Impact of Funding on Research Output: An Empirical Study on 10 Countries

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Abstract

This study reports research on analyzing the impact of government funding on research output. 500807 SCI papers published in 2009 in 10 countries are collected and analyzed. The results show, in China, 0.34% of SCI papers are supported by some grants, among which 84.56% are supported by National Natural Science Foundation of China. Average grants per paper of Chinese SCI papers is 2.95, when in the USA the statistics is 2.93 and in Japan it is 2.40. The results of funding agency analysis show that, China, Germany and Spain are single funding agency predominated countries, while USA, Japan, Canada and Australia are double funding agencies predominated countries, and the source of funding in UK, France and Italy is diversified.

Introduction

Public R&D investment keeps a fast growth in the past 10 years in the world. In the USA, federal funds for R&D increased from \$72.86 billion in 2000 to \$114.45 billion in 2009. In China, with its fast growing economic, the R&D investment also increases rapidly. In 2000, the number is 89.6 billion yuan (about \$11.2 billion); in contrast, in 2009, the R&D investment reaches 580.2 billion yuan (about \$82.9 billion). With the fast growth of R&D investment, government funding is playing a more and more important role in scientists' research and publishing.

Since 2009, three new search field tags about funding information have been added in Web of Science. With these three funding-related field tags, it is possible for us to collect accurate data linking publications to the grants that fund the papers in large scale evaluations.

In this study, we make an aggregate level analysis on the funding-supported SCI papers in 10 countries, in order to perform a quantitative evaluation on the influence of government funding on research output.

Related Work

Several studies have been done to investigate the government funding, giving a variety of results. Boyack & Borner (2003) examined the impact of governmental funding on the amount and citation counts of research publications. Butler (2001) studied the relationship between funding acknowledgement data and total research output in medical and health science in Australia, concluding that funding acknowledgement data can be used to evaluate the performance of a funding agency in the aggregate. Leydesdorff & Wagner (2009) discussed the relations between research funding and research output in 34 countries/regions,

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concluding that, price per paper cannot be estimated. Sandström (2009) analyzed the relation between funding and output, concluding that productivity can be explained by background variables, but that quality of research is un-related to background variables. Other researches (Jain, Garg, Sharma & Kumar, 1998) studied the output of SERC funding in chemical sciences in India, their results indicate higher output and impact as a result of the funding compared to the average. Debackere & Glänzel (2004) studied the decision-making in R&D funding policies.

Data and methods

The source of data

All the data in this study are retrieved from Web of Science. We select top 10 countries which have the most SCI papers in 2009, including the USA, China, Germany, UK, France, Japan, Canada, Spain, Italy, and Australia. The USA, with an amount of nearly 400 thousands SCI papers published in 2009, topped the list. For China, the number is more than 120 thousands.

Research methods

In this study, the first problem to be solved is how to retrieve the funding-supported scientific papers from Web of Science database accurately and completely. We put forward the following retrieving strategy: Assuming that all of the names of scientific funds are beginning with 26 alphabets or the 10 Arab numbers of 0-9. Combining the wildcard of "*", which is provided by Web of Science database. So, in this study, the query is designed as follows to retrieve all the target data: FO=(a* or b* or c* or d* or e* or f* or g* or h* or i* or j* or k* or l* or n* or o* or p* or q* or r* or s* or t* or w* or x* or y* or z* or 0* or 0*

Total data of 500 807 records acquired from the SCI database in Web of Science are stored in XML (eXtensible Markup Language) format. The data fields are parsed by Thomson Reuters. To better distinguish and quantify the contribution of funding to the SCI papers publishing, we design a database and analyze the data in SQL Server.

Research result

SCI papers and funding supported SCI papers

Table 1 presents the top 10 countries in the number of SCI papers and funding supported papers. In 2009, China published 126 931 SCI papers, ranking second. While the number of papers with grant number is 89279, ranking second as well. And the proportion is as high as 70.34%. It can be seen that in China, science foundation plays an extremely important role in supporting and promoting China's SCI paper publishing and scientific development.

The number of SCI papers in the USA is 379 321, which is far more than other countries. The number of papers with grant number is 167 316, which means 44.11% of the USA's SCI paper are supported by funding.

In addition, the proportion of Spain is 51.58%, ranking second. Italy has the lowest proportion of 33.08%, only after France (38.14%).

Country	No. of SC papers	^Y Rank	No. of funding- supported SCI papers	Rank	Proportion	Rank
USA (US)	379 321	1	167 316	1	44.11%	5
China (CN)	126 931	2	89 279	2	70.34%	1
Germany (DE)	102 927	3	42 042	4	40.85%	8
UK	99 832	4	42 563	3	42.63%	7
Japan (JP)	87 582	5	37 700	5	43.05%	6
France (FR)	73 186	6	27 911	7	38.14%	9
Italy (IT)	62 609	7	20 710	9	33.08%	10
Canada (CA)	60 723	8	29 806	6	49.09%	3
Spain (ES)	48 245	9	24 884	8	51.58%	2
Australia (AU)	41 407	10	18 590	10	44.90%	4

Table 1. The number of SCI papers and papers supported by funding in 10 countries

Notes: The records in table 1 is searched in SCI database from September 27 to October 12, 2010.



Figure 1. The number of SCI papers and papers with grant numbers in top 10 countries

Average grants per paper

The method of calculating the average grants of SCI papers in each country is shown as below.

$$F_{average} = \frac{F_{p_1} + F_{p_2} + \dots + F_{p_n}}{n} = \frac{\sum_{i=1}^n F_{p_i}}{n} \qquad (1)$$

In Formula (1), $F_{average}$ denotes the average number of grants for all the SCI paper in one country, p_i denotes paper *i*, F_{p_i} denotes the number of grants for paper *i*. So, in this study, we only investigate those SCI papers supported by funding. The result is shown in Figure 2.



Figure 2. The number of funds for each one paper for the 10 countries

The average grants for Spain is the greatest, and each SCI paper which has 3.33 funding items. When France has 2.99 grants for each paper, the number for China is 2.95, and for the USA is 2.93. Comparatively, Japan's number is the lowest, and it's 2.40. The rest countries' numbers of grants for each paper are between 2.7 and 2.95.

Main funding agencies in 10 countries

In order to investigate the status of main funding agencies in the world, we analyze the collected data in our SQL Server database, find out top 3 funding agencies for each country, and calculate the proportion of SCI papers supported by some kind of funding to the total SCI papers supported by grants. The result is shown in Table 2.

Country	Funding agency	Papers supported by funding	Proportion
	National Institutes of Health	64 464	38.53%
USA	National Science Foundation	38 867	23.23%
	U.S. Department of Energy	6 357	3.80%
	National Natural Science Foundation of China	75 497	84.56%
China	National Basic Research Program of China (973 Program)	8 524	9.55%
	Chinese Academy of Sciences	3 201	1.91%
	Deutsche Forschungsgemeinschaft	14 241	33.87%
Germany	German Research Foundation	2 140	5.09%
	European Union	1 973	4.69%
	Engineering and Physical Sciences Research Council	4 115	9.67%
UV	Wellcome Trust	2 857	6.71%
UK	Biotechnology and Biological Sciences Research Council	2 235	5.25%
Ionon	Ministry of Education, Culture, Sports, Science and Technology of Japan	15 841	42.02%
Japan	Japan Society for the Promotion of Science	8 234	21.84%
	National Institutes of Health	1 720	4.56%
	Centre National de la Recherche Scientifique	2 517	9.02%
France	Agence Nationale de la Recherche	1 693	6.07%
	European Commission	1 626	5.83%
	European Commission	1 214	5.86%
Italy	European Union	1 107	5.35%
	Italian Ministry of University and Research	832	4.02%
Canada	Natural Sciences and Engineering Research Council of Canada	8 777	29.45%

Table 2. Top 3 funding agencies in 10 countries

	Canadian Institutes of Health Research	4 872 16.35%		
	National Institutes of Health	1 905 6.39%		
	Spanish Ministry of Education and Science	7 793 31.32%		
Spain	Spanish Ministry of Science and Innovation	1 795	1 795 7.21%	
	European Union	1 259	5.06%	
	Australian Research Council	3 892	20.94%	
Australia	National Health and Medical Research Council of Australia	2 565	13.80%	
	National Institutes of Health	815	4.38%	

Table 2 lists the names of funding agencies which grant the paper publishing most in each country.

The top 3 funding agencies in USA is National Institutes of Health(NIH), National Science Foundation (NSF) and U.S. Department of Energy. NIH supports the largest number of SCI papers, which is 64464 and accounting for 38.53% of all funding supported papers, while NSF accounts for 23.23%. NIH, as a part of the U.S. Department of Health and Human Services, is the largest source of funding for medical research in the world. NIH invests over \$31.2 billion annually in medical research. More than 80% of the NIH's funding is awarded through almost 50,000 competitive grants to more than 325,000 researchers at over 3,000 universities, medical schools, and other research institutions around the world (http://www.nih.gov/about/budget.htm). And for NSF, as the federal independent institution, is in charge of supporting education and basic research of science and engineering science in USA. The important mission of NSF is to "improve the research and education standard of science and engineering field, meanwhile, avoiding the improper concentration of this kind of research and education activities". NSF accounts for 25% of the government's input of basic research in America (http://www.nsf.gov/pubs/2010/nsf110001/nsfall10001.pdf).

In China, the top 3 funding agencies are: National Natural Science Foundation of China, National Basic Research Program of China (973 Program) and Chinese Academy of Sciences. National Natural Science Foundation of China supports 75497 SCI papers in 2009, which accounts for 84.56% of the total funding supported SCI papers. It can be seen thatNational Natural Science Foundation of China plays an extremely important role and make significant contribution in Chinese scientific papers publishing and S&T development.

For Germany, the top 3 funding agencies are Deutsche Forschungsgemeinschaft, German Research Foundation, European Union, and the proportions are 33.87%, 5.09%, 4.69% respectively.

For UK, the top 3 funding agencies are Engineering and Physical Sciences Research Council, Wellcome Trust and Biotechnology and Biological Sciences Research Council.

Through the table 2 we can see that in Japan, Canada and Australia, NIH is also the one of the top 3 funding agencies, which is from USA. That is because the broad collaboration in health among USA and other countries. Figure 3 presents the detailed information.

	38.53%	National Institutes of Health
USA	23.23%	National Science Foundation
	3.80%	U.S. Departm ent of Energy
01.5(0)		National Natural Science Foundation of China
84.00%	9.55%	973 Program
China	1.91%	Chinese Academy of Sciences
	33.87%	Deutsche Forschungsgemeinschaft
Germany	5.09%	German Research Foundation
	4.69%	European Union
	9.67%	Engineering and Physical Sciences Research.
UK	6.71%	Wellcome Trust
	5.25%	Biotech and Biological Sciences Research
	42.02%	Ministry of Education, Culture, Sports,
Japan	21.84%	Japan Society for the Promotion of Science
	4.56%	National Institutes of Health
	9.02%	Centre National de la Recherche Scientifique
France	6.07%	Agence Nationale de la Recherche
	5.83%	European Commission
	5.86%	European Commission
Italy	5.35%	European Union
	4.02%	Italian Ministry of University and Research
	29.45%	Natural Sciences and Engineering Research.
Canada	16.35%	Canadian Institutes of Health Research
	6.39%	National Institutes of Health
Spain	31.32%	Spanish Ministry of Education and Science
	7.21%	Spanish Ministry of Science and Innovation
	5.06%	European Union
	20.94%	Australian Research Council
Australia	13.80%	National Health and Medical Research
	4.38%	National Institutes of Health

0% 10% 20% 30% 40% 50% 60% 70% 80% 90%

Figure 3. Top 3 funding agencies in 10 countries

As is shown in Figure 3, National Natural Science Foundation of China has the highest proportion of funding supported papers. The number of 84.56% is much higher than others. This result not only elucidates the NSFC's contribution to the scientific research, especially basic research, and papers publishing in China, but also reveals the extremely oneness of scientific research funding sources in China. For Germany and Spain, this kind of situation also exists more or less. For example, in Germany, Deutsche Forschungsgemeinschaft supports 33.87% of funding-supported papers, and German Research Foundation, which ranks second in table 3, only accounts for 5.09%. For UK, France and Italy, the funding source is more diversified.

Conclusion and prospects

Funding plays an important role in science studies and publication. In this study, we investigate the funding-supported SCI papers in 10 countries. The result shows that in China, the proportion of funding supported SCI papers is as high as 70.34%, much higher than other countries. Behind this kind of abnormal phenomenon, there are kinds of deep-seated reasons, and need profounder research in the future.

For the average grants per paper (funding supported paper), we find that Spain, France and China are top 3. In these 3 countries, the average grants per paper reaches more than 2.95.

For the main funding agencies in 10 countries, the results show that China, Germany and Spain are single funding agency predominated. For example, in China, NSFC supported 84.56% of all the SCI papers; in Germany, Deutsche Forschungsgemeinschaft supports 33.87% SCI papers reaches. In contrast, America, Japan, Canada and Australia are double funding agencies predominated. For example, in America, the proportion of NIH is 38.53%,

when the proportion of the second funding agency, NSF, also reaches 23.23%. In addition, for other countries, such as UK, France, Italy, the source of funding is diversified.

This study, whose aim is to evaluate the overall impact of funding to research output, does not deal with the funding policies deeply and funding impacts quantificationally. In the future works, we plan to perform an in-depth analysis of the impacts of funding to scientific research.

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