%
Canada	14	0.5%	34	0.5%	20	0.0%
Japan	30	1.1%	28	0.4%	-2	-0.7%
Malaysia	3	0.1%	28	0.4%	25	0.3%
Australia	4	0.1%	27	0.4%	23	0.2%
Italy	8	0.3%	27	0.4%	19	0.1%
France	7	0.3%	25	0.3%	18	0.1%
South Korea	2	0.1%	23	0.3%	21	0.2%

This Table shows the number and percentage of Indian research publications in Pharmacology & Toxicology which are internationally collaborative by India's top 10 collaborating countries in this field.

In 2001-2005, Indian researchers co-authored 304 publications with other countries, 11.3% of its total research output in this field. By 2006-2010, this had risen to 769 publications, a rise of 153.0%. Whilst this is an impressive rise in volume terms, relative to the growth of Indian publications overall (168.6%), there was a relative fall in the percentage contribution of international collaboration to Indian Pharmacology & Toxicology research, falling from 11.3% in 2001-2005 to 10.6% by 2006-2010. Furthermore, these are the lowest levels of international collaboration amongst all research fields under analysis in this study in the 2006-2010 period.

The USA was India's most frequent collaborating partner in this field, co-authoring 300 publications, a contribution of 4.1% to India's total research output in this field. This was a -1.6% fall on its 2001-2005 contribution. The UK ranked second to the USA, with 88 publications co-authored between the two countries, or 1.2% of India's total research output in this field, a rise of 0.4% on its 2001-2005 levels of contribution.

Publication numbers are small (below 50) particularly in the 2001-2005 period. But it can broadly be said that collaboration has decreased with the established research economies of the USA, Germany and Japan (remaining stable with Canada in terms of percentage contribution to the total base of Indian research in Pharmacology & Toxicology), and it has risen with other countries such as Malaysia, Australia, Italy, France and South Korea.

Section 8.7: International collaboration, Molecular biology & genetics

8.7: International collaboration, Molecular biology & genetics, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	229	14.2%	401	13.9%	172	-0.3%
Germany	64	4.0%	95	3.3%	31	-0.7%
UK	44	2.7%	80	2.8%	36	0.0%
Japan	45	2.8%	69	2.4%	24	-0.4%
France	28	1.7%	65	2.3%	37	0.5%
Italy	17	1.1%	43	1.5%	26	0.4%
Canada	15	0.9%	42	1.5%	27	0.5%
Australia	21	1.3%	32	1.1%	11	-0.2%
Switzerland	8	0.5%	31	1.1%	23	0.6%
Netherlands	9	0.6%	30	1.0%	21	0.5%

This Table shows the number and percentage of Indian research publications which are internationally collaborative in Molecular Biology & Genetics over the periods 2001-2005 and 2006-2010.

In 2001-2005, 419 Indian research publications in Molecular Biology & Genetics were internationally co-authored, and this increased to 745 publications by 2006-2010. This represented (respectively) a 26.0% and 25.9% contribution to India's research base in this field, a slight drop of -0.1%. The growth in internationally co-authored publications was 77.8%, short of the growth in publications in this field overall (78.6%).

The USA was India's most frequent collaborator, co-authoring 401 publications in 2006-2010 which represented 13.9% of India's total research output in Molecular Biology & Genetics. However, this was a slight fall when expressed relative to its 2001-2005 contribution of -0.3%. Germany was India's second most frequent collaborator, but representing a much smaller portion of Indian research output in this field compared to the USA, i.e. 3.3% in 2006-2010 which was a fall of -0.7% on its 2001-2005 contribution (4.0%). The UK is India's third most frequent collaborator: co-authoring 2.8% of India's research publications in this field, more or less unchanged on its 2001-2005 levels of collaboration.

Collaboration has relatively decreased with Japan (-0.4%), but risen with France (+0.5%), Italy (0.4%) and Canada (+0.5%). Publication numbers are really quite small for Australia, Switzerland and the Netherlands, but across the board there have been volume increases in collaboration.

Section 8.8: International collaboration, Biology & biochemistry

8.8: International collaboration, Biology & biochemistry, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	495	8.5%	687	6.5%	192	-2.0%
UK	90	1.6%	152	1.4%	62	-0.1%
Germany	127	2.2%	151	1.4%	24	-0.8%
Japan	98	1.7%	146	1.4%	48	-0.3%
South Korea	23	0.4%	114	1.1%	91	0.7%
France	44	0.8%	102	1.0%	58	0.2%
Canada	48	0.8%	59	0.6%	11	-0.3%
Italy	20	0.3%	57	0.5%	37	0.2%
China	15	0.3%	55	0.5%	40	0.3%
Australia	18	0.3%	51	0.5%	33	0.2%

This Table shows the number and percentage of Indian research publications in Biology & Biochemistry which were internationally collaborative over the periods 2001-2005 and 2006-2010.

In 2001-2005, 1,046 publications were internationally co-authored (18.0% of India's total research output in Biology & Biochemistry) and whilst these publication numbers increased to 1,806 by 2006-2010, this constituted a drop in the percentage contribution of international collaboration to India's total research in this field (a drop of -0.9% to 17.1%). This is because the growth in collaborative publication numbers (72.7%) was not as high as the growth in publication numbers overall (81.8%).

The USA was India's most frequent collaborating partner in Biology & Biochemistry, co-authoring 687 publications in 2006-2010, or 6.5% of India's total research output in this field. This however, was a fall on its 2001-2005 contribution of -2.0%. The UK was India's second most frequent collaborating partner in this field, co-authoring 152 publications in 2006-2010, or 1.4% of India's total research output in this field. This was also a fall on its 2001-2005 levels of contribution. Collaboration also decreased relatively with Germany between the two periods by -0.8%: by 2006-2010, German researchers co-authored 151 publications with Indian researchers, or 1.4% of India's total research output in 2006-2010.

Elsewhere, collaboration relatively decreased with Japan (-0.3%) and Canada (-0.3%). Collaboration relatively increased with South Korea (+0.7%), France (+0.2%), Italy (+0.2%), China (+0.3%) and Australia (+0.2%).

Section 8.9: International collaboration, Microbiology

8.9: International collaboration, Microbiology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	118	8.4%	263	5.8%	145	-2.6%
Germany	39	2.8%	98	2.2%	59	-0.6%
Japan	47	3.4%	86	1.9%	39	-1.4%
South Korea	18	1.3%	69	1.5%	51	0.2%
UK	46	3.3%	67	1.5%	21	-1.8%
France	22	1.6%	45	1.0%	23	-0.6%
Bangladesh	19	1.4%	35	0.8%	16	-0.6%
China	5	0.4%	33	0.7%	28	0.4%
Australia	8	0.6%	32	0.7%	24	0.1%
Taiwan	4	0.3%	25	0.6%	21	0.3%

This Table shows the number and percentage of Indian research publications in Microbiology which are internationally collaborative in the periods 2001-2005 and 2006-2010.

In 2001-2005, 337 publications were internationally co-authored, representing 24.1% of India's total research output in this field. By 2006-2010, 734 publications were internationally co-authored, representing 16.3% of India's total research output in this field. This was a fall of -7.8% and was actually the largest percentage fall in international collaboration across the fields. This may be because growth in publication numbers (221.7%) was so fast (more than trebling) that growth in international collaboration (which more than doubled) did not keep pace (117.8%). It is also important to note that despite the small increases in percentage contribution when expressed relative to India's total research output in Microbiology, collaboration did increase substantially in volume terms.

The USA was India's most frequent collaborating partner in Microbiology, co-authoring 5.8% of India's research publications in this field in 2006-2010. This was a fall on its 2001-2005 contribution (8.4%) or -2.6%. Germany was India's second most frequent collaborating partner, co-authoring 2.2% of India's publications in this field. This was also a decline of -0.6% on its 2001-2005 levels of contribution. Japan was India's third most frequent collaborating partner in this field, co-authoring 1.9% of India's total research output in Microbiology, but this was a fall of -1.4% on its 2001-2005 contribution.

Collaboration relatively decreased with the UK (-1.8%), France (-0.6%), Bangladesh (-0.6%) but relatively increased with South Korea (+0.2%), China (+0.4%), Australia (+0.1%) and Taiwan (+0.3%) but these changes are based on relatively small publication numbers.

Section 8.10: International collaboration, Plant & animal science

8.10: International collaboration, Plant & animal science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	315	3.5%	441	3.6%	126	0.1%
Germany	115	1.3%	178	1.5%	63	0.2%
UK	142	1.6%	150	1.2%	8	-0.3%
Japan	97	1.1%	130	1.1%	33	0.0%
South Korea	49	0.5%	128	1.1%	79	0.5%
China	43	0.5%	92	0.8%	49	0.3%
Australia	55	0.6%	84	0.7%	29	0.1%
France	68	0.8%	73	0.6%	5	-0.2%
Canada	48	0.5%	70	0.6%	22	0.0%
Mexico	18	0.2%	50	0.4%	32	0.2%

This Table shows the number and percentage of Indian research publications in Plant & Animal Science which are internationally collaborative, by India's top 10 collaborating countries in this field.

In 2001-2005, 11.8% of Indian research publications in Plant & Animal Science were internationally collaborative, and this rose to 13.3% by 2006-2010, an increase of +1.5%. These levels of international collaboration are significantly lower than the Indian background figures.

The USA was the most frequent collaborating country with India in the 2006-2010 period, with 441 publications co-authored between researchers in the USA and India in the field of Plant & Animal Science. This represented 3.6% of India's research output in this field, a small increase of 0.1% on the equivalent 2001-2005 figures. Germany ranked second as a collaborating partner with India, with 178 publications in 2006-2010, an increase of +0.2% on the equivalent 2001-2005 levels. International collaboration with the UK fell as a percentage of India's research output by -0.3% between the two periods, and currently stands at 1.2% of Indian research output in the field of Plant & Animal Science.

Collaboration as a percentage share of India's research output in Plant & Animal Science has increased with South Korea (+0.5%), China (+0.3%) and Australia (+0.1%). It has remained static with Japan when expressed as a percentage change in contribution to Indian research output (0% change). It has decreased with France (-0.2%), remained stable with Canada (0% change) and increased with Mexico (+0.2%) although these latter figures are based on small publication numbers.

Looking at raw growth figures, it is notable that there has been an increase in Indian research collaboration across the board, but with particularly large rises in collaborative publications with Mexico, South Korea and China.

Section 8.11: International collaboration, Agricultural sciences

8.11: International collaboration, Agricultural sciences, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	110	2.4%	243	3.3%	133	0.8%
UK	56	1.2%	70	0.9%	14	-0.3%
Germany	42	0.9%	60	0.8%	18	-0.1%
Australia	35	0.8%	54	0.7%	19	0.0%
Canada	28	0.6%	53	0.7%	25	0.1%
Japan	33	0.7%	46	0.6%	13	-0.1%
Philippines	29	0.6%	41	0.6%	12	-0.1%
China	13	0.3%	33	0.4%	20	0.2%
South Korea	7	0.2%	33	0.4%	26	0.3%
Netherlands	18	0.4%	28	0.4%	10	0.0%

This Table shows the number and percentage of Indian research publications which are internationally collaborative in Agricultural Sciences for the time periods 2001-2005 and 2006-2010.

In 2001-2005, 432 publications were internationally co-authored, or 9.5% of India's total research output in Agricultural Sciences. By 2006-2010, publication numbers had increased to 814, or 10.9% of India's research output, an increased contribution of international collaboration to India's research base of 1.5%, and a growth in collaborative publication numbers of 88.4%. Agricultural Sciences had the lowest levels of international collaboration amongst the fields in this study in 2001-2005. It was the second lowest (to Pharmacology & Toxicology) in 2006-2010.

The USA was India's most frequent collaborating partner in Agricultural Sciences, but its contribution was relatively small: 3.3% of India's total research output in Agricultural Sciences, or 243 publications in 2006-2010. The UK was the second most frequent collaborating partner, co-authoring 70 publications, or 0.9% of India's total research output in this field, which was a decrease on its 2001-2005 levels of contribution (-0.3%). Germany was the third most frequent collaborating partner, with researchers in Germany co-authoring 0.8% of India's total research output in 2006-2010. Researchers from Australia and Canada co-authored 0.7% of India's Agricultural Sciences research publications.

Collaboration as a percentage of India’s research output in this field decreased with Japan (-0.1%) and the Philippines (-0.1%), but increased with China and South Korea (+0.2% and +0.3% respectively).

Section 8.12: International collaboration, Environment/ecology

8.12: International collaboration, Environment/ecology, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	189	6.7%	297	5.9%	108	-0.8%
UK	54	1.9%	127	2.5%	73	0.6%
Germany	59	2.1%	109	2.2%	50	0.1%
South Korea	10	0.4%	99	2.0%	89	1.6%
France	27	1.0%	91	1.8%	64	0.9%
Japan	42	1.5%	80	1.6%	38	0.1%
China	22	0.8%	64	1.3%	42	0.5%
Australia	16	0.6%	53	1.1%	37	0.5%
Canada	41	1.5%	52	1.0%	11	-0.4%
Netherlands	15	0.5%	52	1.0%	37	0.5%

This Table shows the number and percentage of Indian research publications in Environment/Ecology which were internationally collaborative over the periods 2001-2005 and 2006-2010.

In 2001-2005, Indian researchers co-authored 496 publications with international collaborators, or 17.7% of its total research output in Environment/Ecology. In 2006-2010, this increased to 1,067 publications, or 21.3% of India's research output in this field. This was an increase of 3.7% on its levels of international collaboration, which indicates higher growth in international collaboration in this field compared to the Indian research background. This also signifies substantial volume growth in the number of internationally co-authored publications - 115.1%, i.e. more than double its 2001-2005 volume.

The USA was India's most frequent collaborating partner in Environment/Ecology, co-authoring 297 publications with Indian researchers, of 5.9% of India's total research output in this field. This was a decrease on 2001-2005 when expressed as a contribution to overall Indian research in this field (-0.8%). Collaboration relatively increased with the UK: 127 publications or 2.5% of India's total research output in this field, an increase of 0.6% on the India's 2001-2005 levels of collaboration with the UK. Germany was India's third most frequent collaborating partner in this field: German researchers co-authored 109 publications in this field, or 2.2% of India's total research output in this field (an increase of 0.1%).

Collaboration increased relatively on 2001-2005 levels with South Korea (+1.6%), France (+0.9%) China, Australia and the Netherlands (all +0.5%) as a contribution to India's research in this field. Japan's contribution increased slightly (+0.1%) and Canada's fell (-0.4%).

It is important to note that across the board, collaboration when expressed as the number of publications has increased quite significantly with all countries: just then when expressed as a contribution to India's research in this field, the change on 2001-2005 percentages may have increased or decreased.

Section 8.13: International collaboration, Geosciences

8.13: International collaboration, Geosciences, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	303	7.5%	476	7.7%	173	0.2%
Japan	155	3.8%	201	3.3%	46	-0.6%
Germany	143	3.5%	200	3.2%	57	-0.3%
France	66	1.6%	151	2.4%	85	0.8%
UK	105	2.6%	150	2.4%	45	-0.2%
Canada	59	1.5%	90	1.5%	31	0.0%
Australia	36	0.9%	81	1.3%	45	0.4%
China	20	0.5%	49	0.8%	29	0.3%
South Africa	23	0.6%	37	0.6%	14	0.0%
Netherlands	6	0.1%	36	0.6%	30	0.4%

This Table shows the number and percentage of Indian research publications in Geosciences which were internationally collaborative over the periods 2001-2005 and 2006-2010.

The percentage of Indian Geosciences publications which were internationally collaborative in 2001-2005 was 22.8%; this increased to 24.0% by 2006-2010 (+1.2%). It is important to note that across the board, collaborative publications increased, from 926 to 1428 (an increase of 60.3%) and that this was faster than the growth in Indian Geosciences research generally (+52.3% increase).

India's most frequent collaborating partner in Geosciences was the USA which co-authored 476 publications with Indian researchers in 2006-2010, or 7.7% of India's total research output in this field. This was an increase of 0.2% on the 2001-2005 period. Japan was the second most frequent collaborating partner in 2006-2010, co-authoring 201 publications with India, or 3.3% of India's total research in Geosciences. This was a decreased relative contribution of -0.6% on its 2001-2005 levels. Germany was the third most frequent collaborating partner with India in Geosciences research, co-authoring 200 publications with Indian researchers, but this was a decreased contribution of -0.3% on its 2001-2005 levels.

In Geosciences research, collaboration relatively decreased over the periods with the UK (-0.2%), but rose significantly with France (+0.8%) and Australia (+0.4%) and China (0.3%). It remained about the same with Canada in terms of contribution to India's research base (0.0%).

Section 8.14: International collaboration, Chemistry

8.14: International collaboration, Chemistry, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	1,098	4.2%	1,658	4.2%	560	0.0%
Germany	663	2.5%	1,146	2.9%	483	0.4%
UK	420	1.6%	668	1.7%	248	0.1%
Japan	414	1.6%	561	1.4%	147	-0.2%
Malaysia	142	0.5%	552	1.4%	410	0.8%
South Korea	144	0.5%	511	1.3%	367	0.7%
France	264	1.0%	414	1.0%	150	0.0%
Spain	178	0.7%	304	0.8%	126	0.1%
Italy	172	0.7%	286	0.7%	114	0.1%
Taiwan	195	0.7%	251	0.6%	56	-0.1%

This Table shows the number and percentage of Indian research publications in Chemistry which are internationally collaborative, by India's top 10 most frequent collaborating countries in this field.

In 2001-2005, India co-authored with other countries 4,249 publications, 16.1% of its total research output. In 2006-2010, India co-authored 7,184 publications, 18.0% of its total research output (an increase of 1.9%). These levels of collaboration in Chemistry are lower than for Indian research overall 18.8% and 19.5% for the two periods), although the increase in collaboration is higher than for Indian research overall (+1.9% v +0.6%).

The raw growth in collaborative publications between the two periods was 69.1%, compared to a growth in publications of 51.6%, indicating that collaborative research publications are increasing both in absolute and relative terms compared to India's overall research output in Chemistry.

India's most frequent collaborating partner in Chemistry in 2006-2010 was the USA, and this accounted for 4.2% of India's total research output in Chemistry, and was no change in percentage terms as a share of India's total research output in the 2001-2005 period. Collaboration as a percentage share of India's Chemistry research output increased with Germany from 2.5% in 2001-2005 to 2.9% by 2006-2010 (+0.4%). There was an increase in collaboration with the UK (+0.1%).

Collaboration in Chemistry research has risen quite substantially, both in percentage terms and in terms of raw volume growth between India with Malaysia and South Korea, with (respectively) +0.8% and +0.7% increases in contribution to India's chemistry research output. By contrast collaboration has fallen in percentage terms with Japan (-0.2%) and Taiwan (-0.1%).

Section 8.15: International collaboration, Physics

8.15: International collaboration, Physics, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	1,567	11.4%	2,003	9.6%	436	-1.8%
Germany	1,111	8.1%	1,488	7.1%	377	-0.9%
France	605	4.4%	990	4.8%	385	0.4%
Japan	744	5.4%	940	4.5%	196	-0.9%
South Korea	447	3.2%	892	4.3%	445	1.0%
UK	433	3.1%	795	3.8%	362	0.7%
Russia	480	3.5%	764	3.7%	284	0.2%
China	468	3.4%	696	3.3%	228	-0.1%
Italy	380	2.8%	541	2.6%	161	-0.2%
Poland	292	2.1%	458	2.2%	166	0.1%

This Table shows the top 10 countries collaborating with India in Physics research.

In 2001-2005, 30.6% of India's research output in Physics was internationally co-authored. This decreased to 29.3% by 2006-2010 (a fall of -1.3%). This is a substantially higher amount of international collaboration compared to the Indian background figures.

The USA is India's most frequent partner in Physics, although the percentage of co-authored publications on the base of its contribution to Indian Physics research has fallen from 11.4% in 2001-2005 to 9.6% in 2006-2010 (a decrease of -1.8%). Germany as a partner has also fallen from 8.1% to 7.1% (a decrease of -0.9%). The percentage of India's research which is co-authored with France has risen (from 4.4% to 4.8% of India's total research output), and fallen with Japan (-0.9%).

Indian research collaboration as a percentage of its research output in Physics has increased with South Korea (+1.0%), the UK (+0.7%) Russia (+0.2%) and Poland (+0.1%), but it has fallen slightly with China (-0.1%) and Italy (-0.2%).

Across the board though, the number of publications produced has increased between 2001-2005 and 2006-2010 and it is important to note that whilst the increases are small when expressed as a percentage share of total Indian research output in Physics, raw volume growth is substantial.

Section 8.16: International collaboration, Space science

8.16: International collaboration, Space science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	316	22.7%	465	22.3%	149	-0.4%
France	114	8.2%	206	9.9%	92	1.7%
UK	107	7.7%	177	8.5%	70	0.8%
Germany	98	7.0%	175	8.4%	77	1.4%
Italy	83	6.0%	119	5.7%	36	-0.2%
Japan	80	5.7%	109	5.2%	29	-0.5%
Spain	45	3.2%	96	4.6%	51	1.4%
Australia	51	3.7%	91	4.4%	40	0.7%
Russia	29	2.1%	82	3.9%	53	1.9%
Netherlands	37	2.7%	70	3.4%	33	0.7%

This Table shows the number and percentage of Indian research publications which were internationally collaborative in Space Science in the periods 2001-2005 and 2006-2010.

In 2001-2005, 629 publications were internationally co-authored, and this increased to 980 publications by 2006-2010. This was a growth in raw volume terms of 55.8%. These internationally co-authored publications contributed to 45.2% of India's total research output in 2001-2005 and 47.1% by 2006-2010, an increase of 1.9%. These levels of international collaboration are the highest amongst all the fields under analysis in this report.

The USA was India's most frequent collaborating partner in this field, with researchers in the USA co-authoring 465 publications with Indian researchers, some 22.3% of India's total research output in Space Science. Whilst this was an increase in volume terms on the 2001-2005 levels of collaboration with the USA, it was a decrease (-0.4%) on the USA's contribution to India's research output compared to 2001-2005. France was the second most frequent collaborating partner with India, co-authoring 206 publications with Indian researchers in 2006-2010, which accounted for 9.9% of India's total research output in this field, an increase of 1.7% on 2001-2005. Collaboration in Space Science as percentage of India's total research output in this field also increased relatively with the UK (+0.8%) and Germany (+1.4%).

It is notable that this group of countries (excluding Russia) do not refer to the countries in the emerging economies research group as seen elsewhere. Collaboration has increased across the board with all these countries when expressed as raw volume growth. However, when expressed as a percentage of India's total research output, it has fallen with Italy (-0.2%) and Japan (-0.5%), but it has increased with Spain (+1.4%), Australia (+0.7%) and the Netherlands (+0.7%). Collaboration in Space Science has increased quite substantially with Russia (+1.9%).

Section 8.17: International collaboration, Materials science

8.17: International collaboration, Materials science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	350	4.3%	558	3.9%	208	-0.4%
South Korea	90	1.1%	458	3.2%	368	2.1%
Germany	277	3.4%	353	2.5%	76	-1.0%
Japan	225	2.8%	304	2.1%	79	-0.7%
France	77	1.0%	184	1.3%	107	0.3%
UK	111	1.4%	173	1.2%	62	-0.2%
Portugal	9	0.1%	109	0.8%	100	0.6%
China	31	0.4%	88	0.6%	57	0.2%
Italy	39	0.5%	76	0.5%	37	0.0%
Singapore	33	0.4%	73	0.5%	40	0.1%
Taiwan	60	0.7%	73	0.5%	13	-0.2%

This Table shows the number and percentage of Indian Material science research publications which are internationally collaborative over the periods 2001-2005 and 2006-2010.

In 2001-2005, 1,485 Indian Materials Science publications were internationally collaborative, and by 2006-2010, this figure had risen to 2,808: a growth in international collaborative publications of 89.1%. As a percentage contribution these publication numbers accounted for 18.3% and 19.6% respectively to India's Materials Science research output, a rise of 1.2%. These figures are not that dissimilar to the background of international collaboration in Indian research as a whole.

The USA was India's most frequent collaborating partner in Materials Science accounting for 3.9% of India's total research output in Materials Science, a fall of 0.4% on its 2001-2005 levels of contribution. Collaboration by contrast increased with South Korea, from 1.1% of India's total research output in Materials Science in 2001-2005 to 3.2% by 2006-2010, an increase of 2.1%.

Collaboration as a percentage contribution to India's Materials Science research output fell with Germany (-1.0%), Japan (-0.7%), the UK (-0.2%) and Taiwan (-0.2%). However, it rose with France (+0.3%), Portugal (+0.6%), China (+0.2%) and Singapore (+0.1%). It remained stable with Italy (0.0%). However, across the board, international collaboration had increased substantially in raw volume terms.

Section 8.18: International collaboration, Mathematics

8.18: International collaboration, Mathematics, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	227	10.8%	318	9.6%	91	-1.2%
Germany	49	2.3%	94	2.8%	45	0.5%
Canada	84	4.0%	91	2.8%	7	-1.2%
China	36	1.7%	88	2.7%	52	1.0%
France	59	2.8%	74	2.2%	15	-0.6%
UK	26	1.2%	62	1.9%	36	0.6%
South Korea	33	1.6%	57	1.7%	24	0.2%
Italy	27	1.3%	51	1.5%	24	0.3%
Japan	25	1.2%	47	1.4%	22	0.2%
Saudi Arabia	11	0.5%	39	1.2%	28	0.7%

This Table shows the top 10 countries collaborating with India in Mathematics research.

In 2001-2005, 31.9% of India's research output in Mathematics was internationally co-authored. This increased to 34.3% in the 2006-2010 period (an increase of 2.3%). This is a substantially higher level of international collaboration compared to the Indian background figures.

The USA is India's most frequent collaborating partner in Mathematics research, representing 9.6% of India's Mathematics research output in 2006-2010 (318 publications); however, this is a 1.2% fall from its relative contribution to Indian mathematics research in the 2001-2005 period (10.8%). Germany and Canada (representing less than a third of the level of USA collaboration) have co-authored 2.8% of Indian Mathematics publications in 2006-2010. However, when expressed relative to 2001-2005 levels of contribution to Indian mathematics research, this is a 0.5% increase for Germany, but a -1.2% decrease for Canada.

Publication numbers are low for countries with the exception of the USA, i.e. less than 100. Broadly speaking though, collaboration has increased markedly as a percentage of India's Mathematics research output with China (+1.0%), Saudi Arabia (+0.7%) and the UK (+0.6%). In volume terms, these are substantial increases, although caution must be exercised given the relatively small publication numbers on which these calculations are based.

Section 8.19: International collaboration, Computer science

8.19: International collaboration, Computer science, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	293	15.9%	386	14.0%	93	-1.9%
Canada	43	2.3%	58	2.1%	15	-0.2%
UK	37	2.0%	53	1.9%	16	-0.1%
France	27	1.5%	52	1.9%	25	0.4%
Singapore	37	2.0%	43	1.6%	6	-0.4%
Germany	39	2.1%	41	1.5%	2	-0.6%
China	18	1.0%	32	1.2%	14	0.2%
South Korea	21	1.1%	32	1.2%	11	0.0%
Australia	17	0.9%	27	1.0%	10	0.1%
Japan	33	1.8%	27	1.0%	-6	-0.8%

This Table shows the number and percentage of Indian research publications in Computer Science which are internationally collaborative, by India's top 10 most frequent collaborating countries in this field.

In 2001-2005, India co-authored 573 publications with other countries, 31.2% of its total research output in Computer Science. By 2006-2010, whilst collaboration had risen in volume terms (to 780 publications, or a 36.1% increase), it fell as a percentage of India's total research output in Computer Science to 28.4% (a fall of -2.8%). This is because the growth in collaborative publications has not been as large as the growth in the number of publications produced by India. However, these levels of collaboration are much higher than for Indian research overall.

The USA was India's most frequent collaborating partner in Computer Science in 2006-2010, with 14.0% of its research output in this area co-authored with researchers in the USA. This however was a fall from the 2001-2005 period of -1.9% from 15.9%, although it was an increase in volume terms.

Canada ranked as India's second most frequent collaborating partner in Computer Science in 2006-2010 contributing to 2.1% of India's Computer Science research publications. The UK ranked and France ranked third (a 1.9% contribution to Indian Computer Science research in 2006-2010). These levels are around one seventh of the contribution of the US showing that the USA is by far the most significant partner.

Elsewhere, publication numbers are perhaps too small (below 50) to make strong inferences. Broadly though, collaboration with Germany and Japan broadly fell in percentage terms (and the latter in volume terms), while collaboration with China, South Korea and Australia increased in both volume terms, although relative increases were modest.

Section 8.20: International collaboration, Engineering

8.20: International collaboration, Engineering, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	586	5.9%	974	5.1%	388	-0.8%
UK	180	1.8%	301	1.6%	121	-0.2%
Germany	254	2.6%	280	1.5%	26	-1.1%
South Korea	62	0.6%	253	1.3%	191	0.7%
Canada	97	1.0%	216	1.1%	119	0.2%
Japan	155	1.6%	206	1.1%	51	-0.5%
France	59	0.6%	181	1.0%	122	0.4%
China	63	0.6%	160	0.8%	97	0.2%
Australia	50	0.5%	152	0.8%	102	0.3%
Singapore	86	0.9%	122	0.6%	36	-0.2%

This Table shows the number and percentage of Indian Engineering publications which are internationally collaborative for the periods 2001-2005 and 2006-2010.

In 2001-2005, 1,794 publications were internationally co-authored and by 2006-2010, this had increased to 3,472 publications. In terms of volume growth, this was a 93.5% increase (just short of a doubling of volume). These internationally co-authored publications contributed to some 18.0% of total Indian research output in Engineering in 2001-2005 which rose to 18.2% by 2006-2010, an increase of 0.2%. These levels were below the background figures for international collaboration in Indian research overall (18.8% in 2001-2005 and 19.5% by 2006-2010) and the increase was smaller.

The USA was India's most frequent collaborating partner in Engineering research. Indian researchers co-authored 974 publications with researchers in the USA, or some 5.1% of Indian research output in Engineering. This however was a relative decrease of -0.8% on 2001-2005 levels of collaboration with the USA. The UK was the second most frequent collaborating partner with India in Engineering research, co-authoring 301 publications with Indian researchers in the 2006-2010 period. This again was a small decrease (-0.2%) on its collaboration in 2001-2005. Germany was the third most frequent collaborating partner in 2006-2010, and co-authored publications contributed 1.5% to India's total research base, but this was a -1.1% decrease on India's levels of collaboration with Germany in 2001-2005, or in raw volume terms, only a 10.2% growth.

Collaboration grew particularly strongly with South Korea (+0.7%), France (+0.4%) and Australia (+0.3%). It also grew with China (+0.2%) and Canada (+0.2%). Collaboration decreased with Japan (-0.5%) and Singapore (-0.2%).

Section 8.21: International collaboration, Economics & business

8.21: International collaboration, Economics & business, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	77	17.1%	165	20.0%	88	2.9%
UK	10	2.2%	54	6.5%	44	4.3%
China	8	1.8%	23	2.8%	15	1.0%
Australia	12	2.7%	20	2.4%	8	-0.2%
Netherlands	8	1.8%	20	2.4%	12	0.6%
Japan	5	1.1%	18	2.2%	13	1.1%
Canada	9	2.0%	17	2.1%	8	0.1%
Germany	4	0.9%	12	1.5%	8	0.6%
France	4	0.9%	8	1.0%	4	0.1%
Spain	2	0.4%	8	1.0%	6	0.5%

This Table shows the number and percentage of Indian research publications in Economics & Business which are internationally collaborative in the periods 2001-2005 and 2006-2010.

In the 2001-2005 period, 133 publications in Economics & Business produced in India were internationally co-authored, or 29.6% of India's total research output in this field. By 2006-2010, this had increased to 317 publications, or 38.4% of India's total research output in this field. In terms of volume growth, this was an increase of 138.3%, but in terms of increased contribution to India's research output in Economics & Business, this was an increase of 8.8%. This makes it the second highest field for international collaboration in India as a percentage of India's research output in a field (second to Space Science) and the second largest change in the percentage of international collaboration between the periods (second to Psychiatry/Psychology). However, it is important to note that these publication numbers are quite small.

The USA was India's most frequent collaborating partner in Economics & Business research, with researchers in the USA co-authoring 165 publications with India, or 20.0% of India's total research output in this field. This was an increase of 2.9% on 2001-2005 levels of collaboration. The UK was the second most frequent collaborating partner with India, co-authoring 54 publications, or 6.5% of India's research output in Economics & Business in 2006-2010. This was a rise of 4.3% on the 2001-2005 levels of collaboration, where only 10 publications had been co-authored. Publication numbers are otherwise too small for other countries to draw meaningful comparisons.

Section 8.22: International collaboration, Social sciences

8.22: International collaboration, Social sciences, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by rank in latest period

	2001-2005		2006-2010		Δ	
	N	%	N	%	N	%
USA	133	8.1%	311	12.0%	178	3.9%
UK	67	4.1%	123	4.7%	56	0.7%
Australia	16	1.0%	45	1.7%	29	0.8%
Canada	8	0.5%	42	1.6%	34	1.1%
Netherlands	9	0.5%	32	1.2%	23	0.7%
France	5	0.3%	21	0.8%	16	0.5%
Belgium	6	0.4%	20	0.8%	14	0.4%
Japan	7	0.4%	19	0.7%	12	0.3%
Switzerland	9	0.5%	18	0.7%	9	0.1%
China	4	0.2%	17	0.7%	13	0.4%

This Table shows the number and percentage of Indian research publications in Social Sciences which are internationally collaborative for the periods 2001-2005 and 2006-2010.

In the 2001-2005 period, 266 publications in Indian Social Science research were internationally co-authored, or 16.2% of India's total research output in that field. By 2006-2010, this had increased to 619 publications, or 23.8% of India's total research output in this field, an increase of +7.6%. This change in the percentage of publications which are internationally co-authored is the third highest amongst all fields. Volume growth has been substantial too (albeit on relatively small publication numbers), i.e. 132.7%.

The USA was India's most frequent collaborating partner in Social Sciences, with researchers in the USA co-authoring 311 publications with Indian researchers, or 12.0% of India's total research output in this field, an increase of 3.9% on 2001-2005 levels of collaboration. The UK was the second most frequent collaborating partner in Social Sciences, with 123 publications co-authored in 2006-2010, or 4.7% of India's research output in this field, a 0.7% increase on 2001-2005 levels. Australia accounted for 1.7% of India's co-authored publications in this field in 2006-2010, and Canada accounted for 1.6%. This an Anglophone grouping.

Publication numbers are otherwise too small (particularly in the 2001-2005 period) for other countries to provide meaningful commentary, although it is notable that collaboration has increased in volume terms with all countries, and also as a percentage contribution to India's total research output in Social Sciences.

9 Journal analysis

The Thomson Reuters Journal Impact Factor is useful for indexing the relative importance of a journal in its field, a higher Journal Impact Factor indicating greater significance because of greater use by other researchers as the foundation for work. We have evaluated the percentage of India's research paper output, as a whole, and disaggregated this by the *Essential Science Indicators®* fields which are published in the top 25% (top quartile) top 50% (top two quartiles) and top 75% (top three quartiles) of journals by Journal Impact Factor. These Tables compare the research output for two time periods, 2001-2005 and 2006-2010. We discuss how this has changed over time in the interpretive commentary accompanying the Table.

Summary

The Table shows the percentage of Indian papers, by field, which were published in journals that were respectively in the top 25% (top quartile), top 50% (top two quartiles) and top 75% (top three quartiles) of journals measured by Journal Impact Factor (JIF). The arrows on the Table indicate whether the change is up (↑ greater than 5%), the change is down (↓ less than 5%) or between the two (→).

Several methodological caveats need to be set out at the start. Firstly, journals in the upper quartiles by Journal Impact Factor are likely to a) publish more frequently and b) have a greater currency in terms of citation impact, thereby drawing greater percentages of research. This is also likely to vary substantially by field depending on the preponderance of certain high impact journals in certain fields. Secondly, there has been an expansion in regional journal coverage within the Thomson Reuters *Web of Knowledge*^{SM}, particularly Asian journal coverage, which will impact on Indian data coverage in particular. A key trend is that for a majority of fields there were decreases in the percentage of papers in the top quartile, top two quartiles and top three quartiles, which by definition means that there were increases in the percentage of papers published in the lowest quartile between 2001-2005 and 2006-2010. This may be due to increased regional journal coverage, but there may also be journal choices at play here, for example between national, regional and international journals. This merits further investigation.

Across Indian research as a whole, papers published in the top quartile of journals by Journal Impact Factor decreased from 29.1% in 2001-2005 to 28.2% by 2006-2010 (-0.9%). Papers published in the top two quartiles of journals by Journal Impact Factor also decreased from 58.3% in 2001-2005 to 57.0% by 2006-2010 (-1.3%). Papers published in the top three quartiles of journal by Journal Impact Factor also decreased from 79.7% in 2001-2005 to 77.0% by 2006-2010 (-2.7%). This, by definition, means that there was an increase in the percentage of papers published in the lowest quartile by Journal Impact Factor between these two time periods.

Looking the percentage of their papers in the top quartile of journals by Journal Impact Factor in 2006-2010, fields which had a comparatively high percentage of papers in this top quartile, included Materials Science (49.2%), Psychiatry/Psychology (46.0%), Computer Science (42.0%) and Immunology (41.2%) whereas fields like Microbiology (14.1%), Plant & Animal Science (18.7%), Neuroscience & Behaviour (19.3%) had far smaller percentages. Looking at the percentage of papers in the top two quartiles in 2006-2010, Materials Science (78.1%) and Psychiatry/Psychology (75.5%) have comparatively high percentages, and are joined by Physics (71.8%) and Engineering (69.5%) in addition to Immunology and Computer Science (both 66.4%). Microbiology and Agricultural Sciences have comparatively smaller percentages of papers in these top two quartiles (30.9% and 39.5% respectively). Looking at the percentage of papers in the top three quartiles of journals by Journal Impact Factor by 2006-2010, the highest percentages are in Space Science (91.9%), Materials Science (91.8%), Psychiatry/Psychology (91.2%) and Physics (90.6%) whereas the smallest percentages are in Agricultural Sciences (49.2%), Plant & Animal Science (60.4%) and Microbiology (60.8%).

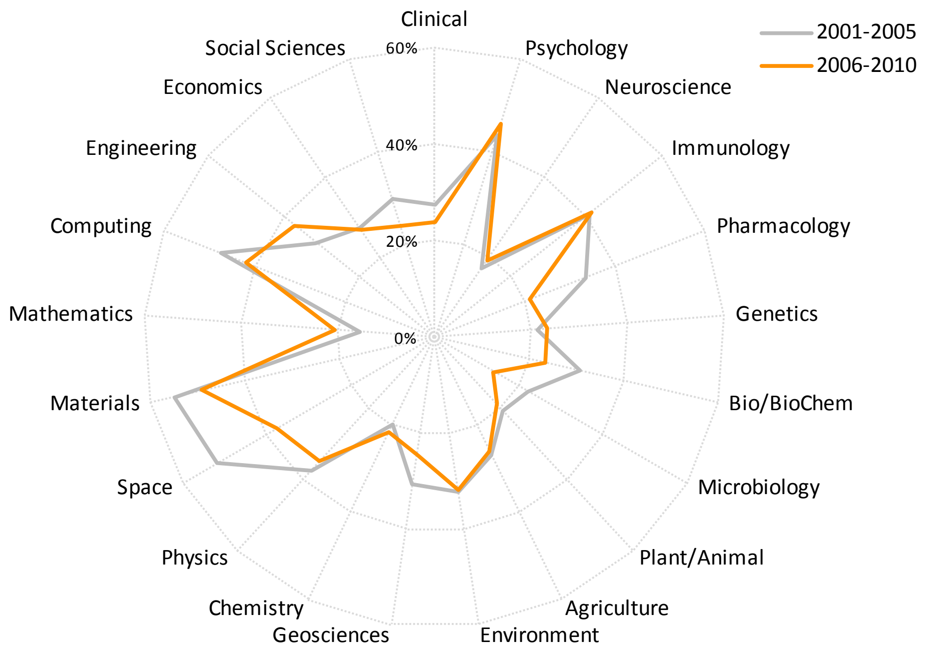
Another interesting observation to make is the change in the percentages between the time periods 2001-2005 and 2006-2010. Here, the data can broadly be divided into three groups. Firstly, there is the group whose percentage of papers across the three divisions of quartiles by Journal Impact Factor have increased (with a parallel decrease in the papers in the lowest quartile). These are (in descending order of change between the two periods in the top quartile), Engineering (+5.8%), Mathematics (+5.0%), Psychiatry/Psychology (2.4%), Neuroscience & Behaviour (2.2%) and Chemistry (2.0%). Engineering and Psychiatry/Psychology had a greater percentage of papers than the quartile percentages across all three quartiles, whereas Mathematics and Neuroscience & Behaviour have less. The second (much larger group) are the fields in which the percentages

of papers across all the three quartiles by Journal Impact Factor decreased, thereby increasing the percentage of papers in the lowest quartile by Journal Impact Factor. These are (in ascending order of the change between the two periods in the top quartile) Pharmacology & Toxicology (-12.4%), Microbiology (-8.0%), Biology & Biochemistry (-7.5%), Geosciences (-6.2%), Social Sciences (-5.9%), Computer Science (-5.5%), Clinical Medicine (-3.4%), Plant & Animal Science (-1.8%), Agricultural Sciences (-1.0%), Economics & Business (-0.7%), Environment/Ecology (-0.6%). Computer Science and Environment/Ecology had a greater percentage of papers than the quartile percentages across all three quartiles whereas Plant & Animal Science had less. Furthermore, Pharmacology & Toxicology and Biology & Biochemistry switched from having a greater percentage of papers than the quartile percentages across all the three quartiles in 2001-2005, to having less by 2006-2010. The final group are the fields where the picture is more mixed in terms of the increases and decreases in the percentage of journals by Journal Impact Factor across the three quartiles. These are in ascending order of the change in the percentage of the papers in the top quartile between 2001-2005 and 2006-2010: Space Science (-14.2%), Materials Science (-6.0%), Physics (-2.6%), Immunology (+0.3%), Molecular Biology & Genetics (+2.0%). With the exception of Molecular Biology & Genetics, the other fields had a greater percentage of papers than the quartile percentages across all three quartiles.

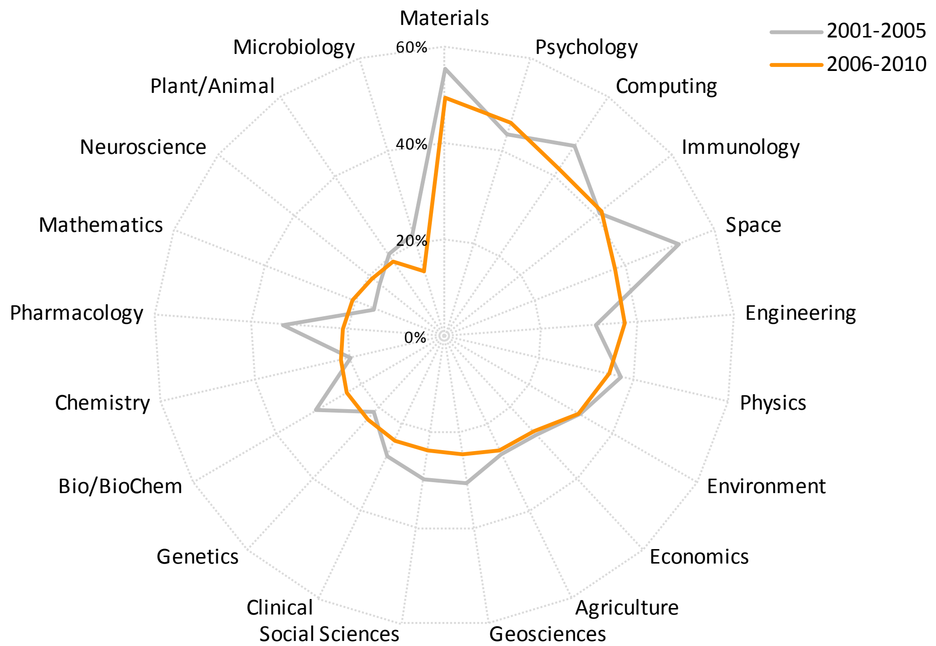
The Table is shown on the double-page spread, following the Figures which summarise the data for the percentage of Indian research which is published in the top 25% (top quartile) of journals by Journal Impact Factor.

Summary Figures – Journal analysis

Percentage papers in the top quartile by journal impact factors (JIF), ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by standard sequence



Percentage papers in the top quartile by journal impact factors (JIF), ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Ordered by percentage papers in the top quartile 2006-2010



Section 9.1: Journal impact factors (JIF), ESI fields

9.1: Journal impact factors (JIF), ESI fields, India
Time period: 2001-2005 and 2006-2010, Source: NCR India 2010, Δ indicates change

	Papers in top quartile			Papers in top two quartiles			Papers in top three quartiles		
	2001-2005	2006-2010	Δ	2001-2005	2006-2010	Δ	2001-2005	2006-2010	Δ
All Subjects	**29.1%**	**28.2%**	→	**58.3%**	**57.0%**	→	**79.7%**	**77.0%**	→
Clinical Medicine	27.3%	23.9%	→	60.9%	52.2%	↓	88.4%	75.1%	↓
Psychiatry/Psychology	43.6%	46.0%	→	72.6%	75.5%	→	85.0%	91.2%	↑
Neuroscience & Behavior	17.1%	19.3%	→	38.4%	49.8%	↑	53.8%	72.0%	↑
Immunology	40.9%	41.2%	→	64.6%	66.4%	→	92.3%	87.5%	→
Pharmacology & Toxicology	33.4%	21.1%	↓	56.8%	43.6%	↓	86.6%	63.3%	↓
Molecular Biology & Genetics	21.4%	23.5%	→	46.3%	45.3%	→	88.0%	79.3%	↓
Biology & Biochemistry	30.8%	23.3%	↓	56.9%	47.1%	↓	87.2%	74.1%	↓
Microbiology	22.1%	14.1%	↓	50.6%	30.9%	↓	87.2%	60.8%	↓
Plant & Animal Science	20.5%	18.7%	→	47.1%	44.5%	→	65.9%	60.4%	↓
Agricultural Sciences	27.0%	26.0%	→	44.5%	39.5%	→	53.3%	49.2%	→
Environment/Ecology	32.3%	31.7%	→	54.3%	54.0%	→	89.8%	88.6%	→
Geosciences	30.7%	24.5%	↓	64.8%	55.4%	↓	73.1%	70.0%	→
Chemistry	19.9%	21.9%	→	51.7%	53.8%	→	69.3%	72.7%	→
Physics	37.4%	34.8%	→	69.9%	71.8%	→	93.4%	90.6%	→
Space Science	51.8%	37.6%	↓	63.1%	54.5%	↓	88.5%	91.9%	→
Materials Science	55.2%	49.2%	↓	75.8%	78.1%	→	95.2%	91.8%	→
Mathematics	15.6%	20.6%	↑	39.7%	43.2%	→	60.7%	68.2%	↑
Computer Science	47.5%	42.0%	↓	71.4%	66.4%	↓	88.1%	87.8%	→
Engineering	31.3%	37.1%	↑	64.0%	69.5%	↑	83.7%	88.1%	→
Economics & Business	27.6%	26.9%	→	60.1%	47.2%	↓	85.0%	77.7%	↓
Social Sciences, general	29.8%	24.0%	↓	54.2%	49.0%	↓	73.8%	71.2%	→

Annex 1 - Bibliometrics and citation analysis

Bibliometrics are about publications and their citations. The academic field emerged from 'information science' and now usually refers to the methods used to study and index texts and information.

Publications cite other publications. These citation links grow into networks, and their numbers are likely to be related to the significance or impact of the publication. The meaning of the publication is determined from keywords and content. Citation analysis and content analysis have therefore become a common part of bibliometric methodology. Historically, bibliometric methods were used to trace relationships amongst academic journal citations. Now, bibliometrics are important in indexing research performance.

Bibliometric data have particular characteristics of which the user should be aware, and these are considered here.

Journal papers (publications, sources) report research work. Papers refer to or 'cite' earlier work relevant to the material being reported. New papers are cited in their turn. Papers that accumulate more citations are thought of as having greater 'impact', which is interpreted as significance or influence on their field. Citation counts are therefore recognised as a measure of impact, which can be used to index the excellence of the research from a particular group, institution or country.

The origins of citation analysis as a tool that could be applied to research performance can be traced to the mid-1950s, when Eugene Garfield proposed the concept of citation indexing and introduced the Science Citation Index, the Social Sciences Citation Index and the Arts & Humanities Citation Index, produced by the Institute of Scientific Information (currently the IP & Science business of Thomson Reuters).[17]

We can count citations, but they are only 'indicators' of impact or quality – not metrics. Most impact indicators use average citation counts from groups of papers, because some individual papers may have unusual or misleading citation profiles. These outliers are diluted in larger samples.

Data source

The data we use come from the Thomson Reuters databases underlying the *Web of Knowledge*℠, which gives access not only to journals but also to conference proceedings, books, patents, websites, and chemical structures, compounds and reactions. It has a unified structure that integrates all data and search terms together and therefore provides a level of comparability not found in other databases. It is widely acknowledged to be the world's leading source of citation and bibliometric data. The *Web of Science*℠ is one part of the *Web of Knowledge*, and focuses on research published in journals, conferences and books in science, medicine, arts, humanities and social sciences.

The *Web of Science* was created as an awareness and information retrieval tool but it has acquired an important secondary use as a tool for research evaluation, using citation analysis and bibliometrics. Data coverage is both current and retrospective in the sciences, social sciences, arts and humanities, in some cases back to 1900. Within the research community this data source is often still referred to by the acronym 'ISI'.

Unlike other databases, the *Web of Science* and underlying databases are selective, that is: the journals abstracted are selected using rigorous editorial and quality criteria. The authoritative, multidisciplinary content covers over 11,500 of the highest impact journals worldwide, including Open Access journals, and over 110,000 conference proceedings. The abstracted journals encompass the majority of significant, frequently cited scientific reports and, more importantly, an even greater proportion of the scientific research output which is cited. This selective process ensures that the citation counts remain relatively stable in given research fields and do not fluctuate unduly from year to year, which increases the usability of such data for performance evaluation.

Evidence, now as part of Thomson Reuters, has extensive experience with databases on research inputs, activity and outputs and has developed innovative analytical approaches for benchmarking and interpreting international, national and institutional research impact.

[17] Garfield, E (1955) Citation Indexes for Science – New dimension in documentation through association of ideas. *Science*: **122**, 108-111.

Database categories

The source data can be grouped in various classification systems. Most of these are based on groups of journals that have a relatively high cross-citation linkage and naturally cluster together. Custom classifications use subject maps in third-party data such as the OECD categories set out in the Frascati manual.

Thomson Reuters frequently uses the broader field categories in the *Essential Science Indicators* system and the finer journal categories in the *Web of Science*. There are 22 fields in *Essential Science Indicators* and 254 fields in *Web of Science*. In either case, our bibliometric analyses draw on the full range of data available in the underlying database, so analyses in our reports will differ slightly from anything created 'on the fly' from data in the web interface.

The lists of journal categories in these systems are attached at the end of this document.

Most analyses start with an overall view across the data, then move to a view across broad categories and only then focus in at a finer level in the areas of greatest interest to policy, programme or organisational purpose.

Assigning papers to addresses

A paper is assigned to each country and each organisation whose address appears at least once for any author on that paper. One paper counts once and only once for each assignment, however many address variants occur for the country or organisation. No weighting is applied.

For example, a paper has five authors, thus:

Author	Organisation	Country		
Gurney, KA	Univ Leeds	UK	**Counts for Leeds**	**Counts for UK**
Adams, J	Univ Leeds	UK	No gain for Leeds	No gain for UK
Kochalko, D	Univ C San Diego	USA	**Counts for UCSD**	**Counts for USA**
Munshi, S	Gujarat Univ	India	**Counts for Gujara**t	**Counts for India**
Pendlebury, D	Univ Oregon	USA	**Counts for Oregon**	No gain for USA

So this one paper with five authors would be included once in the tallies for each of four universities and once in the tallies for each of three countries.

Work carried out within Thomson Reuters, and research published elsewhere, indicates that fractional weighting based on the balance of authors by organisation and country makes little difference to the conclusions of an analysis at an aggregate level. Such fractional analysis can introduce unforeseen errors in the attempt to create a detailed but uncertain assignment. Partitioning credit would make a greater difference at a detailed, group level but the analysis can then be manually validated.

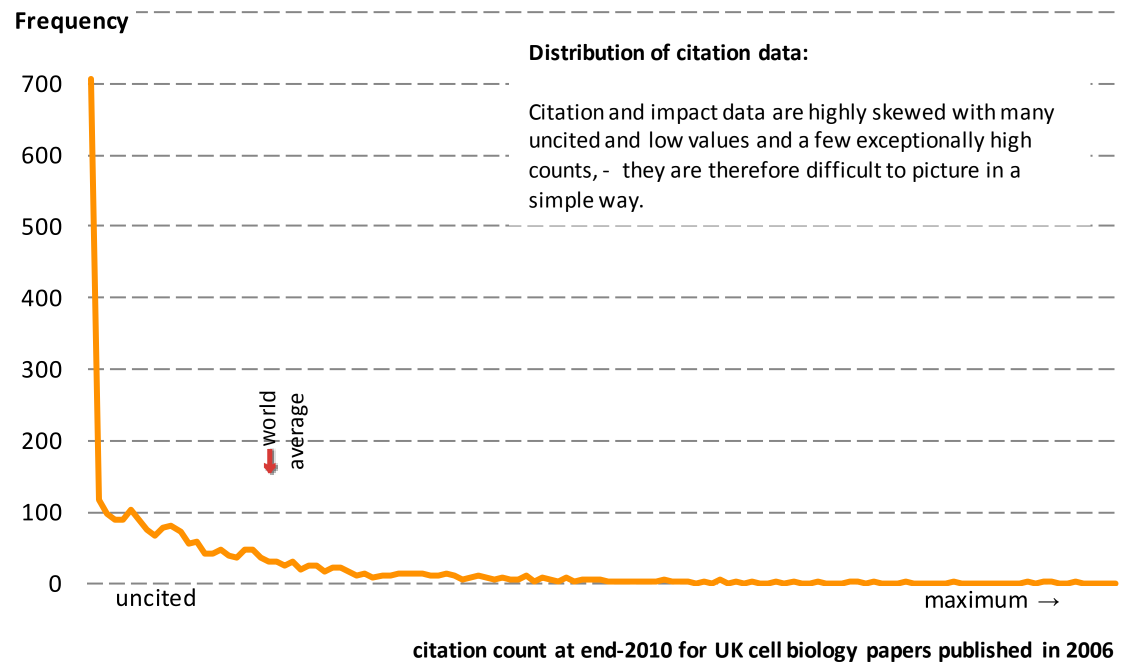
Citation counts

A publication accumulates citation counts when it is referred to by more recent publications. Some papers get cited frequently and many get cited rarely or never, so the distribution of citations is highly skewed.

Why are many papers never cited? Certainly some papers remain uncited because their content is of little or no impact, but that is not the only reason. It might be because they have been published in a journal not read by researchers to whom the paper might be interesting. It might be that they represent important but 'negative' work reporting a blind alley to be avoided by others. The publication may be a commentary in an editorial, rather than a normal journal article and thus of general rather than research interest. Or it might be that the work is a 'sleeping beauty' that has yet to be recognised for its significance.

Other papers can be very highly cited: hundreds, even thousands of times. Again, there are multiple reasons for this. Most frequently cited work is being recognised for its innovative significance and impact on the research field of which it speaks. Impact here is a good reflection of quality: it is an indicator of excellence. But there are other papers which are frequently cited because their significance is slightly different: they describe key methodology; they are a thoughtful and wide-ranging review of a field; or they represent contentious views which others seek to refute.

Citation analysis cannot make value judgments about why an article is uncited nor about why it is highly cited. The analysis can only report the citation impact that the publication has achieved. We normally assume, based on many other studies linking bibliometric and peer judgments, that high citation counts correlate on average with the quality of the research.



The figure shows the skewed distribution of more or less frequently cited papers from a sample of UK authored publications in cell biology. The skew in the distribution varies from field to field. It is to compensate for such factors that actual citation counts must be normalised, or rebased, against a world baseline.

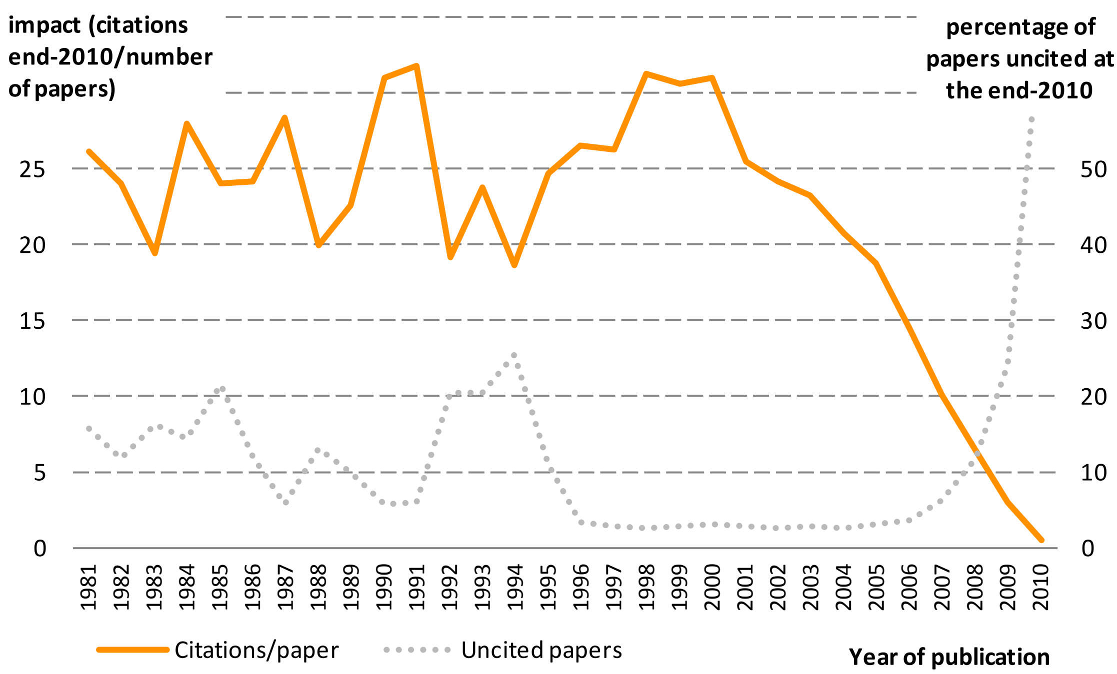
We do not seek to account separately for the effect of self-citation. If the citation count is significantly affected by self-citation then the paper is likely to have been infrequently cited. This is therefore only of consequence for low impact activity. Studies show that for large samples at national and organisational level the effect of self-citation has little or no effect on the analytical outcomes and would not alter interpretation of the results.

Time factors

Citations accumulate over time. Older papers therefore have, on average, more citations than more recent work. The graph below shows the pattern of citation accumulation for a set of 33 journals in the journal category ***Materials Science, Biomaterials***. Papers less than eight years old are, on average, still accumulating additional citations. The citation count goes on to reach a plateau for older sources.

The graph shows that the percentage of papers that have never been cited drops over about five years. Beyond five years, between 5% and 10% or more of papers remain uncited.

Account must be taken of these time factors in comparing current research with historical patterns. For these reasons, it is sometimes more appropriate to use a fixed five-year window of papers and citations to compare two periods than to look at the longer term profile of citations and of uncitedness for a recent year and an historical year.



Discipline factors

Citation rates vary between disciplines and fields. For the UK science base as a whole, ten years produces a general plateau beyond which few additional citations would be expected. On the whole, citations accumulate more rapidly and plateau at a higher level in biological sciences than physical sciences, and natural sciences generally cite at a higher rate than social sciences.

Papers are assigned to disciplines (journal categories or research fields) by Thomson Reuters, bringing cognate research areas together. The journal category classification scheme has been recently revised and updated. Before 2007, journals were assigned to the older, well established Current Contents categories which were informed by extensive work by Thomson and with the research community since the early 1960s. This scheme has been superseded by the 252 Web of Science journal categories which allow for greater disaggregation for the growing volume of research which is published and abstracted.

Papers are allocated according to the journal in which the paper is published. Some journals may be considered to be part of the publication record for more than one research field. As the example below illustrates, the journal *Acta Biomaterialia* is assigned to two journal categories: ***Materials Science, Biomaterials*** and ***Engineering, Biomedical***.

Very few papers are not assigned to any research field and as such will not be included in specific analyses using normalised citation impact data. The journals included in the Thomson Reuters databases and how they are selected are detailed here http://scientific.thomsonreuters.com/mjl/.

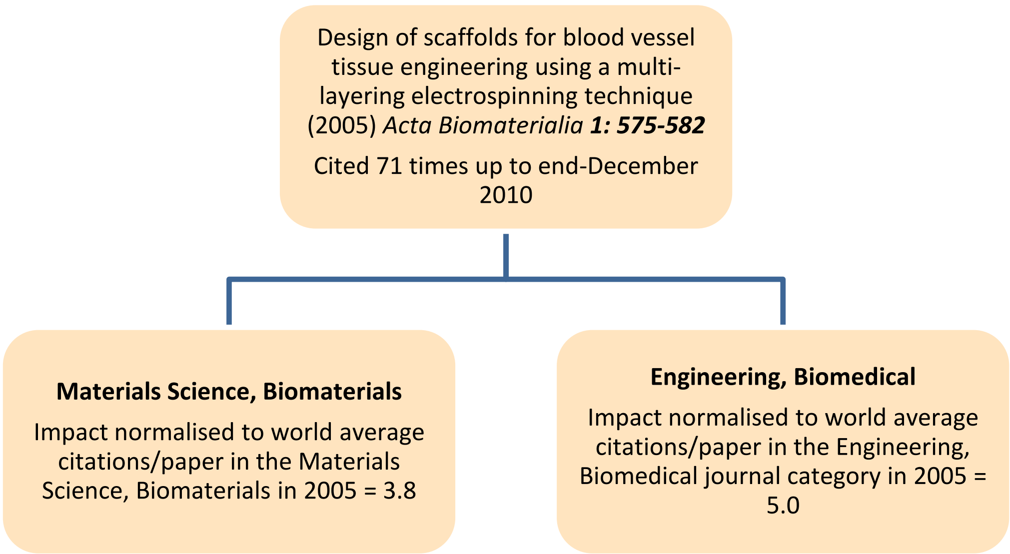
Some journals with a very diverse content, including the prestigious journals *Nature* and *Science* were classified as ***Multidisciplinary*** in databases created prior to 2007. The papers from these ***Multidisciplinary*** journals are now re-assigned to more specific research fields using an algorithm based on the research area(s) of the references cited by the article.

Normalised citation impact

Because citations accumulate over time at a rate that is dependent upon the field of research, all analyses must take both field and year into account. In other words, because the absolute citation count for a specific article is influenced by its field and by the year it was published, we can only make comparisons of indexed data after normalising with reference to these two variables.

We only use citation counts for reviews and articles in calculations of impact, because document type influences the citation count. For example, a review will often be cited more frequently than an article in the same field, but editorials and meeting abstracts are rarely cited and citation rates for conference proceedings are extremely variable. The most common normalisation factors are the average citations per paper for (1) the year and (2) either the field or the journal in which the paper was published. This normalisation is also referred to as 'rebasing' the citation count.

Impact is therefore most commonly analysed in terms of 'normalised impact', or nci. The following schematic illustrates how the normalised citation impact is calculated at paper level and journal category level.



This article in the journal *Acta Biomaterialia* is assigned to two journal categories: ***Materials Science, Biomaterials*** and ***Engineering, Biomedical***. The world average baselines for, as an example, ***Materials science, Biomaterials*** are calculated by summing the citations to all the articles and reviews published worldwide in the journal *Acta Biomaterialia* and the other 32 journals assigned to this category for each year, and dividing this by the total number of articles and reviews published in the journal category. This gives the category-specific normalised citation impact (in the above example the category-specific nci_F for ***Materials Science, Biomaterials*** is 3.8 and the category-specific nci_F for ***Engineering, Biomedical*** is higher at 5.0). Most papers (nearly two-thirds) are assigned to a single journal category whilst a minority are assigned to more than 5.

Citation data provided by Thomson Reuters are assigned on an annual census date referred to as the Article Time Period. For the majority of publications the Article Time Period is the same as the year of publication, but for a few publications (especially those published at the end of the calendar year in less main-stream journals) the Article Time Period may vary from the actual year of publication.

World average impact data are sourced from the Thomson Reuters National Science Indicators baseline data for 2010.

Average citation impact

Research performance has historically been indexed by using average citation impact, usually compared to a world average that accounts for time and discipline. As noted, however, the distribution of citations amongst papers is highly skewed because many papers are never cited while a few papers accumulate very large citation counts. That means that an average may be misleading if assumptions are made about the distribution of the underlying data.

In fact, almost all research activity metrics are skewed: for research income, PhD numbers and publications there are many low activity values and a few exceptionally high values. In reality, therefore, the skewed distribution means that average impact tends to be greater than and often significantly different from either the median or mode in the distribution. This should be borne in mind when reviewing analytical outcomes.

The average (normalised) citation impact can be calculated at an individual paper level where it can be associated with more than one journal category. It can also be calculated for a set of papers at any level from a single country to an individual researcher's output. In the example above, the average citation impact of the *Acta Biomaterialia* paper can be expressed as ((3.8 + 5.0)/2) = 4.4.

Impact Profiles®

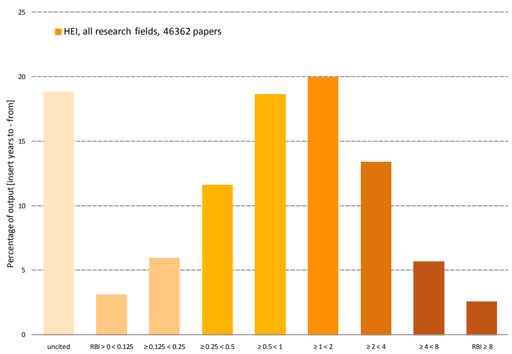
We have developed a bibliometric methodology[18] that shows the proportion of papers that are uncited and the proportion that lie in each of eight categories of relative citation rates, normalised (rebased) to world average. An Impact Profile® enables an examination and analysis of the strengths and weaknesses of published outputs relative to world average and relative to a reference profile. This provides much more information about the basis and structure of research performance than conventionally reported averages in citation indices.

"Highly-cited" papers are defined in our reports as those with an average citation impact (nci_F) greater than or equal to 4.0, i.e. papers which have received greater than or equal to four times the world average number of citations for papers in that subject published in that year. This differs from Thomson Reuters database of global highly-cited papers, which are the 1% most frequently cited for their field and year. The top percentile is a powerful indicator of leading performance but is too stringent a threshold for most management analyses.

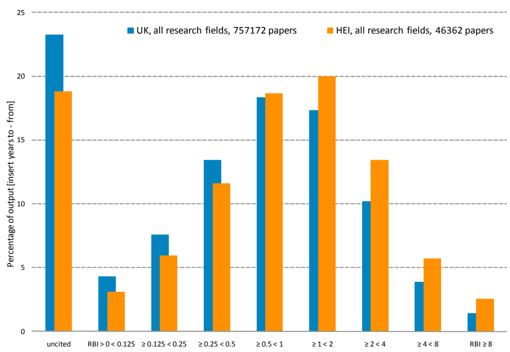
The proportion of uncited papers in a dataset can be compared to the benchmark for the UK, the USA or any other country. Overall, in a typical ten-year sample, around one-quarter of papers have not been cited within the 10-year period; the majority of these are, of course, those that are most recently published.

The Impact Profile® histogram can be presented in a number of ways which are illustrated below.

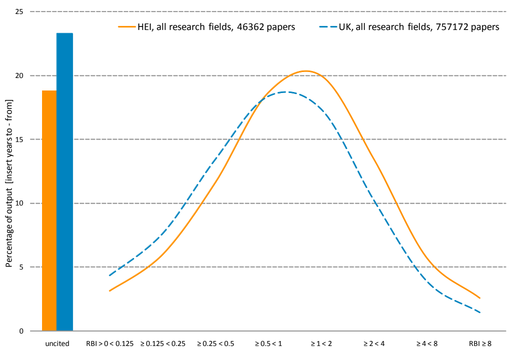
A



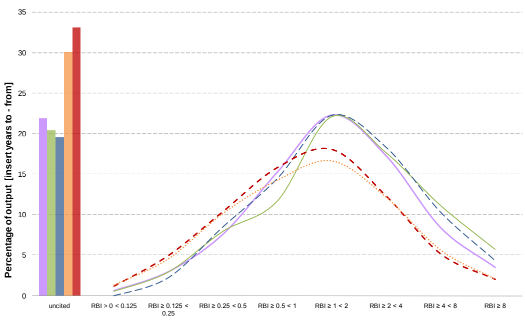
B



C



D



A: is used to represent the total output of an individual country, institution or researcher with no benchmark data. Visually it highlights the numbers of uncited papers (weaknesses) and highly-cited papers (strengths).

B & **C**: are used to represent the total output of an individual country, institution or researcher (**client**) against an appropriate benchmark dataset (**benchmark**). The data are displayed as either histograms (B) or combination of histogram and profile (C). Version C prevents the 'travel' which occurs in histograms where the eye is drawn to the data most offset to the right, but can be less easy to interpret as categorical data.

[18] Adams J, Gurney K & Marshall S (2007) Profiling citation impact: A new methodology. *Scientometrics* **72**: 325-344.

D: illustrates the complexity of data which can be displayed using an Impact Profile®. These data show research output in defined journal categories against appropriate benchmarks: **client, research field X**; **client, research field Y**; **client, research field Z**; **benchmark, research field X+Y**; **benchmark, research field, Z**.

Impact Profiles® enable an examination and analysis of the balance of published outputs relative to world average and relative to a reference profile. This provides much more information about the basis and structure of research performance than conventionally reported averages in citation indices.

An Impact Profile® shows what percentage of papers are uncited and what percentage are in each of eight categories of relative citation rates, normalised to world average (which becomes 1.0 in this Figure). Normalised citation rates above 1.0 indicate papers cited more often than world average for the field in which that journal is categorised and in their year of publication.

Attention should be paid to:

- The percentage of uncited papers on the left of the Figure
- The percentage of cited papers either side of world average (1.0)
- The location of the most common (modal) group near the centre
- The percentage of papers in the most highly-cited categories to the right, (≥4 x world, ≥8 x world)

What are uncited papers?

It may be a surprise that some journal papers are never subsequently cited after publication, even by their authors. This accounts for about half the total global output for a typical, recent 10-year period. We cannot tell why papers are not cited. It is likely that a significant proportion of papers remain uncited because they are reporting negative results which are an essential matter of record in their field but make the content less likely to be referenced in other papers. Inevitably, other papers are uncited because their content is trivial or marginal to the mainstream. However, it should not be assumed that this is the case for all such papers.

There is variation in non-citation between countries and between fields. For example, relatively more engineering papers tend to remain uncited than papers in other sciences, indicative of a disciplinary factor but not a quality factor. While there is also an obvious increase in the likelihood of citation over time, most papers that are going to be cited will be cited within a few years of publication.

What is the threshold for 'highly cited'?

Thomson Reuters has traditionally used the term 'Highly Cited Paper' to refer to the world's 1% of most frequently cited papers, taking into account year of publication and field. In rough terms, UK papers cited more than eight times as often as relevant world average would fall into the Thomson Highly Cited category. About 1-2% of papers (all papers, cited or uncited) typically pass this hurdle. Such a threshold certainly delimits exceptional papers for international comparisons but, in practice, is an onerous marker for more general management purposes.

After reviewing the outcomes of a number of analyses, we have chosen a more relaxed definition for our descriptive and analytical work. We deem papers that are cited more often than four times the relevant world average to be relatively highly-cited for national comparisons. This covers the two most highly-cited categories in our graphical analyses.

Evidence quality index

Another bibliometric indicator which can be very useful in small datasets is the *Evidence* quality index. This indicator is calculated from the citation impact relative to the specific journal in which the paper is published.

For the paper on page 190 which has been cited 71 times to the end-December 2010, the expected citation rate for a paper in *Acta Biomaterialia* published in 2005 would be 18.6. Therefore, this paper has been cited more than expected for the journal. For a set of papers, we calculate the quality index as the percentage of papers which are cited more than expected for the relevant journals.

This indicator should be considered alongside that of normalised citation impact as they are complementary. For example, a given set of publications may have a high *Evidence* quality index and relatively low citation impact. This would imply that these papers were well cited in relation to other papers in that journal and that year but did not perform as well in relation to papers published in more highly-cited journals in the same research field. The interpretation would be that the publications are in relatively low impact journals.

Journal category systems used in our analyses

Web of Science

Acoustics
Agricultural economics & policy
Agricultural engineering
Agriculture, dairy & animal science
Agriculture, multidisciplinary
Agriculture, soil science
Agronomy
Allergy
Anatomy & morphology
Andrology
Anesthesiology
Anthropology
Applied linguistics
Archaeology
Architecture
Area studies
Art
Asian studies
Astronomy & astrophysics
Automation & control systems
Behavioral sciences
Biochemical research methods
Biochemistry & molecular biology
Biodiversity conservation
Biology
Biology, miscellaneous
Biophysics
Biotechnology & applied microbiology
Business
Business, finance
Cardiac & cardiovascular systems
Cell biology
Chemistry, analytical
Chemistry, applied
Chemistry, inorganic & nuclear
Chemistry, medicinal
Chemistry, multidisciplinary
Chemistry, organic
Chemistry, physical
International relations

Classics
Clinical neurology
Communication
Computer science, artificial intelligence
Computer science, cybernetics
Computer science, hardware & architecture
Computer science, information systems
Computer science, interdisciplinary applications
Computer science, software engineering
Computer science, theory & methods
Construction & building technology
Criminology & penology
Critical care medicine
Crystallography
Dance
Demography
Dentistry, oral surgery & medicine
Dermatology
Developmental biology
Ecology
Economics
Education & educational research
Education, scientific disciplines
Education, special
Electrochemistry
Emergency medicine
Endocrinology & metabolism
Energy & fuels
Engineering, aerospace
Engineering, biomedical
Engineering, chemical
Engineering, civil
Engineering, electrical & electronic
Engineering, environmental
Engineering, geological
Engineering, industrial
Engineering, manufacturing
Engineering, marine
Engineering, mechanical
Mining & mineral processing

Engineering, multidisciplinary
Engineering, ocean
Engineering, petroleum
Entomology
Environmental sciences
Environmental studies
Ergonomics
Ethics
Ethnic studies
Evolutionary biology
Family studies
Film, radio, television
Fisheries
Folklore
Food science & technology
Forestry
Gastroenterology & hepatology
Genetics & heredity
Geochemistry & geophysics
Geography
Geography, physical
Geology
Geosciences, multidisciplinary
Geriatrics & gerontology
Health care sciences & services
Health policy & services
Hematology
History
History & philosophy of science
History of social sciences
Horticulture
Humanities, multidisciplinary
Imaging science & photographic technology
Immunology
Industrial relations & labor
Infectious diseases
Information & library science
Instruments & instrumentation
Integrative & complementary medicine
Psychology

Language & linguistics	Multidisciplinary sciences	Psychology, applied
Language & linguistics theory	Music	Psychology, biological
Law	Mycology	Psychology, clinical
Limnology	Nanoscience & nanotechnology	Psychology, developmental
Linguistics	Neuroimaging	Psychology, educational
Literary reviews	Neurosciences	Psychology, experimental
Literary theory & criticism		Psychology, mathematical
Literature	Nuclear science & technology	Psychology, multidisciplinary
Literature, African, Australian, Canadian	Nursing	Psychology, psychoanalysis
Literature, American	Nutrition & dietetics	Psychology, social
Literature, British Isles	Obstetrics & gynecology	Public administration
Literature, German, Dutch, Scandinavian	Oceanography	Public, environmental & occupational health
Literature, romance	Oncology	Radiology, nuclear medicine & medical imaging
Literature, Slavic	Operations research & management science	Rehabilitation
Management	Ophthalmology	Religion
Marine & freshwater biology	Optics	Remote sensing
Materials science, biomaterials	Ornithology	Reproductive biology
Materials science, ceramics	Orthopedics	Respiratory system
Materials science, characterization & testing	Otorhinolaryngology	Rheumatology
Materials science, coatings & films	Paleontology	Robotics
Materials science, composites	Parasitology	Social issues
Materials science, multidisciplinary	Pathology	Social sciences, biomedical
Materials science, paper & wood	Pediatrics	Social sci, interdisciplinary
Materials science, textiles	Peripheral vascular disease	Social sci, mathematical methods
Math & computational biology	Pharmacology & pharmacy	Social work
Mathematics	Philosophy	Sociology
Mathematics, applied	Physics, applied	Soil science
Mathematics, interdisciplinary applications	Physics, atomic, molecular & chemical	Spectroscopy
Mechanics	Physics, condensed matter	Sport sciences
Medical ethics	Physics, fluids & plasmas	Statistics & probability
Medical informatics	Physics, mathematical	Substance abuse
Medical laboratory technology	Physics, multidisciplinary	Surgery
Medicine, general & internal	Physics, nuclear	Telecommunications
Medicine, legal	Physics, particles & fields	Theater
Medicine, research & experimental	Physiology	Thermodynamics
Medieval & renaissance studies	Planning & development	Toxicology
Metallurgy & metallurgical engineering	Plant sciences	Transplantation
Meteorology & atmospheric sci	Poetry	Transportation
Microbiology	Political science	Transportation science & technology
Microscopy	Polymer science	Tropical medicine
Mineralogy	Psychiatry	
Urban studies		
Urology & nephrology		

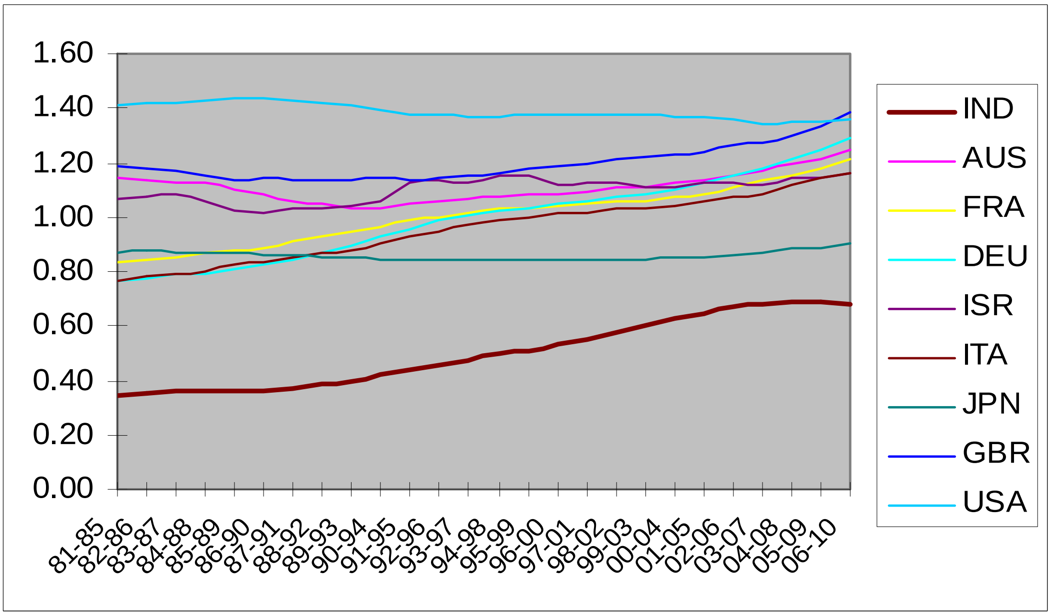
Veterinary
Veterinary sciences
Virology
Water resources
Women's studies
Zoology

Essential Science Indicators

Agricultural Sciences
Biology & Biochemistry
Chemistry
Clinical Medicine
Computer Science
Ecology/Environment
Economics & Business
Education
Engineering
Geosciences
Immunology
Law
Materials Science
Mathematics
Microbiology
Molecular Biology & Genetics
Multidisciplinary
Neurosciences & Behaviour
Pharmacology
Physics
Plant & Animal Science
Psychology/Psychiatry
Social Sciences, general
Space Science

Annexure 2

Comparison of Citation impacts of Indian publications with some developed economies



Comparison of citation impacts of Indian publications with some emerging economies