

Dimensions Report

Dimensions - A Collaborative Approach to Enhancing Research Discovery

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About Dimensions

Dimensions is a modern, innovative, linked research knowledge system that re-imagines discovery and access to research. Developed by Digital Science in collaboration with over 100 leading research organizations around the world, Dimensions brings together grants, publications, citations, alternative metrics, clinical trials and patents to deliver a platform that enables users to find and access the most relevant information faster, analyze the academic and broader outcomes of research, and gather insights to inform future strategy.

Data and expertise that span the research lifecycle were contributed by the teams at Digital Science portfolio companies ReadCube, Altmetric, Figshare, Symplectic, Digital Science Consultancy and ÜberResearch, who came together to realize their unique strengths and share their passion for building tools that benefit the research community. Visit www.dimensions.ai

About Digital Science

Digital Science is a technology company serving the needs of scientific and research communities at key points along the full cycle of research. We invest in, nurture and support innovative businesses and technologies that make all parts of the research process more open, efficient and effective. We believe that together, we can change research for good. Visit www.digital-science.com

About Digital Science Consultancy

Our consultancy team delivers custom reporting and analysis to help you make better decisions faster. With in-depth knowledge of the historical and current research ecosystem, our unique perspective helps get the most value from data on the research lifecycle. Our team of data scientists are experts in using innovative analytical techniques to develop revealing visualisations and powerful insights. We understand the changing research landscape, and we can help you develop an evidence base on which to build the best research management and policy decisions.

About the authors


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Simon Porter is VP of Research Relations and Knowledge Architecture at Digital Science. He spent 15 years at the University of Melbourne in roles spanning the Library, Research Administration, and Information Technology. Simon has forged a career transforming university practices in how data about research is used, both from administrative and eResearch perspectives. In addition to key contributions to research information, visualization and discovery, Simon advocates for research profiling systems and their ability to create new opportunities. Simon established and ran the annual Australasian conference on research profiling, and was the program chair of the 2012 VIVO conference.  <https://orcid.org/0000-0002-6151-8423>

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Creating a Global Context for Better Research Insight

Dimensions is an innovative, linked research data platform, re-imagining discovery and access to research: grant awards, journal and book publications, social media mentions, academic citations, clinical trials and commercial patents all in one place. Dimensions has been developed through a dynamic collaboration across Digital Science and six of its portfolio businesses (ReadCube, Altmetric, Figshare, Symplectic, DS Consultancy and ÜberResearch). With each company focused on different points within the research cycle and each serving diverse stakeholders in the research ecosystem, these teams shared their vision for innovation, and contributed unique experiences, opinions, and values to create the new Dimensions system.

The research ecosystem is the driver not only of innovative knowledge and discovery but of economic competitiveness. Over 25 years there has been an evolution in our understanding of what data about research activity can tell us and how the data can best be used. In the 1990s, the focus was on discovery, citations and historical evaluation. Today, that focus has shifted to research management, then to research impact and now to researchers themselves understanding and using the full range of information on their own and their peers' activities.

Dimensions was created in response to two significant constraints for Digital Science and our development partners. The first constraint was that existing solutions looked at the research landscape solely through that historical publication and citation lens. The second constraint was the way in which existing solutions exposed their data assets: publication records were locked away in proprietary applications with constraints over their use, either because of restrictive terms and conditions or a lack of contemporary APIs. Where less proprietary data existed, significant data holes compromised value for most core use cases.

To address these constraints, and to try to stimulate innovation to support research management, Digital Science worked with more than 100 research organizations and funders to realise a data structure that covered the entire research process: from funding; through publishing of results via attention, both scholarly and beyond; to commercial application and policy making. And we wanted a platform that did this in a way that integrated these diverse data sources and provided consistent links in multiple dimensions.

This document presents six use cases drawn from the work of Digital Science Consultancy, for clients and for public reports. They cover diverse subject areas and global regions, and contrasting use requirements. They all show the value of linking multiple data types, within a common data environment, drawing on a shared suite of subject categories and institutional identifiers to enable well-curated audits of a research portfolio that produce informative analytical outcomes.

Quick Facts	
Number of publication records	89,428,659
Number of funded grants	3,695,703
Number of clinical trials	380,440
Number of patents	34,599,378
Total number of documents in Dimensions	128,104,180
... and what matters most: links between records	appr. 4 billion



Publications and Clinical Trials from Project Funders

Research flow tracked from 12,000 grants through publications and citations to clinical trials

Parkinson's Disease is a degenerative disorder affecting the central nervous system. Like many other conditions, combating the disease relies on contributions from many disciplines, and basic research through to clinical application. Because the Dimensions platform provides a standardised categorical scheme across all research artefacts, it is possible quickly to partition the research. And, because Dimensions indexes grants, publications, and clinical trials across the research cycle, traceable links between inputs and outputs can show funders' research impact.

Most of the 87,310 publications on Parkinson's Disease indexed by Dimensions are primarily classified in the Field of Research (FoR) 1109 - Neuroscience. Secondary classifications divide this into two broad areas: FoR 06 - Biological Sciences, and FoR 11 - Health and Medical Sciences. These groups demonstrate

how different issues associated with Parkinson's Disease are tackled: the brain in 1109 - Neurosciences, 0601 - Biochemistry and Cell Biology, and 0606 - Genetics; the treatments in 1103 - Clinical Sciences; and the patients and carers in 1117 - Public Health and Health Services.

For Parkinson's Disease, Dimensions indexed 12,210 research grants from 1971 to 2018, coming from 175 funders in 33 countries. Figure 1 is an 'alluvial' diagram that shows the flow of grants from the top eight funders (left) to the grant duration (middle) and then through to 14,308 resulting publications (right) distributed by citation count (0 to 3,169 times). Some of the publications are also referenced in 6,181 clinical trials (shown in black).

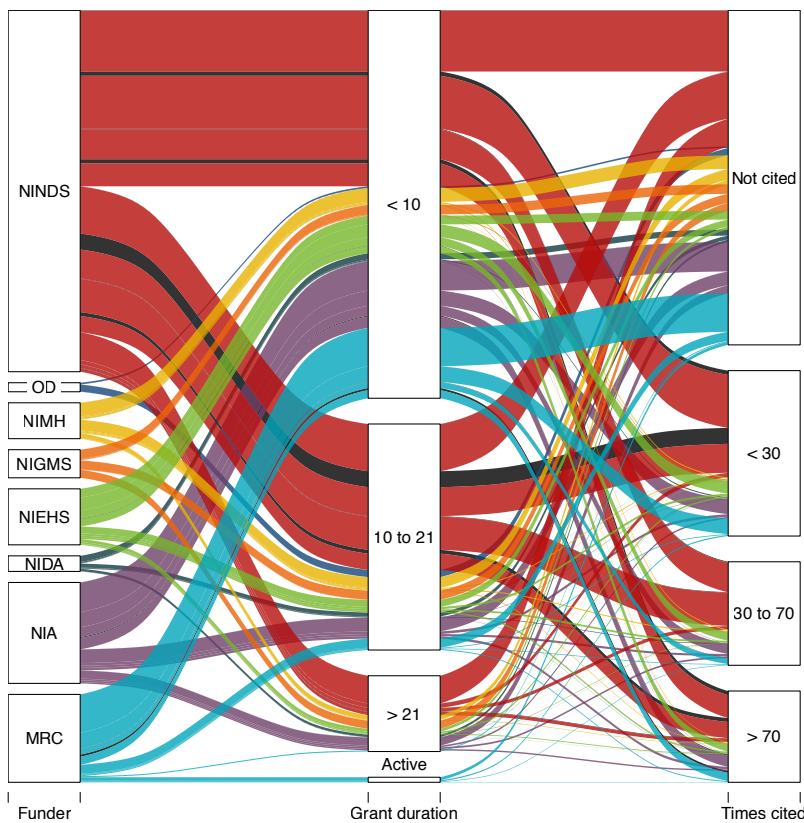


Figure 1 - Funders and their investment in Parkinson's Disease research. MRC: Medical Research Council (UK), NIA: National Institute on Aging (US), NIDA: National Institute on Drug Abuse (US), NIEHS: National Institute of Environmental Health Sciences (US), NIGMS: National Institute of General Medical Sciences (US), NIMH: National Institute of Mental Health (US), NINDS: National Institute of Neurological Disorders and Stroke (US), OD: NIH Office of the Director (US).

This alluvial diagram shows that:

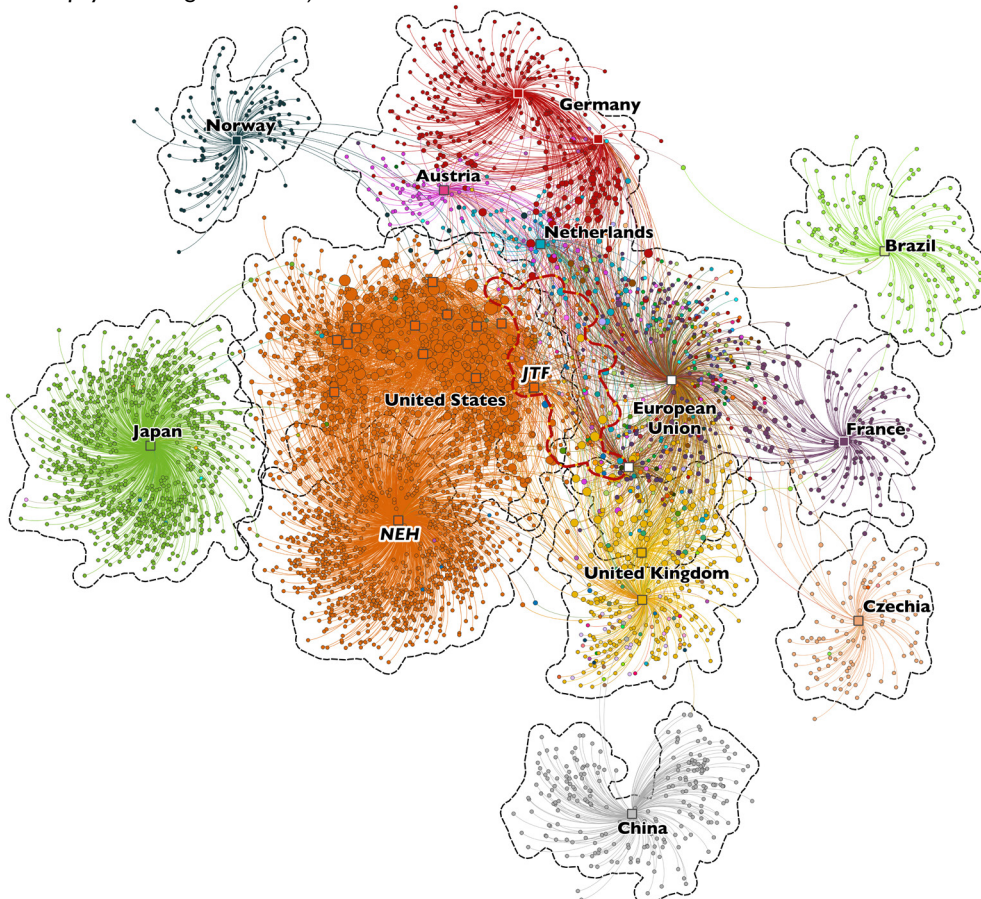
- NINDS funds 57.6 % of Parkinson's research and has an even spread of grant durations in the three time categories.
- Clinical trials only cite papers: that are otherwise cited; rarely from grants longer than 21 years; coming mostly from grants funded by NINDS, MRC and NIA.
- For MRC research, an above-average proportion never gets cited, although the research that gets highly cited is used in clinical trials.
- NIH Office of the Director funded mostly longer grants but most publications do not get cited.



Arts and Humanities

Arts and Humanities are sometimes thought of as less internationally collaborative than Sciences. We explored the dynamic of nationality of funders and research organizations through a network representing funded projects in the Arts and Humanities (FoRs: 19 - Studies in Creative Arts and Writing, 20 - Language Communication and Culture, 21 - History and Archaeology, and 22 - Philosophy and Religious Studies).

International networks are substantial and highlight EU collaboration in Arts and Humanities research



The USA dominates the landscape, with 15 funders giving 4,714 grants (46.1%). The most central organizations (measure by eigenvector centrality) are from the USA (led by UC–Berkeley, UW–Madison, and UCLA), while the top non-USA organization are Oxford, Berlin, and Freiburg universities.

A cluster analysis of the network identified nine classes of organizations receiving funding from the same funders. It revealed two types of funding structures: domestic only (Brazil, China, Japan, Norway, Czech Republic and two USA clusters); and domestic with international collaborators (a USA cluster, the UK with the EU, and [Germany, France, Austria]). A large cluster at the center of the network groups together EU funding to EU countries, and the UK cluster and highlights the importance of intra-European collaboration in Arts and Humanities research.

The 13 USA funders belong to three clusters: National Endowment for the Humanities (NEH) - mainly domestic; John Templeton Foundation (JTF) - domestic with some international collaboration; and 11 other USA funders (e.g. departments in National Science Foundation (NSF) and NASA)) - mostly domestic. NEH is the largest funder, and also funds different research organizations than the other USA funders.

Figure 2 - The network shows frequently represented Arts and Humanities funders [squares] and research organizations [circles]: 27 funders across 13 countries gave 7,422 grants to 4,786 research organizations. Research organizations are sized relative to their centrality



Quantum Technology Research Strategy in the UK

Research funding and publication data enable better insight across the research lifecycle and support strategic decision making

In the 2013 Autumn Statement, the UK government announced a £270 million, 5-year investment for a National Quantum Technologies Programme (NQTP). The Engineering and Physical Research Council (EPSRC) was allocated £234 million to establish four grant initiatives and a national network of Quantum Technology hubs. EPSRC commissioned Digital Science to provide strategic decision support to the Quantum Technologies Strategic Advisory Board.

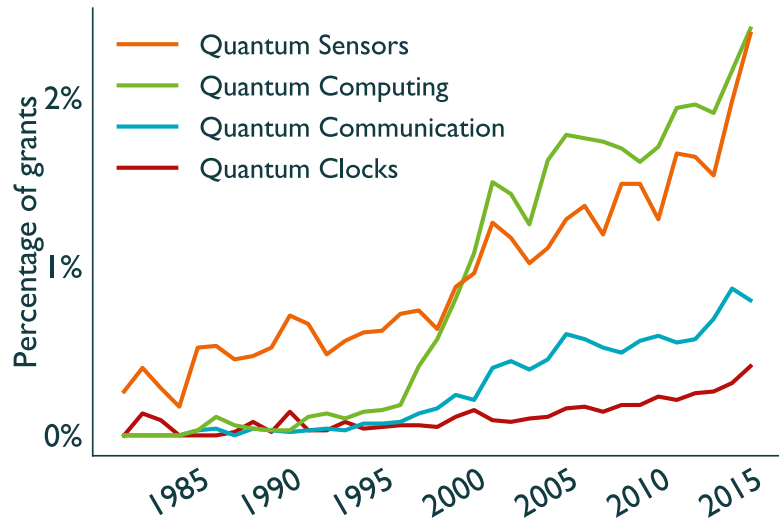


Figure 3 - Percentage of all physics and engineering grants that related to quantum technologies.

Quantum technologies cluster into four main categories shown figure 3. Over the past two decades, the number of quantum technology grants has increased as a proportion of total funding in physics and engineering. Quantum Sensors has had a consistent growth, while Quantum Computing exploded in activity just before the millennium.

There is a well-established citation advantage associated with collaboration. The chord diagram (Figure 4) shows co-authorship across seven countries leading in quantum technology. UK researchers collaborate with colleagues in USA and Germany. The USA, and China, the emergent research power, have the largest output but are proportionally less collaborative.

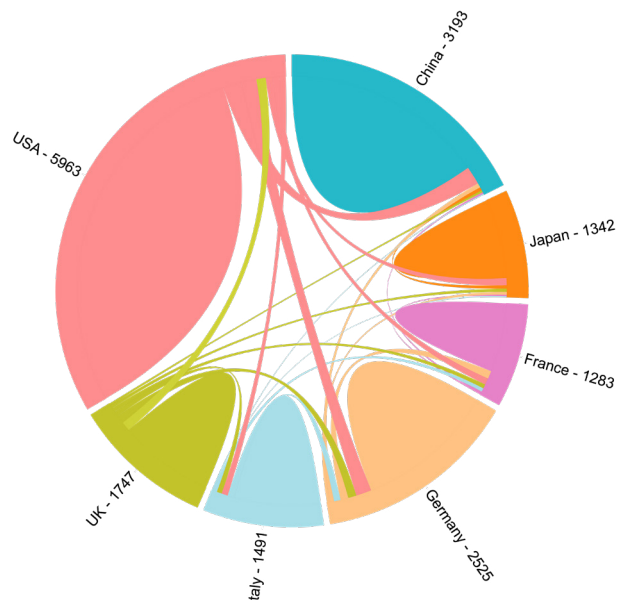


Figure 4 - Publication collaboration in Quantum Sensors.



Lithium-ion Battery Research

Widespread deployment of electrical components and the pressure to secure clean and reliable sources of energy are key factors driving battery technology research. An increasing range of battery use-cases, from mobile devices to electric vehicles, requires high quality research to be rapidly translated into commercially viable products and services.

Dimensions is ideal for analysis of this topic because linked indicators can be created to cover inputs, outputs, and outcomes. We searched Dimensions for one kind of technology (lithium-ion batteries) and compared activity over the period 2006-16 for four leading countries: Australia, Canada, Japan and the UK. The US and China dwarf other countries and are omitted from analysis.

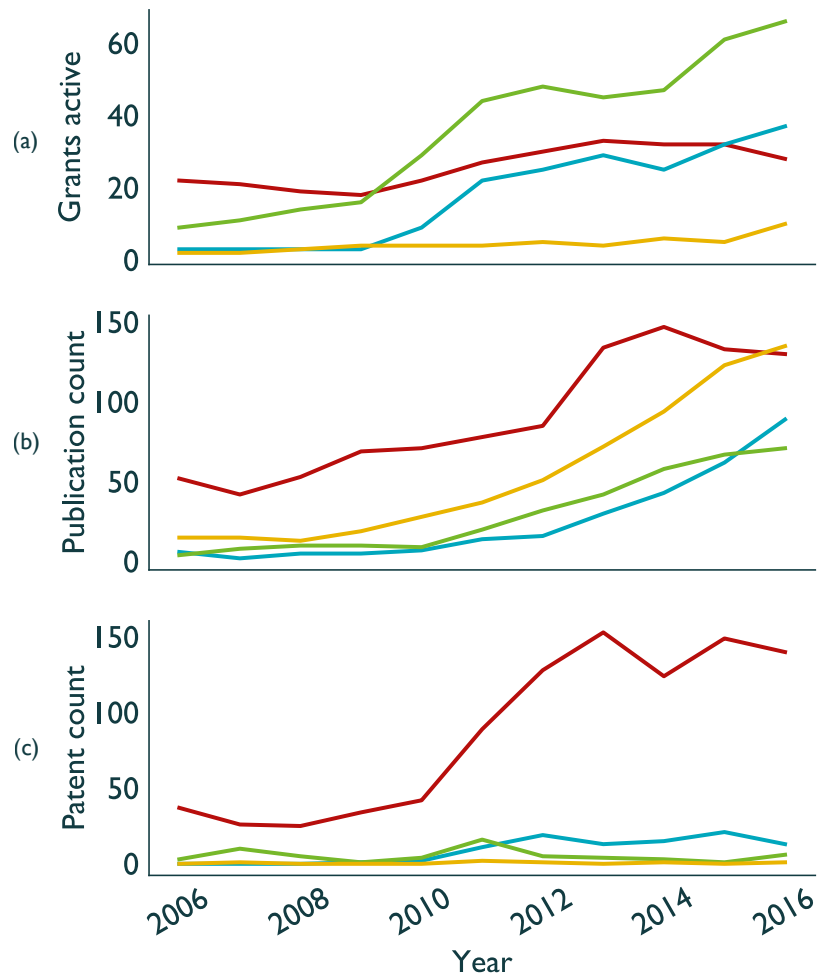
We trace research investment by counting the number of active grants relating to lithium-ion batteries tracked by Dimensions and awarded to institutions in each country in each year (Figure 5.a). While the number of grants is a good proxy for investment, the average length of grants is also a factor (see Figure legend). The data show that the UK and Canada had continued growth in projects but Japan plateaued after 2013.

To determine and compare research success, academic output and citation impact are indexed (Figure 5.b). The figure shows annual output and the mean relative citation ratio (RCR - see Figure legend). Japan has the highest annual output but the lowest average RCR. The UK, Canada and Australia are similar in publication volume and the UK has the highest average RCR of 1.91.

Finally, to measure the wider impact of research in the context of commercial application, we searched Dimensions for relevant patents assigned to organizations from each country (Figure 5.c). Japan far exceeds Australia, the UK and Canada on this indicator, with significant growth between 2010-13. However, further analysis of patent utility (e.g. through patent citation) and economic indicators (e.g. number of successful startups) is required to broaden any interpretation.

Co-analysis of grants, outputs and patents highlights national strategies around innovative technology

Figure 5 - Active grants, articles published and patents led in selected countries



— Japan	grant duration 2.88y, publication RCR 0.93
— UK	grant duration 3.77y, publication RCR 1.91
— Canada	grant duration 2.59y, publication RCR 1.54
— Australia	grant duration 3.11y, publication RCR 1.03



Arctic Research

The overview of research areas, researchers, funders, patent assignees, and countries provides an instrument for evaluation and horizon scanning

The Arctic is a focus of global interest as the impact of climate change is revealed by modern technologies, logistics, and communication. Development of Northern Sea Route and the May 2017 Arctic Science Cooperation Agreement, signed in Fairbanks, Alaska, are both evidence of the international nature of Arctic space where Arctic Council member and observer states (www.arctic-council.org) successfully work together. Arctic-related research grants, patents and publications are produced at many national and international levels. The Dimensions platform provides researchers and decision makers with timely connections between these elements to enable informed decision-making through trend and 'big picture' analysis.

We created a simple keyword search analysis using "Arctic AND Polar" across grants, publications, and patents in Dimensions for 2012-16, across subject area-specific domains and the geographically specific context of the eight Arctic Council member countries. More than 50% of funding linked to the topic, some 40-44% of the identified research publications, and around 40% of patented Arctic-related technologies are being managed collectively by Arctic Council members (Figure 6). The top five national research funders, by



Figure 6 - Arctic Council countries' activity compared to global arctic and polar research.

number of active grants during the five year period, are also identifiable (Figure 7) led by NSF-GEO (with 148 grants), Research Council of Norway (84) and Canadian NSERC (81), the Russian Foundation for Basic Research (68) and the UK's NERC (37 grants).

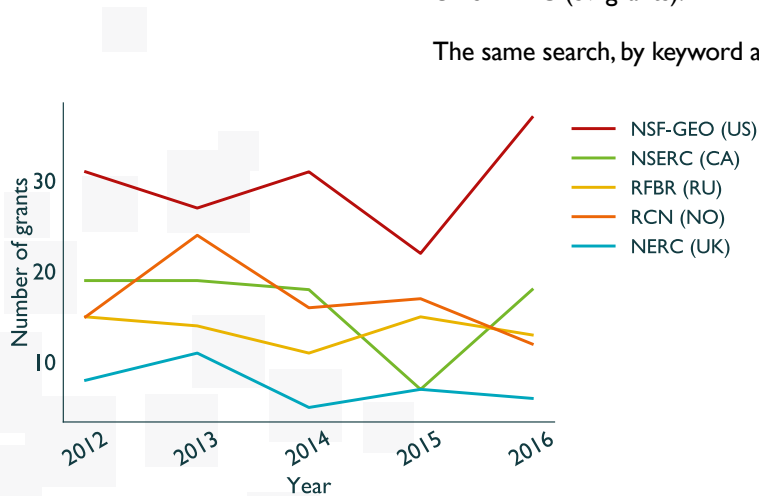


Figure 7 - Five leading national funders of arctic and polar research.

The same search, by keyword and time, can be analysed for detailed subject areas. The specific topics with rising volumes in the three key data elements (grants, publications and patents) are led by Physical chemistry and Materials engineering, which both show steady growth across all of the three elements.

The one-click analysis that Dimensions enables provides a rapid overview of research areas, researchers, funders, patent assignees, and countries. This provides a valuable instrument not only for evaluation but also for science collaboration and horizon scanning.



A Composite Indicator for Publications per Grant

The Dimensions platform provides access to global data for both grants and publications and makes possible the construction of links between different aspects of research. The dataset will enable increasingly sophisticated composite indicators to be created as needed by the research community. We explored a simple composite indicator: the ratio of publications to active grants. This is an imperfect representation of research inputs and outputs, but it offers real value for exploratory purposes. For example, a high ratio of publications to grants (relative to a subject average) might indicate: research areas that do not attract grant funding (e.g. Complementary Medicine); strong industry funding (e.g. Pharmaceutical companies); or internally collaborative research.

To create a Publications-to-Grants Indicator (PGI), we took articles published after 2015 and compared this to a count of active grants in the period 2015–17. Active grant count (as opposed to the funding amount) addresses varying award lengths and funding systems in different countries and is more meaningful for cross-disciplinary comparisons. Indicators were calculated for data grouped in categories denoted by common FoR codes for grant and publication classification.

Countries take different management approaches to national and institutional research funding. It is therefore to be expected that PGI values will vary within a FoR. We looked at Genetics, with a global PGI of 4, as an example of the value range at the country level. Germany is somewhat higher than this (PGI=7) but Australia is a stand-out at PGI=10. One explanation is Australia's collaboration in research funded by other countries: in 2015, 70% of the funding acknowledgements on Genetics papers with Australian author affiliations were to overseas funders, compared to 24% for papers with US affiliations. Internationally collaborative research adds a real productivity boost to investment.

There is also PGI variation at the institutional level within a common national funding system. This is less easily explained by a general analysis and the detected variance points to the value of using indicators like PGI to inform research management. In Australia, PGI varies markedly between the Universities of Queensland (9) and Melbourne (16), although they have similar Genetics output (1,409 and 1,338 publications respectively). This may suggest that Melbourne has other support for Genetics research, or that Queensland's grants cover different kinds of Genetics research. Since this perspective could not have been gained through grant or publication data alone, we believe that composite research indicators will lead to many new research management solutions.

Dimensions will enable increasingly sophisticated composite indicators to be created by the research community

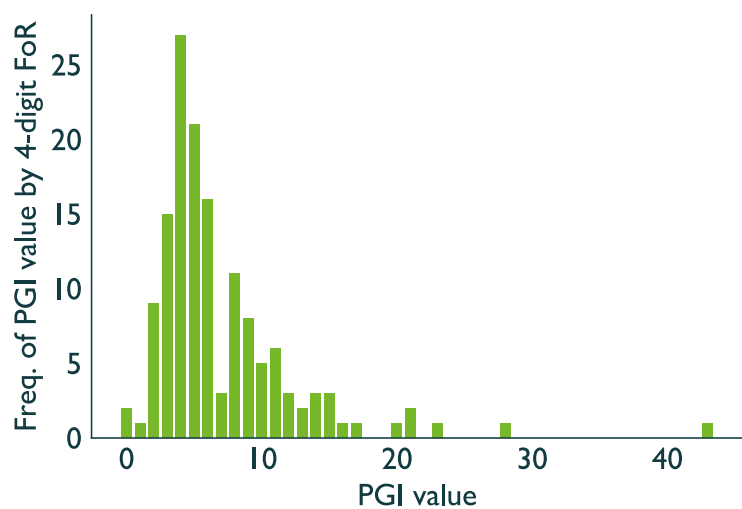


Figure 8 - The PGI shows reasonable global stability across FoRs, with a mode of 4 and 80% of all values in the range 0-10 PGI. Outliers (PGI > 20) include Marketing and Complementary Medicine.



Concluding Insights from Dimensions

The six use cases presented in this report illustrate, above all, the additional value of bringing multiple sources of data about different aspects of research activity together in one uniformly curated analytical platform. They draw on analyses previously commissioned from Digital Science Consultancy and are typical of the kind of custom reporting that can be rapidly developed using the API. By bringing together data about inputs, activity, outputs and outcomes across a standard set of subjects and institutions, new analytical power is unlocked supporting the development of novel composite indicators:

- The common FoR subject categories bring together grants, publications, patents and clinical trials. In the study on Parkinson's Disease, revealing not only the impact of each funder but some important differences between their portfolios.
- The opportunity to link funding to consistent institutional identification demonstrates a much higher level of collaboration than is usually attributed to Arts and Humanities research. This also points up the key contribution that EU funding has made to the research network across Europe, and highlighting the penalty the UK will suffer after Brexit.
- A global picture of research funding is opened up in the EPSRC analysis of Quantum Technologies. We can see the contrasting trends for sub-fields and national contrasts in portfolios.
- A more detailed publication analysis is added to the funding picture in the study on battery technology and the analysis is extended by then bringing in data on patent filings, again highlighting marked national contrasts.
- A second perspective on energy is provided by the analysis for the Arctic Council, pointing up the significant contribution made by them in funding for this key region and the integrated research interests of the rest of the global network.
- Finally, the opportunity for new indicators is fleshed out in the study of publications-to-grants ratios. A simple but powerful composite indicator raises different kinds of questions for research managers, about global norms for productivity and about the differences in portfolio that might be driven by different objectives and funding structures.

This report is an introduction to the opportunities that the Dimensions platform now makes available to research analysts, managers and policy-makers. For researchers themselves this is also a simple and transparent way to review activity data, about their own group and its peers, and about their position in their own institution and network. This will foster a far better understanding of the use of limited resources to enable more and better research.

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