A BIBLIOMETRIC ANALSYIS OF RESEARCH PUBLICATION OUTPUT SUPPORTED BY THE HEALTH RESEARCH BOARD (2013-2016)

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March 2017

Published by:

Health Research Board
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First published 2017

Bibliometric analysis commissioned from CWTS Leiden

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Executive summary

This report presents the results of a bibliometric study of peer reviewed publications fully or partially funded by the Health Research Board (HRB). The bibliometric analysis for this study was commissioned from CWTS Leiden, a world-leader in this area. The results of that analysis were compared, where possible, to a previous Bibliometric study undertaken by the HRB in 2014, which looked at HRB publications from 2000-2012.

HRB-supported publications between 2013 and 2016 were matched to the *Web of Science* database and were linked to a number of units of analysis. The benchmark units chosen by CWTS Leiden reflected ether similar size (HRC New Zeeland) or similar focus (MRC UK and NIHR UK), and HRB publication output was also compared to the publication output of Ireland as a whole. In addition publications were matched by the HRB to Grant types (Projects & Programmes, Infrastructure & Networks, Capacity Building & Leadership, and Co-funded Awards) and HRB Strategic Pillars (Basic Biomedical, Applied Biomedical, Clinical, Population Health and Health Services Research).

The internal coverage, which is an estimate of the importance of *Web of Science* indexed publications for researchers, was above 75% for all units of analysis (average 90.4%.) This indicates that only a small share of the publication output by these units was excluded from this bibliometric analysis. For the citation impact analysis, only publications published in 2013 and 2014 have been taken into account (citations included until 2015).

Key findings

Publication output:

- 1,759 HRB-supported publications in the 2013-2016 publication period were matched to the *Web of Science*, of which 1,730 were citable and were used in the analysis. These included 1,458 articles, 263 reviews and 9 letters. The number of HRB funded publications is increasing over time, and is now responsible for a considerable share of all Irish publications in some journals.
- A small number of awards that commenced as far back as 2001 were still disseminating results through journal publication up to 14 years later. For awards made from 2004 onwards the number of publications produced in the period 2013-2016 became significant, representing a time to publication of 6-7 years at minimum.
- The performance of publications arising from all Grant Types and Strategic Pillars, in terms of citation impact, journal impact and positioning in the top 10% of publications in the field, was above the world averages of 1.0 and 10%, respectively, and higher than Ireland as a whole.

Citation impact, general:

- On aggregate, HRB funded publications a citation impact well above world average and higher than the citation impact of all publications linked with Ireland. One sixth of HRB funded publications belong to the top 10% of highly cited publications in their fields.
- 7.5% of HRB publications had accumulated citation impacts (MNCS) greater than twice the world average and in some cases many times the world average. Their citation impact would be expected to increase even further in the coming years, given that they have been so highly cites so soon after publication.
- In terms of citation impact, two groups of funding organisations could be identified. Publications supported by the HRB and HRC NZ had a high impact (higher than Ireland as a whole) while

publications supported by the UK based funding organisations MRC and NIHR have a very citation high impact. However, this pattern was not consistent at the level of Grant Type, Strategic Pillar or Web of Science research category.

- At the level of Grant Type and Strategic Pillar the citation impact of 'Infrastructure and Networks' and of 'Health Services Research' had the highest citation impact of all HRB publications. One fifth of awards classified as 'Health Services Research' or as 'Co-funded Awards' produced publications in the top 10% in their field.

Citation impact of research fields:

- There was a strong focus on a limited number of fields in each of the HRB Strategic Pillars, with a maximum of nine fields needed to cover more than 50% of the publication output of each Strategic Pillar. For all HRB publications, 12 fields accounted for more than 50% of the publication output.
- The HRB's most important fields of activity in terms of share of publications, were 'Medicine, General & Internal' and 'Neurosciences'. 'Neurosciences' was also a top three field of activity for the other benchmark funding bodies.
- In the top 24 fields, in terms of share of publications, HRB supported publications had a citation impact around, above or very much above world average, although in many fields the UK based funding organisations have an even higher citation impact.
- In some research fields the citation impact of all Irish research publications was (slightly) higher (e.g. 'Biochemistry & Molecular Biology' and 'Cell Biology') than the HRB.
- Publications funded by any of the benchmark funding organisations (including HRB) attracted a citation impact of twice the world average in the field of 'Psychiatry'. The high share of highly cited publications in the field of 'Psychiatry' resulted from publications that belonged to the Grant types 'Capacity-building and Leadership' and 'Projects and Programmes'.
- Some fields (e.g. 'Endocrinology & Metabolism', 'Immunology') with a relatively high HRB citation impact showed a huge range of citation impact scores among Grant types.

Journal and research profiles:

- A comparatively large share of HRB funded publications (and to a certain extent its benchmark units) were published in open-access journals 'PLOS ONE', 'BMJ OPEN' and 'Cochrane Database of Systematic Reviews'. Many of the journals in which a large share of HRB publications was published had a MNJS around world average or slightly lower. However, many HRB researchers have also successfully published in the top 100 ranked journals in the world.
- There has been a clear change in journal usage by HRB-funded researchers, when compared to the previous bibliometric study period (2000-2012), which may reflect the changing HRB focus towards patient oriented, population health sciences and health services research, especially since 2010.
- The ten journals that included the largest share of HRB funded publication output covered 12.9% of all research publications funded by the HRB, and had a considerable overlap with the journals mainly used for publications funded by the benchmarked UK funders.
- In general, similar patterns to the MNCS existed for the journals in which publications funded by the HRB and its benchmark units were published: a moderate Mean Normalized Journal Score (MNJS) for all Irish publications, a high MNJS for publications supported by HRB or by HRC NZ and a very high MNJS for publications supported by the UK MRC or the UK NIHR.
- On aggregate, the HRB, the UK MRC, and the UK NIHR had an MNJS that was lower than their MNCS, which indicates that the citation impact of the contributions they funded was on average higher than the impact of all publications in a journal.
- This ratio carried through into HRB Grant Types and Strategic Pillars and was particularly strong for 'Infrastructure and Networks' and 'Health Services Research', which suggests that publications

arising from these Grant Type and Strategic Pillar are regarded highly by peers, who cite them in their own work.

Co-authorship and Collaboration:

- For HRB, its benchmark units and the Grant Types and Strategic Pillars approximately half of all publications resulted from international collaboration.
- For HRB funded internationally co-authored papers, there has been a steady upward trend over time and the share of such papers have risen from 33.8% (2000-04) and 43.8% (2008-12) to 48% of all HRB publications in the 2013-16 publication period. However, relatively speaking, international collaboration was not as common for HRB funded publications as it was for all publications involving researchers in Ireland, which had more than 60% internationally co-authored publications.
- For the HRB's benchmark units, high citation impact was associated with a large share of publication output from international collaborations. Publications resulting from international collaboration by HRC NZ have a citation impact which was somewhat higher than HRB's, but HRC NZ's citation impact for the other collaboration types was lower than HRB's. However, the collaboration types of the UK based funding organisations with the lowest citation impact still surpassed the HRB's high citation impact for international collaboration.
- The HRB's non-collaborative (institutionally co-authored) publications, which accounted for about 25% of all publications, yielded the highest citation impacts. This is at odds with the collaboration profile of the benchmark units (highest citation impact for international collaboration).
- Publications arising from the Strategic Pillars 'Health Services Research' and 'Clinical Research' had the highest citation impacts for non-collaborative publications.

Citedness:

- On aggregate, just over 16% of HRB-funded publications (2013-2014) remained uncited in 2016. This is in line with the comparator funding organisations and was around half the percentage of uncitedness for all Irish publications. The Strategic Pillars 'Basic Biomedical Research' and 'Clinical Research' had a comparatively low and high uncitedness, respectively. This may be due to difference in citation practices in these different research fields.

1. Background

The *HRB Evaluation Strategy Implementation Plan 2017-2020* includes the systematic collection of outputs, outcomes and impacts metrics for all HRB-funded research at the point of end of grant. This dataset is important to the HRB in allowing it to understand the level of scientific outputs, and subsequent translation into outcomes, of HRB funded research. From a HRB perspective, it is important for us to understand whether our strategic investments, especially in research capacity, leadership and infrastructure, are bearing fruit over time in terms of level, quality impact of our funded research.

High-quality research that is highly regarded by peers (i.e. highly cited research) often gets taken up in subject reviews, systematic reviews, consensus statements and so on, that in turn underpin evidence-based clinical guidelines, clinical care models and health policies. Publication of research findings in peer-reviewed journals is the universal currency of research and allows colleagues to build on the work already done. However, simple counting of publications cannot provide any information on the value placed by peers on particular research results, how much these research results are subsequently taken up in the research system, how a group of publications compares to similar groups of publications elsewhere, and what the trends are in terms of the development or decline of research fields. To examine these aspects of the publication landscape, bibliometric analysis uses quantitative, statistically-based methods to estimate scientific quality and impact of research findings at many levels (field, type of research, institution, country) and through a number of indicators.

This report presents a bibliometric overview of publications funded in whole or part by Ireland's Health Research Board (HRB) and published. Data collection and analysis was carried out by CWTS Leiden, who have internationally recognised expertise in this area. The data set for these analyses was compiled from an internal HRB publication file which was matched to, and supplemented with, data from the *Web of Science* (WoS) database. HRB-funded publication output and citation impact were compared with the bibliometric performance of four benchmark units (Ireland, HRC NZ, UK MRC and UK NIHR.) The publications funded by the HRB were also assigned to a Grant Type and Strategic Pillar, which enabled comparison of publications from different Grant Types and Strategic Pillars. Moreover, where possible, findings from the current analysis were compared to a previous bibliometric analysis of HRB-supported publications from 2000-12, which was published in 2014.[1]

1.1 Health Research Board

The HRB has a statutory responsibility to support, promote and commission health research and to manage health information systems in the areas of alcohol and drug use, disability and mental health. The HRB also has a core role in generating and synthesising high-quality research evidence for the Department of Health, in order to facilitate evidence-based policy-making.[2]

The *HRB Strategic Business Plan 2010–14* marked a shift in strategic emphasis away from basic biomedical research, in order to increase capacity in Ireland for high-quality patient-oriented research, population health sciences, and health services research. This shift in focus toward patient oriented research population health sciences and health services research continued in the HRB Strategy 2016-2020 *Research.Evidence.Action*. These strategies recognised the importance of establishing a coordinated approach, so as to achieve the highest quality health research, and of developing the right skills,

[1] [1] Health Research Board (2014) Bibliometric analysis of HRB-supported publications 2000-12. ISBN 978-1-903669-21-1. http://www.hrb.ie/uploads/tx_hrbpublications/Bibliometric_analysis_of_HRB-supported_publications_2000-12.pdf [Accessed 20.03.2017]

[2] http://www.hrb.ie/about/corporate/

conditions and capacity in the Irish health system, in order to accelerate the translation of research discoveries into real benefits for people.

1.2 CSTS Leiden

CWTS B.V. (Centre for Science and Technology Studies) is an independent contract research organization that provides high-quality research performance and evaluation studies. They aim to assess research performance in comparison with international benchmark values worldwide and/or relevant benchmark institutes. Research performance is measured based on a range of bibliometric indicators. Four key dimensions of performance are measured bibliometrically: Output, impact, context, and collaboration. All of their analyses are fully supported by pre-developed techniques and tools, such as VOSviewer, which is a science mapping and network analysis application developed in house.

1.3 Report outline

This report assesses the bibliometric performance of HRB-supported publications between 2013 and 2016. Chapter 2 briefly introduces the data collection methodology and a definition of bibliometric indicators used.

The baseline bibliometric analysis (Chapter 3) provides an overview of the publication output and citation impact findings at the general level for the HRB and benchmark units (Ireland, HRC New Zealand, Medical Research Council UK and National Institutes of Health Research UK).

Chapter 4 explores publication output and citation impact findings at the level of Grant Type (Projects & Programmes, Infrastructure & Networks, Capacity Building and Co-funded Awards) and Strategic Pillar (Basic Biomedical, Applied Biomedical, Clinical, Population Health and Health Services Research).

In Chapter 5, the journal and research profiles of HRB funded publications is compared with the benchmark units, and is examined across HRB Grant Types and Strategic Pillars.

Chapter 6 focuses on domestic and international co-authorship patterns that can be identified for all units of analysis.

The Appendices contains a thorough discussion and explanation of the indicators used in this report (Appendix I), details on how field-normalised indicators are calculated (Appendix II), Web of Science Scope notes for a selection of health-relevant categories (Appendix III) and a list of Web of Science journal categories (Appendix IV).

An interactive institutional collaboration network VOSViewer map on the basis of HRB funded publications is provided next to this report.

2. Data collection and indicators

Appendix I provides the standard methodology and data definitions used in bibliometric and citation analyses. This chapter discusses bibliometrics, the database, the method of data collection, the main characteristics of the dataset, and the bibliometric indicators used in this report.

2.1 Bibliometrics and citation analysis

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

Research publications accumulate citation counts when they are referred to by more recent publications. Citations to prior work are a normal part of publication, and reflect the value placed on a work by later researchers. Some papers get cited frequently and many remain uncited. Highly cited work is recognised as having a greater impact, and there is evidence that high citation rates are correlated with other qualitative evaluations of research performance, such as peer review.[3] This relationship holds true across most science and technology areas and, to a limited extent, in social sciences and even in some humanities subjects.

Indicators derived from publication and citation data should always be used with caution. Some fields publish at faster rates than others and citation rates also vary. Citation counts must be carefully normalised in order to account for such variations by field. Because citation counts naturally grow over time, it is essential to account for growth by year. Normalisation is usually done by reference to the relevant global average for the field and for the year of publication.

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

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

2.2 Data sources

The CWTS Citation Index (CI) system was used for data collection and bibliometric analysis. The core of this system comprises of an enhanced version of the Thomson Reuters *Web of Science* (WoS) database.

[3] *Evidence* Ltd. (2002) *Maintaining Research Excellence and Volume*: A report by Evidence Ltd to the Higher Education Funding Councils for England, Scotland and Wales and to *Universities UK*. (Adams J, *et al.)* 48pp.

Within this database, the following citation indices are used: Science Citation Index Expanded (SCIE); Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI). CWTS note that their in-house version of the WoS database includes a number of improvements over the original WoS database. Most importantly, their database uses a more advanced citation matching algorithm and an extensive system for address unification.

WoS is a bibliographic database that covers the publications of about 12,000 of the highest-impact journals worldwide, including Open Access journals and over 150,000 conference proceedings. Coverage is both current and retrospective in the sciences, the social sciences, and the arts and humanities. Each publication in WoS has a document type. The most frequently occurring document types are 'article', 'book review', 'correction', 'editorial material', 'letter', 'meeting abstract', 'news item', and 'review'. For this analysis, only articles, reviews and letters were taken into account (a weight of 0.25 was applied to letters). Therefore, the report does not cover conference proceedings, meeting abstracts, books, chapters in books or grey literature, such as reports. This report therefore captures only a specific part of the total output of HRB-supported research over the period, but this part is usually recognised as describing the most direct scientific contribution to the research base.

2.2.1 Preparation of HRB publications file

The HRB supplied CWTS with its publications data captured over the last four years through end-of-grant reports and outputs surveys. CWTS matched these publications to the *Web of Science*. Additional publications were found by searching the funding acknowledgement and address text using the search terms:

*((Funding Organisation OR Address = (**Health Research Board** OR **HRB**)) AND Country = **Ireland**)*

The HRB then assigned these publications to HRB unique grant numbers and linked them to HRB Grant Types (Projects & Programmes, Infrastructure & Networks, Capacity Building and Co-funded Awards) and five HRB Strategic Pillars (Basic Biomedical, Applied Biomedical, Clinical, Population Health and Health Services Research).

The HRB publication file originally comprised 662 records, supplemented by an additional 1,0685 records identified through the funding acknowledgement and address text, yielding 1,730 records in total for analysis. The original HRB publications file relied on publications data provided through end-of-grant evaluation surveys in 2013 to 2015, the response rate for which is approximately 80%. Therefore, the HRB publication file could not include publications relating to HRB grants awarded pre-2013 or post-2015 that may have resulted in publications in the 2013–16 period.

2.3 *Web of Science* journal categories

Journals (and therefore also publications) belong to one or more subject categories, which can be understood as scientific fields, and every article within that journal is subsequently assigned to that category. Subject categories are used for the normalization of indicators.

CWTS uses these categories as the basis for bibliometric analysis because they are well established and informed by extensive work with the research community since inception. Papers from prestigious, 'multidisciplinary' and general 'biomedical' journals such as *Nature*, *Science*, *BMJ*, *The Lancet*, *New England Journal of Medicine* and the *Proceedings of the National Academy of Sciences* (*PNAS*) are assigned to specific categories based on the journal categories of the citing and cited references in each article.

2.4 Definitions

2.4.1 Papers/publications

The terms 'paper' and 'publication' are often used interchangeably to refer to printed and electronic outputs of many types. In these analyses the term 'paper' has been used exclusively to refer to substantive journal articles, reviews and some proceedings papers, and it excludes editorials, meeting abstracts or other types of publication. Papers are the subset of publications for which citation data are most informative and which are used in calculations of citation impact.

2.4.2 Citation Impact

'Citations per paper' is an index of academic or research impact (as compared with economic or social impact). The citation count is the number of times that a citation has been recorded for a given publication since it was published. Not all citations are necessarily recorded, since not all publications are indexed. However, the material indexed by CWTS is estimated to attract about 95% of global citations.

Citation impact can be calculated for papers within a specific research field such as clinical neurology, for a specific institution or group of institutions, or for a specific country. Citation count declines in the most recent years of any time period, as papers have had less time to accumulate citations (papers published in 2010 will typically have more citations than papers published in 2015).

If we wish to assess whether a paper has had a particularly high or particularly low citation impact compared to other papers, the standard practice is to normalize citation counts which are field-specific. Normalizing procedures use statistical methods to calculate citation impact values which are comparable across different fields. Since citation impact is also dependent on time (the longer the publication year is dated back, the higher the citation impact will be), the publication year should be additionally considered in these normalizing procedures.

Moreover, for the same publication year, publications in for instance mathematics have usually received a much smaller number of citations than publications in for instance biology. Each field has its own publication, citation and authorship practices, making it difficult to ensure the fairness of between-field comparisons. To account for these age and field differences in citations, CWTS use normalized citation indicators. In this case, citation impact indicators have been normalized at the level of *Web of Science* subject categories (hereafter: fields). To assess the impact of the publications of a research unit, CSTW rely on the combination of the Mean normalised citation score indicator and the PP(top 10%) indicator, which are strongly complementary to each other.

Mean normalised citation score (MNCS)

The Mean Normalised Citation Score (MNCS) is the average normalised number of citations of all publications of a unit[4]. The normalized citation score of a publication equals the ratio of the actual and the expected number of citations of the publication, where the expected number of citations is defined as the average number of citations of all publications (i.e., research articles and review articles) that belong to the same field and that appeared in the same publication year.

Therefore, if a unit has a value of one for the MNCS indicator, this means that on average the actual number of citations of the publications of the unit equals the expected number of citations. In other words, on average the publications of the unit have been cited equally frequently as publications that are similar in terms of field and publication year. An MNCS indicator of, for instance, two means that on average the publications of a unit have been cited twice as frequently as would be expected based on

[4] Unit refers to a specific publication dataset, such as Grant type, Pilar, HRB, Benchmark Unit etc.

their field and publication year. We refer to Appendix II for an example of the calculation of the MNCS indicator.

The MCS indicator does not correct for field differences and since the MNCS indicator is based on averages and thus citation distributions tend to be highly skewed, the MNCS indicator may sometimes be strongly influenced by a single very highly cited publication. If a unit has one such publication, this is usually sufficient for a high score on the MNCS indicator, even if the other publications of the unit have received only a limited number of citations. Because of this, the MNCS indicator may sometimes seem to significantly overestimate the actual scientific impact of the publications of a research unit.

PP(top 10%)

To counter the potential skewedness of the MNCS indicator, CWTS use another important impact indicator. This is PP(top 10%), the proportion of the publications of a research unit that belong to the top 10% mostly frequently cited publications in the same field and the same publication year. If a research unit has a value of 10% for the PP(top 10%) indicator, this means that the actual number of top 10% publications of the unit equals the expected number. A value of 20% for the PP(top 10%) indicator for instance means that a unit has twice as many top 10% publications as expected.

P(top 10%)

In addition to the PP(top 10%) indicator CWTS also use the P(top 10%) indicator. This indicator equals the number of top 10% publications of a research unit. The P(top 10%) indicator is obtained by multiplying the PP(top 10%) indicator by the P indicator (the total number of publications.)

Self-citations

Calculation of all impact indicators in this report disregards author self-citations. A citation is classified as an author self-citation if the citing publication and the cited publication have at least one author name (i.e., last name and initials) in common. This ensures that indicators focus on measuring only the contribution and impact of the work of a researcher on the work of other members of the scientific community. Sometimes self-citations can serve as a mechanism for self-promotion rather than as a mechanism for indicating relevant related work. The impact of the work of a researcher on his own work is therefore ignored.

2.4.3 Journal impact (MNJS)

In the same way that citation impact can be used as an index of research quality, the average number of citations per paper can be used to indicate the impact and/or importance of a journal. The mean normalised journal score (MNJS) is calculated as the average number of citations of all publications published in the same journal and field and in the same year. Thus, if a unit has a value of 1.0 for the MNJS indicator, this means that on average the unit has published in journals that are cited equally frequent as would be expected based on their field. Likewise, a value of 2.0 for the MNJS indicator that on average a unit has published in journals that are cited twice as frequently as would be expected based on their field. Citing articles may be from the same journal; however, most citing articles are from other journals.

2.4.4 Bibliometric indicators overview

Table 2.1 presents the indicators used in this report. The indicators below are grouped by performance dimensions. Self-citations are excluded before impact indicators are calculated. More detailed information on the indicators and normalization is provided in Appendix I and Appendix II.

Table 2.3: Overview of CWTS bibliometric indicators

Indicator	Dimension	Definition
P	Output	Total number of publications.
TNCS	Impact	Total normalized number of citations.
MNCS	Impact	Mean normalized citation score, that is, the average normalized number of citations.
P(top n%)	Impact	Total number of publications that belong to the top n% of their field.
PP(top n%)	Impact	Proportion of publications that belong to the top n% of their field.
MNJS	Journal impact	Mean normalized journal score, that is, the average MNCS value of the journals in which the publications of a research unit have appeared.
Int cov	Output	Internal coverage. Measured by the proportion of cited references in the analysed publications of a research unit that point to publications indexed in WoS.

2.5 Counting method

When analysing the bibliometric research output of an entity, publications can be counted fully or fractionally. In the case of full counting, publications are fully assigned to an institution or country, irrespective of the number of co-authors from different institutions or countries. If publications are fractionally counted, publications are only partly assigned in the case of co-authorship. In this way, the effect of scientific collaboration is levelled out. Fractional counting is possible at different levels, e.g. countries or institutions. In this report, the publication output was counted fully. Thus, irrespective of the collaboration type, publications were included fully in the publication and citation analysis. The citation impact indicators were calculated on the basis of fractional counting at the institutional level.

It is important to note that since the analysis concerned publication output produced during the period 2013 to 2016 the statistics presented in this report are based on two different periods of analysis. The publication output statistics cover the period 2013 to 2016[5]. However, publications need a reasonable period to attract citations. Therefore, the citation analysis in this report only covers the period 2013 to 2014 for publications and until 2015 for citations.

2.6 Data collection

In this report, publications funded by the HRB were compared with publication output and citation impact by a number of benchmark units:

- All publications that mentioned at least one address in Ireland in the WoS address field.
- All publications mentioning the UK Medical Research Council (UK MRC) in the WoS Funding Acknowledgement field.
- All publications mentioning the UK National Institute for Health Research (UK NIHR) in the WoS Funding Acknowledgement field.
- All publications mentioning the Health Research Council, New Zealand (HRC NZ) in the WoS Funding Acknowledgement field.

Three data collection methods were used for the different entities:

- Information on publications funded by the HRB were collected either by the HRB itself through its end-of-grant reporting or by CWTS on the basis of the Funding Acknowledgment as mentioned in the WoS database. The HRB assigned a Grant Type and Strategic Pillar to all publications.
- Publications funded by UK MRC, UK NIHR and HRC NZ were collected by means of the Funding Acknowledgement in the WoS.
- Publications from Ireland as a benchmark unit were collected on the basis of address information in the WoS.

Table 2.2 presents an overview of the different document types present in the dataset for the period 2013 to 2016. The statistics presented in this report were based on citations of articles, reviews, and letters; non-citables[6] are reported in Table 2.2 for the sake of completeness.

[5] The analysis was performed at a moment when the CWTS *Web of Science* database did not yet fully cover the year 2016. This does only affect output statistics.

[6] Non-citable documents are all documents which do not belong to the category 'article', 'letter', or 'review'. Examples are 'editorial material', 'book review', 'note', 'meeting abstract', 'correction', 'news item'.

Table 2.2 Final dataset (publication years: 2013-2016)

Unit of analysis	Non-citables	Articles	Reviews	Letters	Total publications
HRB	29	1,458[7]	263	9	1,759
Benchmark units					
IRELAND	11,812	26,638	2,473	785	41,708
HRC NZ	3	1,157	97	0	1,257
UK MRC	34	11,823	1,250	7	13,114
UK NIHR	88	14,838	3,133	6	18,065
Grant Types					
Capacity-building and Leadership Awards	6	374	72	2	454
Co-funded Awards	4	55	6	0	65
Infrastructure and Networks	3	139	14	0	156
Projects and Programmes	16	891	171	7	1,085
Strategic Pillars					
Applied Biomedical Research	7	549	97	0	653
Basic Biomedical Research	0	42	9	0	51
Clinical Research	11	354	89	4	458
Health Services Research	7	272	49	3	331
Population Health Sciences	4	244	19	2	269

[7] Three articles belong to two Strategic Pillars, one article belongs to two Grant Types.

3. Overall results and benchmarking

In this chapter, the results of the bibliometric analysis at the general level are presented. Attention is paid to the position of the HRB and its benchmark units (Ireland, HRC New Zealand, MRC UK and NIHR UK).

Key Findings

- The number of citable publications that could be linked to the HRB was 1,730 during the period 2013 to 2016.
- In the period 2013-2015, there was an average of 538 HRB-supported publications per year which was a 16.4% increase on the average number of publications per annum of 450 in the period 2008-2012.
- A small number of awards that commenced as far back as 2001 were still disseminating results through journal publication almost 12 years later. From 2004 awards onwards the number of publications produced in the period 2013-2016 becomes significant, representing a time to publication of 6-7 years at minimum.
- Publications funded by the HRB had a citation impact of 1.34, which was clearly beyond the world average Mean Normalized Citation Score (MNCS) of 1.0, and was higher that Ireland as a whole and HRC NZ, but lower than the MRC and NIHR. The citation impact of HRB supported papers in the 2013-14 period had fallen from both the 2000-04 (1.58) and 2008-12 (1.84) periods. This is less likely to reflect a 'fall' in research quality, rather than reflection of the shorter time period recent papers have had to accumulate citations.
- Just over one sixth (15.7%) of HRB publications were in the top 10% of highly cited publications in their field (PP(top 10%)), which is almost 1.6 times the world average. However, the percentage of HRB supported publications in the top 10% has decreased from 24.3% (2000-04) and 18.2% (2008-12) as the number of HRB papers increased over the same period.
- The number of HRB funded publications in the top 10% of highly cited papers in their field was greater than for Ireland as a whole and HRC NZ, but lower than the UK-based benchmark funding organisations (MRC and NIHR).
- HRB-supported papers are twice as likely to be cited as Irish publications as a whole (uncitedness of 32.9%).
- In the 2008-2012 period just under 20% of HRB-supported papers remained uncited (in 2013), while in the 2013-2014 period, just over 16% of HRB-funded publications remained uncited until 2015. This is an average value as compared with the other funding organisations and suggests a high uptake and use of HRB-supported publications.
- For the journals in which publications funded by the HRB and its benchmark units were published, there was a moderate journal impact score (MNJS) for all Irish publications, a high MNJS for publications supported by HRB or by HRC NZ and a very high MNJS for publications supported by the UK MRC or the UK NIHR.
- The HRB, MRC, and NIHR had a MNJS that was lower than their MNCS, indicating that the citation impact of the contributions they funded was on average higher than the impact of all publications in a journal. For HRC NZ and Ireland as a whole, the MNJS and MNCS were approximately equal.

3.1 Coverage of publications

A bibliometric analysis is a useful tool for research evaluation, but it often does not include all research publications by a department, institute or research program. This is caused by the limitations of the WoS database, which does not include particular research types for example books, and journals with a limited academic reach such as local journals or professional journals. Moreover, the level of indexing by WoS differs per field, while the share of publications indexed determines the usability of citation impact analysis and the completeness of publication sets.

In order to estimate the extent to which WoS indexed publications are used in the field of activity of a publication set, the references in a publication set are analysed to determine the so-called internal coverage. The internal coverage shows the share of references to other publications indexed in the WoS database as a share of all references to any source by publications in a publication set. If one assumes consistent reference behaviour among researchers within a particular field, this indicator can be used to estimate what share of publications is included in the dataset and what share of citations is included in the citation impact calculations.

Table 3.1 presents the coverage of WoS publications by the units of analysis. All units were found to have a high internal coverage (> 70%) and the majority had a very high internal coverage (> 80%). Based on the scores on the internal coverage indicator, a citation analysis as presented in this report is therefore informative, but one should bear in mind that not all types of publication output were covered by this analysis.

3.2 Distribution of publications

In the period 2013-2015, there was an average of 538 HRB-supported publications per year (Figure 3.1). This is a 16.4% increase on the average number of publications per annum of 450 in the period 2008-2012, as per the 2014 report *Bibliometric analysis of HRB-supported publications 2000-12*[8]. This suggests that growth in the number of HRB-supported publications has continued the upward trend observed in that report. It should be noted that data collection for this study was carried out in the second six months of 2016, therefore, in that year 250 HRB-supported publications had been indexed by the *Web of Science* at the time of data collection.

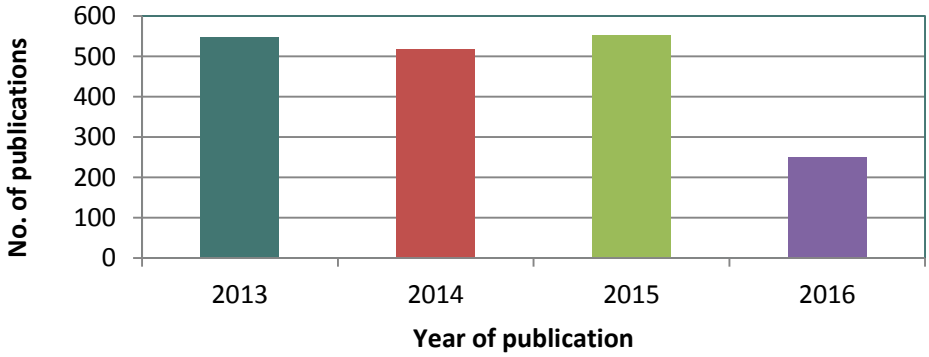

Figure 3.1 Number of HRB-supported publications annually (2013-2016)

Figure 3.2 analyses the start year of awards that generated publications in the period 2013-2015 (no grants awarded in 2016 had yet produced publications.) From this it can be seen that the outputs of

[8] Health Research Board (2014) Bibliometric analysis of HRB-supported publications 2000-12. ISBN 978-1-903669-21-1. http://www.hrb.ie/uploads/tx_hrbpublications/Bibliometric_analysis_of_HRB-supported_publications_2000-12.pdf [Accessed 20.03.2017]

awards that commenced as far back as 2001 were be still being disseminated through journal publication almost 12 years later, although this number was small. The number of publications produced in the period 2013-2016 becomes significant from 2004 onwards, representing a time to publication of 6-7 years at minimum.

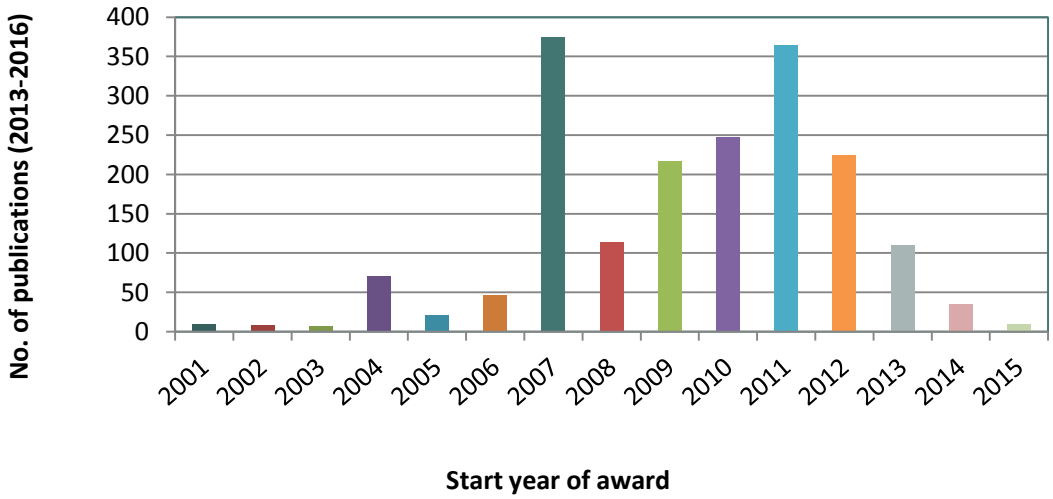

Figure 3.2 Start year of awards that generated publications in the period 2013-2015

3.3 Publication output

The number of citable publications that could be linked to the HRB amounted to 1,730 during the period 2013 to 2016 (Table 3.1). The HRC NZ was comparable in number of citable funded publications (1,254 publications). Unsurprisingly, given their vast differences in scale, Ireland (29,890 publications), the UK MRC (13,080 publications), and the UK NIHR (17,976) had a much larger number of publications to which they could be linked.

Comparison of publication output between benchmark units of different scale, for example, as a proportion of overall annual investment of benchmark units, would suggest that HRB researchers are three times more productive than MRC or NIHR counterparts (comparison of 2015 budget of each benchmark unit versus the total number of publications in 2015.) However, this kind of comparison cannot take into account variables such as the original purpose of those investments across benchmark units, for example for capital projects which would not be expected to yield journal papers. Nor can publications be individually linked to investment, since they may have resulted from research findings from several awards won from different sources, not just the benchmark units. Therefore, comparison of total HRB publication numbers (P) with benchmark units of very different scale is not meaningful as a measure of productivity. This productivity/efficiency dimension has been raised recently in the scientific debate as a limitation to standard bibliometric indicators (as used by CWTS and others).

The number of publications among HRB Grant Types (ranging from 61 for 'Co-funded awards' to 1,069 for 'Projects and Programmes') and Strategic Pillars (ranging from 51 for 'Basic Biomedical Research' to 646 for 'Applied Biomedical Research') reflected the numbers of awards represented in each Grant Type and Strategic Pillar that were active over the period, rather than variable productivity across scheme and broad research area.

Table 3.1 Overview of bibliometric performance by HRB, benchmark units, grant types, and strategic pillars

Unit of analysis	Output (2013-2016)	MNCS	P(top 10%)	PP(top 10%)	MNJS	PP(uncited)	PP(self citations)	Internal coverage
HRB	1,730	1.34	82.13	15.7%	1.20	16.1%	19.9%	90.4%
Benchmark units								
IRELAND	29,890	1.11	937.04	11.5%	1.10	32.9%	23.3%	75.7%
HRC NZ	1,254	1.29	51.37	13.4%	1.31	20.2%	24.5%	87.0%
UK MRC	13,080	1.87	708.93	22.9%	1.74	11.0%	18.4%	92.7%
UK NIHR	17,976	1.61	824.98	20.4%	1.51	16.8%	19.0%	84.8%

3.4 Citation impact

Highly cited work is generally recognized as having a greater impact and is correlated with other qualitative evaluations of research performance, such as peer review. But there are some papers that 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 that others seek to refute. Citation analysis cannot make value judgements about why an article is highly cited.

In aggregate, publications funded by the HRB had a citation impact (MNCS of 1.34) that was clearly beyond the world average MNCS of 1.0. The citation impact of HRB supported papers in the 2013-14 period had fallen from both the 2000-04 (1.58) and 2008-12 (1.84) periods. This is less likely to reflect a 'fall' in research quality, than a 'stabilisation' as the number of papers increased over the same period. When compared to the benchmark units, HRB funded publications had a higher MNCS that Ireland as a whole (1.11) and HRC NZ (1.29), but lower than the MRC and NIHR (1.87 and 1.61, respectively).

Just over one sixth (15.7%) of HRB publications belonged to the top 10% of highly cited publications in their fields (PP(top 10%)), which is almost twice the world average. However, the percentage of HRB supported publications in the top 10% has decreased from 24.3% (2000-04) and 18.2% (2008-12) as the number of HRB papers increased over the same period. When compared to the benchmark units, HRB publications had a higher PP(top 10%) than Ireland as a whole (11.5%) and HRC NZ (13.4%), but were lower than the publications funded by the UK-based benchmark funding organisations (MRC and NIHR) who had a PP(top 10%) of 22.9% (MRC) and 20.4% (NIHR).

In general, similar patterns to the MNCS existed for the journals in which publications funded by the HRB and its benchmark units were published: a moderate MNJS for all Irish publications, a high MNJS for publications supported by HRB or by HRC NZ and a very high MNJS for publications supported by the UK MRC or the UK NIHR.

The HRB, the UK MRC, and the UK NIHR had a Mean Normalized Journal Score (MNJS) that was lower than their MNCS. This indicates that the citation impact of the contributions they funded was on average higher than the impact of all publications in a journal. The citation impact of the journals in which contributions by all researchers in Ireland were published and in which research funded by HRC NZ was published was similar to the citation impact of all publications in these journals.

3.5 Uncited papers

Many journal papers are never subsequently cited after publication, even by their authors. This accounts for about half of the total global output of a typical, recent 10-year period. While there is 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. Papers can remain uncited for many different reasons, including, but not limited to:

- The paper presents important but 'negative' results which are an essential matter of record in their field but make the content less likely to be referenced in other papers;
- The content of the paper is trivial or marginal to the mainstream;
- The paper has been published in a journal not read by researchers to whom it might be interesting;
- The work is a 'sleeping beauty' that has yet to be recognized for its significance.

In addition, there is variation in non-citation between countries and between fields, which is indicative of a disciplinary factor but not necessarily a quality factor. Bibliometrics do not indicate why a given paper is uncited and therefore this indicator should be interpreted with care.

Bibliometric analysis pf HRB publications over the 2000-2015 period indicated an increase in uncited papers in more recent years. In the 2008-2012 period just under 20% of HRB-supported papers remained uncited (in 2013), while in the 2013-2014 publication period, just over 16% of HRB-funded publications remained uncited until 2015. This is an average value as compared with the other funding organisations and suggests a high uptake and use of HRB-supported publications. HRB-supported papers are more likely to be cited that Irish publications as a whole and were around half the percentage of uncitedness for all Irish publications (32.9%).

4. HRB Strategic Pillar and Grant Type

This chapter looks at the performance of HRB-supported publications by HRB Strategic Pillars (Biomedical, Clinical, Health Services and Population Health Research) and by grant type (Project/programme grants, Co-funded Awards, Capacity-building and Leadership, Infrastructure and Networks) between 2013 and 2016. In 2010 the HRB made a strategic commitment to shift its focus to patient oriented research (applied biomedical, clinical), population health sciences and health services research, and away from basic biomedical research in its own schemes (but supported within co-funded schemes with other agencies and organisations.) The aim is to speed up the translation of research outputs into real benefits for patients and the public, closing the gap between research outputs and their application in policy, clinical practice and health service delivery.

Key Findings

- The performance of publications arising from all Grant Types and Strategic Pillars, in terms of citation impact, journal impact and positioning in the top 10% or publications in the field, was above the world averages of 1.0 and 10%, respectively, and higher than Ireland as a whole.
- The number of publications among HRB Grant Types (ranging from 61 for 'Co-funded awards' to 1,069 for 'Projects and Programmes') and Strategic Pillars (ranging from 51 for 'Basic Biomedical Research' to 646 for 'Applied Biomedical Research') reflected the numbers of awards represented in each Grant Type and Strategic Pillar that were active over the period.
- One Grant type ('Infrastructure and Networks') and one Strategic Pillar ('Health Services Research') had a MNCS of 1.75 and 1.55, respectively, that were significantly higher than the citation impact of HRB publications in general, and had the highest proportion of publications in the top 10% in their field (19.8% and 20.5%, respectively.)
- There has been a significant reduction in the MNCS of Infrastructure and Networks when compared to previous bibliometric analysis for the 2000-12 publication period, which had an aggregated MNCS of 4.07 for this grant type. On the other hand, the MNCS for 'Health Services Research' has increased slightly (from 1.47 to 1.55) compared to the 2000-2012 publication period.
- All Grant Types and Strategic Pillars had journal impact scores that were lower than their citation impact scores, indicating that the citation impact of the contributions they funded was on average higher than the impact of all publications in a journal. This ratio was particularly strong for 'Infrastructure and Networks' and 'Health Services Research', which suggests that publications arising from these Grant Type and Strategic Pillar are regarded highly by peers, who cite them in their own work.

4.1 HRB Grant Type

The number of publications among HRB Grant Types (ranging from 61 for 'Co-funded awards' to 1,069 for 'Projects and Programmes') as shown in Figure 4.1 and Table 4.1 reflected the numbers of awards represented in each Grant type that were active over the period, although not the scale of investment in grant type, since considerable more was invested in, for example, Infrastructure and Networks that in Capacity Building and Leadership awards.

Figure 4.2 presents the MNCS, Figure 4.3 presents the PP(top 10%) and Figure 4.4 presents the MNJS performance of HRB-funded publications by Grant Type. From these analyses it can be seen that the

performance of publications arising from all Grant Types was above the world average, and higher than Ireland as a whole.

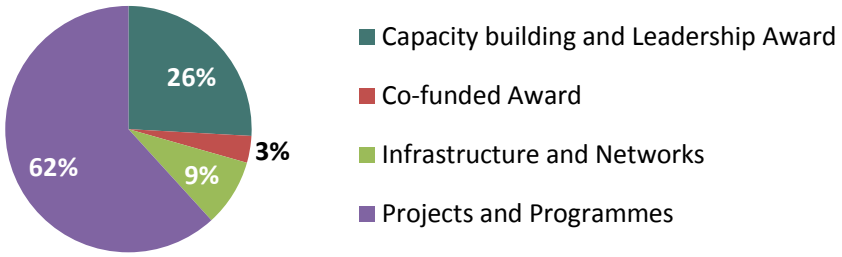

Figure 4.1 Number of publications associated with Grant Type 2013-2016

Infrastructure and Network awards (Clinical Research Facilities, Clinical Networks, Health Research Centres, Imaging and Equipment grants), which accounted for 9% of HRB-supported publications, had the highest score for both MNCS and PP(top 10%), with an MNCS significantly above the world average (1.75) and a PP(top 10%) of almost twice the world average (19.8%.)

However, there has been a significant reduction in the MNCS of this grant type when compared to previous bibliometric analysis for the 2000-12 period, which had an aggregated MNCS of 4.07. Some of this difference may be accounted for by the way in which awards were categorized (as Infrastructure and Special Initiatives) for the 2000-12 period and by a small number of very high impact papers (8.03) in the Health Information System scheme, which ceased in 2004.

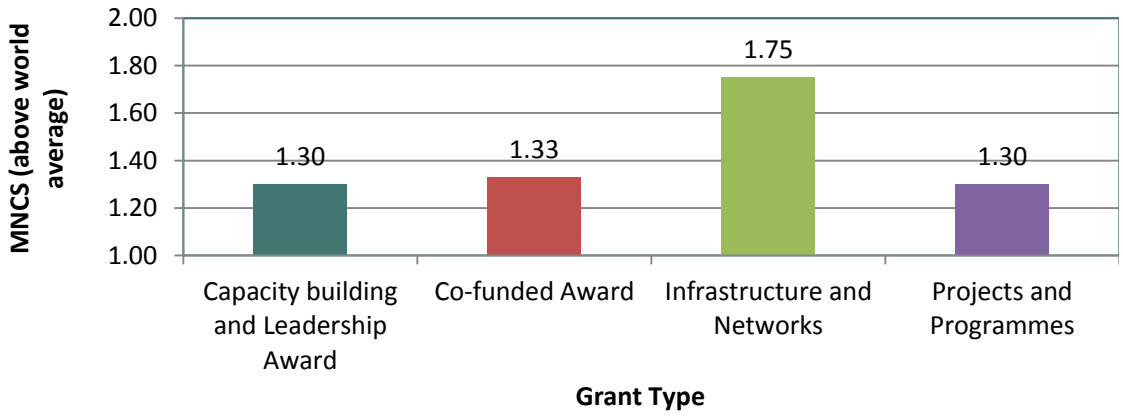

Figure 4.2 MNCS of HRB-funded publications by Grant Type

All other Grant Types had an MNCS above the world average (i.e. 1.30-1.33) and greater than Ireland as a whole (1.11) and HRC NZ (1.29), but significantly lower than both of the UK benchmark units (MRC – 1.87 and NHIR – 1.61). The pattern was similar in terms of share of publications in the top 10% of highly cited publications in their fields (PP(top 10%)), when compared to the benchmark units. All Grant Types had higher PP(top 10%) scores than Ireland as a whole (11.5%) and HRC NZ (13.4%), but significantly lower scores than both of the UK benchmark units (MRC – 22.9% and NHIR – 20.4), with the notable exception of Infrastructure and Networks.

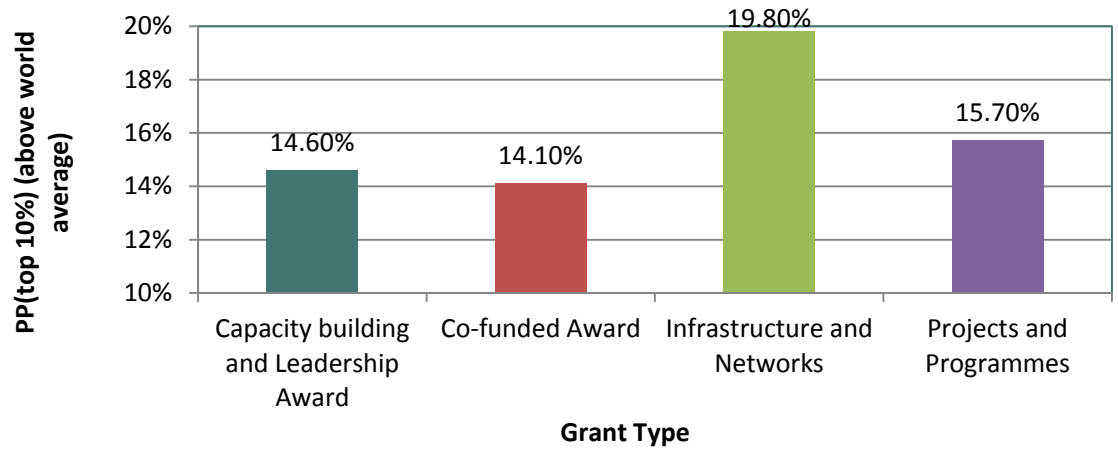

Figure 4.3 PP(top 10%) of HRB-funded publications by Grant Type

From Figure 4.4 it can be seen that the Mean Normalized Journal Score (MNJS) was greater than the world average across all Grant Types, and was above the MNJS of Ireland as a whole. When compared to the benchmark units, the MNJS for all Grant Types was lower than the UK benchmark units (MRC-1.72 and NIHR – 1.51) and was also lower than the aggregated HRC NZ MNJS of 1.31, with the exception of Co-funded awards, which had a slightly higher MNJS score of 1.36.

It should be noted that for all Grant Types, their MNJS was lower than their MNCS, indicating that the citation impact of the contributions they funded was on average higher than the impact of all publications in a journal. This ratio was particularly strong for Infrastructure and Networks, which suggests that publications arising from this grant type are regarded highly by peers, who cite them in their own work.

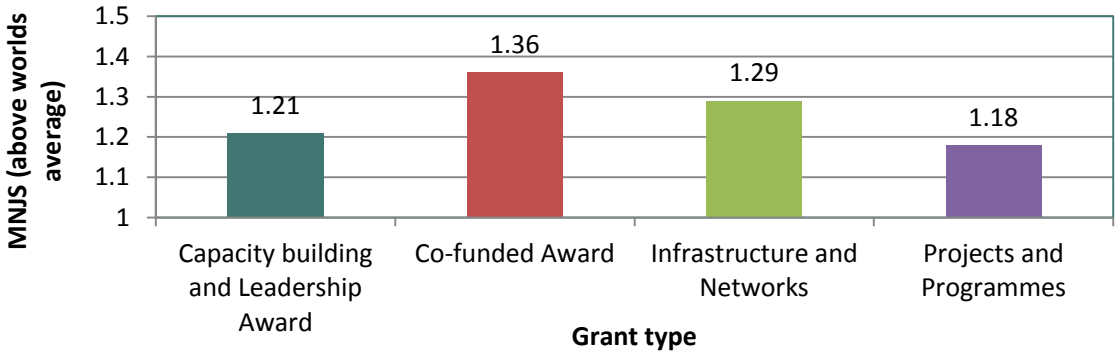

Figure 4.4 MNJS of HRB-funded publications by Grant Type

4.2 HRB Strategic Pillars

The profile of publications emerging from HRB Strategic Pillars has changed significantly from the previous HRB bibliometric study carried out on publications in the 2008-2012 period and reflects a continuing shift in focus of HRB funding. In the previous study publications from awards classified as basic biomedical and applied biomedical were combined into a single Strategic Pillar 'Biomedical'. Likewise, publications from awards classified as 'Population Health Sciences' and 'Health Services Research' were combined into a single Strategic Pillar 'Population Health & Health Services'. To allow comparison across periods, a similar grouping of Strategic Pillars in the 2013-2016 is presented here.

Comparison of the two publication periods shows that the number of HRB funded publications classified as 'Biomedical' has dropped significantly from 62% of publications in the 2008-12 period, to 40% of publications in the 2013-2016 period. The number of publications within the Strategic Pillar 'Clinical Research' has remained constant. As might be expected, given the increased investment made by the HRB in 'Population Health Sciences' and 'Health Services Research' since 2010, the number of publications that could be associated with these Strategic Pillars rose steeply from 13% in the 2008-12 publication period, to 34% in the 2013-2016 publication period.

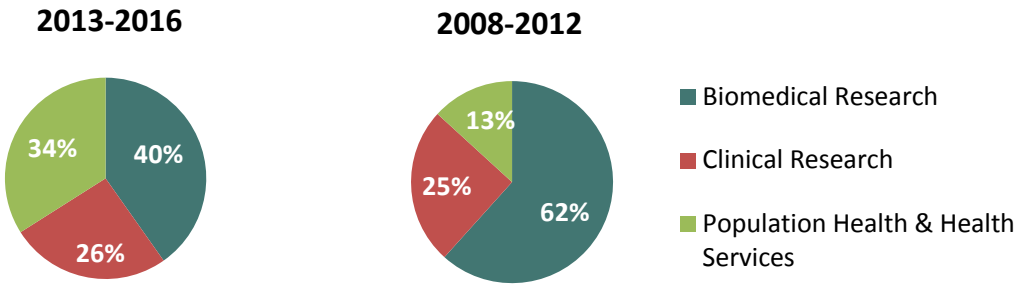

Figure 4.5: Number of publications associated with Grant Type 2008-2012 and 2013-2016

Figure 4.6 presents the MNCS, Figure 4.7 presents the PP(top 10%) and Figure 4.8 presents the MNJS performance of HRB-funded publications by Strategic Pillar. From these analyses it can be seen that the performance of publications arising from all Strategic Pillars was above the world average, and was higher than Ireland as a whole.

The citation impact (MNCS) of HRB publications associated with 'Health Services Research' was over one and a half times greater than the world average, which is in keeping with the upward trend observed for the 2000-2012 publication period (MNCS of 1.47), and makes it the Strategic Pillar with the highest citation impact for HRB funded publications.

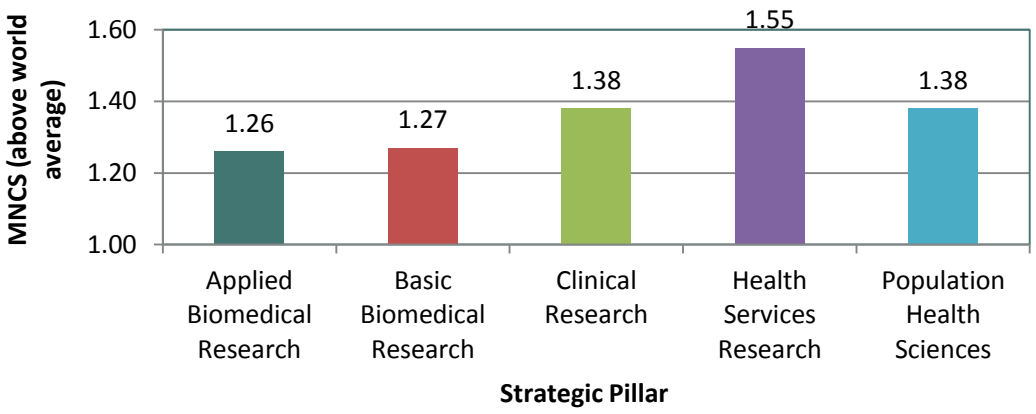

Figure 4.6 MNCS of HRB-funded publications by Strategic Pillars

'Clinical Research' and 'Population Health Sciences' are on a par with the HRB aggregated MNCS (1.34), while 'Basic Biomedical Research' and 'Applied Biomedical Research' are below the HRB aggregated MNCS, but still higher than the MNCS for Ireland as a whole, and for HRC NZ. All Strategic Pillars had MNCS values that were lower than the UK benchmark units (MRC- 1.87, NIHR – 1.61). When compared to the previous publication period (2000-2012) it was noted that there has been a significant decrease in the citation impact of 'Clinical Research' publications, falling from 2.20 in 2000-12 to 1.38 in 2013-16. There has also been a decrease in the citation impact of 'Basic Biomedical Research' and 'Applied Biomedical

Research' publications, from an MNCS of 1.74 in the 2000-2012 publication period to 1.26/1.27 in the 2013-2016 publication period.

The pattern for Strategic Pillars was similar in terms of share of publications in the top 10% of highly cited publications in their field (PP(top 10%)), when compared to the benchmark units. All Strategic Pillars had higher PP(top 10%) scores than Ireland as a whole (11.5%) but had lower scores than the UK MRC (22.9%). However, with respect to 'Health Services Research', the share of publications in the top 10% of highly cited publications (20.5%) was equivalent to the UK NHIR benchmark unit (20.4%).

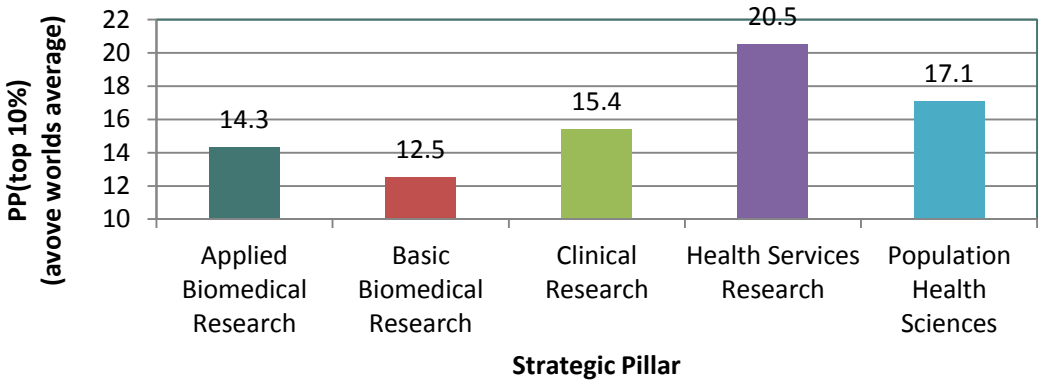

Figure 4.7 PP(top 10%) of HRB-funded publications by Strategic Pillars

Figure 4.8 shows that the Mean Normalized Journal Score (MNJS) was greater than the world average across all Strategic Pillars, and was above the MNJS of Ireland as a whole (1.1). When compared to the benchmark units, the MNJS for all Strategic Pillars was lower than the HRC NZ MNJS of 1.31 and the UK benchmark units (MRC – 1.72 and NIHR – 1.51). It should be noted that for all Strategic Pillars, their MNJS was lower than their MNCS, indicating that the citation impact of the contributions they funded was on average higher than the impact of all publications in that journal. This ratio was particularly strong for 'Health Services Research', which suggests that publications arising from this Strategic Pillar are regarded highly by peers, who cite them in their own work.

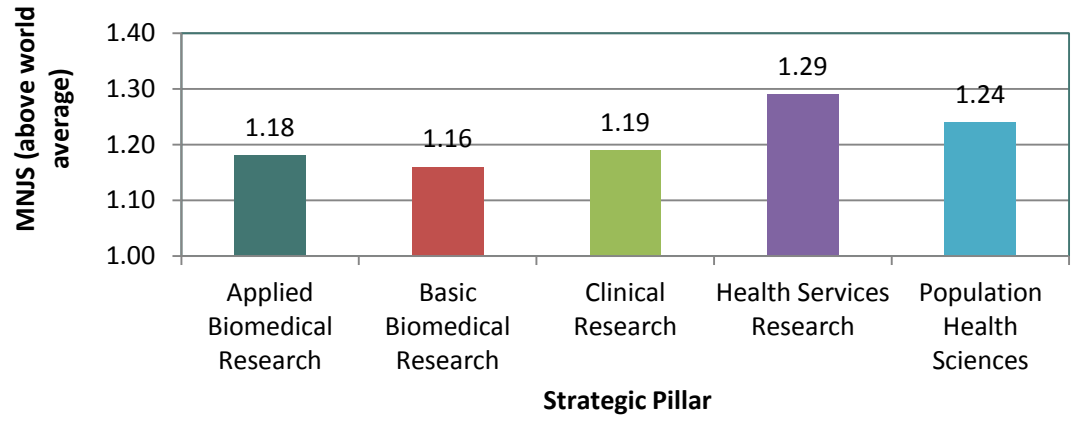

Figure 4.8 MNJS of HRB-funded publications by Strategic Pillars

With regards to uncitedness within the Strategic Pillars and Grant Types, only the 'Basic Biomedical Research' and 'Clinical Research' had a comparatively low (8.7%) and high (20.9%) uncitedness, respectively. A possible cause of this range is a difference in citation behaviour. Given the short citation window (2013-2015), many publications with a more clinical research character will not be cited yet given the development of citation aggregation in clinical research fields as compared to biomedical fields.

Table 4.1 Overview of bibliometric performance by HRB strategic pillar area and grant types

Unit of analysis	Output (2013-2016)	MNCS	P(top 10%)	PP(top 10%)	MNJS	PP(uncited)	PP(self citations)	Internal coverage
HRB	1,730	1.34	82.13	15.7%	1.20	16.1%	19.9%	90.4%
Ireland	29,890	1.11	937.04	11.5%	1.10	32.9%	23.3%	75.7%
Grant Types								
Capacity-building and Leadership Awards	448	1.30	17.73	14.6%	1.21	14.0%	18.0%	86.1%
Co-funded Awards	61	1.33	2.23	14.1%	1.36	18.0%	24.0%	95.4%
Infrastructure and Networks	153	1.75	9.27	19.8%	1.29	15.2%	15.3%	83.6%
Projects and Programmes	1,069	1.30	52.91	15.7%	1.18	17.0%	20.8%	92.0%
Pillars								
Applied Biomedical Research	646	1.26	34.23	14.3%	1.18	14.8%	19.8%	95.7%
Basic Biomedical Research	51	1.27	3.25	12.5%	1.16	8.7%	11.9%	97.0%
Clinical Research	447	1.38	15.84	15.4%	1.19	20.9%	24.1%	89.2%
Health Services Research	324	1.55	16.10	20.5%	1.26	15.5%	18.8%	72.7%
Population Health Sciences	265	1.38	12.72	17.1%	1.24	17.3%	18.9%	83.2%

5. Journal and research profiles

A journal profile gives an overview of the most important journals that have been used for publication. A research profile gives insight into the main fields of activity of a unit and how it performs in those fields in terms of citation impact. Comparing these profiles can highlight differences between units of analysis. In this chapter, the journal and research profile of publications funded by the HRB and publications of the benchmark units are presented.

Key findings

- There has been a clear change in journal usage, when compared to the previous bibliometric study period (2000-2012), which may reflect the changing focus towards patient oriented, population health sciences and health services research, especially since 2010.
- The ten journals that included the largest share of HRB funded publication output covered 12.9% of all research publications funded by the HRB, and had a considerable overlap with the journals mainly used for publications funded by the benchmarked UK funders.
- In the majority of the fields in which HRB supported publications had been published, the HRB's citation impact was above or well above world average, although, the publications funded by UK MRC and/or UK NIHR had an even higher citation impact.
- 7.5% of HRB publications had accumulated citation impacts (MNCS) greater than twice the world average, and in some cases many times the world average. Their citation impact would be expected to increase even further in the coming years, given that they have been so highly cites so soon after publication.
- Many HRB researchers have also successfully published in the top ranked journals in the world.
- In some journals, HRB-funded publication output was a considerable share of all Ireland research output (e.g. BMJ Open, BMC Health Services Research), which reflects the HRB's focus on health research and possibly its policy of encouraging open access publication.
- HRB funded research was published most often in journals belonging to 'Medicine, General & Internal' and 'Neurosciences' (together > 10%). The latter field also features in the top three of UK MRC and HRC NZ.
- In contrast to the other benchmark units, the HRB did not have a strong focus on one or two subject categories. Some Grant Types and Strategic Pillars had a strong focus on a limited number of fields, but this was not the case for all of them.
- At the field level, the citation impact of publications funded by the HRB was generally in line with the citation impact of all Irish research, although higher in some cases.

5.1 Journal usage

The 1,458 HRB-supported journal papers in these analyses were published in 996 journals. This is close to the 1,088 journals observed in the 2014 report *Bibliometric analysis of HRB-supported publications 2000-12*, and which was noted to be highly dispersed over these journals. That said, in the 2013-16 period 12.9% of HRB-supported publications were covered by 10 journals (more detail in Section 5.2). In some journals, HRB-funded publication output was a considerable share of all Ireland research output (e.g. BMJ

Open, BMC Health Services Research), which reflects the HRB's focus on health research and possibly its policy of encouraging open access publication.

5.2 Journal profiles

Journal profiles provide insight into the publication behaviour among researchers within the different units of analysis and their work can be linked with the impact of journals. This section focuses on the most important journals used for publications funded by the HRB and on the journal citation impact of those journals denoted by MNJS. MNJS represents the Mean Normalized Citation Score of all publications in a journal (article, review, and letter) in the period of analysis (2013-2014 for publications, 2013-2015 for citations). Table 5.1 presents the top 24 journals in terms of the number of papers published by HRB-supported researchers.

Table 5.1 HRB-supported papers by journal, PP(top 10%) and MNJS (by volume)

Journal	No of papers (2013-16)	PP(top 10%)	(MNJS)
PLOS ONE	72	10.7%	0.89
BMJ OPEN	34	14.3%	0.83
COCHRANE DATABASE OF SYSTEMATIC REVIEWS	26	18.1%	0.92
BMC HEALTH SERVICES RESEARCH	17	-	0.67
JOURNAL OF IMMUNOLOGY	14	2.7%	1.16
TRIALS	14	-	0.58
IRISH JOURNAL OF MEDICAL SCIENCE	14	-	0.31
SCIENTIFIC REPORTS	14	-	1.34
SCHIZOPHRENIA RESEARCH	12	-	1.11
QJM-AN INTERNATIONAL JOURNAL OF MEDICINE	11	53.1%	0.85
BJOG-AN INTERNATIONAL JOURNAL OF OBSTETRICS AND GYNAECOLOGY	10	10.9%	1.51
BMC FAMILY PRACTICE	9	-	0.55
BMC PREGNANCY AND CHILDBIRTH	9	5.5%	0.92
MOLECULAR PSYCHIATRY	9	43.5%	2.96
JOURNAL OF NEUROSCIENCE	9	6.7%	1.72
INTERNATIONAL JOURNAL OF BEHAVIORAL NUTRITION AND PHYSICAL ACTIVITY	9	-	1.28
JOURNAL OF CLINICAL NURSING	9	7.4%	0.62
CELL DEATH & DISEASE	8	-	1.16
BRITISH JOURNAL OF NUTRITION	8	12.5%	1.01
MULTIPLE SCLEROSIS JOURNAL	8	-	1.12
NEUROLOGY	8	5.2%	1.98
NEUROPHARMACOLOGY	8	-	1.66
SUPPORTIVE CARE IN CANCER	8	42.9%	0.96
AGE AND AGEING	8	66.7%	1.32

There has been a clear change in journal usage, when compared to the previous bibliometric study period (2000-2012), which may reflect the HRB's changing focus towards patient oriented, population health sciences and health services research, especially since 2010. For example, the Journal of Biological

Chemistry, which was the top journal by volume in 2000-2012 (86 papers), was used in the 2013-2016 publishing period for seven papers. Likewise, BMJ Open, in which HRB researchers published 34 papers in the 2013-2016 publishing period was used to publish less than 10 papers in the 2000-2012 period.

Figure 5.1 shows the share of total publications in the HRB top ten journals compared to the share of publication output with the benchmarking units during the period 2013-2016. From this it can be seen that the top ten journals used by HRB researchers, also include quite a share of the publication output by the UK benchmark units (MRC and NIRH), but the differences within those units were still considerable (e.g. UK NIHR' large share of publication output in 'COCHRANE DATABASE OF SYSTEMATIC REVIEWS'). Nevertheless, all benchmark units had a very high publication output in the open access journal 'PLOS ONE'.

Figure 5.2 shows the absolute publication output by the HRB and the benchmark units in the HRB's top ten journals during 2013-2016. This graph has been included to highlight that in some journals, HRB funded publication output was a considerable share of all Ireland's research output (e.g. 'BMJ OPEN', 'BMC HEALTH SERVICES RESEARCH') which reflects the HRBs focus on health research, and possibly its policy of encouraging open access publication.

The MNJS differed considerably per journal for the HRB's top ten most important journals. Some journals attracted an average number of citations around world average (e.g. 'PLOS ONE', 'COCHRANE DATABASE OF SYSTEMATIC REVIEWS'), while the citation impact of all publications in other journals was lower ('BMC HEALTH SERVICES REPORT') or higher than the world average ('SCIENTIFIC REPORTS'). For most benchmark units the citation impact in the majority of journals, even the ones listed in Figure 5.2, is based on a small number of publications. Since this often results in unstable citation indicators, the citation indicators of publication output in journals by units is not presented here.

While many HRB researchers may choose to publish in journals with an MNJS at or slightly above world average, HRB researchers have also successfully published in the top ranked journals in the world. Table 5.2 presents HRB-supported papers by journal and global ranking (SJR ranking 2016 top 100 in all categories) for the 2013-16 publishing period.

Table 5.2 HRB-supported papers by journal and journal ranking

Journal	No of Papers 2013-16	SJR Ranking	Global ranking
NATURE REVIEWS IMMUNOLOGY	1	26.85	7
NATURE GENETICS	1	23.76	11
NATURE	1	21.936	12
IMMUNITY	1	16.214	25
LANCET	3	14.638	29
NEW ENGLAND JOURNAL OF MEDICINE	1	14.619	30
NATURE IMMUNOLOGY	2	13.253	44
SCIENCE	1	13.12	50
LANCET NEUROLOGY	3	11.104	64
JOURNAL OF EXPERIMENTAL MEDICINE	1	10.762	66
SCIENCE TRANSLATIONAL MEDICINE	3	8.931	90
AMERICAL JOURNAL OF HUMAN GENETICS	2	8.769	95
CELL REPORTS	3	8.588	101

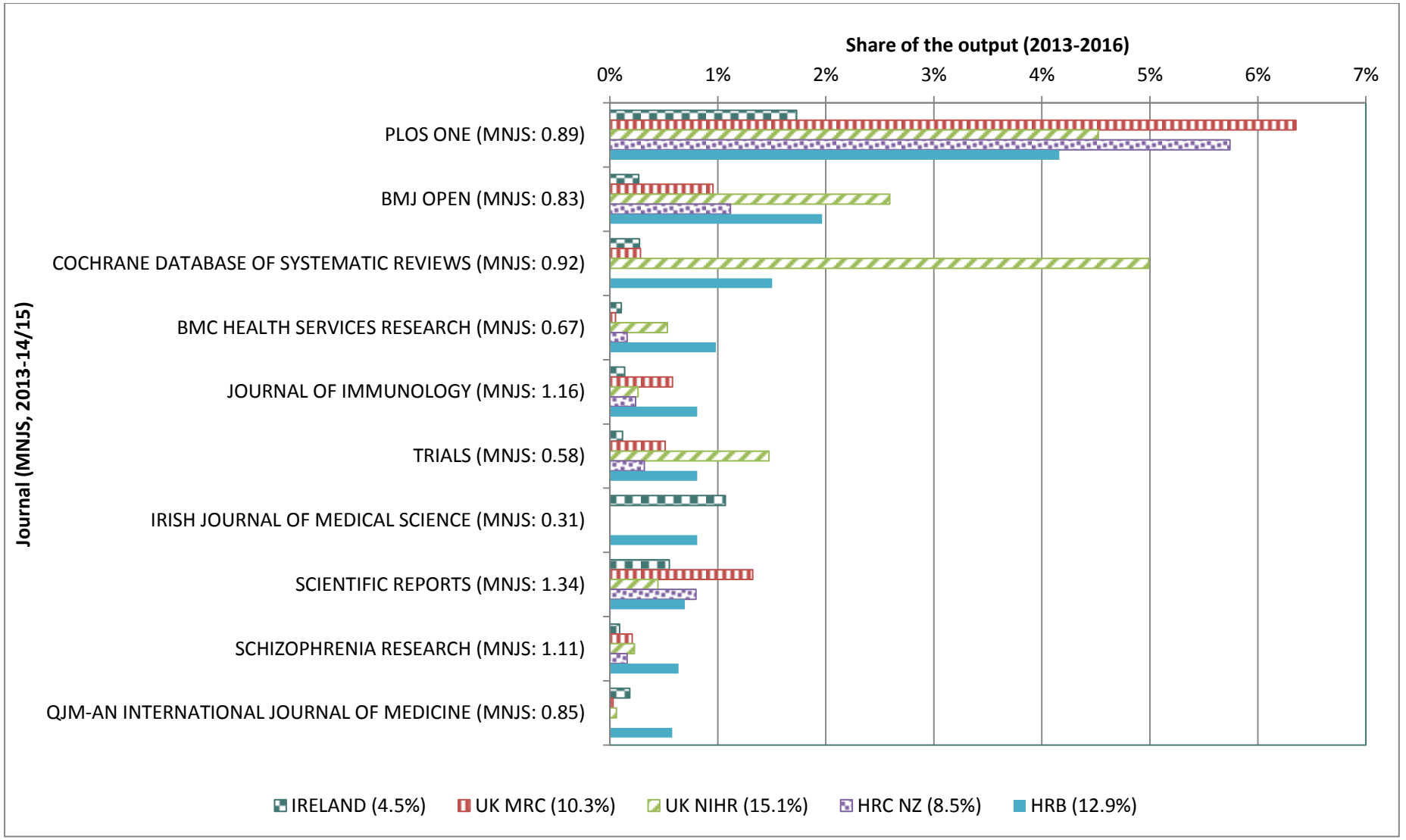

Figure 5.1 Journal profiles of HRB and benchmark units (share of output)

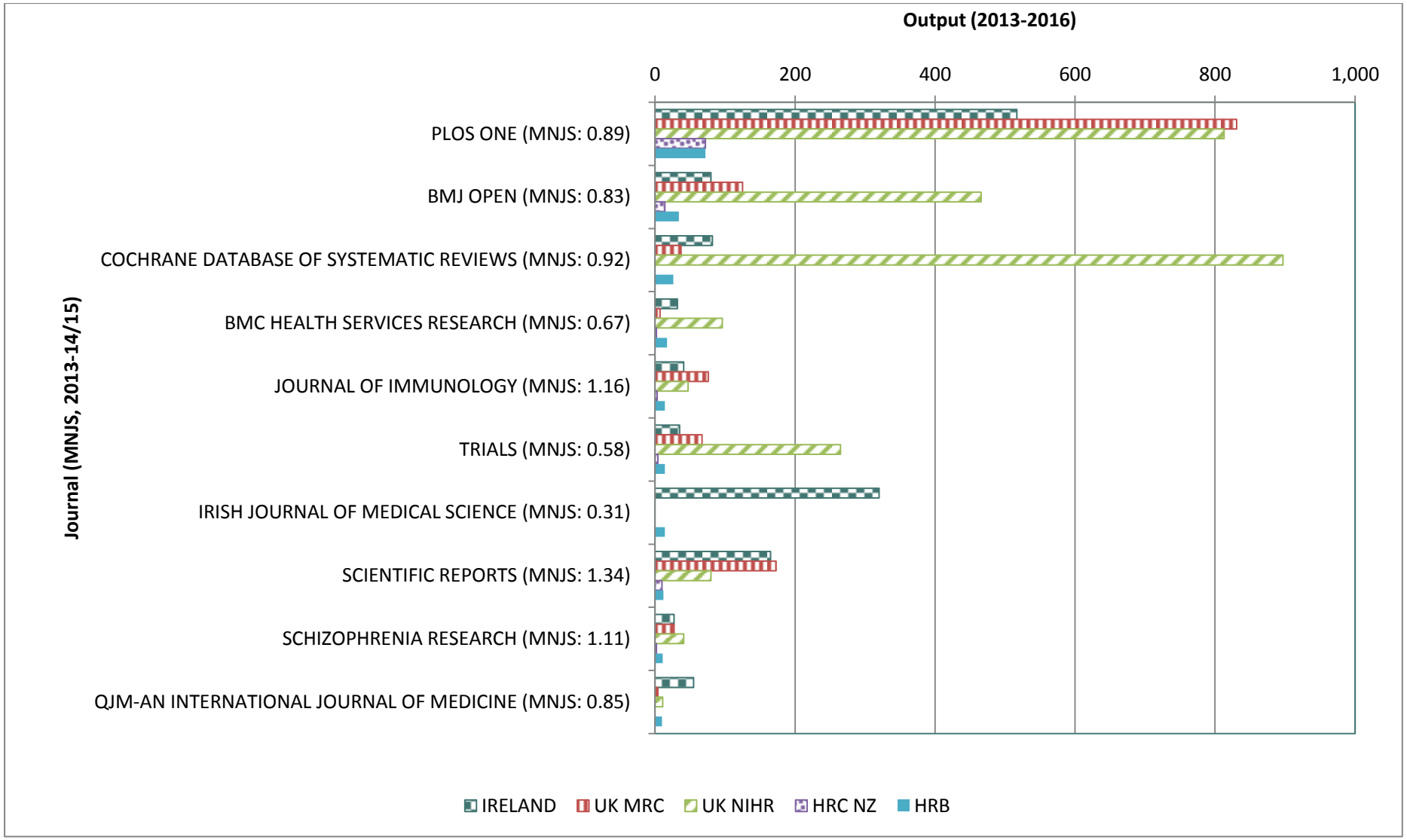

Figure 5.2 Journal profiles of HRB and benchmark units (output)

5.3 Research profile by field

This section of the report analyses trends in papers and citation impact by the most important disciplinary fields associated with publication output funded by the HRB and compares these research profiles to the benchmark units. The fields used are WoS subject categories. Each journal is fully assigned to one or more WoS subject categories (see Appendix III and IV). Thus, those subject categories consist of sets of journals (and, as such, are sets of articles, reviews, and letters). In the Figures presented in this report, the share of the output is defined by the research output during the period 2013 to 2016 while the citation impact indicators are limited to the period 2013 to 2014 for publications and 2013 to 2015 for citations.

5.3.1 Comparison of HRB output share and MNCS by field 2006 to 2016

Table 5.3 compares HRB publication output by WoS journal category across 2006-2012 (7 years) and 2013-2016 (3.5 years), therefore, total numbers of publications would be expected to be lower in all categories in the 2013-2016 period. What this table demonstrates is that there has been a shift in the WoS categories associated with HRB publications over the two publication periods, which reflects the shift in focus of HRB investment towards patient oriented, population health sciences and health services research since 2010 in particular. For example, in 2006-12, 'Biochemistry & Molecular Biology' accounted for the largest share of HRB publications, while in 2013-16 'Medicine, General & Internal' was associated with the largest share of HRB publications, and 'Biochemistry & Molecular Biology' was the 5th most common category with which HRB publications were associated. 'Neuroscience' and 'Oncology' continue to be important categories for HRB researchers. 'Psychiatry' accounted for a greater share of total publication output in 2013-16 (4th) than in 2006-2012 (9th). In contrast, publications associated with 'Immunology' moved from 4th in 2006-12 to 10th in 2013-16.

Table 5.3 HRB publications and citation impact by WoS journal category, 2006-16

Web of Science^{SM} journal category	Code	Papers		Citation impact	
		06-12	13-16*	06-12	13-16
Biochemistry & Molecular Biology	BioChem	354	76	1.16	1.21
Oncology	Oncol	252	80	2.41	1.10
Neurosciences	NeuroSci	233	111	1.34	1.25
Immunology	Immun	172	56	2.21	1.84
Cell Biology	CellBio	178	59	0.82	1.50
Pharmacology & Pharmacy	Pharma	150	64	1.72	1.71
Microbiology	MicroBio	151	33	1.51	1.44
Genetics & Heredity	Genetics	142	36	2.24	2.05
Psychiatry	Psychiatry	137	77	2.71	1.82
Clinical Neurology	ClinNeuro	119	68	2.52	1.37
General & Internal Medicine	GenMed	104	118	2.12	1.12
Research & Experimental Medicine	ExpMed	89	43	1.20	0.79
Infectious Diseases	InfectDis	86	16	1.28	1.59
Biotechnology & Applied Microbiology	BioTech	75	23	1.75	1.34
Gastroenterology & Hepatology	Gastro	70	20	1.85	1.2
Haematology	Haema	73	13	0.94	0.76
Endocrinology & Metabolism	Endo	70	56	0.96	1.89
Public, Environmental & Occupational Health	PubHlth	82	52	1.02	0.82
Biophysics	BioPhys	58	7	1.35	0.81
Peripheral Vascular Disease	Vasc	59	24	1.34	1.79

* 2013-16 contains only 3.5 years of publication output while 2006-12 contains 7 years of publication output

As well as the publication output, changes in the citation impact of HRB funded publications in the different fields of activity are interesting to examine. It was noted that for many of the top 16 WoS categories that accounted for the largest share of HRB publication, the MNCS of HRB publications was less in many instances, when compared to the 2006-12 publication period. For example:

Citation impact is lower, but still above world average (1.0 MNCS):

- Medicine, General and internal (2.04 to 1.12)
- Neuroscience (1.30 to 1.25)
- Oncology (2.32 to 1.10)
- Psychiatry (2.61 to 1.82)
- Clinical Neurology (2.45 to 1.37)
- Immunology (2.26 to 1.84)
- Genetics & Heredity (2.06 to 1.06)

Citation impact is lower than world average (1.0 MNCS):

- Public, Environmental & Occupational Health (1.02 to 0.82)
- Obstetrics & Gynaecology (1.13 to 0.97)
- Medicine, Research & Experimental (1.20 to 0.79)

However, it must be borne in mind that a publication accumulates citation counts when it is referred to by more recent publications; therefore older papers have generally more citations that recent work, and consequently a higher MNCS. Papers less than eight years old are, on average, still accumulating additional citations. Citation rates may also vary between disciplines and fields.

It was also found that the citation impact of the top 16 WoS categories associated with HRB publications in 2013-2016 was higher than the 2006-2012 publication period for some fields, indicating that these more recent papers are being highly cited by peers, which is a strong indicator of quality.

Citation impact is higher in 2013-2016 than 2006-2012 publication period:

- Biochemistry & Molecular Biology (1.17 to 1.21)
- Pharmacology & Pharmacy (1.64 to 1.71)
- Cell Biology (0.84 to 1.50)
- Endocrinology & Metabolism (0.91 to 1.89)

There were also a number of WoS categories associated with HRB publications that had accumulated citation impacts (MNCS) greater than twice the world average and in some cases many times the world average. These publications represented 7.5% of total HRB publication output. Table 5.4 lists the subject categories, number of publications and the MNCS score that these papers had already accumulated by the end of 2016. Their citation impact would be expected to increase even further in the coming years, given that they have been so highly cites so soon after publication.

Table 5.4 Publications and citation impact for highest scoring HRB publications 2013-16

Subject category	Number of publications	MNCS
ALLERGY	1	9.19
GERONTOLOGY	6	6.82
PARASITOLOGY	2	5.07
PLANT SCIENCES	1	4.84
SPORT SCIENCES	16	4.24
BEHAVIORAL SCIENCES	11	3.04
RHEUMATOLOGY	14	2.97
SOIL SCIENCE	1	2.78
GERIATRICS & GERONTOLOGY	24	2.74
BUSINESS, FINANCE	1	2.52
PATHOLOGY	9	2.51
MATERIALS SCIENCE, BIOMATERIALS	12	2.36
ECONOMICS	4	2.26
ORTHOPEDICS	12	2.12
AGRICULTURE, DAIRY & ANIMAL SCIENCE	1	2.10
CARDIAC & CARDIOVASCULAR SYSTEMS	21	2.04

5.3.2 Comparison with benchmark units – share of publication output

Figures 5.3a and 5.3b together represent the 16 most important fields of activity funded by the HRB by share of publication output. All WoS subject categories containing at least 2% of HRB's research output were included. Except for Ireland as a whole, Figures 5.3a/b represents around 30% and 25% of the publication output of HRB and its benchmark units, respectively, and together they represent around 55%-60% of those units' publication output. Given the focus on biomedical fields as compared to the broad range of fields covered by all Irish researchers, the difference between Ireland and the other units is understandable.

For the HRB share of output, 'Medicine, General & Internal' (6.8%) and 'Neuroscience' (6.4%) were the most productive fields in terms of publications. In comparison with the other benchmark units, HRB did not have an extreme focus on particular research fields within its fields of activity. Some benchmark units, however, did have a strong focus. The UK NIHR had a much larger share of its total output in 'Medicine, General & Internal' as compared with the other benchmark units, but this also applies to the HRB to a limited extent. The UK MRC had a comparatively large number of publications in 'Biochemistry & Molecular Biology', and 'Cell Biology'. Finally, the HRC NZ had a comparatively large share of its publication output in 'Endocrinology & Metabolism' and 'Public, Environmental & Occupational Health'. All funding benchmark units except the UK NIHR had a focus on 'Neurosciences' (a top three subject category for the HRB, HRC NZ, and UK MRC).

5.3.3 Comparison with benchmark units – field citation impact (MNCS)

Figures 5.4a and 5.4b present the citation impact of HRB and its benchmark units in terms of mean normalized citation score (MNCS). With a few exceptions ('Public, Environmental & Occupational Health', 'Obstetrics & Gynaecology', 'Medicine, Research & Experimental'), all funding organisations performed

(considerably) above world average. Thus, the MNCS score ranged from 1.00 (world average) to 2.00 for the benchmark units.

Although the citation impact of publications funded by the HRB was higher than the citation impact by all publications linked with Ireland (see Chapter 3), this pattern was not consistent at the field level, because there were some fields for which the citation impact by all Irish research publications was (slightly) higher (e.g. 'Biochemistry & Molecular Biology' and 'Cell Biology').

The most important field of activity in terms of research output, 'Medicine, General & Internal', had a broad range of citation impact scores across the benchmark units, ranging from around 0.75 (Ireland) to around 4.00 (UK MRC) (see Figure 5.4a). Publications funded by any of the benchmark funding organisations (including HRB) attracted a high citation impact in the field of 'Psychiatry' (MNCS of around 2.00). While UK MRC and UK NIHR had the highest citation scores in many fields, the HRB's citation impact was similar to HRC NZ's score in many fields. The HRB had a comparatively high citation impact score in the fields 'Pharmacology & Pharmacy' and 'Endocrinology & Metabolism', although the HRB's score in 'Pharmacology & Pharmacy' was not as strong in terms of PP(top 10%). A comparatively large share of publication output funded by the HRB has been published in the field 'Pharmacology & Pharmacy' (Figure 5.4a). Except for a few cases (e.g. HRB in 'Pharmacology & Pharmacy', HRC NZ in 'Medicine, General & Internal'), the citation impact scores in terms of MNCS were confirmed in a similar share of highly cited publications.

5.3.4 Research Profile for Grant Type and Strategic Pillar

For some Grant Types, there was a clear focus on a limited number of research fields:

- Capacity-building and Leadership: 'Medicine, General & Internal', 'Clinical Neurology'
- Infrastructure and Networks: 'Medicine, General & Internal', 'Nutrition & Dietetics', 'Obstetrics & Gynaecology'

In the case of Co-funded Awards and Project and Programmes there was no concentration of publication output in such a limited number of fields. Given that these awards span all of the Strategic Pillars, and the broad spectrum of health research, this finding was to be expected.

The citation impact differed very much per field and per Grant type. The citation impact at Grant level can reveal patterns underlying HRB's aggregate results. For instance, the high share of highly cited publications in the field of 'Psychiatry' resulted from publications that belonged to the Grant Types 'Capacity-building and Leadership' and 'Projects and Programmes'. Some fields (e.g. 'Endocrinology & Metabolism', 'Immunology') with a relatively high HRB impact showed a huge range of citation impact scores among Grant Types.

Similar differences in share of output, citation impact and the range of citation impact scores were found for the Strategic Pillars. There was a stronger focus on a limited number of fields in each of the Strategic Pillars, with a maximum of nine fields needed to cover more than 50% of the publication output of each Strategic Pillar. For all HRB publications, at least 12 fields accounted for more than 50% of the publication output. This concentration of publication output in a smaller number of fields was not the case for the two most important Grant Types ('Capacity-building and Leadership' and 'Projects and Programmes').

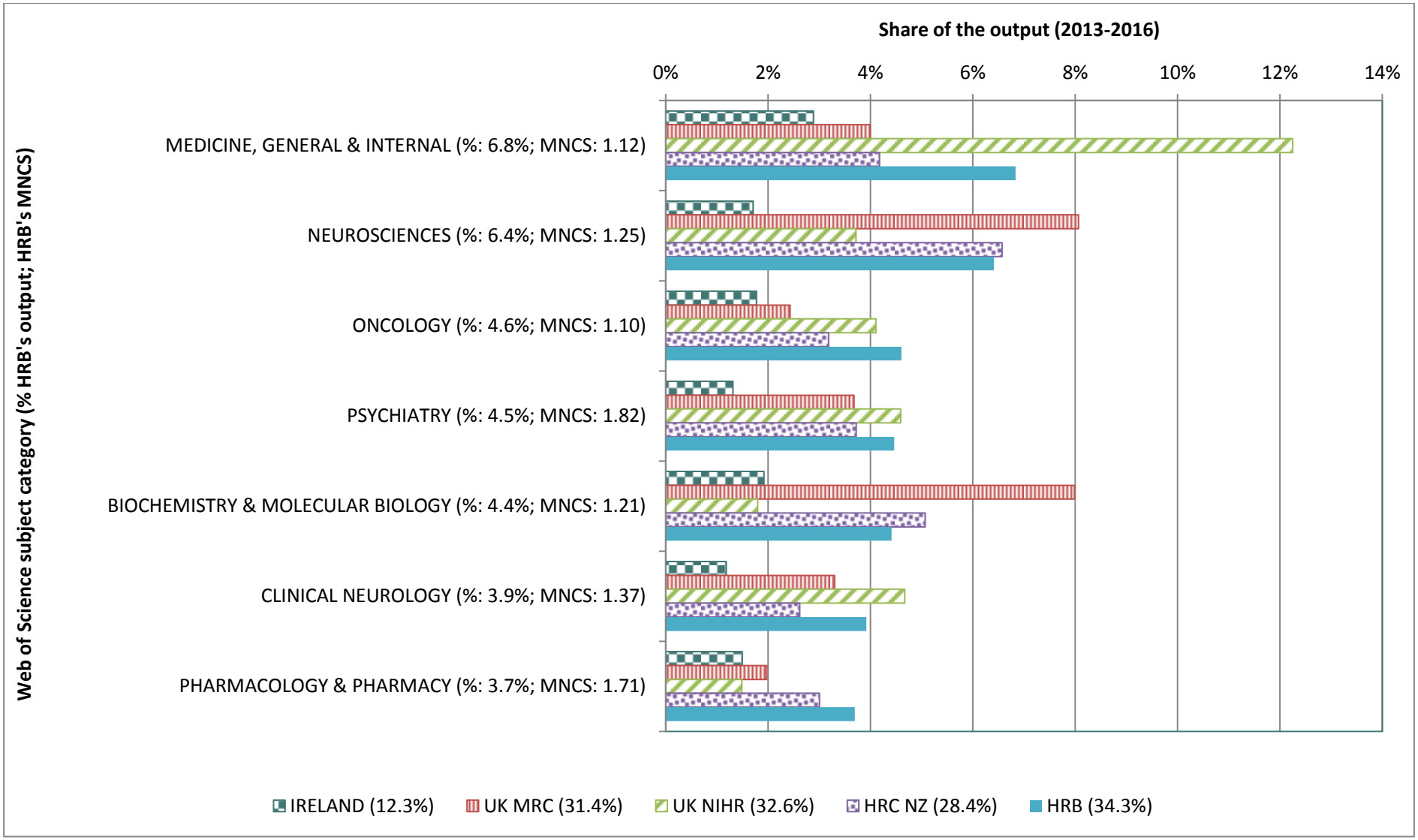

Figure 5.3a Research profiles of HRB and benchmark units (share of output, part 1)

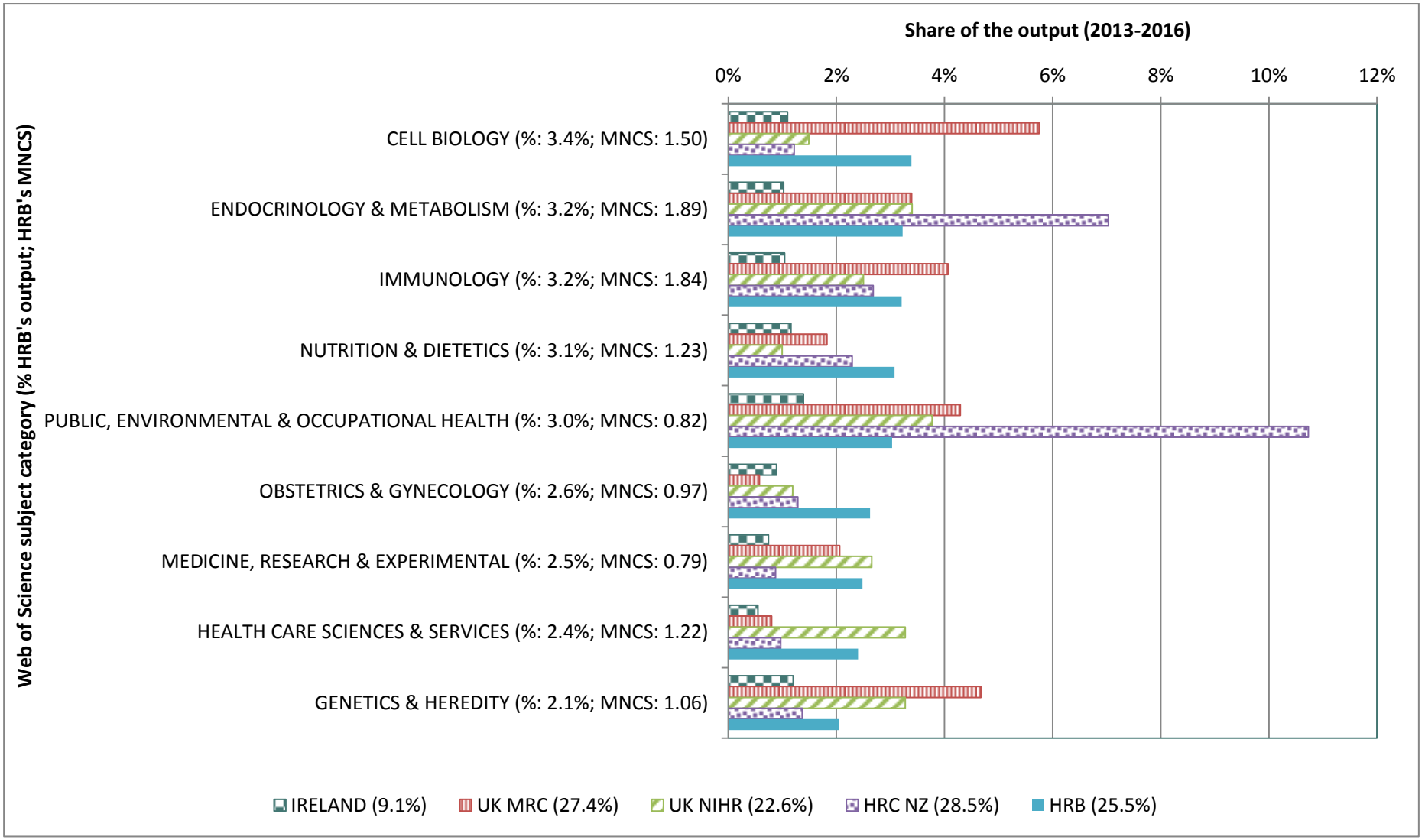

Figure 5.3b Research profiles of HRB and benchmark units (share of output, part 2)

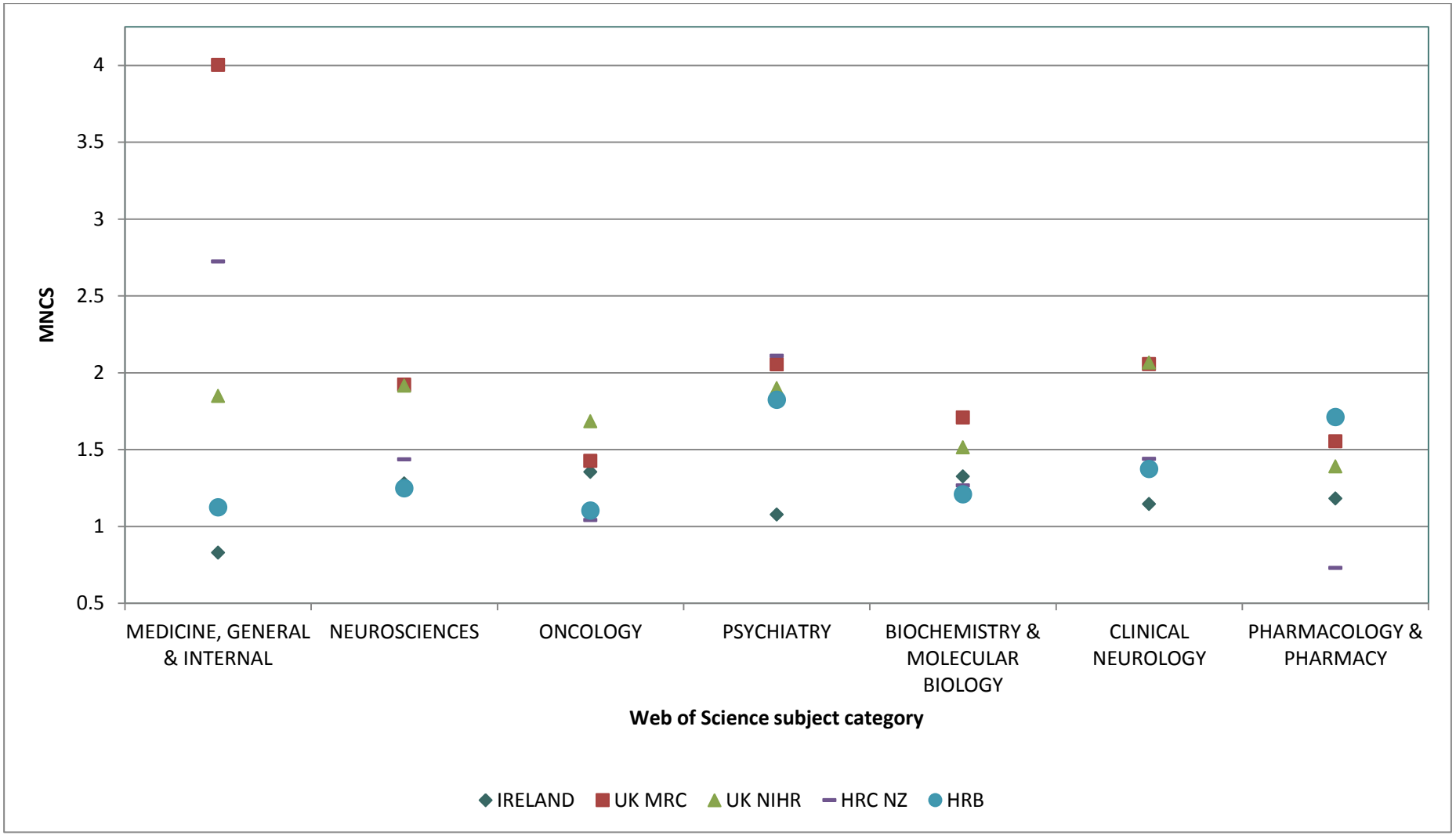

Figure 5.4a Research profiles of HRB and benchmark units (citation impact (MNCS), part 1)

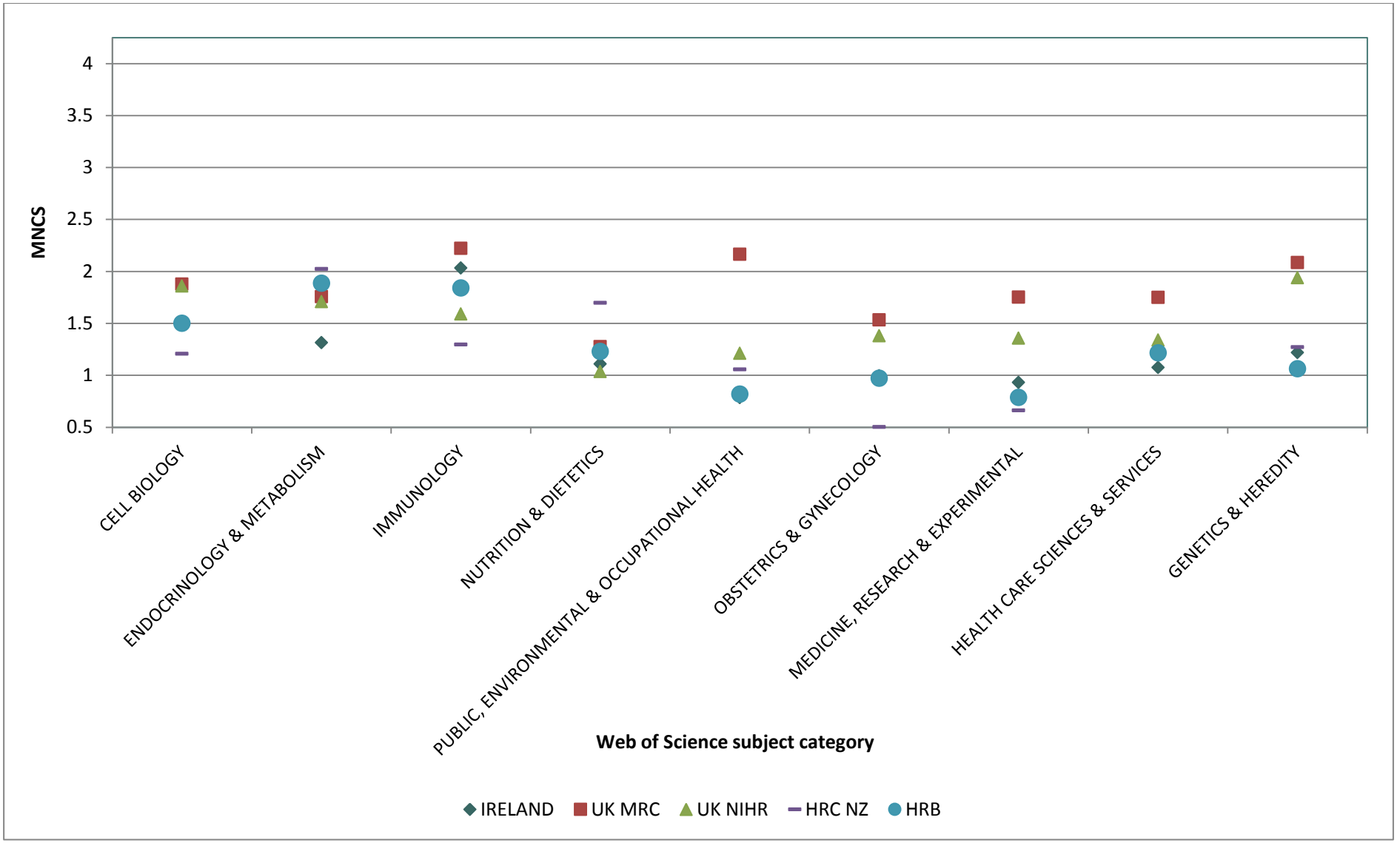

Figure 5.4b Research profiles of HRB and benchmark units (citation impact (MNCS), part 2)

6. Co-authorship and Collaboration

In this chapter, the co-authorship pattern of HRB funded research both at the aggregate level as well as at the level of Grant Types and Strategic Pillars is presented, next to the co-authorship performance by HRB's benchmark units.

Internationally co-authored research is a rapidly growing element of research activity. The reasons for this have not been fully clarified but include increasing access to facilities and resources, increasing access to knowledge and increasing access to people and expertise. In addition, international co-authorship is shown to be associated with an increase in the number of citations received by research papers, although this depends on the partner countries involved. Co-authorship is likely to be a good indicator of collaboration, although there may be collaborations that do not result in co-authored papers, and there may also be co-authored papers that required limited collaboration.

Key findings

- Approximately half of HRB publication output resulted from international co-authorships, and the other half of publication output was split equally between national co-authorship, and institutional co-authorship. Compared to Ireland as a whole, HRB funded researchers had fewer international co-authorships and more national co-authorships.
- As compared with Ireland as a whole, HRB funded researchers were less involved in international co-authorship, and had more publications resulting from national collaboration.
- There is strong collaboration between Irish institutions and university hospitals, and with institutions worldwide, that have resulted in co-authored publications
- For all of the benchmark units, publications resulting from international co-authorship yielded the highest citation impact (both MNCS and PP(top 10%). However, for both of these indicators HRB funded non-collaborative publications (i.e. those in which the authors were from the same institution) had the highest citation impact.
- The share of publications arising from different co-authorship types for HRB Grant Types roughly resembled the co-authorship profile of HRB at the aggregate level. However, the citation impact (MNCS and PP(top 10%) varied according to Grant Type.
- Publications resulting from international co-authorship had the largest share across all of the HRBs Strategic Pillars.
- Publications arising from the Strategic Pillar 'Health Services Research' and 'Clinical Research' had the highest citation impacts for non-collaborative publications (1.8 and 1.68, respectively).

6.1 HRB and benchmark units

Three mutually exclusive co-authorship types can be identified on the basis of address information of publications indexed in the Web of Science, which are taken to indicate the level of collaboration outside of an institution (either nationally or internationally):

- No external co-author: the address information in the publication contains a single institutional address. Such publications can have multiple authors from the same institution (e.g. multiple authors from different schools of a university).

- National co-authors: the address information in the publication contains addresses from one country but from at least two different institutions.
- International co-authors: the address information in the publication contains addresses from at least two countries.

Apart from these collaboration patterns, CWTS has provided a digital interactive collaboration network map that reveals collaborative patterns of the research institutions involved in research funded by the HRB[9]. A static portrayal of this network is presented in Figure 6.1, while the digital map provides a dynamic network analysis that details the publication history of each institution. From Figure 6.1 it is clear that there is strong collaboration between Irish institutions and university hospitals, and with institutions worldwide, that have resulted in co-authored publications.

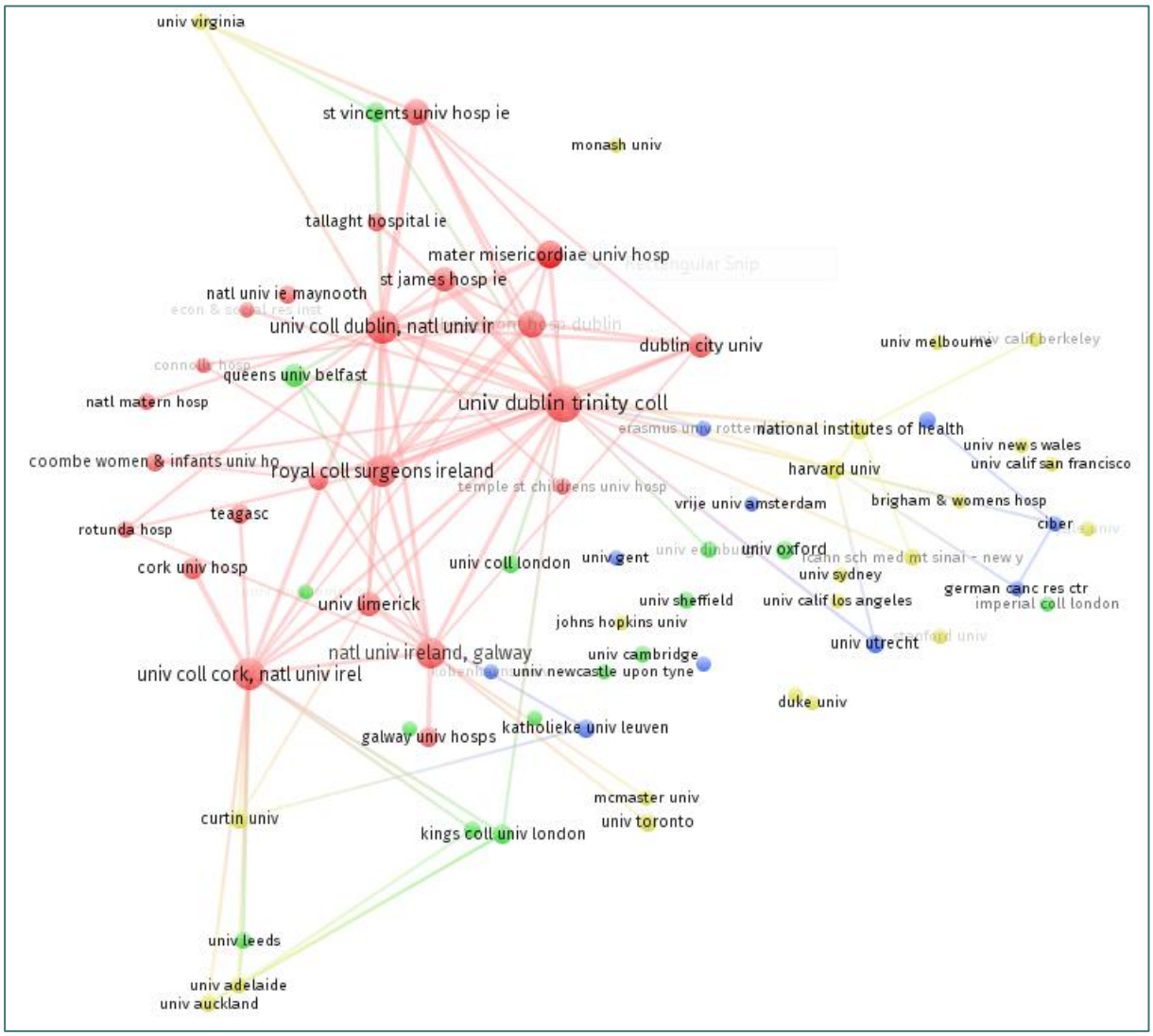

Figure 6.1 Collaboration network map of the research institutions involved in research funded by the HRB

[9] Digital interactive collaboration network link: http://www.vosviewer.com/vosviewer.php?map=https://www.cwts.nl/projects/2016_ie_hrb/map_file_fixed_coordinates.txt&network=https://www.cwts.nl/projects/2016_ie_hrb/network_file_fixed_coordinates.txt&scale=1.25&label_size_variation=0.4&line_size_variation=0.5&n_lines=100

Figure 6.2 shows that for both HRB and its benchmark units, the largest share of publication output (2013-2016) resulted from international collaboration. For most units, the share of publications resulting from international collaboration was around 50% to 60%. For HRB funded internationally co-authored papers, there has been a steady upward trend over time and such papers have risen from 33.8% (2000-04) and 43.8% (2008-12) to 48% of all HRB publications in the 2013-16 publication period.

The proportion of publications resulting from national collaboration or from no collaboration outside of the authors' institution differs per benchmark unit. For the HRB, both publication types had more or less an equal share (around 25%). This was also the case for UK MRC (though the share is lower, around 20%).

As compared with Ireland as a whole, HRB funded researchers were less involved in international co-authorship, and had more publications resulting from national collaboration. A comparatively large share of publications funded by HRC NZ did not result from collaboration while UK NIHR had the highest share of publications stemming from national collaboration and the lowest share of publications resulting from non-collaboration.

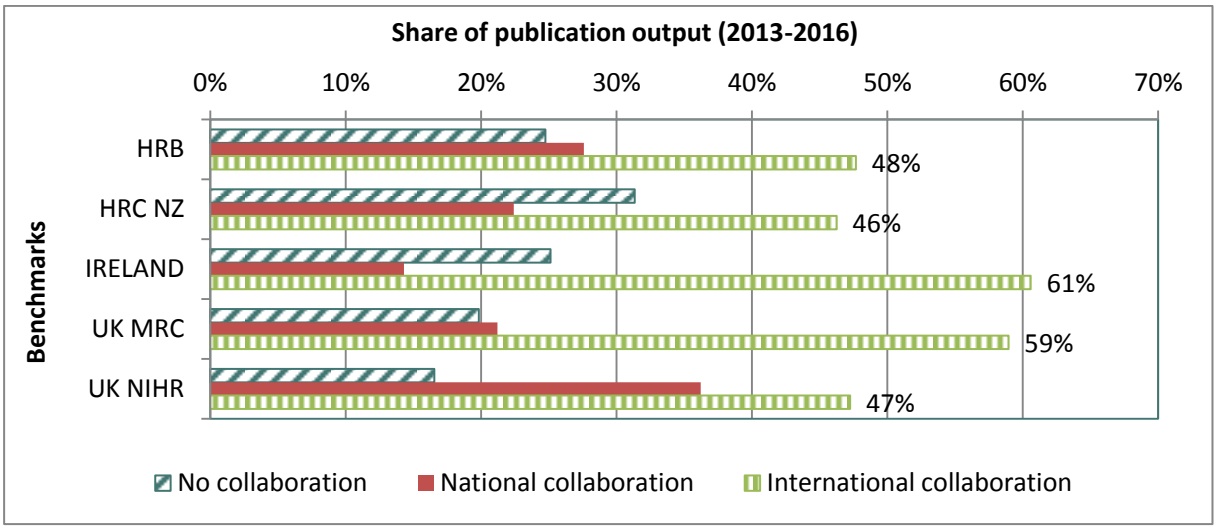

Figure 6.2 Collaboration profiles of HRB and benchmark units (share of output)

The citation impact (MNCS) and share of top 10% of highly cited papers in a field are presented in Figures 6.3 and 6.4, respectively. It was found that for all of the benchmark units, publications resulting from international co-authorship yielded the highest citation impact. However, this was not the case for HRB whose non-collaborative publications (i.e. those in which the authors were from the same institution) had the highest citation impact. Such publications were also the ones with the largest difference in citation impact when compared with the impact of non-collaborative publications from all researchers based in Ireland.

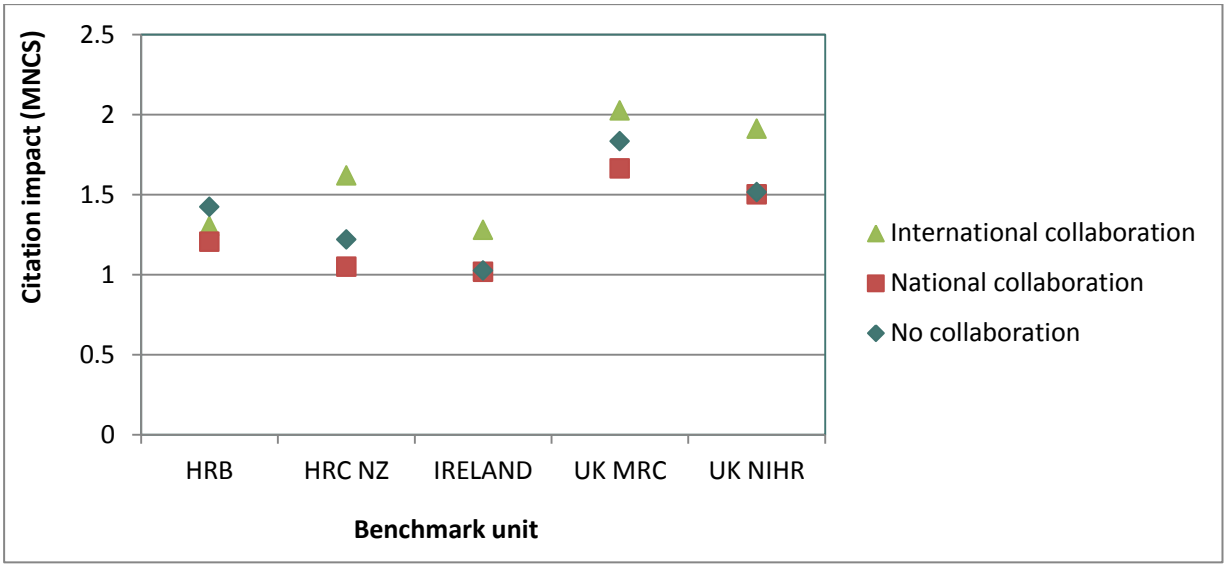

Figure 6.3 Collaboration profile of HRB and benchmark units (impact: MNCS)

Except for international collaboration, HRB funded publications had a higher citation impact than publications funded by the HRC NZ. However, publications funded by the HRB had a lower citation impact on any of the collaboration types than publications funded by UK MRC or UK NIHR. Comparing Figure 6.4 with 6.3 leads to the conclusion that outliers did not have a strong influence on the mean based MNCS indicator.

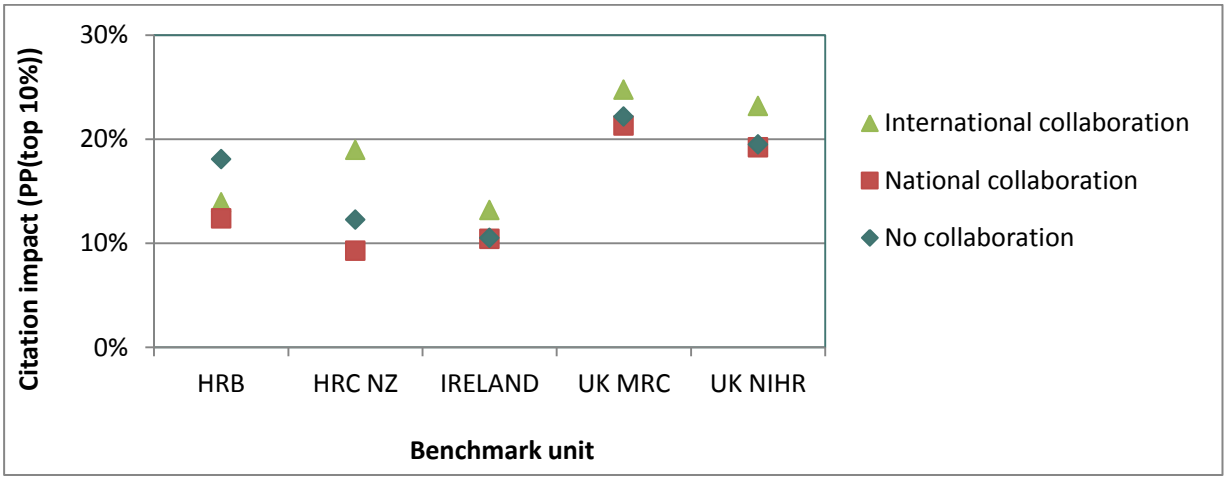

Figure 6.4 Collaboration profile of HRB and benchmark units (impact: PP(top 10%))

6.2 Grant Types

The share of different collaboration types for the Grant Types roughly resembled the collaboration profile of HRB at the aggregate level (Figure 6.5). The largest share of publications was the result of international collaboration for any of the Grant Types. 'Capacity-building & Leadership' had the largest share of publications resulting from international collaboration. At the same time, this Grant type's share of non-collaborative publications was lower than the share of such publications at the aggregate level of the HRB, while publication output within the boundaries of the same country was similar to the HRB's share of national collaboration.

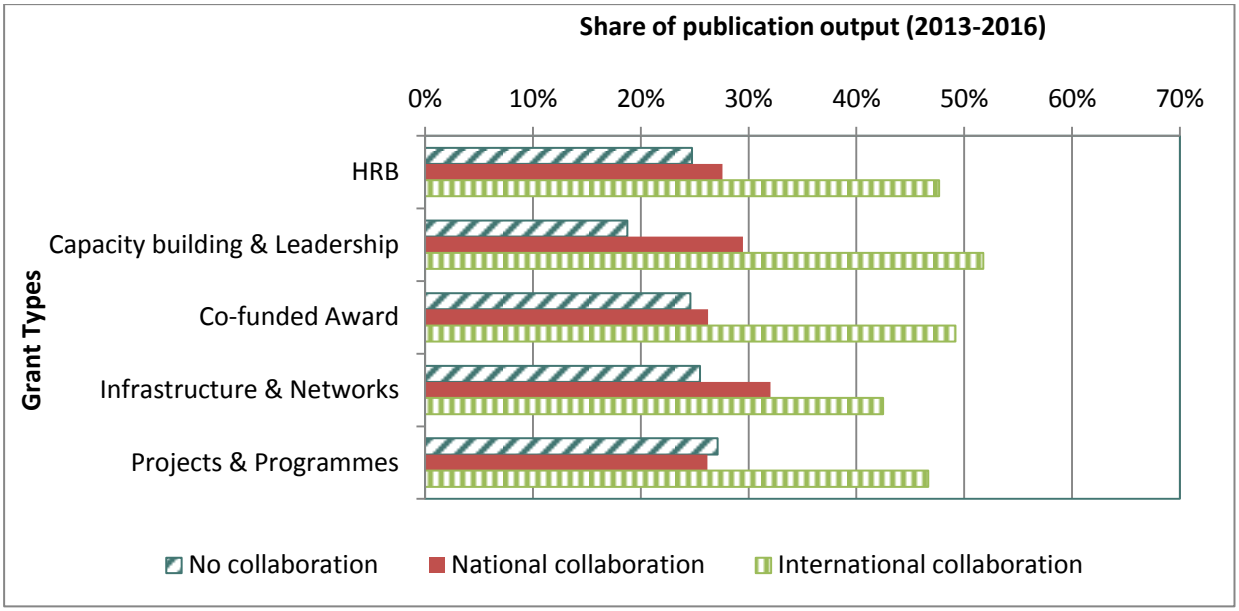

Figure 6.5 Collaboration profiles of HRB Grant Types (share of output)

Citation impacts are presented in Figure 6.6 (MNCS) and Figure 6.7 (PP(top 10%). The citation impact for the Grant Types 'Capacity-building & Leadership' and 'Projects & Programmes' was comparable to the citation impact of the HRB at the aggregate level, and these Grant Types comprised the majority of HRB funded publication output (26% and 62% respectively).

However, for other Grant Types the pattern was quite different. Although national collaboration was comparatively important for publications from 'Co-funded Awards' the citation impact of such publications was much lower than HRB aggregate MNCS, and was less than the world average. On the other hand, international co-authored publications arising from 'Co-funded Awards' had citation scores will over twice the world average (2.22). For 'Infrastructures & Networks' non-collaborative publications yielded a high citation impact (2.23), well over twice the world average, while internationally co-authored publications had an MNCS that was lower than the HRB aggregate .

However, since the number of publications per collaboration type was low for 'Co-funded Awards' publications and for the non-collaborative publications arising from 'Infrastructures & Networks' Grant Types (8-23 publications), individual publications may have had a strong influence on the final results of such small publication sets.

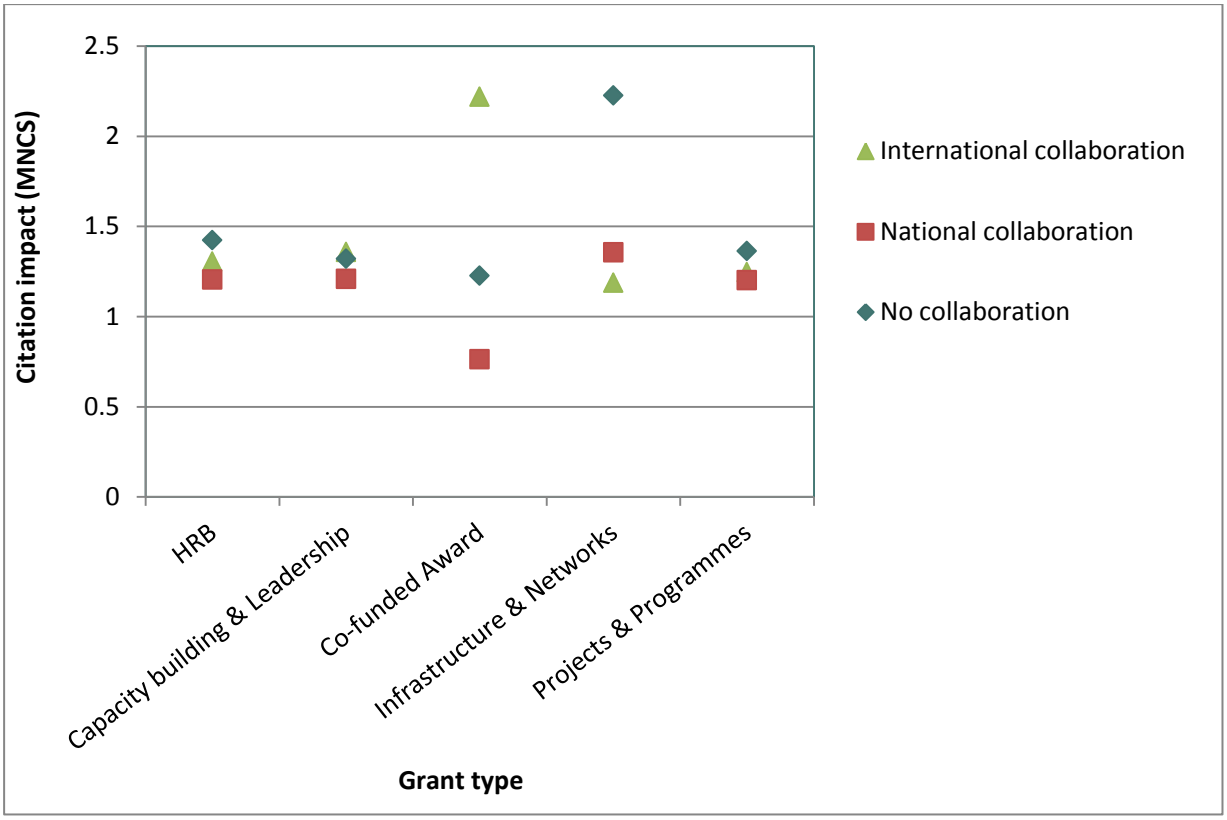

Figure 6.6 **Collaboration profile of HRB Grant Types (impact: MNCS)**

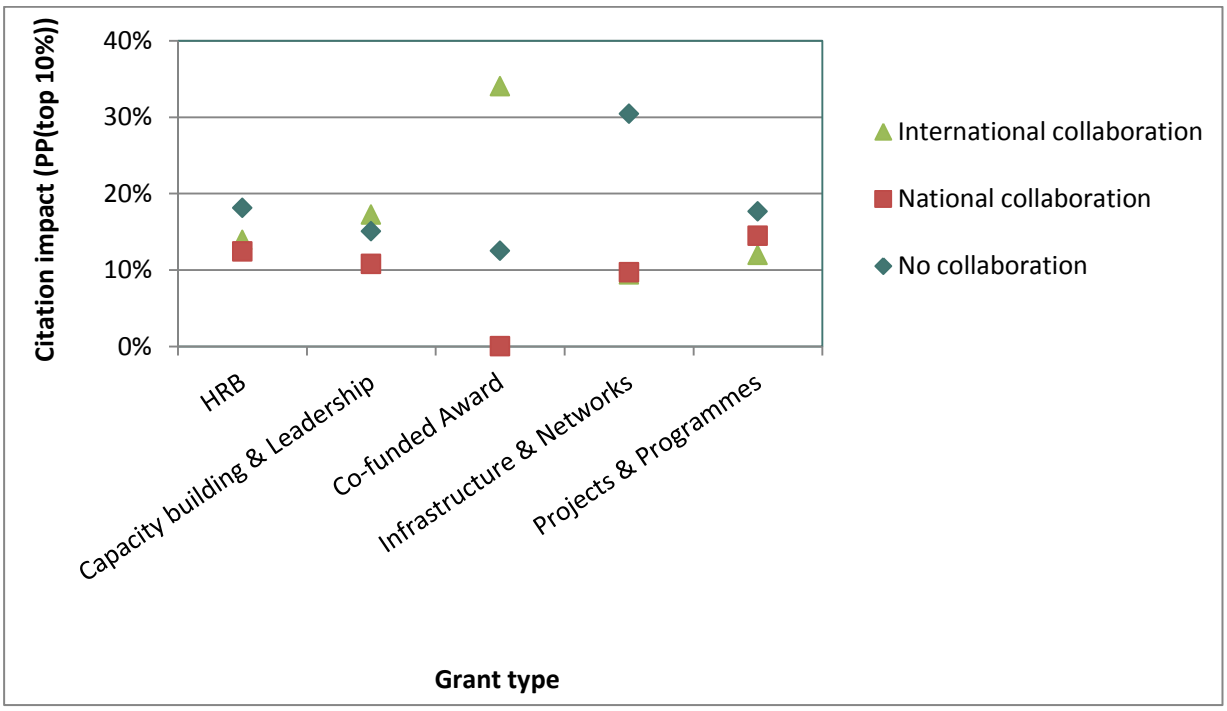

Figure 6.7 **Collaboration profile of HRB Grant Types (impact: PP(top 10%))**

6.3 Strategic Pillars

Figure 6.8 presents the collaboration profiles of the HRB Strategic Pillars. As with aggregated HRB funded publications, publications resulting from international collaboration had the largest share across all of the Strategic Pillars. Regarding the other collaboration types (national collaboration and non-collaboration), the shares of the publication output for the Strategic Pillar 'Applied Biomedical Research' was more or less comparable to HRB as a whole, but this is also HRB's largest Strategic Pillar (37%, see Chapter 2). In the Strategic Pillars 'Clinical Research', 'Health Services Research', and 'Population Health Sciences', the share of publications resulting from national collaboration was larger and the share of non-collaborative publications was lower than the share of such publications for HRB as a whole. The profile of 'Basic Biomedical Research' was very different as compared with the HRB's profile, but the number of publications in this Strategic Pillar was comparatively small, which may partly explain this deviant pattern.

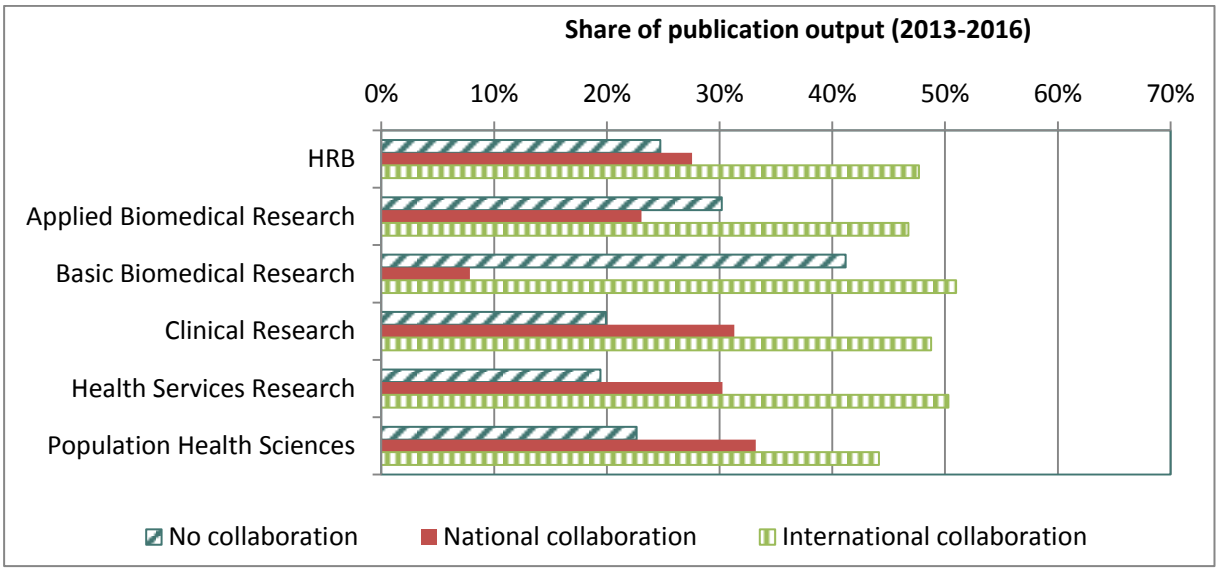

Figure 6.8 Collaboration profiles of HRB Strategic Pillars (share of output)

Regarding citation impact (Figures 6.9 and 6.10), two Strategic Pillars with a substantial number of publications differed considerably from the HRB's collaboration profile in terms of citation impact. Compared with all non-collaborative HRB publications, publications linked with the Pillars 'Clinical Research' and 'Health Services Research' had a much higher citation impact. The comparatively high citation impact for all non-collaborative HRB publications seems to be have been caused mainly by publications that belonged to these two Strategic Pillars. Whereas the citation impact of publications resulting from national collaboration was considerably lower for the Strategic Pillar 'Clinical Research', the publications resulting from international collaboration that belong to the Strategic Pillar 'Health Services Research' had a much higher citation impact than all HRB publications of the respective collaboration types.

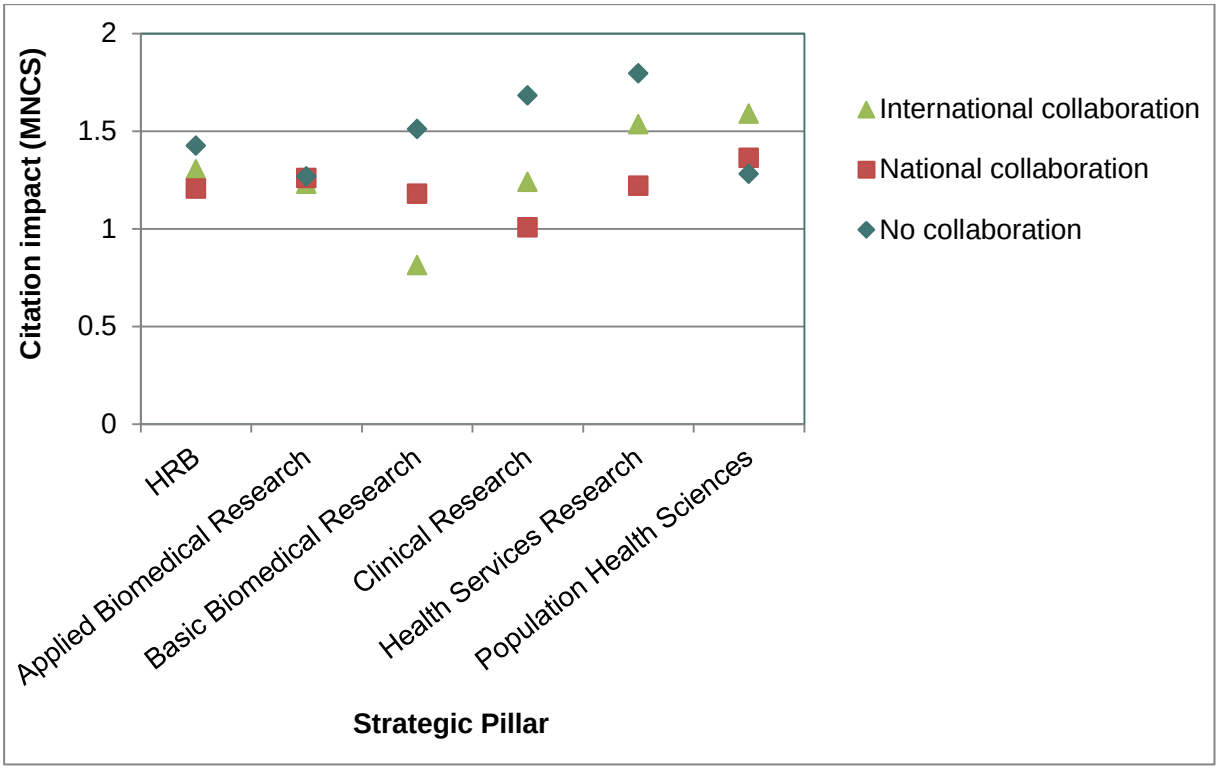

Figure 6.9 Collaboration profile of HRB Strategic Pillars (impact: MNCS)

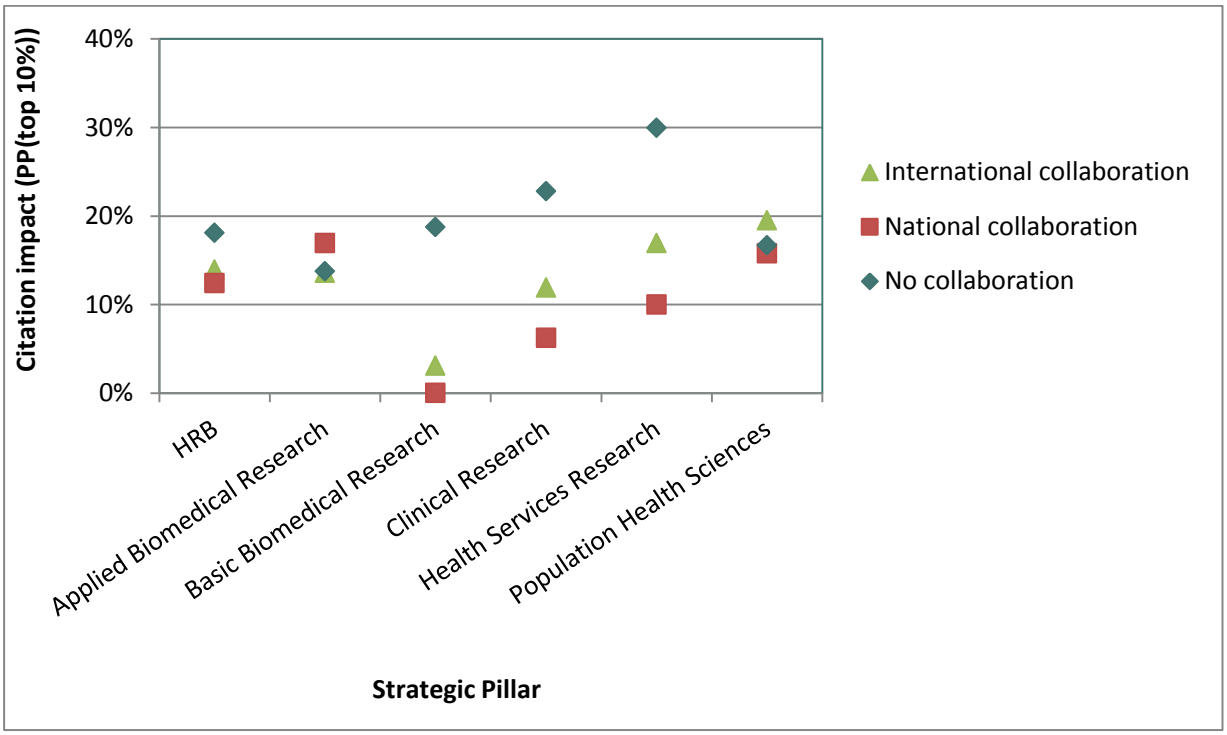

Figure 6.10 Collaboration profile of HRB Strategic Pillars (impact: PP(top 10%))

Appendix I: Bibliometric indicators

In this Appendix, we describe the methods underlying the present bibliometric analysis.

A1.1. Output indicator

The publication output indicator, denoted by P, measures the total publication output of a research unit. It is calculated by counting the total number of publications of a research unit, but including only publications covered by WoS. The counting method is full counting. We stress that letters, research articles and review articles are the only publication types that are taken into account. Other publication types, such as editorial material, meeting abstracts, and book reviews, are not included.

A1.2. Impact indicators

A number of indicators are available for measuring the scientific impact of the publications of a research unit. These indicators relate to the number of times publications have been cited.

Self-citations

In the calculation of all our impact indicators, we disregard author self-citations. We classify a citation as an author self-citation if the citing publication and the cited publication have at least one author name (i.e., last name and initials) in common. In this way, we ensure that our indicators focus on measuring only the contribution and impact of the work of a researcher on the work of other members of the scientific community. Sometimes self-citations can serve as a mechanism for self-promotion rather than as a mechanism for indicating relevant related work. The impact of the work of a researcher on his own work is therefore ignored.

Counting method

In computing the impact indicators, we apply the fractional counting method, where depending on the co-authorship nature of a publication only a certain fraction of the publication is assigned to the research unit. This is opposed to the full counting method. In case of full counting, publications are always fully assigned to research units, regardless of the collaboration nature of the authorship, e.g., single-authored, two authors from the same research unit, or two or more authors from the same or different countries. Impact indicators calculated using fractional counting tend to have lower values than impact indicators calculated using full counting. This is caused by for the fact that collaborative publications on average tend to have a higher citation impact than non-collaborative publications, which is corrected for in fractional counting. Since fractional counting corrects for differences in collaboration behaviour across fields, citation impact results can be compared more fairly across fields. A disadvantage may be, however, that fractional counting is sometimes perceived as less intuitive and more difficult to interpret than full counting.

Non-normalized indicators of citation impact

The total citation score (TCS) indicator gives the total number of citations received by the publications of a research unit. The mean citation score (MCS) indicator equals the average number of citations per publication.

The PP(uncited) indicator reports the number of uncited publications as a proportion of the total number of publications of a research unit.

Normalized indicators of citation impact

Usually, a recent publication has received fewer citations than a publication that appeared a number of years earlier. Moreover, for the same publication year, publications in for instance mathematics have usually received a much smaller number of citations than publications in for instance biology. This is due to the different citation cultures in different fields. To account for these age and field differences in citations, we use normalized citation indicators. In this case, citation impact indicators have been normalized at the level of Web of Science subject categories (hereafter: fields).

The mean normalized citation score indicator, denoted by MNCS, provides a more sophisticated alternative to the MCS indicator. The MNCS indicator is similar to the MCS indicator except that it performs a normalization that aims to correct for differences in citation characteristics between publications from different fields and between publications of different ages. To calculate the MNCS indicator for a unit, we first calculate the normalized citation score of each publication of the unit. The normalized citation score of a publication equals the ratio of the actual and the expected number of citations of the publication, where the expected number of citations is defined as the average number of citations of all publications (i.e., research articles and review articles) that belong to the same field and that appeared in the same publication year.

The MNCS indicator is obtained by averaging the normalized citation scores of all publications of a unit. If a unit has a value of one for the MNCS indicator, this means that on average the actual number of citations of the publications of the unit equals the expected number of citations. In other words, on average the publications of the unit have been cited equally frequently as publications that are similar in terms of field and publication year. An MNCS indicator of, for instance, two means that on average the publications of a unit have been cited twice as frequently as would be expected based on their field and publication year. We refer to Appendix II for an example of the calculation of the MNCS indicator.

Since the MNCS indicator is based on averages and since citation distributions tend to be highly skewed, the MNCS indicator may sometimes be strongly influenced by a single very highly cited publication. If a unit has one such publication, this is usually sufficient for a high score on the MNCS indicator, even if the other publications of the unit have received only a limited number of citations. Because of this, the MNCS indicator may sometimes seem to significantly overestimate the actual scientific impact of the publications of a research unit.

Therefore, in addition to the MNCS indicator, we use another important impact indicator. This is PP(top 10%), the proportion of the publications of a research unit that belong to the top 10% mostly frequently cited publications in their field and publication year.

For each publication of a research unit, the PP(top 10%) indicator determines, based on the number of citations of the publication, whether the publication belongs to the top 10% of all publications in the same field and the same publication year. The PP(top 10%) indicator equals the proportion of the publications of a research unit that are in the top 10% of their field and publication year. If a research unit has a value of 10% for the PP(top 10%) indicator, this means that the actual number of top 10% publications of the unit equals the expected number. A value of 20% for the PP(top 10%) indicator for instance means that a unit has twice as many top 10% publications as expected. We note that in addition to the PP(top 10%) indicator we also have the P(top 10%) indicator. This indicator equals the number of top 10% publications of a research unit. The P(top 10%) indicator is obtained by multiplying the PP(top 10%) indicator by the P indicator.

To assess the impact of the publications of a research unit, our general recommendation is to rely on the combination of the PP(top 10%) indicator and the MNCS indicator. These two indicators are strongly complementary to each other. The MCS indicator does not correct for field differences and should therefore be used only for comparisons of units that are active in the same field.

Indicators of journal impact

We use the mean normalized journal score indicator (MNJS) to measure the impact of the journals in which a research unit has published. For this, we first calculate the normalized journal score of each publication of the unit. The normalized journal score of a publication equals the ratio of on the one hand the average number of citations of all publications published in the same journal and field and in the same year and on the other hand the average number of citations of all publications published in the same field and the same year. The MNJS indicator is closely related to the MNCS indicator. The difference is that instead of the actual number of citations of a publication, the MNJS indicator uses the average number of citations of all publications published in a particular journal and field. The interpretation of the MNJS indicator is analogous to the interpretation of the MNCS indicator. If a unit has a value of one for the MNJS indicator, this means that on average the unit has published in journals that are cited equally frequent as would be expected based on their field. Likewise, a value of two for the MNJS indicator means that on average a unit has published in journals that are cited twice as frequently as would be expected based on their field.

A1.3. Indicators of scientific collaboration

Indicators of scientific collaboration are based on an analysis of the addresses listed in the publications produced by a research unit. We first identify publications authored by a single institution (‘no collaboration’). Subsequently, we identify publications that have been produced by institutions from different countries (‘international collaboration’) and publications that have been produced by multiple institutions from the same country (‘national collaboration’). These types of collaboration are mutually exclusive. Publications involving both national and international collaboration are classified as international collaboration.

Industrial collaboration gives insight into output and impact of publications resulting from collaboration with partners from the private sector.

Appendix II: Calculation of field-normalized indicators

To illustrate the calculation of the MNCS indicator, we consider a hypothetical research group that has only five publications. Table A1. provides some bibliometric data for these five publications. For each publication, the table shows the scientific field to which the publication belongs, the year in which the publication appeared, and the actual and the expected number of citations of the publication. The expected number of citations is the average number of citations per publication in a particular field. (For the moment, the last column of the table can be ignored.) As can be seen in the table, publications 1 and 2 have the same expected number of citations. This is because these two publications belong to the same field and have the same publication year. Publication 5 also belongs to the same field. However, this publication has a more recent publication year, and it therefore has a smaller expected number of citations. It can further be seen that publications 3 and 4 have the same publication year. The fact that publication 4 has a larger expected number of citations than publication 3 indicates that publication 4 belongs to a field with a higher citation density than the field in which publication 3 was published.

The MNCS indicator equals the average of the ratios of actual and expected citation scores of the five publications. Based on Table A1, we obtain

$$\text{MNCS} = \frac{1}{5}\left(\frac{7}{6.13} + \frac{37}{6.13} + \frac{4}{5.66} + \frac{23}{9.10} + \frac{0}{1.80}\right) = 2.08$$

Hence, on average the publications of our hypothetical research group have been cited more than twice as frequently as would be expected based on their field and publication year.

Table A1 Bibliometric data for the publications of a hypothetical research group.

Publication	Field	Year	Actual Citations	Expected Citations	Top 10% threshold
1	Surgery	2007	7	6.13	15
2	Surgery	2007	37	6.13	15
3	Clinical neurology	2008	4	5.66	13
4	Haematology	2008	23	9.10	21
5	Surgery	2009	0	1.80	5

To illustrate the calculation of the PP(top 10%) indicator, we use the same example as we did for the MNCS indicator. Table A1. shows the bibliometric data for the five publications of the hypothetical research group. The last column of the table indicates for each publication the minimum number of citations needed to belong to the top 10% of all publications in the same field and the same publication year.[10] Of the five publications, there are two (i.e., publications 2 and 4) whose number of citations is above the top 10% threshold. These two publications are top 10% publications. It follows that the PPtop10% indicator equals

$$PP_{top10\%} = \frac{2}{5} = 0.4 = 40\%$$

In other words, top 10% publications are four times overrepresented in the set of publications of our hypothetical research group.

[10] If the number of citations of a publication is exactly equal to the top 10% threshold, the publication is partly classified as a top 10% publication and partly classified as a non-top-10% publication. This is done in order to ensure that for each combination of a field and a publication year we end up with exactly 10% top 10% publications.

Appendix III: Selected *Web of Science℠* scope notes

Biochemistry & Molecular Biology is concerned with journals that deal with general biochemistry and molecular biology topics such as carbohydrates, lipids, proteins, nucleic acids, genes, drugs, toxic substances, and other chemical or molecular constituents of cells, microbes, and higher plants and animals, including humans. Journals that focus on biochemistry in cells, tissues or organs and those whose primary focus is the organism of study (such as plants, microbes, and so forth) are excluded, as are journals that focus on methods in biochemistry or molecular biology.

Biophysics covers journals that focus on the transfer and effects of physical forces and energy that is light; sound; electricity; magnetism; heat and cold; pressure; mechanical forces and radiation within and on cells, tissues, and whole organisms.

Biotechnology & Applied Microbiology includes journals that deal with a broad range of topics on the manipulation of living organisms to make products or solve problems to meet human needs. Topics include genetic engineering, molecular diagnostic and therapeutic techniques, genome data mining, bioprocessing of food and drugs, biological control of pests, environmental bioremediation, and bio-energy production. This category also covers journals that deal with the related social, business, and regulatory issues.

Cell Biology includes journals on all aspects of the structure and function of eukaryotic cells. The principle characteristic of journals in this category is an emphasis on the integration at the cellular level of biochemical, molecular, genetic, physiological, and pathological information. This category considers material on specific tissues, differentiated as well as embryonic.

Clinical Neurology covers journals on all areas of clinical research and medical practice in neurology. The focus is on traditional neurological illnesses and diseases such as dementia, stroke, epilepsy, headache, multiple sclerosis, and movement disorders that have clinical and socio-economic importance. This category also includes journals on medical specialties such as paediatric neurology, neurosurgery, neuroradiology, pain management, and neuropsychiatry that affect neurological diagnosis and treatment.

Endocrinology & Metabolism includes journals focused on endocrine glands; the regulation of cell, organ, and system function by the action of secreted hormones; the generation and chemical/biological properties of these substances; and the pathogenesis and treatment of disorders associated with either source or target organs. Specific areas covered include neuroendocrinology, reproductive endocrinology, pancreatic hormones and diabetes, regulation of bone formation and loss, and control of growth.

Gastroenterology & Hepatology includes journals on the anatomy, physiology, biochemistry, and pathology of the digestive system. This category includes specific journals on the prognosis and treatment of digestive diseases; stomach ulcers; metabolic, genetic, infectious and chemically induced diseases of the liver; colitis; diseases of the pancreas and diseases of the rectum.

General & Internal Medicine includes journals on medical specialties such as general medicine, internal medicine, clinical physiology, pain management, military and hospital medicine. Journals focusing on family medicine and primary health care services are placed in the Primary Health Care category.

Genetics & Heredity includes journals that deal with the structure, functions and properties of genes, and the characteristics of inheritance. This category also considers heritable traits, population genetics, frequency and distribution of polymorphism, as well as inherited diseases and disorders of the replicative process. The category is distinguishable from Biochemistry & Molecular Biology by its specific emphasis on the gene as a single functional unit, and on the gene's effect on the organism as a whole.

Haematology covers journals that deal with blood and blood-forming tissues, as well as the functions, diseases and treatments of these systems. Topics included are haemophilia, neoplastic disorders of the blood or lymphoid tissues, and mechanisms and disorders of thrombosis.

Immunology covers journals dedicated to all aspects of immune response and regulation, at the cellular-molecular level as well as the clinical level. Other topics include studies of the interaction between pathogens and host immunity, as well as clinical immunology, emerging immunotherapies, and the immunologic contribution to disease course.

Infectious Diseases includes journals on all aspects of the pathogenesis of clinically significant viral or bacterial diseases including HIV, AIDS, sexually transmitted diseases (STDs). This category is also concerned with journals on host-pathogen interactions, as well as the prevention, diagnosis, treatment, and epidemiology of infectious disease.

Microbiology includes journals dealing with all aspects of fundamental and applied studies of microorganisms, including bacteria, viruses, and fungi. This category also considers journals on the clinical aspects of the occurrence and treatment of microbial pathogens, basic science studies of microbial biochemistry and function, environmental microbiology and bacterial/viral uses in biotechnology.

Neurosciences covers journals on all areas of basic research on the brain, neural physiology, and function in health and disease. The areas of focus include neurotransmitters, neuropeptides, neurochemistry, neural development, and neural behaviour. Coverage also includes journals in neuroendocrine and neuroimmune systems, somatosensory system, motor system and sensory motor integration, autonomic system as well as diseases of the nervous system.

Oncology covers journals on the mechanisms, causes, and treatments of cancer, including environmental and genetic risk factors, and cellular and molecular carcinogenesis. Aspects of clinical oncology covered include surgical, radiological, chemical, and palliative care. This category is also concerned with journals on cancers of specific systems and organs.

Peripheral Vascular Disease covers journals on arterial occlusive disease (atherosclerosis or hardening of the arteries); venous obstruction and clotting; venous incompetence/insufficiency; cerebrovascular disease; aneurysms; vasospastic disorders, and other vascular disorders. This category also covers hypertension, circulation, and stroke. Journals on the diagnosis, treatment, and prevention of heart diseases are covered in the Cardiac & Cardiovascular Systems category.

Pharmacology & Pharmacy includes journals on the discovery and testing of bioactive substances, including animal research, clinical experience, delivery systems, and dispensing of drugs. This category also includes journals on the biochemistry, metabolism and toxic or adverse effects of drugs.

Psychiatry covers journals that focus on the origins, diagnosis, and treatment of mental, emotional, or behavioural disorders. Areas covered in this category include adolescent and child psychiatry, forensic psychiatry, geriatric psychiatry, hypnosis, psychiatric nursing, psychiatric rehabilitation, psychosomatic research, and stress medicine.

Public, Environmental & Occupational Health includes journals dealing with epidemiology, hygiene, and health; parasitic diseases and parasitology; tropical medicine; industrial medicine; occupational medicine; infection control; and preventive medicine. Also included are journals on environmental health; cancer causes and control; aviation, aerosol, and wilderness medicine.

Research & Experimental Medicine includes journals describing general medical research with a particular emphasis on extremely novel techniques and clinical interventions in a broad range of medical specializations and applications, including vaccine development, tissue replacement, immunotherapies, and other experimental therapeutic strategies. Journals in this category reflect clinical interventions that are in early stages of development, using in vitro or animal models, and small-scale clinical trials.

Appendix IV: *Web of Science*℠ journal categories

Acoustics	Classics	Engineering, multidisciplinary
Agricultural economics & policy	Clinical neurology	Engineering, ocean
Agricultural engineering	Communication	Engineering, petroleum
Agriculture, dairy & animal science	Computer science, artificial intelligence	Entomology
Agriculture, multidisciplinary	Computer science, cybernetics	Environmental sciences
Agriculture, soil science	Computer science, hardware & architecture	Environmental studies
Agronomy	Computer science, information systems	Ergonomics
Allergy	Computer science, interdisciplinary applications	Ethics
Anatomy & morphology	Computer science, software engineering	Ethnic studies
Andrology	Computer science, theory & methods	Evolutionary biology
Anaesthesiology	Construction & building technology	Family studies
Anthropology	Criminology & penology	Film, radio, television
Applied linguistics	Critical care medicine	Fisheries
Archaeology	Crystallography	Folklore
Architecture	Dance	Food science & technology
Area studies	Demography	Forestry
Art	Dentistry, oral surgery & medicine	Gastroenterology & hepatology
Asian studies	Dermatology	Genetics & heredity
Astronomy & astrophysics	Developmental biology	Geochemistry & geophysics
Automation & control systems	Ecology	Geography
Behavioural sciences	Economics	Geography, physical
Biochemical research methods	Education & educational research	Geology
Biochemistry & molecular biology	Education, scientific disciplines	Geosciences, multidisciplinary
Biodiversity conservation	Education, special	Geriatrics & gerontology
Biology	Electrochemistry	Health care sciences & services
Biology, miscellaneous	Emergency medicine	Health policy & services

Biophysics	Endocrinology & metabolism	Haematology
Biotechnology & applied microbiology	Energy & fuels	History
Business	Engineering, aerospace	History & philosophy of science
Business, finance	Engineering, biomedical	History of social sciences
Cardiac & cardiovascular systems	Engineering, chemical	Horticulture
Cell biology	Engineering, civil	Humanities, multidisciplinary
Chemistry, analytical	Engineering, electrical & electronic	Imaging science & photographic technology
Chemistry, applied	Engineering, environmental	Immunology
Chemistry, inorganic & nuclear	Engineering, geological	Industrial relations & labour
Chemistry, medicinal	Engineering, industrial	Infectious diseases
Chemistry, multidisciplinary	Engineering, manufacturing	Information & library science
Chemistry, organic	Engineering, marine	Instruments & instrumentation
Chemistry, physical	Engineering, mechanical	Integrative & complementary medicine
International relations	Mining & mineral processing	Psychology
Language & linguistics	Multidisciplinary sciences	Psychology, applied
Language & linguistics theory	Music	Psychology, biological
Law	Mycology	Psychology, clinical
Limnology	Nanoscience & nanotechnology	Psychology, developmental
Linguistics	Neuroimaging	Psychology, educational
Literary reviews	Neurosciences	Psychology, experimental
Literary theory & criticism		Psychology, mathematical
Literature	Nuclear science & technology	Psychology, multidisciplinary
Literature, African, Australian, Canadian	Nursing	Psychology, psychoanalysis
Literature, American	Nutrition & dietetics	Psychology, social
Literature, British Isles	Obstetrics & gynaecology	Public administration
Literature, German, Dutch, Scandinavian	Oceanography	Public, environmental & occupational health
Literature, romance	Oncology	Radiology, nuclear medicine & medical imaging
Literature, Slavic	Operations research & management science	Rehabilitation
Management	Ophthalmology	Religion
Marine & freshwater biology	Optics	Remote sensing

Materials science, biomaterials	Ornithology	Reproductive biology
Materials science, ceramics	Orthopaedics	Respiratory system
Materials science, characterization & testing	Otorhinolaryngology	Rheumatology
Materials science, coatings & films	Palaeontology	Robotics
Materials science, composites	Parasitology	Social issues
Materials science, multidisciplinary	Pathology	Social sciences, biomedical
Materials science, paper & wood	Paediatrics	Social sciences, interdisciplinary
Materials science, textiles	Peripheral vascular disease	Social sciences, mathematical methods
Maths & computational biology	Pharmacology & pharmacy	Social work
Mathematics	Philosophy	Sociology
Mathematics, applied	Physics, applied	Soil science
Mathematics, interdisciplinary applications	Physics, atomic, molecular & chemical	Spectroscopy
Mechanics	Physics, condensed matter	Sport sciences
Medical ethics	Physics, fluids & plasmas	Statistics & probability
Medical informatics	Physics, mathematical	Substance abuse
Medical laboratory technology	Physics, multidisciplinary	Surgery
Medicine, general & internal	Physics, nuclear	Telecommunications
Medicine, legal	Physics, particles & fields	Theatre
Medicine, research & experimental	Physiology	Thermodynamics
Medieval & renaissance studies	Planning & development	Toxicology
Metallurgy & metallurgical engineering	Plant sciences	Transplantation
Meteorology & atmospheric sciences	Poetry	Transportation
Microbiology	Political science	Transportation science & technology
Microscopy	Polymer science	Tropical medicine
Mineralogy	Psychiatry	
Urban studies		
Urology & nephrology		
Veterinary		
Veterinary sciences		
Virology		

Water resources		
Women's studies		
Zoology		