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International comparative performance of mental health research, 1980-2011

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Abstract
Scientific understanding of mental illness, mental health and their neurobiological and psychosocial underpinnings has greatly increased in the last three decades. Yet, little is known about the landscape of this knowledge and how and where it is evolving. This paper provides a bibliometric assessment of mental health research (MHR) outputs from 1980 to 2011. MHR papers were retrieved using three strategies: from key mental health journals; using US National Library of Medicine Medical Subject Heading (MeSH) keywords; and from additional journals in which mental health topics accounted for over 75% of papers. The number of papers per year increased over time in absolute terms and as a proportion of total medical output. The US's proportion of world publication output dropped from 60% in 1980 to 42% in 2011, while the EU increased its share from 27% to 40%. Countries with greater research intensity in mental health generally had higher citation impact, such as the US, UK, Canada and the Netherlands. MHR also became more collaborative: 3% of all MHR papers published in 1980 were the result of international collaboration compared to 22% in 2011. We conclude by noting that the rise in MHR appears to be due to funding and that bibliometrics can help highlight the potential drivers of variation in performance of MHR systems. The paper provides an analytical basis for benchmarking MHR trends in the future.

1. Introduction

The scientific understanding of mental illness, of mental health and of their underlying neurobiological and psychosocial bases has greatly increased in the last three decades. Yet, little is known about the landscape of this knowledge and how and where it is evolving. The objective of this paper is to provide a bibliometric assessment of mental health research (MHR) outputs from 1980 to 2011 across the most productive and emerging countries. Bibliometrics is the quantitative analysis of scientific publications and their citations, typically focusing on journal papers in the peer reviewed literature (De Bellis,

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2009). It is one of a set of evaluation methods that may be used to help assess research (Ismail et al., 2009), and has been used in comparative analysis of other fields of medical science (Lewison et al., 2001; Patel and Sumathipala, 2006).

To our knowledge, no studies have attempted to provide a comprehensive bibliometric assessment of MHR. There have been analyses focused on specific disorders, including schizophrenia (Morlino et al., 1997; Theander and Wetterberg, 2009), bipolar disorder (Clement et al., 2003, López-Muñoz et al., 2006), ADHD (López-Muñoz et al., 2008a), post-traumatic stress disorder (Figueria et al., 2007), eating disorders (Theander, 2002, 2004), treatment for depression (López-Muñoz et al., 2003), forms of treatment (Garcia-Garcia et al., 2008), use of diagnostics (López-Muňoz et al., 2008b), locations or countries (Afifi, 2005; Archambault et al., 2004), or on specific journals (Pincus et al., 1993). However, no study has identified trends in all MHR publications across the major and emerging producers of this literature with a scope that covers the last three decades.

Such knowledge is critical for two reasons. First, the field of MHR itself needs to know where its major producers are and how their roles have evolved overtime. Second, research funders require an evidence base to make informed decisions on operations, policy and strategy (Grant and Wooding, 2010). Bibliometrics contributes to that evidence base by providing those responsible for research management with data capturing trends in research activity and impact, by institute, country, field, etc (Pincus et al., 1993).

In this paper we focus on trends in research outputs over time and by country, the intensity of MHR in comparison to all medical research activity, the impact of the research outputs as measured by citations, and patterns of collaboration. We also specifically compare trends in research outputs in the US and EU-27, as well as Brazil, Russia, India, and China (the BRIC countries), given their position as emerging powers. We begin by explaining how we defined and identified MHR papers. In the discussion we highlight the limitations of the analysis and draw out policy observations.

2. Experimental procedures

Bibliometric data are drawn from a database built by the *Observatoire des Sciences et des Technologies* (OST) based on the Thomson Reuters' Web of Science (WoS) (http://www.ost.uqam.ca/). The WoS includes three databases – the Science Citation Index Expanded™; Social Science Citation Index™; and Arts & Humanities Citation Index™ – covering, as of 2011, ca. 12,000 journals in all disciplines. These databases do not include all papers since some are disseminated through scientific media not indexed by the WoS (e.g. highly specialised journals, national journals, etc). However these databases do cover the predominant share of researchers' scientific output that is most visible to worldwide scientific communities and therefore is most likely to be cited. Although the WoS database includes several types of documents, only articles, research notes and review papers are used since these are generally accepted as the main instruments for communicating original research (Carpenter and Narin, 1980; Moed, 1996).

2.1. Retrieval of papers

A key challenge in any bibliometric analysis is defining and identifying the field for investigation (Moed, 2005) – in this case, MHR. Given the broad nature of MHR – stretching from molecular biology through to the effectiveness of social interventions such as supported employment – we combined three strategies for identifying publications:

- *Key journals*: OST's bibliometric version of the WoS database uses two disciplinary classifications. The first is the journal subject categories developed by Thomson Reuters and used in the WoS (http://apps.isiknowledge.com). The second is the field and subfields classification developed by the Patent Board (formerly CHI Research) (Hamilton, 2003) and used by the US National Science Foundation (NSF) (http://www.nsf.gov/statistics/seind06/). We selected all papers published in the 105 journals to which either Patent Board or Thomson Reuters assigned the 'Psychiatry' classification. This includes both journals covering a wide range of topics, such as the *American Journal of Psychiatry* or the *Journal of Nervous and Mental Disease*, and more specific titles, such as *Schizophrenia Research* or *Psychopharmacology Bulletin*. Using journal classifications has been the standard practice in bibliometric analyses for decades (see Moed, 2005).
- *MeSH headings*: The US National Library of Medicine Medical Subject Headings (MeSH) uses a controlled vocabulary to assign a medical domain to each paper indexed in the PubMed database (http://www.ncbi.nlm.nih.gov/pubmed), and has been used extensively in bibliometric analyses because of its precision (Lundberg et al., 2006; Clarke et al., 2007). Three MeSH headings best describing MHR were chosen: Mental Disorders (excluding Substance-related Disorders), Mental Health Services and Mental Health. It should be noted that the structure of MeSH headings is hierarchical, meaning that, for example, specific diagnoses are picked up as subcategories under the term 'Mental Disorders'. By using MeSH headings we identify papers published in multidisciplinary journals including, for example, *European Neuropsychopharmacology*. These three MeSH headings retrieved in PubMed, as of March 2012, 513,440 papers published between 1980 and 2011 (572 of these papers were from *European Neuropsychopharmacology*, accounting for 41% of its output of articles, notes and reviews since the first paper was indexed on the WoS in 1992). Of these papers, 395,916 were recalled in the WoS using their author name(s), volume number, issue number and pages. Unmatched papers were published in journals that are not indexed by Thomson Reuters and were excluded from our analysis.
- *Additional journals*: Given that the match between the WoS papers and PubMed papers was not perfect, and MHR papers may not always have a proper MeSH heading attributed, it was decided to complement papers to which MeSH headings were assigned with papers published in additional journals that were not assigned the 'psychiatry' classification by the Patent Board or Thomson Reuters but where 75% of papers had a mental health MeSH term. This resulted in an additional 18 journals. Many of these journals were in the fields of developmental or neurodegenerative disorders, including the *Journal of Autism and Developmental Disorders* and the *Journal of Alzheimer's Disease*.

In total, 453,048 MHR papers were retrieved between 1980 and 2011, of which 380,345 were retrieved using MeSH headings and 199,581 using the lists of journals. The overlap between the two methods contained 126,878 papers, which means that 56% of papers were MeSH-retrieved papers published outside core psychiatry journals. Similarly, 36% of papers published in additional journals did not have any of the three MeSH headings assigned. This shows the importance of using both additional journals and MeSH headings to retrieve papers in the area.

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2.2. Indicators

We used the following bibliometric indicators in our analysis:

- *Number of papers*: This is the number of scientific papers by authors from a given country, as found in authors' addresses appearing on papers. Papers are attributed using the 'full' counting method, which means that each country appearing on a paper gets one 'contribution'. In other words, if there are three authors from the US and one author from the UK, both the US and UK get a publication count of one.
- *Average of relative citations (ARC)*: This indicator is based on the number of citations received in other WoS papers by papers during a four-year citation window (including the publication year). Hence, for papers published in 2000, citations are counted until the end of 2003. Papers published in 2009, 2010, and 2011 have an incomplete citation window. The number of citations received by each paper is normalised by the average number of citations received by all MHR papers of the same publication year and subfield, taking into account the fact that citation practices are different for each specialty (Gingras and Larivière, 2011; Moed et al., 1995; Opthof and Leydesdorff, 2010; Schubert and Braun, 1986). When the ARC is greater than 1, it means that a paper or a group of papers scores better than the world average for its research area; when it is below 1, those publications are cited less often than the world average for the research area.
- *Relative Intensity Index (RII)*: This indicates the relative proportion of publications of a given country by MHR area or document type relative to the proportion of the world in the same domain or document type. An RII value above 1 means that an observed group of researchers publishes more in the domain than would be expected, while an index value below 1 indicates the opposite.

3. Results

3.1. Number of papers

Fig. 1 presents the evolution of mental health papers published worldwide since 1980, as well as the percentage that these papers account for among medical papers and for papers published in all disciplines combined. In absolute numbers, the volume of MHR output grew four-fold over the period; from 5810 in 1980 to 27,866 in 2010.[1] The share of MHR publications in the total medical publication output – defined as all biomedical research, clinical medicine, psychology and health papers in the classification used by the US NSF – increased by 87% (from 29% in 1980 to 54% in 2010), and its share among papers published for all (science) disciplines combined increased by 78% (from 13% in 1980 to 23% in 2010). This illustrates that MHR is growing faster than the medical disciplines altogether and science as a whole.

Countries' proportion of the MHR output also changed. The US's proportion of world publication output dropped from 60% in 1980 to 42% in 2011, while the EU increased its share from 27% to 40%. Taken together the BRIC countries increased their proportion of world MHR papers – from 07% in 1980 to 78% in 2011 – thanks mainly to increases in Brazil and China.

Although the UK's scientific output increased from 10% in 1980 to 12% in the mid-1990s, it has remained stable at this percentage since then. Germany's share increased from 6% in the early 1980s to about 8% at the end of the period, while the output of Canadian researchers is roughly at the same level today as it was in the early 1980s—mainly because of an important drop in research output in the mid-1990s. On the other hand, Australia, the Netherlands and Italy significantly increased their participation in the worldwide MHR effort, while France's research remained relatively stable. After increasing from 1980 to the early 2000s, Japan's output decreased steadily thereafter.

3.2. Research impact and intensity

Fig. 2 presents the RII and the ARC in a scatter plot of the top 20 countries for the periods 2000–2005 and 2006–2011. These figures are divided into four quadrants. Countries in the upper right-hand quadrant (ARC > 1 and RII > 1) have a scientific impact above average and have a higher specialisation in MHR compared to the world average. Those in the lower right-hand quadrant (ARC < 1 and RII > 1) are specialised but have a scientific impact lower than the world average, while countries in the higher left quadrant (ARC > 1 and RII < 1) have a scientific impact above the world average but are less specialised. Countries in the lower left quadrant (ARC < 1 and RII < 1) are below world average in terms of impact and specialisation. Finally, the size of the dots is proportional to the number of papers published by a given country in MHR.

Countries with greater research intensity in MHR are generally those with higher scientific impact (upper right-hand quadrant). The US, UK, Canada, the Netherlands, Finland, Australia, Switzerland, Norway and Sweden are in this category for both time periods. They are joined by the EU as a whole, Germany, Italy and Belgium for the 2006–2011 period. Although they publish more MHR papers than expected, Israel and Brazil's scientific impact remains below the world average for both time periods. Finally, for both time period, China, South Korea, Japan, Spain and France obtained fewer citations than the world average and published fewer papers than one would expect.

3.3. Collaboration network

Science is increasingly being performed in international and bigger teams (Larivière et al., 2006; Wuchty et al., 2007). This pattern is observed in MHR; as seen in the inset Fig. 3, MHR papers are increasingly the result of international collaboration. While 3% of all MHR papers published in 1980 were the result of such collaboration, this rose to 22% in 2011. This percentage is slightly greater than the percentage of international collaboration in medical research taken altogether (21%).

Fig. 3 also shows that large countries/regions in terms of research output – such as the US, EU, and Japan – have low international collaboration rates. This is not surprising; it is more difficult for researchers from a bigger country to find collaborators outside their borders, as they encompass an important proportion of the overall scientific world. Alternatively, researchers from small countries – such as Switzerland and Belgium – have a greater probability of

[1]Because of the indexing practices of Thomson Reuters' Web of Science, data for 2011 are preliminary – about 10% of the dataset is missing – which is why we observe a decrease in number of papers.

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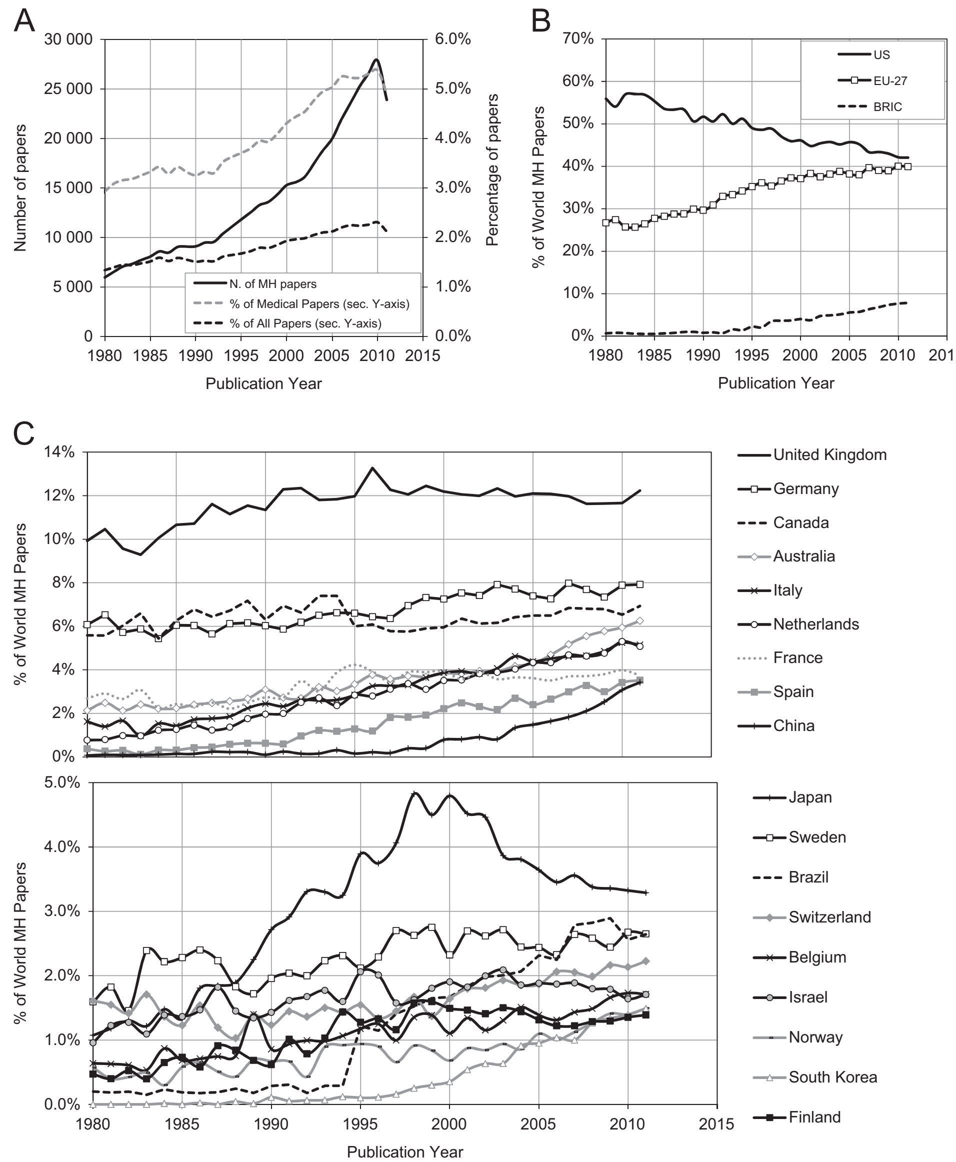

Fig. 1 (A) Number of mental health papers, 1980–2011, and mental health papers as a percentage of all papers and of all medical papers; (B) percentage of world mental health papers for the US, EU 27 and BRIC countries and (C) percentage of world's mental health papers, by country, 1980–2011.
Source: Observatoire des sciences et des technologies (OST) Web of Science (WoS) database.

finding colleagues to co-author with outside their country as there are more mental health researchers outside their borders than within. Nevertheless, size is not the only determinant of countries' international collaboration. Language, geography and history also play a role (Hamilton, 2003). Canada, for instance, has five times the number of MHR papers of Finland, but the two countries have a similar international collaboration rate, mainly due to the important ties between Canada and the US.

4. Discussion

The purpose of this paper is to map global MHR activity since the 1980s. It provides an analytical basis for benchmarking MHR trends for future assessments. In this section we highlight the limitations of our analysis and draw out some observations that have policy implications.

4.1. Caveats and limitations

Before drawing conclusions for the conduct of MHR, it is important to highlight a number of important qualifications when assessing the validity of bibliometric analysis (Moed, 2005). Only journals included in the WoS form part of our analysis. We manage this in two ways. First, we note that the potential exclusion of relevant cited studies is likely to be small as the WoS includes the most visible (and thus cited) share of researchers' scientific output. This means that we are focusing on publications that are most internationally visible to the scientific community but does exclude some subsets of papers. For example the small number of unmatched papers that were

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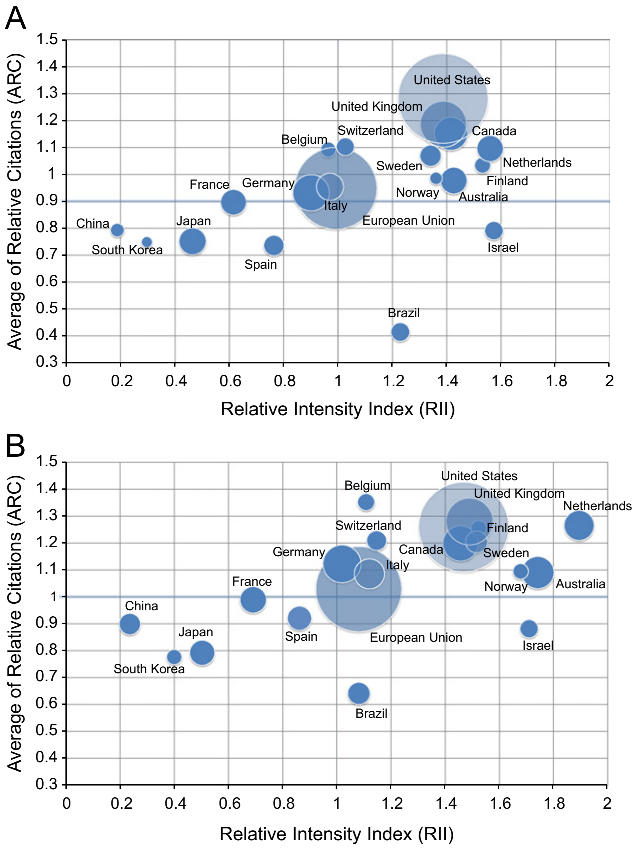

Fig. 2 Scientific impact and relative research intensity in mental health for top 20 countries, (A) 2000–2005 and (B) 2006–2011. *Source*: Observatoire des sciences et des technologies (OST) Web of Science (WoS) database.

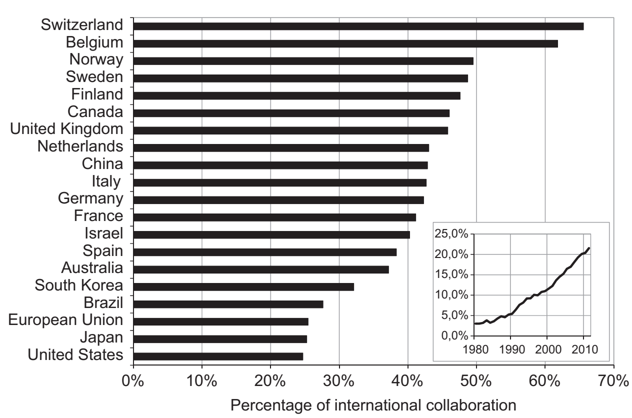

Fig. 3 International collaboration of mental health papers of top 20 most productive countries, 2006–2011. Inset: percentage of mental health world papers with at least two countries, 1980–2011.
Source: Observatoire des sciences et des technologies (OST) Web of Science (WoS) database.

indexed on PubMed but not the WoS and, as discussed below, some non-English language papers. Second, we triangulated three methods of study identification: key journals, keywords, and additional journals to maximise the relevant original studies identified in the database.

Another caveat is what a citation actually represents. Citation analysis is predicated on the notion that the reference practices of researchers can reveal high-performing scientists, papers and institutions, as well as popular and influential areas of research. Unfortunately, there is no theory underpinning this empirical observation (Hanney et al., 2005; Vinkler, 2002). Moreover, citations measure only one dimension of research impact, while the impact of health research in the real world is varied, for example, through the generation of highly qualified personnel or the improvement of clinical care and health. However, at present, data on these other dimensions of research impact, over the time and scale presented here, are not available. So, while the analysis presented is of only one type of quantitative analysis (bibliometrics), which is focused on a particular type of impact (academic), it provides perhaps the best proxy for the overall academic impact of MHR.

Finally, countries whose researchers publish their work in languages other than English are placed at a disadvantage (Archambault et al., 2006). The comparative advantage that the English language confers on the research base in the UK, the US and other English-speaking countries may diminish in the future as English is also used for teaching in countries where it is not the first language. In addition, while national and institutional capacity in English, especially in the sciences, may provide a comparative advantage in the current state of the world, this may change as other languages gain in importance. The comparative advantage conferred to English does not detract from the results presented here, but is an important consideration in their interpretation.

4.2. Policy observations

Despite these limitations, bibliometric analyses, when interpreted carefully, can contribute to the evidence that research funders use to make informed decisions about operations, policy and strategy. Based on the analysis presented above we infer two emergent key policy observations: first, the rise in MHR appears to be due to funding, and second, bibliometrics can help highlight the potential drivers of variation in the performance of MHR systems.

4.2.1. The rise of mental health research appears to be related to funding

One of the most striking observations from this analysis is the disproportionate increase in MHR publications compared to all medical science. As illustrated in Fig. 1(A), the number of MHR publications has grown faster than that of medicine or science as a whole. This observation leads to the question: What has driven this?

One explanation may be an increase in research funding. However, it is difficult to estimate the amount of funding going into different fields of medical science, owing to the plurality and different structures of funding across countries (Grant and Lewison, 1997). Nevertheless, it is possible to consider the role of funding by comparing between a few countries: specifically, for the US we can look at National Institute of Mental Health (NIMH) expenditure over the period and for the UK we can use a previous estimate of

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MHR expenditure between 1980 and 1992 (Buxton et al., 2008). For this analysis, a three-year time lag was built in for publication, and for the US it is worth noting that non-NIMH expenditure is excluded (Grant and Lewison, 1997). From this analysis, as illustrated in Fig. 4, research productivity (i.e. cost per paper) is quite stable in the US, and has only slightly increased in the UK over the period assessed, suggesting that funding is the major driver of publication increase.

4.2.2. Bibliometrics can highlight potential explanations for the variation in research system performance

In Fig. 2, countries in the top right-hand quadrant with high scientific impact and specialisation may be considered 'high performers'. In addition to the US, UK, and Canada, these include a range of smaller countries such as Belgium, Switzerland, Sweden, Finland, and the Netherlands. Here, the questions arise: What may be learned from these top performers? And, what can be done to become a top performer?

To address these questions satisfactorily it would be necessary to undertake a detailed comparative analysis of the MHR system in each (or in a sample) of the high and low performers. To understand variation in performance, we suggest three areas that warrant further research:

- *Specialisation*: Although the relationship that we measure between 2006 and 2011 is moderate (r^2=0·32), it seems that countries that are small (in terms of population size) and specialise in MHR (as measured by the RII) obtain a relatively high citation impact (e.g. Sweden and Finland). Large countries that do not specialise have a lower impact (e.g. Japan and France). If this relationship holds under further examination, it would be important to understand the causative mechanism at play. While specialisation is key to technology and its development (Pavitt, 1999), tracing the benefits of specialisation back to science remains challenging, where there may be roles for interdisciplinarity and specialisation in shaping scientific impact.
- *Collaboration*: Smaller countries with a high proportion of international co-authored papers (e.g. Belgium, Switzerland, and Sweden in Fig. 3) tend to have higher average relative citation rates (Fig. 2(B); r^2=0·35 for 2006–2011). This moderate positive relationship has been observed at the macro level by Glänzel (2009) and in case-study research by Wooding et al. (2011). Several hypotheses can be proposed for explaining the greater impact of research conducted through international collaboration, such as *de facto* international relevance, sharing of resources, better diffusion of research results, and the dominance of English as a scientific language.
- *Competition*: There seems to be an association between citation impact and the competitive research funding environment. The UK, Finland, and Sweden are characterised as being comparatively more 'competitive' by Auranen and Nieminen (2010) than Germany, the Netherlands, and Australia (as measured by the proportion of external funds going to higher education institutes) and these three countries have comparatively higher ARCs. This observation was originally made by May (1997) who noted that differences in research performance may be caused by "differences in the nature of the institutional settings where the scientific research is done", explicitly comparing the performance of research undertaken in institutions to that in universities.

From a strategic viewpoint these hypotheses suggest that relatively large countries that are underperforming in terms of citation – such as Japan, France, Spain, and to a lesser extent Germany and Italy – may need to specialise, collaborate and compete more if they wish to increase their global impact. To test these hypotheses, the next steps must be to consider them as predictors in a multivariate analysis where the dependent variable is overall research performance.

Finally, it is worth noting that the BRIC countries, representing approximately 40% of the world's population, account for 8% of the world's MHR literature. While such an asymmetry is seen in medical science (the BRIC countries accounted for 14% of medical papers published in 2011), it is enhanced in mental health. This asymmetry is more striking given that arguably of all the health needs, mental health is probably more influenced by social and regional contexts than many – and thus perhaps requires even more attention

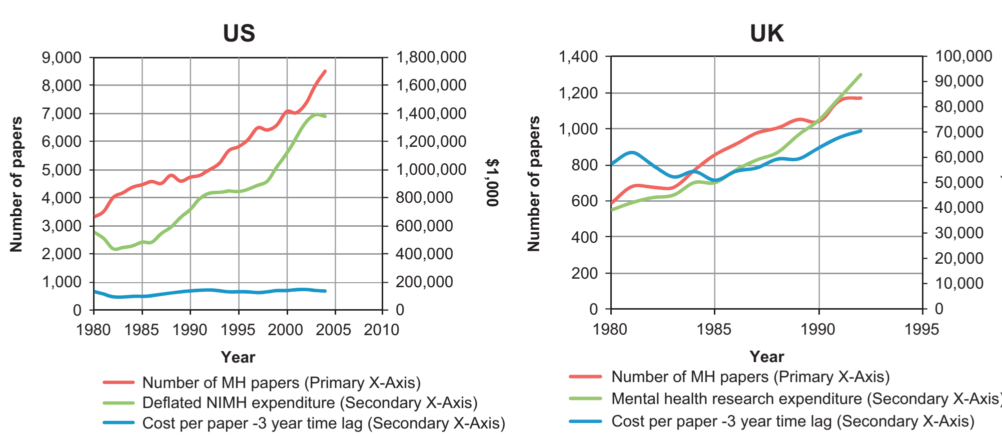

Fig. 4 Research productivity, measured by cost per paper, in the US and UK, over time [NB: cost per paper and total expenditure are expressed on different scales].
Source: Observatoire des sciences et des technologies (OST) Web of Science (WoS) database.

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in terms of locally generated and relevant research. It therefore may be important then that the emerging powers, captured at the leading edge by the BRIC countries, do specifically more to enhance the development of MHR, especially on topics which are more variable across societies and regions.

5. Concluding remark

To quote from Pincus et al. (1993), bibliometric analysis "can be useful ... [from]... assessing the growth and utilisation of knowledge in the field, to planning how to most effectively use limited resources, and to increasing public support for research". With this in mind, this bibliometric study contributes to an evidence base that can help ensure that MHR funding is delivering academic, social, economic, and health benefits to societies, communities, and individuals. Just as science is the effort to discover and increase human understanding of how physical reality works, science policy should also include the effort to seek to understand how science works.

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Contributors

Jonathan Grant and Vincent Larivière conceived of the study and wrote the first draft of the paper, Benoît Macaluso undertook the primary bibliometric analysis with support of Stephanie Diepeveen, Siobhán Ni Chonaill, and Alexandra Pollitt. All authors contributed to and have approved the manuscript.

Conflict of interest

All authors declare they have no conflicts of interest.

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