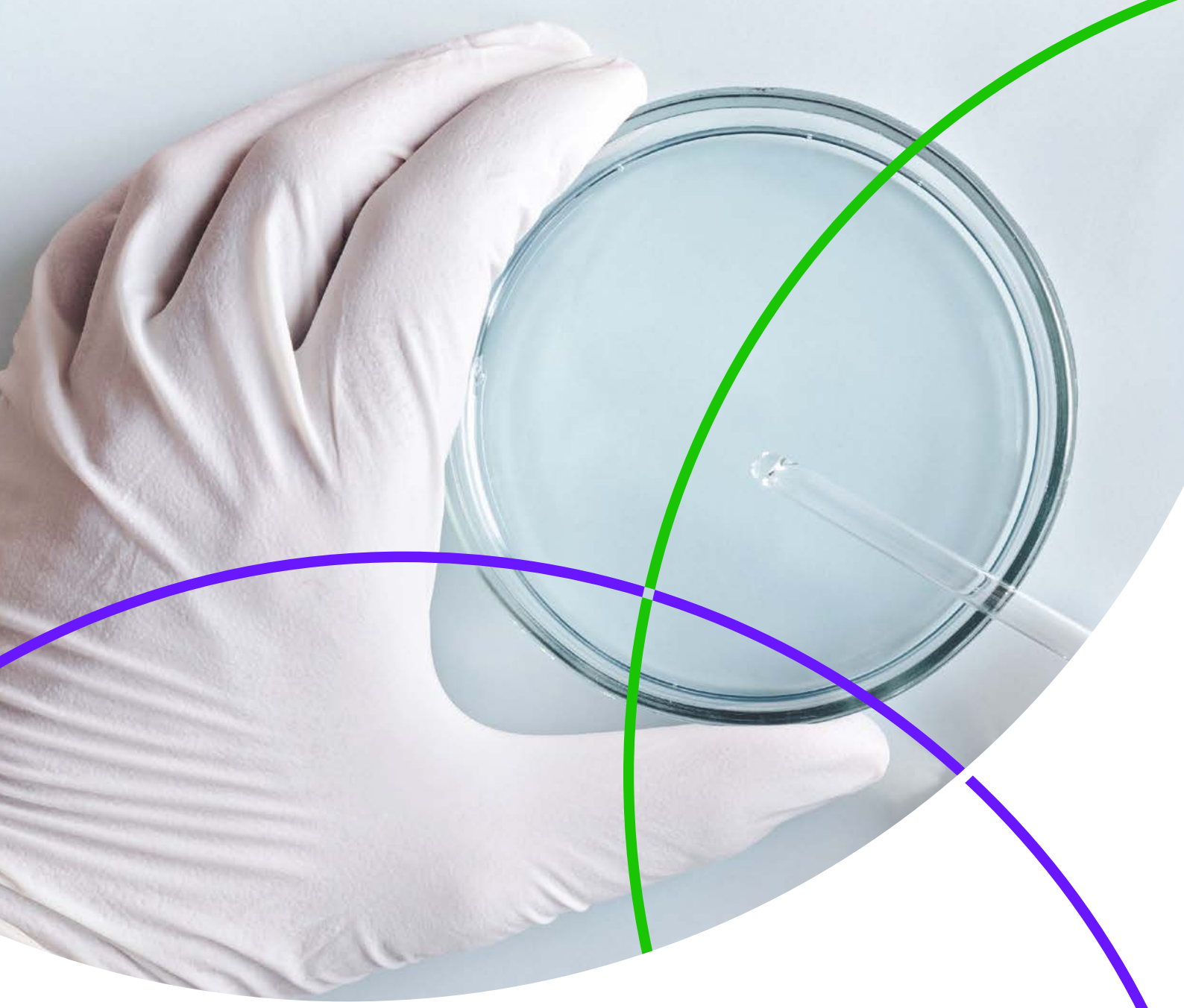

Research in Brazil

A report for CAPES by Clarivate Analytics

Clarivate Analytics

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Authors

Di Cross
Director, Research Data Science & Evaluation

Dr. Cross is an experienced project manager and data analyst. She manages the team of analysts carrying out the day-to-day tasks in response to individual task orders. She provides oversight through individual evaluations to ensure quality of work and proper coordination among project managers, analysts and all other applicable staff in responding to evaluation requests.

Simon Thomson
Senior Scientific Analyst

Dr. Thomson is Senior Scientific Analyst at Clarivate Analytics. He specializes in using bibliometric data to evaluate research activity and performance. Simon holds a PhD in structural biology from the University of Sheffield. He manages a team of analysts and is an experienced project manager. He has led evaluation projects for publishers, funders, universities, and government departments globally.

Alexandra Sinclair
Scientific Analyst

Dr. Sinclair is a Scientific Analyst in the Scientific & Academic Research Professional Services team at Clarivate Analytics. Prior to Clarivate, Alex worked at the Royal Society as part of the policy team looking at research culture and has worked with Sense About Science evaluating the use of evidence in policy making by the British and European governments. Alex's academic background is in Chemistry and she has worked at universities in Europe, Japan and the USA.

This report has been prepared for CAPES by Clarivate Analytics.

It provides a high-level overview of Brazilian research performance describing recent trends and identifying where strengths exist.

Executive Summary

This report considers Brazilian research performance in a global context. It seeks to answer questions about how Brazilian research is changing and how performance has been affected by changes in policy and funding. Using bibliometrics to analyze Brazilian research papers published between 2011 and 2016 we have identified strengths and opportunities for Brazilian research and science policy.

The key findings of this report are:

Productivity

- Brazil is the 13th largest producer of research publications globally (Figure 1) and its research output grows annually (Figure 2).

Impact

- Brazil's citation impact has historically been below the world average but has increased by more than 15% over the past six years (Figure 3).
- Brazil produces some very highly-cited papers and has achieved good rates of papers in the world's top 1% (Figure 4).

Collaboration

- Increasingly Brazilian researchers are working across country borders within and beyond Latin America and the resulting papers have a higher impact than Brazil's domestic research (Figure 8 and Figure 9).
- Overall, industry co-authors only about 1% of Brazilian research papers (Figure 12).
- Large pharmaceutical firms were the most frequent industrial collaborators and Petrobras SA was the only domestic company to collaborate significantly with Brazilian academics (Figure 13).

Comparison with peer countries

- Brazil compares well with neighboring and economically similar countries; having above average increases in impact and international collaboration (Figure 14).
- Brazil has low rates of industrial and international collaboration in common with other rapidly developing countries (Figure 28 and Figure 29).
- Economically similar countries (like India) and regional peers (like Argentina) provide insights into different approaches to supporting research which could be explored further by policy makers.

Opportunities

- The makeup of Brazilian research reveals activity and excellence concentrated in fields which have received targeted sector investment (Figure 30).
- The fields of environment/ecology, psychiatry/psychology and mathematics have a citation impact approaching the world average and are areas in which Brazil could potentially emerge as a leader (Figure 30).
- Increasing inter-sector collaboration between domestic industry and academia would have economic benefit in developing high-tech manufacturing - this approach is already central to the government's science policy strategy.

State and institutional performance

- Research activity in Brazil is focused in a few states (particularly Sao Paulo) but several states perform relatively well on the basis of citation metrics (Figure 36).
- Universidade de Sao Paulo is Brazil's largest publisher of academic research papers (accounting for more than 20% of national output) and Universidade do Estado do Rio de Janeiro and Universidade Estadual de Campinas have well above average levels of papers in the world's top 1% of most highly cited papers (Figure 39).

A more detailed bibliometric analysis would allow the identification of further niche strengths and opportunities areas for Brazil. Clarivate Analytics would be happy to discuss CAPES needs in respect of this.

How does Brazilian research perform on certain key metrics?

An overview of Brazilian research performance in recent years

How many research papers does Brazil produce?

Brazil is the 13th largest publisher of research globally and its output is increasing

Currently Brazil is the 13th in the world in terms of the number of peer-reviewed papers produced between 2011 and 2016 (Figure 1). The majority of papers result research and development (R&D) conducted at publicly funded universities and for over 20 years there have been annual increases in the number of Brazilian papers in the Web of Science indicating an expansion in productive research by the academic sector (Figure 2).

Since 1990 the Brazilian government has set ambitious targets to increase Gross Domestic Expenditure on Research and Development (GERD) as a percentage of Gross Domestic Product (GDP). The present goal is 2% by 2019, which was set in 2014 as part of the National Strategy for Science, Technology and Innovation (ENCTI) 2016-19 which placed domestic innovation central to a strategy for increased productivity, economic and social development.[1] Though these targets have not been met – the most recent GERD data for 2014 stood at 1.17 % of GDP, down from 1.20% the previous year – in real terms funding of research continues to grow.[2] Accordingly, the last decade has seen a large expansion in the university sector, which receives around 60% of GERD spending, and this is reflected in the increased output in published papers seen in this analysis. Concurrently non-government R&D spending has declined in response to the global financial crisis.

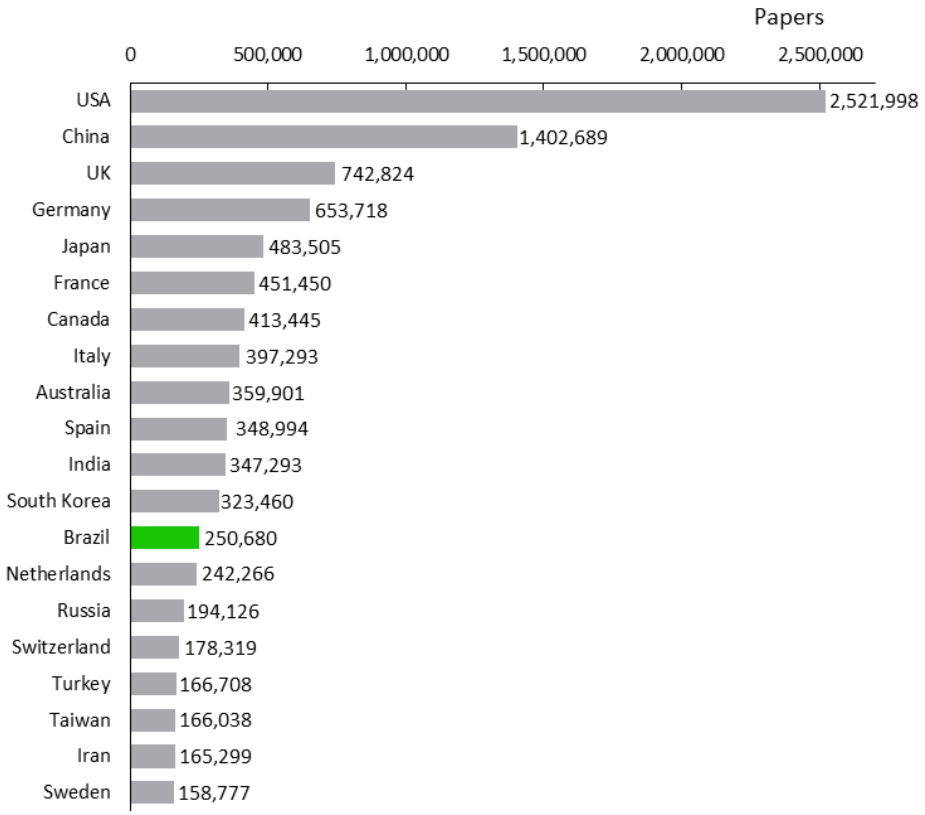


Figure 1. Papers added to Web of Science 2011 - 2016

[1] OECD (2016). OECD Science, Technology and Innovation Outlook 2016. OECD Publishing, Paris. Website: http://dx.doi.org/10.1787/sti_in_outlook-2016-en

[2] http://data.uis.unesco.org/index.aspx?queryid=74# - accessed 13 Dec 2017

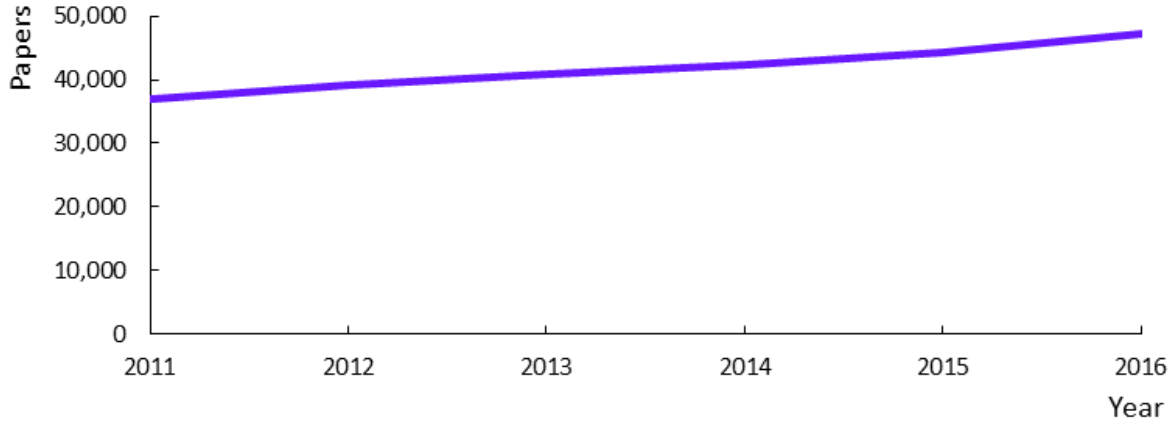


Figure 2 Brazilian papers in the Web of Science 2011 - 2016.

What is the impact of Brazilian research?

Brazil's citation impact has historically been below the world average but has increased by more than 15% over the past six years

The number of citations a paper receives reflects the impact it has had on later research. Papers cite earlier papers to reflect an intellectual contribution. Therefore, a paper (or a collection of papers) with a higher citation count can be said to have had a higher impact on the field to which it related. However, citation rates also depend on the research field and age of a paper (older papers have had more time to collect citations compared with more recent ones).To account for these factors we normalize the citation count for a paper to the world average for the field and year of publication. In this report, the term "citation impact" is used to refer to the average normalized citation count for a paper or group of papers rather than the average citation count per paper. This approach is described more fully in Appendix 1.

Between 2011 and 2016 Brazil's citation impact remained below the world average (Figure 3). However, Brazil's impact has increased year-on-year from 0.73 in 2011 to 0.86 in 2016, a rise of 18%. If this current trend is maintained then by 2021 Brazil will have reached the global average of 1.0.

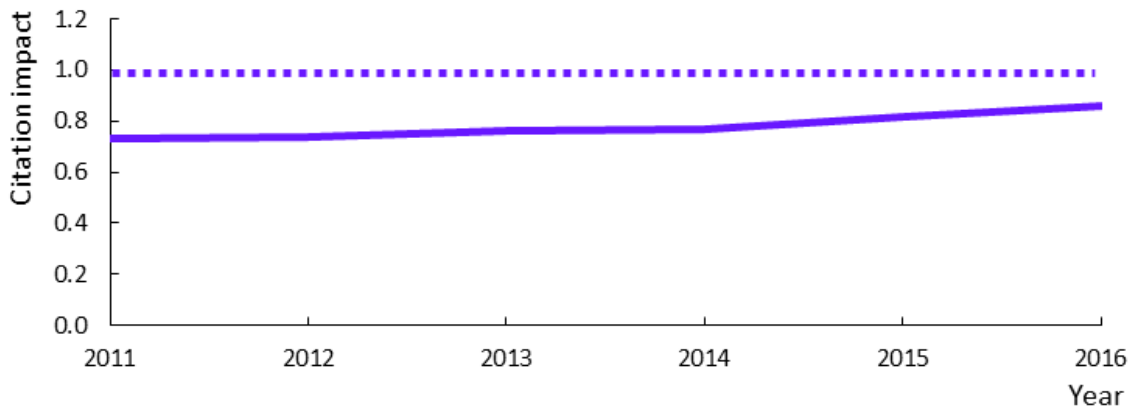


Figure 3 Citation impact for Brazil 2011 – 2016 (world average marked by the dotted line).

Do Brazilian researchers produce excellent research?

Brazil produces some very highly-cited papers and has achieved good rates of papers in the world's top 1%

In addition to analyzing the average performance of Brazilian research using the average citation impact we can assess the extent to which Brazilian researchers have published very high-impact research. This is done by analyzing the percentage of Brazilian papers in the world's top 1% and top 10% of most highly-cited papers.

Remarkably, between 2011 and 2016 the percentage of Brazilian papers in the world's top 1% of most highly-cited papers has increased rapidly to reach the world average (Figure 4). In absolute terms Brazil's output of papers that exceed this threshold has more than doubled from 206 in 2011 to 483 in 2016. Over the same period Brazilian papers in the top 10% has only shown modest increases, roughly proportional to the increase in the total number of Brazilian papers published (Figure 5). As of 2016 only 6.4% of Brazilian papers were in the world's top 10%, well below global average performance. The challenge for Brazil is to build on its very highly-cited core of top 1% papers to develop a broader base of world-leading research.

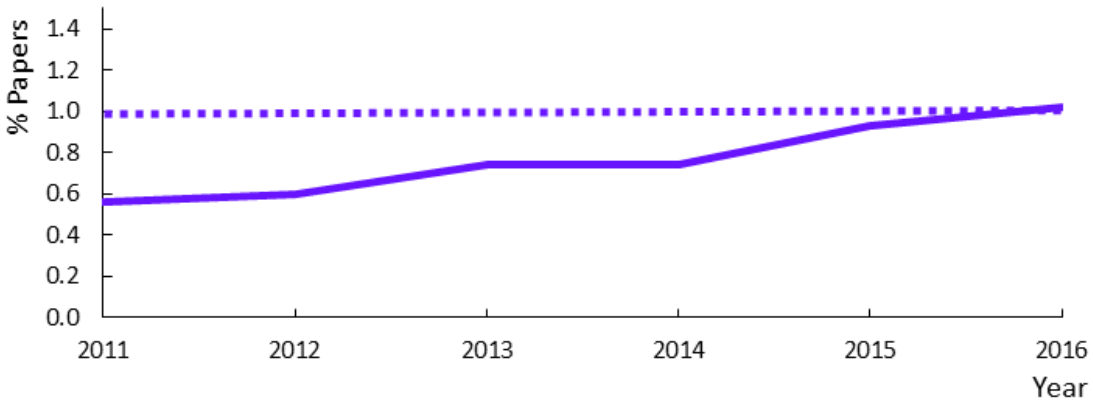


Figure 4 Percentage of Brazilian papers in the world's top 1% of most highly cited papers 2011 – 2016 (world average marked by the dotted line).

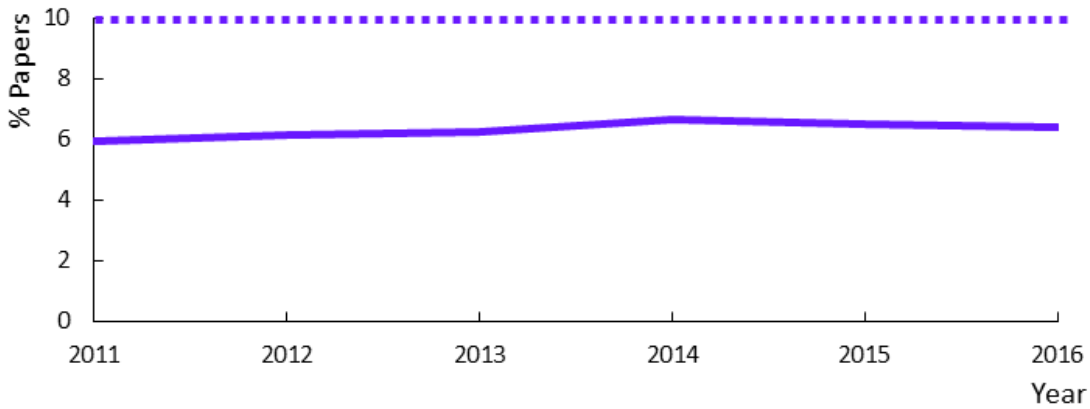


Figure 5 Percentage of Brazilian papers in the world's top 10% of most highly cited papers 2011 – 2016 (world average marked by the dotted line).

How is Brazilian research covered in the Web of Science?

Coverage of Brazilian Journals in the Web of Science has increased resulting in significantly improved coverage

Between 2005 and 2010 there was very a rapid growth in the number of Brazilian research papers in the Web of Science (Figure 6). During this period, the Web of Science coverage expanded to include an additional 87 Brazilian journals. Inclusion of more Brazilian journals shows the Web of Science editors recognition of the quality and international interest in Brazilian research.

This increase in coverage led to the accelerated increase in the number of papers and to a drop in the average citation impact of Brazilian research (Figure 7). In the short-term, increased coverage had a negative effect on the impact of Brazilian research as the new journals had a relatively low average citation impact. Many of these journals are categorized in Essential Science Indicators research fields as clinical science, agricultural sciences and plant & animal science, areas with high local interest and domestic policy impact but perhaps with a lesser relevance to the global research community.

However, the effects were short-lived; within 6 years the trend in citation impact has returned to positive and by 2016 it exceeded the previous maximum (2005), reaching 0.86. If papers from the additional 87 journals are excluded from the analysis (as shown by the dotted lines in Figure 6 and Figure 7) the trends for previous years continue unabated.

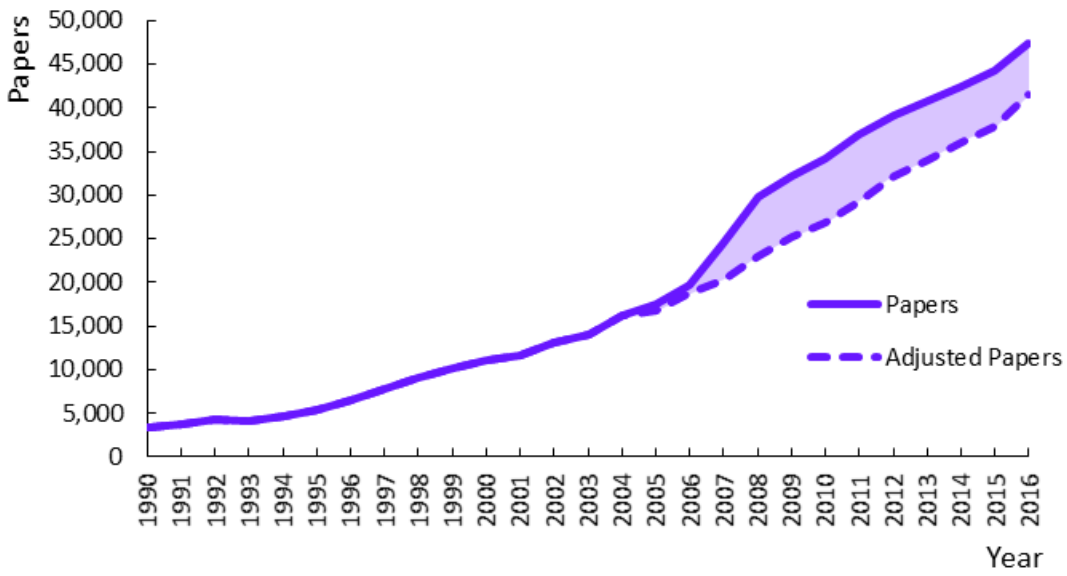


Figure 6 Trend in the number of Brazilian papers in the Web of Science 2011 – 2016 (the dotted line shows the trends when Brazilian journals added between 2005 and 2010 are excluded).

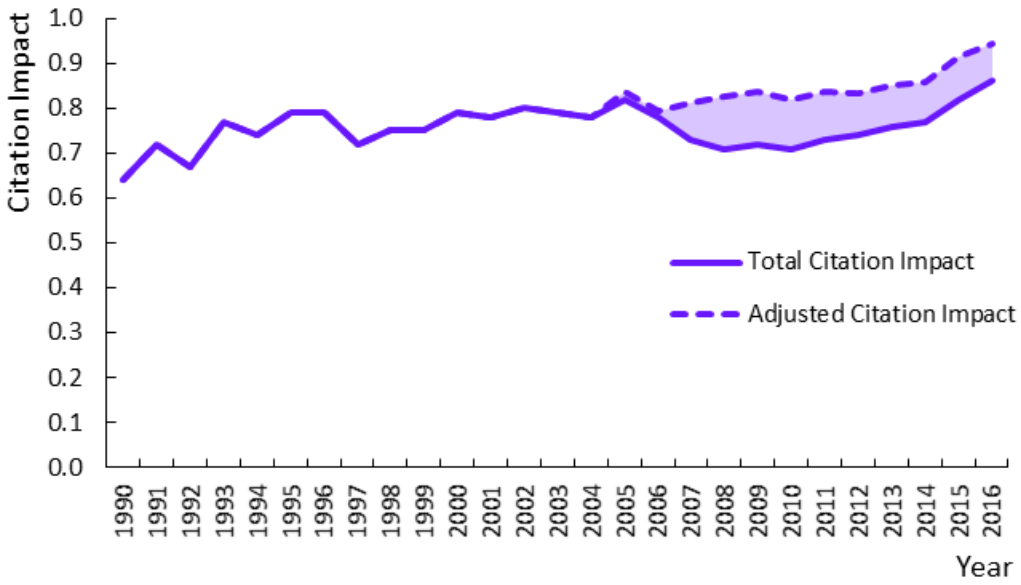


Figure 7 Citation impact of Brazilian papers in the Web of Science between 2011 – 2016 (the dotted line shows the trends when Brazilian journals added between 2005 and 2010 are excluded).

Who does Brazil collaborate with internationally?

Increasingly Brazilian researchers are working across country borders within and beyond Latin America and the resulting papers have a higher impact than Brazil's domestic research.

Collaborating countries

Between 2011 and 2016 Brazil-based researchers co-authored papers with researchers from a total of 123 other countries, and around a third of all Brazilian papers over this period has at least one international collaborator. Annual data show that the percentage of internationally collaborative papers is increasing (Figure 8)

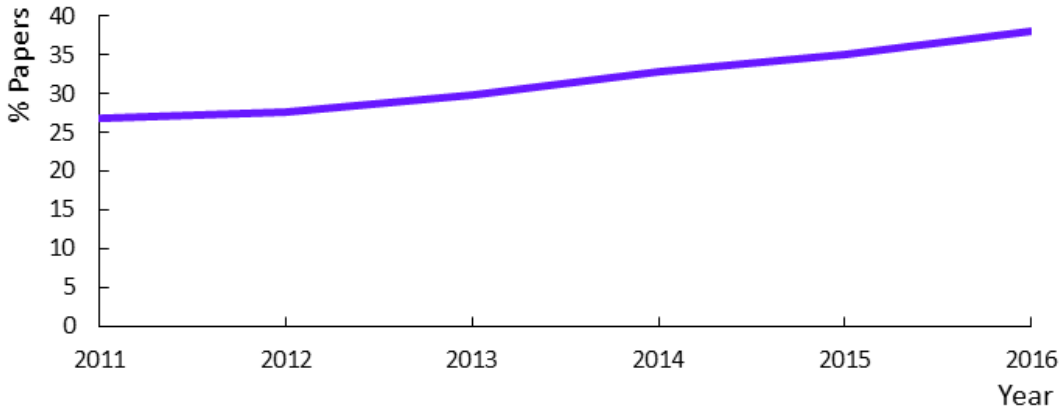


Figure 8 Percent of papers with one or more international collaborator 2011 – 2016.

Collaborating countries can be found in every region of the globe. The most productive collaborations (by number of research papers) are with world leaders in research, like Germany and the USA (Figure 9). Prolific collaborations also exist with nations that have less established research capacity, including regional neighbors (such as Mexico) and the BRICS nations (China, India, Russia and South Africa).

International collaboration correlates to high citation impact. Papers resulting from international collaborations have an average citation impact of 1.31, well above the world average (1.0) and higher than the average citation impact of all Brazilian papers (0.78).

What a few exceptions the citation impact of Brazil's collaborative research is higher when the partner is another country with a rapidly growing research output (such as China and India) rather than with the more established research economies. The reasons for this increase in impact are not clear but it could suggest that a strategy of expanding strategic collaborations with the BRICS countries would yield greater dividends than collaboration with North American and European countries, for instance. This is not to say that collaborations with North American and European countries should be actively avoided; the impact of such research is still very high.

There are indications that Brazil is developing more regional collaboration within Latin America. A long running, successful example of Brazil having regional influence is the National Laboratory for Synchrotron Light (LNLS).[3] As it is the only synchrotron on the continent, researchers from different countries and disciplines have travelled to Brazil to run experiments there. Having operated since 1998 LNLS is reaching the end of its useful life and plans are in progress to replace it by building the world's first ever fourth generation synchrotron provisionally called LNLS-2.[4] With capabilities beyond any existing synchrotron, the LNLS-2 would enable researchers from the region to conduct cutting edge studies without having to travelling to North America, Asia or Europe and has the potential to attract researchers from across the globe.

Country	Papers	Citation impact	Institutions
USA	30,467	1.85	881
UK	11,668	2.66	187
France	10,615	2.43	279
Spain	10,105	2.39	266
Germany	9,957	2.54	185
Italy	7,826	2.73	225
Canada	6,884	2.77	87
Portugal	6,394	1.8	71
Australia	5,371	3.44	79
Netherlands	4,781	3.32	45
Argentina	4,763	2.03	45
Switzerland	4,339	3.53	44
China	4,260	3.68	315
Colombia	3,444	2.7	28
Mexico	3,324	2.97	67
Russia	3,257	3.93	132
Chile	3,143	2.34	52
Japan	3,076	3.92	225
India	3,065	4.36	212
Belgium	3,036	3.26	32

Figure 9 Top 20 countries that collaborate with Brazil 2011 – 2016 by number of papers.

As demonstrated by the LNLS, collaborations are fostered by, and cluster around, large-scale infrastructure projects which often require more than one country to build, fund and maintain. The preeminent example of this is CERN and the Large Hadron Collider (LHC). Brazil was the first Latin American country to become an Associate Member of the CERN Council and has researchers contributing to all four LHC experiments and the theoretical interpretation of the results.[5]

Argentina is Brazil's most frequent Latin American collaborator (Figure 9) and, because of bilateral agreements[6] coordinating joint R &D activities through co-funded projects, this partnership seems only likely to expand. Existing collaborative infrastructure projects include the Argentine-Brazilian Biotechnology Centre (CABBIO/CBAB) and new projects include partnerships on domestic space programs to build and launch SABIA-Mar, an earth observation satellite studying changes in the

[3] www.lnls.cnpem.br/the-lnls/design/ - accessed 13 December 2017
[4] Brum, J.A., et al. LNLS-2: a new high performance synchrotron radiation source for Brazil. Proceedings of PAC09 2009 3116
[5] international-relations.web.cern.ch/stakeholder-relations/states/Brazil - accessed 13 December 2017
[6] www.mrecic.gov.ar/en/argentina-brazil-joint-communique - accessed 13 December 2017

sea and coast.[7] A similar partnership has been agreed by the atomic power agencies to work towards greater integration and to build new nuclear reactors located in both countries for both research and the production of medical radioisotopes. The Brazilian source will be constructed by the Argentine company INVAP.

Which organizations do Brazilian researchers collaborate with?

There are nearly 5,000 foreign organizations that collaborate with Brazilian researchers, the majority of which are academic institutions (Figure 10, Figure 11). A primary focus of Brazilian science policy from the 1990s has been to improve national science skills and broaden the country's international scientific network. To achieve these goals funding was made available to students and scientists to visit, study or research at universities in leading research-intensive countries, mainly the USA, Europe and Canada. Most recently, the Brazil Scientific Mobility Program used federal funds to provided scholarships to send 70,000 (mostly undergraduate) students abroad. Funding was also made available to early career academics from abroad to come and work at Brazilian universities.[8]

At this moment, it is hard to be sure of the effect of these programs on Brazilian R&D, and even to know if students who went aboard returned to Brazil to take up research jobs. However, by 2014 and the launch of ENCTI the focus of science policy seemed to have shifted from sending science students abroad to a broader domestic education agenda and the Brazil Scientific Mobility Program was closed.

[7] www.conae.gov.ar/index.php/espanol/introduccion-sace - accessed 13 December 2017
[8] UNESCO (2015). UNESCO Science Report: towards 2030. UNCESCO Paris. Website: http://unesdoc.unesco.org/images/0023/002354/235406e.pdf

Organization	Country	Papers	Citation Impact	Top 1%	Top 10%
Harvard University	USA	2,666	4.06	10.95	34.17
Pierre & Marie Curie University	France	2,393	3.25	8.11	29.75
Sapienza University Rome	Italy	2,029	4	9.71	36.37
University of Chicago	USA	1,944	4.14	10.19	37.45
Ohio State University	USA	1,920	3.54	9.43	38.44
Lomonosov Moscow State University	Russia	1,886	3.45	8.06	36
University of Paris Sud	France	1,865	3.54	9.12	34.75
University of Toronto	Canada	1,854	4.69	11.17	32.74
Universidade de Lisboa	Portugal	1,848	2.13	4.38	21.54
University of Oxford	UK	1,845	4.61	11.11	35.72
University of Bologna	Italy	1,827	3.72	9.14	37.06
Kurchatov Institute	Russia	1,820	3.05	8.08	37.58
Massachusetts Institute of Technology	USA	1,790	3.72	9.22	36.82
University of Cambridge	UK	1,788	4.63	9.9	33.84
Petersburg Nuclear Physics Institute	Russia	1,787	3.03	7.95	37.83
Alikhanov Institute for Theoretical & Experimental Physics	Russia	1,782	3.03	7.86	37.71
University of Paris Diderot	France	1,711	3.65	8.53	32.32
Institute of High Energy Physics	Russia	1,700	3.07	8	38.12
CERN	Switzerland	1,660	3.36	9.34	38.13
Imperial College London	UK	1,624	4.26	10.22	36.76
University of Wisconsin Madison	USA	1,582	3.21	8.6	34.89
Charles University Prague	Czech Republic	1,578	3.24	8.75	37.07
University of Aix-Marseille	France	1,568	2.97	7.65	29.59
University of Manchester	UK	1,535	3.13	8.34	33.36
University of Rome Tor Vergata	Italy	1,533	3.85	9.33	35.68
University of Pisa	Italy	1,527	3.65	8.71	35.3
University College London	UK	1,526	4.51	11.47	37.16
University of Buenos Aires	Argentina	1,522	2.28	5.26	23.46
STFC Rutherford Appleton Laboratory	UK	1,522	3.63	8.8	36.6
Universite Grenoble Alpes	France	1,520	2.81	6.97	31.12

Figure 10 Top 30 international collaborating organizations by number of papers 2011 – 2016.

Organization	Country	Papers	Citation Impact	Top 1%	Top 10%
University of Melbourne	Australia	1,101	5.82	11.81	39.06
University of Tokyo	Japan	1,033	5.66	12.49	42.4
University of Washington Seattle	USA	1,375	5.58	11.78	37.6
Stanford University	USA	1,254	5.47	12.6	38.68
Northwestern University	USA	1,010	5.33	10.59	37.33
Columbia University	USA	1,372	5.32	11.01	37.39
Johns Hopkins University	USA	1,419	5.07	11.84	36.08
University of Oslo	Norway	1,045	4.99	13.11	41.34
University of Pennsylvania	USA	1,099	4.92	10.65	36.12
University of Copenhagen	Denmark	1,342	4.82	12.82	40.16
University of British Columbia	Canada	1,189	4.76	11.35	35.66
University of Birmingham	UK	1,385	4.75	9.82	38.77
University of Sydney	Australia	1,444	4.72	10.53	35.73
University of Edinburgh	UK	1,338	4.72	10.09	36.1
Ruprecht Karl University Heidelberg	Germany	1,506	4.7	10.49	37.58
University of Toronto	Canada	1,854	4.69	11.17	32.74
University of Cambridge	UK	1,788	4.63	9.9	33.84
University of Oxford	UK	1,845	4.61	11.11	35.72
Yale University	USA	1,282	4.56	11.7	41.58
California Institute of Technology	USA	1,136	4.56	10.92	40.85
University College London	UK	1,526	4.51	11.47	37.16
University of Padua	Italy	1,324	4.42	12.01	38.67
Lund University	Sweden	1,086	4.42	11.79	41.07
New York University	USA	1,121	4.39	8.39	31.67
Istituto Nazionale Geofisica e Vulcanologia	Italy	1,032	4.33	10.27	37.21
University of Minnesota Twin Cities	USA	1,056	4.31	11.55	38.45
Imperial College London	UK	1,624	4.26	10.22	36.76
University of Bristol	UK	1,146	4.2	8.64	32.9
University of California Berkeley	USA	1,341	4.19	11.48	40.12
University of Hamburg	Germany	1,178	4.17	10.53	38.12

Figure 11 Top 30 international collaborating organizations by citation impact 2011 – 2016. Limited to organization with at least 1,000 papers produced in collaboration with Brazil.

Are Brazilian researchers collaborating with industry?

Industry researchers only co-authors around 1% of Brazilian research papers.

Of the 250,680 articles and reviews published by Brazilian researchers between 2011 and 2016, around 1% had at least one author affiliated with industry (Figure 12). Supporting closer working between academic and industry sectors is a stated objective of ENCTI. Inter-sector collaboration is seen to nurture the high-tech industry which is viewed by the Brazilian government as essential for sustainable economic growth; moving the country away from depending on the commodity and service industries that badly declined in following the 2008 global financial crisis.

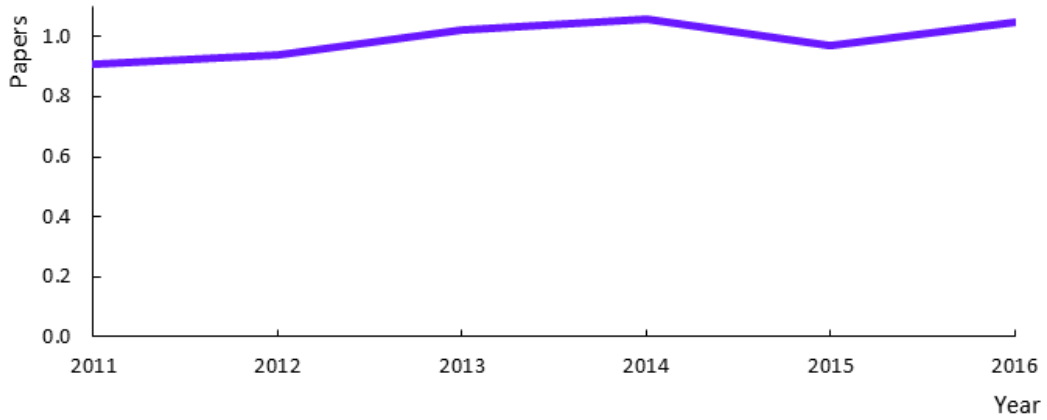


Figure 12 Percentage of papers with an industrial collaborator 2011 – 2016.

Which corporations do Brazilian researcher collaborate with?

There were 232 different corporations that co-authored papers with Brazilian academic authors between 2011 and 2016; and most of these were only involved in very small numbers of papers (Figure 13). Large USA pharmaceutical firms were the most frequent partners. It is noteworthy that the very high impact of the research coauthored with Genentech appears to be driven by involvement in some large multinational medical collaborations (particularly the Global Burden of Disease Study 2013).

Petrobras SA, the only domestic company with significant involvement in collaborative research (Figure 13), alone accounted for 10% of Brazilian industrial R&D funding in 2013. Post 2011, the economic downturn caused a contraction in Brazil's domestic industrial R&D spending and recovery has been slow, exacerbated by a corruption scandal that negatively affected Petrobras' revenues and a lack of trained research personnel.

Governmental interventions to support inter-sector collaboration and knowledge transfer have been introduced as part of ENCTI building on earlier legislative changes. In 2007 the National Law on Innovation reformed the regulatory framework to simplify and encourage collaboration between the public and private R&D and introduced a tax cut for small and medium enterprises (SMEs) that invest in R&D infrastructure. Enacting ENCTI strategy, the funding agency FINEP supports a variety of inter-sector activities, including grants for SMEs to work with local higher education institutions and programs to enable researchers to work flexibility between corporations and universities.

Unfortunately these actions have not had a noticeable effect on the proportion of papers with an industrial collaborator which has remained static at 1% (Figure 12). This could be partly due to how corporations are defined in the Web of Science, which

may miss the domestic SMEs that the Brazilian government has been so keen to support. Furthermore, as many of the interventions introduced to support SMEs R&D only came into effect in 2014, it may be too early to see changes in our metrics.

Corporation	Country	Papers	Citation Impact	Sector
Petrobras SA	Brazil	190	1.04	Petrol
GlaxoSmithKline	UK	108	6.85	Pharmaceutical
Novartis	Switzerland	106	4.00	Pharmaceutical
Roche Holding	Switzerland	81	14.64	Pharmaceutical
Pfizer	USA	79	4.53	Pharmaceutical
Merck & Company	USA	67	7.31	Pharmaceutical
Westat	USA	55	0.86	Professional Services
Bayer AG	Germany	54	3.66	Pharmaceutical
Johnson & Johnson	USA	54	3.58	Pharmaceutical
AstraZeneca	England	53	6.64	Pharmaceutical
Sanofi-Aventis	France	51	4.68	Pharmaceutical
IBM	USA	49	2.11	Computer
Eli Lilly & Company	USA	48	3.77	Pharmaceutical
Bristol Myers Squibb	USA	48	11.13	Pharmaceutical
Amgen	USA	38	6.15	Biotechnology
Johnson & Johnson USA	USA	33	4.33	Pharmaceutical
Genentech	USA	33	30.37	Pharmaceutical
AT&T	USA	32	1.32	Telecommunications
Hewlett-Packard	USA	30	0.96	Software
Bayer Healthcare Pharmaceuticals	Germany	28	4.99	Pharmaceutical

Figure 13 Top 20 collaboration international corporations by number of papers 2011 - 2016.

How does Brazilian research performance compare with other countries?

An evaluation of Brazilian research performance with reference to selected international benchmarks

How does Brazilian research compare internationally?

Brazil compares well with neighboring and economically similar countries with above average increases in impact and international collaboration.

This section compares Brazilian research to two groups of countries selected by CAPES across a series of performance indicators. The first group comprises the BRICS countries (China, India, Russia and South Africa) which are similar having been identified as major emerging economies due to recent industrialization, with large populations and considerable regional influence. A group of other countries were also selected, which includes neighboring countries (Mexico and Argentina) and developed countries Germany, France, Canada, Spain and Japan. The two groups are analyzed separately for clarity. The metrics for Brazil and the other comparators are summarized in Figure 14, Figure 15 and Figure 16 and are discussed in greater depth in the following sections.

Country	Papers	Citation Impact	Top 1%	Top 10%
Brazil	250,680	0.78	0.78	6.32
China	1,402,689	1.00	1.25	10.95
India	347,293	0.78	0.72	7.07
Russia	194,126	0.63	0.66	4.92
South Africa	73,663	1.11	1.6	10.26
Germany	653,718	1.29	1.91	14.37
Japan	483,505	0.90	0.93	8.24
France	451,450	1.24	1.80	13.42
Canada	413,445	1.31	2.00	14.07
Spain	348,994	1.19	1.60	12.67
Mexico	78,318	0.82	1.00	6.69
Argentina	54,546	0.92	1.09	7.43

Figure 14 Productivity and impact of Brazil and comparator countries between 2011 and 2016.

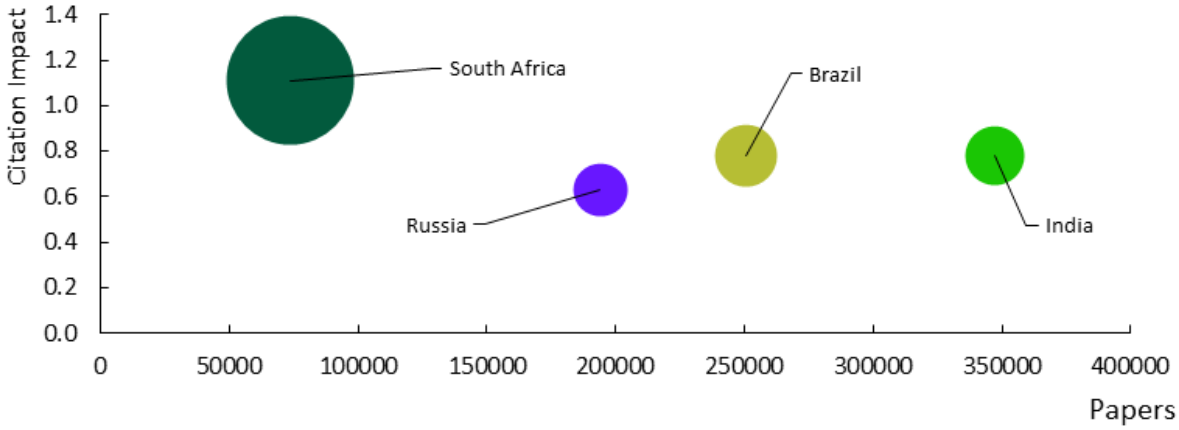


Figure 15 Output and impact of BRICS countries, excluding China. Marker width proportional to the percentage of papers in the world's top 1% most highly-cited papers, 2011 - 2016.

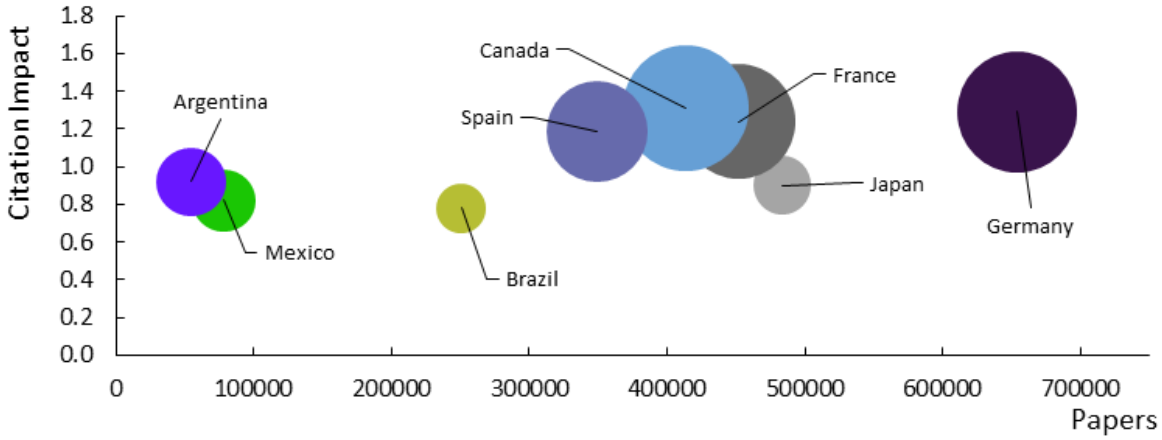


Figure 16 Output and impact of comparison countries, excluding China. Marker width proportional to the percentage of papers in the world's top 1% most highly-cited papers 2011 – 2016.

Which countries published the most papers?

All of the countries analyzed have seen year-on-year increases in number of papers they published

Due to its size (both population and economic) China's research output has grown exponentially since 1990. It is therefore a somewhat difficult comparator because it produces orders of magnitude more papers per year than any other country analyzed. For this reason, it has been omitted from most charts in this Section (excepting Figure 17). Other BRICS countries have experienced less extreme growth; around 1995 Russia's productivity slowed and fell behind India and Brazil in 2006 (Figure 17). Currently Brazil is ranked third in the group just below India

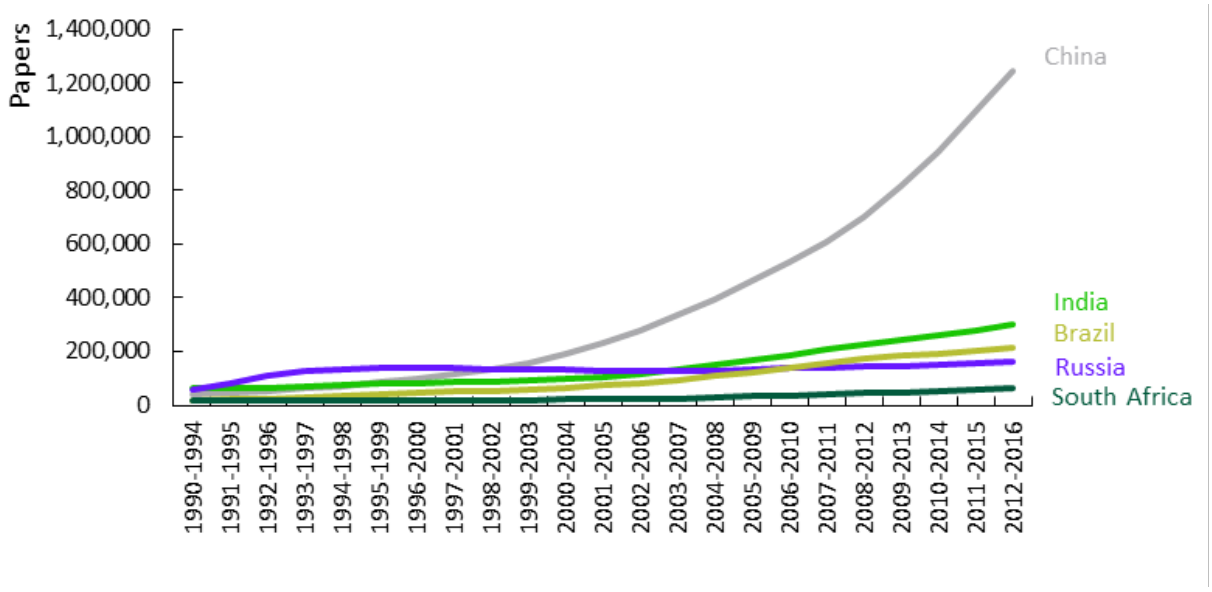


Figure 17 Web of Science papers per 5-year period for BRICS countries.

As shown in Figure 14, Brazil's output is lower than the established countries (Germany, Japan, France and Canada) but it produces three times more papers than its regional peers (Mexico or Argentina).

Which countries have the greatest citation impact?

Of the BRICS, South Africa produced the highest impact research on average. Although it publishes the fewest papers it has above average percentages of papers in the world's top 1% (Figure 20) and top 10% of mostly highly-cited papers (Figure 22) – China also performs above the world average in these metrics.

Since 2011 all BRICS showed a positive trend in their citation impact – Brazil's increase in impact has been very strong (around 15%) and surpassed that of India in 2014 (Figure 18). Only Russia's citation impact increased at a faster rate, but it still lags substantially behind the other countries analyzed.

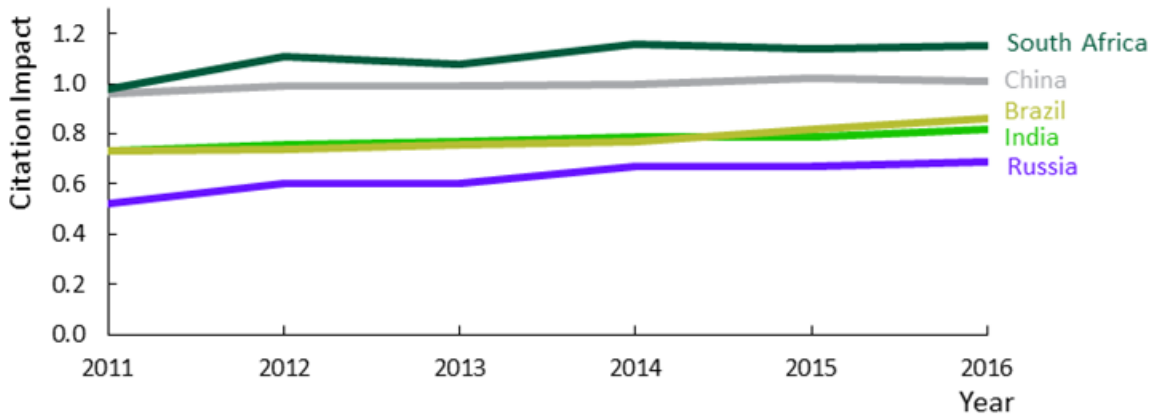


Figure 18 Citation Impact of BRICS countries 2011 - 2016.

Between 2011 and 2016, the citation impact of Brazil, Japan, Argentina and Mexico (Figure 19) remained below the world average. Over this period Brazil is the only country to exhibit a steady increase in citation impact, rather than erratic

fluctuations. The other comparator countries (Canada, Germany, France and Spain) form a second distinct group with a citation impact well above 1.0.

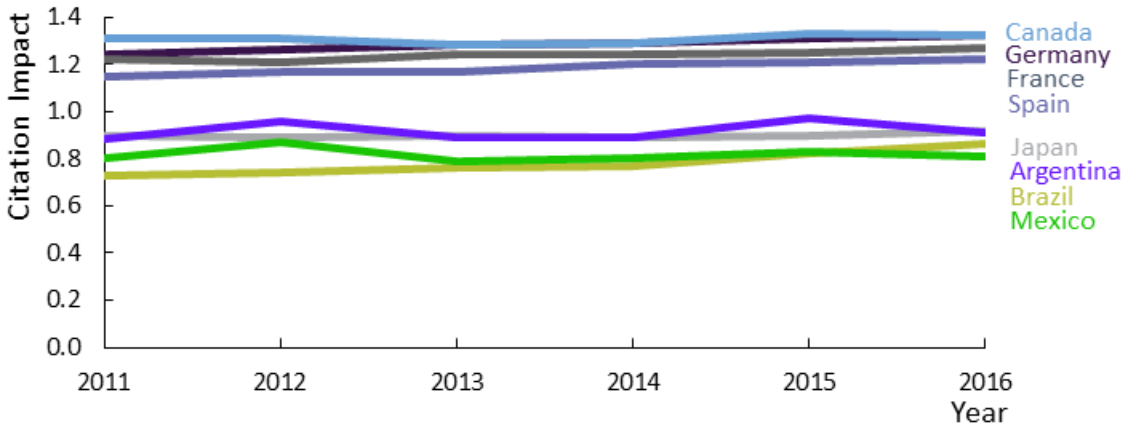


Figure 19 Citation Impact for comparison countries 2011 - 2016.

The increase in Brazil's citation impact appears to be driven by growth in its output of papers in the world's top 1% of most highly-cited papers; from 0.56% of its total output in 2011 to 1.02% in 2016 (Figure 20). This increase is apparent relative to both sets of comparator countries. Brazil moves from being the lowest ranked country in 2011 to overtake India and Russia in 2014 and Mexico and Japan in 2015. Over the same period the percentage of papers in the top 10% has remained relativity constant for all countries (Figure 22) with Brazil remaining just above 6%.

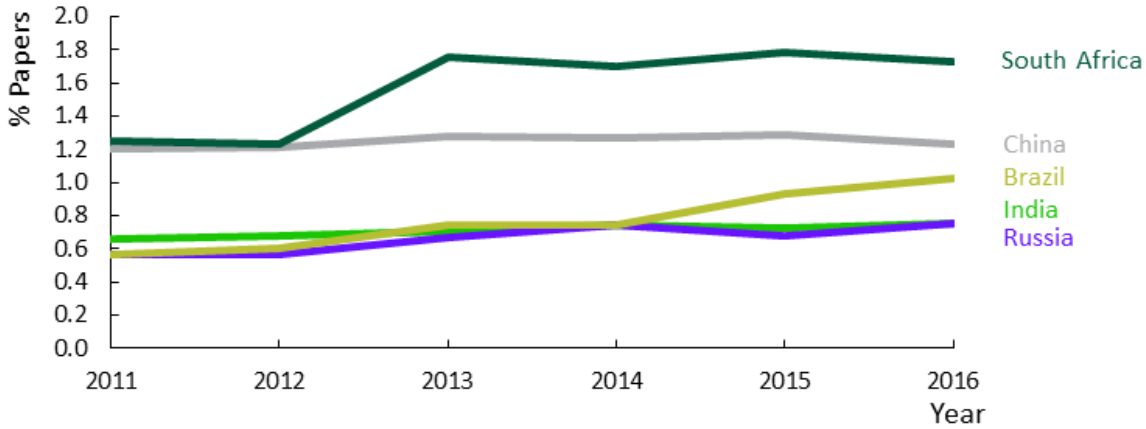


Figure 20 Percentage of papers in Top 1% of all papers for BRICS countries 2011 - 2016.

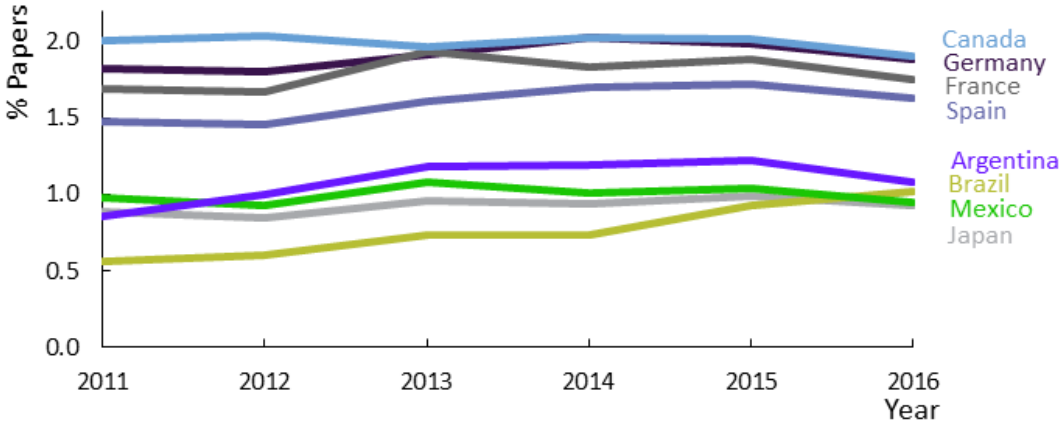


Figure 21 Percentage of papers in Top 1% of all papers for comparison countries 2011 - 2016.

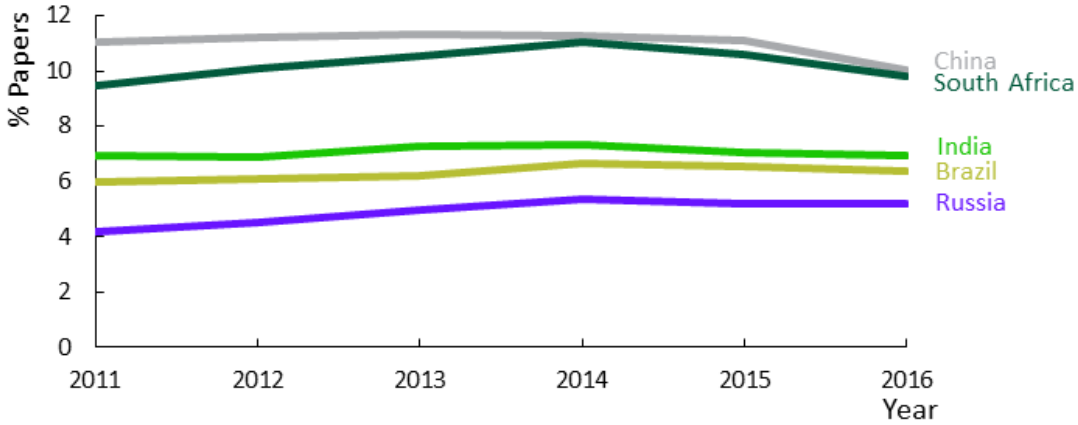


Figure 22 Percentage of papers in Top 10% of all papers for BRICS countries 2011 - 2016.

How does Brazilian research collaboration compare with other countries?

Brazil's rates of international collaboration are below those of most other countries but are increasing more rapidly than most other developing countries

Globally, science has become increasingly collaborative with the analyzed countries each collaborating with around 200 other countries. Citation impact appears to strongly correlate with the rates of international collaboration, as demonstrated by South Africa which leads the BRICS in both citation impact and the percentage of its papers with at least one international collaborator (Figure 23). It is encouraging to see, when comparing the BRICS, that Brazil has shown strong yearly increases in the number of its papers involving international collaboration and, as of 2016, it is second only to South Africa (Figure 23).

Country	Papers	Citation Impact	% International Collaboration
Brazil	80,291	1.31	32.03
South Africa	38,641	1.54	52.46
Russia	65,496	1.24	33.74
China	343,455	1.43	24.49
India	81,289	1.24	23.41
France	252,138	1.55	55.85
Germany	344,691	1.61	52.73
Canada	208,260	1.66	50.37
Spain	170,379	1.56	48.82
Argentina	25,338	1.34	46.45
Mexico	34,749	1.28	44.37
Japan	144,031	1.38	29.79

Figure 23 Effect of international collaboration on productivity and impact of Brazil and comparator countries, 2011 – 2016.

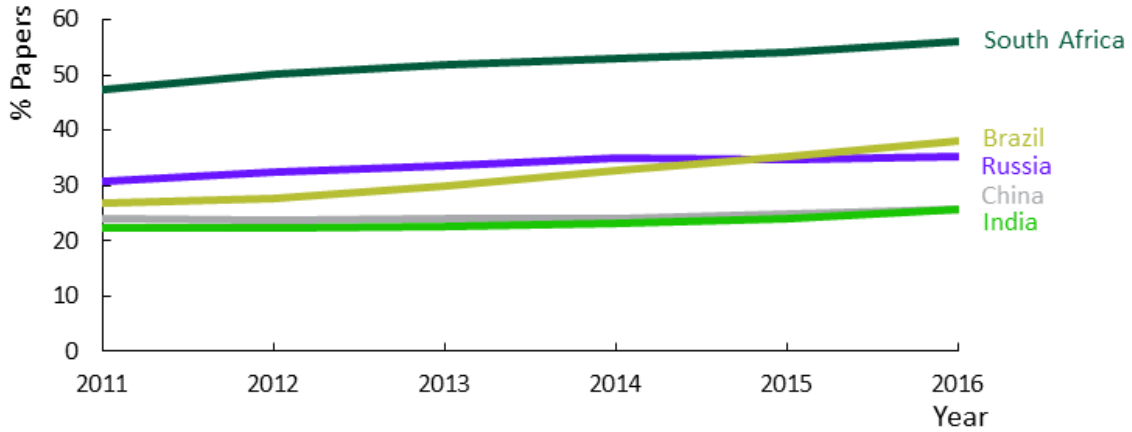


Figure 24 Percentage of papers for BRICS countries with one or more international collaborators 2011 – 2016.

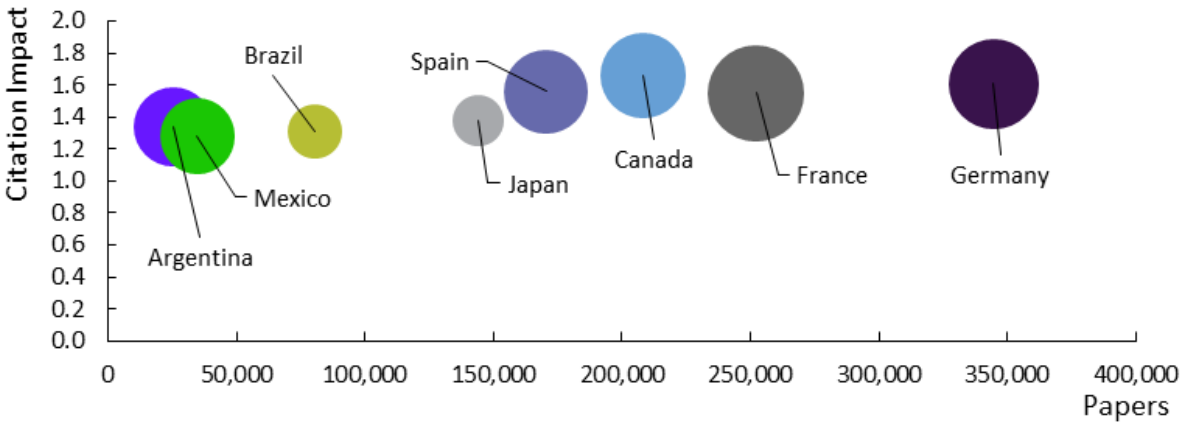


Figure 25 Output and impact of comparison countries papers with international collaboration Marker width proportional to percentage of papers with one or more international collaborators 2011 - 2016.

Overall the BRICS are less internationally collaborative than the other countries analyzed. International collaboration is particularly high for nations with an established research landscapes: France, Germany, Canada and Spain. Figure 25 shows that countries with higher numbers of papers with an international collaborator tend to also have a higher average citation impact. Additionally, regional peers Argentina and Mexico have a higher proportion of international collaborations which could explain their overall higher citation impact (Figure 14). Only Japan is below Brazil in terms of the percentage of its papers that involve international collaboration.

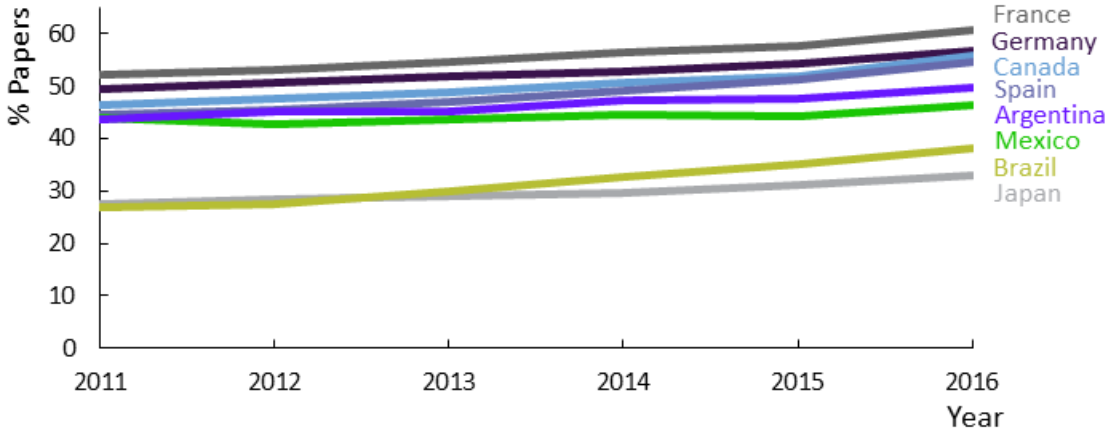


Figure 26 Percentage of papers for comparison countries with one or more international collaborators 2011 - 2016.

Which countries have the most industry collaboration?

Brazil has low rates of industrial collaboration, in common with other rapidly developing countries

Like international collaboration, industrial collaboration generally enhances the citation impact of countries, although India is a notable exception to this rule (Figure 27).

Brazil has relatively low rates of industrial collaboration compared to the other countries analyzed except India and Russia (Figure 28 and Figure 29). Of the BRICS, only China shows steady growth in the percentage of its papers that have an industrial collaborator, and it is the only BRICS country with a notable number of collaborations from domestic corporations. Broadly speaking domestic industrial collaboration seems to be related to higher rates of overall inter-sector collaboration; as seen for France, Germany, Japan and China. However, Argentina seems to be particularly successful at attracting international partners – the reasons for this are unclear and further investigation, beyond the scope of this report, would be required. However, such an analysis could provide useful insights into the differences in research landscapes of Brazil and Argentina.

Country	Citation Impact	% Industrial Collaboration	Corporations	% Domestic Corporations
Brazil	3.20	0.99	232	0.4
China	1.91	1.36	424	17
South Africa	3.76	1.18	150	0
India	2.11	0.69	254	0.4
Russia	4.22	0.69	216	1.4
France	2.67	3.52	389	10.8
Germany	2.51	3.49	410	13.2
Argentina	3.57	2.75	123	0.8
Japan	2.44	2.74	346	15.9
Canada	2.98	2.26	384	0.9
Spain	3.42	1.81	334	2.1
Mexico	4.10	1.34	152	0.7

Figure 27 Effect of industry collaboration on productivity and impact of Brazil and comparator countries, 2011 – 2016

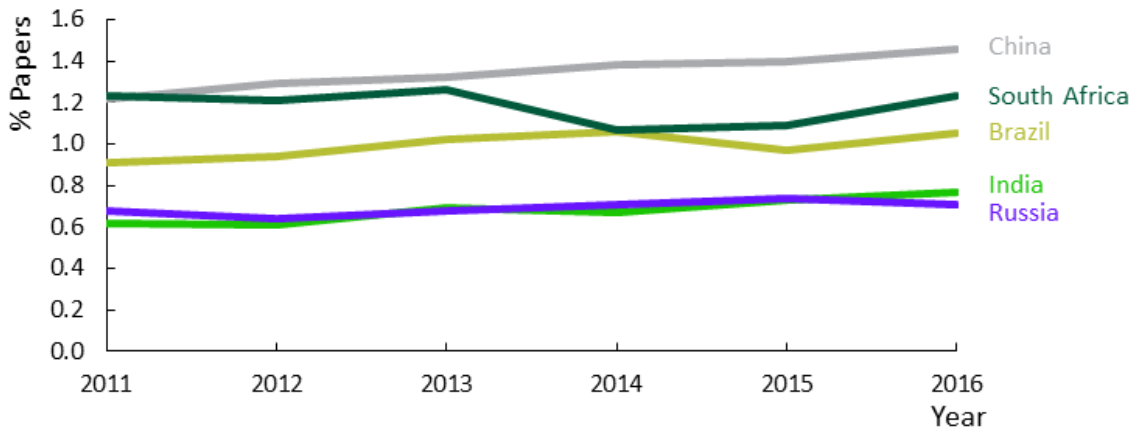


Figure 28 Proportion of papers for BRICS countries with one or more industrial collaborators 2011 - 2016.

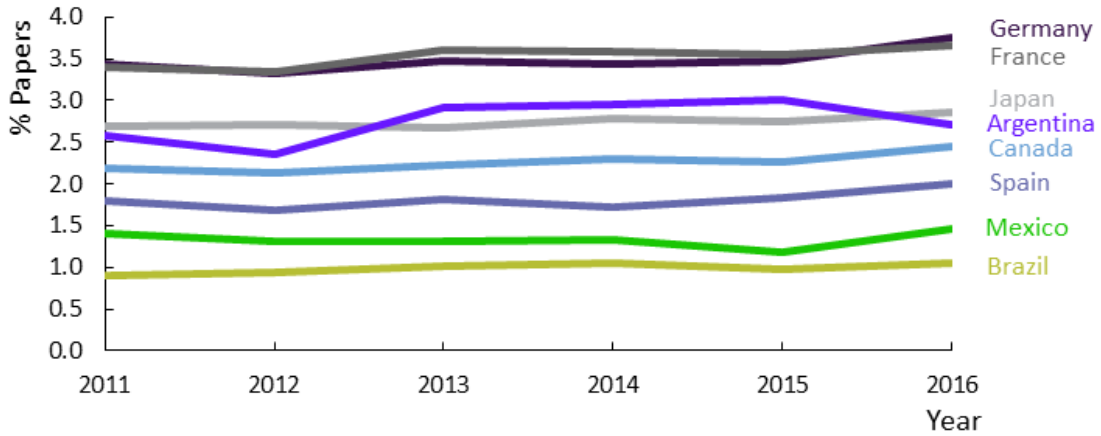


Figure 29 Percentage of papers for comparison countries with one or more industrial collaborators 2011 – 2016.

What are the strengths of the Brazilian research base?

An overview of Brazilian research performance in different fields

In which scientific fields does Brazil excel?

A disaggregated analysis of Brazilian research performance reveals activity and excellence concentrated in fields which have received targeted sector investment.

Here we use two different schemes to categorize Brazilian research into different fields. For a high-level overview, we use the 22 Essential Science Indicators (ESI) fields. And to provide a more granular picture of specific strengths, we use the 252 Web of Science journal subject categories. It should be noted that standard bibliometric methodology uses the subject matter of the journal as a proxy for the subject matter of the constituent papers. This approach is described more fully in Appendix 1.

A significant proportion of Brazilian public R&D funding is targeted to specific sectors; 60% of GERD goes directly to the higher-education research, with a further 10% into non-orientated research and the remaining 30% allocated to specific sectors. The biggest recipients are the agriculture (10%), industrial technology (6%) and health (5%) sectors. Our analysis shows that these areas are also those where research output is highest, using both the ESI fields and Web of Science journal categories (Figure 31).

Another area that has been nurtured through more than a billion USD of direct funding over the past decades is space science. Brazil has sustained a domestic space program since the 1960 which, by the 1990s, had the capacity to launch satellites. Space science has the highest citation impact of all ESI fields (Figure 30). This high average impact is driven by papers arising from participation in larger international collaborations, including a series of very highly cited papers resulting from data releases of the Sloan Digital Sky Surveys (SDSS) (many with over 400 citations), each with hundreds of authors from organizations across the world.[9] International collaboration is very much the norm for contemporary space science research due to the massive cost of sending objects into space which prevents most individual countries supporting a space program on their own. Despite recent decreases in federal spending on space science in favor of fields with direct industrial application, such as energy, Brazil is still is a leading driver in developing a pan-Latin America space strategy.

Going forward R&D spending will be directed towards emerging fields identified as part of the ENCTI strategy. This funding will focus on fields with applications for “defence, water, food, biomes and bioeconomy, sciences and social technologies, climate change, ICTs, energy (including nuclear), health, and converging and enabling technologies”.[10] A similar approach was used to prioritize the fields of materials and nano sciences around the end of the 2010s, with a coordinated increase in spending on specific research projects and supporting infrastructure. Two core centers were created, the National Nanotechnology Laboratory for Agriculture (LNNA) and the Brazilian Nanotechnology National Laboratory (LNNanoO). This has led to a substantial increase in the number of researchers in both materials science and technology transfer.[8]

A sector funding approach has drawbacks and research priorities can be greatly affected by changes in government strategy. The environment is a key area for the Brazilian government as it looks to balance the often-conflicting demands of utilizing and preserving Brazil’s unique natural resources. Shifting priorities have been seen within energy science, where funding had been directed away from renewable ethanol biofuels, towards gas prospecting in deep sea sites off the south-east coast.

[9] Eisenstein, D.J., et al. SDSS-III: massive spectroscopic surveys of the distant universe, the milky way, and extra-solar planetary systems. Astronomical Journal 2011, 142(3): 1.
[10] www.innovationpolicyplatform.org/content/brazil - accessed 14 December 2017

Clinical medicine

High productivity with excellence in select specialisms

The high-level ESI categories indicate clinical medicine to be the most productive subject by number of papers (Figure 30). Clinical science has a citation impact of 0.87, higher than 0.76 for all Brazilian papers. Of the clinically-relevant Web of Science categories (Figure 32) clinical sciences, oncology, infectious diseases, clinical neurology, dentistry, oral surgery & medicine, and cardiac & cardiovascular systems have the highest citation impact.

Curiously, the rate of international collaboration for clinical medicine was 28.78%, below the Brazilian average of 33.08%. This is surprising considering the dominance of large international pharmaceutical companies in industrial collaboration metrics. One factor that might account for this is that many of the Brazilian journals added to the Web of Science between 2005 and 2010 relate to clinical medicine and these tend to be journals with a lower international impact.

Agriculture

High output with low international impact

Brazil has the second largest output of research in the fields of food production and agriculture (after the USA) and these areas have received generous funding of around 10% of GERD. In line with this funding, Brazilian agricultural productivity has risen consistently since the 1970s.

After clinical medicine, Brazil's largest ESI fields of research by publication output are plant & animal science and agricultural sciences (Figure 31). Research in these fields tends to result in many relativity low citation impact papers, but this is most likely a reflection of the fact that such research has a strong national policy importance rather than a broader international impact. And, like clinical sciences, many domestic journals appear in the agricultural sciences and plant & animal science categories.

The analysis of Web of Science categories supports these observations. The citation impact of food science & technology is approaching the world average and Brazil has relatively low rates of international collaborations in this field. Taken together these observations suggest Brazil has a high-quality domestic research capacity in food science & technology (Figure 32). Other Web of Science categories relevant to agriculture (such as plant science, veterinary science and agronomy) also tend to have very low rates of international collaboration.

Physics and space science

Excellence from international collaboration and long term domestic funding

Physics and space science are the only two ESI categories where Brazil has a citation impact well above the world average (1.0) and relatively high percentages of papers in the world's top 1% and top 10% of most highly-cited papers (Figure 30). These areas also exhibit high rates of international collaboration.

The Web of Science gives a more granular picture, showing that particles & fields and astronomy & astrophysics are particularly strong in terms of their citation impact (Figure 32). This may be due to Brazil's involvement in key international projects such as CERN and the SDSS observation study. Both of these collaborations have resulted in several very highly cited papers with hundreds of authors from a huge number of countries.

Emerging fields

Fields that are close to realizing international levels of excellence

The ESI fields of environment/ecology and psychiatry/psychology both have a relatively high average citation impact and a high percentage of papers in the world's top 1% of most highly-cited papers (Figure 30). Mathematics has a high average citation impact and a modest 0.54% of papers in the world's top 1%, but it 8.27% of its papers are in the top 10%, indicating that there is an existing depth of expertise in the field. This was demonstrated by the Brazilian mathematician Artur Avila winning the 2014 Fields Medal, the mathematics equivalent of a Noble Prize. He was educated within Brazil studying for his PhD at The Instituto de Matemática Pura e Aplicada in Rio de Janeiro.

Pathway to excellence

With sufficient support and resourcing, the emerging fields identified above represent a policy opportunity and strategy for Brazil to develop new research strengths, build on its very highly-cited core of top 1% papers to develop a broader base of world-leading research.

Further bibliometric analyses would provide insights into which research disciplines have the greatest potential to reach international levels of excellence. By identifying papers in weaker subjects which are nevertheless among the world's most highly-cited we could identify niche opportunities – sub-disciplines, organizations and individual researchers who with targeted funding and supporting infrastructure could excel.

Clarivate Analytics often uses a SWOT analysis approach to identify which research areas are strengths, weaknesses, opportunities and threats for a country. However, this assignment can only be done on a relative basis and we would need to discuss this with CAPES in order to identify a suitable benchmark. On average Brazil performs below the world average in most fields so this would probably not provide a good reference point for such purposes.

Categories	Papers	Citation Impact	Top 1%	Top 10%	% International Collaborations
Clinical Medicine	46,840	0.87	0.96	5.43	28.8
Plant & Animal Science	30,980	0.66	0.44	4.11	26.9
Agricultural Sciences	25,629	0.59	0.44	4.01	14.0
Chemistry	19,345	0.64	0.08	3.61	30.2
Physics	15,040	1.24	1.70	11.33	55.2
Engineering	12,092	0.85	0.45	6.99	32.2
Social Sciences, general	11,555	0.67	0.62	4.07	21.6
Biology & Biochemistry	11,537	0.69	0.38	4.50	32.6
Environment/Ecology	9,831	0.89	1.11	7.38	40.3
Materials Science	7,528	0.60	0.17	3.49	35.0
Pharmacology & Toxicology	7,456	0.79	0.46	5.10	25.8
Neuroscience & Behavior	7,176	0.79	0.56	5.56	36.8
Molecular Biology & Genetics	6,359	0.64	0.63	4.07	39.3
Mathematics	5,600	0.95	0.54	8.27	46.5
Immunology	5,171	0.88	0.87	6.61	44.4
Microbiology	5,160	0.76	0.58	5.08	37.9
Geosciences	5,042	0.82	0.69	5.91	53.0
Psychiatry/Psychology	3,576	0.91	1.37	7.35	45.6
Computer Science	3,560	0.85	0.56	6.88	43.2
Space Science	2,461	1.37	2.60	10.93	77.7
Economics & Business	1,897	0.58	0.26	4.43	36.0

Figure 30 Brazilian Papers in ESI categories, 2011 – 2016

Categories	Papers	Citation Impact	Top 1%	Top 10%	% International Collaborations
Biochemistry & Molecular Biology	9,078	0.68	0.29	3.34	33.9
Plant Sciences	8,633	0.63	0.39	3.49	29.0
Public, Environmental & Occupational Health	8,282	0.89	1.05	4.30	21.8
Veterinary Sciences	8,099	0.59	0.52	4.94	15.8
Pharmacology & Pharmacy	7,598	0.81	0.49	5.69	27.0
Agronomy	7,263	0.46	0.28	3.55	13.0
Dentistry, Oral Surgery & Medicine	7,134	0.98	0.90	8.89	30.4
Agriculture, Multidisciplinary	7,028	0.43	0.41	2.02	9.5
Materials Science, Multidisciplinary	6,867	0.63	0.19	3.33	39.5
Environmental Sciences	6,732	0.91	0.56	6.89	38.6
Zoology	6,715	0.69	0.43	4.36	28.9
Food Science & Technology	6,539	0.96	0.99	9.05	22.5
Chemistry, Physical	6,449	0.73	0.16	2.64	38.8
Neurosciences	6,404	0.84	0.45	5.01	37.9
Chemistry, Multidisciplinary	5,794	0.47	0.12	1.93	26.3
Parasitology	5,364	0.81	0.48	3.82	28.6
Engineering, Electrical & Electronic	5,208	0.78	0.44	6.43	34.7
Surgery	5,184	0.73	0.58	5.94	21.8
Biotechnology & Applied Microbiology	4,916	0.74	0.41	5.70	32.1
Astronomy & Astrophysics	4,767	1.59	2.24	11.77	72.9
Genetics & Heredity	4,657	0.71	0.58	4.96	38.9
Microbiology	4,645	0.87	0.60	5.77	42.8
Biology	4,414	0.46	0.39	2.51	17.3
Ecology	4,408	1.11	1.93	8.98	51.9
Physics, Particles & Fields	4,248	1.52	2.35	14.64	68.3

Figure 31 Brazilian papers in top 30 Web of Science categories by number of papers, 2011 – 2016.

Categories	Papers	Citation Impact	Top 1%	Top 10%	% International Collaborations
Astronomy & Astrophysics	4,767	1.59	2.24	11.77	72.9
Physics, Particles & Fields	4,248	1.52	2.35	14.64	68.3
Oncology	2,941	1.44	2.28	9.62	46.4
Physics, Multidisciplinary	3,472	1.40	1.73	11.75	47.8
Infectious Diseases	3,733	1.26	1.66	8.36	46.2
Ecology	4,408	1.11	1.93	8.98	51.9
Clinical Neurology	3,160	1.08	1.33	9.37	43.3
Mathematics	3,577	1.01	0.81	8.64	46.7
Psychiatry	3,688	1.00	1.38	7.81	39.9
Dentistry, Oral Surgery & Medicine	7,134	0.98	0.90	8.89	30.4
Food Science & Technology	6,539	0.96	0.99	9.05	22.5
Cardiac & Cardiovascular Systems	2,943	0.95	1.70	7.82	35.6
Environmental Sciences	6,732	0.91	0.56	6.89	38.6
Energy & Fuels	2,897	0.91	0.07	4.45	33.2
Endocrinology & Metabolism	3,378	0.90	0.89	6.28	32.7
Public, Environmental & Occupational H	8,282	0.89	1.05	4.30	21.8
Immunology	4,247	0.89	0.68	6.15	40.4
Mathematics, Applied	3,360	0.89	0.33	6.82	47.4
Microbiology	4,645	0.87	0.60	5.77	42.8
Neurosciences	6,404	0.84	0.45	5.01	37.9
Chemistry, Analytical	4,141	0.83	0.14	5.17	25.7
Nutrition & Dietetics	3,608	0.83	0.72	5.65	22.0
Marine & Freshwater Biology	3,305	0.83	0.76	6.63	35.3
Pharmacology & Pharmacy	7,598	0.81	0.49	5.69	27.0
Parasitology	5,364	0.81	0.48	3.82	28.6

Figure 32 Brazilian papers in top 5 Web of Science categories (with a minimum of 2000 papers) by citation impact, 2011 – 2016.

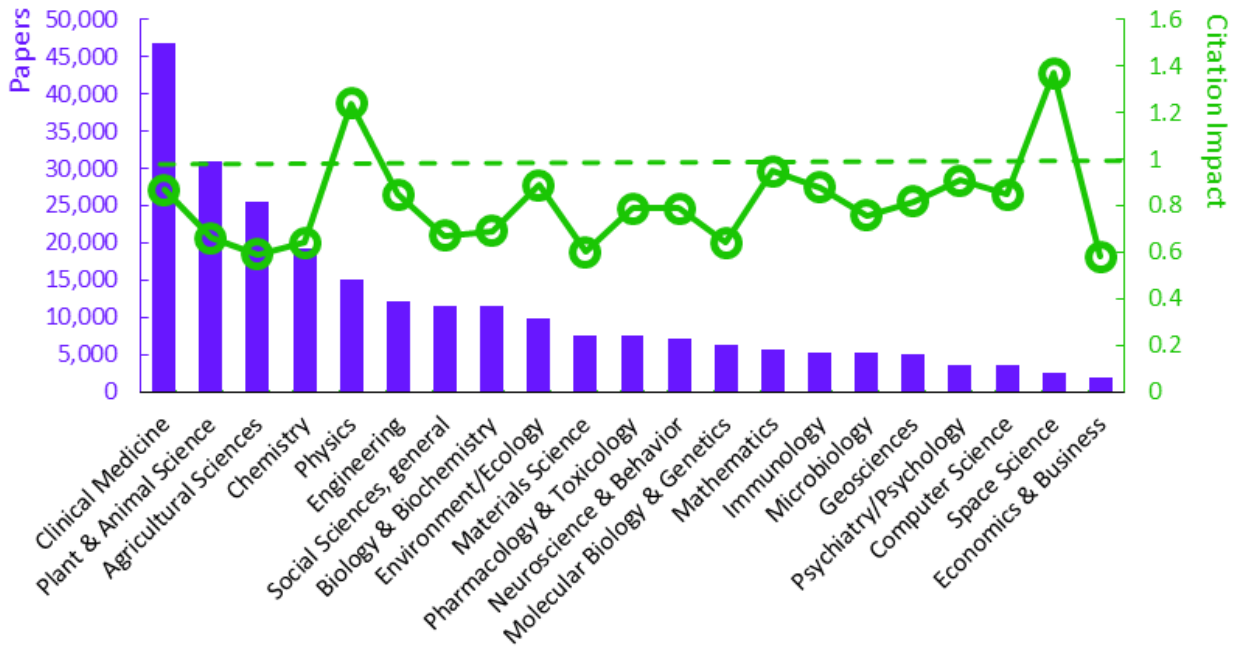


Figure 33 ESI categories by number papers and impact (world average in dotted line) of Brazilian papers, 2011 – 2016.

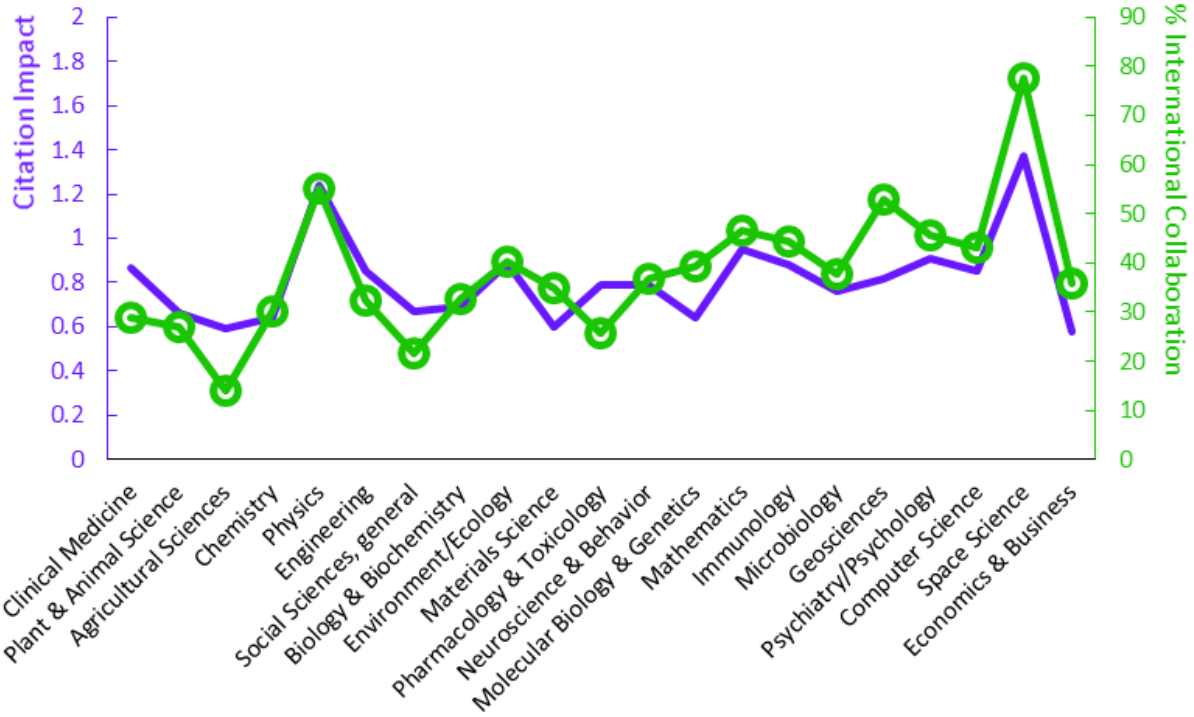


Figure 34 ESI categories by number papers and % international collaboration (world average in dotted line) of Brazilian papers, 2011 – 2016.

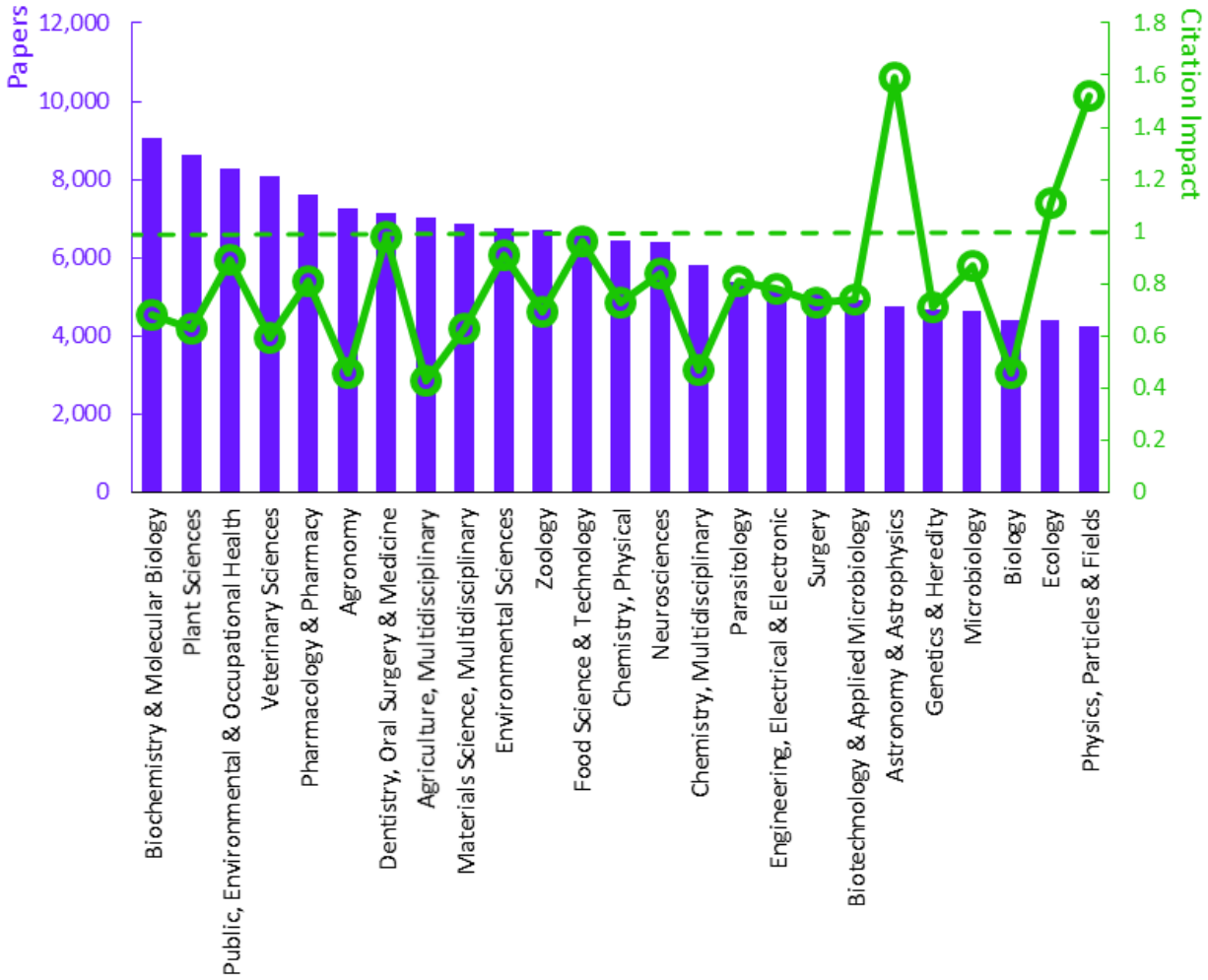


Figure 35 Web of Science categories by number papers and impact (world average in dotted line) of Brazilian papers, 2011 – 2016.

How do Brazilian states and institutions compare to one another?

An overview of Brazilian research performance at the state and organizational level

Which Brazilian states have the strongest research performance?

Research activity in Brazil is focused in a few states (particularly Sao Paulo) but several states perform relatively well on the basis of citation metrics

The data in Figure 36 show that more than 40% of Brazilian research papers have an author affiliated to an institution in Sao Paulo. Sao Paulo also has a relatively high citation impact (0.88), although the Distrito Federal (0.94) and Rio de Janeiro (0.93) have the highest average impact of all the Brazilian states. A similar pattern is observed for the percentage of highly-cited documents (in both the world's top 1% and 10%), with the Distrito Federal, Rio De Janeiro and Sao Paulo all performing well. Despite having a very low output, Acre also has a relatively high average citation impact (0.83) and the highest percentage of papers in the world's top 1% of most highly-cited papers (1.99%). This high average performance is driven by a group of papers relating to ecology in the Amazonian rainforest, particularly the work of Dr. Marcos Silveira of Universidade Federal do Acre. Rio de Janeiro has the highest rates of collaboration with industry (2.28% of papers); predominantly due to strong ongoing collaborations between Universidade Federal do Rio de Janeiro and Petrobras SA. Several states have relatively high rate of international collaboration, most often with the same partners as identified from Brazil as a whole (Figure 9).

Profiles of the ten Brazilian states with the highest research output between 2011 and 2016 are provided in Appendix 2.

State	Web of Science Documents	Category Normalized Citation Impact	% Documents in Top 1%	% Documents in Top 10%	% Industry Collaborations	% International Collaborations
Sao Paulo	111,029	0.88	0.99	7.27	1.02	33.83
Rio De Janeiro	39,996	0.93	1.15	7.80	2.28	37.89
Minas Gerais	36,660	0.76	0.64	5.61	0.79	27.33
Rio Grande Do Sul	30,240	0.84	0.85	6.61	1.08	28.38
Parana	21,858	0.66	0.54	5.14	0.65	23.82
Santa Catarina	12,312	0.84	0.63	6.08	0.89	29.11
Pernambuco	10,589	0.71	0.54	5.18	0.85	26.92
Distrito Federal	10,584	0.94	1.22	6.68	0.94	36.27
Bahia	9,189	0.73	0.78	5.27	0.79	28.11
Ceara	7,559	0.76	0.73	5.97	0.74	28.58
Paraiba	6,276	0.64	0.45	4.70	0.29	20.16
Goias	5,929	0.73	0.78	5.45	0.94	22.04
Rio Grande Do Norte	5,474	0.75	0.62	5.06	0.62	28.64
Para	5,148	0.81	0.99	5.94	0.70	32.69
Espirito Santo	3,837	0.63	0.60	4.56	1.33	24.68
Amazonas	3,735	0.81	1.12	6.93	0.64	34.40
Mato Grosso Do Sul	3,541	0.56	0.34	3.33	0.37	16.83
Mato Grosso	3,209	0.62	0.87	3.99	0.28	19.82
Sergipe	2,658	0.72	0.56	5.38	0.64	24.23
Piaui	2,066	0.53	0.15	3.87	0.19	16.46
Alagoas	1,819	0.71	0.38	6.05	0.44	29.41
Maranhao	1,715	0.73	0.52	4.14	0.35	20.00
Tocantins	900	0.49	0.22	2.56	0.44	19.44
Rondonia	620	0.65	0.48	5.32	0.32	19.19
Acre	452	0.83	1.99	8.41	0.22	27.21
Amapa	391	0.68	0.51	5.37	0.00	23.02
Roraima	349	0.74	1.15	4.87	0.29	19.20

Figure 36 Brazilian research performance disaggregated by State, 2011-2016.

In which disciplines do Brazil's states perform best?

Brazil's states vary in the extent to which they focus on and excel in particular areas of research

To determine the extent to which a state focuses on a particular research area we subtract the percentage of Brazilian national research papers in a given field from the percentage of each state's research output in that field. A value of above 0% indicates that the state is more focused on an area than the national background, while a value below 0% indicates that an area is not a particular focus for a state.

The data in Figure 37 show that Sao Paulo has a particularly high focus on medical research, while Parana is strongly focused on the Life Sciences (mostly related to agriculture, which is also a focus of economic activity in this state) and Rio de Janeiro on the Physical Sciences. Likewise, the data in Figure 38 show that the Distrito Federal has the highest average impact research in Medicine, the Life Sciences and the Earth & Environmental Sciences, and that Rio de Janeiro has the highest average impact in Mathematics and the Physical Sciences. That Rio de Janeiro has a relatively high focus on Mathematics and the Physical Sciences and also a high average impact in this field suggests that it is a key strength and is likely to be a core driver of national performance.

State	Medicine	Life Sciences	Mathematics & Physical Sciences	Engineering & Technology	Earth & Environmental Sciences	Social Sciences
Sao Paulo	6.3%	-5.2%	1.5%	-1.0%	-0.5%	-1.1%
Rio De Janeiro	-2.0%	-11.7%	7.8%	2.0%	0.8%	3.1%
Minas Gerais	-6.5%	10.1%	-1.7%	-0.4%	-0.8%	-0.8%
Rio Grande Do Sul	0.8%	5.3%	-5.2%	-1.0%	0.4%	-0.3%
Parana	-6.6%	13.9%	-4.3%	-0.4%	-0.7%	-1.8%
Santa Catarina	-2.6%	0.6%	-2.1%	3.1%	-0.3%	1.3%
Pernambuco	-5.3%	8.1%	-3.3%	-0.2%	0.8%	-0.2%
Distrito Federal	-6.0%	4.2%	-5.0%	-1.3%	3.0%	5.1%
Bahia	-4.5%	10.2%	-5.1%	-2.2%	0.9%	0.8%
Ceara	-0.9%	3.3%	-0.9%	0.4%	-0.9%	-1.0%

Figure 37 The relative focus of the ten highest output Brazilian states in each of six high-level research fields, 2011-2016, the state with the highest focus is highlighted in green, the state with the lowest focus in each is highlighted in red.

State	Medicine	Life Sciences	Mathematics & Physical Sciences	Engineering & Technology	Earth & Environmental Sciences	Social Sciences
Sao Paulo	0.92	0.73	1.00	0.87	0.98	0.75
Rio De Janeiro	1.05	0.75	1.22	0.72	0.85	0.71
Minas Gerais	0.83	0.58	0.94	0.83	0.83	0.64
Rio Grande Do Sul	1.10	0.61	0.74	0.97	0.78	0.85
Parana	0.78	0.55	0.65	0.87	0.65	0.60
Santa Catarina	1.09	0.65	0.68	0.96	0.87	0.55
Pernambuco	0.80	0.56	0.76	0.87	0.78	0.69
Distrito Federal	1.16	0.78	1.03	0.66	1.00	0.66
Bahia	0.84	0.52	0.69	0.81	0.98	0.87
Ceara	0.81	0.58	0.80	0.99	0.86	0.58

Figure 38 The citation impact of the ten highest output Brazilian states in each of six high-level research fields, 2011-16, the state with the highest focus is highlighted in green, the state with the lowest focus in each is highlighted in red.

Which are the leading universities in Brazil?

Universidade de Sao Paulo is Brazil's largest publisher of academic research papers (accounting for more than 20% of national output) and Universidade do Estado do Rio de Janeiro and Universidade Estadual de Campinas have well above average levels of papers in the world's top 1% of most highly cited papers

Universidade de Sao Paulo has the highest research paper output of any Brazilian higher education institution, more than double that of the next most prolific institution, Universidade Estadual Paulista (Figure 39). Universidade do Estado do Rio de Janeiro has the highest average citation impact of the Brazilian universities and also the highest percentage of papers in the world's top 1% of most highly cited papers – many of these most cited papers relate to the Large Hadron Collider experiments at the European Organization for Nuclear Research (CERN) which are highly collaborative but others relate to topics like the Zika Virus, epidemiology and cancer immunotherapy drug trials. Universidade do Estado do Rio de Janeiro also had the highest rates of international collaboration. Universidade Federal do Rio de Janeiro has the highest rates of industry collaboration which, as noted above, are primarily the result of an enduring partnership with Petrobras SA. Universidade Federal Fluminense also had relatively high rates of industry collaboration, and Petrobras SA is again its most frequent corporate co-author.

University	Web of Science Documents	Category Normalized Citation Impact	% Documents in Top 1%	% Documents in Top 10%	% Industry Collaborations	% International Collaborations
Universidade de Sao Paulo	54,108	0.93	1.06	7.96	0.83	35.83
Universidade Estadual Paulista	20,023	0.79	0.69	6.10	0.30	27.77
Universidade Estadual de Campinas	17,279	0.94	1.22	8.35	1.11	30.57
Universidade Federal do Rio de Janeiro	16,203	0.93	1.11	8.18	1.85	38.70
Universidade Federal do Rio Grande do Sul	14,611	0.89	0.86	6.76	0.98	30.39
Universidade Federal de Minas Gerais	13,294	0.88	0.67	6.24	0.90	31.22
Universidade Federal de Sao Paulo	10,667	0.93	1.05	6.15	1.24	28.78
Universidade Federal do Parana	8,233	0.67	0.44	5.31	0.84	27.45
Universidade Federal de Santa Catarina	7,908	0.91	0.66	6.79	1.09	32.41
Universidade do Estado do Rio de Janeiro	6,433	1.01	1.45	8.98	1.04	39.33
Universidade Federal de Pernambuco	6,420	0.73	0.48	5.51	0.76	30.51
Universidade Federal de Vicosa	6,373	0.63	0.56	4.33	0.60	20.76
Universidade de Brasilia	6,218	0.89	1.13	6.10	0.77	33.07
Universidade Federal de Sao Carlos	5,794	0.72	0.50	6.28	0.62	29.19
Universidade Federal de Santa Maria	5,750	0.65	0.24	4.96	0.45	18.89
Universidade Federal do Ceara	5,621	0.76	0.75	6.12	0.66	29.41
Universidade Federal Fluminense	5,441	0.71	0.70	5.99	1.43	30.42
Universidade Federal de Goias	4,217	0.74	0.81	5.90	0.88	23.33
Universidade Federal da Bahia	4,198	0.81	0.88	6.77	0.69	31.23
Universidade Estadual de Maringa	4,067	0.61	0.44	4.50	0.59	18.83

Figure 39 Research performance of Brazil's leading universities, 2011-2016.

Appendix 1

Bibliometrics and Citation Data

Bibliometrics and Citation Data

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 recognized 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 (now part of Clarivate Analytics).

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 used in this report came from the Clarivate Analytics Web of Science databases which give access not only to journals but also to conference proceedings, books, patents, websites, and chemical structures, compounds and reactions. Web of Science 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 focuses on research published in journals, conferences and books in science, medicine, arts, humanities and social sciences.

The Web of Science was originally created as an awareness and information retrieval tool but it has acquired an important primary 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 was previously 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 18,000 of the highest impact journals worldwide, including Open Access journals, and over 180,000 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.

Clarivate Analytics has extensive experience with databases on research inputs, activities and outputs and has developed innovative analytical approaches for benchmarking and interpreting international, national and institutional research impact.

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.

Clarivate Analytics 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.

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, program or institutional purpose.

Assigning Papers to Addresses

A paper is assigned to each country and each institution 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 may occur for the country or institution. No weighting is applied.

For example, a paper has five authors, thus:

AUTHOR	INSTITUTION	COUNTRY		
Gurney, KA	Univ Leeds	UK	Counts for Univ Leeds	Counts for UK
Adams, J	Univ Leeds	UK	No gain for Univ 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 Gujarat Univ	Counts for India
Pendlebury, D	Univ Oregon	USA	Counts for Univ 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 Clarivate Analytics, and research published elsewhere, indicates that fractional weighting based on the balance of authors by institution 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.

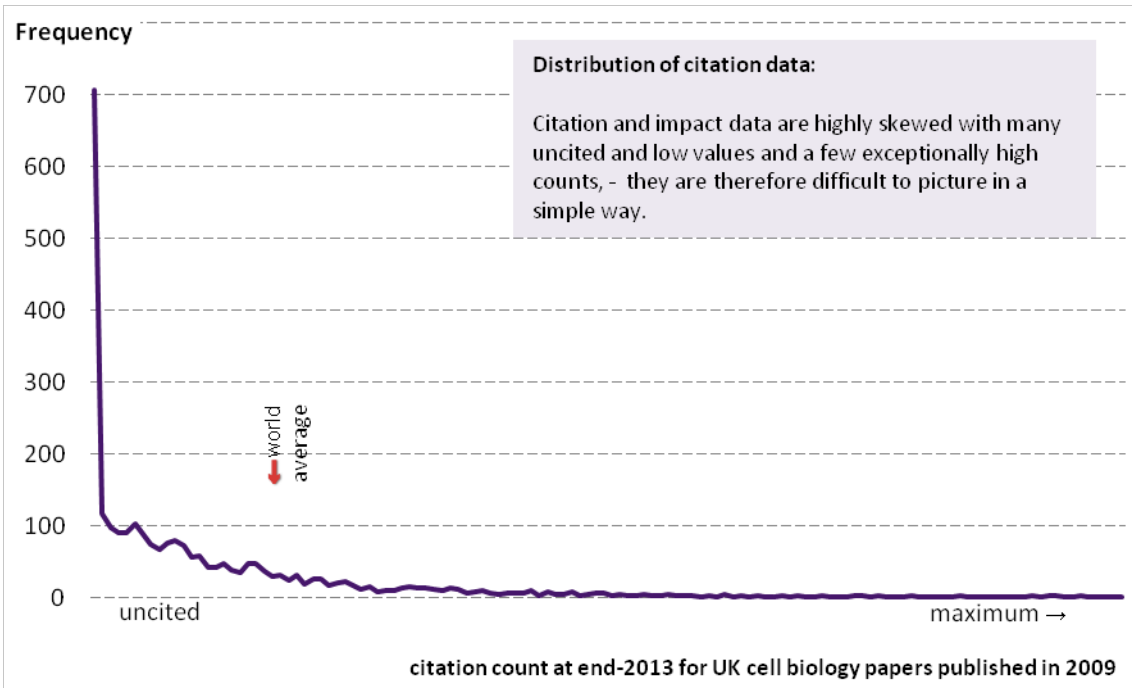
Citation Counts

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 recognized 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 recognized 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.

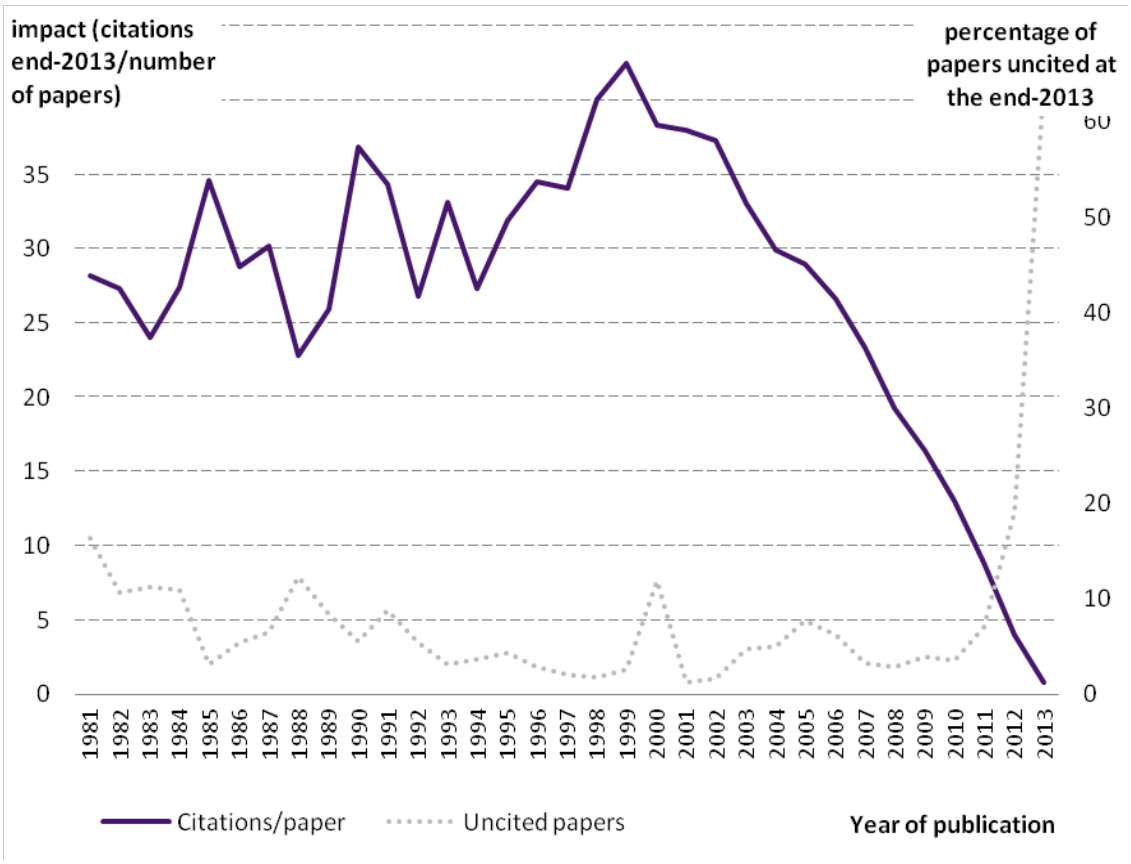
We do not seek to account separately for the effect of self-citation. If the citation count is significantly affected by self-citation then the paper is likely to have been infrequently cited. This is therefore only of consequence for low impact activity. Studies show that for large samples at national and institutional 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 Clarivate Analytics, bringing cognate research areas together. 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 Clarivate Analytics databases and how they are selected are detailed here http://scientific.thomsonreuters.com/mjl/.

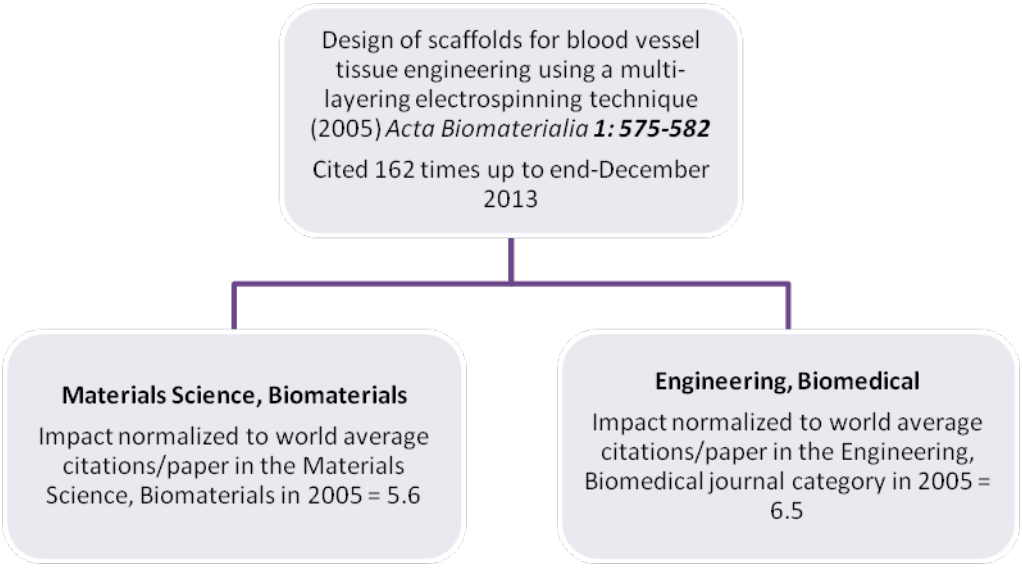
Some journals with a very diverse content, including the prestigious journals Nature and Science were classified as ***Multidisciplinary*** in databases created prior to 2007. The papers from these ***Multidisciplinary*** journals are now re-assigned to more specific research fields using an algorithm 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 citation impact', or nci. The following schematic illustrates how the normalised citation impact is calculated at the 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 5.6 and the category-specific nciF for Engineering, Biomedical is higher at 6.5). Most papers (nearly two-thirds) are assigned to a single journal category while a minority of them are assigned to more than five.

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 ((5.6 + 6.5)/2) = 6.1.

World average impact data are sourced from the Clarivate Analytics National Science Indicators baseline data for 2015.

Mean Normalised 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.

Impact Profiles

We have developed a bibliometric methodology 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.[11] 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.

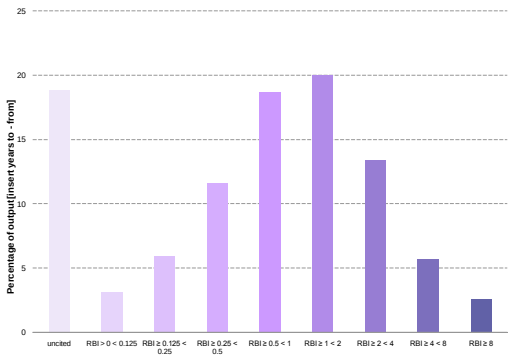
Papers which are "highly cited" are often defined in our reports as those with an average citation impact greater than or equal to 4.0, i.e. those papers which have received greater than or equal to four times the world average number of citations for papers in that subject published in that year. This differs from Clarivate Analytics database of global highly cited papers, which are the top 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.

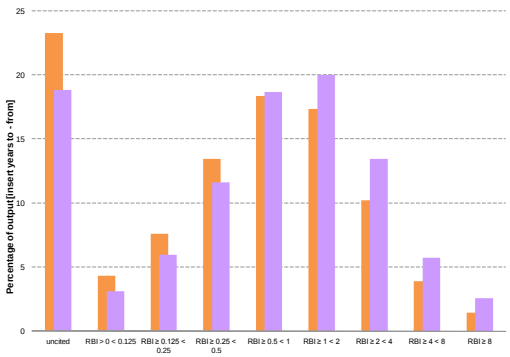
[11] Adams J, Gurney K & Marshall S (2007) Profiling citation impact: A new methodology. *Scientometrics* **72**: 325-344.

The Impact Profile histogram can be presented in a number of ways which are illustrated below.

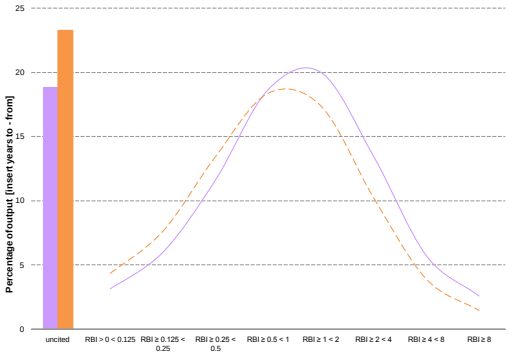
A



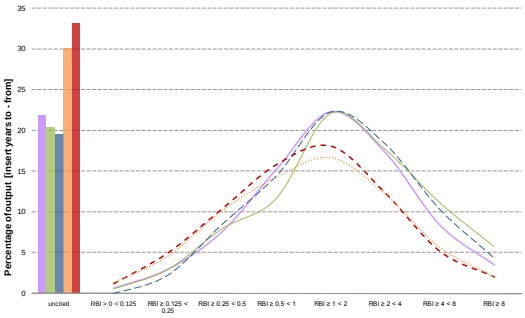
B



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 a 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.

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 proportion of papers are uncited and what proportion are in each of eight categories of relative citation rates, normalised to world average (which becomes 1.0 in this graph). Normalised citation rates above 1.0 indicate papers cited more often than world average for the field in which that journal is categorized and in their year of publication.

Attention should be paid to:

- The proportion of uncited papers on the left of the chart
- The proportion of cited papers either side of world average (1.0)

- The location of the most common (modal) group near the center
- The proportion 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”?

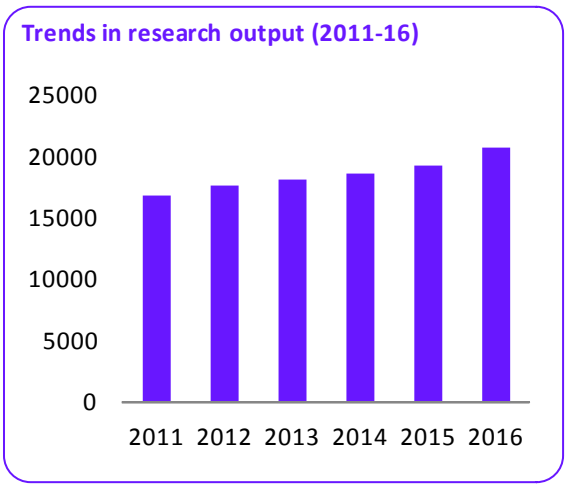
Clarivate Analytics has traditionally used the term “Highly Cited Paper” to refer to the world’s 1% of most frequently cited papers, taking into account year of publication and field. After reviewing the outcomes of a number of analyses, we have chosen a more relaxed definition for our descriptive and analytical work. We deem papers that are in the world’s top 10% of most frequently cited papers, taking into account year of publication and field, to be relatively highly cited for national comparisons.

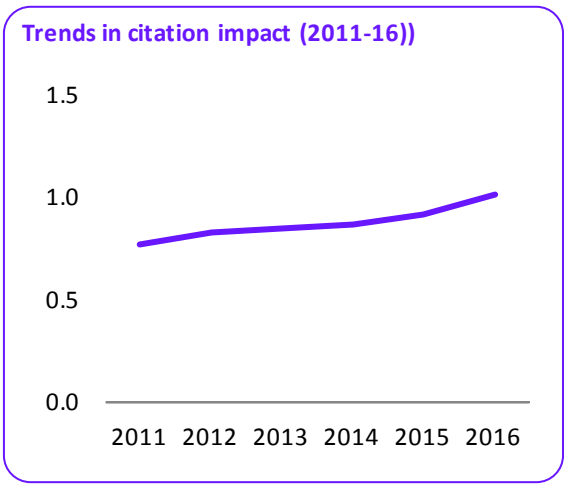
Appendix 2

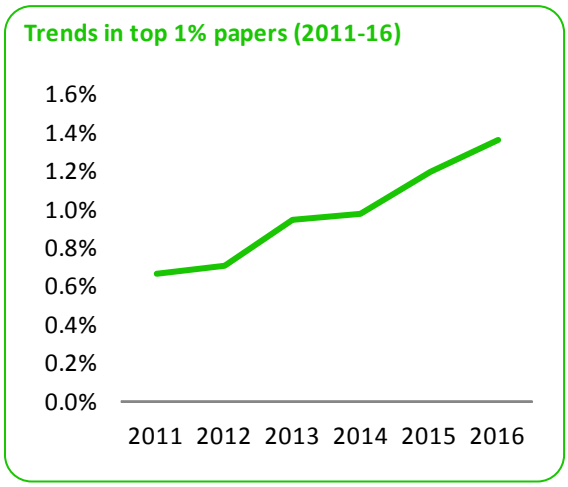
Profiles of Brazil's highest research output states, 2011-2016

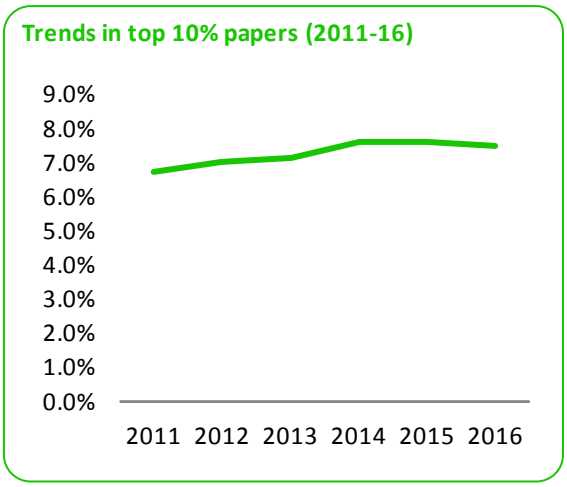
State Profile: Sao Paulo

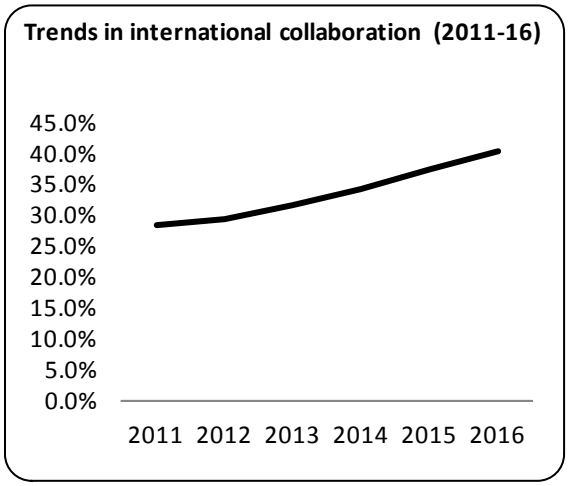
Sao Paulo is the most populous state in Brazil (44.9 million people) and the richest (GDP $588 million and $43.7 per capita). It had the largest research output between 2011 and 2016 (111,029 papers) and on average its papers receive 13% more citations than the Brazilian average for the field and year of publication.

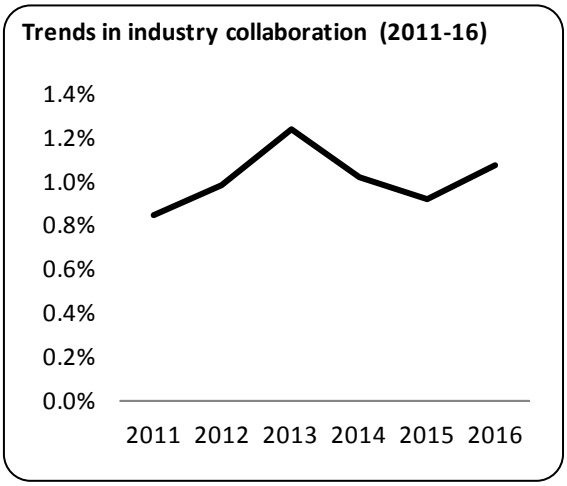






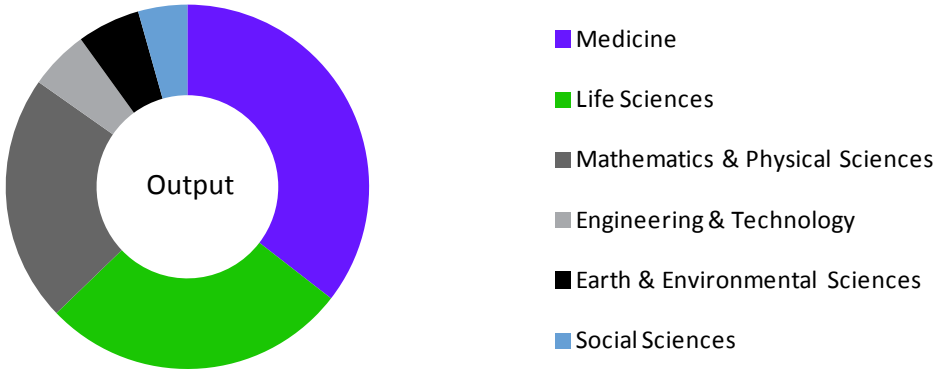






State Profile: Sao Paulo (continued…)

Research Output By Field (2011-16))

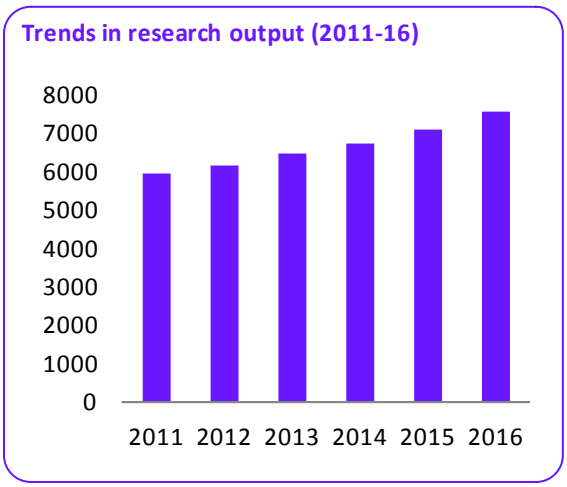


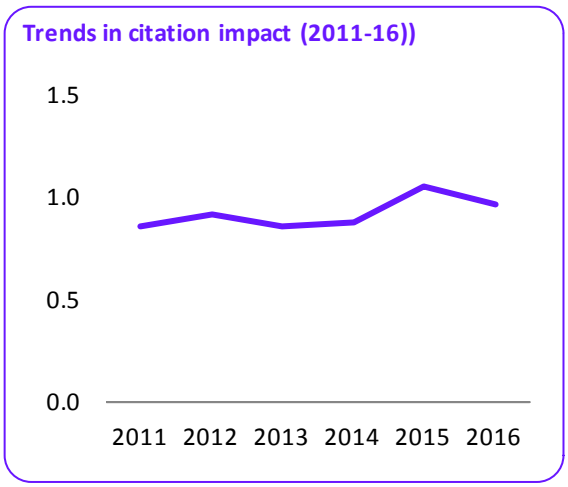
Leading research disciplines (2011-16))

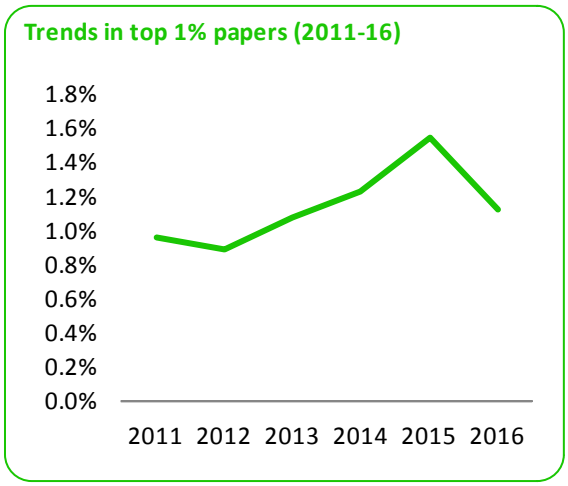
	Papers	Impact	Top 1%	Top 10%	International collaboration
Dentistry	4,268	0.99	0.82	9.23	30.15
Biochem & Molecular Biol	4,246	0.73	0.38	4.03	36.48
Surgery	3,474	0.78	0.78	6.74	22.77
Multidisc Materials Science	3,391	0.63	0.15	3.24	40.28
Physical Chem	3,189	0.73	0.09	2.54	39.29
Pharmacology & Pharmacy	3,130	0.86	0.83	6.39	29.14
Neurosci	3,087	0.86	0.55	5.64	36.48
Veterinary Sci	3,073	0.68	0.72	6.22	17.38
Plant Sci	2,930	0.69	0.55	3.99	31.43
Public Hlth	2,817	1.40	1.49	5.40	22.58
Food Science & Technol	2,772	1.09	1.37	10.79	24.57
Astronomy & Astrophysics	2,676	1.75	2.24	12.97	75.34
Zoology	2,618	0.80	0.46	5.61	31.05
Particle & Field Physics	2,586	1.95	3.60	19.68	75.68
Multidisc Chem	2,474	0.49	0.08	1.82	27.93
Environmental Sci	2,411	1.04	0.87	8.21	37.74
Biotechnol & Appl Microbiol	2,256	0.81	0.62	6.56	35.37
Genetics & Heredity	2,171	0.74	0.55	5.57	41.82
Multidisc Agric	2,169	0.60	1.20	3.87	10.65
Immunology	2,132	0.88	0.56	6.33	38.18
Psychiatry	2,111	1.06	1.52	8.01	40.74
Analytical Chem	2,081	0.85	0.24	5.48	26.67
Microbiol	1,958	0.90	0.56	6.49	43.26
Agronomy	1,944	0.54	0.46	5.30	17.44
Clinical Neurology	1,908	1.08	1.36	9.49	42.51

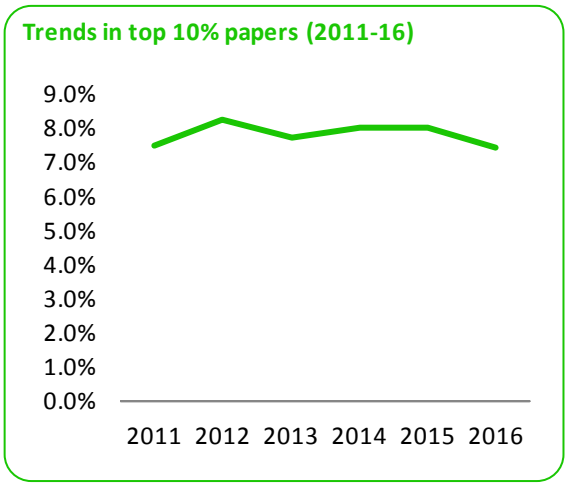
State Profile: Rio de Janeiro

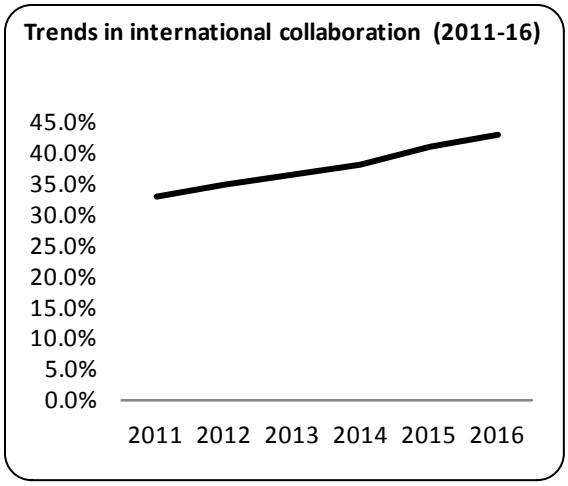
Rio de Janeiro is the third most populous state in Brazil (16.7 million people) and the second richest (GDP $200 million and $39.8 per capita). It had the second largest research output between 2011 and 2016 (39,996 papers) and on average its papers receive 19% more citations than the Brazilian average for the field and year of publication.

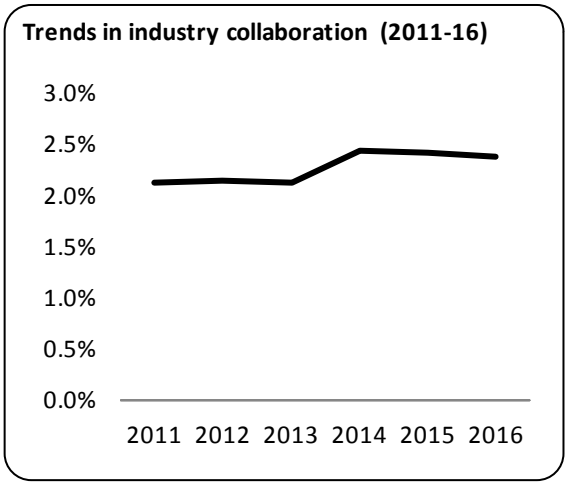






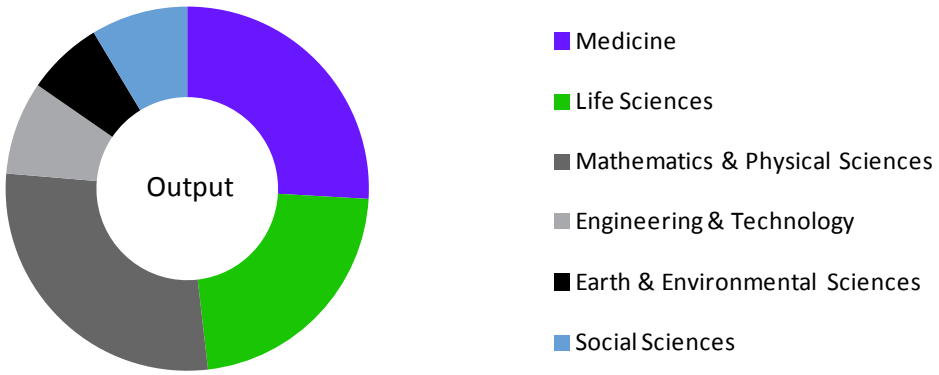






State Profile: Rio de Janeiro (continued…)

Research Output By Field (2011-16))

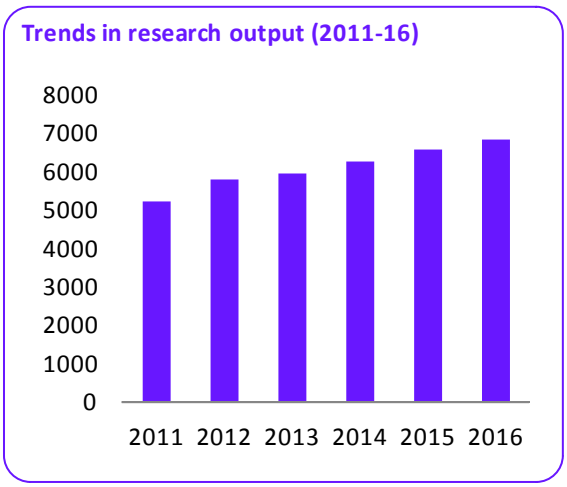


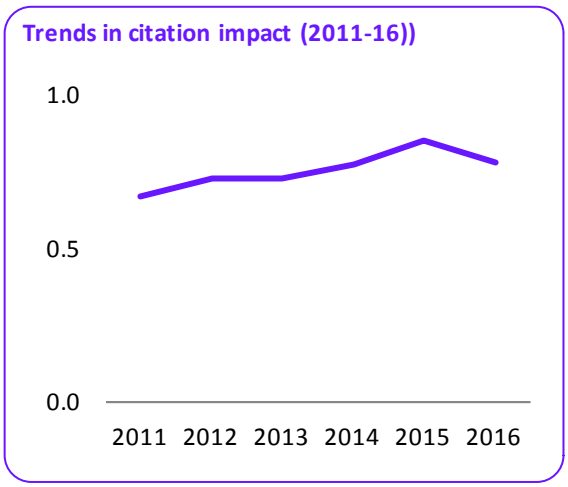
Leading research disciplines (2011-16))

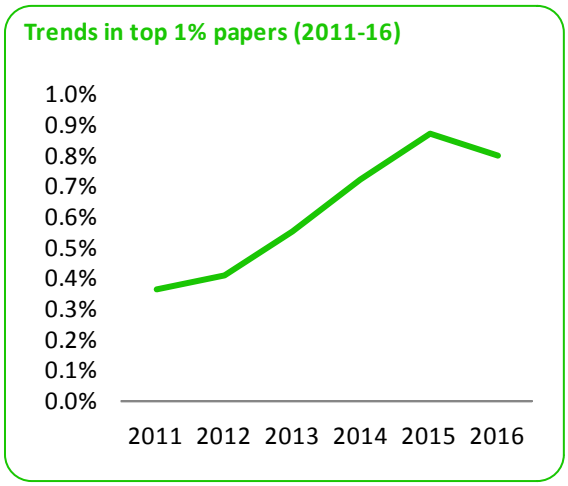
	Papers	Impact	Top 1%	Top 10%	International collaboration
Public Hlth	2,023	0.95	1.19	4.25	20.42
Particle & Field Physics	1,950	2.04	3.44	19.95	84.36
Astronomy & Astrophysics	1,771	2.26	3.61	17.62	84.08
Biochem & Molecular Biol	1,459	0.71	0.14	3.43	35.16
Parasitology	1,452	0.81	0.69	3.65	28.31
Zoology	1,145	0.76	0.70	3.84	24.80
Environmental Sci	1,114	0.88	0.63	5.57	41.74
Infectious Diseases	1,075	1.81	2.79	11.07	53.77
Microbiol	1,073	0.97	0.84	8.39	49.67
Multidisc Materials Science	998	0.62	0.20	2.40	36.97
Pharmacology & Pharmacy	954	0.80	0.63	5.87	32.70
Physical Chem	934	0.69	0.21	1.93	35.33
Plant Sci	920	0.66	0.33	3.26	30.22
Tropical Med	916	0.95	1.64	8.41	28.82
Multidisc Physics	908	1.92	2.97	22.58	60.90
Mathematics	888	1.06	0.90	9.91	51.80
Neurosci	884	0.73	0.23	5.09	43.33
Appl Mathematics	872	0.89	0.34	6.54	54.93
Multidisc Chem	863	0.43	0.23	1.62	27.00
Dentistry	846	1.10	1.54	12.53	29.20
Veterinary Sci	822	0.60	0.61	5.23	12.90
Immunology	816	1.00	0.74	8.70	49.75
Chemical Eng	810	0.71	0.12	5.56	27.28
Electrical & Electronic Eng	737	0.63	0.14	4.88	32.56
Marine & Freshwater Biol	691	0.83	0.87	7.24	31.69

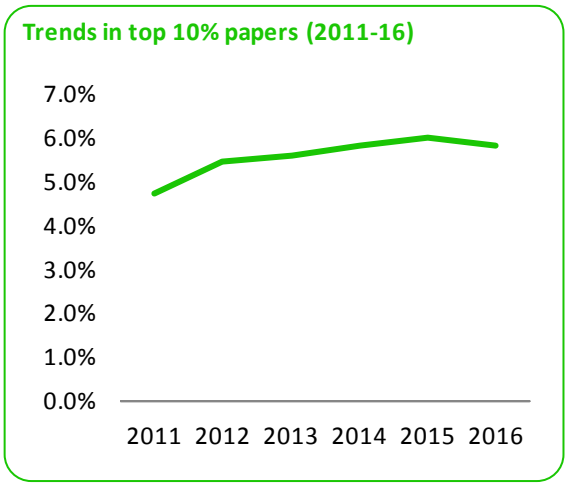
State Profile: Minas Gerais

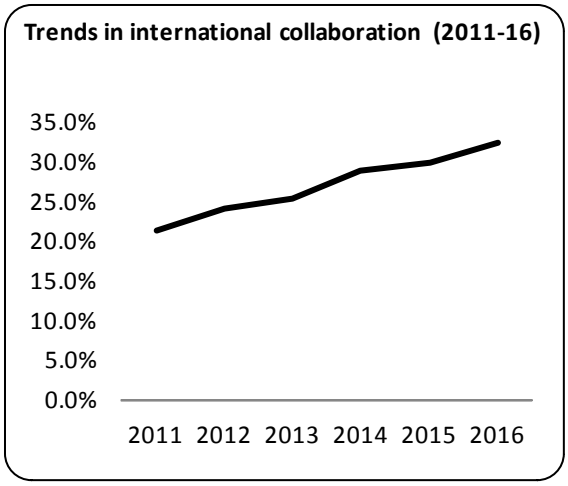
Minas Gerais is the second most populous state in Brazil (21.1 million people) and the third richest (GDP $157 million and $24.9 per capita). It had the third largest research output between 2011 and 2016 (36,660 papers) and on average its papers receive 3% fewer citations than the Brazilian average for the field and year of publication.

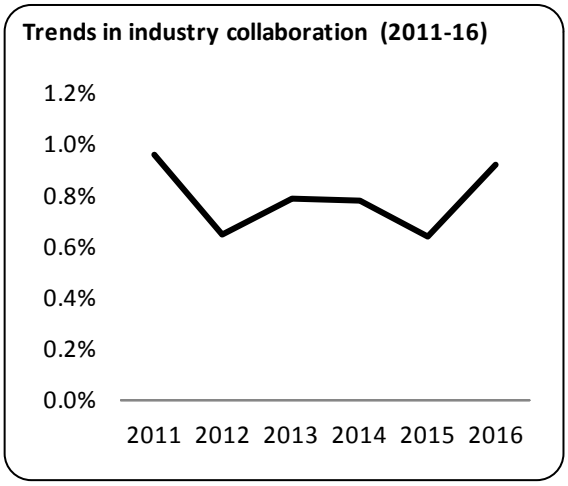






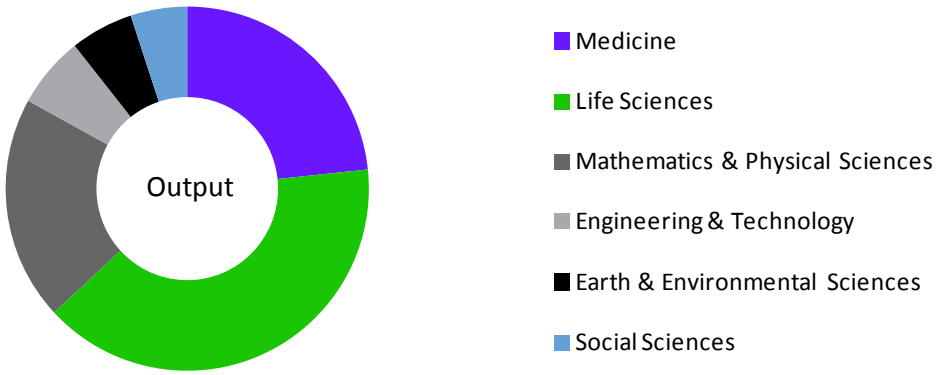






State Profile: Minas Gerais (continued…)

Research Output By Field (2011-16))

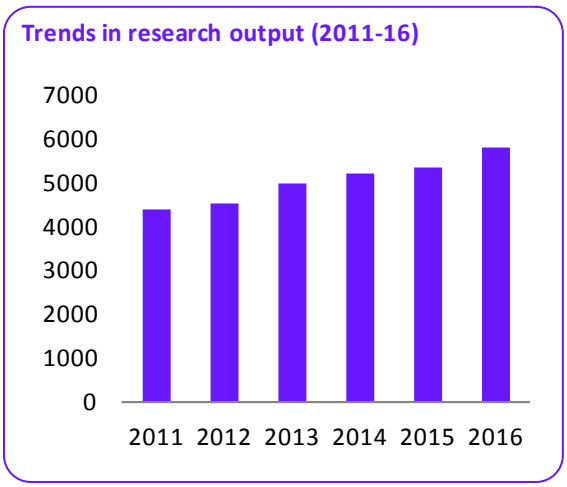


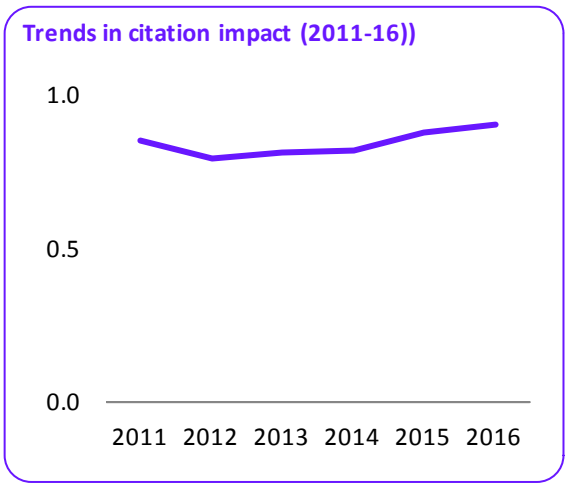
Leading research disciplines (2011-16))

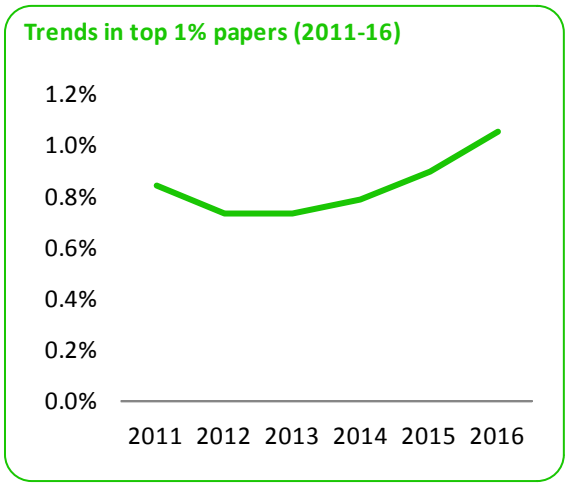
	Papers	Impact	Top 1%	Top 10%	International collaboration
Agronomy	1,938	0.48	0.41	2.99	8.62
Veterinary Sci	1,879	0.56	0.53	3.35	12.88
Multidisc Agric	1,791	0.36	0.17	0.95	7.87
Plant Sci	1,732	0.69	0.58	3.98	23.56
Biochem & Molecular Biol	1,229	0.64	0.24	2.93	30.68
Parasitology	1,202	0.82	0.58	4.16	27.79
Public Hlth	1,186	1.55	1.26	4.72	17.62
Food Science & Technol	1,042	0.91	0.67	7.68	18.62
Agric (Dairy & Animal)	1,023	0.67	0.49	3.91	23.56
Multidisc Materials Science	1,002	0.65	0.20	2.89	34.53
Pharmacology & Pharmacy	1,000	0.76	0.20	4.20	24.00
Biology	946	0.36	0.21	2.11	12.58
Forestry	938	0.35	0.21	1.60	10.55
Physical Chem	935	0.68	0.21	1.82	33.26
Environmental Sci	926	0.79	0.22	5.72	35.21
Entomology	849	0.91	0.59	7.42	23.91
Biotechnol & Appl Microbiol	846	0.64	0.00	4.37	29.31
Multidisc Chem	828	0.42	0.24	1.33	18.96
Dentistry	823	0.91	0.36	6.20	23.82
Microbiol	821	0.95	0.49	4.87	41.78
Genetics & Heredity	784	0.59	0.51	3.70	33.80
Particle & Field Physics	778	2.12	3.86	19.54	84.70
Electrical & Electronic Eng	778	0.79	0.39	7.20	25.06
Zoology	729	0.72	0.69	5.62	26.89
Immunology	727	0.85	0.96	4.81	40.58

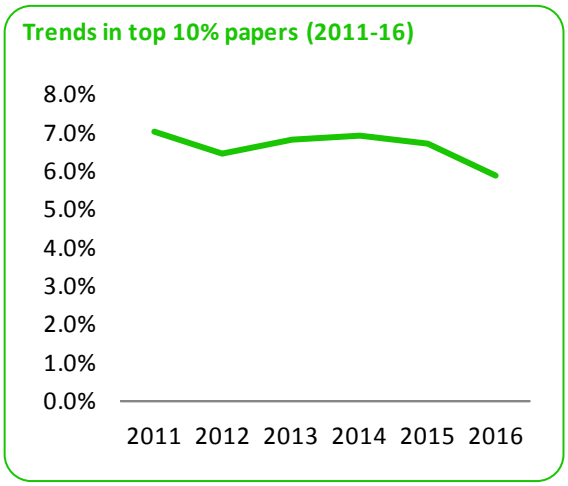
State Profile: Rio Grande do Sul

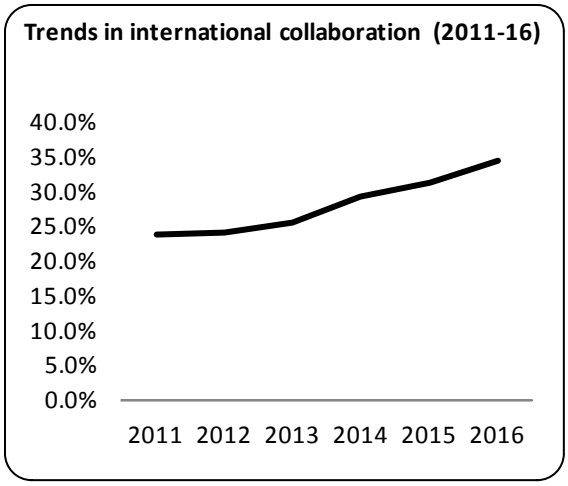
Rio Grande do Sul is the fourth most populous state in Brazil (11.3 million people) and the fourth richest (GDP $116 million and $34 per capita). It had the fourth largest research output between 2011 and 2016 (30,240 papers) and on average its papers receive 8% more citations than the Brazilian average for the field and year of publication.

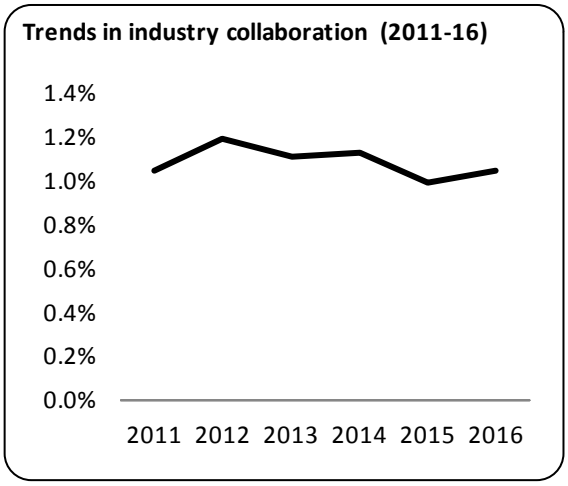






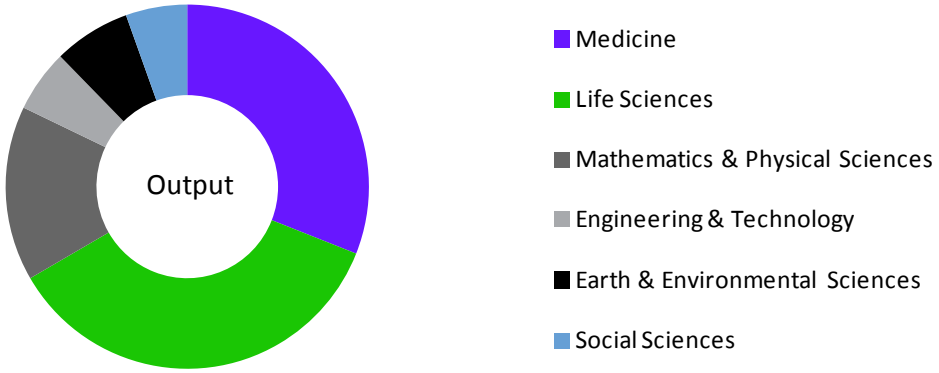






State Profile: Rio Grande do Sul (continued…)

Research Output By Field (2011-16))

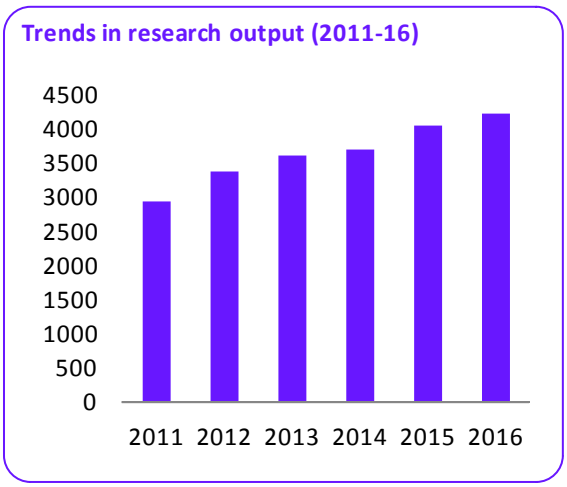


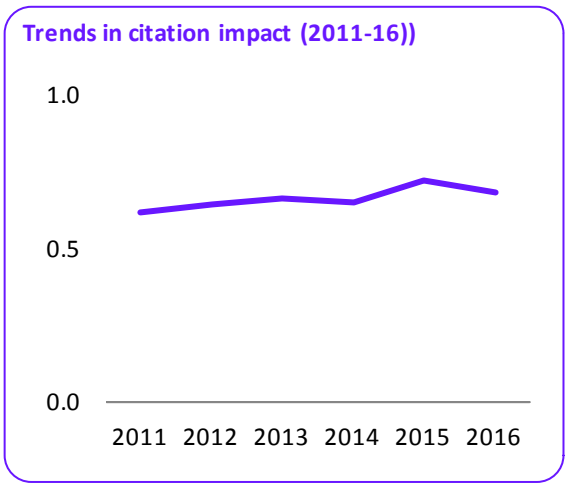
Leading research disciplines (2011-16))

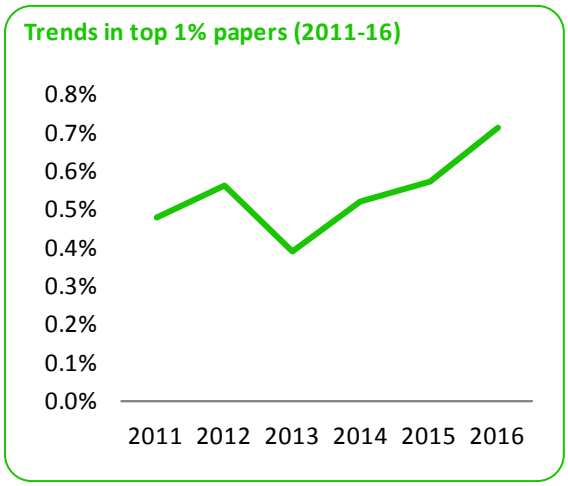
	Papers	Impact	Top 1%	Top 10%	International collaboration
Veterinary Sci	1,377	0.56	0.65	4.87	15.47
Agronomy	1,286	0.42	0.23	2.88	10.81
Neurosci	1,232	0.90	0.32	3.90	30.28
Biochem & Molecular Biol	1,168	0.69	0.26	3.68	28.08
Public Hlth	1,143	1.86	2.71	7.70	25.46
Pharmacology & Pharmacy	1,124	0.88	0.53	7.12	23.22
Plant Sci	1,099	0.57	0.27	3.64	22.29
Dentistry	1,030	1.08	1.17	10.68	34.27
Food Science & Technol	958	0.95	0.31	8.87	17.54
Environmental Sci	926	0.99	0.54	7.88	32.94
Multidisc Agric	925	0.43	0.32	2.05	8.86
Zoology	805	0.72	0.75	4.60	23.73
Psychiatry	766	1.33	2.48	12.79	43.99
Multidisc Materials Science	738	0.57	0.00	2.17	31.98
Multidisc Chem	706	0.47	0.00	1.42	23.23
Genetics & Heredity	688	0.71	0.58	4.94	42.59
Toxicology	598	0.90	0.00	7.19	24.58
Biotechnol & Appl Microbiol	590	0.72	0.51	5.59	20.85
Chemical Eng	563	0.72	0.18	4.80	17.23
Microbiol	550	0.72	0.55	3.82	30.55
Endocrinology	541	1.12	1.29	6.65	32.72
Physical Chem	534	0.79	0.00	2.43	35.21
Electrical & Electronic Eng	527	0.87	0.19	7.59	44.40
Agric (Dairy & Animal)	514	0.74	0.19	5.64	22.76
Biology	488	0.49	0.61	2.66	14.75

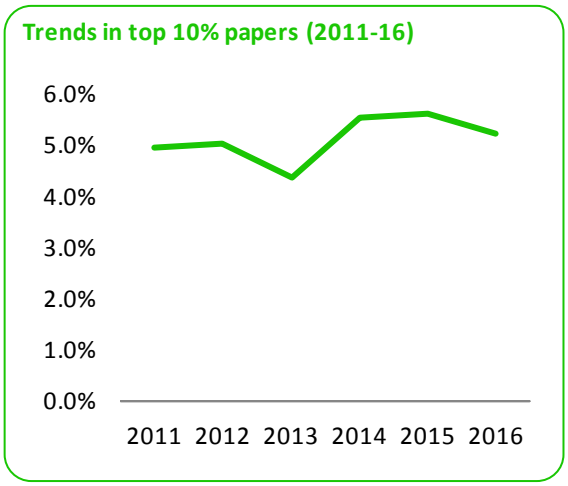
State Profile: Parana

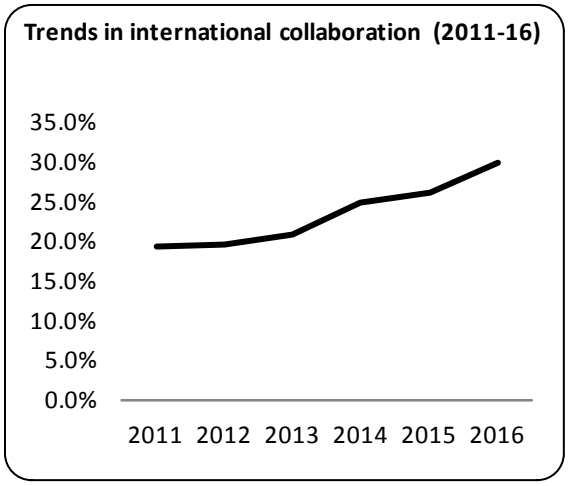
Parana is the fourth most populous state in Brazil (11.3 million people) and the fifth richest (GDP $114 million and $33.8 per capita). It had the fifth largest research output between 2011 and 2016 (21,858 papers) and on average its papers receive 15% fewer citations than the Brazilian average for the field and year of publication.

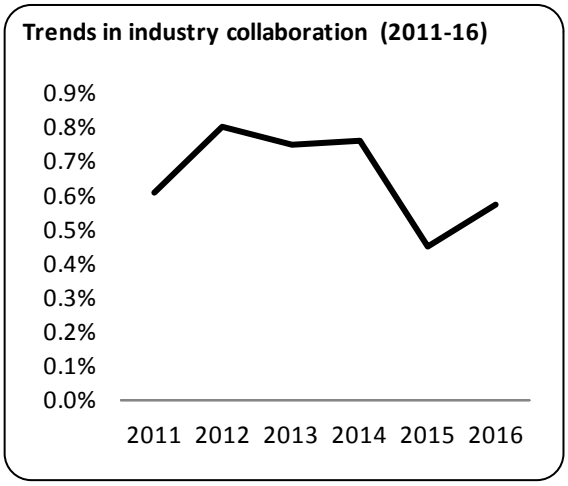






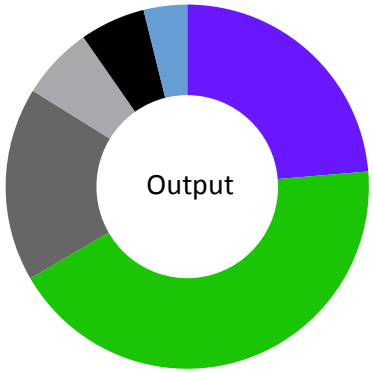






State Profile: Parana (continued…)

Research Output By Field (2011-16))

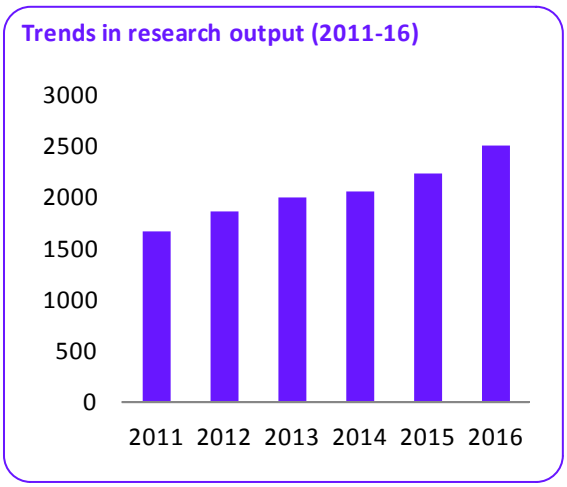


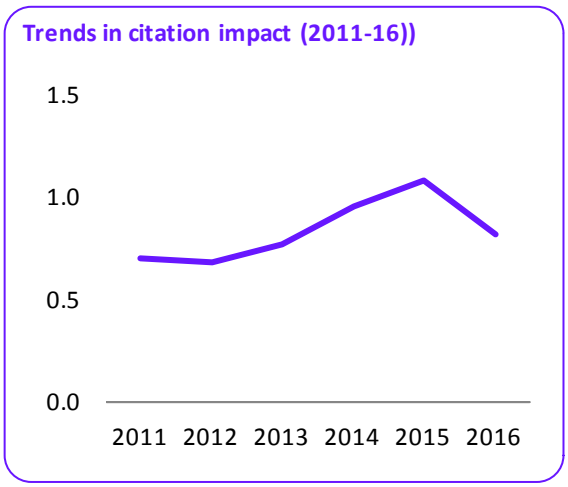
Leading research disciplines (2011-16))

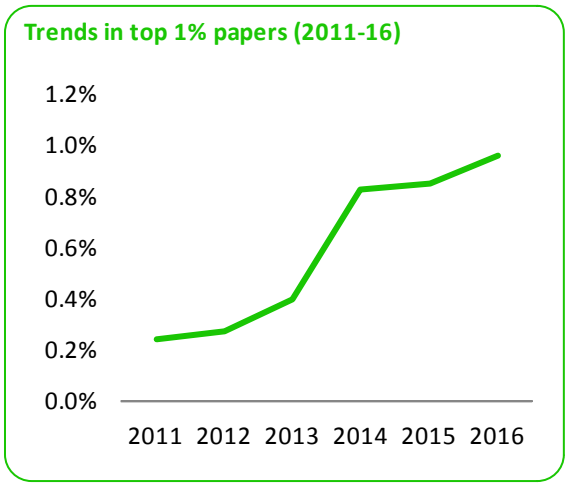
	Papers	Impact	Top 1%	Top 10%	International collaboration
Multidisc Agric	1,383	0.32	0.14	1.23	8.60
Plant Sci	999	0.57	0.50	3.30	21.42
Agronomy	931	0.43	0.11	3.11	11.17
Food Science & Technol	893	0.85	1.12	8.29	17.36
Veterinary Sci	825	0.61	0.48	5.82	16.61
Biochem & Molecular Biol	818	0.58	0.12	2.32	24.33
Pharmacology & Pharmacy	726	0.82	0.41	5.79	19.70
Zoology	702	0.63	0.28	3.28	24.07
Environmental Sci	643	0.86	0.31	4.98	34.06
Dentistry	629	0.94	1.43	7.95	28.93
Physical Chem	570	0.74	0.35	2.63	31.40
Multidisc Materials Science	536	0.63	0.37	2.99	35.63
Biology	529	0.33	0.38	0.95	13.23
Genetics & Heredity	528	0.56	0.38	3.22	26.33
Multidisc Chem	521	0.50	0.38	2.30	20.54
Forestry	497	0.29	0.20	1.01	10.87
Electrical & Electronic Eng	487	0.76	0.62	6.57	34.50
Agric (Dairy & Animal)	482	0.76	0.62	5.39	21.58
Biotechnol & Appl Microbiol	463	0.65	0.43	3.89	26.13
Public Hlth	459	0.82	1.09	5.66	22.22
Chemical Eng	457	0.93	0.66	7.44	23.19
Marine & Freshwater Biol	430	0.89	0.70	7.21	31.16
Microbiol	412	0.76	0.49	3.64	32.52
Neurosci	407	0.76	0.00	5.16	31.70
Appl Chem	399	1.11	0.75	10.78	21.80

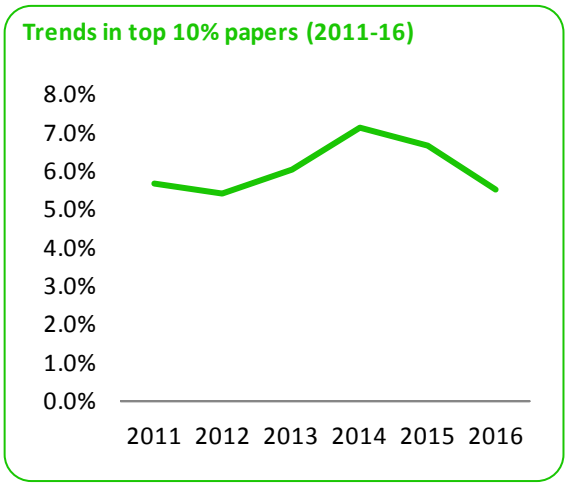
State Profile: Santa Catarina

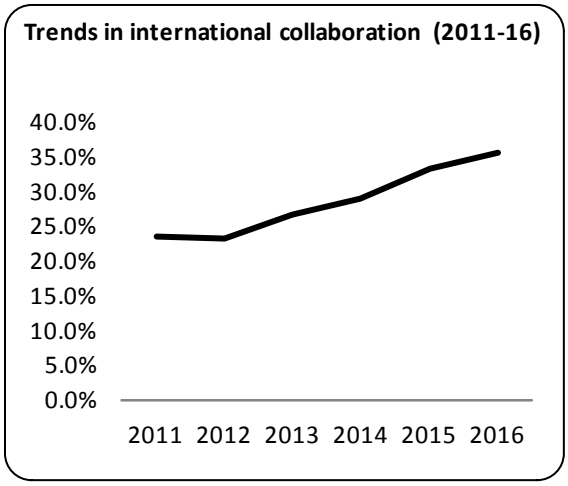
Santa Catarina is the tenth most populous state in Brazil (7 million people) and the sixth richest (GDP $75 million and $36.5 per capita). It had the sixth largest research output between 2011 and 2016 (12,312 papers) and on average its papers receive 8% more citations than the Brazilian average for the field and year of publication.

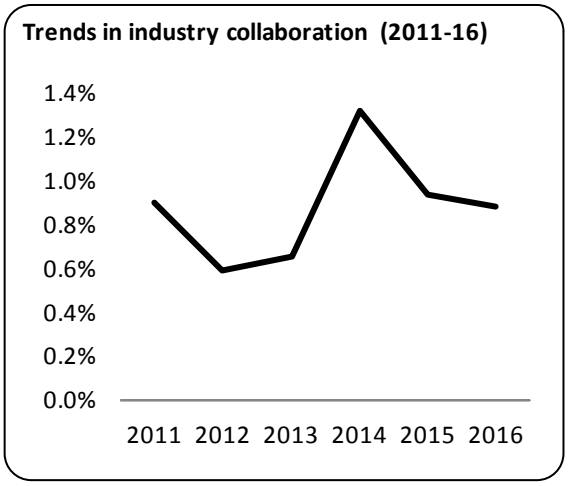






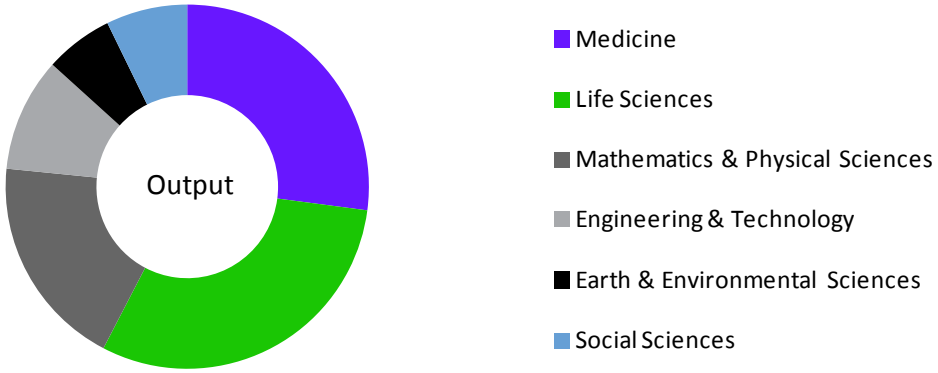






State Profile: Santa Catarina (continued…)

Research Output By Field (2011-16))

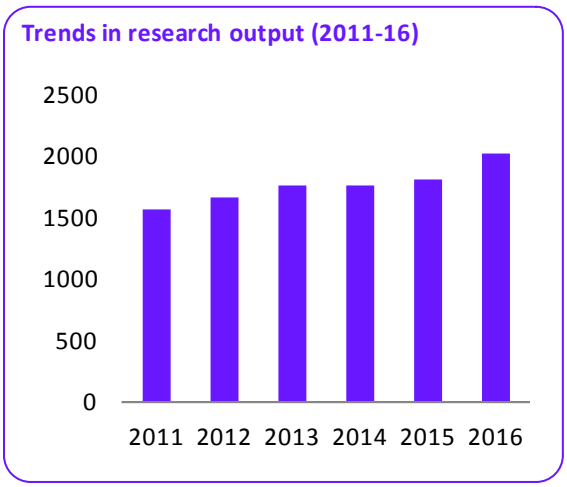


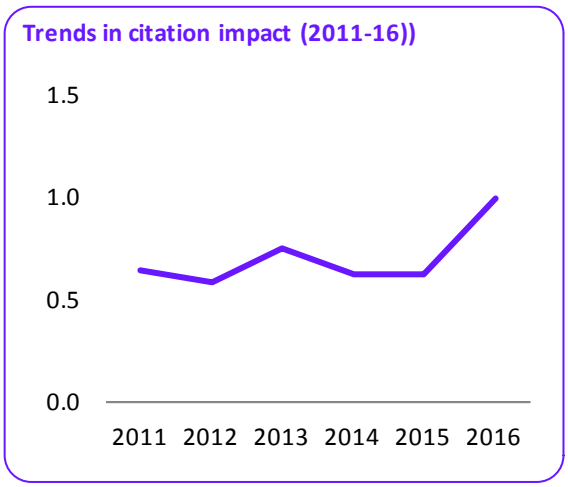
Leading research disciplines (2011-16))

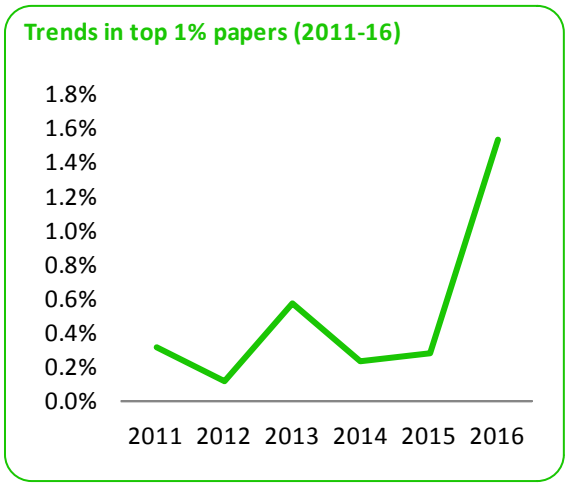
	Papers	Impact	Top 1%	Top 10%	International collaboration
Pharmacology & Pharmacy	629	0.89	0.64	6.36	28.46
Neurosci	609	0.96	0.16	4.27	36.12
Public Hlth	514	2.65	1.95	5.06	21.98
Plant Sci	508	0.66	0.39	2.76	23.23
Environmental Sci	479	0.93	0.00	7.52	40.71
Food Science & Technol	439	0.99	1.14	7.97	18.68
Electrical & Electronic Eng	424	0.81	0.47	7.08	35.38
Biochem & Molecular Biol	404	0.77	0.25	3.47	32.67
Multidisc Materials Science	393	0.55	0.00	1.78	40.46
Veterinary Sci	371	0.55	0.81	3.77	15.09
Chemical Eng	343	0.65	0.00	3.50	34.40
Multidisc Agric	339	0.48	0.59	1.47	11.21
Agronomy	332	0.47	0.30	4.82	11.14
Multidisc Chem	320	0.47	0.00	1.25	28.44
Dentistry	306	0.86	0.00	5.23	47.06
Marine & Freshwater Biol	304	0.92	1.32	8.22	34.54
Physical Chem	291	0.62	0.00	2.06	36.43
Medicinal Chem	268	0.95	0.00	8.21	32.09
Mechanical Eng	259	0.79	0.77	6.56	27.03
Biotechnol & Appl Microbiol	247	0.64	0.00	4.45	21.46
Sport Sci	245	0.48	0.00	3.27	30.20
Nutrition & Dietetics	244	0.78	0.41	5.74	15.57
Energy & Fuels	242	1.02	0.00	7.02	41.32
Fisheries	211	0.92	1.90	7.58	26.07
Parasitology	208	0.67	0.00	3.37	15.38

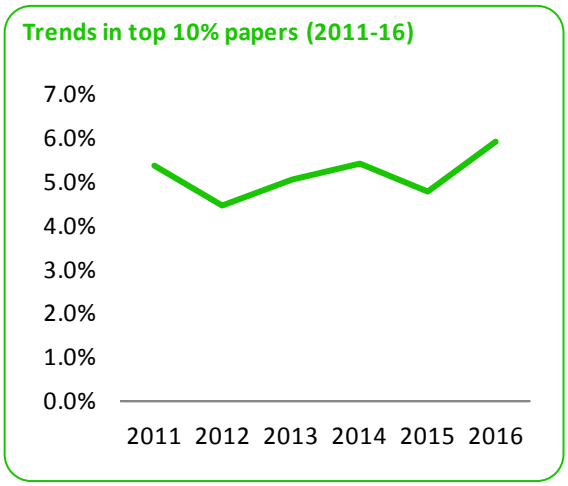
State Profile: Pernambuco

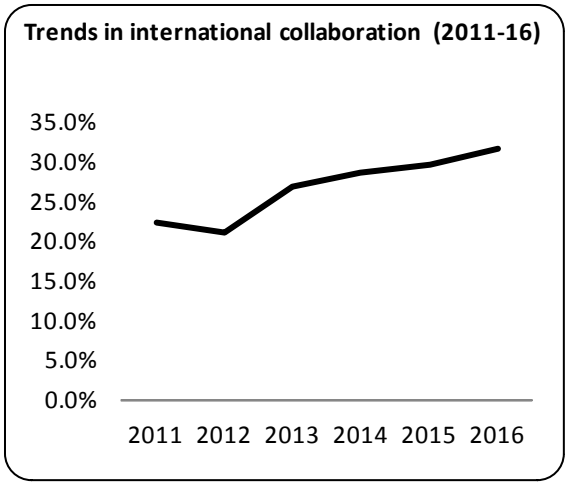
Pernambuco is the seventh most populous state in Brazil (9.5 million people) and the tenth richest (GDP $48 million and $16.8 per capita). It had the seventh largest research output between 2011 and 2016 (10,589 papers) and on average its papers receive 9% fewer citations than the Brazilian average for the field and year of publication.

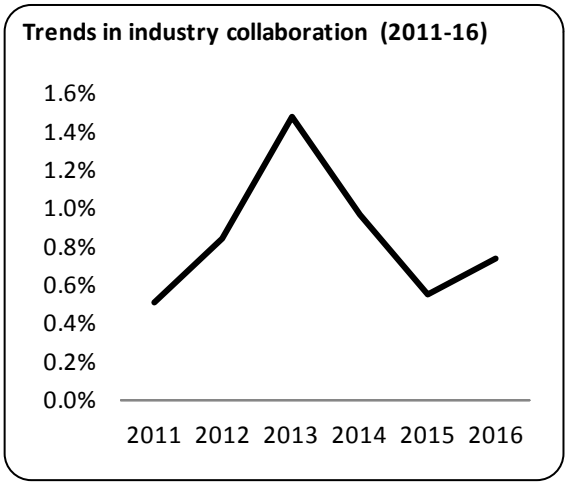






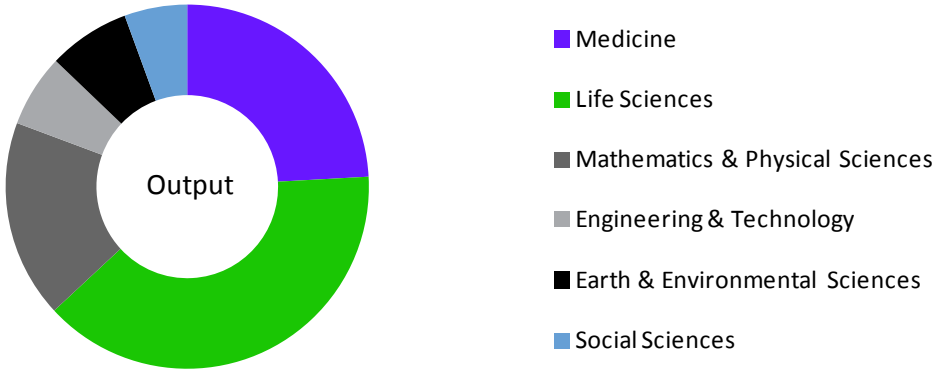






State Profile: Pernambuco (continued…)

Research Output By Field (2011-16))

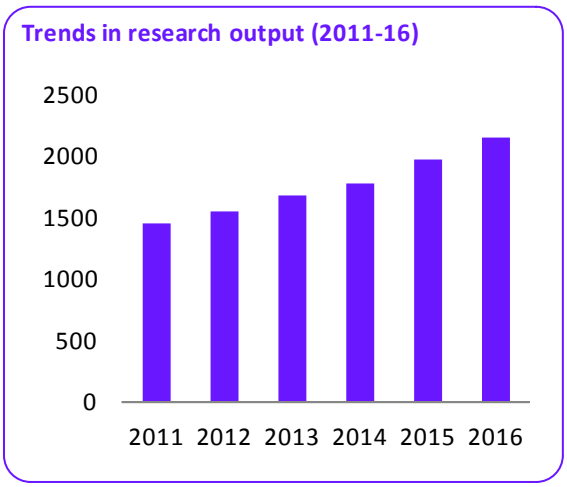


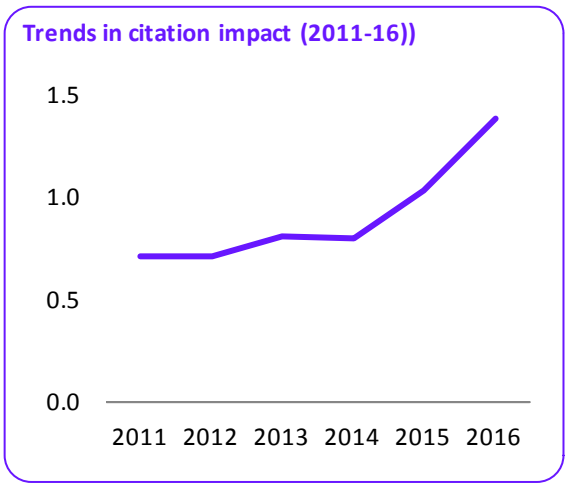
Leading research disciplines (2011-16))

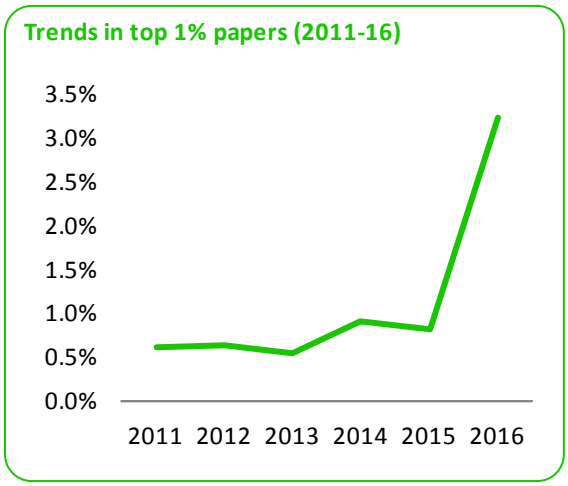
	Papers	Impact	Top 1%	Top 10%	International collaboration
Plant Sci	531	0.54	0.00	1.88	31.26
Veterinary Sci	516	0.53	0.58	5.23	15.31
Public Hlth	448	1.02	1.34	4.02	19.42
Biochem & Molecular Biol	397	0.49	0.00	1.51	26.20
Agronomy	379	0.39	0.00	2.11	10.55
Pharmacology & Pharmacy	335	0.59	0.00	1.49	16.42
Environmental Sci	330	0.71	0.00	3.33	33.64
Multidisc Agric	330	0.42	0.61	1.82	7.27
Parasitology	329	1.09	0.91	7.60	45.90
Marine & Freshwater Biol	292	0.74	1.03	5.14	30.82
Zoology	260	0.61	0.00	3.08	26.92
Biotechnol & Appl Microbiol	243	0.67	0.00	5.35	26.34
Agric Engineering	237	0.29	0.00	1.69	7.59
Ecology	236	1.07	1.69	7.63	50.00
Electrical & Electronic Eng	234	0.94	1.28	8.97	35.47
Genetics & Heredity	223	0.58	0.00	6.73	31.84
Multidisc Chem	218	0.41	0.00	1.38	25.69
Surgery	217	0.61	0.46	5.07	17.97
Physical Chem	211	0.62	0.00	3.79	28.44
Entomology	209	1.00	0.00	9.57	24.88
Multidisc Materials Science	205	0.61	0.00	5.85	37.56
Tropical Med	194	0.63	0.00	5.15	26.29
Statistics & Probability	187	0.83	0.00	10.16	39.04
Biology	184	0.45	0.54	1.63	15.22
Medicinal Chem	176	0.80	0.00	4.55	17.05

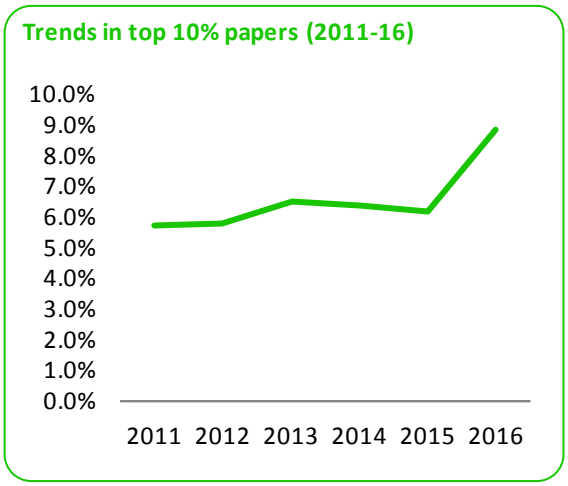
State Profile: Distrito Federal

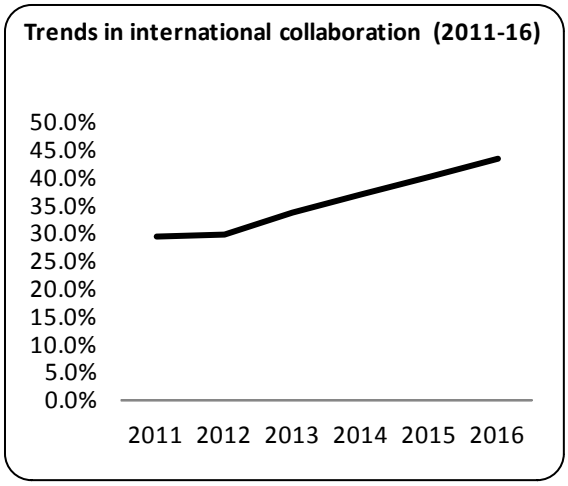
Distrito Federal is the twentieth most populous state in Brazil (3 million people) and the eighth richest (GDP $65 million and $74 per capita). It had the eighth largest research output between 2011 and 2016 (10,584 papers) and on average its papers receive 21% more citations than the Brazilian average for the field and year of publication.

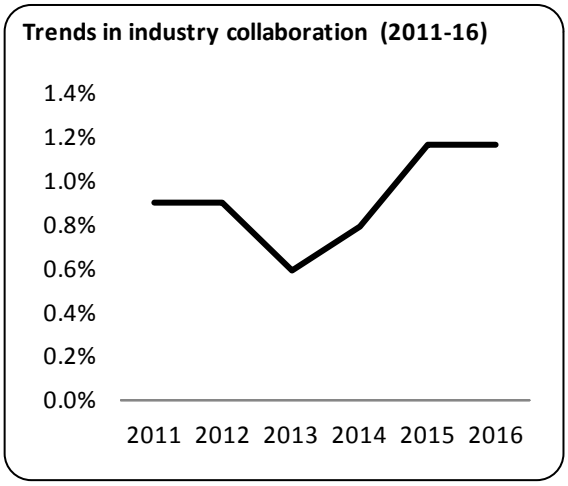






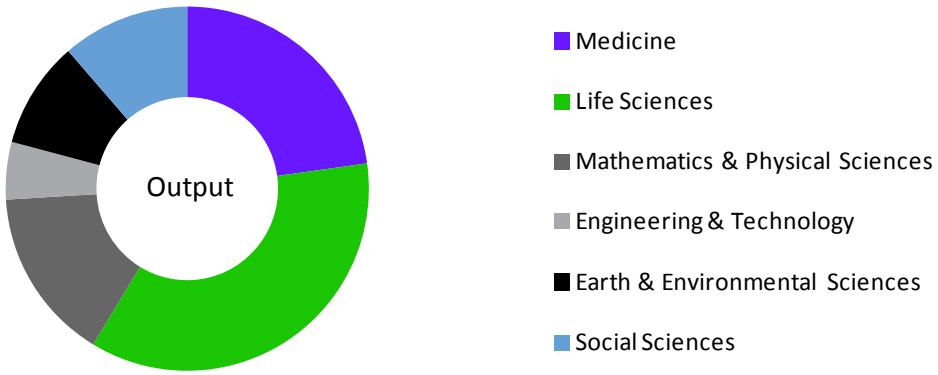






State Profile: Distrito Federal (continued…)

Research Output By Field (2011-16))

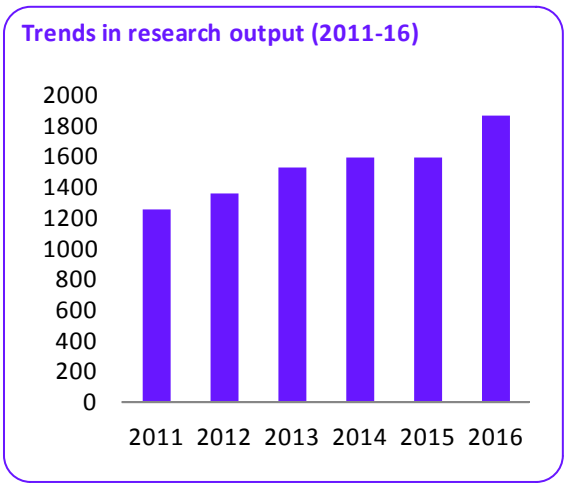


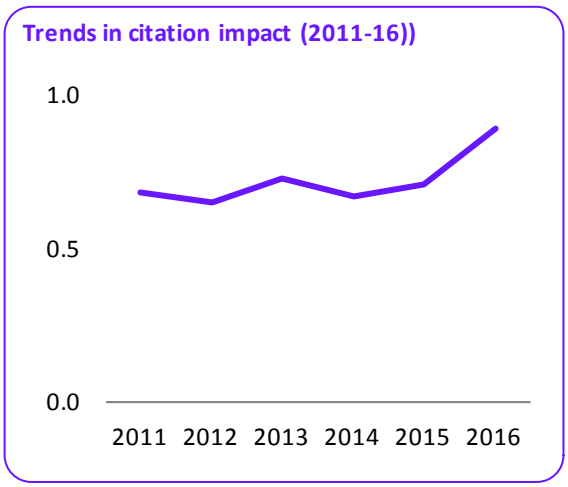
Leading research disciplines (2011-16))

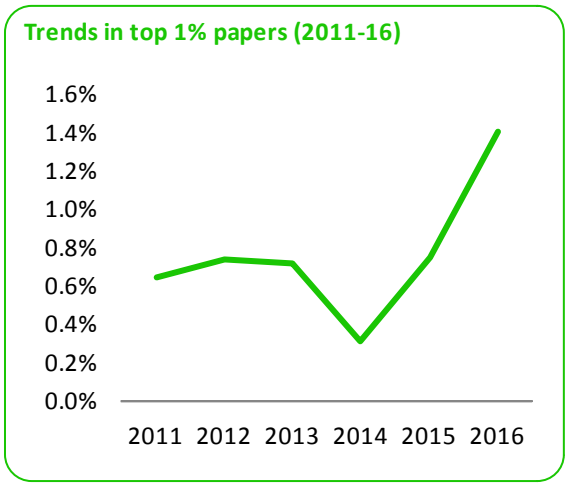
	Papers	Impact	Top 1%	Top 10%	International collaboration
Public Hlth	636	1.79	2.20	6.29	22.48
Plant Sci	552	0.81	0.91	6.70	36.78
Biochem & Molecular Biol	485	0.76	0.41	3.30	39.18
Multidisc Agric	392	1.28	5.10	7.14	12.50
Agronomy	345	0.60	0.58	5.80	22.03
Ecology	339	1.34	2.65	11.80	58.41
Genetics & Heredity	332	0.84	0.90	5.12	37.05
Zoology	328	0.81	1.22	8.23	35.67
Veterinary Sci	324	0.60	0.93	3.70	19.75
Environmental Sci	309	1.25	1.62	9.71	51.78
Biotechnol & Appl Microbiol	272	0.83	0.37	6.25	37.13
Mathematics	260	0.85	0.00	4.62	38.08
Multidisc Geosci	256	0.95	1.17	7.81	57.81
Forestry	234	0.53	0.43	5.13	17.09
Pharmacology & Pharmacy	233	0.86	0.43	6.87	45.92
Physical Chem	221	0.71	0.00	1.36	51.13
Parasitology	218	0.92	0.00	8.72	32.11
Multidisc Materials Science	211	0.76	0.00	5.21	53.08
Economics	211	0.69	0.00	6.16	39.81
Tropical Med	205	0.91	0.49	13.17	26.34
Sport Sci	202	0.64	0.00	4.46	51.98
Multidisc Chem	201	0.52	0.00	1.49	30.85
Electrical & Electronic Eng	199	0.60	0.00	5.03	37.69
Entomology	194	0.92	0.52	6.70	39.18
Biology	189	1.00	1.59	7.41	24.87

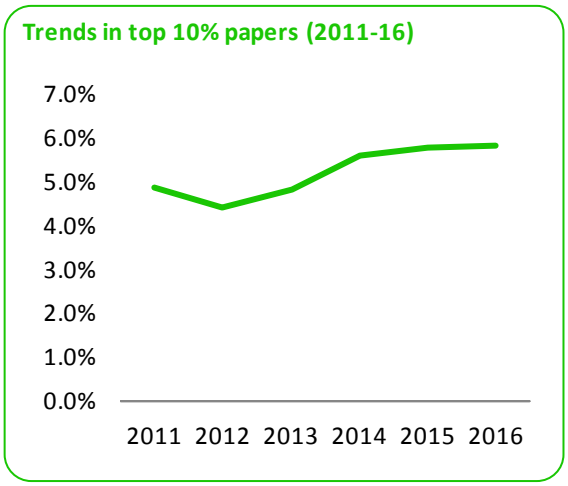
State Profile: Bahia

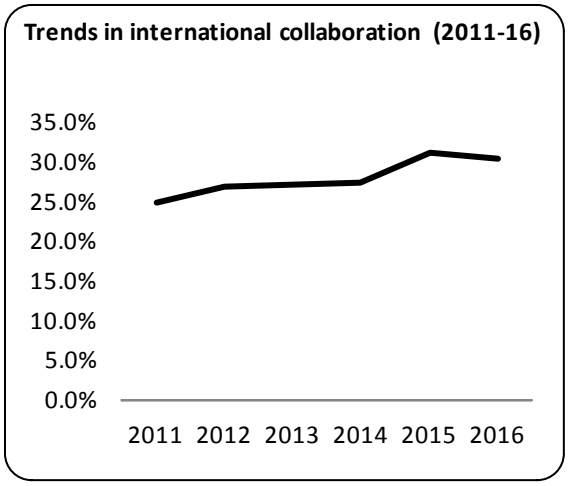
Bahia is the fourth most populous state in Brazil (15.3 million people) and the seventh richest (GDP $74 million and $16.1 per capita). It had the ninth largest research output between 2011 and 2016 (9,189 papers) and on average its papers receive 6% fewer citations than the Brazilian average for the field and year of publication.

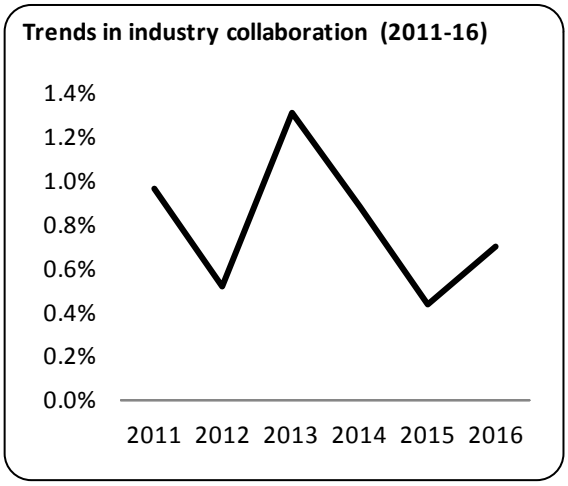






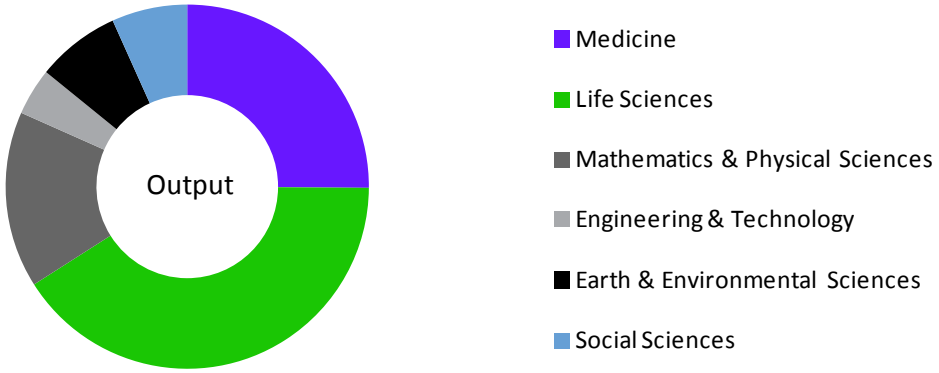






State Profile: Bahia (continued…)

Research Output By Field (2011-16))

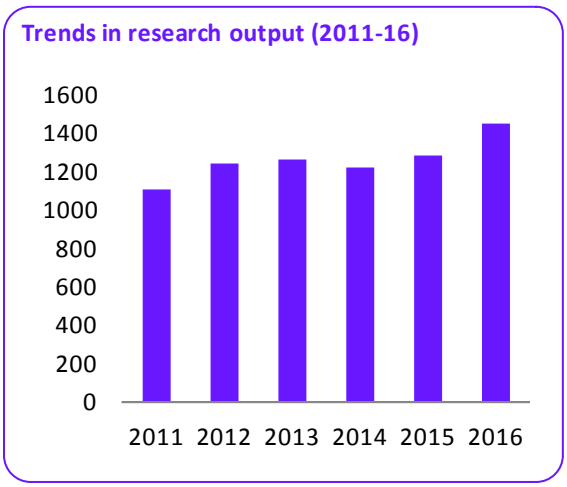


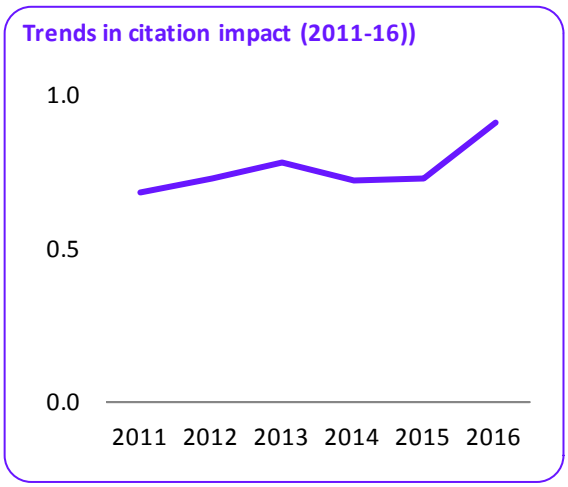
Leading research disciplines (2011-16))

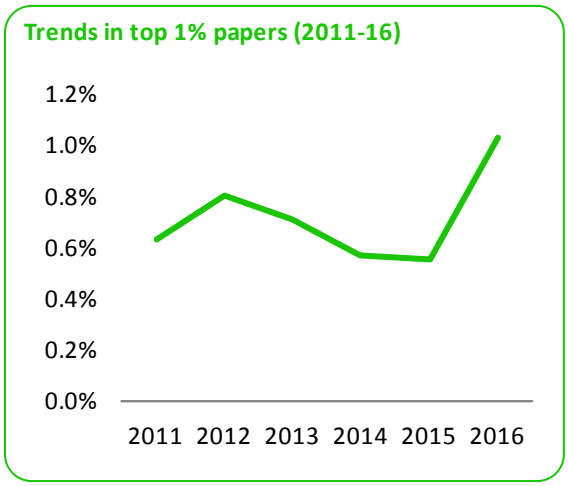
	Papers	Impact	Top 1%	Top 10%	International collaboration
Plant Sci	638	0.53	0.31	2.19	32.29
Public Hlth	482	0.90	2.07	6.64	27.18
Veterinary Sci	372	0.56	0.27	2.96	11.29
Multidisc Agric	365	0.35	0.27	0.82	4.93
Zoology	347	0.69	0.58	3.75	27.95
Agronomy	340	0.40	0.29	2.06	11.47
Biochem & Molecular Biol	327	0.55	0.31	2.14	22.32
Parasitology	291	1.04	1.03	4.47	41.24
Environmental Sci	280	0.82	1.07	5.36	37.14
Genetics & Heredity	279	0.54	0.36	3.94	29.75
Infectious Diseases	268	1.51	2.61	10.82	57.09
Immunology	237	1.16	1.69	7.59	47.68
Marine & Freshwater Biol	224	0.77	0.45	5.80	31.25
Dentistry	220	0.84	0.45	6.82	24.09
Pharmacology & Pharmacy	218	1.03	1.38	5.96	22.48
Entomology	215	0.53	0.00	1.40	19.53
Ecology	214	1.61	5.14	12.15	50.93
Tropical Med	209	1.18	1.91	11.48	47.85
Food Science & Technol	206	0.80	0.00	6.31	14.56
Agric (Dairy & Animal)	203	0.68	0.49	4.43	14.29
Multidisc Chem	202	0.28	0.00	0.00	11.88
Analytical Chem	192	0.88	0.00	4.17	17.19
Physical Chem	185	0.70	0.00	3.24	41.62
Horticulture	169	0.40	0.00	1.18	14.79
Agric Engineering	159	0.36	0.00	3.14	11.32

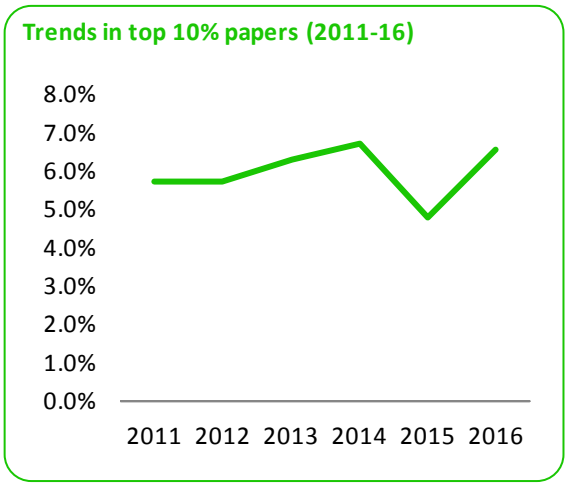
State Profile: Ceara

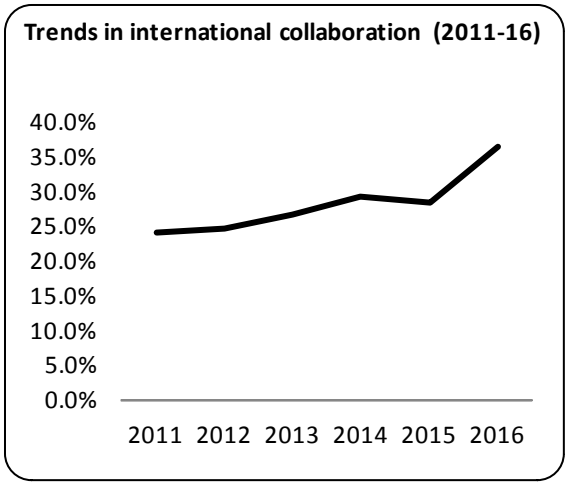
Ceara is the eighth most populous state in Brazil (9 million people) and the twelfth richest (GDP $40 million and $14.7 per capita). It had the tenth largest research output between 2011 and 2016 (7,559 papers) and on average its papers receive 3% fewer citations than the Brazilian average for the field and year of publication.

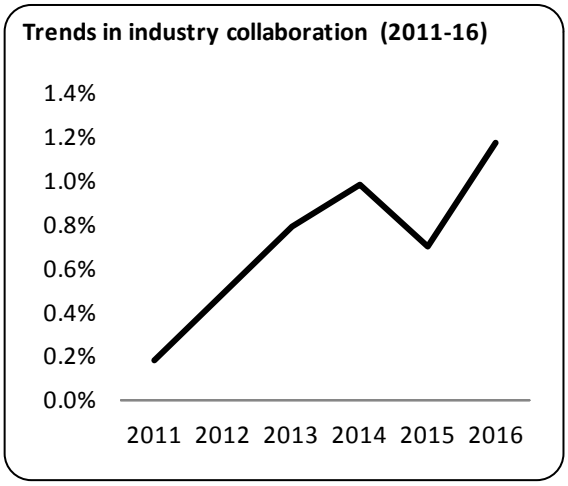




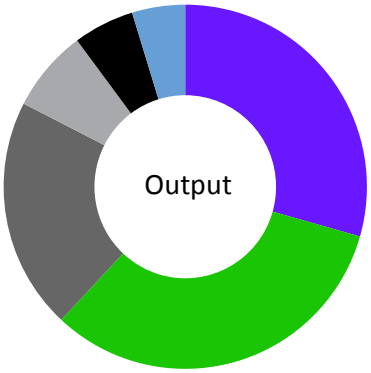








Research Output By Field (2011-16))



- Medicine
- Life Sciences
- Mathematics & Physical Sciences
- Engineering & Technology
- Earth & Environmental Sciences
- Social Sciences

Leading research disciplines (2011-16))

	Papers	Impact	Top 1%	Top 10%	International collaboration
Pharmacology & Pharmacy	427	0.83	0.00	4.68	21.31
Multidisc Agric	367	0.30	0.00	0.27	5.72
Biochem & Molecular Biol	308	0.63	0.00	3.25	30.84
Plant Sci	292	0.69	0.00	2.40	18.49
Public Hlth	291	1.46	2.75	5.84	27.49
Veterinary Sci	290	0.72	0.00	7.59	14.14
Food Science & Technol	249	1.07	2.81	12.05	26.91
Physical Chem	240	0.82	0.00	4.58	42.08
Agronomy	236	0.46	0.00	3.81	9.75
Nursing	232	0.40	0.00	1.29	6.90
Multidisc Chem	227	0.56	0.00	3.08	23.79
Electrical & Electronic Eng	226	0.96	0.88	7.52	36.73
Medicinal Chem	220	0.93	0.91	8.18	20.00
Agric (Dairy & Animal)	212	0.69	0.00	3.30	23.11
Multidisc Materials Science	209	0.67	0.48	3.83	46.41
Environmental Sci	197	0.75	0.00	4.06	35.03
Chemical Eng	190	0.79	0.00	6.32	34.74
Mathematics	186	1.00	1.08	11.29	32.80
Dentistry	170	1.06	2.94	9.41	23.53
Reproductive Biol	157	0.98	0.00	2.55	46.50
Agric Engineering	156	0.41	0.00	1.92	8.33
Appl Chem	154	1.29	3.25	11.69	31.17
Surgery	148	0.51	0.00	3.38	12.16
Zoology	147	0.57	0.00	4.08	23.13
Biotechnol & Appl Microbiol	144	0.88	0.69	8.33	31.25

Who we are

For over half a century Clarivate Analytics has pioneered the world of citation indexing and analysis, helping to connect scientific and scholarly thought around the world. Today, academic and research institutions, governments, not-for-profits, funding agencies, and all others with a stake in research, need reliable, objective methods for managing and measuring performance. Clarivate Analytics provides reporting and consultancy services using customized analyses to bring together several indicators of research performance in such a way as to enable customers to rapidly make sense of and interpret a wide-range of data points to facilitate research strategy decision-making.

Our consultants have up to 20 years of experience in research performance analysis and interpretation. We have extensive experience with databases on research inputs, activity and outputs and have developed innovative analytical approaches for benchmarking, interpreting and visualization of international, national and institutional research impact that provide comprehensive research analysis, evaluation and management. In addition, the Clarivate Analytics regional Sales team will provide effective project management and on-site support to maximize the value of our projects and meet the expectations of the CAPES.

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