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Comparison and evaluation of domestic and international outputs in Information Science & Technology research of China

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The purpose of this paper is to evaluate the basic research performance of key projects in the field of information science & technology funded by National Natural Science Foundation of China (NSFC) from both international and national perspectives during the period 1994-2001, based upon the Science Citation Index (SCI) and China Scientific and Technical Papers and Citations (CSTPC) databases. We compare the international and domestic outputs of the key projects by applying various scientometric indicators and techniques. The findings indicate that, as a whole, the research performances of the key projects have, to different degrees, increased in both international and domestic papers during the period of study. Semiconductor is the internationally most productive sub-discipline and Automatization is the domestically most productive sub-discipline, measured on average per project. The Combination Impact Factor (CIF), which integrates the CSTPC-IF and the SCI-IF into the evaluation process, is further proposed for the combined evaluation of domestic and international outputs of the key projects. In terms of ratio of CIF relative to the funds in each sub-discipline, results also show that Semiconductor is the most productive sub-discipline and Computer is the least productive one. Using correlation analysis a significant and positive relationship between the SCI-IF and the CIF has been found for the evaluated projects.

Introduction

In recent years, how to conduct an appropriate evaluation of scientific research performance from both national and international perspective has been an increasingly hot topic in Chinese research communities and science policy makers (JIN, et al., 2002). China is a vast developing country but only has limited resources for scientific research. Therefore the Chinese government focuses on certain strategic fields and puts the scarce resources into these areas. As a result, some scientometric indicators and methodologies have been applied in the evaluation process (GUAN & WANG, 2004; GUAN & MA, 2004).

In order to catch up with the developed countries in some emerging and promising disciplines, such as information science & technology, biology etc., the National

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Natural Science Foundation of China (NSFC), established to fund peer-reviewed basic researches in scientific frontiers, has been strengthening financial inputs to basic researches in these disciplines in recent years. Setting up key projects that deal with important scientific issues in cutting edge research fields is one of the major measures taken by the NSFC to promote basic researches and to shorten the gap in research quality between China and Western countries. The prospective outputs of these research projects should have significant positive impacts on international colleagues. Therefore, the research outputs of the key projects represent, to a great extent, the highest academic level in the related research areas within China. Scientific papers and their quality are the most important outputs of the key research projects.

The information science & technology has been widely regarded as one of the key research fields for several decades. In China, the information science & technology has the highest priority, as identified by the NSFC and Chinese Science and Technology Ministry (GUAN & WANG, 2004). Furthermore, information science and technology is playing an increasingly important role in the S&T development as well as in economic growth in China (*Annual Report of Science and Technology Development of China*, 2002). Therefore, focusing evaluations on the key projects in this field is necessary and of great practical importance.

Science Citation Index (SCI) is an international database produced by the Institute for Scientific Information (ISI, Philadelphia, PA, USA). It provides a system of scientometric indicators based on the number and citations of the publications indexed, and it is mainly used to measure a country's research performance from the viewpoint of international orientation, international visibility and impact at the international research front (MOED et al., 1995; MOED, 2002; UGOLINI & CASILLI, 2003). There have been many studies focused on evaluating the Chinese scientific performance by using the SCI database and the ISI's annual publication of the *Journal Citation Report* (JCR). ZHANG & ZHANG (1997) measured Chinese research performance in terms of counts of the SCI-covered papers between 1987 and 1993 in different disciplines. The study showed an increasing trend in scientific paper output in China. MOED (2002) tested the validity of using bibliometric indicators created by the SCI database to evaluate Chinese research performance. Based on the amount of Chinese scientific output indexed by the SCI during 1980–1999, it exhibited that Chinese scientific research has a very low impact internationally. REN & ROUSSEAU (2002) analysed the degree of internationalization and visibility of Chinese scientific products (SCI-journals and SCI-Expanded-journals and their papers) during the period 1996–1999. They found that the Chinese journals were still rather "local" and suffered from a low international visibility, although these Chinese journals are covered by the ISI. Indian scientist GARG (2002), using a normalized impact factor originated from the SCI, compared the scientific productivity in India and China. He concluded that although the number of papers indexed by the ISI is less when compared with China, Indian research has more international impact. With a similar method, GUAN & MA (2004) evaluated the scholarly impact of Chinese research in computer science. This study found that the Chinese computer science has enjoyed a rapid development and also has gained a relatively high impact. In addition, GUAN & WANG (2004) employed DEA technique to evaluate the relative efficiency for 21 research projects of "National Science Fund for Distinguished Young Scholars" supported by the NSFC based on the number of papers and citations in the SCI.

Although the SCI has made significant contributions to the development and evaluation of science and technology work in all over the world, there exist some limitations such as language bias and imbalance distribution of the source journals. These factors limit the SCI's usage in measuring the scientific research of those peripheral countries whose national journals are seldom covered by the ISI (ARUNACHALAM & MANORAMA, 1989; BORDONS et al., 2002; DE ARENAS et al., 2002; FIGUEIRA et al., 2003; GARFIELD, 1997; GIBBS, 1995; JIN & WANG, 1999; OSAREH & WILSON, 1995; VAN LEEUWEN et al., 2000, 2001). The case is particularly severe in the third world like China since researchers in theses countries publish most of their studies in domestic journals that haven't been indexed by the SCI or other ISI's databases.

In developing countries, the percentage of the scientific articles appeared in the mainstream literatures is estimated to be only about 50% (GAILLARD, 1989). Most Chinese scientific papers are published in domestic journals, and only a small portion with the highest quality and the strongest impact in Chinese journals is covered by the SCI (JIN et al., 2002; LIANG et al., 2001). Even for those Chinese journals indexed by the SCI, they still suffered from low international visibility (REN & ROUSSEAU, 2002; REN et al., 1999; GUAN & MA, 2004). Therefore, the SCI is not sufficient for assessing domestic research activities (MOED, 2002; NEGISHI et al., 2004).

Since the SCI can't do well in evaluating domestic research performance for developing countries, it is necessary to use some other methods and indicators or even to establish a new database functioning as the counterpart of the SCI (JIN et al., 2002; NEGISHI et al., 2004; WU et al., 2004). In some non-English speaking countries, there have been several studies conducted in assessing the impact and effect of the domestic publications and domestic articles via scientometric indicators and techniques. In RUSSELL's work (1998), by comparing the papers with only national institutes' addresses to the papers with co-authorship from aboard, an increasing internationalization of Mexican science has been discovered. FIGUEIRA et al. (2003) has compared and assessed Brazilian psychiatry papers published in domestic and international journals. In Thailand, researchers built similar scientometric indicators as impact factor and immediacy index for a set of 68 selected Thai academic journals (no one is the SCI covered) to assess their quality and the relationship between citations and journals' age (SOMBATSOMPOP et al., 2002).

Realizing the insufficiency of the SCI, several countries have constructed SCI equivalent databases having a good coverage of domestic journals. In Spain, a database named the Spain Index on Science and Technology (ICYT) was produced by the Centre for Scientific Information and Documentation (CINDOC) to provide the scientometric analysis of the domestic academic publication in Spain (REY-ROCHA & MARTÍN-SEMPERE, 1999). In Japan, the Citation Database for Japanese Papers (CJP) was developed by the National Center for Science Information System (NCSIS) in 1995 (JIN & WANG, 1999; NEGISHI et al., 2004). Until now, China has two local databases focusing on natural science and technology, namely, Chinese Science Citation Database (CSCD) established by the Documentation and Information Center of the Chinese Academy of Science (DICCAS) (JIN & WANG, 1999; JIN et al., 2002) and China Scientific and Technical Papers and Citations (CSTPC) created by the Institute of Scientific and Technical Information of China (ISTIC) in 1988 (WU et al., 2004). Furthermore, Chinese Social Science Citation Index (CSSCI) is developed for the social sciences and the humanity studies (SU et al., 2001). Until year 2000, 1,411 domestic journals (25 in English) are selected as the source journals by the CSTPC, and 180,848 papers as well as 554,324 items of citations are recorded from the book titled *Chinese S&T Journal Citation Reports (CSTJCR) 2000* compiled by the ISTIC.

The reasons why we choose the CSTPC in this paper instead of the CSCD are briefly described as follows: (1) the CSTPC has a wider coverage than the CSCD overall. For example, in 2000, there are in total 1,411 journals covered by the CSTPC and only 1,064 journals covered by the CSCD. (2) In this study, the CSTPC also has a better coverage than the CSCD: there are 150 Chinese journals covered by the CSTPC, in which the domestic papers produced by the key projects were published, and twelve of them are not covered by the CSCD.

Similar to the SCI, the CSTPC has also developed scientometric indicators such as impact factor based on the same calculation procedure originated from the ISI. In this paper, in order to distinguish the impact factors from the SCI and the CSTPC, we name them SCI-IF and CSTPC-IF for the impact factors of the SCI and the CSTPC respectively.

This study focuses on the assessment of basic research of the information science & technology in China from both national and international perspectives, based on scientometric indicators (the SCI-IF and the CSTPC-IF). In doing so, we propose a new indicator – Combination Impact Factor (CIF) to merge the SCI-IF and the CSTPC-IF. The rest of the paper is organized as follows. Data derived from department of the information science & technology of the NSFC are introduced in the next section, followed by the description of some scientometric indicators used in this paper. Then the concentration is laid on the evaluation procedure of the key projects and some main results. Finally, several conclusions are presented in the last section.

Data description

In the NSFC's classification, the information science & technology is further divided into five sub-disciplines, namely, Automatization, Optics and Opto-Electronics (Optics for short), Computer science (Computer for short), Electronics and information system (Electronics for short), and Semiconductor. The first key project was granted in 1990 by the Department of the Information Science & Technology in the NSFC and its work began in 1991. We have collected 58 projects in total. These projects started during the period 1991–1999 and ended during the period 1994–2001. The collection already included all the key projects in the department up to the starting date of this work. The duration of these projects is about three or four years. It should be noted that no project was funded in 1995, and only one project funded in 1998 has finished by the time when our study began. The distributions of sub-disciplines among these 58 projects are as follows: 11 in Automatization, 16 in Optics, 12 in Computer, 9 in Electronics, and 10 in Semiconductor. The NSFC provides an 8-digits ID code to characterize each project, and the code describes the information related to the project, including the project's staring time and its sub-discipline, etc.

The data in the study are derived from the final reports of the key projects. In China, each principal investigator of key project is obliged to provide a final report when s/he finishes the research. All papers appeared in the international and domestic journals should be submitted to the NSFC. Entrusted by the Department of the Information Science & Technology of the NSFC, for each paper produced by the key projects, we check whether it is indexed by the SCI database or by the CSTPC database. Among all Chinese journals related to this study, eight Chinese journals indexed by the CSTPC database have their English versions that are also indexed by the SCI database. There is no paper, however, overlap between the SCI and the CSTPC. The papers appeared in those eight Chinese journals and in their English versions are different and classified as the CSTPC papers and the SCI papers in the evaluation respectively. However, when taking international publication activity into account, we remove those papers appeared in the eight English versions from the SCI papers. In total, the key projects have produced 561 papers covered by the SCI and 1,691 domestic papers in the CSTPC-journals. For the purpose of evaluating the performance of Chinese scientific research from both a national view and an international view, we analyzed some bibliometric indicators retrieved from an international database – the SCI and a domestic database – the CSTPC.

In order to retrieve the information of articles published in scientific journals, search strategies have been used according to the particular characteristics of each database. In the SCI, we can search for the title of the publications involved in this study on web-based version of the JCR (http://www.isiknowledge.com), and download the record of each one for a given year. For each item of the records, the bibliometric detail for a particular journal contains title of the journal, ISSN code, total cites in the current year, impact factor, immediacy index, article numbers in the current year, and cited half-life in the current year. All the records in the present study were extracted from the JCR 2000 version. Namely, the indicator values for each journal were first calculated for 2000. Data on domestic papers covered by the CSTPC were obtained from the CSTJCR. In a similar way, we selected the publications in which the key projects publish their scientific outputs, so the related bibliometric information of the journals can be retrieved for the study. Then, we established an Excel table, including following items: ID numbers of the key projects, disciplines of the key projects, duration of the key projects, funds of the projects, and the amount of the SCI-papers and the CSTPC-papers.

Bibliometric indicators and methodology

Indicators of publication production

Count of scientific papers is a classical indicator of research output. It is mainly used to measure the performance of researchers, research institutions, and countries (BRAUN & SCHUBERT, 2003; DAIGLE & ARNOLD, 2000; MAY, 1997). It has been suggested that the funded papers have significantly more impact than the unfunded ones (LEWISON, 1998; MARTÍN-SEMPERE et al., 2002; JIN et al., 2002; WU, et al., 2004). The publication production of a key project is measured by the number of articles in the SCI database or the CSTPC database. The number of articles published in the SCI-journals is denoted as SCI-PAP and the number of articles published in the CSTPC-journals is denoted as CSTPC-PAP. Calculating these two indicators enables us to determine, for each key project in the information science & technology, the number of publications covered by the SCI or the CSTPC database. In accordance with the recommendation of SCHUBERT et al. (1989), only articles, letters, notes, and reviews were considered here.

There are two relative indicators used to exhibit the publication activities in domestic and international journals. The Trend to Publish Home (TPH) (REY-ROCHA & MARTÍN-SEMPERE, 1999) is defined as the ratio between the number of articles published in domestic journals and the total number of articles, i.e. the sum of the papers published by the key projects in the CSTPC-journals as well as in the SCI-journals. Another measure is the International Publication Activity (IPA) (MOED, 2002), defined as the percentage of articles in the SCI-journals, with the Chinese SCI-journals being removed, relative to the total number of articles published either in the CSTPC or the foreign SCI-journals.

Indicators of publication impact

Three indicators are used in this study to represent the impact of the papers produced by the NSFC's key projects in the area of information science & technology.

1. SCI Impact factor. The journal impact factor, first introduced by Garfield & Sher, and published annually in the JCR, indicates the mean citations of the articles in the journal in a given period (GARFIELD & SHER, 1963; GARFIELD, 1972, 1994). In the JCR, this given period is two years. Impact factor, as a citation based indicator, can reflect the quality, prestige and international visibility of a journal. The impact factor is regularly published, standardized, fast and easily obtained and ready-to-use. These advantages make it a prominent international evaluation tool for a journal. However, measuring by impact factor also has several limitations such as incomparability between different disciplines, inaccurate length of citation measurement window, and limited availability, since it is only available for the SCI journals (BORDONS et al., 2002; ROUSSEAU & VAN HOOYDONK, 1996; SOMBATSOMPOP et al., 2004).

The Impact factor calculated by the ISI, denoted as SCI-IF, has been used not only in the process of academic evaluation, such as evaluating journals (RAMÍREZ et al., 2000), journal articles (BASU & AGGARWAL, 2001; FERNÁNDEZ & GÓMEZ, 2002), research activities (MOED, 2002), and researchers' performance (KOSTOFF, 1997), but also in monitoring the status of local science and technology activities and the allocation of research funds.

In this study, the SCI-IF is used as a principal indicator to delineate the impact of SCI-paper production of the key projects. On the ISI's website, the journals are classified by categories, and can be sorted in a descending order in terms of impact factors that are available directly from the website "http://www.isiknowledge.com".

2. CSTPC Impact Factor. Many studies have explored to establish indicators and procedures especially adapted to evaluating domestic journals in peripheral countries. As early as 1974, a simple method called "First approximation" was used to evaluate the domestic and foreign journals depending on the language of the paper and the site of publication in Hungary (VINKLER, 2002). In this method, the papers are scored by 0.5; 1.0; 1.5 points when published in domestic Hungarian journals, domestic English journals and foreign journals, respectively. SEN et al. (1989) determined the impact factors for non-SCI journals by taking into account the SCI citations of the papers published in the evaluated journal as well as domestic citations. In this model, the calculation procedure is the same as that of the impact factor provided by the ISI. SANZ et al. (1995) introduced a new indicator expressed as the contributions in domestic journals from authors who usually publish in mainstream journals. In order to obtain the impact factors for domestic journals, CARCÍA-RUÍZ (1999) conducted a citation analysis via the references in papers. Along the same line, MARTÍN-SEMPERE et al. (2002)

calculated the impact factors for the Spanish domestic journals in the geography field of two-year window and three-year window by considering the citations of the domestic papers in the SCI-database.

In the CSTPC, the impact factors, denoted as the CSTPC-IF, was calculated by the ISTIC and published in the book CSTJCR. In terms of the CSTPC-IF, all the citations and articles are included in the CSTPC-database and the time window is two years. Therefore, in the current study, the indicator the CSTPC-IF is used to evaluate the impact of the domestic papers produced by the key projects.

3. Combination Impact Factor. The research output of the key projects funded by the NSFC well represents the highest academic level of basic research in China. Therefore, the researchers of the key projects not only publish their discoveries in domestic journals, but also pursue publication in international journals. Therefore, the evaluation based on any single database, either a domestic one (such as the CSTPC) or an international one (such as the ISI's), is not representative of the actual research performance of these key projects. In order to measure the Chinese scientific research from both a national view and an international view, JIN & WANG (1999) used Chinese SCI-journals as a bridge between the SCI and local Chinese databases. Following their idea, in this study, we combine the SCI-IF and the CSTPC-IF into one new comprehensive indicator. We call this "the Combination Impact Factor (CIF)". This new indicator is created based on the following assumptions: Chinese SCI-journals covered by the ISI are the top journals in China although they may have low international visibilities, and most of their Chinese-language versions are also covered by the CSTPC if they have. Hence, the Chinese SCI-journals are taken as the bridge connecting the SCI-IF and the CSTPC-IF since they have both types of the impact factors. The followings are the detailed descriptions of the calculation procedure for the CIF.

- In order to retrieve the Chinese SCI-journals, we select the option of "view a group of journals by country" on the webpage of JCR, with "PEOPLES R CHINA**"** as the key word. This step results in 46 journals in 2000.
- The selected journals cover different categories both in the SCI-database and in the CSTPC-database. The division of categories is different in these two databases. Since the categories in the CSTPC are comparably roughly classified, we attempt to unify the SCI-categories according to the CSTPC-categories and divide the SCI-categories that are related to this study into 23 groups (See Table 1). Chinese SCI-journals related to this study are listed in 9 categories for the year 2000 (See Table 2). It should be noted that the category groups in Table 1 cover all the journals in this study, whereas the category groups in Table 2 only include Chinese SCI-journals.

Table 1. Category unification and classification of the SCI and the CSTPC

The unified categories			
1	AERONAUTICS & ASTRONAUTICS	13	MATERIAL SCIENCE AND TECHNOLOGY
2	ASTRONOMY	14	MATHEMATICS
3	BIOLOGY	15	MECHANIC ENGINEERING
4	CHEMISTRY	16	MECHANICS
5	CHEMISTRY ENGINEERING	17	MEDICINE
6	COMPUTER SCIENCE AND TECHNOLOGY	18	METALLURGY
7	ELECTRONIC COMMUNICATION	19	MULTIDISCIPLINE
8	ENGERGY SCIENCE AND TECHNOLOGY	20	NEUROSCIENCE
9	ENVIRONMENT	21	PHARMACOLOGY
10	INFORMATION SCIENCE AND SYSTEM SCIENCE	22	PHYSICS
11	LIGHT INDUSTRY AND TEXTILE	23	TRAFFIC AND TRANSPORTATION
12	MANEGEMENT		

Source: 2000 JCR Science Edition and 2000 CSTJCR
Remarks: Only including the categories to which all papers produced by the key projects are related.

Table 2. Coefficient for each category group and average coefficient for Chinese SCI-journals

CATEGORY GROUP	α
BIOLOGY	0.08
CHEMISTRY	0.40
MATHEMATICS	0.28
PHYSICS	0.19
MECHANICS	0.49
PHARMACOLOGY	0.31
MEDICINE	0.02
MULTIDISCIPLINE	0.04
MATERIAL SCI. TECH.	0.10
AVERAGE FOR CATEGORIES	0.21

Source: 2000 JCR Science Edition, 2000 CSTJCR, and authors' calculation
Remarks: Only including those categories to which papers produced by the key projects are related.

- In order to connect the SCI-IF to the CSTPC-IF, we define a parameter, denoted as α_c, to represent the weight for the CSTPC-IF compared to the SCI-IF in the c^{th} category group. The calculating procedure of α_c is shown as follows.

$$\alpha_c = \frac{1}{n_c}\sum_{j=1}^{n_c}\alpha_{cj} \tag{1}$$

$$\alpha_{cj} = \frac{RIF(SCI)_{cj}}{RIF(CSTPC)_{cj}} \tag{2}$$

$$RIF(SCI)_{cj} = \frac{c_j \Big/ \sum_{j=1}^{J_s} c_j}{p_j \Big/ \sum_{j=1}^{J_s} p_j} = \frac{c_j / p_j}{\sum_{j=1}^{J_s} c_j \Big/ \sum_{j=1}^{J_s} p_j} = \frac{(SCI\text{-}IF)_j}{(SCI\text{-}GIF)_c} \tag{3}$$

$$RIF(CSTPC)_{cj} = \frac{c_j \Big/ \sum_{j=1}^{J_c} c_j}{p_j \Big/ \sum_{j=1}^{J_c} p_j} = \frac{c_j / p_j}{\sum_{j=1}^{J_c} c_j \Big/ \sum_{j=1}^{J_c} p_j} = \frac{(CSTPC\text{ - }IF)_j}{(CSTPC\text{ - }GIF)_c} \tag{4}$$

where α_c means the average value of weight in the c^{th} category group ($c = 1,2,\cdots 9$); n_c is the number of the journals in the c^{th} category group. α_{cj} is the weight for the j^{th} Chinese SCI-journal in the c^{th} category group, $RIF(SCI)_{cj}$ and $RIF(CSTPC)_{cj}$ indicate the Relative Impact Factor (EGGHE & ROUSSEAU, 2002) in the SCI database and the CSTPC database, respectively. p_j and c_j indicate the number of papers published in and citations obtained by the j^{th} journal. J_s represents the total number of the SCI journals that are included in the s-category group. J_c represents the total number of the CSTPC journals that are included in the c^{th} category group. The *GIF* (Global Impact Factor), is the impact factor of a meta-journal – a set of considered journals in an ISI-JCR subject category – representing the mean level of the quality of the journals (EGGHE & ROUSSEAU, 1996).The calculated values of α_c are also shown in the Table 2.

- Let CIF_k denote the Combination Impact Factor for the k^{th} project, k = 1,2,.... K (K = 58 in this study). Taking α_c as the coefficient of the CSTPC-IF, we can determine the CIF for each key project according to the following equations.

$$CIF_k = (SCI\text{ - }IF)_k + UIF_k \tag{5}$$

where

$$(SCI\text{ - }IF)_k = \sum_{i=1}^{C_k}(SCI\text{ - }IF)_k^i \tag{6}$$

$$UIF_k = \sum_{j=1}^{D_k} \alpha_c (CSTPC\text{ - }IF)_k^j \tag{7}$$

where C_k,D_k represent the amount of the papers indexed by the SCI-database and the CSTPC-database of the k^{th} project respectively, $(SCI\text{ - }IF)_k^i$ indicates the SCI impact factor for the i^{th} SCI-paper of the k^{th} project, and i = 1,2,.... C_k. $(SCI\text{ - }IF)_k$ means the sum of the SCI impact factors of the k^{th} project. $(CSTPC\text{ - }IF)_k^j$ indicates the CSTPC impact factor for the j^{th} CSTPC-paper of the k^{th} project, and j = 1,2,.... D_k, and $(CSTPC\text{ - }IF)_k$ is the sum of the CSTPC impact factors of the k^{th} project. UIF_k is the unified impact factor for the papers indexed by the CSTPC-database of the k^{th} project. If a journal is excluded from the category groups in Table 2, the value of α_c is assumed as 0.211 – the mean value of weight for the total CSTPC-papers. Therefore the combination measurement of the key projects' domestic and international output can be performed by Eqs (5)–(7).

The definition of the CIF in the equation (5) is clear. That is, the CIF for any project consists of two parts. One of them is the SCI-IF produced by the project. The other is the unified CSTPC-IF produced in the local journals, which is a SCI-IF equivalent for the local CSTPC papers. Coefficient α_c is a bridge to connect the two databases. In this way, two types of research outputs can be unified in terms of α_c.

Results

Comparison between outputs of domestic and international journals

In this study, we measure the outputs of the key projects in the information science & technology from both domestic and international views. For each project, the total amount of domestic papers (indexed by the CSTPC) and the total amount of international papers (indexed by the SCI) represent the quantity of the paper outputs, respectively.* And the sum of the CSTPC-IF and the SCI-IF of a project indicate the quality of the paper outputs.

The key projects represent the highest level of the basic scientific research in China, and most of the paper outputs of the key projects in the information science & technology field during 1994–2001 are indexed by the SCI and the CSTPC. The total number of the papers in this study is 2,252. There are roughly three times more articles in the domestic database (the CSTPC) than in the international counterpart (the SCI) (1,691 vs. 561). Hence, the majority (75%) of the Chinese scientific research output in the field of information science & technology lacks international visibility.

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* In practice, the paper outputs of a project are developed continuously after the project start-up. However, in order to simplify the process of data collection and calculation, for a project, the papers are assumed as the outputs in the year when the project is finished.

Table 3 indicates inputs in terms of average deflated funds. To convert the funds into real RMB, the funds are deflated by the Chinese retail price index (base year 1991, the start year of the funding). In this paper, the impact factors of the SCI and CSTPC journals are used to be a proxy of the quality of these papers. For consistency, values of impact factor are all taken in the year 2000. Then, we add impact factors to yield a total for the SCI papers or for the CSTPC papers for each key project. Therefore, for each project, it has a SCI-IF and a CSTPC-IF to indicate the quality of the papers.

The values in terms of various scientometric indicators are calculated as the average per project per year and are shown in Table 3 as well. 561 papers published in the SCI-indexed journals with the total SCI-IF of 733.6, and 1691 papers published in the CSTPC-indexed journals with the total CSTPC-IF (in 2000) of 573.4.

Table 3. Average inputs and outputs per project in each year[a]

Finished Year	Funds (1 000 RMB[b])	Change[c]	SCI-PAP	Change	SCI-IF	Change	CSTPC-PAP	Change	CSTPC-IF	Change
1994	629.6	NA	3	NA	5.9	NA	8	NA	3.3	NA
1995	578.7	0.9	8	2.7	10.6	1.8	25	3.1	7.9	2.4
1996	724.2	1.3	4	0.5	3.6	0.3	22	0.9	6.6	0.8
1997	514.9	0.7	10	2.5	9.4	2.6	32	1.5	11.8	1.8
1998	515.3	1.0	20	2.0	13.3	1.4	130	4.1	46.8	4.0
1999	446.0	0.9	6	0.3	8.6	0.6	24	0.2	7.8	0.2
2000	548.1	1.2	14	2.3	21.7	2.5	32	1.3	10.6	1.4
2001	422.0	0.8	28	2.0	44.0	2.0	15	0.5	5.7	0.5

Remarks: [a] To convert the funds into real RMB, the funds are deflated by the Chinese price index (base year 1991, the starting year of the funding); [b] Exchange rate: 8.27RMB=1US$; [c] Change = the value in the current year/the value in the previous year

Table 3 indicates that during the period in our investigation, the average investment per project per year shows a descending trend with slight fluctuating. On the other hand, the outputs of the funded key projects can be roughly divided into three stages – (1994, 1995), (1996–1998) and (1999–2001) according to their changing patterns. All the outputs (the SCI-PAP, the SCI-IF, the CSTPC-PAP and the CSTPC-IF) in the first and second stages have increasing patterns. The SCI-PAP and the SCI-IF increased during the most recent years (1999–2001). The CSTPC-PAP and the CSTPC-IF, however, increased during 1999–2000 and decreased during 2000–2001. We can examine the changes of the input and output per project year after year, and such changes are also shown in Table 3. The changes of inputs and outputs show an inverse direction before 1998. Therefore, heavier investment in the key projects alone does not necessarily lead to better research performance in the early years. The changing trends of the CSTPC-

PAP and the CSTPC-IF are the same as that of input after 1998, and the SCI-PAP and the SCI-IF also have the same changing trend as that of input after 1998, except in 2001. This indicates that the outputs of the key projects are more closely related to the inputs in the more recent years. The exception shown in the year 2001 may ascribe to the most productive project in term of the SCI-PAP and the SCI-IF.

Figure 1 and Figure 2 exhibit the total and average outputs in terms of quantity as well as impact factors for domestic papers and international papers over the studied years.

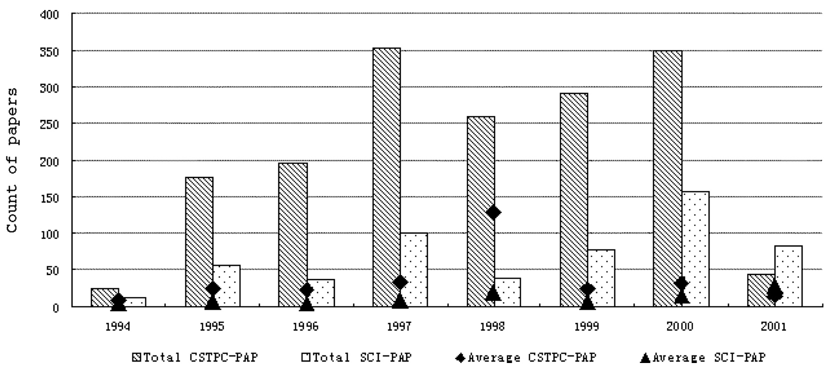

Figure 1. Distribution of paper counts from 1994 to 2001

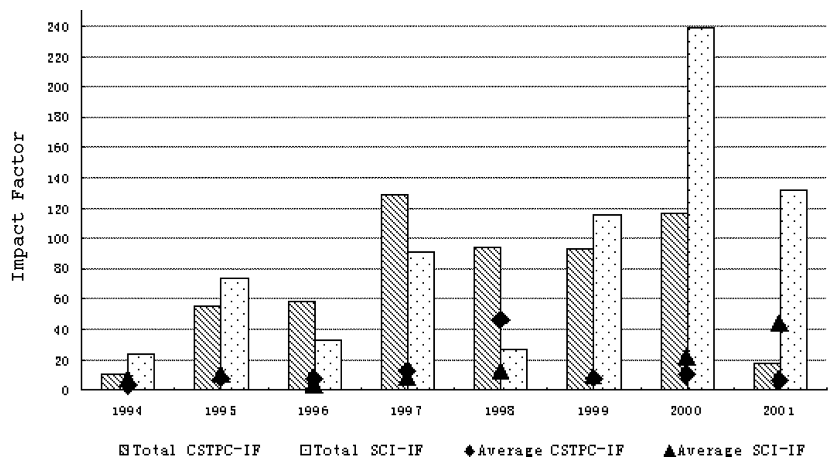

Figure 2. Distribution of paper impact factors from 1994 to 2001

In the context of total values of paper outputs, there is no clear trend appeared because of the varied project numbers each year. However, an upward trend was observed for the average values in terms of international paper amount and impact factor. The average domestic outputs went through an up-and-down with a peak occurring in 1998.

Table 4 describes the distribution details of the key projects in terms of input and output indictors for each sub-discipline in each year. From the international view, among the five sub-disciplines, Optics is the most productive and the most international visible one. The number and impact factors of the SCI papers for Optics are 171 and 263.3, accounting for 30% of the total SCI papers and 36% of the SCI-IF. In terms of the paper outputs per project for each sub-discipline, however, Semiconductor is the most SCI-productive and visible sub-discipline with the highest average values of the SCI-PAP and the SCI-IF. Computer, on the other extreme, produces only 22 SCI-papers and 8.4 impact factors in total, merely with shares of 4% of the total SCI papers and 1% of the SCI-IF. Thus, it is also the least SCI-productive and the least visible sub-discipline.

With regard to the domestic outputs of the key projects, Automatization is the most outstanding sub-discipline with far more outputs compared to the other four sub-disciplines. The number and impact factors of the CSTPC papers for Automatization are 670 and 232.9, which shares of 40% of the CSTPC papers and 41% of the CSTPC-IF. Semiconductor is the least productive sub-discipline in terms of the CSTPC-PAP and Electronics is the least in terms of the CSTPC-IF. At the level of average per project, Automatization is the most productive sub-discipline in terms of the domestic outputs. On the other hand, Semiconductor and Optics produced the least CSTPC-IF and CSTPC-PAP, respectively. Table 4 also reveals that at the level of sub-discipline, the variations between the most and the least productive sub-disciplines is bigger for international outputs than for domestic outputs.

Figure 3 and Figure 4 give the shares of the international papers and domestic papers per project in each sub-discipline. Obviously, in terms of paper counts, the CSTPC-PAPs take a higher percentage than the SCI-PAPs in all the five sub-disciplines (See Figure 3). Strikingly, a significant higher percentage of papers in domestic database than international one (92% vs. 8%) was observed in the field of Computer, followed by Automatization (85% vs. 15%). Since most of the papers produced by the key projects are indexed by the SCI and the CSTPC, the difference between the SCI-PAPs and the CSTPC-PAPs may attribute to the publishing preference of Chinese researchers. In particular, the researchers in Computer and Automatization published much more papers in domestic journals. In view of the quality analysis, the CSTPC-IF holds a lower share than the SCI-IF except for Automatization and Computer.

Table 4. Production and impact of NSFC's key projects

	Funds (1 000 RMB[a])	SCI-PAP	SCI-IF	CSTPC-PAP	CSTPC-IF
Automatization					
1994	NP	NP	NP	NP	NP
1995	378.1	13	10.4	61	23.1
1996	1363.9	0	0.0	27	8.9
1997	1346.2	48	45.7	202	74.7
1998	578.1	28	22.7	203	65.0
1999	678.8	11	5.6	76	26.8
2000	1103.9	22	12.2	101	34.5
2001	NP	NP	NP	NP	NP
Total	5449.0	122	96.7	670	232.9
Average (per project)	495.4	11	8.8	61	21.2
Optics					
1994	1382.5	12	23.7	21	7.7
1995	1483.2	13	18.2	69	21.8
1996	NP	NP	NP	NP	NP
1997	1088.5	15	17.6	14	5.7
1998	NP	NP	NP	NP	NP
1999	2500.7	22	31.5	101	33.2
2000	1008.4	24	40.3	27	9.0
2001	1266.0	85	132.0	44	17.0
Total	8729.3	171	263.3	276	94.3
Average (per project)	545.6	11	16.5	17	5.9
Computer					
1994	506.3	0	0.0	4	2.2
1995	256.2	0	0.0	0	0.0
1996	1652.3	5	2.1	55	27.7
1997	1129.7	4	1.1	62	31.6
1998	452.5	11	3.8	56	28.7
1999	311.1	0	0.0	15	4.6
2000	1138.8	2	1.5	76	40.2
2001	NP	NP	NP	NP	NP
Total	5446.9	22	8.4	268	135.0
Average (per project)	453.9	2	0.7	22	11.2

Table 4. (cont.)

	Funds (1 000 RMB[a])	SCI-PAP	SCI-IF	CSTPC-PAP	CSTPC-IF
Electronics					
1994	NP	NP	NP	NP	NP
1995	1000.0	26	40.6	33	6.3
1996	1489.8	0	0.0	15	3.1
1997	1933.0	32	26.8	66	15.3
1998	NP	NP	NP	NP	NP
1999	529.2	9	4.3	21	5.7
2000	1295.4	18	34.9	108	22.4
2001	NP	NP	NP	NP	NP
Total	6247.4	85	106.6	243	52.8
Average (per project)	694.2	9	11.9	27	5.9
Semiconductor					
1994	NP	NP	NP	NP	NP
1995	933.3	4	4.9	12	4.0
1996	2012.1	32	30.5	99	19.2
1997	NP	NP	NP	NP	NP
1998	NP	NP	NP	NP	NP
1999	1499.0	35	73.7	86	25.2
2000	1038.2	80	133.1	17	5.6
2001	444.5	10	16.4	20	4.5
Total	5927.1	161	258.6	234	58.5
Average (per project)	592.7	16	25.9	23	5.8

Note: NP indicates there is no project in the year
Remarks: [a] Exchange rate: 8.27RMB=1US$.
Source: NSFC and authors' calculation

Strikingly, the impact factor values of domestic papers in Computer take an overwhelming higher percentage than international papers do (94% vs. 6%). On the contrary, the projects in Semiconductor produced much more the SCI-IF than the CSTPC-IF (82% vs. 18%). The difference between the SCI-IF and the CSTPC-IF at the level of sub-discipline is mainly due to the difference of impact factor values between the two database. The average impact factor value in the SCI (1.3) is approximately 4 times higher than in the CSTPC (0.3) , which indicates lower quality of the CSTPC-journals in comparison with the SCI-journals.

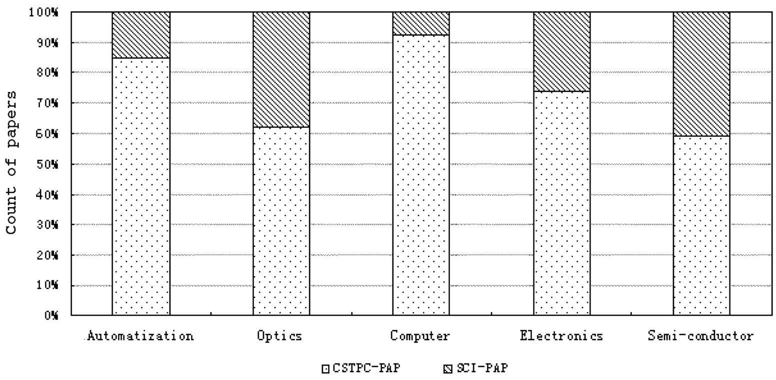

Figure 3. Share of the amount of the key projects' articles, domestic versus international journals

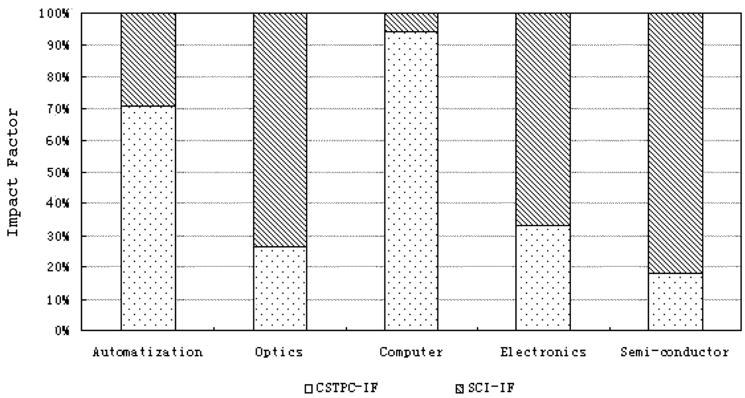

Figure 4. Shares of the IFs of the key projects' articles, domestic versus international journals

Table 5 reflects that for information science & technology, the publication profiles of the NSFC's key projects in domestic journals vary substantially depending on the sub-discipline. The values of The Trend to Publish Home (TPH) are relatively lower for the projects of Semiconductor and Optics than other sub-disciplines, with the values of 59% and 62% over the period 1994-2001, respectively. On the other hand, Computer showed the highest TPH value (TPH = 92%) in the information science & technology. The time series data in TPH show a gradually growth trend during 1994–1996 and reach a peak in 1998 after a slight drop in 1997 at an overall level. Despite of the decrease after 1998, domestic journals are still important communication channel for Chinese researchers in the information science & technology. It should also be emphasized that Chinese authors are gradually turning to publish their works in international journals in recent years, especially in the SCI journals.

Table 6 presents the ratio of the SCI papers (without those published in Chinese SCI-journals) relative to the total number of papers published in either the SCI or the CSTPC journals produced by key projects. The ratio is denoted as International Publication Activity (IPA). There are 76 articles published in Chinese SCI-journals, accounting for 14% of the total SCI-papers and 3% of the total papers produced by the key projects. The distributions of IPA for each sub-discipline and the evolution trend of IPA during the studied period are contrary to those of TPH, as represented in Table 6. Among the five sub-disciplines, Semiconductor shows a highest IPA (IPA = 37%), followed by Optics (IPA = 32%). On the other hand, Computer has gained poor results in internationalization of its works (IPA = 5%). At an overall level for all key projects in the information science & technology, an increase in IPA is exhibited in recent years, especially in 2001, the last year of the studied period.

Table 5. Trend to Publish Home (TPH), by sub-discipline

Sub-discipline	Total	1994	1995	1996	1997	1998	1999	2000	2001
Automatization	85%	NA	82%	100%	81%	88%	87%	82%	NA
Optics	62%	64%	84%	NA	48%	NA	82%	53%	35%
Computer	92%	100%	NA	92%	94%	84%	100%	97%	NA
Electronics	74%	NA	56%	100%	67%	NA	70%	86%	NA
Semiconductor	59%	NA	75%	76%	NA	NA	71%	18%	67%
Total	75%	68%	76%	84%	78%	87%	79%	69%	41%

Source: NSFC and authors' calculation

Table 6. International Publication Activity (IPA), by sub-discipline

Sub-discipline	Total	1994	1995	1996	1997	1998	1999	2000	2001
Automatization	13%	NA	18%	0%	16%	12%	12%	11%	NA
Optics	32%	24%	9%	NA	21%	NA	17%	45%	61%
Computer	5%	0%	NA	7%	2%	12%	0%	3%	NA
Electronics	23%	NA	39%	0%	32%	NA	17%	14%	NA
Semiconductor	37%	NA	25%	24%	NA	NA	25%	73%	30%
Total	22%	22%	20%	15%	18%	12%	17%	27%	55%

Source: NSFC and authors' calculation

After comparing the international and domestic outputs produced by the key projects through various scientometric indicators and methods, we found that, Semiconductor achieves the best results in the SCI outputs per project, and Automatization holds the top position in terms of the domestic outputs.

Core journals for key projects in the information science & technology

The significant scientific literature appears in a small core of journals (GARFIELD, 1996). One of the main concerns of our study is to identify the core journals related to the key projects. In a descending order in terms of paper counts that are published by the key projects, the core journals are those which covered 50% of articles in the SCI-database and the CSTPC-database, respectively. With this aim, the total articles in each journal published by the key projects are considered to generate the core journals. As a result, 18 SCI-journals (13% of the total SCI-journals) and 13 CSTPC-journals (9% of the total CSTPC-journals) are most frequently used by the researcher of the key projects for publication in the information science & technology. Table 7 gives the distribution of the 31 core journals, characterized by database covering and country of publication.

Table 7 shows that the top three publication journals indexed by the SCI in terms of paper counts published by the key projects are *Applied Physics Letters, Journal of Crystal Growth* and *Chinese Physics Letters*, whose SCI-IFs in 2000 are 3.9, 1.4 and 0.6, respectively. *Acta Automatics Sinica, Control Theory & Applications* and *Journal of Software* are the CSTPC-journals that are most frequently used by the researchers of the key projects, with the CSTPC-IFs of 0.5, 0.3 and 0.6 in 2000, respectively. Among 18 core SCI-journals, apart from 3 Chinese journals, 8 of them are published in the USA, 4 in Netherlands, 2 in England and 1 in Switzerland. With reference to the CSTPC core journals, 9 out of 13 are published by Chinese Science Academy, indicating the higher level of academic authority and the good academia in Chinese Academy of Science. It should be noticed that some core journals selected in this study may be originated from one or two productive projects. However these core journals can at least show the overall profile of the publication activity.

Table 7. Core journals that covered 50% of articles

Journal	Indexed by database	Country of publication	%articles
Appl. Phys. Lett.	SCI	United States	7%
J. Cryst. Growth	SCI	Netherlands	6%
Chin. Phys. Lett.	SCI	China	5%
J. Appl.Physics	SCI	United States	4%
Phys. Rev. B	SCI	United States	3%
Sens. Actuator A-Phys.	SCI	Switzerland	3%
Int. J. Infrared Millimeter Waves	SCI	United States	2%
Microw. Opt. Technol. Lett.	SCI	United States	2%
Appl. Phys. A-Mater. Sci. Process.	SCI	United States	2%
Appl. Surf. Sci.	SCI	Netherlands	2%
Automatica	SCI	United States	2%
Opt. Commun.	SCI	Netherlands	2%
Prog. Nat. Sci.	SCI	China	2%
Sci. China Ser. E-Technol. Sci.	SCI	China	2%
Thin Solid Films	SCI	Netherlands	2%
Int. J. Syst. Sci.	SCI	England	2%
Solid State Commun.	SCI	United States	2%
Electron. Lett.	SCI	England	1%
*Acta Automatics Sinica**	CSTPC	China	6%
*Control Theory & Applications**	CSTPC	China	6%
*Journal of Software**	CSTPC	China	5%
Acta Electronica Sinica	CSTPC	China	5%
Journal of Zhejiang University	CSTPC	China	5%
*Chinese Journal of Computers**	CSTPC	China	4%
*Acta Optica Sinica**	CSTPC	China	4%
Control and Decision	CSTPC	China	4%
*Chinese Journal of Semiconductor**	CSTPC	China	3%
*Chinese Journal of Lasers**	CSTPC	China	3%
Journal of Shanghai Jiaotong University	CSTPC	China	2%
*Information and Control**	CSTPC	China	2%
*Acta Physica Sinica**	CSTPC	China	2%
Total			50%

Remarks: * indicates the journal published by Chinese Science Academy
Source: NSFC and authors' calculation

Combination measurement

In the present work, a new indicator – Combination Impact Factor (CIF) is developed to measure the research performance of the NSFC's key projects in the information science & technology from an integral point of view. The CIF of each project for each year calculated by Eqs (1)–(7) is given in Table 8. The change of the CIF per project year after year is also given in Table 8. We compare the change of the CIF with the change of funds and find that an inverse pattern appeared between the changes of the two indicators before 1998 and in 2001, while an accordance pattern existing between them during the period 1998–2000. Hence, from the integral viewpoint, it can be concluded that the outputs have more close relationship with the inputs in recent years. An exception appeared in 2001 because of an outstanding project in that year.

Table 8. Mean values of the inputs and outputs of each project in each year[a]

Year	Funds (1 000 RMB[b])	Change[c] of funds	CSTPC-IF	SCI-IF	UIF	CIF	Change of CIF
1994	629.6	NA	3.3	7.9	0.6	8.5	NA
1995	578.7	0.9	7.9	10.6	1.5	12.1	1.4
1996	724.2	1.3	6.6	3.6	1.4	5.0	0.4
1997	514.9	0.7	11.8	8.3	2.3	10.6	2.1
1998	515.3	1.0	46.8	13.3	9.9	23.1	2.2
1999	446.0	0.9	7.8	9.6	1.7	11.4	0.5
2000	548.1	1.2	10.6	21.7	2.0	23.7	2.1
2001	422.0	0.8	5.7	44.0	1.0	45.0	1.9
Total	31799.7	–	573.4	733.6	115.5	849.1	–

Remarks: [a] To convert the funds into real RMB, the funds are deflated by the Chinese price index (base year 1991, the starting year of the funding); [b] Exchange rate: 8.27RMB=1US$; [c] Change = the value in the current year/the value in the previous year

Figure 5 represents the evolutionary trend of the annual average values per project of the SCI-IF, the CSTPC-IF and the CIF during the period 1994–2001. Two main results can be pointed out. The first concerns the values of the SCI-IF, the CSTPC-IF and the CIF on average per year. The CIF is higher than the SCI-IF in every year during the studied period. However, compared with the CSTPC-IF, the CIF is lower than the CSTPC-IF during the period 1996–1998 due to the higher CSTPC-IF. The second fact is that, compared with the CSTPC-IF, the SCI-IF is closer to the CIF, except during 1996–1998 when the key projects produced more the CSTPC-papers than the SCI-papers, which can be explained by Figure 2. Therefore, the CIF is similar to the dominant one between the CSTPC-IF and the SCI-IF.

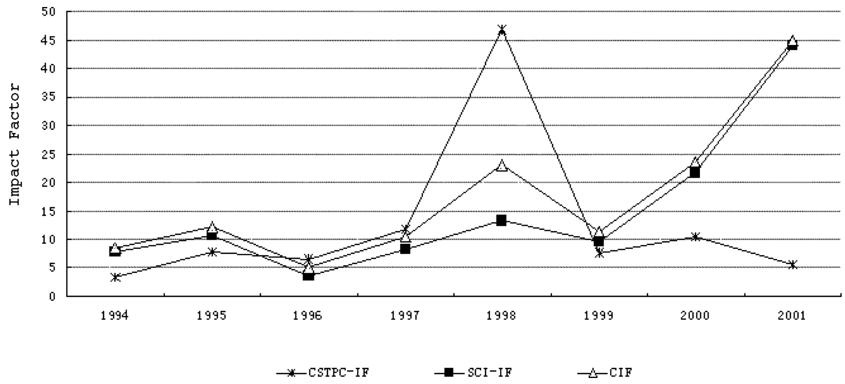

Figure 5. The distribution of three indicators for paper impact per project in each year

In the attempt to explore the relationship between the SCI-IF, the CSTPC-IF and the CIF, we carry out correlation analysis at a level of individual project for two groups – the SCI-IF vs. the CIF and the CSTPC-IF vs. the CIF. Processed by SPSS 11.5 software, the results of the Pearson Correlation are displayed in Table 9. A strong positive correlation was shown between the SCI-IF and the CIF with coefficient 0.993 at a significant level $p<0.01$ (Sig.(2-tailed) = 0.000). On the contrary, the correlation coefficient between the CSTPC-IF and the CIF is very low (0.106), which indicates that the correlation existed between the CSTPC-IF and the CIF is weak. Therefore, the CIF depends more on the SCI-IF. The CSTPC-IF only contributes marginally to CIF. In consideration of numbers of the SCI and the CSTPC papers, this may underestimate the domestic outputs a little bit. Thus, it remains an open question whether there is any more rational instrument than the CIF to deal with the issue. This is a future research direction.

Table 9. The correlation between three impact factors

	N	Mean	S.D.	Correlation	sig.(2-tailed)
SCI-IF	58	12.7	21.5	0.993**	0.000
CIF	58	14.6	21.6		
CSTPC-IF	58	9.9	12.2	0.106	0.429
CIF	58	14.6	21.6		

** Correlation is significant at the 0.01 level (2-tailed)
Source: Authors' calculation by SPSS 11.5

Further analysis of each sub-discipline is shown in Table 10, reporting the average outputs in each discipline, as well as the research performance identified by the ratio of the CIF relative to Funds. The figures of related to individual sub-discipline in Table 10 are all averages per project. For example, in Table 10, Performance = CIF/ Funds, where the "CIF" is average per project in each sub-discipline, and "Funds" is also the average value per project in each sub-discipline. Therefore, the performance is the ratio of average output to average input per project within each sub-discipline. The ratio indicates the productivity of each sub-discipline. Table 10 shows that the CIF values are more close to the SCI-IF values in Optics, Electronics and Semiconductor since the values of the SCI-IF in these sub-disciplines are higher than ones of the CSTPC-IF, in accordance with the findings in the previous analysis (see Figure 4). The ratios of CIF/Funds characterize the efficiency of the usage of the Funds. Among the five sub-disciplines, Semiconductor has the highest ratio (CIF/Funds = 0.05), followed by Optics (CIF/Funds = 0.03). On the other hand, Computer and Electronics have lower efficiency in using funds compared with the average value (0.03). Again, Computer is the least efficient (CIF/Funds = 0.01) among the five sub-disciplines. The performance in the IF also presents the importance of the SCI-IF compared with the CSTPC-IF. Thus, the researchers of these key projects should be encouraged to publish their products in the SCI covered journals to achieve higher international visibilities.

Table 10. The performance of the key projects in each sub-discipline

	Funds (1 000 RMB[a])	CSTPC-IF	SCI-IF	Performance (SCI-IF/Funds)	CIF	Performance (CIF/Funds)
Automatization [b]	495.4	21.2	8.8	0.02	13.1	0.03
Optics [b]	545.6	5.9	16.5	0.03	17.5	0.03
Computer [b]	453.9	11.3	0.7	0.002	3.0	0.01
Electronics [b]	694.2	5.9	11.9	0.02	12.9	0.02
Semiconductor [b]	592.7	5.9	25.9	0.04	27.3	0.05
Average(per sub-discipline)	6359.9	146.7	114.7	0.02	169.8	0.03
Average(per project)	548.3	12.7	9.9	0.02	14.6	0.03
Total	31799.7	733.6	573.4	0.02	849.1	0.03

Remarks: [a] Exchange rate: 8.27RMB=1US$; [b] Averages per project in each-discipline
Source: NSFC and authors' calculation

At individual project level, the outstanding projects and the poor productive projects are classified according to the values of the CIF and are reported in Table 11. The top three projects according to their CIF values in a descending order are labeled as "high productive projects". "Low productive projects" are those in the last ten positions since their CIF sum contributes to only about 0.5% of the total. The ID codes of the top three projects are 69736010, 69738020 and 69636010, respectively, of which the first and the third belong to Semiconductor and the second one is a key project in Optics. The CIF values of the top three projects sum up to 278.5, constituting 33% of the total CIF values produced by the 58 key projects. In the context of the SCI-IF and the CSTPC-IF, the total values of the high productive projects are 274.8 and 20.3, contributing to 38% and 4% of the total, respectively. For the quantity of the paper outputs of the key projects, the three high productive projects published 143 SCI-papers (26% of total) and 64 CSTPC-papers (as 4% of total). Furthermore, no matter whether the impact or productivity of the key projects is taken into consideration, the three high productive projects are also the top three ordered by the SCI-IF values. However, the CSTPC-IF and the CSTPC-PAP of the high productive projects are negligible compared to the SCI outputs. Therefore, in our study, domestic outputs do not show significant effect on evaluated results, especially on the most outstanding projects. This result is certainly in accordance to the definition of CIF indicator.

Table 11. Comparison of inputs and outputs of high and low productive research groups

Project ID		Funds (1 000RMB[a])	Paper counts			Impact Factor		
			SCI-PAP	CSTPC-PAP	Total	SCI-IF	CSTPC-IF	CIF
High	69736010	589.3	65	12	77	113.4	4.0	114.0
	69738020	449.0	46	14	60	90.6	5.4	91.7
	69636010	707.1	32	38	70	70.9	11.0	72.9
	Mean	581.8	48	21	69	91.6	6.8	92.8
	S.D.	129.2	16.6	14.5	8.5	21.3	3.7	20.6
Low	69233030	256.2	0	0	0	0.0	0.0	0.0
	69636020	226.3	0	0	0	0.0	0.0	0.0
	69637040	450.3	0	7	7	0.0	2.2	0.3
	69138010	582.5	1	3	4	0.2	1.1	0.4
	69637020	452.5	0	7	7	0.0	1.7	0.4
	69133010	506.3	0	4	4	0.0	2.2	0.5
	69135010	804.0	0	6	6	0.0	1.8	0.5
	69332010	552.3	0	17	17	0.0	3.2	0.7
	69633020	311.1	0	15	15	0.0	4.6	0.7
	69434010	310.0	0	8	8	0.0	3.9	0.8
	Mean	445.2	0.1	7	7	0.02	2.1	0.4
	S.D.	177.3	0.3	5.7	5.6	0.07	1.5	0.3

Remarks: [a] Exchange rate: 8.27RMB=1US$.
Source: NSFC and authors' calculation

The outputs distribution of the projects in the five sub-disciplines is almost in balance for the 10 low productive projects (for Computer and Optics, each sub-discipline has three low productive projects, Automatization has two, Semiconductor and Electronics have one, respectively). The low productive projects produce no SCI-papers except for Project No. 69138010 that merely produces 1 SCI-paper with a low SCI-IF value of 0.2, and they publish few CSTPC-papers with the exception of 69233030 and 69636020. Accordingly, the unimportance of the CSTPC-IF in the CIF is proven in regard to low productive projects, too. However, at individual project level, through comparing the means between the top projects and the low productive projects, a significant difference in research outputs definitely exists (92.8 vs. 0.4 for the CIF, more than 200 times!), although the average investment in the low productive projects is only slightly lower than that in the high productive projects (445.2 vs. 581.8). This supports that the investment strength in the key projects plays an insignificant role in the research performance.

Figure 6 is a radar plot of average CIF per project in each sub-discipline. Remarkably, Semiconductor achieves the best performance and computer does the worst at the project level if examined by the average CIF per project: the value of Computer is only 1/9 of that of Semiconductor. The radar plot in Figure 7 describes the distributions of total CIF in each sub-discipline. We clearly observe that Optics and Semiconductor achieve the best performances in terms of the total CIF at sub-discipline level.

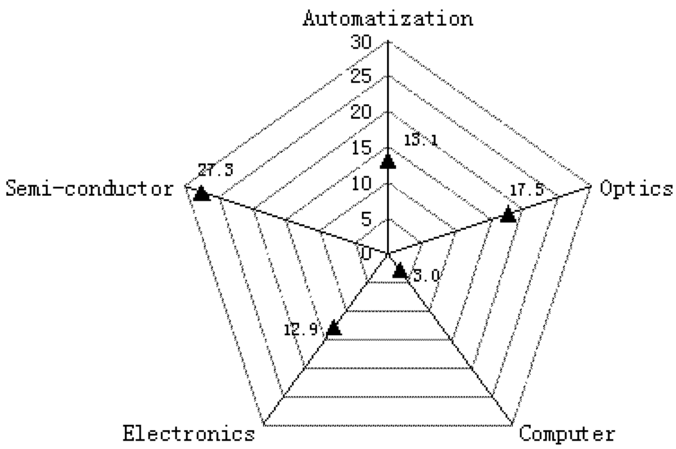

Figure 6. Radar plot of the average CIF per project

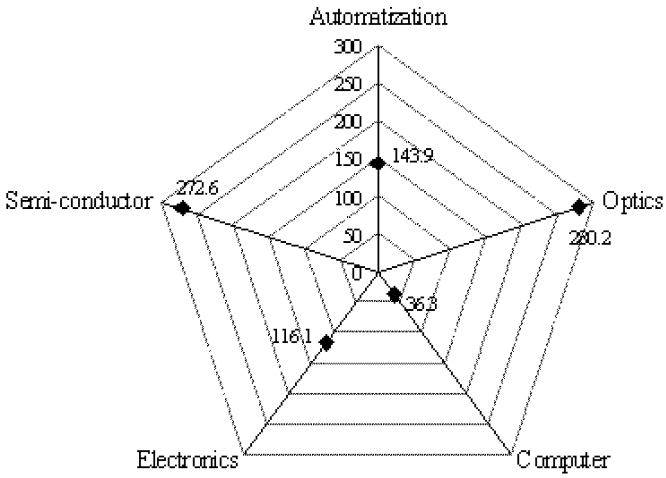

Figure 7. Radar plot of the total CIF

As shown in Table 10 and Figure 6, there are huge discrepancies across the topic areas in terms of outputs per unit of input and the tendency to publish internationally, particularly between Computer and Semiconductor. The variations in outputs per unit of input and tendency to publish internationally across sub-disciplines may attribute to many reasons. A major possible reason for such big differences between Computer and Semiconductor in outputs per unit of input and tendency to publish internationally is that Computer sub-discipline is more industrial-oriented than Semiconductor. However, the patents and software, the major outputs of R&D activities oriented toward industry, are not taken into account in this paper. Therefore, it is also important in the future study to develop a multi-dimensional instrument to test whether it introduces noticeable biases in the performance evaluation for such key projects by taking only publication into account.

Conclusions

This paper has presented some studies using scientometric indicators and techniques to evaluate the key projects in the department of the information science & technology of NSFC. Since domestic papers are important for the developing countries, this evaluation is approached from different points of view, considering both international and domestic paper outputs. The investigation is based upon the well-established databases: the SCI and the CSTPC and the combination of these papers by using the Combination Impact Factor (CIF). The major findings are summarized as follows:

1. The output of the key projects during 1994–2001, as covered by the SCI and the CSTPC databases, amounts to a total of 2,252 papers. 75% of them were published in domestic journals. The researchers still focused on domestic journals although these projects stand for the highest academic level in the information science & technology in China.

2. As a whole, the research performances of the key projects have increased to different extents both in terms of domestic outputs and international outputs during the study period. Remarkably, the SCI-PAP and the SCI-IF in the year 2001 are 9.4 and 7.4 times as many as those in 1994, respectively, although the investment in the year 2001 is only 0.7 times as many as that in the year 1994.

3. On average per project at sub-discipline level, Semiconductor is the most productive sub-discipline internationally, including both the SCI-PAP and the SCI-IF, whereas Computer is the least productive and least influential sub-discipline in terms of the international measures. As far as domestic outputs are concerned, Automatization produced the highest in either the CSTPC-PAP or the CSTPC-IF.

4. Eighteen SCI-journals and thirteen CSTPC-journals are identified as core journals. Researchers of the key projects in the information science & technology published their high quality papers with great preferences in the USA and Netherlands. As for core CSTPC-journals, Nine out of the thirteen are published by Chinese Science Academy.

5. The results based on the newly proposed indicator CIF verify again that Semiconductor is the most productive sub-discipline and Computer is the least productive one. The output trends in terms of the CIF are similar to those of the SCI-IF.

6. A significant, positive correlation between the SCI-IF and the CIF at individual project level is presented, whereas, there is hardly a correlation between the CSTPC-IF and the CIF. This reveals that the domestic outputs do contribute much less to the new proposed indicator CIF than international outputs do.

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