Fraunhofer ISI Discussion Papers *Innovation Systems and Policy Analysis* No. 35
ISSN 1612-1430
Karlsruhe, August 2013

Publication activity in the Science Citation Index Expanded (SCIE) database in the context of Chinese science and technology policy from 1977 to 2012

Junying Fu, Rainer Frietsch, Ulrike Tagscherer

Fraunhofer Institute for Systems
and Innovation Research ISI

Contents Page

Figures

Abstract

It is well known that the number of China's publications has increased at a remarkable rate over the last three decades. However, many related issues still remain unknown, like the scientific impact of those papers, the journals in which Chinese scientists publish their papers, and the relationship between the trend of China's publication activity and its S&T policy as well as other related governance issues. By using bibliometric methods, this paper finds that China's citation number which ranks fourth worldwide does not run parallel to the publication number that ranks second in the SCIE database, implying its publications haven't had the impact that was expected. Its citation rate ranks 78th though it has increased steadily. China's publications are mostly published in the lower impact journals but they attract more citations than the journals' expected values. China's S&T related inputs, including funding and personnel, have exhibited remarkable increasing trends during the four stages of S&T policies since 1977. Besides S&T investments, utilitarian practice nationwide may partly be responsible for the tremendous increase of SCI papers, especially when the performance-based evaluation system is mostly employed. It is essential to create a flexible environment and promote a scientific spirit combined with developing broader and more plural forms of the S&T assessment system, which would make "developing an innovation country" more realistic for China.

1 Introduction

Science and technology (S&T) policy is concerned with the allocation of resources for scientific research and technical development, which is difficult to separate from educational policy. It includes government encouragement of science and technology as the roots of a strategy for industrial development and economic growth; but it also includes the use of science in connection with problems of the public sector (OECD 1971). The differentiated patterns of S&T policy have developed in the United States, Germany, France, the UK and Japan, so they are always "country-specific". In the case of China, the specificities of the S&T system are not only the result of historical, political and cultural factors, but also, or perhaps even more so, of economic regimes. China's S&T policy has progressed through several stages with different focal points and emphases after the Cultural Revolution ended in 1977. China's policies have helped the establishment and thereafter the adjustment of the science and technology system, and have served to co-ordinate scientific and technological activities (Gu 2001).

The Science Citation Index Expanded (SCIE) database is a multidisciplinary database produced by Thomson Scientific, which indexes over 8,600 of the world's leading scientific and technical journals across a broad array of disciplines (Thomson Reuters 2010). It is regarded to be the solid basis for bibliometric analysis, which is employed broadly by researchers, institutions, and governments as important indicators to assess scientific performance at all levels. Its users include individuals, departments, sectors, countries and regions. SCI papers as well as the citation rate for China have exhibited exponential growth (Frietsch et al. 2008; Zhou/Leydesdorff 2006). The aim of this study is to illustrate the trend of China's SCI publication activity in the context of national S&T policy over the past three decades; at the same time, to find out the driving forces behind the dramatic changes.

2 Data and Methods

The analyzed data were retrieved from the SCIE database during the period 1980-2011. The data of previous years has been disregarded as the number of publications before 1980 was much lower and cannot be compared with what has been available since then. In this study, the analysis covers four types of documents – "articles", "letters", "notes" and "reviews", which represent the scientific achievements. The top four most productive countries are included; they are the USA, China, Great Britain, and Germany. At the same time, another developing country, India, has also been included since it is in a similar situation to China, i.e. it also has a large population, and ongoing social and economic reforms.

This analysis is primarily based on whole counting, which means that each country that makes contributions to the list of publications gets one credit for its participation because it can be assumed that international co-publications, entailing considerable efforts to coordinate with foreign colleagues by overcoming geographic obstacles as well as barriers caused by different scientific policy, culture and history, deserve a higher weighting than national co-publications as well as single-authored publications. So fractional counting, in which a country is credited a fraction of a publication in terms of its share in the number of participating countries, is not used here. And it has also been shown that methods of counting do not change country rankings in terms of the share of publications. Another methodological question is related to author self-citation. As it is noted that the external citations are the most relevant for evaluative purposes, this study follows the recommendation of CWTS to exclude self-citation (Nederhof et al. 1993).

The bibliometric indicators employed in this study are described as follows:

2.1 Absolute number as well as share of publications and citations

The share of publications for countries are considered when an international comparison is made due to an obviously and continually increasing number of publications in peer-reviewed journals indexed in the SCIE database (Larsen/von Ins 2010; Testa 2012). At the same time, citations received are further observed as a bibliometric indicator of the impact of papers because the counting of publications treats all publication alike without regard to their widely different values (Larsen/von Ins 2010). Many scientists have noted that citation counts of a paper usually peak or reach a level close to the highest score in the third year after publication. (Nederhof AJ 2006), and citations obtained in early years are found to be a good predictor for those obtained in later years (Adams J 2005). Therefore, a three-year citation window, which mostly balances precision with timeliness (Wang 2013) is used, i.e. the number of citations received during the first three years after publication date are counted, including the year of publication.

2.2 Observed citation rate (OCR) and Relative citation rate (RCR)

Observed citation rate (OCR), defined as the total number of citations over its total number of publications, is an indicator that is often used to compare scientific impacts of publications among countries, fields, institutions, and journals.

Relative citation rate (RCR) here is defined as a comparison between the observed citation rate of a country and the world citation average. If the observed citation rate is equivalent to the world average level, it means a neutral value of one; value above one implies that the observed citation rate is above average; value below one implies the citation rate is below average. However, theoretically speaking the range of values will be between 0 and + ∞, which is little illustrative for graphics and interpretation. Then a transformation method is used (Grupp et al. 2001), where the range of value is between -100 and +100, positive values of this index show an above-average citation rate; negative values of this index show a below-average citation rate; values of 0 are regarded as being equivalent to the world average. The RCR value is calculated as follows:

$$RCR_k = 100 \tanh \ln (CitRate_k / CitRate_w)$$

Where $CitRate_k$ denotes the observed citation rate of a country k. $CitRate_w$ denotes the citation rate of the world.

2.3 International Alignment (IA)

The Fraunhofer ISI has used a journal-specific expected citation count (Achleitner et al. 2008; Grupp et al. 2001; Schmoch/Qu 2009) to describe whether the authors of a country release their achievements in internationally more or less visible journals, compared to the world average. In general, a country's high share of publications in internationally visible journals implies its intensive and active participation in knowledge creation, diffusion, exchange and sharing. Therefore, journal-specific based citation indices IA lead to better analyses of high citation rates. It becomes possible to examine whether they are based on scientifically valuable publications, or on a good ranking of a publication.

Similarly to the RCR index, positive IA values mean that journal-specific expected citation rates, resulting from the average citation rate of journals in which the country's authors have published their papers, is higher than the world average, or vice versa; values of 0 indicate the equivalence of the world average. The IA value is calculated as follows:

$$IA_k = 100 \tanh \ln (EXP_k/OBS_w)$$

Here OBS_w denotes the actual observed citation rate of all publications in the world. EXP_k denotes the expected citation rate of the journals where the authors of the country k have published their papers.

2.4 Scientific Regard (SR)

Also based on journal-specific expected citation rates, the Fraunhofer ISI has used the Scientific Regard (SR) to evaluate the scientific activity for countries (Achleitner et al. 2008; Grupp et al. 2001; Schmoch/Qu 2009). If the observed average citation rate of a country is higher than the journal-specific expected citation rate, resulting from the average citation rate of journals in which the country's authors have published their papers relative to the citation rate within journals, the SR value is positive, and vice versa; values of 0 indicate the equivalence of the average citation rate of the journals. The SR value is calculated as follows:

$$SR_k = 100 \tanh \ln (OBS_k/EXP_k)$$

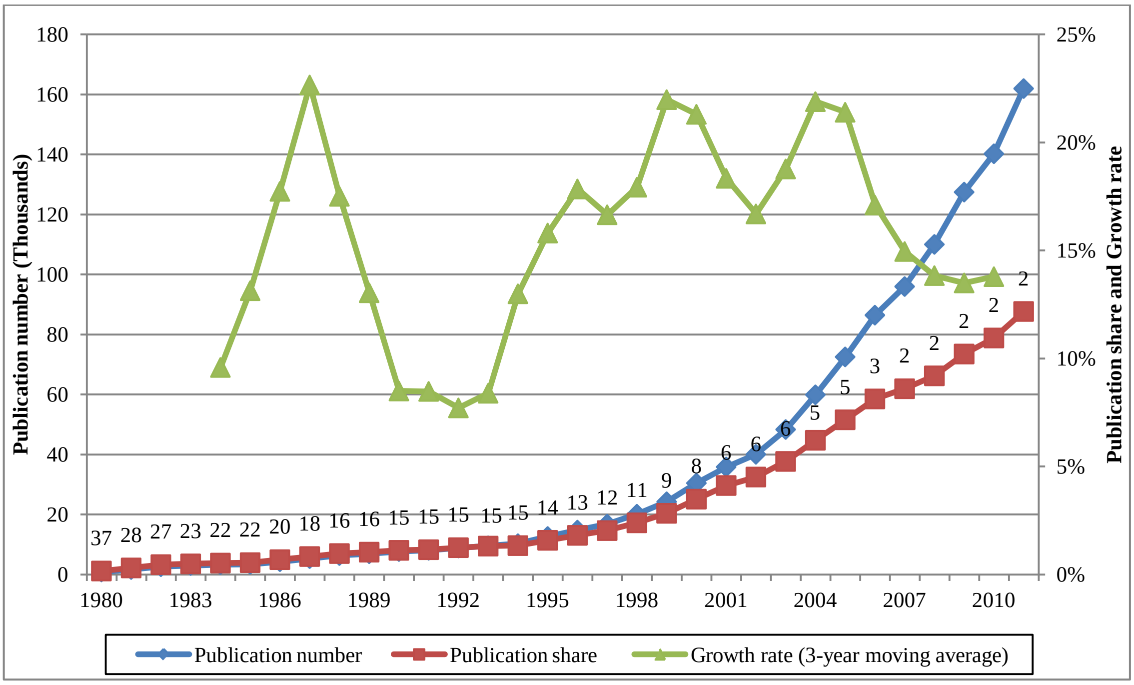
Where OBS_k denotes the actual observed citation frequency of publications of country k. EXP_k denotes the expected citation rate resulting from the average citation frequency of the journals where the authors of this country have published their papers.

3 Results

3.1 China's publication number and share in the world

Figure 1 displays China's absolute number of publications as well as its annual growth rate, and its publication share in worldwide publications in the SCIE from 1980 to 2011. It can be seen that the numbers of publications released by Chinese authors go up constantly at a remarkable speed, with a compound annual growth rate (CAGR) of 18.41% during the past three decades. Especially during 1986-1988, and 1996-2006, the 3-year moving average growth rates impressively reached the highest points, between 17 and 23%. At the same time, China's publication share in total publications has also increased tremendously from 0.16 to 12.17% though the publication numbers of all countries show continuously increasing trends. However, the slowing trend has been noted in the growth of China's publication share since 2006 after a tremendous increase for a decade. In order to understand China's publication activities further, its ranking in the world is also displayed in the figure. It can be found that China ranks 37th at the beginning of 1980s, and reaches 9th place in 1999. It has ranked second since 2007 due to its dramatic growth of publications, following the USA.

Figure 1 China's publication number as well as 3-year moving average growth rate, and publication share as well as its ranking in the world in the SCIE



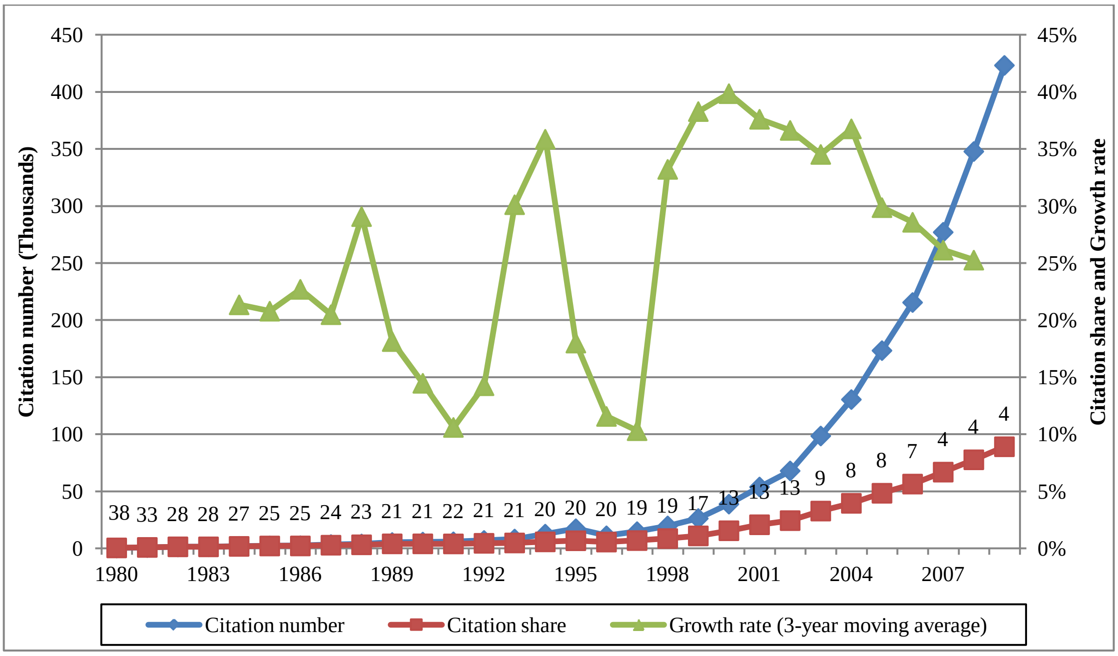
Source: SCI database, searches and calculations by Fraunhofer ISI.

Four stages could be distinguished according to the publication number as well as the trend of growth rate: the preliminary stage (before 1985) with small shares of SCI papers; the slowly developing stage (1985-1993) with increasing shares and a cycle of growth rate from the highest point to the lowest ones; the quickly developing stage (1994-2006) with a continuous and remarkable increase of SCI papers and the constantly high growth rate; and the steadily developing stage (2007-2011) with a stable and comparative low growth rate.

3.2 China's citation number and share in the world

As shown in Figure 2, the absolute number of citations for China has also risen notably over the past three decades, with a CAGR of 27.32% that is obviously higher than that for publication numbers, mostly due to the extraordinary small base of citation numbers. Accordingly, the share within all citations for China also increased tremendously from 0.05% to 8.91% in 2009 though for almost all countries citation numbers have also been up continuously. It is noted that the 3-year moving average annual growth rates of citation numbers for China reached the highest points, between 30 and 40% during 1993-1994, and 1998-2004, in which the publication numbers also grew at rather high speeds. China ranked 38th according to its citation number three decades ago, which is at a similar level to its publication number. However, it reached 9th place until 2003, which is four years later than the publication number. China has begun to exceed other countries rapidly and has ranked fourth since 2007, following the US, Great Britain, and Germany.

Figure 2: China's citation number as well as 3-year moving average growth rate, and citation share as well as its ranking in the world in the SCIE



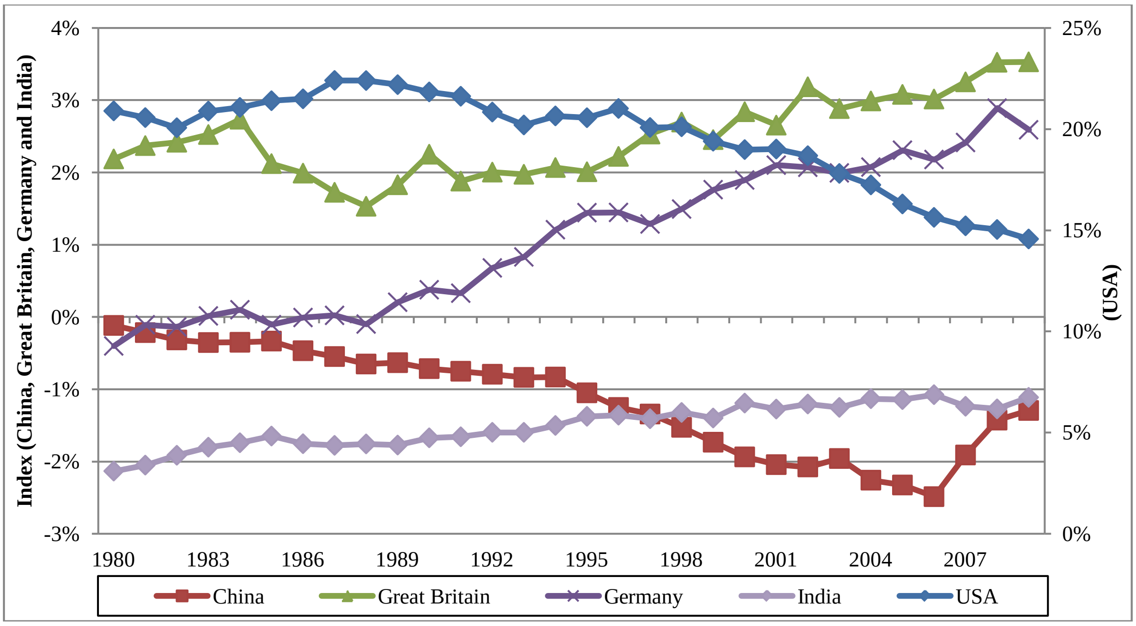
Source: SCI database, searches and calculations by Fraunhofer ISI.

3.3 Differences between shares of citations and publications

It is safe to assume so far that China has improved its publication numbers in the internationally visible journals indexed by SCIE, which represents the increase of the quantity of China's scientific research achievements. At the same time, it has also improved the citation numbers received by those publications, which represents the increase of the quality of China's scientific research achievements. However, it still remains unknown how large the difference between the quantity improvement and the quality improvement is. As Figure 3 shows, a comparison of the share of citations and publications for selected five countries is described. The USA rank first in terms of the difference between citations share and publications share, with a value of 14.6% in 2009, followed by Great Britain and Germany. However, the reverse applies to China as it received 8.9% of citations with 12.2% of publications, implying that China's papers have not received the same impact in the global scientific community. India seems to perform similarly, with a difference of -1.11% in 2009.

On the other hand, it can be found that the gap between the citation share and the publication share for China continued to widen with each passing year until 2006, however, since 2007 it has been narrowed greatly. China experienced an obviously enlarged gap, especially from 1995 to 2006, in which the number of China's SCI papers also increased with great speed, implying the possible existence of "publication inflation". This seems to have gradually improved after 2006. All observed countries show continuously positively increasing trends based on the differences between shares of citations and publications, implying that the citation shares rise faster than the publication shares among those countries over the past three decades, except the USA and China that are the exact opposite.

Figure 3: Comparison of share of citations and publications of selected five countries in the SCIE database



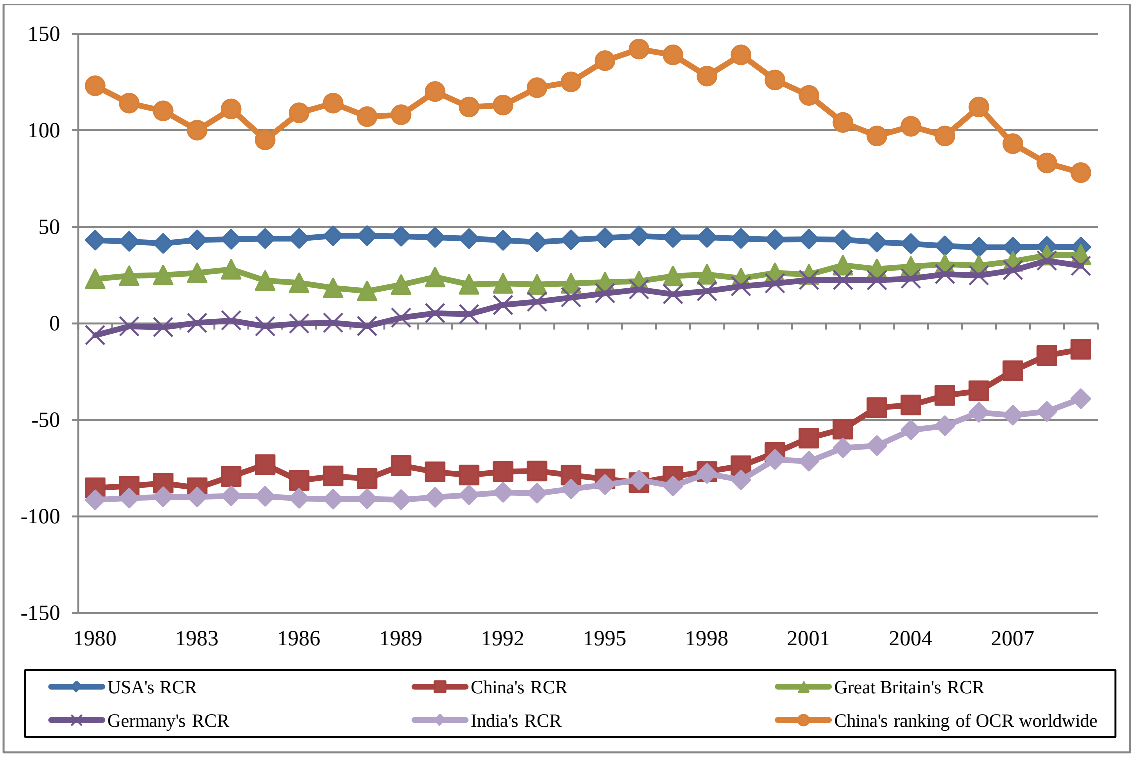
Source: SCI database, searches and calculations by Fraunhofer ISI.

3.4 China's citation rate

A steady increase of the observed citation rates (OCR) for all countries over three decades could be found partly due to the sustained growth of the number of references per paper in all fields (Larsen/von Ins 2010) and a large rise in the number of journals indexed in SCIE. In order to better understand the increase of China's citation rate that also occurs in other countries, its ranking in the global context has to be looked at. Citations which are attracted in all years after the papers have been published are counted since a comparison among countries is performed here. It can be seen that China's ranking has notably risen, especially since 2007 when its worst rankings in 1994 to 2000 were between 125th and 142th worldwide. China ranked 78th in 2009, the highest point based on the OCR, but it is largely different from the ranks based on publication number and citation number, which are second and forth respectively.

Relative citation rates (RCR), which are obtained by a comparison with the world average citation level, can help to better understand countries' performance on a global scale. As shown in Figure 4, RCR for China and India are always below the world average level, which is represented by 0. On the other hand, the figure also shows the fastest growing indices for China by over 70, and for India also by 52; Germany shows a moderate increase by 36; while the USA is the only one with a decrease of its index by -4%. It is also noted that China enters into new phases of high growth in RCR in 1997 and 2007 respectively though its RCR figures still cannot catch up with other top industrialized countries.

Figure 4: RCR (three-year citation window) for selected five countries in the SCIE as well as China's ranking of OCR (all-year citation window).

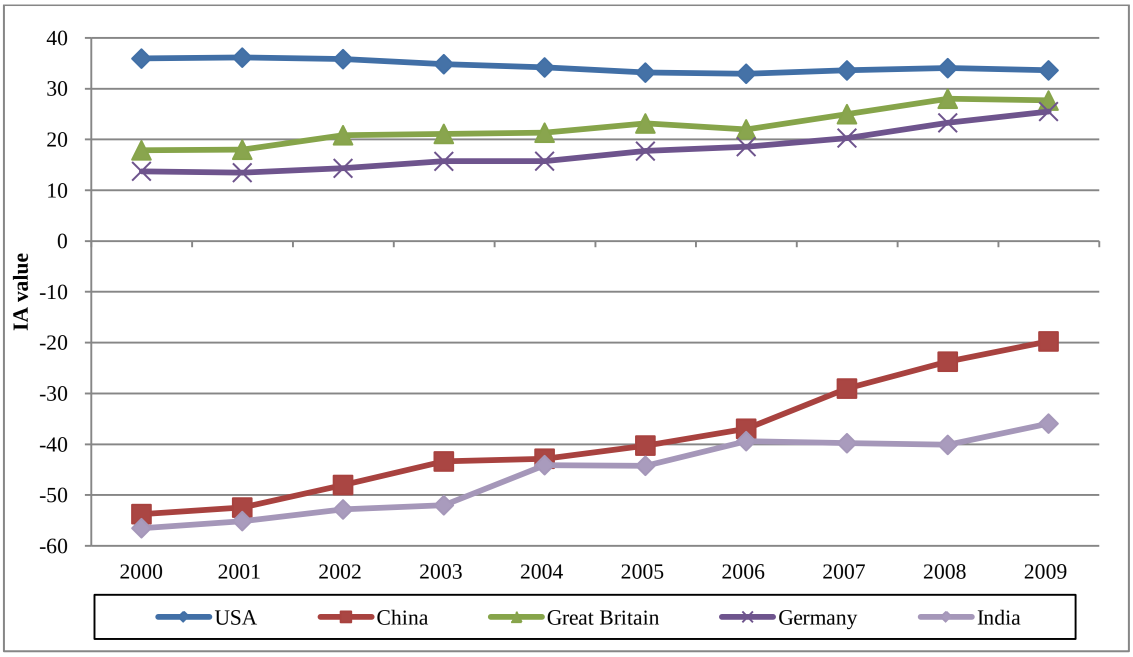


Source: SCI database, searches and calculations by Fraunhofer ISI.

3.5 International Alignment (IA) values

Furthermore, IA values for selected countries are observed in Figure 5. The USA has had stable and top IA values among five countries in the past ten years though it shows a slightly decreasing trend. While the IA-index for Great Britain as well as for Germany have improved tremendously from about 16 to about 27 in the past ten years, implying that scientists from both countries have increasingly preferred to share their achievements with the international community in highly visible journals. At the same time, a rather low IA value of -20 for China can be seen, showing the smaller scientific impact of journals in which Chinese scientists have published their achievements. However, China has shown a continuously increasing trend in the past decade and even an obvious growth of its IA figures after 2007 though it is still much lower than the world average level, implying its efforts to enhance the scientific capacity and improve its international influence by rising shares of publications in higher impact journals, while India has shown stagnant growth in IA figures since 2006 in spite of the increasing trend in preceding years.

Figure 5: Index of the International Alignment (IA) for selected five countries in the SCIE

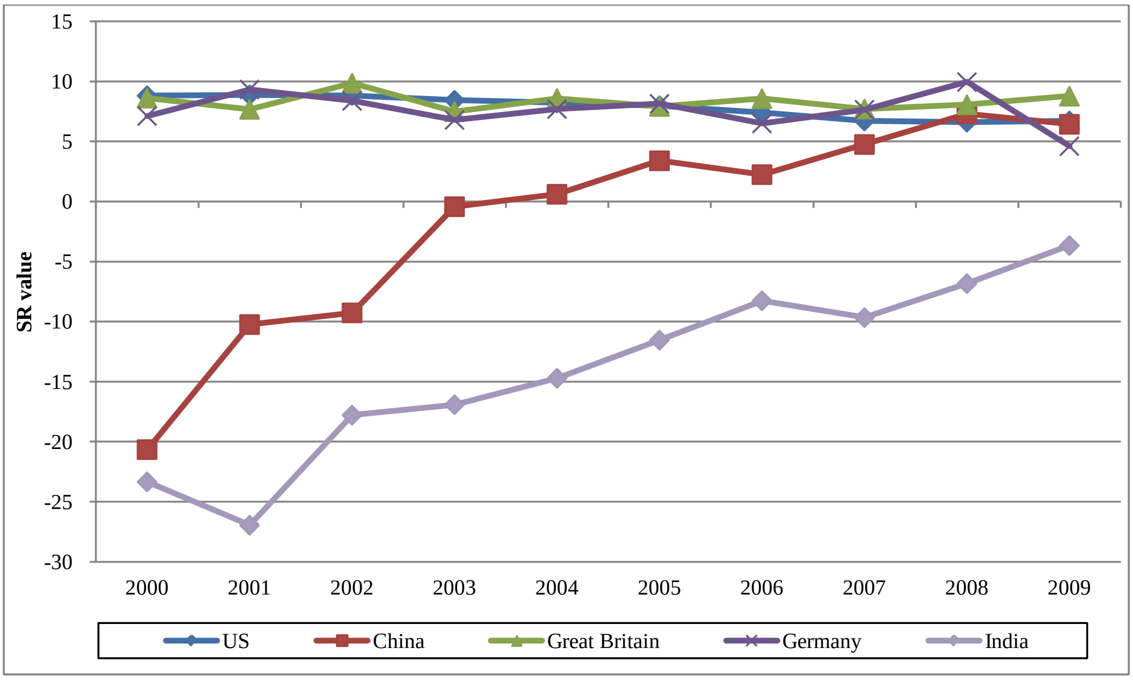


Source: SCI database, searches and calculations by Fraunhofer ISI;

3.6 Scientific Regard (SR) values

The scientific performances in selected countries are further investigated according to the journal-specific SR values for journal publications. As presented in Figure 6, China shows a continuously and significantly increasing trend especially after 2003 and a rather high SR value in 2009, at a similar level to the USA. However, the IA index for China is much lower; it then can be inferred that China's publications have been issued in the lower impact journals, but they have attracted more citations than other papers in the same journals. Similar trends and implications can be found in India. In comparison, both positive SR and IA figures are displayed for the USA, Great Britain and Germany in recent years, implying publications contributed by those countries attract more citations as can be expected for the highly visible journals in which they appear.

Figure 6: Index of the Scientific Regard (SR) for top 10 countries in the SCIE



Source: SCI database, searches and calculations by Fraunhofer ISI;

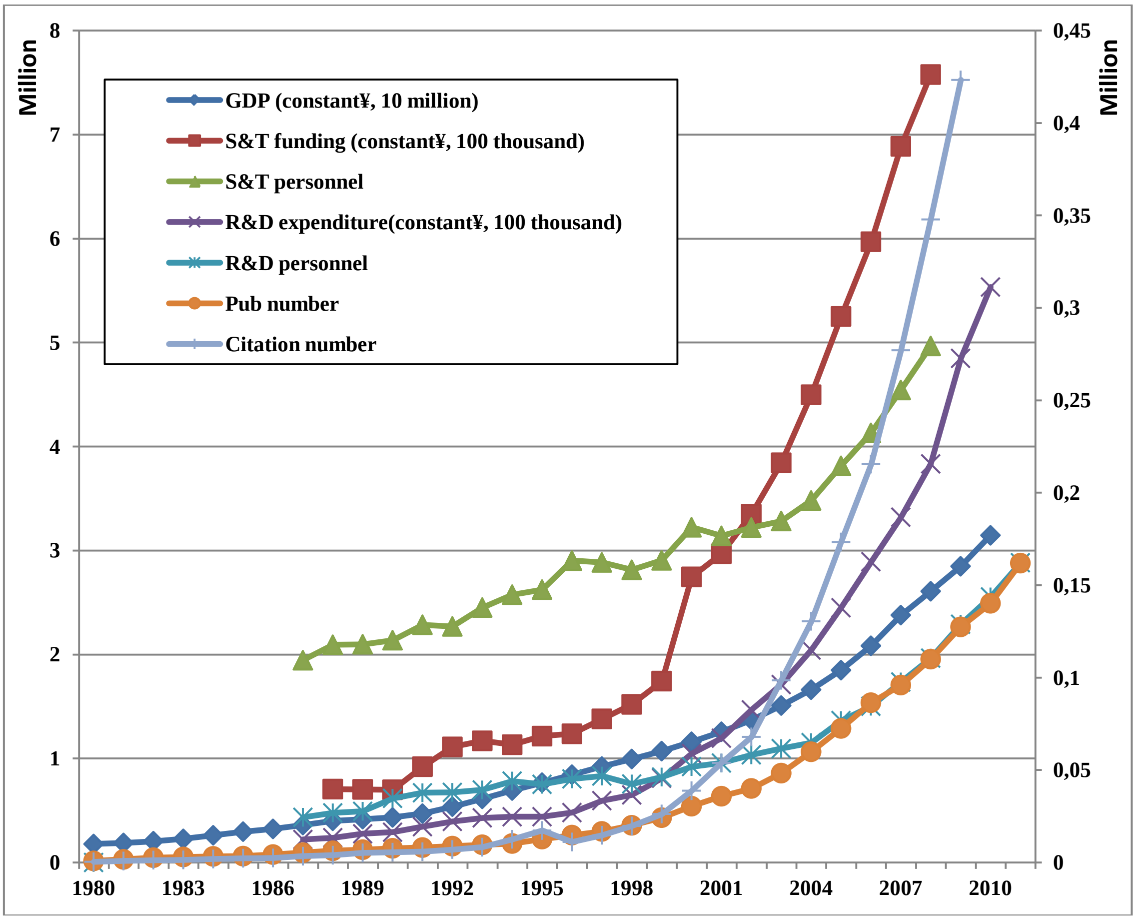
3.7 Relationship between S&T inputs and publication outputs

According to the China Statistical Yearbook issued by the National Bureau of Statistics of China, scientific and technological activities (STA) are defined as an organized activity related to creation, development, dissemination and application of S&T in the fields of natural science, agricultural science, medical science, engineering science, as well as the humanities and social science (National Bureau of Statistics 2012). Research and development (R&D) include systematic and creative activity in order to increase the stock of knowledge, and the use of this stock of knowledge to devise new applications. The definitions of STA and R&D correspond with those provided by the OECD (OECD 2002; OECD/Eurostat 2005). In addition to R&D, STA comprise scientific and technical education and training, and scientific and technological services (OECD 2002).

Funding for STA (S&T funding) refers to the funding gained for STA from governments, enterprises, and finance institutions and so on. Personnel engaged in STA (S&T personnel) comprise persons who are engaged in STA or specialize in S&T management, and persons providing services directly for S&T activities. As defined by the Statistical Bureau, their actual working time for S&T activity accounts for more than 10% of the total working time. Expenditure on R&D (R&D expenditure) is the actual expenditure that the inspected institution spends on R&D activities. The full-time equivalent of R&D Personnel (R&D personnel) is defined as the sum of full-time workers and part-time workers engaged in R&D activities, in which the latter will be converted to the former (National Bureau of Statistics of China 2007).

As can be seen in Figure 7, S&T related inputs, including funding and personnel, all show increasing trends. Both S&T funding and R&D expenditure soar at the point of 2000, with CAGR values of 12.6% and 15.0% respectively over two decades. In 2004 China's S&T personnel as well as R&D personnel grew rapidly on the basis of constant increase over the past two decades. Now China's number of persons engaged in STA ranks in first place worldwide (China Association for Science and Technology 2010).

Figure 7: China's S&T fund and personnel as well as SCI publication and citation



Source: SCI database, searches and calculations by Fraunhofer ISI; China Statistical Yearbook on Science and Technology; Organisation for Economic Cooperation and Development (OECD).

4 Discussion

Scientific publication, as a major kind of scientific achievement as well as a vehicle for knowledge dissemination, certainly reflects the performance and changes of national S&T systems as well as the innovation policies. This paper addresses that China's publication activity is coordinated generally with the process of S&T evolution, as well as the related governance, regulation, and academic environment.

4.1 Development of China's present S&T system

The process of developing and completing the S&T systems in China over the past three decades could be divided into four stages in terms of related S&T policies, strategic purposes, investment as well as accomplishments.

4.1.1 The restoration stage (1977-1984)

In the first stage, Chinese governments made great efforts to resume the S&T system, which had developed a comprehensive structure, embracing the Chinese Academy of Sciences (CAS), the Chinese Academy of Agricultural Science, the Chinese Academy of Medicine Sciences and a large number of institutions for industrial technologies by the end of the 1950s (Gu 2001), while becoming inactivated during the period of the Cultural Revolution (1967–1976). In 1977, the State Scientific and Technological Commission (SSTC) which was merged with the CAS in 1970 restarted work which included the drawing up of S&T development plans and policies, and drafting a national basic research program, the national high-tech R&D program and the S&T Enabling Program (Ministry of Science and Technology MOST 1998). At the same time, college entrance examinations also resumed. They marked the starting point of the present Chinese S&T policies. The National Science Conference, a milestone in the history of China's S&T policy was held in 1978, and at which Deng Xiaoping emphasized the essential roles of S&T as the productive forces, and of intellect as the main component of the working-class. Meanwhile the first national S&T plan "1978-1985 National Scientific and Technological Development Compendium" was approved (Ministry of Science and Technology MOST 2000; Zheng 2004).

During this stage, China's S&T fund was probably rather low due to the low GDP level. As to scientific publications, only excellent scientists released their achievements mostly in national journals that published a low number of papers due to the limited journal category and quantity. Many Chinese S&T workers did not know about the SCI database, so the number of SCI papers contributed by Chinese authors increased slowly in correspondence with the very inception of S&T development. Also, the citation rates were at their lowest levels. As a result, the gap between the publication share and the citation share for China during this period was the smallest.

4.1.2 The initial stage of the reform (1985-1994)

China entered into the second stage, which focused on the reform of the S&T management system and began with the issuing of the Decision of the State Council concerning the Reform of the Science and Technology Management System in 1985. This was the first nationwide reform of the S&T system since China's Reform and Opening-up Policy was initiated in 1978, which aimed to make S&T progress the main driving force for economic growth and social development. It also enhanced the weak links between S&T and the market-oriented economy by fully mobilizing the enthusiasm and creativity of intellectuals, including the creation of the "technology and talent market", and increasing labour mobility in an immobile labour market which had previously been rather rigid and in which jobs and work places could not be changed freely (Fang 2012; Gu 2001; Liu 2008). Related policy measures were implemented in the following years, like the diminishing of government financial appropriation, the publication of Patent Law and Professional Technical Position Regulations, and the assignment of decision-making autonomy to R&D institutes, as well as the implementation of the Employment Contract Law. At the same time, the System of National Natural Science Funds and National High-tech R&D Program (863 Program), State Key Laboratory, postdoctoral system and "211 Project" were also set up in order to strengthen the basic research, boost overall high-tech development and R&D capacity, and improve the quality of higher education as well as cultivate centres of research excellence. The above measures were almost all pushed by the "1986-2000 Scientific and Technological Progress Plan", which was one of the profoundest scientific policies. However, it was adjusted by the "1991-2000 Ten-Year Plan for Scientific and Technological Progress and Outline of the 8^{th} Five-Year Plan" in 1992 according to the development of S&T and economy at that time. However, Du and Lu (2006) noted that at this stage policy-makers had not thrown off the bonds of the planned economic system yet, but had made many S&T related regulations with definite and detailed research plans that were appointed by an administrative method. Though, they seldom led to innovation success.

With the progress of S&T development and recovery of normal scientific research, China's SCI papers increased with a CAGR of 12.97% at this stage. In 1994, China increased seven places to be the 15^{th} in the world according to the number of SCI papers, while its rank based on the number of citations rose from 26^{th} to 21^{st}. In consequence, the gap between China's publication share and citation share during this period was enlarged slowly and continuously. The observed citation rate showed a slight increase in the world average growth rate since China's relative citation rate remained fixed over the decade.

4.1.3 The deepening stage of reform (1995-2005)

The "Decision of the Central Committee of the Communist Party of China and State Council on Accelerating the Progress of Science and Technology" was issued in 1995, implying that China had stepped into a new stage of the S&T system. The core part of Chinese S&T policy embraced the strategy that "science and education will revive the nation", and the strategy for sustainable development, in which S&T and education were put in the most prominent position during the economic and social development. Correspondingly, the Chinese government placed a high value on S&T development, and has pushed to increase related funding quickly and continuously since then (Hua/Tang 2010). Therefore the National Basic Research Program (973 Program) was initiated to strengthen basic research, as a policy measure to actualize those S&T strategies. At the same time, developing the national innovation system and promoting innovative capability were put forward in 1996 as another policy measure. Whereafter, CAS started the Knowledge Innovation Program; at the same time the "Action Plan for Vitalizing Education toward the 21st Century" was issued in 1999, in which the listed Chinese universities were urged to become first class universities worldwide, i.e. "985 universities" that extended to 39 universities from originally just Peking University and Tsinghua University.

During this decade, the number of China's SCI papers increased tremendously, with a CAGR of 19.05%. China's ranking jumped from 14th to 5th in terms of SCI papers number, following the USA, Great Britain, Germany and Japan in 2005. However, the citations attracted by China's SCI papers did not rise at the same pace as the increase of publications, which remained in 8th place worldwide in 2005. As a result, the gap of shares of citations and publications soared to record level, which was increasingly larger than that for India which was also included in the emerging countries and has increased its publications quickly in recent years. However, the observed citation rate as well as the relative citation rate for China at this stage both rose, obviously partly as a result of the comparative low origin of citation numbers they started from. Based on the expected citation rate for published items in the SCI database (Garfield 1994), it is possible to inspect the placement of a publication in a journal, which has a comparatively high or poor impact on the scientific community. It is noted that Chinese scientists did not show much behaviour changes when choosing the journals in which they published their achievements between 2000 and 2005. Indian researchers also preferred the same less visible journals. At the same time, China reached and then exceeded the citation averages compared to similar items published in the same journal since 2003, implying a growth of some sort of scientific visibility for China.

4.1.4 The rising stage (2006 onwards)

In 2006, the "National Outlines for Medium and Long-term Planning for Scientific and Technological Development (2006-2020)" as well as the "Decision of the Central Committee of the Communist Party of China and the State Council on Implementing the Outlines of Science and Technology Planning and Strengthening the Capabilities in Indigenous Innovation" were issued, which announced formally the aim of building an innovation-oriented country. Improving the innovation capability and promoting knowledge creation has become the principle objective of S&T policy at this stage. It is regarded as an essential solution for China's low level of industrial technologies and lack of key technologies. Citation attracted by SCI papers, which could reflect the performance of national science systems as a part of the national innovation systems as well as the impact on the scientific community, attracts the attention of China's policy-makers. In 2011, the "12th five-year science and technology development plan" was issued and put forward in order to raise China's citation ranking from 8th in 2010 to 5th by the end of 2015, showing the decision of the Chinese government to improve the quality of SCI papers, as well as the national innovation capacity and international influence. In 2012, the "Higher Education Innovation Ability Promotion Plan (2011 plans)" officially started, aiming to push ahead with knowledge innovation, technology innovation, as well as regional innovation, and serve as a supporter of developing the national innovation system by integrating innovative resources, promoting in-depth cooperation among universities, research institutes, as well as industry, and converting scientific achievement into productivity more efficiently.

The current S&T policy has put great emphasis on quality but not quantity of scientific publications, and has made an impact on China's publication activity. This could be reflected in the moderately decreasing growth rate of SCI papers compared with previous stages though China's number of publications has been ranked in second place since 2007, following the USA. On the other hand, the difference between publication share and citation share for China has narrowed tremendously since 2006, which has reached a similar level to India. At the same time, the observed citation rate as well as relative citation rate for China has risen remarkably. This is much higher than that for India and has reached a level close to that for Japan though all the indicators for those Asian countries still remain lower than the world average. China ranks 78th worldwide based on the citation rate of 2009. Furthermore, Chinese authors have tried to publish papers in higher visible journals since its IA value at this stage has gone up rather markedly. Certainly, China still has a long way to go before it becomes a scientific power as far as the scientific impact and contribution are concerned.

4.2 Driving forces behind the increase of China's SCI papers

Many researchers have pointed out that alterations in both the number of faculty members who are active in research and the total amount of research funding each year may explain the general publication pattern (Baskurt 2011), and that it is the reason why the right-skewed success distributions can often be observed in science (Nag et al. 2013). On the other hand, the average citation impact of funded research articles, which account for nearly 23% of the scientific publications, has increased compared to the average impact of non-funded publications (Boyack/Jordan 2011; Stamou et al. 2009). However, publication activity may differ worldwide due to different S&T policies and governance, funding patterns, models of economic growth, social environment, distribution of top universities and top scientists, scientific spirit as well as tradition. Moreover, China belongs to the emerging countries which do not have a long history of scientific research and experience of research governance, so special characteristics should exist especially after China has entered a phase of quick economic development and profound social reform.

4.2.1 First key driver: Substantial growth in China's scientific investment

It can be seen in Figure 7 that the increase of SCI papers as well as the citation number coincides with the tendency of scientific inputs. R&D expenditure is funding which is used in the process of scientific and technological promotion and innovation. These results are in line with previous researches in general, implying R&D investment is indispensable to promoting research capability and capacity for indigenous innovation.

On the other hand, it is impossible to ignore the significance of talents. In fact, valuing education and talent fostering have made a tremendous difference to China's S&T development. Anyway, it would be impossible for China to become the second most productive country for SCI papers without an enormous number of S&T workers. However, the relationship between SCI papers and human capital is usually difficult to measure directly since it is influenced by many uncertain factors especially as China is in a period of dramatic transformation. Chinese scientists were not aware of the importance of SCI papers and therefore did not try to publish at all. In addition, their research capacity has also built up. But as S&T human capital increases, scientific publications increase, but not necessarily to the same extent.

4.2.2 Second key driver: The utilitarian practice nationwide

Apart from the substantial rise of investment in S&T following the social and economic development in China, there are also other factors that may be responsible for the tremendous increase of China's SCI papers. First of all, the utilitarian practice on every level. What do we mean by utilitarian practice? The function of science should comprise two aspects: a function of recognition, which is to seek truth, i.e. "science for science's sake" (Shen 2007); and a social function that can contribute to social and economic development. A century ago, modern science was accepted by the Chinese mostly due to its social function, making the nation strong and rich, and overtaking developed countries. So whether S&T could be used in practice became the major goal and standard of scientific activities. The recognition function has actually always been ignored (Lin 2007). The utilitarianism or utilitarian practice means that scientific and technological activities have their practical aims that are not beyond economic and political judgment. On the national level, utilitarianism means emphasis is put on the application of science that could quickly boost economic growth, etc., but not on the quest for concealed scientific fundamentals. On the institutional level, utilitarianism means adjustments of the governance approaches to gain superficial achievements in terms of national appraisals and rigid tasks, in order to get a better ranking and more administrative as well as financial support. On the individual level, utilitarianism means adjustments to the general research direction in order to gain reputation as well as benefits like academic titles, program funding, PhD degrees, and salary bonuses in addition to the rather low and fixed salary. Under these utilitarian circumstances, "publication inflation" seems inevitable once the number of SCI papers is employed as a major appraising or evaluation approach for scientific research. In fact, this has raised most concerns and launched broad debates even over the value of the SCI system as well as the simplistic use of scientometric tools for the appraisal of S&T organisations or individuals (Roessner 2000; Weingart 2005).

4.2.2.1 National level: Mission-oriented S&T policy and heavy government involvement in S&T activity

There is growing concern about the popularity of utilitarianism in the scientific community. On the one hand, individuals have little curiosity and interest in natural facts; on the other hand, they insist on finding out what can be done about them (Leiss 1993). As a result, S&T that could help to reach or come close to specific purposes like economic prosperity and military enhancement are defined as "important and prioritized" fields and receive substantial funding; while the other fields that do not lead to those purposes directly such as basic research are becoming stagnant and diminish. Science begins to lose its own independence and is in pursuit of the truth, which actually has never been stressed in history, as Suttmeier (1989) pointed out that "science for science's sake" has not been a meaningful theme in China over the past century. At the same time, lack of such a scientific spirit would also make it easier to bring about utilitarianism. In the end, the results from utilitarian practice usually go the opposite way, i.e. the development of "important and prioritized" fields is limited and restrained because the basic science, which is the source and foundation for other applied sciences falls behind (Ding/Liu 2012; Li 2008; Qian 1985).

Such scientific utilitarianism could show up as a material-oriented or mission-oriented policy on the national level, which is inevitable for China since it is a large developing country and has to face more immediate challenges like a large population, a weak economic foundation, lack of food security, and a great gap compared to industrialized countries. Without a doubt, in China the feature of mission-orientation is still obvious now, besides social needs and the common challenges of sustainable development, all STA have to conform to the national goals preset by the government, for example the "indigenous innovation" scheme has now been the main driving force (Meng 2007). Anyway, it would be understandable that S&T should be a measure to realise the national goals under the special circumstances. Furthermore, another feature of China's S&T policy is heavy government involvement in choosing specific industrial segments, technology options and specific "winners" of funding or support (Chiang 2011). It has been noted that although a mission-oriented model has its historical and contextual reasons and could be regarded as a strategy for China to deal with S&T development under disadvantaged conditions, the model is likely to stifle interest and creativity (Li 2012). Therefore, the question is what China's policy-makers should do nowadays to encourage a pursuit of truth in scientific society.

Concerning the effect of S&T policy on the trend of SCI papers, as Shelton (2012) noted, government funding and spending in the higher education sector always encourage publications as a long-term research benefit. However, "publication inflation" is also expected from a performance-based system where aggregate publication counts are a key component (Butler 2003). As Pouris (2012) pointed out, in South Africa the primary incentive fuelling the recent growth in publication numbers is the country's new funding formula which subsidizes universities by more than 100,000 South African Rand (ZAR) (about US$ 10,170) for each publication that their staff produces. In the same way, it could be imagined to what extent China's publication activity would be affected, especially when the performance-based assessment is used more frequently and the results of such an assessment relates more directly to financial funding and support. As a result, publications may increase disproportionally with a poor quality and low value. So the other question that China's governments should face is how to eliminate these negative influences brought about by the rigid and mechanistic assessment system and heavy government involvement at present.

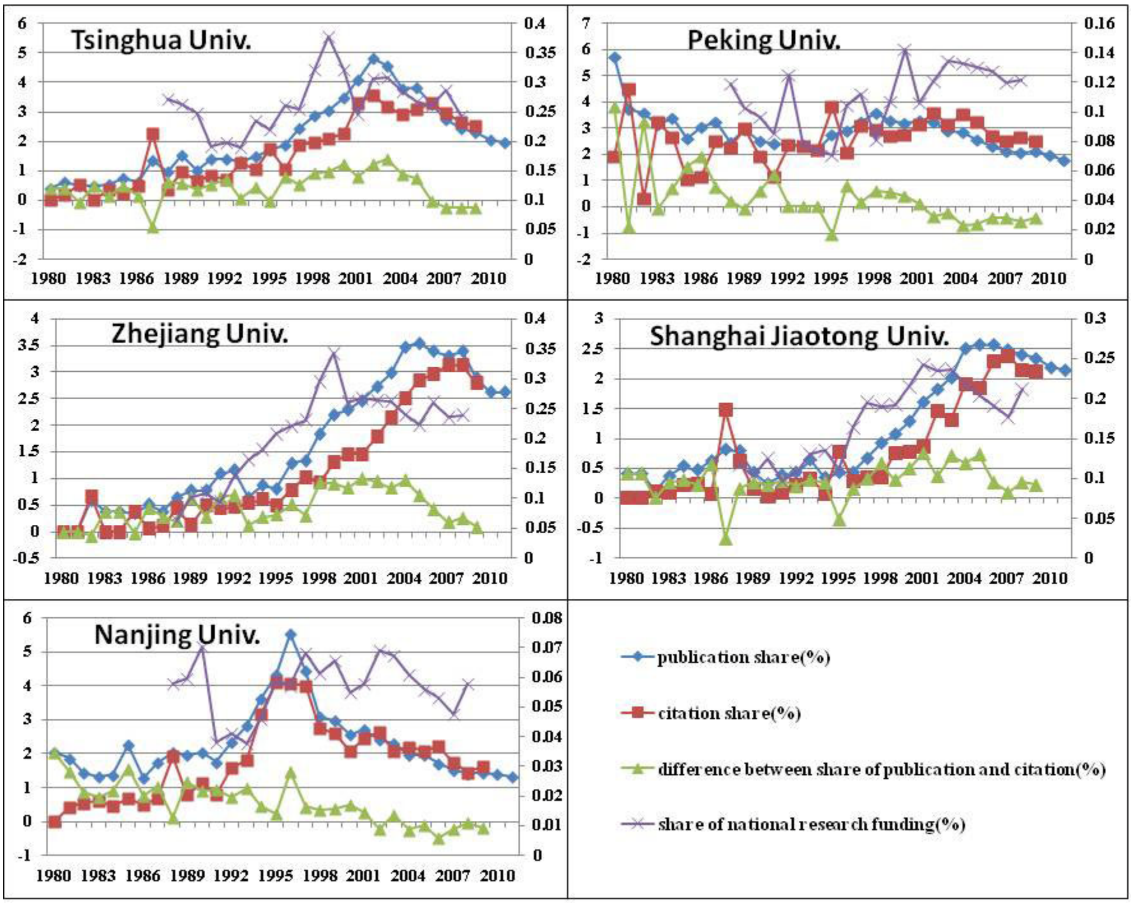
4.2.2.2 Institutional level: Utilitarian governance

Besides the national level, governance patterns on an institutional level would have a direct and essential effect on scientific outputs. The concept of SCI papers was introduced to the Chinese scientific community by the Institute of Scientific and Technical Information of China (ISTIC) at the request of SSTC in 1987. After that, Nanjing University was the first to employ it to evaluate the scientific performance of individuals, laboratories and departments, as well as the qualification of postgraduate's (Gong/Qu 2010). Meanwhile, an incentive bonus of about 500-1,000 yuan (about US$ 60 to US$ 120), the equivalent of about one month's salary at that time, donated by entrepreneurs, was paid out for each SCI paper (Swinbanks et al. 1997). The positive effect of the introduction of the SCI system and related research assessment should be addressed under the circumstances. First, the SCI system could be regarded as an international platform for Chinese scientists to communicate knowledge by reading and submitting comparatively high quality papers. Furthermore, neither a peer review in its true sense, due to lack of immediate as well as excellent peers, and the strong cultural resistance to assessment, particularly at the individual level (Swinbanks et al. 1997), nor other quantitative assessments existed then. As a result, some arbitrary S&T related judgements and allocations had to be made, which was improved greatly by introducing the Western assessment system into China at that time.

However, at the end of the last century, using SCI papers as a major S&T appraisal, spread nationwide. Almost all of China's research organizations, including universities and CAS institutes, started to follow Nanjing University sooner or later by paying a lot of attention to SCI papers. On an individual level, except bringing a comparatively high bonus that usually equals one or two months' salary for common Chinese researchers, most importantly, to publish SCI papers is almost used as one of the indispensable requirements for gaining high academic titles, receiving funds on both the national level and regional level, obtaining doctoral degrees, and so on. On an institutional level, the number of SCI papers becomes a major indicator for appraisal and ranking of organizations. Increasingly intense competition for funding and ranking among research organizations and universities aggravates the requirement for publishing more SCI papers. By this time, it is obvious that the SCI paper-based evaluation system has been overemphasized and overused in China, thereby China overshoot the goal.

The proportion of SCI papers contributed by universities now stands at 82.86% in China (Institute of Scientific and Technical Information of China ISTIC 2012), an overwhelming percentage; therefore in this study China's top five universities are selected to illustrate the effect of the utilitarian governance of institutions on the increase of SCI papers. Nanjing University listed its "core journals" and "first class journals" in 1990 (Gong/Qu 2010), then it had ranked first based on the number of SCI papers among all of China's universities for several years since 1992. Before Nanjing University introduced the SCI into its appraisal system, it was impossible for the University to get into the top ten Chinese Universities, but after the SCI was introduced, it ranked first nationwide for 7 years. This was regarded as a fantastic achievement. Similarly tremendous growth could be found in four of China's other top universities: Tsinghua University, Peking University, Zhejiang University, and Shanghai Jiaotong University, which issued the SCI paper related regulations in 1998 (Zhang 2005), 1996 (Wu et al. 2002), 1999 (Zhejiang University 1999), and 1998 (Shao 2003) respectively. Figure 8 displays trends of the publication share and citation share within China's SCI papers as well as their differences, and funding shares for these universities. Here only first authors were counted since in most cases only the first author is suitably qualified according to those regulations. Publication activity for those top five universities could be characterized as follows: first, the release of related documents, without exception, would be followed by a sharp increase of publication shares, which would reach their peaks in 2-7 years respectively. Secondly, citation shares would grow correspondingly. However, an increase of the citation share is much slower than that of the publication share. When the publication share peaks, the gap between the publication share and the citation share would be the largest. Thirdly, the citation share would catch up with or even exceed the publication share gradually after the latter reaches the highest point and slows down. It seems that the shorter time used for the university to peak, the less negative influence brought by SCI related governance. An example is Peking University, for which the citation share has exceeded the publication share in about 5 years. Finally, the trend of publication activity shows an equivocal relationship with funding during the following years after SCI paper related documents have been issued, i.e. the peak of publication share could appear before or after the peak of S&T related investment at those universities.

Figure 8: Trends of share of publication and citation, as well as funding share for China's top five universities



Source: SCI database, searches and calculations by Fraunhofer ISI; S&T statistic information compilation of Institutions of high education.

Note: data of funding in 2003 and 2004 are used the mean values between 2002 and 2005 since the related data were not published in the Compilations for those two years.

Negative influences are possibly caused by the scientific utilitarianism existing on national and institutional levels. Among them are distorting science, pursuit of instant success and benefit from superficial and short-term researches instead of basic and long-term researches that take a rather longer time to get achievements, as well as worsening of positive-outcome bias, and even scientific misconducts (Fanelli 2012; Lin 2007). Furthermore, there is concern that under the pressure of gaining scientific funding most researchers have to change their topics and directions frequently in terms of national updated priorities or international focal points to improve the chance of getting funding and citations. On the other hand, they have to spend much of their time preparing the cumbersome application and conclusion of projects. As a consequence, few researchers can avoid compliance with national research priorities and do their utmost to pursue their studies, which may partly account for the fact that it is hard to cultivate top scientists under China's indigenous circumstances. There is yet another concern that SCI based assessment may discourage efficient and deep cooperation among scientists as well as institutions since only the first author is recognized for getting awards, promoting academic titles, gaining doctoral degrees. Obviously, the consequence of adopting and adapting Western techniques of research assessment is partly moves away from its original purpose, to improve the productivity and the quality of their research output. On the contrary, SCI papers, which should be the consequent outcomes of scientific discovery, have become the final purpose for some researchers. In these cases, S&T activity has even lost its utilitarian attribute of promoting social and economic development. If this situation gets serious, it would lead to inefficient and valueless researches, as well as low innovation capacity despite the rapidly increasing number of SCI papers.

In practice, "publication inflation" is a challenge that many countries and regions have to face. Butler (2003) pointed out that due to the increased culture of evaluation faced by the academic sector, journal publication productivity for Australia has increased dramatically with decreased impact over the last decades of the past century. Also, since the introduction of performance based assessment in the mid-1980s and the payment of bonuses Taiwan's output of SCI papers has increased seven-fold (Swinbanks et al. 1997). The Chinese government had already noticed the problem caused by the mechanical evaluation system as well as the serious consequences, and issued a specific document in 2003 aiming at solving it: "A Decision to Improve Scientific and Technical Evaluations" (Ministry of Science and Technology MOST et al. 2003). It addressed the issue that the number of publications indexed in the SCI and EI database is only one of the quantitative indicators of S&T evaluation, and evaluation of individuals' academic level. Citation numbers attracted by papers should be stressed, and also be treated diversely in terms of different disciplines. However, it did not take effect markedly due to the lack of detailed governance methods and other evaluation measures complementing the SCI paper-based assessment. In fact, some empirical analyses have proved that the academic departments focus on different outputs (publication number, citation number, funding, etc.), which lead to different results (Agasisti et al. 2012). In order to facilitate more rigorous and accountable policy appraisal, both broader and more plural forms of S&T indicators and visualisation tools are needed (Rafols et al. 2012), which will be helpful to change the current assessment system based merely on the number of publication and awards. As it is impossible to ignore the consequence of "publication inflation", some of China's pioneering universities started to change governance measures on the institutional level. First of all, when a qualification for a high academic title is appraised, a representative production, be it a paper or a book, which should be provided by the scientist himself and represent his top achievements, together with a peer review system, has been laid out by Beijing

University in 2005, followed in recent years by Fudan University and Renmin University. According to this way, the quality but not the quantity of research is stressed, and it is believed that this is to some extent an effective way against the present utilitarian practice.

5 Conclusions

The number of China's SCI papers has grown at a remarkable rate since the 1990s and reached the second place worldwide in 2007, which has attracted close attention all over the world as has the striking growth of China's GDP. We found such increase is in general in conformity with China's S&T related inputs like R&D expenditure which has notably risen in terms of China's related S&T policies since the end of the last century. Meanwhile, the citation rate as well as the visibility of journals in which Chinese publications appear has improved. However, what concerns the scientific community is that the citation number has not increased at the same pace as the publication number, especially in the period 1995-2006, which may have resulted from the "publication inflation" that was derived from the utilitarian practice nationwide. After the SCI database was introduced into China in 1987, the SCI paper-based evaluation system was formed and gradually prevailed all over the country at all levels. As a matter of fact, both the publication number and citation number, which are just part of quantitative bibliometric indicators and reflect the trend of scientific and technological developments from one aspect, should be brought into the performance evaluation system combined with other qualitative measures such as peer reviews. At the same time, close attention should be paid to the possible inflation caused by overemphasis and overdependence on publication outputs; otherwise, the more SCI papers are produced, the more severe the inflation. On the other hand, the elimination of an incentive for utilitarian practice, like less government involvement in S&T activity and comparatively free and flexible circumstances for researchers, the input of true scientific spirit, as well as the provision of desirable living conditions that allow a decent standard of living even without bonuses to encourage scientists to devote themselves to a scientific career, is also essential. China has experienced a marvellous success in S&T development in the past decades, but policy-makers still need to take further actions to fight negative influences caused by utilitarian practice and develop an S&T evaluation system suited to China's situation, which may bring the objective of "developing an innovation country" closer.

6 References

Achleitner, A.-K./Allmendinger, J./Grupp, H./Harhoff, D./Luther, J./Soete, L./Schmoch, U./Stenke, G. (2008): *Research, Innovation and Technological Performance in Germany. EFI Report 2008*. Berlin: Expertenkommission Forschung und Innovation (EFI).

Adams J (2005): Early citation counts correlate with accumulated impact, *Scientometrics,* 63, 567-581.

Agasisti, T./Catalano, G./Landoni, P. (2012): Evaluating the performance of academic departments: an analysis of research-related output efficiency, *Research Evaluation,* 21, 2-14.

Baskurt, O.K. (2011): Time series analysis of publication counts of a university: what are the implications?, *Scientometrics,* 86, 645-656.

Boyack, K.W./Jordan, P. (2011): Metrics associated with NIH funding: a high-level view, *Journal of the American Medical Informatics Association,* 14, 423-431.

Butler, L. (2003): Explaining Australia's increased share of ISI publications-the effects of a funding formula based on publication counts, *Research Policy,* 32, 143-155.

Chiang, J.C. (2011): Innovation with Chinese characteristics with the new policies work. Online: http://web.resource.amchamchina.org/cmsfile/2011/01/26/f2f8a5667ac17e70c49219e8355055a4.pdf (accessed: 12.04.2013).

China Association for Science and Technology (2010): *Research report on development of China's S&T human capital*. Beijing: China Science and technology press (in Chinese).

Ding, C.J./Liu, Y.Q. (2012): Analysis on gains and losses of utilitarianism, *Journal of Donghua University (Social Science),* 12, 69-75.

Du, S.M./Lu, Y.B. (2006): Comment on S&T policy during national technology innovation, *Science and Technology Management Research,* 26, 4-7, 20.

Fanelli, D. (2012): Negative results are disappearing from most disciplines and countries, *Scientometrics,* 90, 891-904.

Fang, X. (2012): China's reform of the science and technology management system-changed and unchanged over three decades, *Studies in Science of Science,* 30, 1441-1443.

Frietsch, R./Hinze, S./Tang, L. (2008): *Bibliometric data study: Assessing the current ranking of the People's Republic of China in a set of research fields* (= Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis No. 15). Karlsruhe: Fraunhofer ISI.

Garfield, E. (1994): Expected citation rates, half-life, and impact ratios. Online: http://thomsonreuters.com/products_services/science/free/essays/expected_citation_rates/ (accessed: 10.04.2013).

Gong, F./Qu, M.F. (2010): A case study of Nanjing University: The influence of introducing SCI into assessment system on the quality of basic research in mainland Chinese universities, *Higher education of science,* 3, 4-17.

Grupp, H./Schmoch, U./Hinze, S. (2001): International alignment and scientific regard as macro-indicators for international comparisons of publications, *Scientometrics,* 51, 359-380.

Gu, S.L. (2001): Science and technology policy for development: China's Experience in the Second Half of the Twentieth Century, *Science, Technology & Society,* 6, 203-234.

Hua, J.Y./Tang, D. (2010): International comparison of S&T investment system and its implication on our S&T policy, *Science & Technology Progress and Policy,* 27, 25-30.

Institute of Scientific and Technical Information of China ISTIC (2012): Statistical data of Chinese S&T papers 2012. Online: http://download.people.com.cn/2012tjjg/2012papers02.pdf (accessed: 15.03.2013).

Larsen, P.O./von Ins, M. (2010): The rate of growth in scientific publication and the decline in coverage provided by science citation index, *Scientometrics,* 84, 575-603.

Leiss, W. (1993): *The domination of nature, translated by Yue, C.L., Li, J.H.* Chongqing: Chongqing Press.

Li, G.Q. (2008): My opinions on the science utilitarianism, *Sci-Tech Information development & Economy,* 18, 143-144.

Li, Y.C. (2012): Demand-side innovation policies in promoting mission-oriented innovation - the case of new energy vehicles in China. In: Fraunhofer Institute for Systems and Innovation Research ISI (ed.): *Towards Transformative Governance? Responses to mission-oriented innovation policy paradigms*. Karlsruhe, Stuttgart: Fraunhofer Verlag, 211-213.

Lin, Z.W. (2007): On the dissolution of scientific utilitarianism in China, *Studies in Dialectics of Nature,* 23, 76-80.

Liu, L. (2008): Four milestones of China's S&T policy since reform and opening-up, *Forum on Science and Technology in China,* 24, 3-5, 23.

Meng, Y. (2007): A mission-oriented pattern of S&T policy in China. Online: www.cspo.org/igscdocs/Yu%20Meng.pdf (accessed: 20.03.2013).

Ministry of Science and Technology MOST (1998): Missions of the Ministry of Science and Technology. Online: from http://www.most.gov.cn/eng/organization/Mission/index.htm (accessed: 10.04.2013).

Ministry of Science and Technology MOST (2000): Historical development schemes of science and technology. Online: http://www.most.gov.cn/kjgh/lskjgh/ (accessed: 10.04.2013).

Ministry of Science and Technology MOST/Ministry of Education/Chinese Academy of Sciences/Chinese Academy of Engineering/National Natural Science Fund Committee (2003): A Decision of improve scientific and technical evaluations. Online: http://www.most.gov.cn/fggw/zfwj/zfwj2003/200512/t20051214_54930.htm.2013-04-10 (accessed: 10.04.2003).

Nag, S./Yang, H./Buccola, S. (2013): Productivity and financial support in academic bioscience, *Applied Economics,* 45, 2817-2826.

National Bureau of Statistics (2012): *2011 China Statistical Yearbook on Science and Technology*. Beijing: China Statistics Press.

National Bureau of Statistics of China (2007): China statistical yearbook-Explanation of summary statistics indicators. Online: http://www.stats.gov.cn/tjsj/ndsj/2007/indexch.htm (accessed: 10.04.2013).

Nederhof AJ (2006): Bibliometric monitoring of research performance in the social sciences and the humanities: A review, *Scientometrics,* 66, 81-100.

Nederhof, A.J./Meijer, R.F./Moed, H.F./van Raan, A.F.J. (1993): Research Performance Indicators for University Departments - a Study of an Agricultural University, *Scientometrics,* 27, 157-178.

OECD (1971): *Science growth and society: a new perspective; Report of the Secretary-General's Ad Hoc Group on New Concepts of Science Policy*. Paris: OECD.

OECD (ed.) (2002): *Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development*. Paris: OECD.

OECD/Eurostat (2005): *Oslo Manual: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data. 3rd edition*. Paris: OECD.

Pouris, A. (2012): Scientometric research in South Africa and successful policy instruments, *Scientometrics,* 91, 317-325.

Qian, Z.X. (1985): Utilitarianism and academy. In: Chen, S. (ed.): *Selections from Debates on Eastern and Western Cultures from around the May Fourth Period*. Beijing: China Social Sciences Publishing House.

Rafols, I./Zwanenberg, P.V./Stirling, A. (2012): Towards indicators for 'opening up' science and technology policy. In: Fraunhofer Institute for Systems and Innovation Research ISI (ed.): *Towards Transformative Governance? Responses to mission-oriented innovation policy paradigms*. Karlsruhe, Stuttgart: Fraunhofer Verlag, 307-302.

Roessner, D. (2000): Quantitative and qualitative methods and measures in the evaluation of research, *Research Evaluation,* 9, 125-132.

Schmoch, U./Qu, W. (2009): *Performance and Structures oft he German Science System in an International Comparison 2008* (= Studien zum deutschen Innovationssystem No. 6-2009). Berlin: Expertenkommission für Forschung und Innovation (EFI).

Shao, C.F. (2003): To observing the effect of research governance from the tremendous increase of Shanghai Jiaotong University's publication, *Journal of Chengdu University of Technology, Science & Technology Edition,* 30, 330-332.

Shelton, R.D./Leydesdorff, L. (2012): Publish or patent: bibliometric evidence for empirical trade-offs in national funding strategies, *Journal of the American Society for Information Science and Technology,* 63, 498-511.

Shen, W.Q. (2007): What is 'Science for Science's Sake': A Typology Study of the Idea of Pure Science, *Peking University Education Review,* 1.

Stamou, S./Tzekou, P./Zotos, N. (2009): Quantifying the impact of funded research works - ICDIM'09, 4th International Conference on Digital Information Management. Ann Arbor, Michigan.

Suttmeier, R.P. (1989): *Research and revolution*. Chang Sha: The PLA National Defense University Press, (translated into Chinese by Yuan, N.S.).

Swinbanks, D./Nathan, R./Triendl, R. (1997): Western research assessment meets Asian culture, *Nature,* 389, 113-117.

Testa, J. (2012): The Thomson Reuters Journal Selection Process. Online: http://thomsonreuters.com/products_services/science/free/essays/journal_selection_process/.

Thomson Reuters (2010): Science citation index expanded. Online: http://thomsonreuters.com/products_services/science/science_products/a-z/science_citation_index_expanded/ (accessed: 02.04.2013).

Wang, J. (2013): Citation time window choice for research impact evaluation, *Scientometrics,* 94, 851-872.

Weingart, P. (2005): Impact of bibliometrics upon the science system: Inadvertent consequences?, *Scientometrics,* 62, 117-131.

Wu, Q./Zhang, G.H./Zhu, X. (2002): Evaluation of the quality of scientific journals and the analysis of the scientific publications by the natural scientists of Peking University, *Science Research management,* 23, 113-119.

Zhang, X.A. (2005): The application of SCI in the evaluation for universities' scientific research in China, *Journal of Adult Education of Gansu Political Science and Law Institute,* 3, 153-156.

Zhejiang University (1999): *Notice on the approval and transmission of the reward measures for scientific and technological progress*.

Zheng, Q.Y. (2004): Primary discussion on Chinese science policy around the National Science Conference in 1978, *Journal of Dialectics of Nature,* 26, 56-62, 111.

Zhou, P./Leydesdorff, L. (2006): The emergence of China as a leading nation in science, *Research Policy,* 35, 83-104.