Original Article

Scientific publishing in different countries: what simple numbers do not tell

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Background: The evaluation of scientific productivity is a well-established approach for assessing the quality of scientific activity of a single scientist, of a team of scientists, as well as of a university or a country.

Methods: In this article, we aim to provide an update analysis of scientific publishing of the eight countries, seven of which belonging to the so-called "G7" (i.e., Canada, France, Germany, Italy, Japan, the UK and the US) plus China. The scientific output has then been normalized for the number of inhabitants and for the gross domestic product (GDP).

Results: For the total number of publications, the US occupies the first position in the ranking, followed by China and UK. When the national scientific production is reported as number of publications for inhabitants, the UK and Canada are at the top of the ranking. Finally, when the national scientific production is reported in terms of number of publications for GDP, China is at the first place followed by the US.

Conclusions: This analysis shows that the use of the total number of publications as the only index for assessing the quality of the scientific production of a single country may be misleading.

Keywords: Science; publications; research; gross domestic product (GDP)

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Introduction

The evaluation of scientific productivity is a well-established approach for assessing the quality of scientific activity of the single scientist, of a team of scientists, as well as of a university or a country. Nevertheless, when used alone to assess the scientific productivity, the total number of publications may be misleading since it does not consider the number of inhabitants and the local availability of economic resources (i.e., the gross domestic product; GDP). It has been previously shown that normalization of scientific productivity for the GDP and for the number of inhabitants may actually provide more reliable information in the area of biomedical research than using the total number of publications alone (1). In this article, we provide an update analysis of scientific publishing of eight countries, in more recent years and using a different scientific database (i.e., Scopus instead of Medline) which is not limited to biomedical research. This analysis may be helpful to develop a model which may be more useful for understanding the real inclinations and the trends of different countries around the world.

Methods

Data about the number of publications per year for each country, number of inhabitants and national GDP were retrieved from the official databases of Scopus (2),

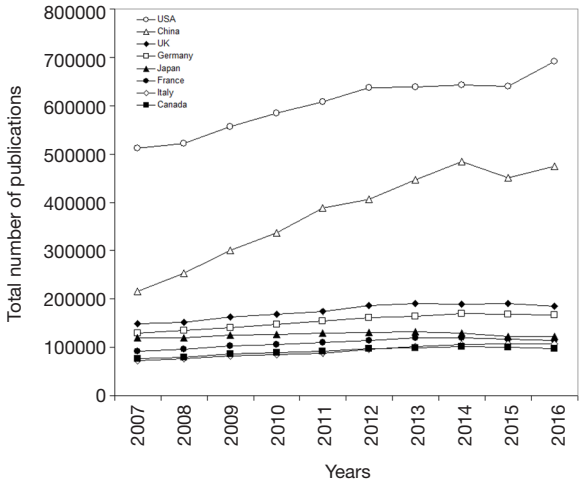

Figure 1 Overall number of scientific articles published by the eight countries in the past 10 years.

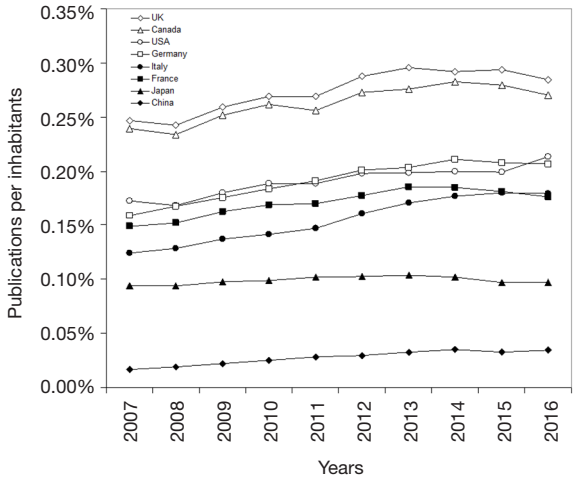

Figure 2 Overall number of scientific articles published by the eight countries in the past 10 years normalized for the number of inhabitants.

Worldometers (3) and of the Organisation for Economic Co-operation and Development (OECD) (4). The analysis was restricted to the Countries belonging to the so-called "G7" (i.e., the seven countries with the major advanced economies, consisting of Canada, France, Germany, Italy, Japan, the UK and the US) plus China (i.e., the country displaying the largest increase in GDP and number of publications), and was limited to the past 10 years (i.e., from years 2007 to 2016).

Results

The results of the electronic search are shown in *Figures 1-3*. As regards the total number of publications indexed in Scopus, it is not surprising that the first position in the ranking is firmly occupied by the US, which has published nearly 35% of all articles in the past 10 years, followed by China (~21% of all publications) and UK (~10% of all publications) (*Figure 1*).

Italy and Canada both lie at the bottom of the list, with ~5% of all publications each. The specific analysis of the trends reveals that China and Italy have exhibited the sharpest increase in their number of publications over the past 10 years (+2.2-fold and +1.5-fold, respectively), whereas Japan has displayed the slowest increase during the same period (+1.03-fold increase) (*Figure 1*).

The ranking is completely revolutionized when the national scientific production is reported as number of publications for inhabitants, wherein the UK (~20% of total) and Canada (~19% of total) occupy the first two positions in the ranking, whereas Japan (~7% of total) and China (~2% of total) lie at the bottom of the list (*Figure 2*).

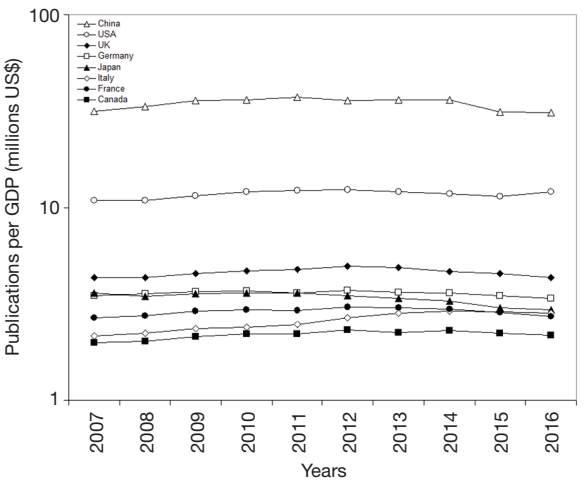

Figure 3 Overall number of scientific articles published by the eight countries in the past 10 years normalized for the GDP.

The trend is similar to that reported in *Figure 1*, with China exhibiting a 2.1-fold increase followed by Italy (1.4-fold increase) and Germany (1.3-fold increase) (*Figure 2*).

When the national scientific production is reported in terms of number of publications for GDP, the ranking is again different, with China (~53% of total) and the USA (~18% of total) occupying the first two positions and France

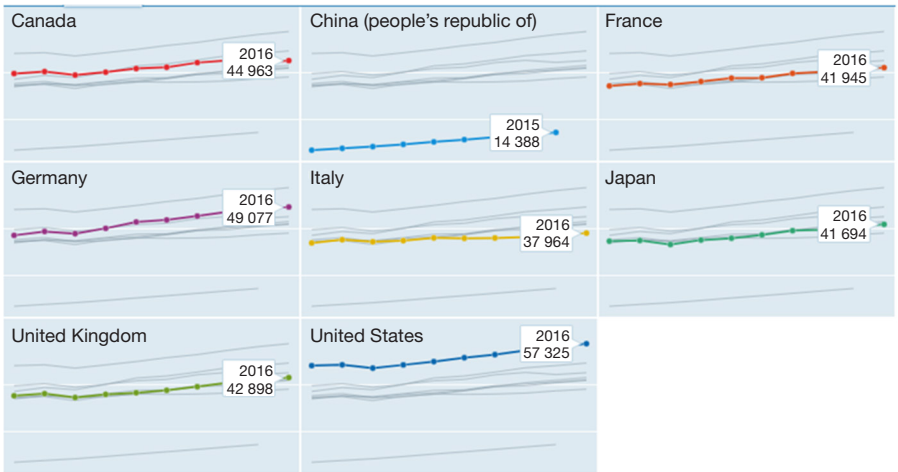

Figure 4 Progression of the GDP in the past 10 years.

(~4% of total) and Canada (~3% of total) at the bottom of the list (*Figure 3*).

In this case, the trend is especially favourable for Italy (1.3-fold increase), followed by US (1.10-fold increase), Canada (1.09-fold increase) and France (1.02-fold increase) (*Figure 3*). Interestingly, the trend is negative for all the other countries, with Japan displaying a nearly 1.2-fold decrease.

Discussion

The results of our analysis show that the ranking of the US in terms of scientific productivity is quite constant across the different methods used to standardize the national scientific production, being first in terms of total number of publications, second when the number of publications is normalized for the GDP and third when number of publication is normalized for the number of inhabitants. Unlike the US, China exhibits the largest variations, occupying the second place as total number of publications (*Figure 1*), the first when the number of publications is normalized for the GDP (*Figure 3*), but the last place when the number of publications is normalized for the number of inhabitants (*Figure 2*). This actually means that the number of scientists who publish scientific articles in China remains low, as previously highlighted in another analysis (5), but the scientific output is noteworthy when related to the availability of economic resources. Indeed a curve flattening has been observed in the past 2 years (*Figure 3*), but China still accounts for more than half (i.e., 52%) of the overall scientific production normalized for the GDP. Another interesting consideration can be done for Italy. Despite the growth of the GDP in the past 10 years has been the slowest among all countries (i.e., +12% compared to a mean increase of 35%) (*Figure 4*), the scientific productivity has increased by approximately 30% (*Figure 3*), so reflecting (more or less like China) a remarkable optimization in the use of economic resources.

An inverse phenomenon can be observed for Canada. Despite lying in the last position for total number of publications (*Figure 1*) and for total number of publication normalized for the GDP (*Figure 3*), Canada is at the second place when the total number of publications is normalized for the number of inhabitants (*Figure 2*), thus meaning that the there is a relatively high number of prolific scientists in this Country. Notably, in a previous study it was found that Canada had the highest biomedical research productivity after adjustment for the GDP (1). This difference can be clearly explained by two leading aspects. First, the former study was based on a Medline search, and so only included biomedical studies, which actually represent less than half of all documents included in Scopus. Then, the previous study was carried out between the years 2002 and 2012. The country has displayed the second lowest increase in the overall number of publications indexed in Scopus (i.e., only followed by Japan) (*Figure 1*) over the past 2 years, which probably reflects a slowing down of scientific production.

Conclusions

In conclusion, the results of our analysis clearly show that the use of the total number of publications as the only index

for assessing the quality of the scientific production of a single country may be highly misleading. China and Canada represent the most valuable examples, as described before. Therefore, normalization of scientific publishing for the number of inhabitants and for the GDP seems the more rational approach for obtaining reliable insights into the national scientific productivity worldwide.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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