Mapping Australia's research strengths from an international perspective

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Deliverable

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EXECUTIVE SUMMARY

This paper has been prepared as part of a set of inter-connected projects that aim to raise awareness amongst European-based researchers of the funding opportunities that support collaboration with colleagues in a range of non-European nations. The paper develops and tests a methodology for mapping a nation's research strengths from an international perspective based upon ratios of Relative Citation Impact (RCI). Thomson-Reuters *National Science Indicators* (NSI) data are used to map Australia's standing vis-à-vis EU Member States and other selected nations. These ratios are expressed in a matrix that indicates whether Australia has a higher, comparable, or lower RCI performance than a given nation for a specific research field. The results indicate that this method provides a feasible means of assessing relative research strengths in a clear and easily grasped manner.

1. Preamble

This paper is part of a set of inter-connected projects aimed to raise awareness amongst European-based researchers of the funding opportunities that support collaboration with colleagues in a range of non-European nations. Projects with this focus, funded by the European Commission, are now underway in Australia, Brazil, Canada, China, India, Mexico, New Zealand, Russia, South Africa, South Korea, and the USA. These projects target both research and innovation support programmes. They are known collectively as ACCESS4EU projects.[2]

These moves to develop a more coordinated relationship between the European Union and a range of non-EU countries may point the way towards more effective multilateral coordination over these matters in the future.

The Australian project is led by the *International Bureau of the German Federal Ministry of Education and Research* and also involves the *Forum for European-Australian Science and Technology cooperation* (FEAST), the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO) and *The British Council*.

The various national projects are cooperating over the development of a standard database architecture that aims to make it easier to understand and compare different nations' research funding arrangements. The projects are also collecting and disseminating data on:

- access opportunities for European researchers in each country;
- the distinctive research and innovation strengths and capacities of third countries;
- current levels of European participation in third country programmes;
- current third country policies on international collaboration as it may affect European participation; and

[2] Details of this new collective initiative, which is known as ACCESS4EU, can be obtained from: http://www.access4.eu/.

- any obstacles to the participation of European researchers in third country programmes.

2. Introduction

This discussion paper provides an overview of Australia's research performance, as tracked by Thomson-Reuters indexed publications, from a European Union perspective.

The aim is to provide EU-based researchers and policy-makers with a clear and easily grasped picture of competence gradients between individual EU Member States and Australia. As outlined in more detail below, this has the potential to assist decision-making about international collaboration at a number of levels – information about comparative research performance is not always presented in relevant ways or readily available. There are also opportunities to build upon the analysis presented below into the future to further improve this transparency.

3. Policy and Strategy Issues

This paper draws upon previous work on these issues in Matthews, Biglia and Murphy (2009). This earlier work presented a policy-oriented framework for mapping international differences in research performance together with details of relative citation performance (in an extensive Technical Annex) between Australia and individual EU Member States.

The policy-oriented framework is based upon a payoff matrix (see Figure 1).

Figure 1: Bilateral cooperation pay-off matrix

	Country Y **Capability Index > 1.0**	**Country Y** **Capability Index < 1.0**
Country X **Capability Index > 1.0**	X: Forge-ahead opportunity Y: Forge-ahead opportunity	X: Pull-down risk Y: Pull-up opportunity
Country X **Capability Index < 1.0**	X: Pull-up opportunity Y: Pull-down risk	X: Catch-up opportunity Y: Catch-up opportunity

Source: Matthews, Biglia and Murphy (2009)

This framework distinguishes between four types of bilateral research and innovation cooperation scenario:

- *forge-ahead opportunities* – a situation in which both parties are currently strong performers (RCIs above 1.0);
- *pull-up opportunity and pull-down risk* – two situations in which one party is a strong performer and one party is a weak performer; and
- *catch-up opportunities* – a situation in which both parties are weak performers.

It is important to stress that there is a strong rationale for collaboration in each of these four quadrants. International research and innovation cooperation of course takes place at a number of levels simultaneously – individual researchers, collaborative teams, institution-to-institution and government-to-government. Bilateral and multilateral modalities are also employed across these levels. The framework above is oriented towards the bilateral element of international collaboration strategies, but can easily be extended to inform broader strategic decision-making.

As highlighted in a previous report on reciprocity in international research and innovation collaboration (Matthews and Harris 2010), these strategic decisions about international collaboration – particularly at the national policy level – take place within a complex framework of overlapping national and international policy objectives. Particular decisions about bilateral research and innovation collaboration will therefore be linked to considerations of foreign policy, trade, industry competitiveness and international cooperation on key global issues. Improving transparency about comparative research performance and providing an initial framework for improving strategic decision-making about research collaboration should also assist those making such decisions to explicitly link them to this broader framework.

When *forge-ahead* opportunities exist both parties stand to gain by exploiting economies of scale and scope in these research fields together with other synergies between distinctive capabilities (such as research infrastructure assets). In such circumstances the potential benefits will tend to be fairly symmetrical, and as a result relatively unproblematic compared to the other scenarios.

When a mix of *pull-up opportunities and pull-down risks* exist the situation is more asymmetric and potentially problematic. One party may stand to gain more than the other party. In this case it is important to be clear as to why the cooperation is prioritised, particularly in relation to other 'collateral benefits' in the diplomatic and trade domains.

When *catch-up opportunities* are present both parties stand to gain from cooperation for similar reasons as in the *forge-ahead* case. In such situations there can be much to be gained from pooling resources, capabilities and research infrastructures – generating greater scale and scope in the research effort to mutual advantage.

By intent, this framework greatly simplifies international collaboration rationales. Precisely because international research and innovation collaboration is a complex and multi-faceted issue, it is useful to provide a relatively simple framework that can then be built upon by adding additional levels of complexity.[3]

One way of implementing the framework is to consider the Relative Citation Impact (RCI) metric. RCI refers to the ratio of average citations per paper for a county in a given research field (or thematic area) divided by the average citations per paper in

[3] There are a range of implicit assumptions sitting behind this sort of conceptualisation. One such assumption is that researchers view potential collaborative relationships in a similar manner to the policy community. In reality, the way in which inter-personal relationships stimulate and mediate collaboration matters greatly. In particular, the 'relational capital' built-up over time is a key risk-reduction mechanism and will, therefore, naturally tend to drive international collaboration patterns. Given the risks faced, this aspect of the collaboration landscape will be as important, if not more important, than imbalances and convergences in demonstrated science and innovation capability. This dimension can be added to the current framework in future work.

that research field or thematic area globally. A RCI ratio greater than 1.0 indicates higher than world average performance. An RCI ratio below 1.0 indicates lower than world average performance.

When operationalising this framework it is useful to make borderline revealed capabilities explicit by introducing a grey area between the different capability areas – resulting in a 3x3 rather than a 2x2 matrix.

The following table (Figure 2) summarises the results obtained using Thomson-Reuters National Science Indicators data at a high level of aggregation. The table profiles the overall bilateral state-of-play for Australia vis-à-vis the EU-27 in aggregate.

As subsequent results show, there is great variation within the EU-27 and consequently this aggregate EU-27 based view can be misleading. It is therefore important to recognise that specific and distinct bilateral cooperation pay-offs exist between Australia and different EU Member States. There are clearly also differences in scale and research intensity between the research efforts of Australia and the EU in aggregate, as there are between Australia and individual Member States (Section 5 below provides more detail to begin to address these issues).

Figure 2: S&I Cooperation pay-off matrix at the 24 research field level

	EU-27 Strengths **Relative Citation Impact > 1.1**	**EU-27 Borderline** **Relative Citation Impact 0.9-1.10**	EU-27 Weaknesses Relative Citation Impact < 0.9
Australian Strengths **Relative Citation Impact > 1.1**	Geosciences Physics Plant & Animal Science	Clinical Medicine Ecology/Environment Education Mathematics Space Science	
Australian Borderline **Relative Citation Impact 0.9-1.1**	Agricultural Sciences	Biology & Biochemistry Chemistry Computer Science Engineering Immunology Materials Science Microbiology Molecular Biology & Genetics Multidisciplinary Science Neurosciences & Behaviour Pharmacology Psychology/Psychiatry Social Sciences, general	
Australian Weaknesses **Relative Citation Impact < 0.9**			Economics & Business Law

Source: Matthews, Biglia and Murphy (2009)

The picture that emerges for the Australia-EU-27 relationship is that most research fields lie in the borderline areas with an RCI of between 0.9 and 1.1, but with a significant number of fields in which Australia has clear strengths and the EU-27 exhibit borderline performance.

There are three fields: geosciences, physics and plant & animal sciences in the *forge-ahead* quadrant where there are mutual advantages to cooperation based upon further exploiting existing clear strengths.

There are two research fields (economics & business, and law) in which both the EU-27 and Australia exhibit clear weaknesses.

4. Methodology and Data Sources

The analysis reported here used the same data source as Matthews, Biglia and Murphy (2009): Thomson-Reuters National Science Indicators (NSI). This dataset provides a convenient nation-by-nation summary of key publication and citation performance statistics.

We set out to develop a methodology that would provide a clear and succinct picture of how well-positioned a particular non-EU nation (in this case Australia) is as a potential research partner or location for spending time as an EU researcher *from an EU perspective*. Citation behaviour is a widely used indicator of relative research performance. Hence this measure was adopted as the most convenient means of assessing Australia's performance relative to those EU nations for which NSI data are available.

We sought to generate a table that would express relative citation performance against Australia by nation and research field, thus creating a relative performance matrix.

The approach adopted was as follows.

1. Extract NSI data on citation performance by nation and research field;
2. Calculate *Relative Citation Impact* (RCI) for each nation and research field;
3. Construct a set of tables that express the RCI gradient between any two nations for a particular research field as the ratio of respective RCIs;
4. Extract specific RCI ratios linking each nation and Australia for each research field;
5. Calibrate the results using a 'traffic light' colour coding system as defined in the following table.

Table 1: Colour Code of RCI's

Ratio of RCIs	Status	Colour code
Greater than 1.1	Australia's RCI stronger than the comparator nation	Green
Between 0.9 and 1.1	Difference in RCI ratios too close to infer a significant difference	Amber
Less than 0.9	Australia's RCI weaker than the comparator nation	Red

Certain other non-EU countries were retained in the dataset to help calibrate the results (Canada, China, New Zealand, South Africa, and the USA).

5. Findings

Table 2 contain the results of these calculations. Each row tells us the ratio of RCIs between the respective country and Australia by research field with Australia's RCI performance as the numerator.

In overall terms (and as would be expected) Australia only exhibits relatively strong RCI performance in this set of bilateral comparisons with EU Member States when these Member States are of low R&D intensity.

So for instance, there are three 'amber', 19 green and only one 'red' research field in the Portugal-Australia bilateral comparison. In contrast, there are 11 'amber', three 'green' but ten 'red' research fields in the Germany-Australia bilateral comparison. In the three green fields (education, law, and social sciences) the results are strongly (English) language dependent rather than necessarily reflecting underlying competencies. This language specificity is a well-known and inevitable problem with using Thomson-Reuters (and similar) publications datasets.

Figure 3 contains a graph of the number of research fields for which Australia has a higher RCI than each nation listed. Whilst there are no research fields in which Australia has an RCI greater than that of the US, most EU Member States do stand to gain from 'pull-up' based collaboration with Australia.

Figure 4 provides an alternative view: the number of research fields in which Australia exhibits stronger RCI performance in bilateral comparisons.

Table 2: International citation performance gradients against Australia by nation and research field

	Agricultural Sciences	Biology & Biochemistry	Chemistry	Clinical Medicine	Computer Science	Ecology/ Environment	Economics & Business	Education	Engineering	Geosciences	Immunology	Law
AUSTRIA	0.96	0.97	0.95	1.00	0.88	1.05	1.05	1.30	1.00	1.05	1.00	2.92
BELGIUM	0.73	0.92	0.93	0.79	0.87	0.89	0.83	0.84	0.83	0.93	1.13	1.25
BULGARIA	1.23	2.88	1.64	1.50	1.63	1.81	4.32	n/a	1.24	1.73	2.16	n/a
CANADA	0.86	0.98	0.93	0.87	0.86	0.99	0.81	1.07	0.97	1.14	1.01	0.87
CHINA	1.29	1.94	1.45	1.49	1.14	1.78	0.98	1.78	1.23	1.53	2.48	3.17
CYPRUS	1.37	2.15	1.45	1.81	0.87	2.09	1.12	1.41	0.98	3.11	1.90	n/a
CZECH REPUBLIC	1.40	1.85	1.33	1.08	1.20	1.27	2.73	6.75	1.00	1.55	1.55	2.78
DENMARK	0.66	0.88	0.72	0.79	0.83	0.86	0.76	2.11	0.69	0.88	1.23	n/a
ESTONIA	1.37	1.47	1.26	1.11	1.45	1.04	1.76	3.55	1.48	1.45	1.95	n/a
EU-27	0.90	1.03	0.99	1.14	1.01	1.09	0.91	1.11	1.03	1.11	1.12	1.31
FINLAND	0.69	0.96	1.07	0.85	1.06	0.89	1.06	0.88	0.85	0.89	1.12	0.76
FRANCE	0.83	1.05	1.00	1.08	1.01	1.01	0.94	1.57	0.98	1.01	0.97	1.42
GERMANY	0.95	0.90	0.88	1.07	0.90	1.00	1.01	1.19	0.89	0.87	0.99	1.71
GREECE	0.86	1.50	1.19	1.45	1.12	1.48	1.37	1.34	1.15	1.43	1.72	1.03
HUNGARY	2.38	1.27	1.29	1.09	1.04	1.44	1.08	1.52	0.89	1.33	1.59	n/a
INDIA	2.27	2.19	1.57	2.55	1.45	2.25	1.46	2.18	1.50	2.40	2.98	1.26
IRELAND	0.89	0.96	0.92	1.05	1.11	1.49	1.31	1.69	1.19	1.14	0.84	2.47
ITALY	0.85	1.15	1.01	1.00	0.95	1.27	1.03	2.55	1.04	1.20	1.12	1.35
LATVIA	2.13	1.65	2.21	0.77	0.83	1.36	0.70	2.70	1.34	0.64	1.72	1.66
LITHUANIA	1.50	1.96	1.87	1.54	1.27	3.07	1.37	n/a	1.37	1.83	3.04	n/a
LUXEMBOURG	1.21	1.21	2.06	1.09	1.53	0.99	1.39	2.70	1.16	2.45	0.94	3.36
MALTA	n/a	1.97	6.13	1.33	n/a	1.20	1.64	5.40	2.88	1.28	1.07	n/a
NETHERLANDS	0.69	0.92	0.68	0.82	0.82	0.85	0.74	0.75	0.81	0.94	1.32	1.91
NEW ZEALAND	0.95	1.17	1.09	1.04	0.91	0.90	1.05	1.50	1.09	1.08	1.75	2.09
POLAND	1.27	1.91	1.58	1.12	0.96	2.04	1.27	3.55	1.18	1.97	1.17	1.66
PORTUGAL	0.98	1.53	1.29	1.02	1.06	1.27	1.17	1.59	1.16	1.53	0.32	3.36
ROMANIA	1.40	1.45	2.81	1.18	1.13	1.38	1.43	0.68	1.26	1.80	2.12	n/a
SLOVAKIA	1.31	2.76	1.65	1.10	1.36	2.34	3.01	1.78	1.17	1.75	2.72	n/a
SLOVENIA	0.89	1.88	1.34	1.62	1.46	1.65	1.52	n/a	1.19	1.57	n/a	n/a
SOUTH AFRICA	1.13	1.51	1.43	1.11	1.37	1.11	2.00	2.60	1.47	1.52	1.04	15.86
SPAIN	0.93	1.27	1.00	1.06	1.29	1.20	1.15	1.75	1.00	1.41	1.33	1.73
SWEDEN	0.66	0.91	0.85	0.89	0.87	0.82	0.77	1.30	0.85	1.00	1.26	1.22
UK	0.66	0.82	0.85	0.94	0.96	0.86	0.76	1.08	1.03	0.92	0.95	1.13
USA	0.79	0.78	0.69	0.86	0.69	0.94	0.60	1.01	0.83	0.66	0.84	0.47

Source: THOMSON REUTERS® National Science Indicators®

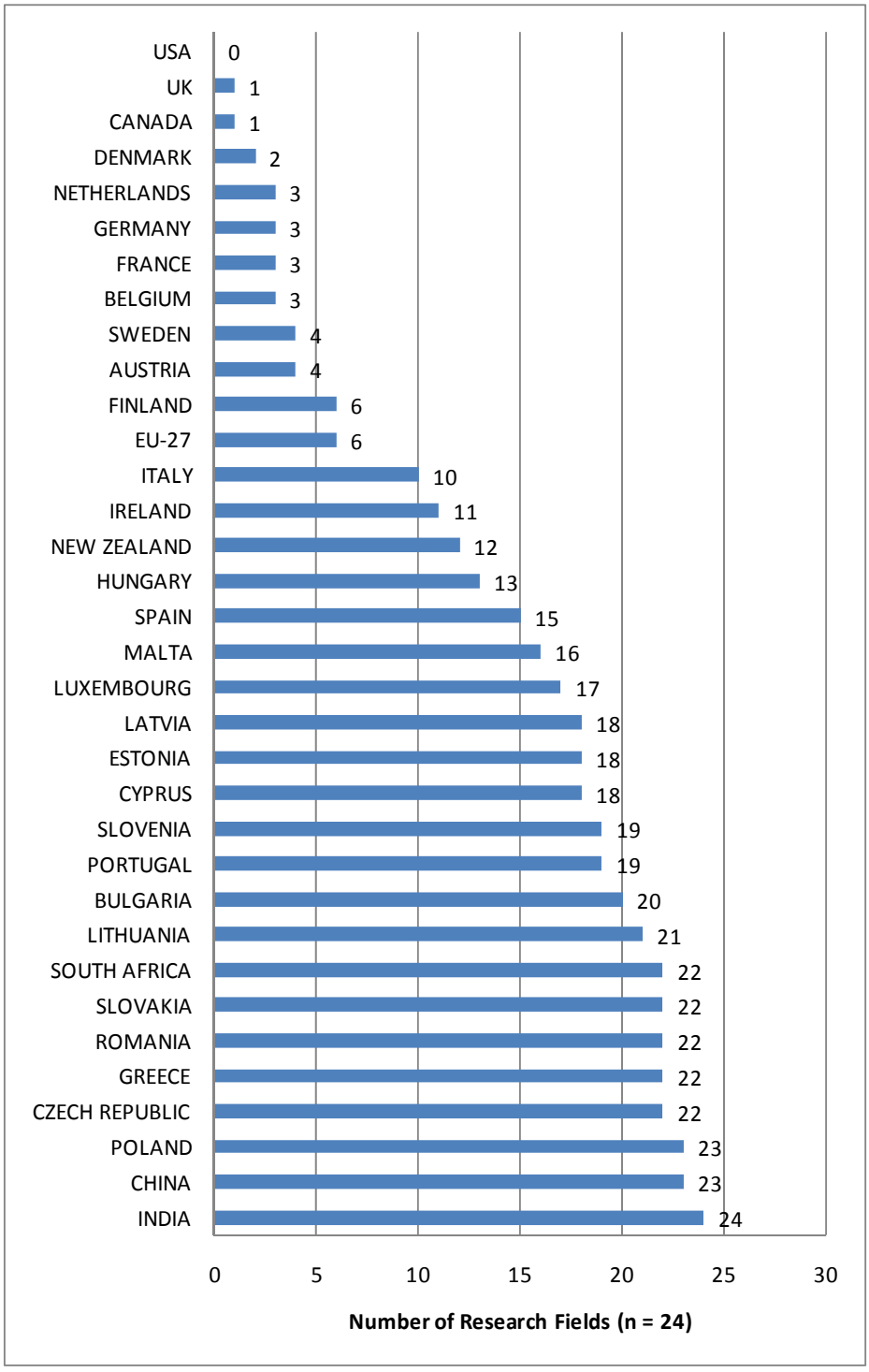
Note: This table was calculated from data that appeared in an earlier discussion paper by FEAST (Matthews, Biglia and Murphy 2009)

Table 2: International citation performance gradients against Australia by nation and research field (continued)

	Material Science	Mathematics	Micobiology	Molecular Biology & Genetics	Multidisciplinary	Neurosciences & Behaviour	Pharmacology	Physics	Plant & Animal Science	Psychology/ Psychiatry	Social Science, general	Space Science
AUSTRIA	0.83	0.93	1.00	0.78	1.13	0.87	0.93	0.74	0.96	0.92	0.95	1.79
BELGIUM	0.86	0.94	0.93	0.92	0.81	0.88	0.87	1.08	0.95	0.87	0.92	1.29
BULGARIA	1.66	1.34	1.99	1.41	3.36	1.42	1.89	1.56	1.88	0.90	1.06	2.51
CANADA	1.01	1.04	0.99	0.93	0.82	0.85	0.94	0.93	1.00	0.88	1.00	0.76
CHINA	1.19	1.28	1.81	2.11	1.63	1.59	1.89	1.68	1.47	1.38	1.26	2.23
CYPRUS	1.91	1.29	0.93	2.32	0.78	1.10	1.71	1.36	1.21	1.80	2.00	0.62
CZECH REPUBLIC	1.38	1.12	1.88	1.61	1.15	1.53	1.18	1.33	1.30	2.19	2.50	1.69
DENMARK	0.65	0.85	0.83	0.80	0.60	0.93	0.91	0.75	0.82	0.76	0.85	0.81
ESTONIA	0.80	2.27	1.49	0.83	1.28	1.93	0.97	1.38	1.04	1.37	1.48	3.42
EU-27	0.98	1.08	1.05	0.94	0.93	0.91	0.95	1.06	1.00	0.96	1.05	1.13
FINLAND	1.16	1.11	1.14	0.96	1.24	1.01	0.96	0.87	0.97	0.91	0.86	1.62
FRANCE	0.91	0.99	0.97	0.93	0.91	0.95	0.98	1.03	0.80	0.99	1.24	1.04
GERMANY	0.88	1.04	0.92	0.85	0.77	0.84	0.87	0.89	0.83	0.99	1.26	0.90
GREECE	1.24	1.30	1.49	1.30	2.14	1.46	1.36	1.14	1.52	1.76	1.47	2.14
HUNGARY	1.14	1.37	1.49	1.15	1.07	1.00	0.90	1.07	1.43	0.75	1.32	0.83
INDIA	1.38	1.84	2.07	2.29	3.02	1.81	1.76	1.55	2.01	1.47	1.90	2.12
IRELAND	0.86	1.51	1.01	0.99	0.85	0.91	1.08	1.00	1.16	0.99	1.24	1.30
ITALY	0.96	1.06	1.24	1.13	1.15	0.95	1.01	1.02	1.29	0.81	1.00	1.09
LATVIA	1.39	1.69	1.40	1.85	3.81	1.71	2.07	1.61	0.89	0.84	2.68	8.14
LITHUANIA	2.04	1.07	1.83	2.51	3.53	1.65	1.44	1.76	2.09	1.23	2.59	2.54
LUXEMBOURG	1.83	1.11	1.20	0.97	1.80	1.18	0.90	1.78	0.80	1.66	1.98	n/a
MALTA	2.13	0.89	2.06	6.11	5.72	1.25	33.18	2.01	0.82	0.77	2.12	n/a
NETHERLANDS	0.72	1.13	0.83	0.81	0.75	0.91	0.88	0.74	0.78	0.83	0.88	0.89
NEW ZEALAND	1.32	1.37	1.30	1.23	1.40	0.86	1.00	1.24	1.12	1.03	1.05	1.21
POLAND	1.82	1.46	2.25	1.70	1.44	1.42	1.44	1.36	2.39	1.12	1.90	1.12
PORTUGAL	1.13	1.47	1.59	1.18	1.38	1.12	1.11	1.16	1.28	1.63	1.33	0.80
ROMANIA	1.50	1.71	1.81	1.55	2.64	2.18	2.14	1.94	1.79	2.42	1.38	2.05
SLOVAKIA	1.83	1.35	1.00	1.62	4.10	1.82	1.30	1.57	1.60	2.99	2.53	4.91
SLOVENIA	1.36	1.09	1.86	1.82	1.58	1.67	1.57	1.10	1.69	1.54	2.65	1.85
SOUTH AFRICA	1.74	1.19	1.32	1.71	1.81	1.16	1.36	1.78	1.46	1.51	1.06	1.40
SPAIN	0.97	n/a	1.28	1.20	0.96	1.01	1.20	0.98	1.13	1.24	1.17	1.14
SWEDEN	1.03	0.90	0.95	0.84	0.65	0.88	0.80	0.92	0.81	1.11	0.83	0.90
UK	0.86	0.98	0.85	0.75	0.82	0.75	0.76	0.88	0.74	0.83	0.94	0.95
USA	0.70	0.90	0.77	0.74	0.62	0.71	0.78	0.79	0.91	0.80	0.88	0.91

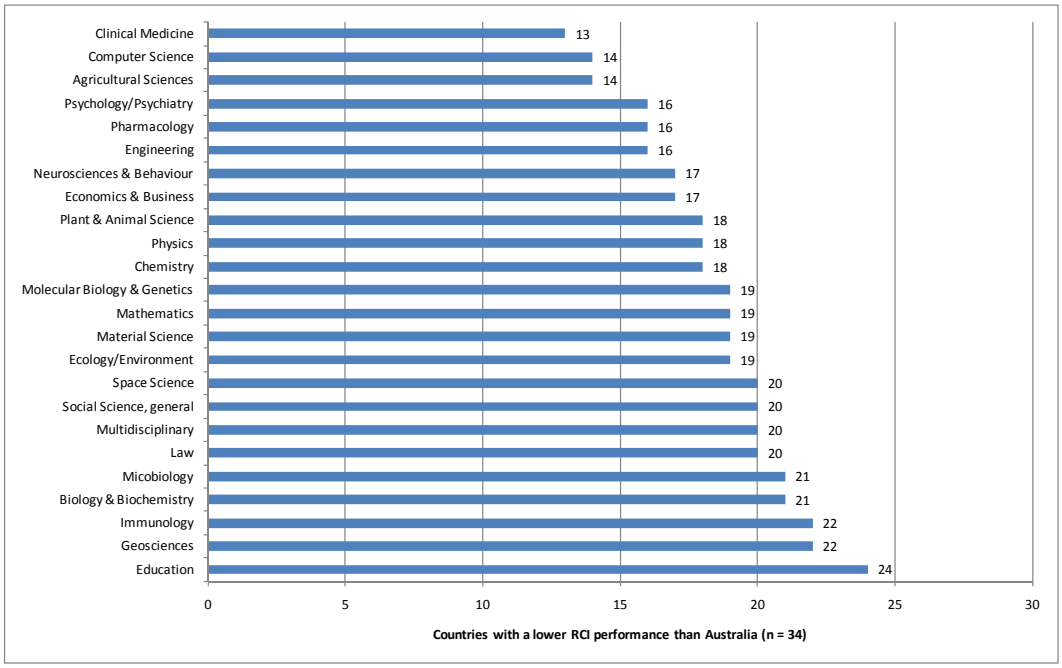
Source: THOMSON REUTERS® National Science Indicators®

Figure 3: Number of research fields in which Australia has a higher RCI



Source: THOMSON REUTERS® National Science Indicators®

Figure 4: Research fields for which Australia exhibits stronger RCI performance in bilateral comparisons



Source: THOMSON REUTERS® National Science Indicators®

6. Conclusions

The methodology and data presented in this paper provide a clear and succinct mechanism for EU countries to identify research fields in which a particular non-EU nation, in this case Australia, is stronger (or weaker) than a specific EU country. This is intended to inform strategic decision-making at a number of levels, with clear immediate relevance to policy-makers considering bilateral research and innovation collaboration.

The approach also highlights the broader and more complex matrix of national and international policy objectives within which such decisions are made. The framework and data provided here provides a platform for further work on international research capability gradients aimed at improving transparency and decision-making.

Comparative metrics of the performance of national innovation systems offer another possible avenue for compiling and presenting data in an accessible way to inform strategic decisions about international collaboration – these could be compiled by ACCESS4EU projects using a *pull-up/pull-down* matrix to build upon the methodology provided here for comparing research publications data. This could also be linked to measures of openness as outlined in Matthews and Harris (2010).

Finally, in addition to this work at the level of national systems and policy, further work could also be conducted in a coordinated way to benchmark the performance of comparable and significant institutions within selected countries. For example,

CSIRO is undertaking work to benchmark itself more rigorously against comparable multi-disciplinary applied research organisations, including leading European agencies – at the institutional level, this allows for the inclusion of a range of metrics including, but not limited to, publications data, capturing the range of ways in which research and innovation lead to social, economic and environmental impact.

7. References

Matthews, M., Biglia, B., and Murphy, B. (2009). *A Comparison of Australian and European Union research performance profiles*. FEAST Discussion Paper 2/09. Forum for European-Australian Science and Technology cooperation [FP7-222747]: Canberra.

Matthews, M. and Harris, P. (2010). *Enhancing reciprocity in international cooperation in research: issues and metrics.* AUS-ACCESS4EU Project [FP7-244485]. Discussion Paper: Canberra.