Mapping knowledge production and scholarly communication in China
Zhou, P.

Citation for published version (APA):
Zhou, P. (2009). Mapping knowledge production and scholarly communication in China
Mapping knowledge production and scholarly communication in China

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. D.C. van den Boom
ten overstaan van een door het college voor promoties ingestelde commissie,
in het openbaar te verdedigen in de Agnietenkapel
op donderdag 7 mei 2009, te 14:00 uur

door

Ping Zhou

egeboren te Sichuan, China
Promotiecommissie:

Promotor: Prof. dr. S. Blume
Prof. dr. W. Glänzel

Copromotor: Prof. dr. L. Leydesdorff

Overige leden: Prof. dr. K. Schönbach
Prof. dr. A.F.J. van Raan
Prof. Y. Wu
Prof. dr. J. Grin
Dr. W. de Nooy

Faculteit: Faculteit der Maatschappij – en Gedragswetenschappen

The work described in this thesis has been carried out at:
- Amsterdam School of Communications Research (ASCoR), University of Amsterdam, Amsterdam, The Netherlands;
- Steunpunt O&O Indicatoren at the Department of Managerial Economy, Strategy and Innovation, Catholic University of Leuven, Leuven, Belgium; and
- Institute of Scientific and Technical Information of China, Beijing, China.

Author contact:

Ping.Zhou@econ.kuleuvn.be
zhoup@istic.ac.cn
This thesis is dedicated to my dearest parents and daughter.

献给我亲爱的父母和女儿。
Preface

In 2004, I went to Amsterdam School of Communications Research (ASCoR), the University of Amsterdam (UvA), as a visiting scholar with a scholarship from the China Scholarship Council (CSC). Professor Loet Leydesdorff worked as my academic advisor. It was my first time living outside of China. I had to adapt to a completely new environment, which was a very big challenge for a person who had been used to Chinese lifestyle. It seemed that the life in Amsterdam was completely not as what I expected. Several days after my arrival, I had already started to count down how many days left for my staying in Amsterdam. It is not exaggerative at all to say passing one day like passing one year for me. I even intended to return to China immediately. It was Loet and his wife Margaret who helped me pass the difficulties.

Before coming to ASCoR, I only had experience in data cleaning for the China Scientific and Technical Papers and Citation Database (CSTPCD) and basic education background for writing Chinese papers. My experience in writing research articles in English is empty. I still remember how my first international publication which was coauthored with Loet came out: it had been commented and revised by Loet for about ten rounds. I don’t know how Loet felt when he saw how terrible my first draft was. But I know how much time and painstaking effort he had contributed to my progress. In my later studies, whenever needed, Loet always provides timely advice and comments which broaden my view and lighten my thoughts. The process of solving questions raised by Loet is neither easy nor funny at all, some times, is a painful experience. But when I finally reach the target, great happiness and increased confidence are the best compensation.

In addition to helping raise my academic proficiency, Loet also supported me to applying scholarships. We applied two scholarships in 2005: Marie Curie Incoming International Fellowships (IIF) from the EU’s FP6 and a scholarship from the Royal Netherlands Academy of Arts and Sciences (Koninklijke Nederlandse Akademie van Wetenschappen, KNAW). We passed the first round of evaluation for the IIF but failed in the second round because of lacking some application skills. But we won the KANW scholarship which could support me studying at ASCoR as a PhD student for two years. It was a pity that the KANW scholarship was given up since I decided to stay in China instead of going back to Amsterdam for the next two years’ study. While the scholarship only covers cost for studying in Amsterdam.

I am very grateful for Loet in helping achieve academic progress and for his wife Margaret in helping me adjust to the life in Amsterdam.

Deep thanks to Professor Wolfgang Glänzel who is also my promoter. The opportunity of working at the Steunpunt O&O Indicatoren (SOOI), Catholic University of Leuven (Katholieke Universiteit Leuven, in abbreviation KULeuven), improves my expertise a lot. As the director of the SOOI, Professor Glänzel frees me from routine work so that I can focus on my PhD study. His PhD course entitled “Bibliometrics as a Research Filed” helps me understand bibliometrics theoretically, historically, and critically. Whenever needed, his help is always available. Through his practical action, professor Glänzel presents a good model as a devoted researcher.
From him, I learn not only academic knowledge, but also the way of being a good researcher.

My special thanks to Professor Stuart Blume for kindly accepting as my PhD promoter. Without his help, I could not have the chance of being a PhD student of the University of Amsterdam.

Thank Professor Wu Yishan, the chief engineer of the Institute of Scientific and Technical Information of China (ISTIC). Whenever I meet problems or puzzles about China, Professor Wu would be the first one to be consulted, and his help would always be on time.

Great thanks to my colleagues Bart Tijs and Wouter Jeuris. Both helped me in translating the summary of this dissertation into Dutch. In addition, Bart provides a lot of help in data processing.

The ASCoR research & PhD program managers Dr. Sandra Zwier and Dr. Maaike Prangsma have offered me a lot of help. Here I express my thanks to both of them.

Finally, I’d like to convey sorry to my dearest daughter for not being able to stay with her as long as we wish and thank her for understanding and supporting me working for the PhD.

Ping Zhou
Leuven, December 2008
# Contents

Publications since 2005........................................................................................................................................1
Summary.......................................................................................................................................................2
Samenvatting..............................................................................................................................................6

## PART I  OVERVIEW

1. Introduction........................................................................................................................................11
2. Outline of the Dissertation...............................................................................................................25
3. Methods and Materials......................................................................................................................37

## PART II MAIN STUDIES

4. The emergence of China as a leading nation in science...............................................................41
5. Regional analysis on Chinese scientific profile..............................................................................61
6. In-depth analysis on China’s international collaboration in science............................................80
7. Is China also becoming a giant in social sciences?.......................................................................98
8. A comparison between the China Scientific and Technical Papers and Citations Database and the Science Citation Index in terms of Journal hierarchies and inter-journal Citation Relations.................................................................124
9. Visualization of the citation environments in the CSTPCD journal set........................................137
10. The citation impacts and citation environments of Chinese journals in mathematics..............148
11. Analysis on the citation environments of Chinese journals in computer science...................163

## PART III  OUTCOMES

12. Conclusions, discussions, and perspectives.................................................................................178
13. Policy implications............................................................................................................................202

BIBLIOGRAPHY..............................................................................................................................................207
Publications since 2005


5) Zhou, Ping & Loet Leydesdorff, A Comparison Between the China Scientific and Technical Papers and Citations Database and the Science Citation Index in Terms of Journal Hierarchies and Inter-journal Citation Relations, *Journal of the American society for Information science and Technology*, 58(2):223–236, 2007.


8) Zhou, Ping & Loet Leydesdorff, 计算机类期刊引文环境分析 (Analysis on citation environments of journals in computer science), *情报学报 (Journal of China Society for Scientific and Technical Information)*, 2007, 26(6), 923-933.

9) Zhou, Ping & Loet Leydesdorff, 中国科技期刊引文环境的可视化 (Visualization of the Citation Impact Environments in the CSTPC Journal Set), *中国科技期刊研究 (Chinese Journal of Scientific and Technical Periodicals)*, 16(6), 2005, 773-780.


Summary

As knowledge has become an engine of social, economic, and cultural development and since China has achieved its economic miracle by keeping around 10% annual growth of GDP for more than 10 years, the dynamics of Chinese knowledge production have become an interesting subject for both policy makers and academic analysis. The increased economic strength enables Chinese government to spend more for research and development. China’s dedication to constructing an innovation-oriented country shows its determination in this regard. In addition to internal motivation, external factors such as international collaboration and the increasing return of overseas Chinese also contribute to China’s progress in science and technology. All these facts imply that China is highly active in knowledge production, which may lead, at least partly, to reshaping the world structure in terms of the current “triad model” of the leading sciento-economic powers (i.e., the USA, the EU, and Japan). But such a hypothesis can only be persuasive after being studied systematically. This dissertation entitled Mapping Knowledge Production and Scholarly Communication in China is dedicated to this purpose.

The dissertation is conducted through bibliometric methodology and is divided into three parts. Part I provides an overview of issues including knowledge production and scholarly communication, the relevant situation in China, and the application of bibliometrics. The core of the dissertation is Part II which covers the major studies of the dissertation. Conclusions, discussions, and policy implications are elaborated in Part III.

Part I has three chapters (i.e., Chapters 1 to 3). After reviewing some basic knowledge and theoretical issues in knowledge production and scholarly communication, Chapter 1 introduces the Chinese situation from the perspective of input and knowledge output. Since the dissertation focuses on scholarly communication through academic journal literature, information about China’s journal management system and journal accessibility is provided. The Chinese situation relevant to journal citation databases is also introduced. The chapter contains a literature review about the Chinese knowledge production system. The objectives of the dissertation are specified. The outline of the dissertation is provided in Chapter 2 where each of the major studies covered in Part II is summarized. Chapter 3 explains the methods and materials used in the dissertation. Information about which data sources are selected, what software is used, and why certain methods are applied can be found in this chapter.

The journal articles which form the core of this dissertation are reprinted in Part II. This part is composed of two sections. Section 1 includes Chapters 4 to 7 and focuses on exploring the Chinese knowledge production. In addition to Chinese knowledge production in both the natural and social sciences, Chinese regional performance in science and the role of international collaboration are explored. Chapters 8 to 11 form section 2 which engages in investigating Chinese scholarly communication. Relevant studies analyzed the citation performance of Chinese journals in the domestic and the international community. Comparative studies complement the analysis.
In Chapter 4, I ask the question of whether China has emerged as a leading nation in science. Indicators like publications, citations, and R&D investment in comparison with the leading nations including the USA, the UK, Germany, France, and Japan have been analyzed. As an important Asian country in both economy and science, South Korea is also included in this study. Publication activity in nanotechnology will be explored since this field is so important that it is included in the strategic plans of many nations. The results show that China has become an advanced nation in terms of scientific knowledge production. This country’s research output in nanotechnology is impressive. But the international impact of Chinese authors in terms of citations is problematic since Chinese publications are not well cited compared to those from the other leading nations.

After knowing China’s overall performance in the natural sciences, it is necessary to investigate further about regional contribution to Chinese science. This is done in Chapter 5. The results show that regional contributions to China’s knowledge production are highly skewed. Beijing, Shanghai, Hong Kong, and Jiangsu are the top four regions in terms of both publications and citations. Hong Kong seems to have reached its potential in publishing international papers. However, the correlation between R&D expenditure and knowledge output of Chinese leading regions is relatively low. In other words, higher investments do not necessarily result in higher productivity of publications.

Chapter 6 aims at investigating international collaboration. In the ten years from 1997 to 2007, Chinese internationally co-authored publications increased remarkably. But the growth is lower than the one of China’s total publications: unlike most of the countries whose number and share of internationally co-authored publications dramatically increased during the last two decades (Schubert & Braun, 1990; Glänzel & Schubert, 2004; Wagner, 2008; Leydesdorff & Wagner, 2008), the relative contribution of international collaboration in China decreased. The most important S&T partners of China are four: the USA, Japan, Australia, and Singapore. Japan and Singapore are geographically close to China. This may imply that two factors (i.e., scientific proficiency and distance) are significant in determining the possibility of international collaboration, in addition to cultural and political issues.

My study of China’s performance in the natural sciences (Chapter 4) indicated that China has taken a leading position in publications in the natural sciences. Is China also becoming a giant in the social sciences? This is the question that I address in Chapter 7. Compared to the natural sciences, the social sciences are more connected to and imbedded in (and thus affected by) the social and political system to which they are oriented. The fact that the adoption of the Opening-up policy in 1978 promoted Chinese publications in the social sciences further proved the close relation between social sciences and political system. China has a rather low world share in both publications and citations in the social sciences. The developing trend of the two indicators is accelerating slowly. But China’s world share of publications grows exponentially in recent years (i.e., 1997 - 2007).

With regard to scholarly communication, my studies of both the overall situation and in specific disciplines (see, Chapters 8 to 11) show that on average Chinese scholars provide less references than their international counterparts. High-quality international journals have a higher rank in the hierarchy than do their Chinese counterparts. Authors who publish in high-quality Chinese journals prefer to cite articles in international journals above domestic ones. The international visibility of Chinese journals differs between disciplines. Among Chinese journals in the selected disciplines (i.e., general science, materials science, and the life sciences), the visibility of journals in materials science have relatively higher visibility
than that of journals in the life sciences. This corresponds to the relative strength of China in these fields.

Part III covers Chapters 12 and 13. Chapter 12 provides conclusions, discussion, and perspectives, whereas the policy recommendations are provided in Chapter 13. Based on my series of studies, the following conclusions can be formulated:

- Chinese knowledge production continues to grow exponentially and there is no sign showing that the increasing speed will slow down;
- While having the publication characteristics of that of the formal socialist countries with extreme activity in chemistry and physics, the Chinese publication system is also very active in mathematics. China is relatively inactive in the life sciences;
- The Chinese pattern of international collaboration is different from most of the advanced countries: the national share of internationally coauthored publications goes down while that of most countries goes up. But my study shows that international collaboration helps raise China’s visibility and impact at both overall and disciplinary levels. Only mathematics is an exception in which international collaboration slightly lowers China’s visibility;
- The distribution of regional contributions to China’s publications and citations is highly skewed;
- Contrary to its fast progress in the natural sciences, China moves forward slowly in the internationalization of social sciences. But because of the limited coverage of the data source (i.e., the Social Science Citation Index) and the close tie between the social sciences and national, cultural, social, and political environment, publication activity can be very local or national. The present result which is based on an international data source cannot represent the overall situation about China’s research in the social sciences. It is necessary to analyze Chinese domestic publication databases in the social sciences in order to better understand the Chinese situation in this regard. Unfortunately, data was lacking during the period of this dissertation research so that I was not able to analyze the Chinese domestic publication activity in the social sciences;
- Compared to their international counterparts, Chinese scholars are less active in communicating with their counterparts through scientific literature since they provide fewer references in their publications. In the domestic community, knowledge mainly flows from high-quality journals to the lower ones. Knowledge communication between Chinese and international scholars are not equal. Chinese authors mainly play a role as knowledge receivers while international authors play as citation sources.

Since the dissertation adopts a bibliometric methodology and bibliometrics has not been well-developed yet, it is necessary to discuss pertinent problems in applying bibliometric methods for research evaluation. In Chapter 12, I provide a critical review of the use of citation analysis for this purpose. This chapter first provides a definition of bibliometrics, and proceed with a discussion of the relation between bibliometrics and other specialties in the study of science, the increasingly important role of bibliometrics in science management and research evaluation, and so on. In addition to general problems in applying bibliometrics to research evaluation, specific issues that may affect the interpretation of the results in the above studies are also discussed.

Policy implications are provided in Chapter 13 for different players in knowledge production and scholarly communication. The following are the key points:

- enhancing the innovativeness of research;
strengthening both domestic and international collaboration;
establishing scholarly communication networks;
improving access to academic media;
constructing a more feasible evaluation system;
increasing accessibility of Chinese journals for international readers;
providing open access;
publishing an English version of journals;
cooperating with international publishers and online journal database providers; and
scholars being more active in informal communication and improving English proficiency.

In general, China has achieved remarkable progress in raising the quantity of scientific publications. But quantity does not equal to quality. The citation impact of Chinese publications is still low. To some extent, increasing quantity is relatively easier than raising quality. China has to face more rigorous challenges on the way to a world scientific leader.
Samenvatting

Kennis is een motor geworden voor sociale, economische en culturele ontwikkeling en China heeft een economisch wonder bereikt door de jaarlijkse groei van het BNP rond 10% te houden gedurende meer dan 10 jaar. Hierdoor is de dynamica van de Chinese kennisproductie een interessant onderwerp geworden voor zowel beleidsmakers als de academische gemeenschap. De versterkte economie stelt China in staat om meer te investeren in onderzoek en ontwikkeling. Naast de interne motivatie om China uit te bouwen tot een innovatie georiënteerd dragen externe factoren zoals internationale samenwerking en de toenemende terugkeer van Chinezen vanuit het buitenland bij aan China’s vooruitgang in wetenschap en technologie. De Chinese kennisproductie kan leiden tot, ten minste gedeeltelijk, het hervormen van de wereldstructuur in termen van het triad-model van de leidende wetenschaps-economische machten (t.w., de USA, EU en Japan). Maar deze hypothese kan enkel overtuigend zijn na systematisch onderzoek. Dit proefschrift, met de titel *Mapping the Knowledge Production and Scholarly Communication in China*, is hieraan een bijdrage.

Het proefschrift is opgebouwd aan de hand van bibliometrische methodologie en bestaat uit drie delen. Deel I geeft een overzicht van onderwerpen zoals kennisproductie en academische communicatie, de situatie in China, en de toepassing van bibliometrie. De kern van het proefschrift zit in Deel II dat de voornaamste en grotendeels reeds in de internationale literatuur gerapporteerde onderzoeken omvat. Conclusies, discussies en beleidsimplicaties worden uitgebreid besproken in Deel III.

Deel I bestaat uit drie hoofdstukken (t.w., Hoofdstukken 1 t/m 3). Na een introductie van de theoretische onderwerpen zoals kennisproductie en academische communicatie wordt in Hoofdstuk 1 de Chinese situatie geïntroduceerd vanuit het perspectief van input en output van het kennisysteem. Aangezien in het proefschrift de nadruk wordt gelegd op communicatie in gepubliceerde tijdschriften wordt informatie gegeven over China’s tijdschrift beheersysteem en tijdschrift toegankelijkheid. De Chinese situatie relevant voor de tijdschrift-citatiedatabank wordt ook besproken. Het hoofdstuk bevat een literatuur review over het Chinese kennisproductiesysteem. De doelstellingen van het proefschrift worden geformuleerd. Een overzicht van het proefschrift komt aan bod in Hoofdstuk 2 waarin elk onderzoek in Deel II samengevat wordt. Hoofdstuk 3 legt de methodes en materialen uit die gebruikt worden in het proefschrift. Informatie over welke databronnen geselecteerd zijn, wat voor software er gebruikt is en waarom bepaalde methodes gebruikt zijn kan gevonden worden in dit hoofdstuk.

De tijdschrift artikelen die de kern van deze thesis vormen zijn ondergebracht in Deel II. Dit deel bestaat uit twee delen. Sectie 1 bevat de Hoofdstukken 4 t/m 7 en legt de nadruk op het verkennen van de Chinese kennisproductie. Naast Chinese kennisproductie in zowel de natuur- als sociale wetenschappen zijn ook Chinese regionale prestaties in wetenschap en de rol van internationale samenwerking verkend. Hoofdstukken 8 t/m 11 vormen sectie 2, waarin de Chinese academische (scholarly) communicatie onderzocht wordt. In deze onderzoeken worden de citatie prestatie van Chinese tijdschriften in de nationale en internationale gemeenschap geanalyseerd. Vergelijkingen met andere landen informeren de analyse.
In Hoofdstuk 4 stel ik de vraag of China een leidende natie op het vlak van wetenschap is geworden. Indicatoren zoals publicaties, citaties en R&D investeringen in vergelijking met de leidende landen, waaronder de USA, UK, Duitsland, Frankrijk en Japan, werden geanalyseerd. Als een belangrijk Aziatisch land in zowel economie als wetenschap is Zuid Korea ook opgenomen in deze studie. Publicatie-activiteit in nanotechnologie zal onderzocht worden omdat dit veld zo belangrijk is dat het opgenomen is in de strategische plannen van veel naties. De resultaten tonen dat China een geavanceerde natie is geworden in de wetenschap in termen van wetenschappelijke kennisproductie. De onderzoeksoutput in de nanotechnologie is indrukwekkend. Maar de internationale impact van Chinese auteurs op het vlak van citaties is problematisch doordat Chinese publicaties niet vaak geciteerd zijn vergeleken met die van andere leidende naties.

Na China’s algemene prestaties in de natuurwetenschappen te kennen is het nodig om verdere regionale bijdragen tot de Chinese wetenschap te onderzoeken. Dit wordt gedaan in Hoofdstuk 5. Het resultaat toont dat de regionale bijdragen tot China’s kennisproductie zeer ongelijk verdeeld zijn. Beijing, Shanghai, Hong Kong en Jiangsu zijn de top vier regio’s in termen van zowel publicaties als citatie-impact. Hong Kong lijkt zijn potentieel bereikt te hebben in het publiceren van internationale papers. Evenwel, de correlatie tussen R&D uitgaven en kennis-output van leidende Chinese regio’s is laag. Met andere woorden, hogere investeringen leiden niet perse tot hogere productiviteit van publicaties.

Hoofdstuk 6 onderzoekt internationale samenwerking. In de tien jaar van 1997 tot 2007, is het aantal publicaties met internationale co-auteurs opmerkelijk gestegen. Maar de groei is lager dan die van China’s totale aantal publicaties: in tegenstelling tot de meeste landen waar het aantal en aandeel van publicaties met internationale co-auteurs dramatisch gestegen is tijdens de voorbije twee decenia (Schubert & Braun, 1990; Glänzel & Schubert, 2004; Wagner, 2008; Leydesdorff & Wagner, 2008) is de relatieve bijdrage van internationale samenwerking in China gedaald. De belangrijkste S&T partners van China zijn er maar vier, de USA, Japan, Australië en Singapore. Japan en Singapore zijn dicht aan China. Dit kan betekenen dat twee factoren (t.w., wetenschappelijke competenties en afstand) beslissend kunnen zijn in de mogelijkheid op internationale samenwerking, in aanvulling bij culturele en politieke zaken.


Met betrekking tot wetenschappelijke communicatie tonen mijn onderzoeken van de algemene situatie en specifieke disciplines (Hoofdstuk 8 t/m 11) aan dat Chinese wetenschappers gemiddeld minder referenties leveren dan hun internationale tegenhangers. Internationale tijdschriften van hoge kwaliteit hebben een hogere plaats in de hiërarchie dan
hun Chinese tegenhangers. Auteurs die publiceren in Chinese tijdschriften van hoge kwaliteit kiezen ervoor om artikelen uit internationale tijdschriften te citeren in plaats van Chinese. De internationale zichtbaarheid van Chinese tijdschriften is verschillend tussen disciplines. Tussen Chinese tijdschriften in de geselecteerde disciplines (t.w., natuurwetenschappen en levenswetenschappen) is de zichtbaarheid van tijdschriften in de natuurwetenschappen relatief hoger dan tijdschriften in de levenswetenschappen. Dit komt overeen met de relatieve kracht van China in deze velden.

Deel III omvat Hoofdstukken 12 en 13. Hoofdstuk 12 geeft conclusies, discussies en perspectieven; de beleidsadviezen zijn opgenomen in Hoofdstuk 13. Gebaseerd op mijn onderzoeken kunnen de volgende conclusies geformuleerd worden:

- De Chinese kennisproductie blijft exponentieel groeien en er is geen teken dat deze versnelling zal afnemen;
- Terwijl China de publicatierasteristieken heeft van die van de vroegere socialistische landen met extreme activiteit in de chemie en fysica is het Chinese publicatiesysteem ook heel actief in de wiskunde. China is relatief inactief in de levenswetenschappen;
- Het Chinese internationale samenwerkingspatroon is anders dan van de meeste geavanceerde landen: het nationale aandeel van publicaties met international co-auteurschap gaat omlaag terwijl dat van de meeste landen omhoog gaat. Maar mijn studie toont dat internationale samenwerking China’s zichtbaarheid en impact helpt stijgen, zowel op algemeen als op disciplair niveau. Alleen wiskunde is een uitzondering waarin internationale samenwerking de zichtbaarheid van China licht doet dalen;
- Regionale bijdragen tot China’s kennisproductie zijn zeer ongelijk verdeeld;
- Ondanks de snelle vooruitgang in de natuurwetenschappen maakt China traag vooruitgang met het internationaliseren van de sociale wetenschappen. Maar door de gelimiteerde dekking van de bron-data (t.w., de Social Science Citation Index) en de hechte band tussen de sociale wetenschappen en de nationale, culturele, sociale en politieke omgeving kan publicatieactiviteit zeer lokaal of nationaal zijn. Het voorliggende resultaat, dat gebaseerd is op een internationale data-bron, kan daarom niets zeggen over de algemene situatie op vlak van China’s onderzoek in de sociale wetenschappen. Het is nodig om Chinese binnenlandse publicatiedatabanken in de sociale wetenschappen te analyseren om zo de Chinese situatie beter te begrijpen in dit opzicht. Spijtig genoeg ontbraken deze data tijdens de periode van onderzoek voor deze thesis waardoor ik de binnenlands publicatieactiviteit in de sociale wetenschappen van China niet kon analyseren;
- Vergeleken met hun internationale tegenhangers communiceren Chinese scholars minder actief met hun tegenhangers, via wetenschappelijke literatuur, aangezien ze minder referenties aanleren in hun publicaties. In de binnenlandse gemeenschap vloei kennis voornamelijk van kwaliteitspublicaties naar de lagere. Kenniscommunicatie tussen Chinese en internationale wetenschappers is niet gelijk. Chinese auteurs nemen deel als kennisontvangers, terwijl international auteurs deelnemen als citatiebronnen.

Doordat de uiteenzetting een bibliometrische methodologie aanneemt en de bibliometrie nog niet zo ver ontwikkeld is, is het nodig een aantal problemen bij het toepassen van bibliometrische methodes voor onderzoeksevaluatie te bespreken. In Hoofdstuk 12 geef ik een kritische kijk op het gebruik van citatieanalyse voor dit doeleind. Dit hoofdstuk geeft eerst een definitie van bibliometrie en gaat verder met een discussie over de relatie tussen
bibliometrie en andere specialiteiten in de studie van de wetenschap, het groeiende belang van de bibliometrie in wetenschapsbeheer en onderzoeksevaluatie, en zo voort. Naast algemene problemen bij het toepassen van bibliometrie op onderzoeksevaluatie worden ook specifieke zaken die de interpretatie van de bovenstaande studies kunnen beïnvloeden, besproken.

Beleidsimplicaties worden gegeven in Hoofdstuk 13 voor verschillende spelers in de kennisproductie en wetenschappelijke communicatie. De volgende zijn de sleutelpunten:

- de innovatie van onderzoek verbeteren;
- binnenlandse en internationale samenwerking versterken;
- opzetten van academische communicatiennetwerken;
- verbeteren van toegang tot academische media;
- ontwikkelen van een toepasbaarder evaluatiesysteem;
- toegankelijkheid van Chinese publicaties verhogen voor internationale lezers;
- open toegang geven;
- Engelse versies van tijdschriften publiceren;
- met internationale publishers en databankleveranciers samenwerken;
- Wetenschappers actiever laten zijn in informele communicatie en de Engelse vaardigheid verhogen.

In het algemeen heeft China een opmerkelijke vooruitgang geboekt met het verhogen van het aantal wetenschappelijke publicaties. Maar kwantiteit is niet gelijk aan kwaliteit. De citatieimpact van Chinese publicaties is nog steeds laag. In zekere mate is kwantiteit verhogen eenvoudiger dan kwaliteit verhogen. China moet nog moeilijke uitdagingen overwinnen om een wereldleider te worden op wetenschappelijk vlak.
PART I

OVERVIEW
Chapter 1

Introduction

The last decades of the 20th century have been a turning point in the global development process. Knowledge has become the engine of social, economic, and cultural development in today’s world. Knowledge-intensive economic activities are now a factor of production and of strategic importance in the leading countries. They have also become the main indicators of the level of development and the readiness of every country for a further economic and cultural growth in the 21st century. In order to incorporate more directly knowledge and technology in their theories and models and to understand the role of knowledge and technology in driving productivity and economic growth, economists introduced a new term—‘knowledge-based economy’ (Foray & Lundvall, 1996; Abramowitz & David, 1996), which is directly based on the production, distribution, and use of knowledge and information (OECD, 1996a).

Since the adoption of the Open-up and Reform policy in China in 1978, the Chinese economy has been growing. Based on indicators from OECD’s Science, Technology and Industry Scoreboard (STIS), Criscuolo and Martin (2004) concluded that China was catching up rapidly with other dynamic Asian economies and the Triad (i.e., Europe, the USA, and Japan; OECD, 2004). Such a conclusion was based on the STIS data in 2002. Four years later (in 2006), China had jumped to the fourth position in terms of GDP from the sixth position in 2003, only after the U.S., Japan, and Germany. From 2003 to 2006, the average growth rate of Chinese GDP was 10.4%, while the world average was 4.9% (Xinhua Net, 2007a).

In order to keep its economic development sustainable, the Chinese government has implemented a series of plans and policies (Zeng & Wang, 2007). One of the most important plans that directly affects the knowledge production process is the National Medium- and Long-term Plan for Science and Technology Development 2006-2020 (Xinhua Net, 2006). The plan was launched in 2006 and aims at structuring China as an innovation-oriented country. It clearly shows China’s strategic ambition to shift its economic growth pattern from the one which heavily relies on a low cost labor force, low value-added products, and resources and energy consumption to a new pattern in which knowledge plays a major role for economic growth. The plan sets two priorities: 1) promoting S&T development in selected key fields; and 2) enhancing innovation capacity. While outlining major strategic tasks for the innovation targets, the Chinese President Hu Jintao said that China would embark on a new path of innovation with Chinese characteristics, the core of which was to adhere to innovation, seek leapfrog development in critical fields, make breakthroughs in key technologies and common technologies to meet urgent requirements in realizing sustained, coordinated economic and social development, and make arrangements for frontier technologies and basic research with a long-term perspective.

In the contemporary world, globalization makes the world more closely connected. National or regional economy becomes a component in the world economic system. According to the International Monetary Fund (IMF), China’s economic growth rate will reach 11.2% in 2007 and will supersede that of the USA for the first time, becoming a country which contributes the most to world economic growth (China Daily, 2007). This means that China’s prosperity will also bring benefit to other related countries. As Anne O. Krueger, the First Deputy
Managing Director of the International Monetary Fund (IMF), addressed at the American Enterprise Institute Seminar in 2005: China's role is increasingly important in the world economy, and its growing role raises questions for the country itself and the world (IMF, 2005).

When knowledge plays a critical role for the economy, mapping China’s knowledge production and knowledge related communication is significant both to China and the world.

1. Some basic terms

Before processing further it is necessary to clarify a few terms relevant to knowledge at the level of the social system. Lundvall and Johnson (1994) generalized four types of knowledge: ‘know what’, ‘know why’, ‘know how’, and ‘know who’. Knowledge is conveyed in schools where students learn to ‘know what’, in universities where they learn to ‘know why’, in the workplace where they learn to ‘know how’, and, as they become part of networks, they learn to ‘know who’ (Lundvall 2000). Knowledge can also be categorized into two types: formal vs. informal knowledge. Formal knowledge is produced through systematic enquiry, and disseminated largely through publication in peer-reviewed journals (Whitley, 2000). Informal knowledge is acquired through personal experience, outside of the formal learning environments such as schools and training courses. This paper focuses on formal knowledge which will be only called “knowledge” later on. Knowledge activities include knowledge transmission, knowledge production, knowledge communication, as well as knowledge application. In terms of sectors, major players in a knowledge system include government departments, educational and research institutions, industries, and publishing agencies. Government departments are responsible for providing an environment that ensures and encourages knowledge activities by drawing national strategies, policies and plans, and providing financial support for R&D activities; educational and research institutes are major forces for knowledge transmission, production, and application through education and R&D activities; industries, especially high-tech industries, focus on transferring knowledge into products; publishing agencies engage in knowledge transmission. These players are self-organized and interact with each other.

Knowledge is closely related to science. What is science? Science refers to system of acquiring knowledge. This system uses observation and experimentation to describe and explain natural phenomena. The term science also refers to the organized bodies of knowledge people have gained using those systems. Science as defined above is sometimes called pure sciences to differentiate it from applied sciences, which are the application of research to human needs. Fields of science are commonly classified along two major lines: 1) the natural sciences, the study of the natural world, and 2) the social sciences, the systematic study of human behaviour and society.

1.1 Knowledge production

Knowledge production can be defined as activities in achieving new knowledge or codifying meaning. Research and development (R&D) is the major form of knowledge production and can be generalized into three stages:

- Formation of research ideas. In addition to background knowledge in relevant fields, knowing the state-of-the-art is also important;
- Implementation of research. This is the core stage in knowledge production, with the purpose of solving research questions or puzzles, seeking new discoveries, and
generating novel thoughts;
- Publication or graduation of research output. Output of knowledge production can be a seminar, an article, a patent, or educated graduates and researchers (Gault, 2005).

Although the activity of knowledge production existed when research activity first appeared, studying characteristics of knowledge production is relatively new. Great efforts have been made by relevant researchers aiming at building up theoretical support of this new field. In their book entitled *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, Gibbons and his colleagues (1994) generalized two distinct modes of knowledge production: Mode 1 and Mode 2. Mode 1 is defined as traditional research which is academic, investigator-initiated and discipline-based knowledge production. Starting to emerge from the mid 20th century, Mode 2 is context-driven, problem-focused and interdisciplinary. Mode 2 involves multidisciplinary team brought together for short periods of time to work on specific problems in the real world. The communication in Mode 2 is a Three-Tiered System: 1) communication between science and society; 2) communication among scientific practitioners; 3) communication with the entities of the physical and social world. Mode 2 is developed out of Mode 1. Both modes exist in knowledge production. In later years, three of the six authors of the book explained further about the two modes (Nowortny *et al*., 2001, 2003). While receiving considerable support, this theory is also criticized (Etzkowitz & Leydesdorff, 2000; Fuller, 2000; Shinn, 2002). Etzkowitz and Leydesdorff argue that

“The so-called Mode 2 is not new; it is the original format of science before its academic institutionalization in the 19th century. Another question to be answered is why Mode 1 has arisen after Mode 2: the original organizational and institutional basis of science, consisting of networks and invisible colleges. Where have these ideas, of the scientist as the isolated individual and of science separated from the interests of society, come from? Mode 2 represents the material base of science, how it actually operates. Mode 1 is a construct, built upon that base in order to justify autonomy for science, especially in an earlier era when it was still a fragile institution and needed all the help it could get.” (Etzkowitz & Leydesdorff, 2000, p 116).

Shinn (2002) complains: 'Instead of theory or data, the New Production of Knowledge - both book and concept - seems tinged with political commitment'. Some writers have invented a mode 3 knowledge, which is mostly used to refer to emotional knowledge or social knowledge. But these writers miss the whole point of Gibbons *et al*. which was not to catalogue types of knowledge but to describe types of knowledge production or research. Etzkowitz and Leydesdorff use the notion of the Triple Helix of the nation state, academia and industry to explain innovation, the development of new technology and knowledge transfer (Leydesdorff, 2000, 2003a, 2005; Leydesdorff & Meyer, 2006; Leydesdorff & Fritsch, 2006; Leydesdorff, *et al*., 2006; Etzkowitz & Leydesdorff, 1995, 2000; Leydesdorff & Etzkowitz, 2001a, 2001b). The Triple Helix as an analytical model adds to the description of the variety of institutional arrangements and policy models an explanation of their dynamics. The authors defined three types of Triple Helix models. In Triple Helix I, the nation state encompasses academia and industry and directs the relations between them. The strong version of this model could be found in the former Soviet Union and in Eastern European countries. Triple Helix II consists of separate institutional spheres with strong borders dividing them and highly circumscribed relations among the spheres. Triple Helix III generates a knowledge infrastructure in terms of overlapping institutional spheres, with each
taking the role of the other and with hybrid organizations emerging at the interfaces. Since 1996, five international triple-helix conferences have been held.

Mode 2 emphasizes more on generalizing the characteristics of knowledge production while the Triple-Helix theory focuses on the network overlay of communications and expectations that reshape the institutional arrangements among universities, industries, and governmental agencies (Etzkowitz & Leydesdorff, 2000). Both modes see the importance of communication in knowledge production.

1.2 Scholarly communication

In the Mode 2 theory, communication in knowledge production is a three-tiered system: communication between science and society, communication among scholars, and communication with the entities of the physical and social world.

Borgman defined scholarly communication as ‘how scholars in any field...use and disseminate information through formal and informal channels’ (Borgman, 1990: 13-14). Scholarly communication is the process by which scholarly information is produced, disseminated, preserved, and used. Traditionally, scholars within academia create the information and then turn to publishers to produce and package the information. Libraries purchase the information from the publishers, organize it, and provide access to the publications. This allows for the widespread dissemination of scholarly information and continued use of it by scholars.

Major elements of scholarly communication include scholars who produce and receive knowledge, media that transmit knowledge, and repositories (e.g., libraries and online databases) for storing and disseminating knowledge. Media for scholarly communication can be in printed form like printed journals, books, conference proceedings, theses, and dissertations; or in electronic form such as e-journals, author’s self-archived documents, and open access journals. There is another form of scholarly communication: the processes by which scholars communicate with one another as they create new knowledge and by which they measure its value with colleagues prior to making a formal article available to the broader community.

Compared to other forms of media in scholarly communication, scientific journals play a significant role for the following reasons:

- Journal publications are peer-reviewed, which ensures the quality to some extent;
- Compared to books, journal publications reflects more recent research output;
- Journals are regularly published, which ensures the continuity of scholarly communication;
- Well-established journal citation databases such as the Web of Science of produced by Thomson Reuters and Elsevier’s Engineering Information (EI Compendex) and the SCOPUS etc. make it possible to conduct bibliometric analysis based on scholarly publications.

Authors produce knowledge in the form of journal publications, and in the meantime, acquire knowledge from those listed in their references. Through their publications, authors further transmit the knowledge in the reference list. Knowledge production and scholarly communication are closely related and dependent on each other. Scholarly communication
exists in each stage of knowledge production, and knowledge production ensures the sustainability of scholarly communication.

2. The Chinese situation

The Chinese system of knowledge production is considerably different from its western counterparts (Lundvall, 1992; Nelson, 1993; OECD, 1996b). In recent years, the Chinese system boomed, first in terms of increased government funding for R&D, but then increasingly because of expansion of the business expenditure in R&D (Li & Zeng, 1999, 2001; Leydesdorff & Zeng, 2001; Zhou & Leydesdorff, 2006). Business expenditure in R&D (BERD) has become larger than in-house government expenditure (GOVERD) since 1997. In such a situation, growing numbers of scientific output can be expected (Arunachalam, et al., 1993; Zhang & Zhang, 1997; Moed, 2002; Jin & Rousseau, 2004).

2.1 Input for knowledge production

Input for knowledge production includes two factors: R&D expenditure and knowledge stocks which can be measured in terms of the R&D workforce and the number of university enrolment and degree holders (OECD, 1996). This section provides an overview on these two indicators.

R&D expenditure

China’s investment in R&D has kept growing for over ten years. The ratio of R&D to GDP has been raised from 0.83% in 1999 to 1.4% in 2006 (MOST, 2007). The total investment in 2006 is estimated as 300 billion RMB (about 40 billion US$).

![Figure 1. Ratio of R&D expenditure to GDP in China: 1999-2006. Source: Statistics of the Ministry of Science and Technology (MOST), 2007.](Image)

According to the National Medium- and Long-term Plan for Science and Technology Development 2006-2020, the ratio of R&D expenditure to GDP will be over 2.5% in 2020. By the year 2020, China’s GDP will reach 36 trillion RMB (about 4.8 trillion US$) based on a conservative annual increase speed of 7.12%. This will result in China’s R&D reaching 0.9 trillion RMB (around 0.12 trillion US$) (Sina, 2006).
Knowledge stocks

Current R&D personnel are the major players for knowledge production. But the role of training manpower for future R&D is also significant. Chinese universities are responsible for educating and training qualified human resources. In the meantime, Chinese research institutes are also active in training graduate students, doctoral students, and post-doctoral fellows.

University enrolment and degrees

The Chinese higher education system is different from that of most of the Western countries in the following aspects:

- The Chinese higher education system was formally interrupted for over ten years (from 1966 to 1978) and severely damaged because of the Cultural Revolution;
- The main-stream of higher education institutions are state-owned;
- There are mainly two ways for people to get higher education: full-time and part-time. To be enrolled as a full-time undergraduate student, one must pass the national College Entrance Examination (CEE) which is held annually. The Adult College Entrance Examination (ACEE) is another form of college entrance examination. Working people or those failed in the CEE may try ACEE. The ACEE students use their free time to study and can also get accepted diplomas or degrees.

A very small percentage of the population could access to higher education before 1999 when China intentionally started enlarging its college education scale. The gross college enrolment rate in 1999 was less than 8%. The rate was even lower in the early years (this number was only 2.7% in 1990). In 2006, the rate increased to 22% with over 25 million enrolled undergraduate students (MOE, 2007a). By the year 2010, the gross enrolment for undergraduate students will reach 25%, according to the Minister of Education (Sina, 2005). In fact, the undergraduate enrollment rates in some big Chinese cities have already been very high. For instance, the enrolment rate in Beijing was 73.6% in 2007, which is more than three times higher than the average of the country.

Thus the year 1999 can be considered as a watershed. From 1977 to 1998, China’s higher education was a kind of elite education since it was only accessible to a small part of the population. Starting from 1999 when China started to popularize its higher education by enlarging higher education scale and increasing the rate of enrollment of undergraduate students.

Graduate and doctoral education develops fast in China as well. The enrolment of graduate and doctoral students has continued to increase since 1998. The average annual growth rate of enrollment for graduate students is 28.6%, while that for doctoral students is 23.8%. In 2006, the newly enrolled numbers of graduate and doctoral students were 341,970 and 55,955 respectively, making the total numbers of graduate and doctoral students reach 896,615 and 208,038 (MOE, 2007b). Compared to the 90s of the 20th century, the newly enrolled doctoral students have increased by 15 times. With the growing rate of higher education enrolment, China’s degree ratio rises as well. According to the National Science Foundation (NSF) of the USA, China’s degree ratio stood at 1.2 per 100 in 1990 but jumped to 5.0 per 100 in 2003 (NSF, 2007).
R&D workforce

The workforce in science and technology has also been increasing. In 2006, China has 2.64 million scientists and engineers, which is about one million more than that (1.67 million) in 1997. In addition to the increased number of domestically trained R&D personnel, increasing number of Chinese with degrees outside of China have returned. In the meantime, the Chinese government has adopted a series of policies aiming at attracting more Chinese with foreign degrees to return. For example, in 2006 the Ministry of Personnel of China announced a plan entitled “the ‘Eleventh Five-Year Plan’ for the Return of Overseas Chinese Students” (CPG, 2007a). In 2007, sixteen Chinese governmental departments jointly established a green channel for the return of high-level overseas Chinese scholars and students (CPG, 2007b). Statistics from the National Science Foundation of the US shows that from 1989 to 2003, about 34,000 Chinese were recipients of US S&E doctorates. Although only around 20% of them planned to return to China (NSF, 2007), these returnees may bring new blood for China’s development. Statistics from Chinese Ministry of Education (MOE) shows that there were about 1.067 million Chinese studying abroad until 2006, and 0.275 million of them have returned to China. Within 2006, around 42,000 Chinese studying abroad have returned to China (Xinhua Net, 2007b).

2.2 Knowledge output

Scientific literature including academic journals and books, partial patents, and academic conference proceedings are major output of knowledge production. Statistics from the Ministry of Science and Technology (MOST) shows that China’s patent and scientific publications increase exponentially (Figure 1-2).

![Figure 2. Major indicators for knowledge production. Source: China Science & Technology Statistics Data Book. The Ministry of Science and Technology of China. Available at: http://www.sts.org.cn/sjkl/kjtzdt/index.htm.](image-url)
In a competitive world one would not expect exponential growth of output to be sustainable. I conjecture that a mechanism for growth other than the ones we already know for smaller countries (for example, Spain and South Korea), must be working because of the large amount of skilled human resources and growing R&D investment in China.

2.3 Media for scholarly communication

This dissertation focuses on knowledge output which is communicated among scholars and which can be studied and analyzed with bibliometric methods. With this context, the dissertation only covers communications among authors or reviewers or readers who publish or review or read knowledge output through academic journals. In the later text, the term ‘journal’ will be used to represent academic journals.

The journal management system

A scholarly communication system based on journals normally involves research institutions, researchers (or authors), journal editorial boards, and journal publishers. But in the Chinese situation the role of government is significant. Firstly, to create a new journal, one must apply for a China Standard Serial Number (i.e., CN number) for the journal, which is under strict control. Issues relevant to journal content, supplements, change of titles, and enlargement must get approval from administrative departments. Secondly, in order to promote journal development, Chinese government provides financial and/or policy support to some high-quality journals so as to raise their international competence.

The Chinese journal management structure is special and, sometimes, confusing because of the involvement of different government departments (Figure 3).

![Figure 3. Management structure of Chinese journals.](image)

Note for the abbreviations:
GAPP: General Administration of Press and Publication
MOST: Ministry of Science and Technology
In terms of administration and control of journals, two levels of government departments are responsible. At the national level is the General Administration of Press and Publication (GAPP) which is directly led by the State Council of China. At the provincial/regional level is the local Administration of Press and Publication (APP) in each province or municipalities. In addition to making regulations and policies relevant to journal publishing and development, the GAPP is also responsible for the approval of new journals and regular censorship. Provincial APPs are responsible for administration and controls of local journals.

Chinese academic journals are mainly affiliated to research institutes, universities, and academic associations/societies, and these institutions belong to or closely related to relevant government departments. In other words, relevant government departments are responsible for journals under their umbrella. This leads to Chinese journals managed by different governmental departments. The GAPP and entities in charge manage journals from different aspects. The GAPP emphasizes on qualification, censor, and control while entities in charge focus on improving journal quality and competence.

In order to improve the quality of Chinese journals, relevant government agencies have launched various projects. At the national level are the GAPP’s ‘Journal Phalanx of China’, the Ministry of Science and Technology (MOST)’s ‘Development Strategy Research for Competitive S&T Journals’, and the National Natural Science Foundation (NSFC)’s ‘Key Academic Specific Fund’.

The GAPP’s project was launched in 2001 and covers 1,518 journals among which 793 are in social sciences and 725 are in science and technology (Wang, 2004). The MOST’s project was launched in 2005 and intends to reach two major goals by 2020: 1) establishing a set of journals with international competence; 2) constructing a journal evaluation system and incentive mechanism integrated with international ones (Guo, 2006). The NSFC project provides financial support for journals covered by the SCI, SCIE, SCI-Search, and the top 50 journals ranked with annual total citations in the Chinese Journal Citation Reports (CJCR) (NSFC, 2008). The CJCR journals are those included in the Chinese Scientific and Technological Papers and Citations Database (CSTPCD). Details about the CSTPCD will be introduced later. The NSFC journal fund is applied annually. Other departments or organizations including the MOE, the CAST, the CAS have also their own projects to support journals under their management.

**Journal accessibility**

By 2006 China had 9,468 journals, among which 4,758 are in science and technology and 2,339 are in the social sciences and humanities (Jiang, 2007; Ren 2007). The rest are relevant to culture, education, literature, art, children readings, and paintings. Among the S&T journals, those from research institutes, universities, and academic associations/societies account for 28.8%, 25.6%, and 24.3% respectively (Ren, 2007).

There are three major online journal providers in China: the Wanfang Data, the China National Knowledge Infrastructure (CNKI), and the VIP. Both Wanfang Data and the CNKI provide English online service for foreign users. Traditionally, Chinese universities and research institutes mainly subscribe to printed journals. With the popularization of the Internet, online journal subscription becomes more popular.
In addition to domestic journals, Chinese universities with sufficient budget are also subscribers of international journals. Online journals are especially welcome by Chinese researchers because of its convenience and speediness. The Chinese Academy of Sciences (CAS) has its own library which provides online access to both domestic and international online journals. But not all universities and research institutes can afford to subscribe to international journals. Many research institutes rely on journals subscribed by sectoral information centers.

2.4 Citation databases

Among the reasons that cause researchers publish their output, sharing ideas and staking a claim to their ideas and work are important ones. But how do we know the productivity of individuals or scientific entities and how is the feedback an entity’s scientific output in the scholarly community? Citation databases based on journal publications make it possible to conduct various statistics and analysis. In the international community, the ISI Web of Knowledge produced by Thomson Reuters in the USA is the oldest and has wide-spread influence in scientific community. The ISI databases based on scientific journals include the Web of Science (WoS) and Journal Citation Index (JCR). The WoS contains the Science Citation Index Expanded (SCIE) for publications in the natural sciences, the Social Sciences Citation Index (SSCI) for publications in the social sciences, and the Arts & Humanities Citation Index (A&HCI) for publications in arts and humanities. Publications in the natural sciences since 1955 are covered in the SCIE, publications in social sciences since 1956 are covered in the SSCI, and publications in arts and humanities since 1975 are covered in the A&HCI. Journals from all over the world especially from the USA and the European region are selectively covered in the WoS. In recent years, an Elsevier database the SCOPUS with similar structure and function as those of the WoS has been constructed. These databases, especially the ISI databases have been widely applied in evaluation of research performance and in determination of R&D budget.

Based on domestic publications, some institutions have constructed Chinese journal citation databases among which two are in the natural sciences and the other two are in the social sciences. In 1987, the Institute of Scientific and Technical Information of China (ISTIC) established a database – China Scientific and Technical Papers and Citations Database (CSTPCD). In 2007, the CSTPCD covered 1723 S&T journals (ISTIC, 2007). ISTIC hosts annual press release conferences about the statistics based on the CSTPCD, which has been an important event in the Chinese science community. The results are reported by major Chinese media such as China Central Television Station (CCTV) and Chinese S&T Daily. In 1989, the Documentation and Information Centre of the Chinese Academy of Sciences (DICCAS) started to construct a similar database – the Chinese Science Citation Database (CSCD) which covers 1083 journals in the period 2007-2008 (CSCD, 2008).

Compared to S&T databases, databases in the social sciences emerged later. The first Chinese citation database in the social sciences – the Chinese Social Science Citation Index (CSSCI) was established in 2000 by Chinese Social Sciences Research Evaluation Center affiliated to Nanjing University. The CSSCI covers 680 journals in the period 2007-2008 (CSSCI, 2008). Another database entitled the Chinese Humanities and Social Science Citation Database (CHSSCD) is produced by the Centre for Documentation and Information attached to the Chinese Academy of Social Sciences. The first citation database of the CHSSCD appeared in
2000 (Zhou, 2002). The CHSSCD covered 662 journals in 2001. In terms of social visibility, the CSSCI is better known than the CHSSCD.

3. Existing studies

3.1 Qualitative studies

Nowadays, the number of publications, reports, and seminars about China keeps increasing. These outputs mainly focus on Chinese science and technology from the perspective of policies, R&D expenditure, technological innovation (Song, 1997; Baark, 2001; Hu & Jefferson, 2004; DMOS, 2007; NSF, 2007; OECD, 2007).

As the largest country with unique social and economic development approach which sets the country apart from many other countries in its science and technology, the Chinese government plays a critical role in promoting S&T development. Through the paper of Dr. Song Jian, the former minister of the Ministry of Science and Technology (MOST) of China, one can know how Chinese government guides the direction of its S&T. In his paper, Dr Song reviewed China’s reform and opening in S&T which corresponds to the reform and opening in economy; China’s national strategic objectives, national programs for science and technology development, and other relevant important issues in Chinese S&T (Song, 1997).

Individual researchers show their interests in China’s development. At the conference entitled “China’s Economic Transition: Origins, Mechanisms, and Consequences” held in Pittsburgh, Hu & Jefferson (2004) presented their study with a similar title as that of Dr Song. The two authors first compared China’s level of S&T activity with the levels of other countries—both the OECD countries and other emerging industrial economies, and focused on three indicators of S&T outputs including patents that have been granted to the residents of China compared with other nations and two indicators of the relative technological sophistication of China’s exports.

Apart from individual researchers, institutions are interested in China’s progress as well. Wilsdon and Keeley from the UK’s think tank DEMOS presented their research report about China in 2007. The authors conducted their investigation by holding a series of research seminars and fieldwork, visiting Chinese cities including Beijing, Shanghai, Guangzhou, Shenzhen, Chongqing, Chengdu and Kunming. In-depth interviews and a handful of focus groups were conducted with around 170 people from government, foreign embassies, business, academia and the media. The report covers a wide range of topics: people, regions in the rise, network of innovation, culture, and collaboration. In the end, Wilsdon and Keeley concluded that China has 1) a focused and strategic approach to science and innovation policy which is being supported by dramatic increases in funding at every level, and in overall share of GDP devoted to R&D; 2) the world’s largest scientific force and some world-class universities; 3) dynamic publication system with strength in selected fields as materials science and nanoscience. Wilsdon and Keeley noticed that the role of enterprise in China’s national innovation system has been recognized. Multinational R&D is being located in China and there is a gradual move towards using China for high-value, global-facing research by some of the world’s most innovative companies. Chinese government encourages oversea Chinese scientists and engineers return to China through various ways. Intellectual property rights get better protection. But the two authors also announced China’s weak points. First, they doubt national innovation can be planned. This point aims at China’s National Medium- and Long-Term Plan for Science and Technology Development. Wilsdon and Keeley
emphasize that China does have enormous university graduates, but dramatic variations in quality exist since only top 50 universities are truly world class. “Once you below the top 100, standards plummet fast” (Wilsdon & Keeley, 2007). The unevenly distributed capabilities for science and innovation may also lead to unrest and conflict that derails wider efforts to promote economic and political reform. Chinese companies invest little in R&D with a few exceptions of some international players. The imbalanced relation between Chinese publications and citations is also mentioned by Wilsdon and Keeley. “China often involves the fresh application of techniques and methods that have been developed by others” (Wilsdon & Keeley, 2007).

3.2 Quantitative studies

The existence of academic publication databases enables researchers to conduct quantitative studies on China’s performance in science and technology. Researchers mainly focused on two aspects: 1) publications and citation impact (Arunachalam et al., 1993; Zhang & Zhang, 1997; Mély et al., 1998; Moed, 2002, Jin & Rousseau, 2004), and 2) media of publications (i.e., journals, Ren & Rousseau, 2004; Leydesdorff & Jin, 2005; Jin et al., 2005).

*Studies of China’s overall performance in science*

An early paper can be seen in 1993. After the end of the Cultural Revolution (1966-1976), China gradually shifted its focus from class struggle to economic construction. Science and education get increasing emphasis by the government. Arunachalam et al. noticed China’s progress in science and remarked ‘the sleeping dragon wakes up: a scientometric analysis of the growth of science and the usage of journals in China’ (Arunachalam, et. al., 1993). This announcement was based on an analysis on publications indexed by the *Science Citation Index* (SCI) produced by the Institute for Scientific Information (ISI) in the period of 1981-85. In 1997, Zhang and Zhang further confirmed China’s growth in the later period 1987-1993 based on the same database (Zhang & Zhang, 1997).

In 1998 Mély et al. announced China’s progress in science after examining the impact of the drastic reorientation of science funding systems which occurred in China (PRC) in the midst of the eighties. A decade after this turning point the pattern of Chinese publications from the SCI CD-ROM reflects some effect of China’s policy: the authors found a neat increase of international publications after China’s Opening – up policy.

Using more databases including the CD-ROM versions of the *Science Citation Index* (SCI), the *Social Science Citation Index* (SSCI), *Arts and Humanities Citation Index* (A&HCI), and *Specialty Indexes* covering Mathematics and Computer Science (CompuMath), Chemistry, Biochemistry, Biotechnology, Neurosciences, and Materials Science produced by the Institute for Scientific Information (ISI), Moed analyzed Chinese publications activities in 1990-1999 and found that Chinese publications increased rapidly (Moed, 2002).

Comparison analysis had been done as well. For example, Jin & Rousseau (2004) compared China with its international counterparts based on the ISI’s and Chinese domestic databases (i.e., the *Chinese Science Citation Database*, the *CSCD*). The authors obtained different results in terms of rankings. Zhou and Leydesdorff (2006) explored China’s overall performance in science with a specific focus on nanoscience and nanotechnology. The development of China’s R&D investment is also included in this paper. The two authors

22
concluded that China has emerged as a leading nation in science. This paper is included in the dissertation as Chapter 4.

Studies of Chinese journals

In their studies of Chinese journals, Ren and Rousseau (2004) analyzed the internationalization and the visibility of Chinese journals covered by the Institute for Scientific Information (ISI) with focus on physics and chemistry journals. For these journals the country of origin of published papers and their citation patterns are analyzed. The composition of journal editorial boards was analyzed so as to measure the internationality of journals. The authors concluded that Chinese journals were still rather "local" and suffered from a low visibility in the world.

Leydesdorff and Jin (2005) studied Chinese journals from a different perspective by applying methods and software developed for mapping journal structure contained in aggregated journal-journal citations in the SCI and the Chinese Science Citation Database (CSCD) of the Chinese Academy of Sciences. Using factor-analytical and graph-analytical techniques the authors revealed the journal relations and found that the CSCD exhibits the characteristics of “Mode 2” in the production of scientific knowledge more than its western counterparts. In the same year, Jin et al. (2005) investigated both international and domestic citation networks of Chinese journals. Based on 36 journals covered by both the CSCD and the SCI in 2001, the authors concluded that the communication scope of Chinese journals was mainly limited to Chinese domestic community. Scholarly communication between Chinese and international researchers was asymmetrical: knowledge mainly flowed in, instead of flowed out of the Chinese science community.

From various perspectives Zhou and Leydesdorff (2005, 2007a, 2007b) explored the characteristics of Chinese scholarly communication based on more recent data, a different Chinese database (i.e., the CSTPCD) in addition to the SCI, and better developed visualization software. In addition to getting similar results as those of Jin et al. get in 2005, more results have been obtained. Details are delineated in Chapters 8 – 11 in the dissertation.

4. Research objectives of the PhD project

The studies mentioned above contribute to understanding Chinese science from different perspectives. But these outputs are fragmentary and are insufficient in: 1) providing an overall picture about knowledge production in China since there is no research about Chinese performance in the social sciences; 2) unable to provide an updated result about Chinese science when scientific studies develops rather rapidly. Furthermore, there are no systematic studies on Chinese scholarly communication.

My PhD program intends to provide an updated and comprehensive map about the knowledge production and scholarly communication in China with bibliometrics as a major tool.

Bibliometrics has two major objectives. The first one is trying to build more quantitatively robust models of the development of the sciences, technology, and innovation (Elkana et al., 1978). Until now, there is no agreed upon model of national innovation, which makes it hard to reach a consensus in terms of what makes one innovation system more innovative (Valdez, 2008). The second objective of scientometrics is to use the variables in these models as
indicators for performance measurement (Martin & Irvine, 1983; Martin, 1996). Nowadays, research assessment has become common practices in science management and scientometrics can play a major role in this business.

I am interested in the first objective of scientometrics and try to operationalize knowledge production and communication. China is my first target. My current focus is the Chinese knowledge production and scholarly communication from scientometric perspective so as 1) to make contribution to the establishment of a quantitative model for the development of Chinese science; 2) to explore if the Chinese situation adds more blocks for the establishment of citation theory, and 3) to find out policy implications for relevant Chinese players in knowledge production and communication. Four questions will be addressed which are 1) How does China perform in knowledge production? 2) How do Chinese regions contribute to knowledge production? 3) What is the role of international collaboration? and 4) How Chinese scholars communicate domestically and internationally?
Chapter 2

Outline of the Dissertation

The main study of the dissertation is divided into two sections (Figure 1). Section 1 includes Chapters 3 to 7 dealing with Chinese knowledge production. Section 2 is composed of four chapters (i.e., Chapters 8 to 11) focusing on Chinese scholarly communication. The WoS, the JCR, and the CSTPCD are the main data sources.

Figure 1. Structure of the studies.
1. Knowledge production (Chapters 4-7)

The Chinese scientific system has experienced dynamic development, in which three factors have played important role. First, the total R&D expenditure increases with a considerable rate. For example, from 2001 to 2003, the average growth rate of R&D expenditure (GERD) was 18.6% (MOST, 2006). The share of R&D expenditure in GDP amounted to 1.3% in 2003. This figure is expected to surpass 2.5% by the year 2020. In addition, making the contribution rate of science and technology exceed 60% and entering top five countries in citation rate are also the targets set in China’s National Medium- and Long-Term Plan for Science and Technology Development (2006-2020). Second, R&D manpower graduating from both domestic and foreign universities keeps increasing. In 2006, the newly enrolled numbers of graduate and doctoral students were 341,970 and 55,955 respectively, making the total numbers of graduate and doctoral students reach 896,615 and 208,038 (MOE, 2007b). Compared to the 90s of the 20th century, the newly enrolled doctoral students have increased by 15 times. Furthermore, growing number of overseas Chinese with degrees outside of China have been returning, which further enhances and enlarges Chinese research capacity. Third, quantitative evaluation for individual scholars and research institutions requires scientists to publish more. Since a Chinese university first adopted quantitative evaluation based on publications covered by the WoS in the late 80’s of last century, quantitative evaluation has been widely practiced by Chinese research institutions. Publications have become a critical indicator in research evaluation.

1.1 The emergence of China as a leading nation in science (Chapter 4)

The overall situation of China’s performance in science is the first issue to be illustrated. The following questions need to be investigated: 1) What is the output of Chinese knowledge production? 2) Does the Chinese output keep pace with the input? 3) How is the feedback in terms of citations from the international community? 4) How does China act in nanotechnology? The reason to specify nanotechnology is because this field is so important that it is included in the strategic plans of many nations. These questions are explored in Chapter 4. Comparison is done among leading scientific countries. The European Union as an entity and Asian countries including Japan and South Korea have been taken into account. Only document type articles, letters, notes, and reviews in the SCIE are counted. Main results are as the following:

**Publications**

The number of China’s publications grows rapidly. In 2004, China took the fifth position. Only three year later in 2007, China became the second biggest country in terms of publications (Zhou & Leydesdorff, 2008). Among the selected countries or the EU, China is the only country that has exponential growth in world share of publications.

**Citation impact**

Citation impact of Chinese publications and journals is problematic. Chinese publications are not well cited by international scholars. Chinese journals are isolated in the international citation environment. Inclusion in the Science Citation Index Expanded (SCIE) for Chinese journals does not equal to integrating into the world system of scholarly communication. Chinese journals are integrated with their international counterparts in terms of citing...
relations. The fact that Chinese publications are not well cited by international authors implies that the overall quality of Chinese publications is still low.

**Performance in nanotechnology**

China does well in nanotechnology. Since nanotechnology is a highly interdisciplinary field, it is very difficult to identify which papers belong to this field. After experimenting with various methods to delineate a journal set which would be representative of nanoscience and nanotechnology, I finally classified two sets of journals: 1) core nanotechnology journals, and 2) nano-relevant journals to map the productivity in this field. In the core set journals, Chinese world share of publications in nanotechnology increases more rapidly than the other selected countries or the EU. In 2004, China has taken the second position in this indicator. China’s world share in nano-relevant publications also grows exponentially from 1998 to 2004, which implies that China has surplus capacities to launch more research in nanotechnology since expertise and manpower are available in nano-relevant sciences. More publications can be expected since this China has higher than average percentage world shares in nano-relevant fields.

**R&D expenditure**

Based on OECD data, the study shows that China’s R&D expenditure grows exponentially from 1994 to 2002 in terms of total amount in BERD (Business Enterprise Expenditure on R&D), HERD (Higher Education Expenditure on R&D), and GOVRD (Government Intramural Expenditure on R&D). The ratio of GERD to GDP also increases in an exponential way.

In general, China has emerged as a leading nation in science in terms of knowledge production in the meantime taken the lead in nanotechnology. But China’s international citation impact is problematic since Chinese publications are not well cited by its international counterparts. The main reason for the low citation impact of Chinese publications is because of their relatively low quality at an overall level. In terms of the efficiency of R&D investment, China’s output does keep pace to the input.

**1.2 Regional analysis on Chinese scientific profile (Chapter 5)**

China is a huge country with numerous ethnic groups and geographically and topologically different regions. Its economic development varies extensively among different regions. The two metropolises, Beijing and Shanghai, and other provinces like Guangdong and Zhejiang, are far more developed than many other regions. A report about the economic status of Chinese provinces issued by the Standard Chatered Bank (SCB) may explain well such large variation. The SCB ranked Chinese provinces according to their Purchasing Power Parity (PPP) in 2007 ([http://finance.ifeng.com/news/hgjj/200809/0911_2201_779286.shtml#](http://finance.ifeng.com/news/hgjj/200809/0911_2201_779286.shtml#)). The two metropolises Beijing and Shanghai are not listed in the table. Guangdong ranks the first with a PPP of 889 billion USD while the PPPs of Qinghai, Ningxia, Hainan, and Gansu are in billion USD 22, 24, 35, and 78 respectively. The PPP of Guangdong is 40 times higher than that of Qinghai. Guangdong is predicted to be the world’s 14th economic entity by the SCB while the poor regions are still struggling to feed their residents’ stomachs in some of their extremely poor areas.
Since the overall knowledge output of China is an integrated contribution of various regions, are regional contributions to Chinese knowledge production also vastly skewed like their economic situation? In other words, do the rich regions contribute the most? Which regions are active in which fields? When international collaboration increases all over the world, which regions are active in such kind or collaboration? Chapter 5 tries to answer these questions by investigating the following:

National share of publications

Beijing, Shanghai, Hong Kong, and Jiangsu are the top four regions in national share of publications. But the publication development of these regions differs. Beijing’s position is unshakable, although its share started to decline since 2003. Hong Kong’s national publication share started to decline since 2002 and lost its second position after 2004. If the present trend continues, Hong Kong’s third position will be replaced shortly by Jiangsu which grows slowly but steadily.

Publication activity of fields

Except Hong Kong, the other Chinese leading regions are predominant in chemistry and physics, in the meantime active in other fields. Beijing and Jiangsu share similar patterns: in addition to be extremely active in physics and chemistry, the two regions are also active in mathematics, geosciences & space sciences, and engineering. Shanghai is also active in chemistry, physics, and mathematics, but not active in geosciences & space sciences. Publication activities of the three Mainland regions in the 12 disciplines are very much imbalanced. They are active in chemistry, physics, mathematics, and geosciences & space sciences, but are the least active in neuroscience & behavior, general & internal medicine, and non-internal medicine. However, compared to the early period 2000-2002, the Mainland regions have shifted a little bit from the most to the less active fields. Compared to the Mainland, Hong Kong is very active in engineering and mathematics. Its activity in other fields is relatively more balanced than the Mainland.

Regional citation impact

From 2000 to 2004, Beijing occupies the first position in national share of citations, but its share starts to decline since 2002. Hong Kong’s national share of citations experienced ups and downs while keeping its second position in this indicator. Shanghai struggled to keep its third position. Jiangsu moves up slowly in the fourth position. In terms of relative citation impact, indicators like RCR, NMCR, and MECR/FECR are applied. Hong Kong performs the best measured by these indicators.

International collaboration

The four most active regions in terms of publications (i.e., Beijing, Hong Kong, Shanghai, and Jiangsu) also take the lead in collaborating with international counterparts. Over half (53%) of China’s international collaboration happened in the four regions. Beijing is the most active, but its national share in international collaboration has declined since 2003 and kept relatively stable in the coming years. In the studied period, Hong Kong’s share keeps declined since 2001 and is about to give its second position to Shanghai. Opposite to Hong Kong, Shanghai has become active in international collaboration since 2003 and takes increasing national share in the following years. As the fourth most active region in
international collaboration, Jiangsu keeps its position with a relatively stable share in the studied period.

Citation impact of domestic vs. internationally co-authored publications

International co-authored publications have higher citation impact than that of regional ones. International collaboration is an important way for Chinese regions to raise their citation impact.

R&D expenditure

Beijing takes the first position in both publications and R&D expenditure but gradually loses some share in the two indicators since 2003. Shanghai keeps relatively stable position in the two indicators. This municipality ranks higher in national publication share than that of its R&D expenditure. The situation in Jiangsu is inverse: Jiangsu ranks higher in national share of R&D expenditure than that of publications. Situations of some other regions are worth of mentioning: as the third largest R&D investor since 2004, Guangdong just took the sixth in publications. Hubei ranks out of the top 10 in R&D expenditure but takes the fourth in publications. Spearman’s rank correlation coefficient shows that correlation between the Chinese regions’ R&D expenditure and their publication output is low.

Regional contributions to China’s knowledge production are highly skewed. Regional citation impact in terms of national share of citations basically corresponds to their productivity. Hong Kong has reached its potential in publishing international papers. Correlation between R&D expenditure and knowledge output of Chinese leading regions is low. In other words, higher invest does not necessarily result in higher productivity measured by publications.

1.3 In-depth analysis on China’s international collaboration in science (Chapter 6)

Since 1978 when China started to adopt the Opening-up policy, China has established S&T collaboration relations with more than 150 countries or regions, and has signed inter-governmental S&T cooperation agreement with over 90 countries. What is the result of China’s international collaboration? Who are China’s main partners? In which fields China’s international collaboration is more active? This chapter attempts to address these questions. Research profile and citation impact of international collaboration with respect to the domestic ‘standards’ will also be explored.

In ten years from 1997 to 2007, Chinese international co-authored publications increased remarkably. But the growth speed is lower than that of China’s total publications: unlike most of countries whose numbers and shares of internationally co-authored publications dramatically increased during the last two decades (Schubert & Braun, 1990; Glänzel & Schubert, 2004), those of China decreases.

China does have enhanced collaboration relations with some countries. But the most important partners are only four which are the USA, Japan, Australia, and Singapore. Except the USA, Japan and Singapore are close to China. This may imply that two key factors may decide the possibility of international collaboration: scientific proficiency and geographic distance. Cultural and political issues may also play roles in determining international collaboration.
In addition to having similar characteristics with the other former socialist countries in terms of publication patterns (i.e., being active in chemistry and physics), China is also active in mathematics. The activity of China’s international collaboration is the opposite: international collaboration is active in those fields that China is less active. In other words, International collaboration compensates China’s disciplinary deficiency.

China’s international collaboration has increased but its national share of international collaboration decreases. International collaboration helps raise China’s citation impact at the overall level and in most individual fields except mathematics.

**1.4 Is China also becoming a giant in the social sciences? (Chapter 7)**

After knowing that China has become a leading nation in terms of publications in the natural sciences, a question comes out naturally: is China also becoming a giant in the social sciences?

Compared to the natural sciences, the social sciences are more connected to and imbedded in (and thus affected by) the social and political system to which they are oriented. From a historical viewpoint, most disciplines in the social sciences are also younger than scientific fields or traditional areas in the humanities. Communication behaviour of scientists in the social sciences essentially differs from that of their colleagues in the natural sciences and applied sciences. Bibliometric methods originally designed for the analysis of basic research in the sciences has to be adapted to the peculiarities of the social sciences. The divergence of communication finds, among others, its expression in the particular choice of communication channels, the publication language and specific citation behaviour (Glänzel & Schoepflin, 1999; Hicks, 2004). I therefore focus on those disciplines in which the communication behaviour is rather similar to the one of the natural sciences so that scientometric methodology can be applied. The following issues are the main focus of this study.

*The development of publications*

The fact that the social sciences are closely related to social and political system is typically reflected in China. In 1978 the Opening-up Policy was adopted. The results show that Chinese publications did have visible increase afterwards. Other social and political issues were also reflected in the development Chinese publications in the social sciences. China’s production speed has been accelerated since 1997, which may imply that China has launched its catching-up race in the social sciences. China’s world share of publications in 2006 was still low even though there is a notable increase since 1997. Not only China, all the word shares of other Asian countries are very low as well. Publications included in the SSCI are mainly from the USA, and Canada, and the EU nations.

*Publication activity of fields*

China is more active than the world standard in economics and business administration, and is quite below the average in psychology. Publication activity in social, political and communication sciences is also lower than the average.

*International collaboration*
Increased international collaboration in the social sciences was observed. Except the national share of collaborative papers is increased, international collaboration links with the USA and Singapore have been strengthened. In addition, the EU-15, Australia, Canada and the UK are also China’s important partners. On the other hand, intensity of collaboration with Japan has considerably decreased although the total number of joined publications somewhat grew at the same time.

Citation impact

China’s world share of citations is even lower than that of its publications. In fact, except New Zealand, citation shares of the major Asian countries including Japan, China and South Korea, are less than their publication shares. On the contrary, the world share of citations of the USA is much higher than that of its publications. In addition, over half of citations are referred to publications from the USA. Citation shares of some EU-15 countries such as the UK, Germany and The Netherlands, are also higher than their publication shares.

China progresses slowly on the way to the internalization of social sciences. The development of the social sciences is much slower than that in the natural sciences in China in this regards (Zhou & Leydesdorff, 2006, 2008).

2. Scholarly communication

In the dissertation, citation relations among journals are used to explore how Chinese scholars communicate. Journals cite each other forming a social network in science. Nodes in the network are journals which form various clusters because of their disciplinary similarity. This kind of intellectual organization of knowledge in terms of journals is different from the social organization of the sciences in terms of institutions and people. Therefore studying the communication network of journals may 1) enables us to explain the scientific enterprise as a result of these two interacting and potentially coevolving dimensions (Whitely, 1984; Leydesdorff, 1998); 2) construct a baseline for measuring effectiveness of political interventions; 3) develop a more reasonable measurement, for instance, an indicator similar to the Impact Factor (IF) proposed by Garfield (1979) for evaluating journals.

Chapters 8 to 11 aim at figuring out the characteristics of Chinese scholarly communication with focus on 1) the communication pattern and 2) international integration of Chinese scholars. Journal citation databases including the Journal Citation Reports (JCR) in the WoS of Thomson Reuters and the China Scientific and Technical Papers and Citations Database (CSTPCD) are the main data sources. The study is conducted at three levels: the database level, the specialty level and the institutional level (i.e., university journals and journals from Chinese Academy of Sciences).

Since communication pattern differs among fields, for example, scholars in mathematics cite less than those in other fields like genetics (Leydesdorff, 2008b). It is necessary, therefore, to investigate if Chinese scholars in different fields have different citation patterns.

Communication patterns of Chinese scholars in mathematics and computer science are explored in this dissertation, because China’s performance is most pronounced in mathematics (DICCAS, 2004), and computer science is critical for the development of information science and technology. Furthermore, the latter field is closely related to bibliometrics. Visualization tool Pajek is applied in Chapters 9 and 10 so as to better describe
citation relations among journals. A new indicator (i.e., \(c/n\) ratio) proposed by Loet Leydesdorff (Leydesdorff & Cozzens, 1993; Leydesdorff, 2004a) for measuring journal citation impact is applied.

2.1 A comparison between the China Scientific and Technical Papers and Citations Database and the Science Citation Index in Terms of journal hierarchies and inter-journal citation relations (Chapter 8)

This chapter focuses on the communication pattern of Chinese scholars in domestic and international communities, and how Chinese publications are received by their international counterparts. The Chinese domestic database, the China Scientific and Technical Papers and Citations Database (CSTPCD) and the Science Citation Index (SCI) are selected for this study. Domestic and international comparison will be done at both the database level and field level.

The results show that Chinese scholars provide less reference literatures than their international counterparts. High-quality international journals have a higher rank in the hierarchy than do their Chinese counterparts. Authors who publish in high-quality Chinese journals prefer to cite articles in international journals instead of domestic ones. For some high-quality Chinese journals, no domestic journals are included in the citation graph when the threshold is set at 1% of their citing environments. High-quality Chinese journals have high citation impact in the domestic community. Communications between Chinese and international scholars are imbalanced: Chinese authors prefer to cite articles in international journals over domestic ones, their international counterparts do not return the same: the international visibility of Chinese journals is low.

The international visibility of Chinese journals differs among disciplines. Among journals in general science, materials science, and the life sciences, journals in materials science have a relatively higher visibility while the visibility of journals in the life sciences is the lowest. This reflects the relative strength of China in these fields.

2.2 Visualization of the citation environments in the CSTPCD journal set (Chapter 9)

Journal classification in terms of disciplines is still a disputing issue in bibliometric community. Some researchers have contributed with different solutions (Pinski & Narin, 1976; Moed, Burger, Frankfurt, & Raan, 1985; Glänzel & Schubert, 2003). But no solutions are widely accepted. For lack of an agreed-upon alternative, the ISI subject categories are often used for “comparing like with like” (Martin & Irvine, 1983). These categories are assigned by the ISI staff on the basis of a number of criteria, including the journal’s title, citation patterns, and so on (McVeigh, pers. commun., 9 March 2006). Such classifications, however, match poorly with classifications derived from the database itself on the basis of analysis of the principal components of the networks generated by citations (Leydesdorff, 2006a). Using a different methodology, Boyack, Klavans, and Börner (2005) found that in somewhat more than 50% of the cases the ISI categories corresponded closely with the clusters based on inter-journal citation relations. These results accord with the expectation: many journals can be assigned unambiguous affiliations in one core set or another, but the remainder, which is also a large group, is very heterogeneous (Bradford, 1934; Garfield, 1972).
Leydesdorff (2002, 2003, 2004a, 2004b) considers the aggregated journal-journal citations provided by the Journal Citation Reports of the (Social) Science Citation Index as a huge matrices of cited and citing journals, respectively. Scientific journals tend to cite one another in dense clusters which represent specialties. However, some (e.g. interdisciplinary) journals cite and are cited across different fields (Narin et al., 1972). This is well-known of Science and Nature at the top of the hierarchy, but there are also hierarchies spanning fields at lower levels (Doreian 1986; Doreian & Fararo, 1985). For example, the journals of American professional associations may function as elite institutions across cognitive delineations among specialties (Bensman, 1996). While the majority of the journals remain embedded in one or more specialized publication and citation structures, the matrix thus is nearly decomposable (Simon, 1973). In other words, the vectors of the journal distribution span a multi-dimensional space in which clouds can be distinguished, but the delineation of these clouds at the edges remains fuzzy (Bensman, 2001) and varies with the perspectives chosen by the analyst (Leydesdorff & Cozzens, 1993; McKain, 1991). Particularly, if one wishes to construct a baseline against which to measure change, the distinctions among variations, measurement errors, auto-correlations in the data, and structural change may become too uncertain to be meaningful (Leydesdorff, 1991; 2002).

The possibility to provide journal maps online using visualization techniques from social network analysis has changed the situation dramatically (Otte & Rousseau, 2002). Leydesdorff (2007a) has provided online journal maps for those covered by the SCIE and the SSCI. Chapter 10 applies the same set of routines developed by Leydesdorff and the visualization techniques to Chinese journals covered by the CSTPCD and presents examples in terms of how to analyze a specific citing/cited network. These routines and visualization tools have already been used in former relevant chapters.

Through the online data source, users can get both citing and cited networks of a specific journal so as to get hierarchies among journals. The practical applications of a visualization and quantification of the citation impact environments of journals are numerous. Librarians, for example, can use this information to improve the quality of their collections or compose a list of core journals relevant to their specific needs (Hirst, 1978). Prospective authors may be interested in neighbouring discourses and how these are relevant for their publication and citation profiles. The maps represent the subject structure in terms of the positions of the nodes and the links between them. The links allow users to detect the clusters in the graph either visually or by using more sophisticated tools like graph-theoretical algorithms (e.g., Bollen et al., 2005). The size of the nodes can be used to represent the percentage of the citations within a specific citation environment either including or excluding within-journal (self-) citations. If it is deemed no longer feasible to provide an objectified representation at the cluster level, one might leave the choice of the entrance journal, the choice of the clustering, and therewith the perspective to the end-user.

2.3 The citation impacts and citation environments of Chinese journal in mathematics (Chapter 10)

Since citation culture in different fields varies, this chapter focuses on investigating citation performance of Chinese journals in a specific field, mathematics. The reason for selecting the citation pattern in mathematics is because China does relatively better in this field. Two typical Chinese journals: the Journal of Mathematics Education (JME) and the Acta Mathematica Sinica (AMS) are selected for this purpose. The AMS has both Chinese and English versions which are abbreviated as AMS-C and AMS-E respectively. The AMS-C is
covered by the Chinese database, the CSTPCD and the AMS-E is included in the Thomson Reuters database the SCIE. Both the JME and the AMS-E have high impact factors among journals in mathematics.

In the domestic science community, the JME mostly cited itself, while the AMS-C is active in providing references to other journals, especially in 2003 when within-journal citations of the AMS-C is almost invisible. Authors in both the JME and the AMS-C prefer citing international journals to domestic ones. The citing patterns of Chinese journals show that international publications are the main knowledge sources of Chinese scholars.

Chinese journals in mathematics have citation impact on both domestic and international journals. In the domestic environment, the citation impact can be seen among domestic mathematics journals and university journals. In the international environment, however, the impact of Chinese mathematics journals is lower than that of their international counterparts. This may imply that Chinese scholars assess the quality of articles published in Chinese journals lower then those published in international journals.

This study also reminds the complexity of journal evaluation. In addition to global impact factors, other elements like local citation impact and the specific role of a journal should be considered. It is inappropriate to compare journals serving for different audience. The JME has the highest impact factor, but its citation impact on other journals is very weak since most citations of the JME are within-journal citations. Although the impact factor of the AMS-C is less than that of JME, AMS-C’s citation impact on other scientific journals is the highest in its local cited environment.

2.4 Analysis on the citation environments of Chinese journals in computer science (Chapter 11)

The main purpose of this chapter is similar to that of Chapter 10 only with different field focus. This chapter explores citation patterns of Chinese scholars in computer science. The main reason for selecting this field is because computer science has been widely applied in science and human life. In addition, the development of bibliometric methods, for instance, data processing and the visualization of citation relation among journals, relies heavily on computer science and technology. The study is based on the Chinese database, the CSTPCD. Two journals, the Journal of Software (JoS) and the Journal of Computer Research and Development (JCRD) are selected since both have high impact factor among Chinese journals in computer science. In addition to exploring the citation patterns of Chinese scholars in computer science, comparison between the JoS and the JCRD is also conducted so as to see similarities and difference between the two journals.

The result is similar to that of Chapter 9 in terms of the citation patterns of Chinese scholars. Chinese scholars in computer science also prefer citing publications in international journals to domestic ones. Comparison between the JoS and the JCRD shows that the citation impact of the JoS is higher than that of the JCRD. Both journals have high citation impact in Chinese domestic community.
3. Outcome of the studies

Based on the above studies, I arrange two chapters (i.e., Chapters 12 and 13) for the outcomes. Conclusions, discussion, and perspectives are included in Chapter 12. Policy implications are provided in Chapter 13.

3.1 Conclusions, discussion, and perspectives (Chapter 12)

China has become a major producer of scientific publications. While having the publication characteristics of that of the formal socialist countries with extreme activity in chemistry and physics, the Chinese publication system is also very active in mathematics. China is relatively inactive in the life sciences. Regional contributions to Chinese publications are highly skewed. Several economic developed regions such as Beijing, Hong Kong, Shanghai, and Jiangsu are usually the top contributors of Chinese scientific publications. The Chinese pattern of international collaboration is different from most of the advanced countries: the national share of internationally coauthored publications goes down while that of most countries goes up. But my study shows that international collaboration helps raise China’s visibility and impact at both overall and disciplinary levels. Only mathematics is an exception in which international collaboration slightly lowers China’s visibility. Contrary to its fast progress in the natural sciences, China moves forward slowly in the internationalization of social sciences. But because of the limited coverage of the data source (i.e., the Social Science Citation Index) and the close tie between the social sciences and national, cultural, social, and political environment, publication activity can be very local or national. The present result which is based on an international data source cannot represent the overall situation about China’s research in the social sciences. It is necessary to analyze Chinese domestic publication databases in the social sciences in order to better understand the Chinese situation in this regard. Unfortunately, data were lacking during the period of this dissertation research so that I was not able to analyze the Chinese domestic publication activity in the social sciences.

Compared to their international counterparts, Chinese scholars are less active in communicating with their counterparts through scientific literature since they provide fewer references in their publications. In the domestic community, knowledge mainly flows from high-quality journals to the lower ones. Knowledge communication between Chinese and international scholars are not equal. Chinese authors mainly play a role as knowledge receivers while international authors play as citation sources.

Since the dissertation adopts a bibliometric methodology and bibliometrics has not been well-developed yet, it is necessary to discuss pertinent problems in applying bibliometric methods for research evaluation. In Chapter 12, I provide a critical review of the use of citation analysis for this purpose. This chapter first provides a definition of bibliometrics, and proceed with a discussion of the relation between bibliometrics and other specialties in the study of science, the increasingly important role of bibliometrics in science management and research evaluation, and so on. In addition to general problems in applying bibliometrics to research evaluation, specific issues that may affect the interpretation of the results in the above studies are also discussed.

Regarding to knowledge production and scholarly communication, I present three viewpoints in the third section (i.e., Perspectives) of Chapter 12. My first point suggests use some specific terms to differentiate players in knowledge production and scholarly communication.
In allusion to the situation of China who is the major producer of scientific publications but has very low citation impact, I propose to use terms like knowledge producer, knowledge provider, and knowledge receiver to differentiate the different roles of academic authors or unit. The second and third points further analyze reasons that cause China’s current performance in knowledge production and scholarly communication. Regarding to the exponential growth of Chinese publications, I generalized three reasons: 1) continuous and increasing investments in R&D; 2) the huge reservoir of human resources; and 3) research evaluation mechanism. As to the unique style of Chinese scholarly communication (i.e., favouring foreign publications over domestic ones but without getting the same return from foreign authors), I analyzed the objective and subjective factors including journal accessibility, impact of journal editorial requirements, English language proficiency and reading habits of Chinese authors.

3.2 Policy implications (Chapter 13)

Policy implications are provided in Chapter 13. China has achieved amazing progress in production of scientific knowledge. But this country’s citation impact is not proportionate to the rapid growth of its scientific publications: the citation impact of Chinese publications is still low. Such a sharp contrast requires adjustment of a wide range of measures pertinent to knowledge production and scholarly communication. In this chapter, I generalized some suggestions specifically to government agencies, authors, academic institutions, and journal editors. Each suggestion is provided based on analysis of pertinent problems or shortcomings. Main suggestions include:

- enhancing the innovativeness of research;
- strengthening both domestic and international collaboration;
- establishing scholarly communication networks;
- improving access to academic media;
- constructing a more feasible evaluation system;
- increasing accessibility of Chinese journals for international readers;
- providing open access;
- publishing an English version of journals;
- cooperating with international publishers and online journal database providers, and
- scholars being more active in informal communication and improving English proficiency.

4. Other studies

In addition to the above major studies, I have also explored other issues pertinent to China’s knowledge production and scholarly communication. Relevant publications are listed in the Appendix.
Chapter 3

Methods and Materials

1. Materials

The ISI Thomson Corporation located in the USA produces various data sources including the Web of Science (WoS) and the Journal Citation Index (JCR) for bibliometric research. The WoS is composed of the Science Citation Index Expanded (SCIE), the Social Sciences Citation Index (SSCI), the Arts & Humanities Citation Index (A&HCI), the New Conference Proceedings Citation Index- Science (CPCI-S), and the New Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH). Except the SCIE, the ISI also provides CD-ROM version of the Science Citation Index (SCI). ISI databases used in the dissertation are mainly the SCIE, the SCI, the SSCI, and the JCR.

As mentioned in the introduction, China has a large journal population, but only a few are covered by the WoS. Take the SCIE for example, among the 4758 Chinese S&T journals, only 75 were included in the SCIE (about 1.6%) in 2006 (JCR, 2007). Inclusion of Chinese journals in the social sciences is even lower: among the 2339 journals only four (about 0.2%) are included in the Social Sciences Citation Index (SSCI). The poor coverage of Chinese journals may cause biased results for mapping the Chinese knowledge production and scholarly communication. For example, the WoS is a good way to map a nation’s international visibility, but it provides limited information about China’s domestic dynamics in communication. For this reason, Chinese data sources are used in relevant topics in the dissertation. The Chinese data source is the China Scientific and Technical Papers and Citations Database (CSTPCD) and the Chinese S&T Journal Citation Reports (CSTJCR) produced by the Institute of Scientific and Technical information of China (ISTIC). These two databases are for S&T publications. China has databases for the social sciences, but they are not used in the dissertation because of accessibility problem.

For data about R&D expenditure, OECD’s Main Science and Technology Statistics is used. Statistics about research output and manpower from the website of the Ministry of Science and Technology of China is also used when necessary.

A set of routines developed by Leydesdorff and Cozzens (1993) and further modified by Leydesdorff (2004a) is used to generate aggregated journal-journal citation matrices on the basis of a seed journal or a set of seed journals. But these routines did not separate citing and cited dimensions of a seed journal. Accepting my suggestion, Leydesdorff revised the routines in 2005 making it possible to get separated citing or cited environments. Percentage of a journal’s citation contribution is also calculated automatically by the routines. Citation data in a matrix is normalized using the cosine as similarity measure (Salton & McGill, 1983). The citation matrices are imported into SPSS for factor analysis. Results of the factor analysis are in ASCII format and can be read directly into Pajek where the algorithm of Kamada-Kawai (1989) is used for the visualization.

2. Methods
In addition to bibliometric indicators such as number of publications, world share of publications, total citation rates, and world share of citations, some indicators which have not been applied to studies relevant to China are applied in this dissertation. These indicators include Activity Index (AI) or Relative Specialisation Index (RSI) for measuring publication activities in fields, relative citation indicators like Mean Observed Citation Rate (MOCR), Mean Expected Citation Rate (MECR), Relative Citation Rate (RCR), Field Expected Citation Rate (FECR), and Normalized Mean Citation Rate (NMCR). Relevant definitions for these indicators are listed in the following (Glänzel et al., 2006):

- **Activity Index (AI)** is defined as the ratio of the share of a given field in the publications of a given country to the share of the same field in the world total publications. This indicator (known and used in economics as Comparative Advantage Index typically calculated with export data) has originally been introduced by FRAME (1977) in bibliometrics and long used in macro studies (for instance, Schubert et al., 1989). It is easy to see that AI may take values in the range \([0, \infty]\); its neutral value is 1. AI = 0 indicates a completely idle research field. AI < 0 indicates a lower-than-average and AI > 1 a higher-than-average activity. It is important to note that AI reflects a certain internal balance among the fields in the given country, that is, AI > 1 values in several.

- **Relative Specialisation Index (RSI)** is defined in the REIST-2 (1997) and is closely related to the Activity Index (AI). Relation between the RSI and the AI can be described as
  \[
  RSI = \frac{AI - 1}{AI + 1}
  \]
  The value range of RSI is \([-1, +1]\).

- **Mean Observed Citation Rate (MOCR)**. MOCR is defined as the ratio of citation count to publication count (see Braun et al., 1985).

- **Mean Expected Citation Rate (MECR)** is a journal-based citation measure which expresses one expected citation rate of a publication set. The expected citation rate of a single paper is defined as the mean citation rate of all papers published in the same journal in the same year. Here a three-year citation window to one source year is used. MECR is then defined as the average of the individual expected citation rates over the given publication set. This indicator can preferably be standardized through dividing MECR by the Field-Expected Citation Rate (FECR) which is calculated in the same manner as MECR but instead of the journal citation impact the average impact of the corresponding subfields is used (Glänzel et al., 2008). This ratio expresses if papers are, on an average, published in journals with higher or lower citation impact than the corresponding subfield citation standards. Therefore, we can consider this indicator also a measure of relative “visibility”. It should be mentioned that a version of this relative measure, namely, FCSm/JCSm is used at CWTS in Leiden (Moed et al., 1995).

- **Relative Citation Rate (RCR)**. RCR is defined as the ratio of the two previous measures, that is, RCR = MOCR/MECR. It should be stressed that in the studies, a 3-year citation window to one source year is used for the calculation of both the enumerator and denominator of RCR. RCR = 0 corresponds to uncitedness; RCR < 1 (RCR > 1) means lower (higher)-than-average citation rate. RCR = 1 if the set of papers in question attracts just the number of citations expected on the basis of the citation impact of the journals where the papers have been published (Braun et al., 1985). Again, a version of this relative measure, namely, CPP/JCSm is used at CWTS (Moed et al., 1995).

- **Normalized Mean Citation Rate (NMCR)** is defined analogously to the RCR as the ratio of the Mean Observed Citation Rate to the weighted average of the mean citation rates of subfields, that is, NMCR = MOCR/FECR. This indicator is a second relative
citation rate; in contrast to the RCR, NMCR gauges citation rates of the papers against the standards set by the specific subfields. Its neutral value is 1 and NMCR>1 (NMCR<1) indicates higher (lower)-than-average citation rate than expected on the basis of the average citation rates of the underlying subfields. NMCR has been introduced by Braun and Glänzel (1990) in the context of national publication strategy.

The methods developed for mapping the journal structures contained in aggregated journal-journal citations in both the SCI or the CSTPCD is applied. Using visualization tool Pajek journal structures are delineated in pictures.

Collecting data for interdisciplinary journals is not an easy task. In order to map China’s position in nano-science and nano-technology, various methods have been experienced. In addition to core-journals, I distinguish a nano-relevant set which forms the citation environment of the core journals and thus may provide the seedbed for further developments in this field. The performance data of nations/region in these limited sets can be compared with the performance indicators over the file of the SCI.

A full counting or integer counting scheme is applied whenever a country occurred in the by-line of a paper. Only publications recorded as articles, letters, notes, and reviews are counted. Because of the extensive presence of international co-authorship, national bibliometric indicators such as publications and citation counts based on this full-counting scheme are not additive. In other words, they can not be summed up over countries to regions or supranational units. While counting citations, a three-year citation window is used.

Major scientific countries or regional important countries are selected for comparative analysis. Selected countries include the USA, Japan, the UK, Germany, France, and South Korea. Other countries such as Canada, Australia, and Singapore may also be involved in certain cases. The EU-15 and EU-25 are added to the comparisons so as to provide a perspective at the global level.

The Web-of-Science installation has some limitations on the retrieval. The system does not provide an exact number when the recall is larger than 100,000, and the download for each save is limited to 500. The recalls that are larger than 100,000 are separated into several smaller segments. Boolean algebra is used when necessary (because of international co-authorships). In the case of the EU-15 or the EU-25, the correction for international co-authorships is not a sine cura. The number of Boolean operators increases rapidly with the number of sets to be combined.

While analyzing regional contributions to Chinese scientific output, publications have been determined on the basis of an item-by-item procedure, using special identification keys, made up of bibliographic data elements. Publications were assigned to Chinese provinces on the basis of their corporate addresses which appear in the by-line of the publication. For this, a thesaurus has been made up of cleaned names of Chinese cities and provinces with all their spelling variances. Unresolved cases have been cleaned manually for the concerned records. Erroneously indexed publications were removed.

When it comes to field categories, major field categories developed by Glänzel & Schubert (2003) on the basis of the field assignment of journals are adopted.
PART II

MAIN STUDIES
The emergence of China as a leading nation in science

Ping Zhou a,b,*, Loet Leydesdorff b

a Institute of Scientific and Technical Information of China, 35 Xianing Road, Beijing 100038, PR China
b Amsterdam School of Communications Research (ASCoR), University of Amsterdam, Kloveniersburgwal 48, 1012 CX Amsterdam, The Netherlands

Received 28 February 2005; received in revised form 18 July 2005; accepted 24 August 2005
Available online 9 November 2005
Reprinted with permission of the publisher

Abstract

China has become the fifth leading nation in terms of its share of the world’s scientific publications. The citation rate of papers with a Chinese address for the corresponding author also exhibits exponential growth. More specifically, China has become a major player in critical technologies like nanotechnology. Although it is difficult to delineate nanoscience and nanotechnology, we show that China has recently achieved a position second only to that of the USA. Funding for R&D has been growing exponentially, but since 1997 even more in terms of business expenditure than in terms of government expenditure. It seems that the Chinese government has effectively used the public-sector research potential to boost the knowledge-based economy of the country. Thus, China may be achieving the (“Lisbon”) objectives of the transition to a knowledge-based economy more broadly and rapidly than its western counterparts. Because of the sustained increase in Chinese government funding and the virtually unlimited reservoir of highly skilled human resources, one may expect a continuation of this growth pattern in the near future.

Keywords: Publications, Citations, World share, Highly cited papers, Nanotechnology

1. Introduction

In recent years, China’s economy has been growing fast. The average annual GDP growth rate was 9.9% during the period 1992–2001 (National Bureau of Statistics of China, 2002). This extraordinary growth is happening in a context in which some other countries are experiencing stagnation and/or recession. Such economic growth can be expected to have positive effects on China’s scientific research and development (R&D) because, for example, more funding can be made available for R&D. Since the relation between knowledge-based innovations and the economy is interdependent and mutually enhancing (Frey, 2004), the growth of the scientific and technological capacities of China can be expected to reinforce its economic development.

In the transition to a knowledge-based economy, R&D expenditure has been considered as an important indicator for evaluating a country’s investment in...
its knowledge base. The European Summit of 2000 in Lisbon, for example, agreed to strive for a ratio of 3% Gross Expenditure in R&D (GERD) over GDP in 2010 (European Commission, 2000, 2005). The ratio of GERD/GDP for China has been increasing exponentially during the last decade despite the spectacular increase in the denominator (GDP). In 2003, the GERD/GDP-ratio for China was 1.31%, while only 5 years ago this ratio was 0.70% (China Science and Technology Statistics Data Book, 2004).

Another factor closely related to the emergence of Chinese science is the return of overseas scholars. China’s rapid and sustained economic development has motivated an increasing number of overseas scholars to return (Wang and Zheng, 2005). In order to encourage overseas Chinese scholars to join the construction of the Chinese knowledge-based economy, Chinese governments at various levels have developed policies favourable to the return of emigrants. As a result, 81% of the members of the Chinese Academy of Sciences and 54% of those of the Chinese Academy of Engineering are returned overseas scholars (Xing, 2004). These returned overseas scholars play important roles in China’s economic and scientific development.

Is the output of these efforts keeping pace with the input? If so, how is the impact of publications in terms of citations developing? (Jin and Rousseau, 2004). In a paper published in Nature, the Chief Scientific Adviser to the UK Government, Sir David A. King, compared certain major countries including the USA, the EU countries, and China (King, 2004). Among other indicators, the author suggested a relationship between wealth intensity (GDP per person) and citation intensity (citations per paper). On this indicator for the impact of scientific performance, China was at the very bottom, just above India and Iran. In a reaction to King’s (2004) paper, however, Ronald Kostoff – a scientometrician working for the US Navy – called the report “misleading” because it underestimated the emerging role of China in critical technologies like nanotechnology. Kostoff (2004) claimed that if a composed indicator is used, China could be shown to have surpassed the United States during the first 8 months of 2004 in terms of research output in this field. On Kostoff’s indicator the UK figures only seventh after China, the USA, Japan, Germany, France, and South Korea.

These conflicting views inspired us to analyse China’s performance in R&D using scientometric indicators (Zhou and Leydesdorff, 2004; Leydesdorff and Zhou, 2005). In this study, we extend the scientometric analysis with input statistics as provided by the OECD, a more detailed analysis of China’s performance in nanotechnology, and an analysis of the Chinese publication system in terms of international and domestic journals. Thus, we are able to provide a more integrated picture of the knowledge base of the Chinese system. In the final sections, we draw some conclusions and suggest normative implications for the further development of China’s research potential.

2. Methods and materials

The scientometric analysis is based on using the various versions of the Science Citation Index. We use indicators like total publications, world share of publications, total citation rates, percentage of world share of citations, as well as the top one percent of most highly cited papers in order to measure scientific output. The analysis focuses on the six major countries (the USA, Japan, UK, Germany, France, and China), and we added the EU-15 and the EU-25 because this provides an additional perspective at the global level. We also included South Korea because this comparison may teach us something about the differences in the dynamics between Asian versus other OECD countries.

For the input indicators, we used the OECD’s Main Science and Technology Statistics published online and in print (OECD, 2004). One should note that the normalization of the Chinese currency in terms of its equivalent purchasing power parity in US dollars has remained a subject of some discussion (Davies, 2003; Shi, 2004). The online data was retrieved in the period between 24 November, 2004 and 24 January, 2005.

For the delineation of the field of nanoscience and nanotechnology, we use statistical techniques which were developed in other contexts (Leydesdorff and Cozzens, 1993; Leydesdorff, 2004). These techniques are applied to aggregated journal–journal citation relations as provided by the Journal Citation Reports of the Science Citation Index 2003. Since “nanotechnology” as a field of science is highly interdisciplinary, we experiment with different delineations of the field in terms of relevant journals. In addition to core-journals, we distinguish a nano-relevant set which forms the cita-
tion environment of the core journals and thus may provide the seedbed for further developments in this field. The performance data of nations in these limited sets can be compared with the performance indicators over the file of the Science Citation Index.

The Web-of-Science installation of the Science Citation Index allows for the measurements including the most recent year (2004), but there are some limitations on the retrieval. The system does not provide an exact number when the recall is larger than 100,000 and the download for each save is limited to 500. In order to solve the first problem, we separated the recalls that are larger than 100,000 into several smaller segments, then searched the results for each segment, and recombined them using Boolean algebra for the necessary corrections (because of international coauthorships). In the case of the EU-15 and EU-25, the correction for international coauthorships is not a sine cura. The number of Boolean operators increases rapidly with the number of sets to be combined.1 At the level of each unit of analysis (country or set of countries) we use integer counting. Publications with an address in Hong Kong were merged with the data for China both before and after 1997 (the year when Hong Kong was returned to China) in order to prevent trend breaches.

In accordance with current practice in scientometrics (Braun et al., 1991), we have limited the analysis to articles, reviews, letters, and notes. For mapping the citation patterns of Chinese domestic journals, we used the same routines as for the nano-technology journals. These routines enable us to zoom into local structures by choosing an entrance journal for the analysis and then to visualize the relevant environments. The algorithm of Kamada and Kawai (1989) will be used for the visualizations. All representations are based on using the cosine among the citation vectors of journals as a measure for similarity (in the citing and cited dimensions, respectively); cosine values smaller than 0.2 are suppressed and the line thickness varies with the value of the similarity measure.

3. Results

In order to provide a clear picture of China’s research performance, this section is organized in four subsections. Each subsection specifically focuses on one topic. First, we discuss the results related to China’s general performance in terms of publications and citations, respectively, in Sections 1 and 2. Publications and citations are two key indicators for evaluating research output. Data about nanotechnology follows in Section 3. We compare China with major countries like the USA, the UK, Germany, France, Japan, the EU-15, and the EU-25, and we include South Korea in order to assess whether the effects which we found were specific to China or applicable more generally to Asian nations. In the final section of this part, we compare the relations between input and output indicators for these (sets of) countries.

3.1. Publications with a Chinese address

Jin and Rousseau (2004) already signalled the exponential growth in scientific publications with a Chinese address. In 1999, China was in the 10th position (China Science and Technology Statistics Data Book, 2000). Five years later (2004) China had become the fifth largest country in terms of scientific publications, after the USA, Japan, the UK, and Germany, respectively. However, if we look at values for the EU-15 and the EU-25 on this indicator, the number of scientific publications of the EU-15 is 15% higher than that of the USA; and for the EU-25 the number is even more than 23% higher (Fig. 1).

In order to show the historical development during the last decade, we collected data for the seven above-mentioned countries, the EU-15, and the EU-25 for the last 10 years (Fig. 2). China is the only country of which the percentage share shows exponential growth, while South Korea’s growth trend was significant as well. However, Korea’s increase trend is linear instead of exponential. Japan, the UK, and France were relatively stable; Germany’s output showed an increase during the period 1995–1998 as an effect of the unification (Leydesdorff, 2000). The world share of publications of the EU-15 (articles, reviews, letters, and notes) surpassed that of the USA in 1994 (cf. King, 2004). The world share of publications of the EU-15 has been approximately 5% higher than that of the USA since

---

1 Let us call the search results of four subsets \( A, B, C, \) and \( D \), respectively. Any two subsets can be combined using: \( R = (A + B) - \overline{AB} \). For three subsets, \( R = (A + B + C) - \overline{ABC} \). Adding a fourth segment \( D \) to \( R \) then requires the following calculations: \( R = (R + D) - \overline{ABD + (CD) + \overline{ADC} + \overline{BCD}} \) = \( \overline{ABCD} \).
1998. The trend line of the EU-25 is similar to that of the EU-15. The USA’s share decreased from 1995 to 2000, but the indicator is relatively stable thereafter.

Table 1 provides the percentages of world share in tabular format using the types of publications deemed most relevant for this assessment (articles, reviews, letters, and notes). From this table one can see in greater detail how the differences between countries have developed. The resulting picture is surprisingly dynamic. For example, Japan has surpassed the UK by taking the second position since 1997. China has been the only country to have its world share increase by more than 1% within a single year (2003–2004). Korea’s sustained increase is also remarkable.

In general, approximately 35% of world publications are from the EU countries, while approximately...

Table 1
Percentage of world share of the seven countries under study, EU-15 and EU-25 (Web-of-Science data)

<table>
<thead>
<tr>
<th>Year</th>
<th>China</th>
<th>France</th>
<th>FRG</th>
<th>Japan</th>
<th>Korea</th>
<th>UK</th>
<th>USA</th>
<th>EU-15</th>
<th>EU-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>1.69</td>
<td>5.98</td>
<td>7.45</td>
<td>8.49</td>
<td>0.48</td>
<td>8.89</td>
<td>34.73</td>
<td>33.78</td>
<td>35.04</td>
</tr>
<tr>
<td>1994</td>
<td>1.70</td>
<td>5.99</td>
<td>7.54</td>
<td>8.37</td>
<td>0.58</td>
<td>8.97</td>
<td>33.66</td>
<td>34.12</td>
<td>35.96</td>
</tr>
<tr>
<td>1995</td>
<td>2.05</td>
<td>6.09</td>
<td>7.62</td>
<td>8.65</td>
<td>0.79</td>
<td>8.88</td>
<td>33.54</td>
<td>34.36</td>
<td>36.21</td>
</tr>
<tr>
<td>1996</td>
<td>2.31</td>
<td>6.18</td>
<td>7.93</td>
<td>8.94</td>
<td>0.99</td>
<td>9.02</td>
<td>32.29</td>
<td>35.59</td>
<td>37.98</td>
</tr>
<tr>
<td>1997</td>
<td>2.66</td>
<td>6.31</td>
<td>8.32</td>
<td>8.98</td>
<td>1.16</td>
<td>8.73</td>
<td>31.94</td>
<td>35.72</td>
<td>37.60</td>
</tr>
<tr>
<td>1998</td>
<td>2.90</td>
<td>6.48</td>
<td>8.82</td>
<td>9.42</td>
<td>1.41</td>
<td>9.08</td>
<td>31.63</td>
<td>36.85</td>
<td>38.82</td>
</tr>
<tr>
<td>1999</td>
<td>3.44</td>
<td>6.67</td>
<td>9.52</td>
<td>9.58</td>
<td>1.58</td>
<td>9.08</td>
<td>31.24</td>
<td>36.72</td>
<td>38.66</td>
</tr>
<tr>
<td>2000</td>
<td>3.89</td>
<td>6.31</td>
<td>8.69</td>
<td>9.49</td>
<td>1.76</td>
<td>9.22</td>
<td>30.93</td>
<td>36.55</td>
<td>38.67</td>
</tr>
<tr>
<td>2001</td>
<td>4.30</td>
<td>6.33</td>
<td>8.68</td>
<td>9.52</td>
<td>2.01</td>
<td>8.90</td>
<td>31.01</td>
<td>36.55</td>
<td>38.77</td>
</tr>
<tr>
<td>2002</td>
<td>4.98</td>
<td>6.10</td>
<td>8.50</td>
<td>9.43</td>
<td>2.17</td>
<td>8.60</td>
<td>30.75</td>
<td>34.89</td>
<td>38.16</td>
</tr>
<tr>
<td>2003</td>
<td>5.51</td>
<td>6.10</td>
<td>8.35</td>
<td>9.40</td>
<td>2.43</td>
<td>8.46</td>
<td>30.68</td>
<td>35.96</td>
<td>38.02</td>
</tr>
<tr>
<td>2004</td>
<td>6.52</td>
<td>5.84</td>
<td>8.14</td>
<td>8.84</td>
<td>2.70</td>
<td>8.33</td>
<td>30.46</td>
<td>35.16</td>
<td>37.99</td>
</tr>
</tbody>
</table>

30% is from the USA during the last 3 years. The Japanese share of publications wanders around 9%.

3.2. Citations to Chinese papers and Chinese journals

3.2.1. Citations to Chinese papers

China's total citation rate is still low when compared with citation rates for other nations (Jin and Rousseau, 2004). However, this indicator has also been on the increase at an exponential rate during the last decade (ISTIC, 2003, 2004). Fig. 3 provides the number of citations in each year for publications with a Chinese address for the first author during the preceding 10 years. (The first author is often the corresponding author.) In other words, a 10-year citation window is used on the set of articles, reviews, and letters in each year, including internationally coauthored publications, but only if the first author has a Chinese address. The data are total citations without excluding self-citations.

The figure shows that the increase in the citation rates is even above the best exponential fit of the curve during the last 2 years. This momentum of the Chinese publication system in terms of gaining citations can also be made visible by the increase of the per-
King (2004) considered the indicator of the top one percent of the most highly cited papers as the most important measure of a country’s influence in science. Using his data, we plotted the percentage change of a country’s highly cited papers in Fig. 5. (See for a discussion of King’s metrics: Braun et al., 2005; Evidence, 2003). China’s contribution increased on this indicator as well, although the absolute numbers are still low (0.22% and 0.33% for the two periods 1993–1997 and 1997–2001, respectively). Among the countries with an increase in the percentage of highly cited publications, China ranked sixth, with an increase almost similar to that of South Korea in the fifth position (45.9%). Note that English is a native language in countries with an even higher increase (Ireland, India, South Africa, and Singapore). In other words, authors in these countries have a language advantage.

3.2.2. Citation patterns of Chinese journals

China is a large country not only in terms of its scientific publications, but also in the large number of scientific journals it produces. More than 4400 of science and technology journals were published in China in 2001, and around half a million scientific papers are published annually in these journals (Jin and Rousseau, 2004). Two institutions have organized this domestic data in a format similar to that of the Science Citation Index of the Institute of Scientific Information in the USA. One database, the China Scientific and Technical Papers and Citations Database (CSTPCD), is produced by the Institute of Scientific and Technical Information of China (ISTIC). In 2003, 1576 journals were included in this database. The other, the Chinese Scientific and Technical Papers Database (CSPTD), is produced by the Chinese Academy of Sciences. There are also several databases that focus on specific fields, such as biomedical journals (BIBIF), geosciences (GISIF), and economics (ECONIF). These databases provide a comprehensive view of China’s scientific output and its citation patterns.
ence Citation Database (CSCD), is produced by the Documentation and Information Centre of the Chinese Academy of Sciences, and covered 1046 journals in 2001.

The citation patterns of Chinese journals are different in their domestic and in their international environments. To explore these differences, we chose Acta Chimica Sinica as an entrance journal for two reasons. First, chemistry is among the fields in which China performs well (MOST and LCAS, 2004, at pp. 5–6 and p. 29). One can expect a more elaborate citation network for journals with a high profile than for journals in relatively weak fields. Secondly, this specific journal is covered both by the domestic and the international (SCI) databases, while it publishes in Chinese. For the domestic database, we used the CSTPCD as the data source.2

Using Acta Chimica Sinica as the seed journal, Fig. 6 shows that Chinese scientists cite publications in other domestic journals. Domestic journals in the same fields have close citation relations. In other words, they integrate with each other. Fig. 6 shows this for the being-cited patterns of the journals, but a similar picture emerges if we compare their citing behaviours. Chinese journals in this field (chemistry) are firmly integrated into a single unity in terms of their citation relations. The relation with marginal journals is focused on a few hubs, but the core group is extremely well interconnected.

How is the situation in the international environment? Fig. 7 indicates that there are strong citation relations between Acta Chimica Sinica and international journals in the ‘citing’ dimension. This means that this journal is actively citing international journals in a pattern shared among these journals. In other words, Chinese scientists actively absorb knowledge produced by their international counterparts. International scientific literature has an impact on Chinese scientists.

However, the ‘cited’ relations between Chinese journals like Acta Chimica Sinica and international ones are mediated by the Chinese Journal of Chemistry. In Fig. 8, this journal functions as an articulation point between the Chinese and the international graphs. This means that the research output of Chinese scientists is not reflected by their international counterparts. Cited relations between international journals and Chinese journals are channelled through specific journals which function as citation windows on the Chinese literature. As Acta Chimica Sinica is published in Chinese, we conjecture that journals published in Chinese have not

---

merged into the international academic environment even if they are included in the Science Citation Index. They form an isolated group within the citation relations of the set.

How is the situation of Chinese journals published in English? Let us check this by replicating the analysis for the Chinese Journal of Chemistry as an entrance journal. This journal functions as a bridge between...
international journals and the Chinese group of journals made visible in Fig. 8 on the left side. Its cited situation is better than that of Acta Chimica Sinica (Fig. 9).

The Chinese Journal of Chemistry is cited by its international counterparts, but its relations with other Chinese journals makes it special and therefore non-central. (A similar configuration can be shown for the other Chinese journal in English, that is, the Chinese Chemical Letters.) On the top left side of the picture are the journals that are published in Chinese, but included in the Science Citation Index. These results suggest that use of the Chinese language is an important factor that affects the international visibility of Chinese journals by isolating them from the international communication.

In summary, our analysis shows that Chinese journals are integrated with one another in the domestic citation environment. However, their citation patterns in the international environment are more complex. Inclusion in the Science Citation Index is not a sufficient condition for integration into the world system of scientific publications. Chinese journals are integrated with their international counterparts in terms of their citing relations, but the cited relations are not well
established, especially for those published in Chinese. The language is a barrier for Chinese publications by authors who wish to be recognized in the international environment.

3.3. A focus on nanotechnology

Nanotechnology has been a key field for science and technology policies in recent years. In 2000, US president Bill Clinton launched an initiative to promote nanotechnology entitled the National Nanotechnology Initiative: Leading to the Next Industrial Revolution. Since then, EU countries, China, Japan, and South Korea, etc., have all adopted nanotechnology as an S&T policy priority. The Chinese government, for example, declared nanotechnology a critical R&D priority in their Guidance for National Development in 2001. In the same year, the Chinese Ministry of Science and Technology, the National Development and Reform Commission, the Ministry of Education, the Chinese Academy of Sciences, and the National Natural Science Foundation jointly issued a Compendium of National Nanotechnology Development (2001–2010). This can be considered as a strategic plan.

The potential importance of nanotechnology is generally acknowledged. Nanotechnology may have a significant influence on social and economic development and national security as well as people’s daily lives. On the scientific side, developments in nanotechnology can be relevant for various fields such as physics, chemistry, material sciences, biology, and medicine (Meyer, 2001). In general, the development of new technologies provides challenges and new opportunities to existing fields of science (Rosenberg, 1982).

Since nanotechnology is a highly interdisciplinary field, it is difficult to identify which papers belong to this field. The set of papers with “nano” in their titles may be a better source in terms of providing information in nano-papers (Schummer, 2004).

We experimented with various methods to delineate a journal set which would be representative of nanoscience and nanotechnology. The Web-of-Science in 2004 contained eight journals with “nano” in their title. Four of these journals (the Journal of Nanoscience and Nanotechnology, Nano Letters, Nanotechnology, and IEEE Transactions on Nanotechnology) have a high communality in their cited patterns given relevant journal environments. Factor analysis of the cited patterns can be used as an indicator for the development of new and emerging specialties. The journals with communality in their being cited patterns are recognized in the relevant environments as belonging to a single group (Leydesdorff et al., 1994).

To understand not only the current situation, but also historical developments in nanotechnology in terms of publications, we need data for at least three successive years. IEEE Transactions on Nanotechnology was not included in SCI before 2003, and can provide only 2-year data. Therefore, we focused on the remaining three core nano-journals, among which Journal of Nanoscience and Nanotechnology and Nano Letters were first covered by SCI in 2002, while Nanotechnology was covered as early as 1994.

Research in an interdisciplinary field like nanotechnology needs input from knowledge in other fields such as physics, chemistry, biology, or electronics. Publications cited by the core nano-journals can be considered as relevant knowledge sources of nanotechnology. After some experimentation with different journal environments, we decided to consider all journals with citation relations above the 1% level to the four core journals of nanotechnology as “nano-relevant” journals (Fig. 10). These 85 journals cover the publication space for authors with communications potentially relevant for the nano-field. The authors who publish in these journals constitute also the human resources and the knowledge bases which can be activated by priority programs in nanoscience and nanotechnology.

Fig. 10 shows that the three core Journal of Nanoscience and Nanotechnology, Nano Letters, and Nanotechnology indeed act as a core set at the interfaces among physical chemistry, material science and solid-state physics, while IEEE Transactions on Nanotechnology is more related to electronics and is less central to the interface. In other words, Fig. 10 further
legitimates the selection of these three journals (Journal of Nanoscience and Nanotechnology, Nano Letters, and Nanotechnology) as a core set in nanotechnology.

We compared the national contributions in these two sets, that is, of the three core journals and the 85 nano-relevant journals. The mapping of the 85 nano-relevant journals is provided in Fig. 10. The central position of the core journals is highlighted by using circles around each of them.

3.3.1. Results from core nanotechnology journals

The year 2000, when the National Nanotechnology Initiative was published, can be considered as a watershed in the history of nanotechnology (President’s Council, 2005). In addition to the implementation of national policies that assumed nanotechnology/nanoscience as a priority field, the influence was also reflected in the emergence of new journals in this field. While the journal Nanotechnology existed already before 2000, the other two core nano-journals (Journal of Nanoscience and Nanotechnology, Nano Letters) were first published in 2001, and these journals were immediately covered by the SCI in 2002 (that is, after only 1 year of citations).

Since the first two journals (Journal of Nanoscience and Nanotechnology, Nano Letters) were not covered by the SCI until 2002, we collected data in two ways with the year 2002 as a dividing point. The first way was to collect the number of papers published in Nanotechnology from 1994 to 2004, in order to see the historical change; the second way was to collect the number of papers published in the three core journals distinguished above from 2002 to 2004. As before, we use only the articles, letters, notes, and reviews published in these journals as indicators, and compare China with the other major countries, the EU-15, and the EU-25 in terms of their research output on this indicator.

Fig. 11 shows that the USA, the UK, and France were visible in this context from the very beginning, while research results with a Chinese address were published only since the year 2000. But China’s progress is remarkable. Its world share increased obviously from 2001 to 2003, and it has become the second largest single country (after the USA) since 2003. The share of the EU-15 has surpassed that of the USA since 2000. The expansion of the EU with the 10 accession countries does not make much difference on this indicator.

Fig. 12 expands the domain to the three core journals indicated above. One of the newly added journals (Nano Letters) is published by the American Chemical Society and thus part of an elite structure of journals highly integrated in the American system (Bensman
and Wilder, 1998). The USA, therefore, can expect to be represented in this set more than the EU. However, China has become the second largest single country in 2004 in terms of this indicator. While European countries have declined or remained stable, China and South Korea have maintained continuous growth trends in both sets.

3.3.2. Results using the 85 “nano-relevant” journals

Fig. 13 shows the percentage of world share of publications in the 85 nano-relevant journals. The share of China increases in an exponential way, while the increase for South Korea is again linear. The pattern is very similar to the overall output patterns shown in Fig. 2 above, but the percentages for some core countries are much higher than in the previous case. The UK has a higher percentage share when measured over the whole file; Japan and Germany have a larger world share in nano-relevant fields than in terms of their respective world shares of total publications.

For the USA, the percentage of world share of publications in nano-relevant fields is higher than the average for all fields of science as exhibited in Fig. 2. After a decline in 2000, the percentage rises in 2001 after the publication of the National Nanotechnology Initiative in 2000. However, the USA’s share decreased in later years since other relevant countries also began increasingly to invest in nanotechnology. The recent evaluation report of the President’s Council of Advisors on Science and Technology (2005, p. 14) mentions this relative decrease on the basis of a much larger data set.
Fig. 13. Percentage of world share of nano-relevant publications. (based on collecting all documents using the keyword “nano*”). In the underlying study, Zucker and Darby (2005) found also China as the second largest producer of publications in this “nano*” area.

The EU-15 had a better performance compared to the USA in the nano-relevant set. Its world share has remained around 7% higher than that of the USA since 2002. However, the developing trend of both the EU-15 and the USA were similar, and they all lost some share after 2001. The addition of the other ten new EU countries contributed another 4% to the EU’s world share. However, the trend of the EU-25 was similar to that of the EU-15 after 2001. The percentage of world shares of most of the other countries included in this study are also higher than their respective percentage shares of publications in Fig. 2. These countries are Japan, Germany, France, South Korea and China.

In our opinion, these results indicate that some countries have surplus capacities to launch more research in nanotechnology, since expertise and manpower are available in nano-relevant sciences. One can expect more publications to come out of the countries with higher than average percentage world shares in nano-relevant fields because of available knowledge bases. However, China has continued additionally to increase its funding in this field as a priority area and, therefore, may be able to increase its share further provided that the conversion of input into output is efficient. Let us now turn to the issue of the relation between input and output.

4. Funding and input–output ratios

The funding system of R&D in China is very different from that of Western countries where R&D is mainly conducted in universities. China’s R&D is concentrated in public-sector research, partly because of the legacy of the Soviet system of a strong Academy of Science.3

3 There is still some debate about purchasing power parity (PPP) in relation to the Chinese RMB’s exchange rate (Davies, 2003; Shi, 2004). Furthermore, the government and higher education expenditures cover all fields of natural sciences (including agricultural and medical sciences) and engineering (NSE), as well as social sciences and humanities, while the business enterprise sector covers only the fields of NSE. There are only a few organizations in the private non-profit sector. Hence, no R&D survey has been carried out in this sector, and consequently this data is not available. However, the line between public and private sectors in China is not easy to draw, due to this country’s public “branch institutes.” In the past, research by these institutes was completely funded by the government. With the further reforms of the S&T system many of these institutes have been transformed into corporations, and no longer receive public funding. Since the system is still in transition, some institutes receive both public and private funding.
Fig. 14 shows that the Chinese government has effectively used its public-sector research potential to boost the knowledge-based economy of the country. This investment has triggered business expenditure in R&D (BERD) during the second half of the 1990s. All growth curves are exponential, but the rates of growth in GOVERD (“Government Intramural Expenditure” or, in other words, public-sector research) are approximately three times as large as in the university sector, and the funding levels are also almost three times as large. This pattern of government spending in R&D in China is different from that of the West. BERD surpassed GOVERD in 1997, and the distance between the two has increased ever more since then.

The sustained increase in R&D funding in China is, of course, backed by the rapid growth of the country. The ratio of GERD/GDP is an important indicator. The “Lisbon agreement” (European Commission, 2000), for example, set 3% GERD/GDP as a target for EU nations to be reached by the year 2010. In order to obtain a picture of the relations between GERD and GDP, we gathered related data from OECD Main Science and Technology Statistics, and included data of the above-mentioned countries, EU-15 and EU-25 (Fig. 15).

Despite the enormous increase of the GDP in the nominator, the Chinese GERD/GDP ratio has been increasing exponentially since 1996. From 1996 to 2002, this figure has risen from 0.60% to 1.23% (OECD, 2005). The percentage in China has doubled within only 7 years, while this percentage has remained relatively stable (approximately 1.9%) for the EU-15 (OECD, 2005). Among the other major countries, Japan has had the highest GERD/GDP, and it has been able to maintain a linear growth for this indicator. Since 2001, Japan is the only country whose GERD/GDP has surpassed 3%. South Korea’s GERD/GDP in 2001 and 2002 were 2.92% and 2.91%, respectively, but among the European nations only Sweden and Finland are above the 3% level. Among the other EU countries, the GERD/GDP ratios of Germany and France were higher than that of the EU-15 on average, while the UK fluctuated around the average in terms of this indicator. Interestingly, given the Lisbon objective, one does not yet see convergence among EU nations on this indicator.

Industry does not primarily publish scientific articles, but industrial innovations are reflected in patents (Jaffe and Trajtenberg, 2002). However, we focus in this study on the scientific side of the development. From this perspective, the institutional patterns in Chinese output are more in line with the western counter-
parts of China. For example, Fig. 16a and b show the shares of publications of universities, research institutes, hospitals, and business included in 2003 in the domestic CSTPCD and the international SCI, respectively (ISTIC, 2004). As elsewhere, universities are the largest shareholders, while hospitals and research institutes also make a considerable contribution to Chinese S&T publications. Hospitals are important producers of publications in the domestic sciences, but not internationally. Public research institutes made in absolute numbers the second largest contribution to international science. Enterprise research contributes only marginally to international publications, but it provides a share of 6% of the national publications.

In order to make this data comparable with those of western nations, we have added the Government Intra-Mural Expenditure on R&D (GOVERD) and Higher Education Expenditure on R&D (HERD) together as the total government input to R&D. These normalized expenditures (OECD, 2004) can then be plotted against output measured in terms of the percentages of world share of publications as provided in Fig. 2 above. Fig. 17 shows the relations between input and output for the countries under study and the EU.
China’s output shows a linear relation with input ($r^2 > 0.98$). In other words, the increase in R&D expenditure by the Chinese government is used efficiently: with the increase of R&D investment, the country’s percentage of world share grows proportionally. The dynamics can thus be considered as a self-reinforcing mechanism. The possibility to publish internationally and to participate in the knowledge-based economy is continuously reinforced within the Chinese system. For example, researchers at many universities receive a considerable bonus in their salaries when they publish in journals that are included in the Science Citation Index.

The link between funding and scientific production is not deterministic, and probably even less so for highly developed countries. In the Western (liberal) model, scientific development is relatively autonomous, while the Chinese government probably has more steering mechanisms, since it has also inherited elements of the old Soviet model. Notwithstanding these differences in the mediating mechanisms in the various countries, Fig. 17 shows several interesting features at the systems level. For example, German unification has led to a stepwise increase of output in relation to similar input in the middle of the 1990s. Japan exhibits a different pattern because this country first decreased funding and then expanded it again in the later part of the 1990s. The decrease did not lead to a loss in the percentage of world share, but the reversal of this trend has made the system a bit more productive.

The USA greatly increased intramural funding of R&D within government agencies after “9/11,” but this increase has not been reflected in an increase of world share of publications. One of the reasons might be that the emergence of other scientific countries like China and South Korea has put pressure on traditional advantages. However, several European countries and Japan have also improved their performance on these indicators, albeit more modestly. Another reason might be that a large proportion of this American funding is spent on classified research which does not lead to publications. The input levels between the EU and the USA were similar, but the efficiency in the EU was higher than that of the USA. In other words, during the 1990s the EU has become more productive in terms of scientific publications than the USA.

The development of the input–output ratio for South Korea is most remarkable because linear growth was maintained during a number of years. As noted, Korea...
has been a member of the OECD since 1996 and it has adopted a western pattern of funding. Perhaps more than any other OECD-country, however, South Korea defines its performance also in relation to China as a major competitor. Although South Korea has not been able to keep pace with China in extending its absolute data of funding, its GERD/GDP is still much higher than that of China: in 2002, the GERD/GDP of South Korea (2.91%) was more than twice that of China (1.23%).

5. Discussion

We have mainly relied on three databases: the Science Citation Index of the ISI, the China Scientific and Technical Papers and Citations Database of the ISTIC, and the Main Science & Technology Indicators of the OECD. These databases are statistical and therefore introduce uncertainties and potential sources of error. We noted the ongoing debate in the literature about the conversion of the Chinese currency into normalized US dollars in the case of the OECD database. The two publication and citation databases (i.e., the domestic one and the international one) both have a problem of representation with reference to the underlying population. In the case of the People’s Republic, we happen to have a precise count of 4497 scientific journals published in 2003 (Ren, 2004). Of these 1506 were included in the CSTPCD and 67 in the SCI.

Inclusion in the SCI has been debated in terms of national, language, and disciplinary biases. Van Leeuwen et al. (2001), for example, have argued that the language bias of the coverage has consequences for international comparisons of national research performance. Sivertsen (2003), however, found no bias of the ISI-database when evaluating Scandinavian publications. The ISI has admitted a bias against including journals published in languages other than those using the Latin alphabet.

For the purpose of our study, the language bias does not pose an analytical problem given our research question. The focus of this study is on the visibility and the translation of the Chinese S&T capacity into the international arena. The latter is partly operationalized as publications in English. Publications of Chinese authors in languages other than Chinese and English (e.g., in Russian) have not been considered. Given this research question, we found also a representation of journals in Chinese within the international database, and although this can obviously be considered as an underrepresentation of the Chinese potential, we were able to signal the danger of the relative isolation of publications in the Chinese language despite their inclusion in the ISI database. Of course, the Chinese percentage world share of publications and citations in this database would increase further if more Chinese journals were included, but for the purpose of our research the possible underrepresentation only strengthens our conclusions about the emergence of China as a leading nation in science.

The disciplinary bias of the ISI-database in favour of biomedicine and the life sciences is a more important reason for concern. Recently, Park et al. (2005) signalled that the research portfolio of the Netherlands is much more compatible with the journal portfolio of the SCI than with that of South Korea. The authors conclude that this might have a considerable effect when comparing these two countries using this database. Asian countries like China and Korea have strengths and weaknesses in the portfolio that are different from those of Western countries (and the latter group is not homogenous as well). This effect may partly explain the enhanced visibility of China in a subset like the one which we constructed as “nano-relevant.”

As noted, the “nano-core” journals are more deeply integrated into the elite journal structure of the United States. These journals can be expected to have a bias in favour of accepting papers from elite institutions in the USA and in other advanced countries, and may not be easy to access by scholars from more peripheral locations. We noted that the Chinese contribution in these core journals has been increasing considerably, as has the Chinese contribution to the one percent most highly cited papers.

Part of this may be the result of international collaboration with Chinese authors. According to the ISTIC (2002, 2003), the number of internationally coauthored publications with at least one Chinese address increased from 7807 in 2002 to 11,739 in 2003. Internationally coauthored papers in 2003 thus accounted for 23.6% (that is, more than one-fifth) of its total publications included in the SCI. (Among the 11,739 publications, 5942 (50.6%) papers were first authored by authors with a Chinese address.) The first five countries to cooperate with China are the USA, Japan, Germany,
the UK, and Australia. Four of these countries rank as the first four in terms of publications in 2004. The partnership with Australia points to the importance of the geographical factor.

When coauthorship relations are normalized, China appears to have become well integrated into the Asian-Pacific region during the 1990s (Wagner and Leydesdorff, 2005). Some authors have recommended normalizing S&T indicators in terms of the size of the respective populations. In the case of China as a developing nation, such a pro capita normalization would have dramatic effects, and the phenomena to which we wished to draw attention would completely disappear. The size of the scientific community in a nation could be considered as another factor. A large scientific community may lead to a relatively large within-country citation rate, while scholars in small nations may have to rely more on international colleagues. A correction of the citation rates of the USA or China for the within-country citations, however, would have very large effects on the citation indicator (Seglen, 1997).

This indicator would have a meaning in terms of the networking of international collaboration and influence more than in terms of national performance.

6. Conclusions

China has become a major player in the production of scientific papers. Its contribution to world science shows exponential growth (Figs. 1 and 2), which is unique in the world. Scientific research activities in the EU countries are the most productive in the world. In terms of this indicator, the EU countries have left the USA behind during the 1990s. More than 68% of the scientific papers included in the SCI are from the EU countries and the USA together. In other words, these countries make the biggest contribution to world science, while the contribution of Asian countries, mainly Japan, China, and South Korea, are in second place (Fig. 2 and Table 1).

Along with the exponential increase of scientific publications, the citation rates of Chinese publications are increasing exponentially as well (Fig. 3). Other indicators measuring the impact of publications, such as the percentage of world share of citations and the number of most highly cited publications, also demonstrate the increased status of Chinese publications (Figs. 4 and 5). Chinese journals play important roles in the communication of Chinese scientists in the domestic environment. However, in the international environment, Chinese journals have integrated with their international counterparts in terms of Chinese papers citing articles written by others, but the cited relations have not yet been established. Journals which publish in Chinese are not often cited in the international literature even if they are included in the Science Citation Index.

China’s performance in nanoscience and nanotechnology is remarkable as well. Although it started research in this field later than the other major countries like the USA, France, Germany, and Japan, China’s world share of publications in nanotechnology has increased rapidly. Using various indicators, we found China in 2004 in the second position behind the USA. China’s potential in further expanding research in this field is large as well, which can be seen through its higher world share of publications in nano-relevant fields compared with its world share of publications over the entire file. In 2004, China’s world share of publications was on average 6.52%, while its world share in nano-relevant publications was 8.34%. The increase rates for the exponential fits of the curves are correspondingly higher (the coefficients of the exponents are 0.126 and 0.133, respectively). Again, more than half of the world publications in nanoscience and nanotechnology are from the USA and the EU countries, while China, Japan, and South Korea account for most of the remaining share (Figs. 11 and 12).

The Chinese government pays unprecedented attention to the development of science and technology and the transition to a knowledge-based economy. More than any other country in the world, funding for R&D is growing not only absolutely, but also relative to the spectacular growth in the gross national product (Figs. 14 and 15). It is noteworthy that business investment in R&D is increasing even faster than government expenditure. This increased investment has been reflected in the output: China’s output in terms of scientific publications is also increasing exponentially (Figs. 2 and 17), and thus one may assume an efficient coupling between input and output. Among the countries studied, Japan has the highest GERD/GDP ratio, and its trend shows linear growth, but like most countries it spends more to maintain approximately the same share (Cozzens et al., 1990). The EU countries grow
slowly in terms of this indicator, but they are still more than one percent below the target of 3% (GERD/GDP) set by the “Lisbon” agreement. The USA’s investment is higher than that of the EU countries, but with less output in scientific publications.

As mentioned above, there are 4497 scientific journals published in mainland China in 2003 (Ren, 2005), among which, only 67 were included in SCI in that year, while 274,438 papers were included in the 1576 journals covered by the CSTPCD in 2003. This data shows that China has huge human resources in science and technology. With exponentially increasing funding and proper guidance of scientific policies, one can expect that China’s increased momentum in scientific publications is sustainable. The problem for China is not the production of scientific publications, but the dissemination and visibility of scientific publications in the international communication system of science.

7. Policy implications

During the period 1997–2001, China’s percentage of world share of citations was only 1.56%, standing in the thirteenth position in the world. It seems that Chinese citation rates are not compatible with its number of publications. The c/p (citations over publications) ratio was only 2.96 during this period, while the highest ratio was that of 9.69 in Switzerland (King, 2004). Some authors have analysed this lagging behind of citations as an indicator of a lack of quality in the system (Jin and Rousseau, 2004; Poo, 2004; Wu, 2004). According to these authors, the following factors in the production system of science would have a negative effect on the impact of Chinese science: the institutional evaluation system for research proposals; research output is rigid; investment in basic research is too low; and the higher-education system is not sufficiently internationalized.

In addition to continued attention to improving the quality of research, it therefore may be urgent to take measures to increase the visibility of Chinese publications. Most scientists are inclined to think that a high-quality research result will be noted and resonate in the international communication without further efforts. Of course, a high-quality paper needs to contain novelty, but this is not a sufficient condition for its diffusion. The production and diffusion of knowledge are different dynamics. The dynamics of production involve developing and designing a research project, gathering funding and other resources, and then conducting the research. It involves communication between researchers and research administrators who control research funds.

The diffusion rate is limited by the quality of the communication dynamics among the authors, their audiences, and the editorial boards of scientific journals. At this stage, the quality of communication skills (e.g., one’s ability to organize a paper in English), communication channels, and communication networks are key factors that affect the communication results and therewith the visibility of publications. From this second perspective, we are able to make the following suggestions for improving China’s performance at the global level of science.

7.1. Focus on international journals

High-quality journals attract more scientific readers, and publication in such journals leads to higher visibility and therefore higher citation rates. Chinese scientists may consider changing their focus from domestic journals to international ones, especially those with high impact factors. When analysing the citation patterns of Chinese journals, we found that Chinese journals have remained isolated from the international community even if they are published in English and included in the SCI. The visibility of Chinese authors in world science has remained relatively low. This means that papers published in Chinese journals cannot have as much impact as those published in international journals in English. Therefore, publishing papers in international journals is one way to increase the international visibility of Chinese papers.

China has a communication system of national journals which may be extremely important for the diffusion of scientific knowledge into the economy. This system is a legacy of the previous period with its emphasis on autarchy. In the current transition to a knowledge-based economy, this “Mode 2” set of journals that is already integrated with its applicational contexts (Gibbons et al., 1994) may itself be an asset.
However, these journals should not be used as alternative output channels for academic publications which can also be published internationally. The differentiation between these two publication systems can be made a subject of further reflection.

Competition to publish papers in international journals, especially high impact journals, is fierce. With the precondition that research is original and/or leading-edge, the author’s writing ability in English is very important in this stage. A scientist needs to make his/her paper well-organized and to highlight the points that are original or creative. In general, the ability to present a paper that properly reflects the significance of research is a very important skill in scientific communication.

7.2. Improve the quality and visibility of Chinese journals

Chinese journals are still by far the main channels for Chinese scientists to communicate with their international counterparts. Their quality and visibility directly influence the citation rates of Chinese papers negatively. High-quality journals need high-quality papers. Absorbing high-quality papers, especially papers produced by influential world scientists, affects a journal’s quality. The relatively low quality and international attractiveness of Chinese journals has already been recognized by the Chinese government. The Ministry of Science and Technology (MOST) plans to select some promising Chinese journals and help them raise their quality to become world-class S&T journals, by means of financial support (SciDev.Net, 2004). Other journals may consider to publish online and as open-access journals in order to enhance their visibility (Harnad and Brody, 2004).

7.3. Strengthen international collaboration

Our study shows that the EU countries and the USA are the major contributors to world science. In other words, the majority of world-class scientists are located in these countries, and these countries have excellent research conditions (laboratories and funds) as well. In addition to helping Chinese scientists improve their research skills and expand their perspectives, cooperation with scientists in these countries can expand the communication networks available to Chinese scientists and provide access to research networks for Chinese publications, thus raising their visibility. After a cooperation project is finished, Chinese scientists should remain in close touch with their international counterparts to ensure that collaboration and communication are sustained. In recent years, China has broadly expanded its scientific cooperation, which can be seen through the continuously increased number of coauthored scientific papers (Wagner and Leydesdorff, 2005). However, more chances and possibilities still exist and remain to be explored.

Acknowledgements

We would like to thank Ma Zheng of the statistics team of the Institute of Scientific and Technical Information of China for providing us with relevant data and we are grateful to Wu Yishan and Ronald Rousseau for useful comments on previous versions of this paper.
Chapter 5

Regional analysis on Chinese scientific profile

Ping Zhou, Bart Thijs, Wolfgang Glänzel. Accepted by *Scientometrics*

1. Introduction

In recent years, China has made tremendous progress in science (Zhou and Leydesdorff, 2006, Glänzel et al., 2007, 2008). Based on scientific publications collected in the Science Citation Index Expanded (*SCIE*), China was the fifth in terms of world share of publications (Zhou and Leydesdorff, 2006). This record was rewritten within a short period of three years: China jumped to the second in 2006 and progressed further in 2007 (Leydesdorff and Wagner, 2007; Zhou & Leydesdorff, 2008).

The extraordinary progress of China has caused broad interests around the world. The following facts can be representative for this interest: 1) the publication entitled “The Emergence of China as a Leading Nation in Science” (Zhou & Leydesdorff, 2006) has been among the top 10 publications in the SCOPUS\(^1\) category of economics, econometrics and finance in terms of being cited during the most recent three years (2006-2008); 2) Upon the request of the European Union, Frietsch and his colleagues (2007) conducted a specific study on China’s research fields; 3) in a report entitled “Asia’s Rising Science and Technology Strength,” the National Science Foundation (NSF, 2007) concluded that “The largest and fastest-growing actor is China” …

As a large country in terms of both population and geographic size, China experiences progress based on collective contributions of its administrative regions. The above mentioned research outputs have provided an overall picture about China’s performance in science. This study will investigate further so as to distinguish major contributors, disciplinary activities, and the citation impact of Chinese administrative regions.

Among Chinese provincial-level administrative regions, most are called provinces, some are named municipalities, and some are special administrative regions. For convenience, we will simply call all these different provincial administrative territories REGIONS.

2. Data sources and methods

The numbers of publications and citations are derived from the Science Citation Index Expanded (*SCIE*) of Thomson Scientific (Philadelphia, PA, USA). The year span for publications is from 2000-2006. For citation analysis, we use a three-year window for publications in 2000-2004. Only document types named as Articles, Letters, Notes and Reviews are taken into consideration. Citations received by these publications have been determined on the basis of an item-by-item procedure, using special identification keys, made up of bibliographic data elements.

Publications were assigned to Chinese regions on the basis of their corporate addresses which appear in the by-line of the publication. In order to assign publications to regions, a thesaurus

\(^1\) Scopus is an abstract and citation database of research literature and quality web sources.
has been made up of cleaned names of Chinese cities and regions with all their spelling variances. Unresolved cases have been cleaned manually for the concerned records. ERRONEOUSLY indexed publications were removed.

The field analysis applies the 12 major fields developed by the Glänzel and Schubert (2003) on the basis of the field assignment of journals. The 12 major fields include: Agriculture & Environment, Biology (Organism & Supra-organismic level), Biosciences (General, Cellular & Subcellular Biology, Genetics), Biomedical research, Clinical & Experimental Medicine I (General & Internal Medicine), Clinical & Experimental Medicine II (Non-Internal Medicine Specialties), Neuroscience & Behaviour, Chemistry, Physics, Geosciences & Space Sciences, Engineering and, finally, Mathematics.

The data for R&D expenditure are collected from the official website of the Ministry of Science and Technology of China (MOST) under the sub-title “Statistics on Science and Technology”.

3. Methods and Results

We use standard methodology developed at SOOI (Steunpunt O & O Indicatoren, i.e., Policy Research Center for R&D Indicators at the Katholieke Universiteit Leuven) for the analysis of national and regional publication output. In the first part of the study, regional research profiles are analysed, particularly, publication activity by regions including regional contributions to the national total, the disciplinary publication profiles of the regions and their peculiarities. The second part is devoted to the analysis of citation impact. In addition to the standard indicators, journal- and field-based relative citation indicators are used to plot the regional citation impact with respect to the international standard. International collaboration of Chinese regions is explored in the third part. Active regions in international collaboration are explored. Comparison between the citation impact of regionally and internationally co-authored publications is conducted so as to evaluate the effect of international collaboration. Regional peculiarities in terms of coherence between publications and R&D expenditure are analyzed. The evolution of the regional profile of Chinese research in the sciences is discussed on the basis of the seven-year period (i.e., 2000-2006). Detailed analysis is mainly on the first four most productive regions (i.e., Beijing, Hong Kong, Shanghai, and Jiangsu) since these regions’ are the most distinctive in national shares of publications and citations (Figures 1, 2, 4, and 5).

3.1 Publication profiles

From 2000 to 2006, China has achieved remarkable progress in scientific publications. Within seven years, China’s world share of publications increased exponentially from 3.9% to 8.4%, which is more than doubled. In this section, we will explore the regional publication profiles in terms of respective publication contributions and publication activities in different fields.

3.1.1 Regional contributions to Chinese national publications

International publications are unevenly distributed among Chinese regions. Taking the year 2006 for example, the four most productive regions (i.e., Beijing, Shanghai, Hong Kong, and Jiangsu) contributed 46%, which is about half, of Chinese publications. Beijing was the most prolific with publication as many as twice of Shanghai. (Figures 1 and 2). But there are 12
regions whose national share of publications is less than 1%. The total share of the 12 regions is only 4.3%. These low productive regions are Yunnan, Shanxi, Jiangxi, Guangxi, Xinjiang, Guizhou, Inner Mongolia, Qinghai, Hainan, Macao, Ningxia, and Tibet.

**Figure 1.** Regional publications in 2006.

**Figure 2.** Development of major regions in terms of national share of publications.
As China’s biggest publication producer, Beijing’s position is unshakable, although its share began to decline since 2003. Hong Kong’s national publication share started to decrease since 2002 and lost its second position after 2004. If the current trend continues, Hong Kong’s third position will be shortly replaced by Jiangsu which grows slowly but steadily. In fact, the absolute number of publications from Hong Kong continued to rise after 2004, but the growth rate cannot catch up with the increasing growth rate of Chinese publications (Figure 2).

3.1.2 Publication activity of the leading regions

In this section, we use the Activity Index (AI) to measure regional performance in the 12 major fields. AI was originally introduced by Frame (1977) in scientometrics and later applied in macro studies (Schubert and Glänzel, 1989). The Chinese regional AI is defined as the ratio of the share of a given field in the publications of a given region to the share of the same field in the world total publications. AI values can be in the range \([0, \infty]\). While AI=0 indicates a completely idle research field, AI=1 means an average research activity, and AI>1 indicates an above-average publication activity. The value of AI reflects a certain internal balance among the fields in the given region, that is, AI>1 values in several fields must always be balanced by AI<1 in others: in no regions can all AI values be greater (less) than 1 (Glänzel et al, 2006).

Early studies (REIST-2) defined four basic paradigmatic patterns in publication profiles which while be applied in analyzing Chinese regions. The four patterns are:

I. The ‘western model’ with clinical medicine and biomedical research as dominating fields,

II. The characteristic pattern of the former socialist countries with excessive activity in chemistry and physics,

III. The ‘bio-environmental model’ with biology and earth and space sciences in the main focus, and

IV. The ‘Japanese model’ with engineering and chemistry being predominant.

The Activity Index (AI) in two periods (i.e., 2000-2002 and 2004-2006) of Beijing, Shanghai, Hong Kong, and Jiangsu is shown in (Figure 3). Except Hong Kong, the other Chinese leading regions have the characteristic of pattern II: these regions are predominant in chemistry and physics. But Chinese regions are active in other fields as well. Beijing and Jiangsu share similar patterns: in addition to be extremely active in physics and chemistry, the two regions are also active in mathematics, geosciences & space sciences, and engineering. Compared to Beijing and Jiangsu, Shanghai is not active in the geosciences & space sciences.

Publication activities of the three Mainland regions in the 12 disciplines are very imbalanced. They are active in chemistry, physics, mathematics, and the geosciences & space sciences, but are least active in neuroscience & behavior, general & internal medicine, and non-internal medicine. However, compared to the early period 2000-2002, the Mainland regions have shifted attention from the most to the less active fields.

Compared to the Mainland, Hong Kong is very active in engineering and mathematics. Its activity in other fields is relatively more balanced than the Mainland.
3.2 Citation impact

Indicators including number of citations, share of national citations, and indicators for relative citation impact are used in this section.

3.2.1 Regional contributions to Chinese national citations

Beijing received the highest citation rate (i.e., 49,474 citations) for papers published in 2004. The second, third, and fourth positions were taken by Hong Kong, Shanghai, and Jiangsu respectively. Regional citation distributions are highly skewed: the first four regions contributed more than half (52%) of China’s total citations. This means the aggregated citation impact of the remaining 29 Chinese regions is less than that of the first four regions. The national citation shares of as many as 14 regions are less than 1% (Figure 4).
From 2000 to 2004, Beijing occupies the first position in the national share of citations, but its share begins to decline since 2002. Hong Kong’s national share of citations experienced ups and downs while keeping its second position on this indicator. Shanghai struggled to keep its third position, Jiangsu moves up slowly in the fourth position. The rest regions like Hubei and Zhejiang increase their catching-up speed by winning more share in national citations (Figure 5). The citation impact of Anhui province is worth mentioning. Although this province only took the 10th position in terms of publications, it occupies the sixth in citation impact from 2000 to 2004. But Anhui’s position is challenged by Zhejiang and is about to lose (Figures 4 and 5).

Figure 4. Citations received by individual regions for papers published in 2004.

Figure 5. Development of major regions in terms of national share of citations (SCIE, 2000-2004).
Comparing regional ranks in national share of publications and national share of citations in 2004 we found that 16 regions had no position change in the two indicators, among which are the top five regions (i.e., Beijing, Hong Kong, Shanghai, Jiangsu, and Hubei) which are marked with grey shade in Table 1. There are eight regions ranking higher in national share of citations than in national share of publications. This implies that these regions’ publications have higher citation impact than those ranked higher in national share of publications. In this context, the case of Anhui and Fujian is worth mentioning; in the citation ranking, Anhui was four positions and Fujian was three positions above their ranks in national share of publications.

Table 1. Ranks of regions in national share of publications and citations.

<table>
<thead>
<tr>
<th>Region</th>
<th>Rank in national share of publications in 2004</th>
<th>Rank in national share of citations in 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEIJING</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HONG KONG</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SHANGHAI</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>JIANGSU</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>HUBEI</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>ZHEJIANG</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>LIAONING</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>SHANDONG</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>GUANGDONG</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>ANHUI</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>SHAANXI</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>TIANJIN</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>JILIN</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>SICHUAN</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>HUNAN</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>GANSU</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>FUJIAN</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>HEILONGJIANG</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>HENAN</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>HEBEI</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>SHANXI</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>YUNNAN</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>CHONGQING</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>GUANGXI</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>JIANGXI</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>XINJIANG</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>GUIZHOU</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>INNER MONGOLIA</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>QINGHAI</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>NINGXIA</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>MACAO</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>HAINAN</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>TIEBET</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>

3.2.2 Relative citation impact
Since a three-year citation window is applied in this study, the most recent year can only be 2004. In order to show accumulative changes, we split the time span into two: 2000-2001 and 2003-2004. The following standard indicators are used:

- **Mean Observed Citation Rate (MOCR)** is defined as the ratio of citation count to publication count (Braun et al., 1985).
- **Mean Expected Citation Rate (MECR)** is a journal-based indicator. It expresses the expected citation rate of a given paper set. The journal-based expected citation rate of a single paper is defined as the average citation rate of all papers published in the same journal, in the same year, in a three-year citation window. MECR is defined as the average of these individual expectations over a given paper set (Braun et al., 1985). A similar measure (JCSm) is used at CWTS (Moed et al, 1995).
- **Field Expected Citation Rate (FECR)**. Analogously to the previous indicator, the field-expected citation rate of a single paper is defined as the average citation rate of all papers published in the same year in the same subject defined in the Appendix. In order to obtain valid results, the same publication period and citation window has to be used as in the case of the previous to indicators. An analogous measure (FCSm) is used at CWTS (Moed et al, 1995).
- **Normalised Mean Citation Rate (NMCR)** is defined analogously to the RCR as the ratio of the Mean Observed Citation Rate to the weighted average of the mean citation rates of subfields, that is, NMCR = MOCR/FECR. This indicator is a second relative citation rate; in contrast to the RCR, NMCR gauges citation rates of the papers against the standards set by the specific subfields. Its neutral value is 1 and NMCR>1 (NMCR<1) indicates higher (lower)-than-average citation rate than expected on the basis of the average citation rates of the underlying subfields. NMCR has been introduced by Braun and Glänzel (1990) in the context of national publication strategy. A similar measure (CPP/FCSm) is used at CWTS (Moed et al, 1995).
- **Relative Citation Rate (RCR)** is the ratio of MOCR to MECR. RCR = 0 corresponds to uncitedness; RCR < 1 represents lower-than-the-average; RCR> 1 represents higher-than-the-average; finally RCR = 1 means that the papers received the number of citations expected on the basis of the average citation rate of the publishing journals (Braun et al., 1985). The CWTS version is called CPP/JCSm (cf. Moed et al, 1995).

The ratio of the two previous indicators (MECR/FECR) expresses whether the region publishes on an average in higher (lower) impact journals than expected on the basis of the subfields where the region was active (cf. Glänzel et al., 2009). Table 2 presents indicator values of RCR, NMCR, and MECR/FECR of 33 Chinese regions in the period 2000-2004 ranked by NMCR.
Table 2. List of regions ranked by NMCR in 2000-2004.

<table>
<thead>
<tr>
<th>RANK</th>
<th>REGION</th>
<th>RCR</th>
<th>NMCR</th>
<th>MECR/FECR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HONG KONG</td>
<td>1.06</td>
<td>1.07</td>
<td>1.01</td>
</tr>
<tr>
<td>2</td>
<td>MACAO</td>
<td>1.08</td>
<td>0.92</td>
<td>0.85</td>
</tr>
<tr>
<td>3</td>
<td>ANHUI</td>
<td>1.04</td>
<td>0.82</td>
<td>0.80</td>
</tr>
<tr>
<td>4</td>
<td>SHANGHAI</td>
<td>1.01</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>5</td>
<td>FUJIAN</td>
<td>1.06</td>
<td>0.72</td>
<td>0.68</td>
</tr>
<tr>
<td>6</td>
<td>JILIN</td>
<td>0.99</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>7</td>
<td>LIAONING</td>
<td>0.97</td>
<td>0.68</td>
<td>0.70</td>
</tr>
<tr>
<td>8</td>
<td>BEIJING</td>
<td>0.96</td>
<td>0.68</td>
<td>0.71</td>
</tr>
<tr>
<td>9</td>
<td>ZHEJIANG</td>
<td>1.10</td>
<td>0.68</td>
<td>0.62</td>
</tr>
<tr>
<td>10</td>
<td>JIANGSU</td>
<td>0.96</td>
<td>0.65</td>
<td>0.68</td>
</tr>
<tr>
<td>11</td>
<td>GUANGDONG</td>
<td>1.04</td>
<td>0.65</td>
<td>0.62</td>
</tr>
<tr>
<td>12</td>
<td>TIANJIN</td>
<td>1.00</td>
<td>0.63</td>
<td>0.63</td>
</tr>
<tr>
<td>13</td>
<td>HUNAN</td>
<td>1.02</td>
<td>0.62</td>
<td>0.61</td>
</tr>
<tr>
<td>14</td>
<td>HUBEI</td>
<td>0.98</td>
<td>0.61</td>
<td>0.62</td>
</tr>
<tr>
<td>15</td>
<td>SICHUAN</td>
<td>0.96</td>
<td>0.59</td>
<td>0.62</td>
</tr>
<tr>
<td>16</td>
<td>SHANXI</td>
<td>0.92</td>
<td>0.59</td>
<td>0.65</td>
</tr>
<tr>
<td>17</td>
<td>HEILONGJIANG</td>
<td>0.95</td>
<td>0.59</td>
<td>0.62</td>
</tr>
<tr>
<td>18</td>
<td>HENAN</td>
<td>1.00</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>19</td>
<td>GUANGXI</td>
<td>0.99</td>
<td>0.58</td>
<td>0.59</td>
</tr>
<tr>
<td>20</td>
<td>SHANDONG</td>
<td>0.93</td>
<td>0.56</td>
<td>0.60</td>
</tr>
<tr>
<td>21</td>
<td>JIANGXI</td>
<td>1.00</td>
<td>0.55</td>
<td>0.55</td>
</tr>
<tr>
<td>22</td>
<td>TIEBET</td>
<td>0.69</td>
<td>0.55</td>
<td>0.79</td>
</tr>
<tr>
<td>23</td>
<td>INNER MONGOLIA</td>
<td>0.91</td>
<td>0.55</td>
<td>0.60</td>
</tr>
<tr>
<td>24</td>
<td>SHAANXI</td>
<td>0.93</td>
<td>0.55</td>
<td>0.59</td>
</tr>
<tr>
<td>25</td>
<td>YUNNAN</td>
<td>0.87</td>
<td>0.53</td>
<td>0.61</td>
</tr>
<tr>
<td>26</td>
<td>CHONGQING</td>
<td>0.91</td>
<td>0.53</td>
<td>0.58</td>
</tr>
<tr>
<td>27</td>
<td>QINGHAI</td>
<td>0.93</td>
<td>0.52</td>
<td>0.56</td>
</tr>
<tr>
<td>28</td>
<td>GANSU</td>
<td>0.95</td>
<td>0.51</td>
<td>0.53</td>
</tr>
<tr>
<td>29</td>
<td>GUIZHOU</td>
<td>0.90</td>
<td>0.50</td>
<td>0.55</td>
</tr>
<tr>
<td>30</td>
<td>HEBEI</td>
<td>0.91</td>
<td>0.50</td>
<td>0.54</td>
</tr>
<tr>
<td>31</td>
<td>XINJIANG</td>
<td>0.96</td>
<td>0.49</td>
<td>0.51</td>
</tr>
<tr>
<td>32</td>
<td>NINGXIA</td>
<td>0.84</td>
<td>0.44</td>
<td>0.52</td>
</tr>
<tr>
<td>33</td>
<td>HAINAN</td>
<td>0.63</td>
<td>0.27</td>
<td>0.42</td>
</tr>
</tbody>
</table>

With all the three indicators above 1, Hong Kong performs best. The second best region is Macao with citation impact above average level of the journals publishing papers from Macao. Beijing takes the lead when scale measurement indicators, such as number of publications or citations and national share of publications or citations, are used. But when indicators for relative citation impact are used, Beijing does not appear in the top six. There are 11 regions with above-average level based on journals publishing papers from these regions among which Zhejiang does the best according to the RCR, however the impact is on average far below the corresponding subject standard (NMCR<1). Again, Beijing is not among them. The low ration of the two expected citation rates MECR/FECR indicates that all regions – except for Hong Kong – still publish on average in lower-than-field-standard impact journals.
Figure 6 presents the RCR and NMCR of Beijing, Hong Kong, and Shanghai in the 12 fields. Except publications in mathematics, chemistry, and clinical & experimental medicine that have average level of citation impact, publications from Beijing in many fields have lower citation impact than the average level of publications published in the same set of journals. Beijing is active in chemistry, physics, geosciences & space sciences, but only has average relative citation rate (RCR) in chemistry and mathematics. Beijing’s citation impact
normalized by fields (NMCR) is much lower than average. Shanghai performs generally better than Beijing based on journal citation measures. But when measured by field, Shanghai’s citation impact is also much lower than world standard. Hong Kong does best. Its relative citation impact is above average in many fields.

The better performance of Hong Kong is well represented in Figure 7. Hong Kong is the unique region whose normalized mean citation rate (NMCR) based on fields is higher than world average. Hong Kong also publishes papers in journals with higher citation impact in the corresponding field citation standard. All publications from the rest regions have lower-than-average field citation impact and publish in journals with lower-than-average citation impact in corresponding fields.

![Figure 7. Relative citation impact indicators for some regions (2000–2004).](image)

(A=Hong Kong, B=Macao, C=Anhui, D=Tibet, E=Shanghai, F=Jilin, G=Beijing, H=Liaoning, I=Fujian, and J=Jiangsu).

3.3 International collaboration

China’s international collaboration increased exponentially in the seven-year period (i.e., 2000-2006) when measured with internationally co-authored publications (Figure 8). In this section, we mainly investigate active regions and effect of international collaboration.
3.3.1 Active players in international collaboration

The four most active regions in terms of publications, namely, Beijing, Hong Kong, Shanghai, and Jiangsu, also take the lead in collaborating with international counterparts. Over half (53%) of China’s international collaboration happened in the four regions. Beijing is the most active region in international collaboration, but its national share declined since 2003 and remained relatively stable in the following years. In the studied period, Hong Kong’s share continues to decline since 2001 and is about to give its second position to Shanghai. Opposite to Hong Kong, Shanghai has become active in international collaboration since 2003 and takes increasing national share in the years thereafter. As the fourth most active region in international collaboration, Jiangsu keeps its position with a relatively stable share in the studied period (Figure 9).
3.3.2 Citation impact of overall vs. internationally co-authored publications

We calculate RCR, NMCR, and MECR/FECR of a region’s overall internationally published papers and its internationally co-authored papers so as to find the difference between the two sets. The results show that except a few regions including Macao, Tibet, Ningxia, Jiangxi, Liaoning, Heilongjiang, and Jilin with higher overall RCR than that of their internationally co-authored publications, and the overall NMCR and MECR/FECR of all the 33 regions are lower than international ones. This indicates that internationally co-authored publications have higher citation impact than regional ones. International collaboration is an important way for Chinese regions to raise their citation impact (Figure 10²).

² In Figure 10, “Intl” represents a region’s internationally co-authored publications and “Reg” represents a region’s overall international publications. The RCR (Intl-Reg) equals to the RCR of a region’s internationally co-authored publications minus the RCR of the region’s overall international publications. NMCR (Intl-Reg) is the difference between the NMCR of a region’s internationally co-authored publications and the NMCR of a region’s overall international publications. The MECR/FECR (Intl-Reg) is the difference between the MECR/FECR of a region’s internationally co-authored publications and the MECR/FECR of a region’s overall international publications.
Figure 10. Difference of relative citation impact between internationally co-authored publications and overall regional publications (accumulative data of 2000-2004).

3.4 Regional R&D expenditure
The continuous growth of Chinese economy enables China to invest more in research and development. From 2000 to 2006, Chinese R&D expenditure increased in an exponential way (Figure 11). The ratio of R&D to GDP keeps growing and reached 1.42% in 2006 (MOST, 2007). The R&D data in this study are from the MOST which does not cover Hong Kong in its statistics.


The increased R&D expenditure of China is the outcome of both regionally and nationally increased expenditure. From 2000 to 2006, each region has invested more in R&D. In terms of absolute amount, Beijing increased most (27.73 billion RMB) and Tibet increased least (0.03 billion RMB) in the seven years. Regional share of national R&D expenditure in 2006 is ranked in Figure 12.
More than 60% of China’s R&D expenditure is from the top six regions (i.e., Beijing, Jiangsu, Guangdong, Shanghai, Shandong, and Zhejiang) (Figure 12). Beijing takes highest share in the studied period (2000-2006), and the gap between Beijing and the other regions is wide. In 2006, Beijing’s national share of R&D was 14.4%, while that of the second largest R&D investor Jiangsu was 11.5%.

Although still taking the first position in R&D expenditure, Beijing’s share declined since 2003 while those of most regions increase. In the seven years (2000-2006), Jiangsu surpassed Guangdong and has become the second largest R&D investor since 2004. The fast growing expenditure of Zhejiang is worth mentioning. In 2000, Zhejiang ranked the ninth but jumped to the sixth in 2004 and is challenging the fifth position occupied by Shandong in 2006 (Figure 13). Shanghai raised its national share very slowly and keeps staying in the fourth position in the seven years.
It is clear that Beijing takes the first position in both publications and R&D expenditure but gradually loses national share on the two indicators since 2003. Shanghai keeps relatively stable position in the two indicators. This municipality ranks higher in national publication share than that of R&D expenditure. The situation in Jiangsu is inverse: Jiangsu ranks higher in national share of R&D expenditure than that of publications. Situations of some other regions are worth of mentioning: as the third largest R&D investor since 2004, Guangdong just took the sixth in publications. Hubei ranks out of the top 10 in R&D expenditure but takes the fourth in publications. Table 3 lists R&D expenditure of the first ten regions in national share of publications. Spearman’s rank correlation coefficient, which here amounts to 0.41, confirms the low correlation between the ten regions’ R&D expenditure and their publication output. Since the publication profiles of these regions are similar, a bias caused by subject-specific peculiarities can practically be excluded.
Table 3. Top ten publication regions and their ranks in R&D expenditure in 2006.

<table>
<thead>
<tr>
<th>Region</th>
<th>Rank of Publications</th>
<th>Publications</th>
<th>R&amp;D expenditure (GERD, 100 Million RMB)</th>
<th>Rank of R&amp;D expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEIJING</td>
<td>1</td>
<td>22264</td>
<td>433.0</td>
<td>1</td>
</tr>
<tr>
<td>SHANGHAI</td>
<td>2</td>
<td>10647</td>
<td>258.8</td>
<td>4</td>
</tr>
<tr>
<td>JIANGSU</td>
<td>3</td>
<td>7086</td>
<td>346.1</td>
<td>2</td>
</tr>
<tr>
<td>HUBEI</td>
<td>4</td>
<td>5610</td>
<td>94.4</td>
<td>11</td>
</tr>
<tr>
<td>ZHEJIANG</td>
<td>5</td>
<td>5369</td>
<td>224.0</td>
<td>6</td>
</tr>
<tr>
<td>GUANGDONG</td>
<td>6</td>
<td>4599</td>
<td>313.0</td>
<td>3</td>
</tr>
<tr>
<td>LIAONING</td>
<td>7</td>
<td>4363</td>
<td>135.8</td>
<td>7</td>
</tr>
<tr>
<td>SHANDONG</td>
<td>8</td>
<td>4291</td>
<td>234.1</td>
<td>5</td>
</tr>
<tr>
<td>SHAANXI</td>
<td>9</td>
<td>3635</td>
<td>101.4</td>
<td>9</td>
</tr>
<tr>
<td>ANHUI</td>
<td>10</td>
<td>3465</td>
<td>59.3</td>
<td>15</td>
</tr>
</tbody>
</table>

4. Conclusion and discussion

The regional distribution of scientific publications in China is highly skewed; a few regions are very productive while most are not. Regions with large reservoir of research personnel have superiority in taking the lead in number of publications or citations, consequently, national share of publications or citations: Beijing, Shanghai, Hong Kong, and Jiangsu take the lead and Qinghai, Hainan, Macao, Ningxia, and Tibet are almost invisible when measuring number of publications or citations.

In addition to keeping the activity pattern of the former socialist countries with predominant activity in physics and chemistry, regions from Mainland China are active in mathematics. Some regions are also active in the geosciences & space sciences. But publication activity of these regions in neuroscience & behavior, general & internal medicine, and non-internal medicine is very weak. For historical reason, Hong Kong is not affected by the socialist model and has its own activity pattern with extremely activity in engineering and mathematics. Compared to regions in Mainland, other fields in Hong Kong are relatively balanced.

A large contribution to the national publication output does not necessarily results in a large contribution to national citations as well. A majority of regions’ ranks in national share of publications correspond to their ranks in national citation share. Some regions’ publications, however, reach higher citations impact than those published more. Anhui and Fujian are typical examples for such regions.

Relative citation impact of the leading regions from the Mainland is still lower than the world average. Although these regions have achieved great progress in raising their scientific production, they still need to work hard to raise international citation impact, especially relative citation impact. Hong Kong performs the best no matter in terms of indicators on production scale or on average quality.
The decrease of Hong Kong in national share of publications may imply that Hong Kong has reached its potential in publishing international papers. But the situation in Chinese Mainland regions is different: they have huge reservoirs of human resources and many of them have not published internationally yet. For historical reasons, Chinese Mainland researchers mainly publish in domestic journals. With China’s effort of integrating to the outside world, more and more Mainland researchers shift from publishing domestically to internationally. This trend has already been seen in China’s remarkable growth in international publications, and there is no sign showing China’s growth rate will slow down or stop (Zhou and Leydesdorff, 2008).

International collaboration helps Chinese regions to raise their publication profiles both quantitatively and qualitatively.

High R&D expenditure does not necessarily bring high output of publications because scientific publications are only one form of R&D output. In the Chinese case, high investment in R&D does have some relevance to scientific productivity in publications, in particular, prolific regions usually invest more in R&D.
Chapter 6

In-depth analysis on China’s international cooperation in science

Ping Zhou & Wolfgang Glänzel. Scientometrics, Special Issues S&TI 2008 Vienna

1. Introduction

The spectacular rise of the emerging economies (e.g., O’Neill, 2005) has become a favourite topic of the recent literature on science and technology policy. The centre of gravity of growth in science and technology has actually moved away from the US and Japan, passing the European Union towards China, as has shown in many literatures (Leydesdorff & Zhou, 2005; Zhou & Leydesdorff, 2006; Zhou & Leydesdorff, 2008; Zhou et al., 2009; Kostoff et al., 2007; Glänzel et al., 2008; Rousseau, 2008). This development has already measurable effect on the balance of power as measured by scientific production. Nonetheless, countries of other world regions are undergoing dramatic growth and thus contributing to the global changes as well. In fact, scientific literature reports on the impressive developments in South America (e.g., Zanotto, 2002, Glänzel et al., 2006, Leta et al., 2006, Zitt et al., 2006), but also within the EU and in its direct neighbourhood (Glänzel, 2008). The spectacular development often goes with an intensifying international collaboration.

Since the adoption of the Opening-up policy in 1978, China has achieved a spectacular growth in both economy as well as visibility in the world’s scientific literature. Recently China has overtaken France in economy and, at least according to the publication output indexed in the Web of Science, in scientific research as well (Glänzel et al. 2008). Since 2006 China holds position two just behind the US in terms of publication activity (Leydesdorff & Wagner, 2007; Zhou and Leydesdorff, 2008). International collaboration has also been expanded and strengthened. In 30 years after the adoption of the opening-up policy, China has established S&T collaboration relations with more than 150 countries or regions, and has signed inter-governmental S&T cooperation agreement with over 90 countries. When internationally co-authored publications in most countries dramatically increased during the last two decades (Schubert & Braun, 1990; Glänzel & Schubert, 2004), whether growth of competitiveness in research is accompanied by an intensification of collaboration in China as well? Which countries are China’s major scientific partners, and which fields are active in international collaboration? What is the role of international collaboration in China? All these questions will be investigated in a global context. In addition, research profile and citation impact of international collaboration with respect to the domestic ‘standards’ will also be explored.
2. Methods

The study is mainly based on publications from 1997 to 2007 in the Science Citation Index Expanded (SCIE) version of the Institute of Thomson Scientific (Philadelphia, PA, USA). All documents recorded as article, letter, note, proceedings paper or review will be taken into account. The papers were assigned to countries based on the corporate address given in the by-line of publication. All countries indicated in the address field are thus taken into consideration.

Publications are assigned to 12 major subject fields according to the classification scheme developed by Glänzel and Schubert (2003) which, in turn, is based on ISI’s Subject Categories. The 12 major fields include: Agriculture & Environment, Biology (Organism & Supra-organismic level), Biosciences (General, Cellular & Subcellular Biology, Genetics), Biomedical research, Clinical & Experimental Medicine I (General & Internal Medicine), Clinical & Experimental Medicine II (Non-Internal Medicine Specialties), Neuroscience & Behaviour, Chemistry, Physics, Geosciences & Space Sciences, Engineering and, finally, Mathematics.

The set of bibliometric indicators developed at the ISSRU (Budapest) and the ECOOM (Leuven) (see, e.g., Glänzel et al., 2003) is used to gauge publication activity and citation impact against both the Chinese national and the world standard. In particular, the effect of collaboration on the national disciplinary research profile, on citation impact and its change in time is studied.

3. Results

Comparative analysis between Chinese internationally co-authored and domestic publications is conducted. The first section deals with publication activity with major focus on the evolution, main players, and field diversity of publications. The second part explores citation impact based on different indicators which will be introduced in relevant sections.

3.1 Publication profile

After reviewing the development of publications of China in comparison with other leading nations, we investigated major players and active fields in international collaboration.

3.1.1 An overview
China takes the second position only after the USA in 2007 in terms of the percentages of world share of scientific publications based on the SCIE (Zhou & Leydesdorff, 2008). The rapid growth of China would be more prominent if it is compared with the emerging countries (Figure 1). South Korea had experienced slight growth before 2004 and keeps a stable share afterwards.

When Chinese publications increase remarkably, how is the situation of internationally co-authored papers? We separate the Chinese publications into two sets: set one includes all the Chinese publications and set two only counts the internationally co-authored papers. Detail information is shown in Figure 2. Both numbers of the two sets increase obviously. But the increasing rate of set two is lower than that of set one. In other words, the number of China’s internationally co-authored publications grows slower than its total number of publications.

**Figure 1.** Percentages of world share of publications of several selected countries (1992-2007).
In order to investigate the situation in other countries, we list the share of internationally co-authored publications of relevant countries in Table 1. Most countries’ shares of international collaborations have been increased steadily. Only those of the emerging countries including China, Brazil, and Turkey decrease. This phenomenon implies that the growth rate of international collaboration in the emerging countries is lower than that of these countries’ non-internationally co-authored publications. The situation in many other countries is the other way round.

Many EU member countries have high share of internationally co-authored papers. This is quite plausible. European integration encourages individual mobility of researchers within the European Union. On the other hand, the auspices of the European Commission are maybe the most important factor for stimulating the process of regional international scientific collaboration. Many multinational research projects are only possible in the framework of the large European programmes, above all, the European Framework Programmes. International collaboration among the EU countries has thus become very intensive. But if considering the EU as an entity, its collaboration share with none EU countries is less significant (cf. Table 1).

The top six countries with high national share of internationally co-authored publications are from the EU, including Switzerland, Sweden, The Netherlands, France, Germany, and the UK. Switzerland is one of the most active countries in international collaboration. Over 60% of Swiss publications in 2007 are internationally co-authored.
Sweden and The Netherlands are also active in this regard, with over 50% of their total publications are internationally-co-authored.

**Table 1. National share of internationally co-authored publications (in %).**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>46.7</td>
<td>56.8</td>
<td>63.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>38.5</td>
<td>48.1</td>
<td>54.3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>36.3</td>
<td>46.0</td>
<td>50.7</td>
</tr>
<tr>
<td>France</td>
<td>33.3</td>
<td>42.4</td>
<td>49.4</td>
</tr>
<tr>
<td>Germany</td>
<td>31.9</td>
<td>41.4</td>
<td>48.0</td>
</tr>
<tr>
<td>UK</td>
<td>27.7</td>
<td>38.2</td>
<td>45.5</td>
</tr>
<tr>
<td>Canada</td>
<td>31.5</td>
<td>40.8</td>
<td>45.0</td>
</tr>
<tr>
<td>Australia</td>
<td>27.6</td>
<td>39.0</td>
<td>44.3</td>
</tr>
<tr>
<td>Italy</td>
<td>32.0</td>
<td>37.0</td>
<td>40.3</td>
</tr>
<tr>
<td>Spain</td>
<td>28.6</td>
<td>34.9</td>
<td>40.2</td>
</tr>
<tr>
<td>Russia</td>
<td>25.7</td>
<td>34.7</td>
<td>34.1</td>
</tr>
<tr>
<td><strong>Brazil</strong></td>
<td><strong>34.4</strong></td>
<td><strong>32.7</strong></td>
<td><strong>30.2</strong></td>
</tr>
<tr>
<td>EU15</td>
<td>19.6</td>
<td>25.6</td>
<td>29.4</td>
</tr>
<tr>
<td>USA</td>
<td>18.0</td>
<td>24.8</td>
<td>28.9</td>
</tr>
<tr>
<td>Korea</td>
<td>24.4</td>
<td>25.1</td>
<td>27.6</td>
</tr>
<tr>
<td>Japan</td>
<td>15.0</td>
<td>19.8</td>
<td>24.0</td>
</tr>
<tr>
<td><strong>China</strong></td>
<td><strong>24.4</strong></td>
<td><strong>23.7</strong></td>
<td><strong>21.9</strong></td>
</tr>
<tr>
<td>India</td>
<td>12.3</td>
<td>18.7</td>
<td>19.9</td>
</tr>
<tr>
<td><strong>Turkey</strong></td>
<td><strong>17.3</strong></td>
<td><strong>17.7</strong></td>
<td><strong>16.1</strong></td>
</tr>
</tbody>
</table>

The national publication shares of international collaboration of Canada and Australia are also high. The largest producers of scientific publications, the USA and the EU have lower shares of international collaboration, but this is to a large extent due to the size effect described by Schubert and Braun (1990).

Compared to the EU countries and North American countries, all the major Asian countries including China, Japan, South Korea, and India have low rate of international collaboration.

3.1.2 Major domestic players

This section aims at finding out Chinese regions that are active in international collaboration. Details are shown in Table 2.
Table 2. Share of international collaboration (in %) of regions with more than 1%.

<table>
<thead>
<tr>
<th>Province</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>26.4</td>
<td>26.5</td>
<td>26.5</td>
<td>24.5</td>
<td>24.6</td>
<td>24.4</td>
<td>24.6</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>18.5</td>
<td>17.3</td>
<td>15.9</td>
<td>15.6</td>
<td>13.6</td>
<td>12.2</td>
<td>11.1</td>
</tr>
<tr>
<td>Shanghai</td>
<td>9.7</td>
<td>8.9</td>
<td>8.7</td>
<td>9.5</td>
<td>9.8</td>
<td>10.1</td>
<td>10.7</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>6.3</td>
<td>6.4</td>
<td>6.6</td>
<td>6.3</td>
<td>6.6</td>
<td>6.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Hubei</td>
<td>4.3</td>
<td>3.6</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Guangdong</td>
<td>3.1</td>
<td>3.1</td>
<td>3.7</td>
<td>3.6</td>
<td>4.2</td>
<td>4.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Liaoning</td>
<td>3.6</td>
<td>3.7</td>
<td>4.3</td>
<td>4.2</td>
<td>4.0</td>
<td>4.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>3.0</td>
<td>2.6</td>
<td>3.4</td>
<td>3.8</td>
<td>4.2</td>
<td>4.4</td>
<td>4.2</td>
</tr>
<tr>
<td>Shandong</td>
<td>2.6</td>
<td>2.1</td>
<td>2.6</td>
<td>3.2</td>
<td>3.1</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Anhui</td>
<td>3.3</td>
<td>2.9</td>
<td>2.8</td>
<td>3.0</td>
<td>3.3</td>
<td>3.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>2.5</td>
<td>2.7</td>
<td>2.9</td>
<td>2.9</td>
<td>2.6</td>
<td>2.6</td>
<td>2.7</td>
</tr>
<tr>
<td>Tianjin</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.3</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Sichuan</td>
<td>2.1</td>
<td>1.9</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Hunan</td>
<td>1.2</td>
<td>1.7</td>
<td>1.7</td>
<td>1.9</td>
<td>2.3</td>
<td>2.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Jilin</td>
<td>2.3</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
<td>2.2</td>
<td>2.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>1.1</td>
<td>1.4</td>
<td>1.4</td>
<td>1.5</td>
<td>1.8</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Fujian</td>
<td>1.4</td>
<td>1.5</td>
<td>1.7</td>
<td>1.6</td>
<td>1.5</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Gansu</td>
<td>1.6</td>
<td>1.3</td>
<td>1.7</td>
<td>1.8</td>
<td>1.5</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Yunnan</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.0</td>
<td>1.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Among the 33 provinces, only three including Beijing, Shanghai, and Hong Kong are the most active. Almost half of China’s international collaborations happened in the three regions. While nine regions including Jiangxi, Guizhou, and so on take no national share in this regard. If we use national share of internationally co-authored publications as a measurement of national visibility in international collaboration we will find that such visibility of most Chinese regions is extremely low or even zero.

3.1.3 International partners

Two indicators will be applied to measure China’s international collaboration relations, which are 1) strength of mutual collaboration links and 2) (unidirectional) collaboration affinity (Glänzel, 2000, 2001; Glänzel & Schubert, 2001).

Salton’s measure is used to define indicator of strength of mutual collaboration link between two countries, which is the number of joint publications divided by the square root of the product of the number (i.e., the geometric mean) of total publication outputs
of the two countries. This indicator takes the publication size of two collaborated countries into account. Co-authorship affinity measures the relative roles of a country to another country and to the world in terms of publications. If $C_j$ is the total number of internationally co-authored publications of country j, then

$$S_i = C_{ij}/C_j.$$

Where $S_i$ is the share of country i in the total number of internationally co-authored papers of country j. $C_{ij}$ is the number of joint publications between countries i and j. If the total number of publications of country i and the world are $P_i$ and $P_w$ respectively, the share of a partner country i in the “rest of the world” total is $W_i = P_i/(P_w - P_j)$. If $S_i$ is higher than $W_i$, country i is more important to country j than to the world in terms of publications.

(Unidirectional) affinity

Countries with relatively higher share in China’s internationally co-authored publications in 1997 and 2007 are shown in Table 3.

**Table 3. Important contributors to China’s internationally co-authored publications.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>29.1</td>
<td>1</td>
<td>39.4</td>
<td>1</td>
</tr>
<tr>
<td>Japan</td>
<td>16.4</td>
<td>2</td>
<td>13.3</td>
<td>2</td>
</tr>
<tr>
<td>Germany</td>
<td>10.9</td>
<td>3</td>
<td>9.5</td>
<td>4</td>
</tr>
<tr>
<td>UK</td>
<td>8.6</td>
<td>4</td>
<td>8.6</td>
<td>3</td>
</tr>
<tr>
<td>Canada</td>
<td>6.2</td>
<td>5</td>
<td>7.7</td>
<td>5</td>
</tr>
<tr>
<td>France</td>
<td>5.7</td>
<td>6</td>
<td>7.4</td>
<td>7</td>
</tr>
<tr>
<td>Italy</td>
<td>4.4</td>
<td>7</td>
<td>5.2</td>
<td>12</td>
</tr>
<tr>
<td>Australia</td>
<td>3.5</td>
<td>8</td>
<td>4.8</td>
<td>6</td>
</tr>
<tr>
<td>South Korea</td>
<td>3.4</td>
<td>9</td>
<td>4.7</td>
<td>8</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.1</td>
<td>10</td>
<td>2.4</td>
<td>11</td>
</tr>
<tr>
<td>Singapore</td>
<td>2.4</td>
<td>11</td>
<td>2.2</td>
<td>9</td>
</tr>
<tr>
<td>Russia</td>
<td>2.3</td>
<td>12</td>
<td>2.0</td>
<td>13</td>
</tr>
<tr>
<td>Spain</td>
<td>2.2</td>
<td>13</td>
<td>1.9</td>
<td>15</td>
</tr>
<tr>
<td>Sweden</td>
<td>2.2</td>
<td>14</td>
<td>1.7</td>
<td>10</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2.1</td>
<td>15</td>
<td>1.2</td>
<td>14</td>
</tr>
</tbody>
</table>

Among China’s international partners, the USA, Japan, Germany, the UK, and Canada take major part of China’s international publications. Over 71% of China’s internationally co-authored publications are jointly written with authors from the five countries. Although the shares of the five countries have changed 10 years later, the five
are still the most important contributors to Chinese internationally co-authored publications. Furthermore, collaborative relations between China and the five countries have been strengthened in 2007 since their collective contribution to China’s internationally co-authored publications has surpassed 78%. The USA takes the biggest share in China’s internationally co-authored publications and collaboration between the two countries was further strengthened in 2007. It must be noticed that the collaboration links of each country pair are treated separately, co-publication counts and shares are not additive, and thus cannot be summed up to the total over any part of the world.

The status in terms of joint publications of relevant countries with China changed in the two years (i.e., 1997 and 2007). In 1997, the USA and the UK were more important contributors to world total publication output than they were to China’s internationally co-authored publications, while the status of Japan and Germany are the opposite. By 2007, the importance of the USA, Singapore and Australia to China has been increased sharply, but that of Japan and Italy has been decreased notably. Even so, Japan is still more important to China than to the world. China’s top five important partners (i.e., the USA, Japan, the UK, Germany, and Canada) are also more affinitive to China than they are to the world. Above all the relation between China and Singapore is worth of mentioning. Singapore’s share in China’s internationally co-authored papers is about 7 times of its world share of publications, which is the highest among those of any countries.

Table 4. Co-authorship affinity of China ranked by percentage share of partner countries in China’s total internationally co-authored publications in 1997 and 2007

(W = Share of partner countries in the total minus that of China, C = Share of partner countries in China’s total internationally co-authored publications).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>33.41</td>
<td>29.07</td>
<td>32.68</td>
<td>39.36</td>
<td>USA</td>
</tr>
<tr>
<td>Japan</td>
<td>8.93</td>
<td>16.44</td>
<td>8.37</td>
<td>13.29</td>
<td>Japan</td>
</tr>
<tr>
<td>Germany</td>
<td>8.35</td>
<td>10.94</td>
<td>9.01</td>
<td>9.55</td>
<td>UK</td>
</tr>
<tr>
<td>UK</td>
<td>9.01</td>
<td>8.64</td>
<td>8.49</td>
<td>8.63</td>
<td>Germany</td>
</tr>
<tr>
<td>Canada</td>
<td>4.40</td>
<td>6.15</td>
<td>5.10</td>
<td>7.74</td>
<td>Canada</td>
</tr>
<tr>
<td>France</td>
<td>6.28</td>
<td>5.71</td>
<td>3.25</td>
<td>7.36</td>
<td>Australia</td>
</tr>
<tr>
<td>Italy</td>
<td>3.99</td>
<td>4.36</td>
<td>6.02</td>
<td>5.24</td>
<td>France</td>
</tr>
<tr>
<td>Australia</td>
<td>2.64</td>
<td>3.54</td>
<td>3.06</td>
<td>4.80</td>
<td>South Korea</td>
</tr>
<tr>
<td>South Korea</td>
<td>1.15</td>
<td>3.41</td>
<td>0.73</td>
<td>4.71</td>
<td>Singapore</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2.50</td>
<td>3.09</td>
<td>1.94</td>
<td>2.39</td>
<td>Sweden</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.31</td>
<td>2.39</td>
<td>2.75</td>
<td>2.21</td>
<td>Netherlands</td>
</tr>
<tr>
<td>Russia</td>
<td>3.77</td>
<td>2.27</td>
<td>5.02</td>
<td>1.97</td>
<td>Italy</td>
</tr>
<tr>
<td>Spain</td>
<td>2.70</td>
<td>2.24</td>
<td>2.87</td>
<td>1.91</td>
<td>Russia</td>
</tr>
<tr>
<td>Sweden</td>
<td>1.91</td>
<td>2.19</td>
<td>2.05</td>
<td>1.65</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.75</td>
<td>2.12</td>
<td>3.86</td>
<td>1.24</td>
<td>Spain</td>
</tr>
</tbody>
</table>
**Mutual collaboration strength**

A country with bigger number of publications may have more chances to jointly publish with a selected country, therefore, may take higher share in the selected country’s internationally co-authored publications. This prevent from looking into the collaboration strength between two countries. For instance, as the largest producer of world scientific publications, the USA can easily take a big share in another country’s internationally co-authored publications even the number of joint publications with the country only takes a very small share in the internationally co-authored publications of the USA. In other words, the USA is important to the selected country, but it is not true vice versa. If both countries’ total numbers of publications are taken into consideration, the relative mutual collaboration strength can be reflected. Figures 3 and 4 are mutual collaboration strength between China and other important countries. The values are based on Salton’s measure.

![Map of mutual collaboration strength between China and other countries](image)

**Figure 3.** Countries with relatively stronger mutual collaboration strength with China in 1997 (0.010 ≤ value of dotted line < 0.025; value of solid line ≥ 0.025).

There were eight countries with visible mutual collaboration strength with China in 1997 (Figure 3). Hong Kong was the only region with the strongest mutual collaboration with China. In this picture, Hong Kong is considered as an independent region but not in Figure 4 since it is part of China after 1997.
Most countries collaborating with China in 1997 are still China’s partners ten years later. Mutual collaboration strength with the USA, Japan, Australia and Singapore has been enhanced and become the strongest. In the meantime mutual collaboration strength with countries Sweden, France, and Malaysia has also been reinforced (Figure 4). Compared to 1997, China’s collaboration relation with Cyprus becomes at least weaker since Cyprus does not appear in the collaboration map in 2007.

The USA and Japan are China’s most important partners in terms of mutual collaboration strength and unidirectional collaboration affinity. Collaboration relation between China and Singapore is unusually strong when taking Singapore’s general productivity into account.

Figure 4. Countries with relatively stronger mutual collaboration strength with China in 2007 (0.010 ≤ value of dotted line < 0.025; value of solid line ≥ 0.025).

3.1.3 Active fields in international collaboration

In order to investigate the national publication profiles of international collaboration, we applied the Relative Specialisation Index (RSI) which is defined in the REIST-2 (1997) and is closely related to the Activity Index (AI). AI was originally introduced by Frame (1977) which is a version of the economists’ Comparative Advantage Index. Definitions of the AI and the RSI are expressed as follows.
AI = \frac{\text{the world share of the given country in the publications in the given field}}{\text{the overall world share of the given country in publications}}

or, equivalently,

AI = \frac{\text{the share of the given field in the publications of the given country}}{\text{the share of the given field in the world total of publications}}

and finally

RSI = \frac{AI - 1}{AI + 1}.

RSI shows in how far the national publication profile is in line with or deviates from the world standard of subject distribution of publication activity. By definition, the values of RSI range between -1 and +1. RSI < 0 means a lower-than-average activity; RSI > 0 indicates a higher-than-average activity; and RSI = 0 reflects a completely balanced situation. RSI = 0 for all fields corresponds to the “world standard” (cf., REIST-2, 1997).

Earlier studies (e.g., REIST-2, 1997) distinguished the following four basic paradigmatic patterns in publication profiles:

1) The ‘western model’ with clinical medicine and biomedical researcher as dominating fields,
2) The characteristic pattern of the former socialist countries with excessive activity in chemistry and physics,
3) The ‘bio-environment model’ with biology and earth and space sciences in the main focus,
4) The ‘Japanese model’ with engineering and chemistry being predominant.

The AI and RSI indicators can also be used to analyze the profile shift of national publication activity in collaborative research from the national standard. In particular, Glänzel (2001) has shown that the relative specialisation of internationally co-authored publications often deviates from the domestic one and that in principle four cases occur in this deviation or disciplinary shift, particularly,

1) no significant deviation between the two profiles in the country,
2) increase of national peculiarities through international co-publications,
3) weakened national characteristics, and
4) deviation that cannot be classified in any other category.
The upper diagram in Figure 5 shows that China’s subject profile clearly follows the basic paradigmatic pattern of the former socialist countries with pronounced activity in chemistry and physics and less activity in the life sciences (cf., REIST-2, 1997), but in addition, China is also active in mathematics.

In terms of the deviation of disciplinary shift in international collaboration, the Chinese situation applies to the third case summarized by Glänzel (2001): international collaboration compensates China’s field activity: the more active fields in domestic research the less active in international collaboration, vice versa (Figure 5). International collaboration in chemistry, physics, and mathematics is less active compared to that in neuroscience and behaviour, clinical and experimental medicine,
biomedical research, biosciences, biology, geosciences and space sciences, and agriculture.

3.2 Citation impact

As citation culture differs among disciplines, we select relative indicators to measure citation impact. These indicators are either journal based or field based therefore can better reflect the real situation. Relevant indicators and their definitions are listed below:

- **Mean Observed Citation Rate (MOCR).** MOCR is defined as the ratio of citation count to publication count (Braun *et al.*, 1985).
- **Mean Expected Citation Rate (MECR)** is a journal-based citation measure which expresses one expected citation rate of a publication set. The expected citation rate of a single paper is defined as the mean citation rate of all papers published in the same journal in the same year. Here a three-year citation window to one source year is used. MECR is then defined as the average of the individual expected citation rates over the given publication set. This indicator can preferably be standardized through dividing MECR by the Field-Expected Citation Rate (FECR) which is calculated in the same manner as MECR but instead of the journal citation impact the average impact of the corresponding subfields is used (Glänzel *et al.*, 2008). This ratio expresses if papers are, on an average, published in journals with higher or lower citation impact than the corresponding subfield citation standards. Therefore, we can consider this indicator also a measure of relative “visibility”. It should be mentioned that a version of this relative measure, namely, FCSm/JCSm is used at CWTS in Leiden (Moed *et al.*, 1995).
- **Relative Citation Rate (RCR).** RCR is defined as the ratio of the two previous measures, that is, RCR = MOCR/MECR. It should be stressed that in this study, a 3-year citation window to one source year is used for the calculation of both the numerator and denominator of RCR. RCR = 0 corresponds to uncitedness; RCR < 1 (or RCR > 1) means lower (or higher)-than-average citation rate. RCR = 1 if the set of papers in question attracts just the number of citations expected on the basis of the citation impact of the journals where the papers have been published (Braun *et al.*, 1985). Again, a version of this relative measure, namely, CPP/JCSm is used at CWTS (Moed *et al.*, 1995).
- **Normalised Mean Citation Rate (NMCR)** is defined analogously to the RCR as the ratio of the Mean Observed Citation Rate to the weighted average of the mean citation rates of subfields, that is, NMCR = MOCR/FECR. This indicator is a second relative citation rate; in contrast to the RCR, NMCR gauges citation rates of the papers against the standards set by the specific subfields. Its neutral value is 1 and NMCR>1 (or < 1) indicates higher (lower)-than-average citation rate.
rate than expected on the basis of the average citation rates of the underlying subfields. NMCR has been introduced by Braun & Glänzel (1990) in the context of national publication strategy. A similar measure (CPP/FCSm) is used at CWTS (Moed, et al., 1995).

3.2.1 The overall situation

The two indicators of both total Chinese publications and internationally co-authored publications in three years (i.e., 1997, 2001, and 2005) have been investigated (Figure 6).
Both the RCR and the NMCR of Chinese total and internationally co-authored publications have increased after each five year interval. The relative citation impact of internationally co-authored publications is higher than that of Chinese total publications. In other words, international collaboration increases China’s citation impact. The raising effect to the RCR keeps going down from 1997 to 2005, while the raising effect to the NMCR has also been weakened from 1997 to 2001 and later on keeps stable till 2005. This phenomenon implies that the increase function of international collaboration to the RCR and the NMCR of Chinese publications has been lowered since 2001 while China’s domestic citation impact keeps rising.

3.2.2 Publication profiles
Figure 7 shows the difference of the relative citation rate (RCR) of publication profiles of China’s total and internationally co-authored publications. In both 1997 and 2005, the RCRs of internationally co-authored publications in most subject categories are higher than those of China’s total publications. Collaboration in mathematics is an exception since the RCR of the China’s total is higher than that of international collaboration. This is again an example that international collaboration does not always pay off (Glänzel & Schubert, 2001). The raising effect of international collaboration in most subjects has weakened from 1997 to 2005 except the fields in clinical & experimental medicine and neuroscience & behaviour.

\[ \Delta \text{NMCR (int - tot)} \]

\[ \begin{array}{c}
\text{AGRI} & 0.3 \\
\text{BIOL} & 0.2 \\
\text{BIOS} & 0.1 \\
\text{CLI1} & 0.1 \\
\text{CLI2} & 0.1 \\
\text{CHEM} & 0.1 \\
\text{CL12} & 0.1 \\
\text{ENGM} & 0.1 \\
\text{PHYS} & 0.1 \\
\text{GEOS} & 0.1 \\
\text{NEUR} & 0.1 \\
\end{array} \]

Figure 7. Change of the NMCR between internationally co-authored and China’s total publications.

International collaboration also raises the value of the NMCR of Chinese publications, except in mathematics whose citation impact is lowered by international collaboration and the lowering effect become worse in 2007. However, the citation raising effect of international collaboration in many subject categories has decreased remarkably ten years later. The subjects in which China is extremely inactive, namely, clinical & experimental medicine and neuroscience & behaviour still increasingly benefit from international collaboration (Figure 8).

4. Conclusions

International collaboration measured by scientific publications has been increased obviously in China. But the growing speed of the number of internationally co-authored publications does not catch up that of China’s total publication. In other words, the
growth of China’s research output measured by publication activity does not go with intensification of international collaboration. When national share of internationally co-authored publications increase in most countries, for example, the EU countries and the North American countries, that of China, Brazil, and Turkey decreases. This may imply that the growth rate of international collaboration in the emerging countries is lower than that of these countries’ non-internationally co-authored publications. The situation in many other countries is the other way round.

The EU countries have high national share of internationally co-authored publications. But the intensity of collaboration differs between within and outside the EU: collaboration within the EU is more significant than that with non-EU countries. International collaboration also takes high share in national publications in Australia and Canada but is not high in the USA. All the selected Asian countries (i.e., South Korea, Japan, China, and India) have less share of international collaboration in their publication activity.

International collaboration partly contributes to China’s scientific output. International collaboration compensates China’s deficiency of field activity. China follows the basic paradigmatic pattern of the former socialist countries with pronounced activity in chemistry and physics and less activity in the life sciences (REIST-2, 1997), in the meantime research activity is also remarkable in mathematics. Publication activity in China’s international collaboration are the opposite with clear activities in neuroscience and behaviour, clinical and experimental medicine, biomedical research, biosciences, biology, geosciences and space sciences, and agriculture.

Distribution of international collaboration among Chinese regions is highly skewed: almost half of international collaboration is conducted only in three regions (i.e., Beijing, Shanghai, and Hong Kong). National visibility of international collaboration in many regions is extremely low or even zero.

The USA, Japan, the UK, Germany, and Canada are China’s most important partners, among which the USA and Japan take the lead. Mutual collaboration link between China and Australia or Singapore has been enhanced. The relation between China and Singapore is unusual. Although Singapore has low international visibility in world share of publications, its share in China’s internationally co-authored publications is rather high.

Citation impact of China’s overall publications and internationally co-authored publications has increased considerably, although the share of internationally co-authored papers decreased over the last ten years. This applies to both journal- and subject-normalised mean citation rates (RCR and NMCR, respectively). International
collaboration increases China’s overall citation impact. But such raising effect is weakening.

The citation impact of international collaboration differs among subject categories. Internationally co-authored publications in most subject categories attract on average more citations than domestic papers. This applies above all to the medical sciences. The situation in mathematics is unique since international collaboration lowers China’s citation impact, and the lowering effect becomes even stronger ten years later. The citation raising effect of international collaboration in subject categories in which China is less active continues to grow.

Acknowledgement

We would like to thank Balázs Schlemmer for his creative assistance in preparing the ‘scientopographical’ maps of this paper.
Is China also becoming a giant in social sciences?

PING ZHOU,a,b  BART THIJS,a  WOLFGANG GLÄNZEL,a,c

a Katholieke Universiteit Leuven, Steunpunt O&O Indicatoren, Dept. MSI, Leuven, Belgium
b Institute of Scientific and Technical Information of China, Beijing, China
c Institute for Research Policy Studies, Hungarian Academy of Sciences, Budapest, Hungary


Introduction

Recent papers in bibliometrics have shown that the old model of world leadership of three major players in economy, science, and technology – the USA, the EU and Japan – does no longer hold in the 21st century. With its fast and continuous development in economy, China is emerging as a leading nation in science [ZHOU & LEYDESDORFF, 2006; GLÄNZEL & AL., 2007, 2008] and has ranked second since 2006 in terms of scientific publications [LEYDESDORFF & WAGNER, 2007; ZHOU & LEYDESDORFF, 2008], overtaking France, Germany and the UK. Bibliometric studies relevant to China’s research performance in the sciences have been done from various perspectives.
A question comes out naturally: is China also becoming a giant in social sciences? This paper will focus on this issue and will provide an overall picture about China’s performance in social sciences.

Social sciences are a group of academic disciplines that aim at studying human society, social systems and the individual relationships in and to society by means of theoretical and empirical research. Compared to the natural sciences, the social sciences are more connected to and imbedded in (and thus affected by) the social and political system to which they are oriented. From a historical viewpoint, most disciplines in the social sciences are also younger than science fields or traditional areas in the humanities. One should take into account that communication behaviour of scientists in the social sciences essentially differs from that of their colleagues in the sciences and applied sciences. Bibliometric methods originally designed for the analysis of basic research in the sciences has to be adapted to the peculiarities of the social sciences. The divergence of communication finds, among others, its expression in the particular choice of communication channels, the publication language and specific citation behaviour [GLÄNZEL & SCHOEPFLIN, 1999; HICKS, 2004]. We therefore focus on those disciplines in which the use of the scientific method including quantitative and qualitative methods is emphasised and in which the communication behaviour is rather similar to that in the sciences. However, before we deal with the bibliometric analysis, let us have a look at the peculiarities of the social sciences in China.

For historical and social reasons, the development of the Chinese social sciences considerably differs from those in Europe and America. Based on former studies relevant to the history of Chinese social sciences [DONG, 1999; CHENG, 2004; JIANG, 2005], the development of Chinese social sciences can be summarized as five major periods:

1. Starting period (1900–1915).
   Some social science disciplines just emerged. Theoretical systems, structures, frameworks, and even concepts and scopes of relevant disciplines had not yet been formed;

2. Formative period (1915–beginning of 1930)
   After several cultural and political movements since 1915, the Chinese system for the social sciences was established on the whole;

3. Localization of social sciences (beginning of 1930–1949)
   Since social sciences were originated in the West, localization of the social sciences in the Chinese context had become a common sense among Chinese social scientists;


Sciometrics
Since the establishment of the Peoples Republic of China in 1949, the Chinese social sciences faced a completely new era but experienced a zigzag route. Little progress was made in this period, especially during the Cultural Revolution which lasted for 10 years (1966–1976), research and education in the social sciences were completely stopped.

(5) Relatively faster development (since 1978)

Since 1978 when China started adopting its Reform and Opening-up Policy (ROP), Chinese social sciences embraced a period of fast development: academic research becomes more active; the number of research institutes increased; research manpower is enlarged; domestic and international academic exchanges become frequent; and more and more scholars are sent abroad. In addition, the return of Hong Kong enlarges China’s research and educational force as well.

In this paper, we investigate three major topics taking into account the restrictions concerning the application of bibliometric standard tools to the social sciences. These topics cover:

(1) the evolution of Chinese publication output in all fields of the social sciences from 1974 to 2006;
(2) China’s publication profiles and its change in time based on selected social science fields in the period 1997–2006;

Data sources and data processing

Data sources

The study is based on data from the Social Sciences Citation Index (SSCI) of Thomson Scientific (formerly known as Institute for Scientific Information, ISI, Philadelphia, PA, USA). The SSCI database forms jointly with the Science Citation Index Expanded (SCIE) and the Arts & Humanities Citation Index (AHCI) the Web of Science. As a multidisciplinary index to the journal literature of the social sciences, the SSCI fully indexes more than 1,725 journals across 55 ISI Subject Categories, and it indexes individually selected, relevant items from over 3,300 of the world’s leading scientific and technical journals. In comparison with ISI’s SCIE, the two databases are practically identical in terms of their structures except for one issue concerning the coverage of journals that will be discussed below. They use the same bibliographic fields with coincident components. Nevertheless, social sciences and natural sciences have different attributions which may bring some fundamental variations. One must be cautious and have the following points in mind while using the SSCI data:

Social science literature is more fragmented.
Compared to social science literature, natural and life science literature is more consensual and international. A core of important, international, mostly English-language journals has been identified and fully indexed into the SCIE. The bibliometric community has adopted the SCIE as a standard source in relevant research and evaluations. By contrast the social sciences constitute a broad and rather heterogeneous collection of disciplines. They are fragmented because social scientists develop fewer consensus and adhere to more competing paradigms than do natural scientists [Hicks, 1999]. Lack of consensus within a field has been associated with a higher proportion of books in that field’s literature because journal publishing has often been seen both as a signal of greater consensus and as a unifying force in itself [Pierce, 1987]. Relevant studies [Bourke & al., 1996; Winterhager, 1994] have proved that social scientists publish in more types of literature than do natural scientists. Another study [Delamont, 1989] shows that authors commonly do not cite relevant work outside their school of thought. These fragment the literature such that in the worst cases, no core of literature in a field can be identified [Nederhof & Zwaan, 1991].

Social sciences are inherently more national oriented.

Social sciences are related to the social, political, economic and legal systems which they study. Theoretical concepts in the social sciences are subtle and are often expressed in national languages and can sometimes be fully appreciated only in the original language [Hicks, 1999]. Compared to natural scientists, social scientists both write and read fewer foreign language papers or even foreign journals [Kyvik, 1988]. The heavy emphasis on local audiences and local material among social scientists also fragments social science literature, making it more difficult to cover the literature comprehensively in a single international database.

Several biases exist in the SSCI

Similar to the SCIE, the SSCI has national, language and disciplinary biases. Using the national bias as an example, among the 1768 journals covered by the SSCI, 55.9% of them were from the USA and 37.2% of them were from the EU-15 in 2006. Asian journals only take a very small share. The journals from the major Asian countries (China, Japan, South Korea, Singapore, New Zealand, and India) only took about 1.3%. Nevertheless, those European or American journals are open to accept papers from any countries. Theoretically speaking, there is no country bias in these journals, but language bias does exist. Among all the publications in the SSCI in 2006, 95% are in English. Language bias may affect a nation’s visibility, especially for social sciences when theoretic problems are usually expressed in national languages and can sometimes be fully appreciated only in the original language [Hick, 1999]. Furthermore, several fields like, for instance, law mainly refer to national issues and consequently prefer the use of the national language for publication. Regarding to disciplinary bias, the SSCI data may affect a nation’s visibility because different nations may have different
emphasis or strong point in different fields. A nation can be well presented when its strong fields are well covered by the SSCI, vice versa.

Social sciences largely rely on communication channels other than international journals.

In many fields of the social sciences non-journal literature is more important than in the sciences. The centrality of books in social science literature has already been pointed out by Hicks [1999]. Beyond books and monographs, other communication channels such as working paper series play an important part in several social-science disciplines. All these literatures can be frequently cited; but even social science journals are cited but not indexed in the SSCI. Butler [2003] has shown that the share of the Australian academic output in the social sciences and humanities fields published in non-ISI journals amounts to 25%–44% of all journal literature.

As mentioned above, there is one issue that structurally distinguishes the SSCI from the SCIE database, namely that the SSCI not only has journals that are fully covered, but also journals that are selectively covered. These journals are covered by other ISI databases but only selected papers are indexed in the SSCI. This situation may cause problems in bibliometric analysis, especially for the correct subject assignment and finding appropriate reference standards for citation analysis [Glänzel, 1996]. In this study, selectively covered papers have therefore not been taken into consideration.

Despite the above weak points of the SSCI in terms of bibliometric analysis, the database is valuable when statistics is based on some fields that are relatively well covered or on research that is internationally oriented. It is also persuasive to use the dataset to describe a nation’s historical development in social sciences. Data of the ISI for the Arts and Humanities is not used for our study since fields in this category are even less represented than social sciences [Moed, 2005].

Glänzel & Debackere [2005] have analysed the publication output of social sciences in Belgium and the citation impact of papers indexed in the SSCI; they came to the conclusion that bibliometric standard tools can be applied to a set of selected disciplines of the social sciences in a similar manner as it is long practiced in the sciences. The results are also in line with earlier findings [Glänzel, 1996; Glänzel & Schopfelin, 1999; Katz, 1999; Godin, 2002]. As a results of the Belgian study we have selected a set of ISI Subject Categories, aggregated those to six subfields and three major disciplines in which bibliometric standard analysis can be conducted. The hierarchical structure of these fields can be found in the Appendix.

Data processing

Two sets of data are collected. The first set includes data in all fields for China so as to provide an overall view about China’s development from 1974 to 2006 in the social sciences. In order to avoid confusions, China is used to represent the Peoples Republic

Sciencemetrics
of China (PRC), and “Chinese Mainland” for the area currently administered by the PRC excluding the two special administrative regions (SARs) Hong Kong and Macao. Data of Chinese Mainland and Hong Kong are collected separately based on country assignment in order to view the development in the two regions distinctively. For historical reasons, the ISI addressed a country code to Hong Kong for data before 2002, five years after Hong Kong’s return to China. In addition, some publications from Hong Kong were assigned to Chinese Mainland since 1998. This situation existed until 2002 when Hong Kong’s publications were completely assigned to China.

The second set of data contains publications in three main fields comprising Economics & business administration, Social, political & communication sciences and Psychology with six subfields (see Appendix). This selection is based on the experience limitations of bibliometric application to disciplines in the social sciences like, for instance, history and law (see [BUTLER, 2003; HICKS, 2004; GLÄNZEL & DEBACKERE, 2005]). The above-mentioned three main fields and six subfields were selected for analyzing China’s publication profiles and citation impact in comparison with relevant countries or region. The fields selected are either well-covered by the SSCI or have international publication behaviour.

For both sets, only publications recorded as articles, letters, notes and reviews are included in the study. A full-counting or integer-counting scheme was applied, that is, a full count was recorded whenever a country occurred in the by-line of the paper. Because of the extensive presence of international co-authorship, national bibliometric indicators such as publication or citation counts based on this full-counting scheme are not additive, that is, they can not be summed up over countries to regions or supra-national units. A share of x% of a country in the world’s total publication output means that x% of all papers have one or more co-authors with an address in this country.

For international comparison and the analysis of internationally co-authored publications, all countries indicated in the address field were considered. Duplicates have, of course, been removed. In addition to individual countries, the supra-national region EU-15 has been selected. In order to guarantee a fair approach and to obtain consistent results for the EU-15, that is, the union with 15 member countries has been used for the full period. Intra-EU co-publications have been de-duplicated to avoid double counting.

For the citation analysis, a three-year citation window beginning with the publication year had been applied. The slow ageing of social sciences literature would speak in favour of the choice of a longer windows [GLÄNZEL & SCHOEPFLIN, 1999], however the choice of three years still allows the evaluation of recent research results.

---

1 In this study the constitution of the European Union till 2003 is used so as to coincide with the former paper [ZHOU & LEYDENSØRFF, 2006]. The members of the EU15 are Austria, Belgium, Denmark, England, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and Sweden.
on one hand, and this period is, at least at higher levels of aggregation, long enough to
determine future citation impact, on the other hand [GLÄNZEL, 1997]. The three-year
citation window has already successfully been applied in earlier studies (e.g.,
[GLÄNZEL, 1996]). The last publication year that could be processed this way was
therefore 2004 (with citations received in the period 2004–2006).

Methods and results

Evolution of Chinese publications in all fields

From 1949 when the Peoples Republic of China was established to 1976 when the
Cultural Revolution was ended, several cultural and political vibrations made China’s
research and education in social sciences stagnated or even backward. Since 1978,
China has adopted the Reform and Opening-up Policy (ROP), which brings China to a
new development stage. Nonetheless, in the period 1979–1991, the reform was
suspended to some extent for some political reasons. It wasn’t until 1992 when the
former Chinese leader Deng Xiaoping made his famous speech while visiting the
southern part of China and after the Fourteenth Congress of Chinese Communist Party,
that China finally accepts the market economy. Reforms in education, science, and
technology started ever since. The ideology of Chinese people was further liberated.
Their initiatives for reform and construction were greatly promoted. Chinese reform
entered a new stage where Chinese economy grows fast and steadily. Another big event
that might affect China’s production in both natural and social sciences is the return of
Hong Kong in 1997. Not mentioning economical and political influence to mutual
sides, we confer that Hong Kong may contribute a big share to China’s publications.

The SSCI includes publications since 1972. But the data for Chinese Mainland were
0 and 2 respectively in 1972 and 1973, so we will report only from 1974 onwards.
Considering Hong Kong’s return in 1997, we include Chinese data from 1974 to 2007
and divide the data into three sets: two sets for Hong Kong and the Mainland from 1974
to 2007, the third one for China combining publications from both the Mainland and
Hong Kong together. The starting year for the third set of data is 1997. Collaborated
publications between the Mainland and Hong Kong are only assigned to Hong Kong not
to the Mainland. In other words, the data set for the Mainland does not contain the
collaborated publications between the Mainland and Hong Kong (Figure 1).
The publication share corresponds approximately to the social and political events happened in Chinese Mainland. Before 1978 when the ROP was adopted, the publication counts of Chinese Mainland never exceeded 10: the world share of the Mainland was almost zero in this period. The historical development of the Mainland publications can be characterized as the following three periods:

Start-up period (1978–1988)

Since 1978, the world share of the Mainland share started to increase from 0.01% and reached the first maximum of 0.23% in 1988, which is an increase by 2200 percent.


From 1989 to 1998, the world share of the Mainland fluctuated slightly and never surpassed the 1988 peak (0.23%). The number of publications only increased from 153 to 161.

Dynamic growth period (1999–)

Starting from 1999, the Mainland has entered a completely new period: its world share of publications increased sharply. From 1999 to 2007, the world share increased by 1.15% (from 0.24% to 1.39%). In 1999, the Mainland published 205 papers; in 2007, this figure increased to 1507.

Figure 1. Evolution of the publication output of the PRC, the Mainland China and Hong Kong (all fields combined, 1974–2007)
Hong Kong’s start point was somewhat higher than that of the Mainland. The Mainland has caught up with Hong Kong by the end of the 1980s, but not really overtaken Hong Kong until 2002. The gap between Hong Kong and the Mainland was small from 1974 to 1992 but was enlarged in the period 1992–1999. The disparity reached its maximum in 1999. Publication output from Hong Kong was more than three times higher than that of the Mainland. In the new millennium, the Mainland has finally surpassed Hong Kong in terms of their publication activity (cf. Figure 1).

Since the return of Hong Kong in 1997, Hong Kong’s publications were calculated as that of China. From 1997 to 2007, the world share of publications of China grows exponentially. The mainland and Hong Kong contribute to Chinese publications differently in different periods. From 1997 to 2001, Hong Kong contributed the most; since 2001 especially 2006, the Mainland has undoubtedly become the major player in terms of publications.

The trend line implies that China, following its remarkable activity in the sciences, has started its catching-up race in social sciences.

*International co-authorship links*

According to De Solla Price [1963], team work and consequently collaboration is one of the characteristics of ‘big science’. Cronin & al. [2003] have shown that massive scientific collaboration – originally a characteristic of the sciences – became established in the social sciences and humanities as well. During the last decades research collaboration has increased at practically all levels of aggregation [Leclerc & Gagne, 1997; Glänzel, 2001; Glänzel & Schubert, 2004]. Several factors, such as peculiarities of national science systems, economic factors, the growing importance of interdisciplinarity and other intra-scientific factors, geopolitical and/or cultural affinity and as well as certain aspects of mobility and migration at the individual level are pointed out playing an important part in establishing collaboration links [Schubert & Braun, 1990; Katz & Martin, 1997; DeB. Beaver, 2001; Glänzel & Schubert, 2004]. Above all, international co-authorship links have undergone dramatic structural changes in the last decades. Besides stable links between countries and coherent clusters, new nodes and links in the international co-publication network have crystallised. International co-authorship is in general accepted as a basically positive phenomenon. Severe political and economic changes as observed, for instance, in the economies in transitions in Eastern Europe and new members of the European Union have a strong influence on collaboration patterns [Glänzel & Schlemmer, 2006]. Thus, extensive collaboration might also be used as means for compensation for the negative financial effects which have hit the basic research system of several East-European countries before and after the political and economical changes of the nineties [Braun & Glänzel, 1996].
In order to visualise the evolution of China’s collaboration network in the social sciences we map China’s co-authorship links broken down by country pairs for two sub-periods 1997–1999 and 2004–2006. We use Salton’s index \( r_{ij} \) to measure the strength of co-publication links. This (cosine) measure can be derived from a Boolean vector space model. Each country is represented by a Boolean vector the components of which take the value 1 or 0 according as the country has contributed to the corresponding paper by co-authorship or not. The cosine measure is then defined as the cosine of the angle between the vectors representing two countries. A similar model has been described in the context of bibliographic coupling [Sen & Gan, 1983; Glänzel & Czerwon, 1996]. As has been shown in these papers, Salton’s (cosine) measure can then simply be defined as follows

\[
r_{ij} = \frac{p_{ij}}{(p_i \cdot p_j)^{1/2}},
\]

where \( p_i \) is the number of publications of China, \( p_j \) the number of publications of the partner countries and \( p_{ij} \) the number of joint publications. In verbal terms, this measure is defined as the number of joint publications divided by the square root of the product of the number (i.e., the geometric mean) of total publication outputs of the corresponding pair of countries [Glänzel, 2001]. We have only chosen partner countries with at least 10 joint publications to guarantee statistical reliability of the results. The change of China’s scholarly co-operation can best be visualized by ‘scientopograhical’ maps (see Figure 2a,b).

An increase of China’s international collaboration in the social sciences was observed; the share of internationally co-authored papers increased from about 44% in 1997–1999 to about 48% in 2004–2006. However, not only the share of collaborative papers rose but the strength of the links increased as well. While in the first sub-period rather weak links are predominant (except the medium strong link with the US), we find already two strong links in the second period, namely those with the USA and Singapore. Other important partners are the EU-15, Australia, Canada and the UK. Although the general ranking according to the link strength has not changed between the two periods, the strong increase of co-publication strength with Singapore, South Korea, and the EU-15 is worth mentioning. The increase of collaboration with EU-15 from 1.53% in 1997–1999 to 2.42% in 2004–2006 mirrors that with the US (form 3.38% to 4.88% in the same periods). On the other hand, intensity of collaboration with Japan considerably decreased although the total number of joined publications somewhat grew at the same time.

**Publication output in selected fields**

Data collected in this section are limited to those fields listed in the appendix. The data for China include those from both Chinese Mainland and Hong Kong.
Figure 2a. Co-authorship map for China in all social-sciences fields combined in 1997–1999 based on Salton’s measure (thick line ≥ 0.04, 0.04 > solid line ≥ 0.02, 0.02 > dotted line ≥ 0.01, other important links <0.01 without line). Source: University of Alabama, Cartographic Research Lab (geographical map).

Figure 2b. Co-authorship map for China in all social-sciences fields combined in 2004–2006 based on Salton’s measure (thick line ≥ 0.04, 0.04 > solid line ≥ 0.02, 0.02 > dotted line ≥ 0.01, other important links <0.01 without line). Source: University of Alabama, Cartographic Research Lab (geographical map).
China’s share in the world total

In 2006, there were 1176 Chinese publications included in the SSCI, which was 1.5% of total in the database. Japan’s share was 0.1% more than that of China. Nearly half the publications in the selected fields are from the USA. Seven of the top ten countries are from Europe and three (i.e., the USA, the UK, and Australia) have English as their native language. English is also one of the two official languages in Canada. Some EU-15 countries, publish in English even though their official languages are not English, making them a higher visible chance. The Netherlands and France can be a good example. Dutch researchers tend to publish in English while French publish in French. Among the publications indexed in the SSCI in 2000–2006, 23.5% of French publications were non-English; while that of the Dutch was 0.96%. This phenomenon may contribute to some extent to France’s lower share with respect to the Netherlands (Figure 3).

Some variance exists between the SCIE and the SSCI for relevant countries/region (Table 1). In 2006, the USA, the EU-15 and the UK have higher publication shares in the SSCI than in the SCIE. Publications from the EU-15 and the USA took 77.1% in the SSCI, while that of the EU-15 and the USA in the SCIE was 54.3%.
In addition to investigating world shares of publications in one year (2006), we analyzed the historical track of relevant countries/region from both the West and the East for the comparison. The time span is from 1997 to 2006 (Figures 4 and 5).

Table 1. World share of publications in the SSCI and the SCIE 2006

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>SSCI</th>
<th>SCIE</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>45.8%</td>
<td>29.5</td>
</tr>
<tr>
<td>EU-15</td>
<td>31.3%</td>
<td>24.8</td>
</tr>
<tr>
<td>UK</td>
<td>12.8%</td>
<td>7.8</td>
</tr>
<tr>
<td>Germany</td>
<td>5.7%</td>
<td>7.7</td>
</tr>
<tr>
<td>France</td>
<td>2.4%</td>
<td>5.6</td>
</tr>
<tr>
<td>Japan</td>
<td>1.6%</td>
<td>7.8</td>
</tr>
<tr>
<td>China</td>
<td>1.5%</td>
<td>8.4</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.8%</td>
<td>2.9</td>
</tr>
</tbody>
</table>

As the largest publication producer in the social sciences insofar covered by the SSCI, the USA has experienced some ups and downs. In 10 years, the world share of the USA decreased 3.3%. On the contrary, EU-15’s world share increased by 7.5%. The UK has also experienced an increase (2.5%), even though its base number is already high (10.3%). The growth of Germany is quite visible (1.8%) while that of France is not (0.1%). The growth of China is rather slow compared to most of the countries in Figure 4. In the ten-year span, China’s publication share increased only by 0.6% but this progress is visible (Figure 5).

Figure 4. Evolution of China’s publication output compared with selected countries/region in the West
In the following a comparative analysis in Asia will be conducted. For this purpose we have selected China, Japan, South Korea, India, and Singapore. China is the second largest producer and has the highest growth rate. The gap between China and Japan is narrowing. The growth of South Korea and Singapore is visible in recent years.
The world shares of all the five Asian samples have been increased. China increased the most (0.6%), although this data is low in comparison with most countries in Figure 4. South Korea’s growth (0.5%) is similar to that of China. India’s growth is the least (Figure 5).

**Activity Index (AI)**

Activity Index (AI) was introduced by FRAME [1977] and has been applied in macro studies [SCHUBERT & AL., 1989] ever since. It is defined as the ratio of the share of a given field in the publications of a given country to the share of the same field in the world total publications. Based on AI, one can tell the relative activity of fields within a country. When AI=1, it means a country’s publication share in a field is the same as its world share. In other words, a country’s activity in a field is at the average level of its publication activities. AI<1 indicates a below-average activity, AI>1 indicates an above-average activity, and AI=0 indicates the country has no research in this field.

In order to compare the evolution of publication activity in the selected three main fields (psychology, economics and business, and social, political & communication sciences which) in relevant countries/region, we collected and calculated average AI by dividing the data into two groups. Data for group one is from 1997 to 2001 and data for group two is from 2002 to 2006 (Figures 6 and 7). The reason for calculating the accumulated data instead of using data from an individual year is because the total number of publications of some Asian countries is rather small, which may cause large bias.
As USA accounts for more than 40% of all world papers their publication activity in the three main fields sets the pace. As a result USA shows values all around the average level.

The EU-15 has its own pattern which is different from that of the USA or Asia. In terms of publication activity, the EU-15 is close to the average in economics and business administration; above the average in psychology; and lower than the average in social, political and communication sciences.

China is relatively more active than the world standard in economics and business administration, and is quite below the average in psychology. Publication activity in social, political and communication sciences is also lower than the average.

The publication activities of the other selected Asian countries, except Japan, are similar to that of China: research in economics and business administration is above the average. Singapore’s pattern is more close to that of China. Some changes have taken place in terms of activity in social, political and communication sciences in countries like South Korea. From period one to period two, the pattern of South Korea goes somewhat different.

Japan’s pattern is somewhat like that of the EU-15 instead of that of most Asian countries: publication activity in psychology in both Japan and the EU-15 is above average. Yet, Japan’s publication activity in psychology is more dynamic than the world average.

For most of the countries/region under study, there is no obvious change in terms of publication activities in the two periods (1997–2001; 2002–2006). South Korea is an exception: it is approaching the world average in terms of publication activity in psychology.

**China’s citation impact in the social sciences**

In addition to analyzing Chinese publications, investigating Chinese citation impact is also important since it provides information about how Chinese publications are perceived by the international community. Relevant topics including world share of citations and standard citation indicators will be explored in this part.

**National citation impact in all social science fields combined**

Because of the underlying 3-year citation window citations could be counted for publications till 2004 with the citation windows 2004–2006. In the latter period, China ranked 15th in terms of world share of citations with the three selected fields as a whole. Compared to its world publication share, China’s citation share is four positions behind. Japan’s citation share is one position behind its publication share. But the ranks in citation shares of the USA, EU-15, UK, Canada and Germany corresponds to their ranks of publication shares (Figure 8).
Except New Zealand, citation shares of the major Asian countries including Japan, China and South Korea, are less than their publication shares. On the contrary, the world share of citations of the USA is much higher (11.6%) than that of its publications. In addition, over half of citations are referred to publications from the USA. Citation shares of some EU-15 countries such as the UK, Germany and The Netherlands, are also higher than their publication shares.

Investigating the world share of citations from historical perspective we found that the USA lost 2.5 percentage points of world share between 1997–1999 and 2002–2004 while most of the major countries earn more. EU-15 nations especially the UK, Germany, The Netherlands, Switzerland, Spain and Belgium are the major winners. Canada and Australia are also important winners. China’s gain is not quite obvious (0.4 percentage points) compared to other major citation receiving countries.

Relative citation indicators

In what follows, standard citation indicators will be used to shed light on the impact of national research in the social sciences in all fields combined. Since a three-year citation window is applied in this study, the latest citation data collected are for the year 2004.

For the analysis the following set on indicators is used.
i) Mean Observed Citation Rate (MOCR). MOCR is defined as the ratio of citation count to publication count (see [BRAUN & AL., 1985]).

ii) Mean Expected Citation Rate (MECR) is a journal-based citation measure which expresses one expected citation rate of a publication set. The expected citation rate of a single paper is defined as the mean citation rate of all papers published in the same journal in the same year. Here a three-year citation window to one source year is used. MECR is then defined as the average of the individual expected citation rates over the given publication set. This indicator can preferably be standardized through dividing MECR by the Field-Expected Citation Rate (FECR) which is calculated in the same manner as MECR but instead of the journal citation impact the average impact of the corresponding subfields is used [GLÄNZEL & AL., 2008]. This ratio expresses if papers are, on an average, published in journals with higher or lower citation impact than the corresponding subfield citation standards. Therefore, we can consider this indicator also a measure of relative “visibility”. It should be mentioned that a version of this relative measure, namely, FCSm/JCSm is used at CWTS in Leiden (see [MOED & AL., 1995]).

iii) Relative Citation Rate (RCR). RCR is defined as the ratio of the two previous measures, that is, RCR = MOCR/MECR. It should be stressed that in this study, a 3-year citation window to one source year is used for the calculation of both the enumerator and denominator of RCR. RCR = 0 corresponds to uncitedness; RCR < 1 (RCR > 1) means lower(higher)-than-average citation rate. RCR = 1 if the set of papers in question attracts just the number of citations expected on the basis of the citation impact of the journals where the papers have been published [BRAUN & AL., 1985]. Again, a version of this relative measure, namely, CPP/JCSm is used at CWTS (see [MOED & AL., 1995]).

iv) Normalised Mean Citation Rate (NMCR) is defined analogously to the RCR as the ratio of the Mean Observed Citation Rate to the weighted average of the mean citation rates of subfields, that is, NMCR = MOCR/FECR. This indicator is a second relative citation rate; in contrast to the RCR, NMCR gauges citation rates of the papers against the standards set by the specific subfields. Its neutral value is 1 and NMCR>1 (NMCR<1) indicates higher (lower)-than-average citation rate than expected on the basis of the average citation rates of the underlying subfields. NMCR has been introduced by BRAUN & GLÄNZEL [1990] in the context of national publication strategy. A similar measure (CPP/FCSm) is used at CWTS [MOED & AL., 1995].

Table 2 presents indicator values of the 30 most active countries in the period 2002–2004 ranked according to the NMCR. Most of the countries with relative citation impact higher than the neutral value of 1.0 are from the EU.

The USA no more occupies the leading position when relative citation indicators are applied. Nonetheless, publications from the USA still have very high indicator values. The citation impact of Canada is above world average as well.
The citation indicators of the selected Asian countries (China, Japan and South Korea) are below world average. The low position of Japan is remarkable. The citation impact of individual Chinese publications is even lower that of South Korea.

Citation shares of individual fields

The research activity in the three selected fields has been discussed earlier. Accordingly, we will investigate the citation impact of each of the selected fields in this section so as to see if the citation impact of each field corresponds to its activity. In order to ensure the results reflect the situation in the period discussed, we calculated first the world share of citations of each field for the two leading powers in the social sciences, the US and the EU, in the full period 1997–2004. The USA takes majority of the citations in the three main fields (economics & business administration, psychology, and social, political & communication sciences). But the USA’s share is decreasing in recent years. As the second largest citation receiver, the EU-15 is earning higher shares. In particular, the citation pattern of the EU-15 corresponds to its research activity index.
(AI): the field which had higher AI had higher world citation share, vice versa. Such pattern has been kept during the complete period. Moreover the share of citations of the EU was slightly but steadily increasing over the whole period.

In order to obtain more stable patterns, we have subdivided the period 1997–2004 in two time spans: 1997–1999 and 2002–2004 for the selected Asian countries. This solution avoids fluctuations caused by their smaller publication output but still allows the analysis of the evolution. The results are shown in Figure 9.

![Figure 9. World share of citations of the selected Asian countries (1997–1999: top, 2002–2004: bottom)](image)

The world share of citations of Asian countries were still low, but the emergence of these countries in the two periods is visible (Figure 9).
Figure 10. Relative citation impact indicators for publication years 2002–2004 (capitals) vs. 1997–1999 (italics) in economic/business (top), social/politics/communication (centre) and psychology (bottom) (C=China, E=EU, J=Japan, K=South Korea, S=Singapore, U=USA)
Except Japan, China and the other Asian countries (i.e., South Korea, and Singapore) share similar citation patterns. The citation patterns and the publication activity of these countries are similar as well. Japan has kept its citation patterns from period one to period two. Its citation patterns and publication activity are similar. In addition, the Japanese patterns are similar to those of the EU-15.

In addition to the share of citations in the world total, we present relative citation rates in relational charts (see Figure 10). The leading role of the US in all three fields is obvious from the charts. By contrast, citation impact of the European Union more or less meets the world standard. Only the field Social, political & communication sciences shows a somewhat more advantageous picture for the EU-15. Generally, the patterns of relative indicators in the two other fields are more polarised. In what follows we will shortly discuss the major trends in the three fields separately.

Economics & business administration: Within the group of selected Asian countries one can distinguish two subgroups, particularly, China and Singapore with both higher relative impact and higher relative visibility, and Japan with rather lower-impact characteristics. Alone South Korea changed from the high-impact to the low-impact group.

Social, political & communication sciences: All countries are closer to the centre of the diagram representing the world standard. Above all, the indicator values of China, Japan increased considerably from 1997–1999 to 2002–2004.

Psychology: We find a similarly polarised situation as in Economics and business. The relative citation indicators reflect a rather disadvantageous situation of the selected Asian countries.

In all, the Asian group does not yet reach the standard set by the USA and the EU-15 with their high impact and visibility and with their stable RCR>1 values.

Conclusions

The development of Chinese publications

Although the social sciences have appeared in China for about 100 years, the visible growth in terms of international publications just started several years ago: Chinese publications especially publications from the Mainland were almost invisible in the international community before 1999. The year 1999 can be considered as a turning point of Chinese social sciences. The adoption of Opening-up Policy in 1978 had some positive but limited impact on Chinese social sciences.

Since the return of Hong Kong in 1997, the world share of Chinese publications grows exponentially according to the SSCI database. Hong Kong is a major contributor to Chinese publications, although its role started to go down since 2005. Hong Kong
China’s international collaboration has increased. The USA and Singapore are two major countries collaborating with China. Other important Chinese partners include the EU-15, Australia, Canada, and the UK. Collaboration strength with Singapore, South Korea, the USA, and the EU-15 increased, but decreased only with Japan.

**International comparison**

China has not yet taken off in the internalization of social sciences. The development of social sciences is slower than that in natural sciences in China [Zhou & Leydesdorff, 2006]. Although Chinese publications began to grow visibly in 1999, the gap between China and the West represented by the USA and the EU is too wide to be reduced within a short period.

Not only China, other major Asian countries including Japan, South Korea, New Zealand, Singapore and India do not perform well in terms of internationalization. It seems that the *SSCI* reflects the publication performance of the West (Europe and the USA) more than that of the East. Japan as one of the major players in the sciences has a quite low world share in the social sciences. The citation shares of most Asian countries (including China and Japan) were lower than their publication shares. In 2006, the world share of publications of China is 1.5% while its world share of citations is just 0.6%. On the contrary, both the USA and the EU-15 have higher world share of citations compared to their world share of publications. This implies that publications from the USA and the EU-15 have higher citation impact than those from Asia.

Based on the *SSCI*, the USA is the biggest publication contributor, and receives most citations. EU-15 ranks second. In 2006, 84% of publications are from and 90.5% citations are referred to the USA and the EU-15. The publication contribution and citation impact of the USA is decreasing while that of the EU-15 is growing. The most active countries among the EU-15 are the UK, Germany, and the Netherlands.

Citation impact of Asian countries including China, Japan, Singapore, and South Korea are very low. In the past years, these countries had earned more shares in terms of publications and citations, but the increased amount was marginal.

Regarding to publication activity in the three selected main fields, the USA sets the standard or world average. The EU-15 and Japan have similar patterns: both are above world average in psychology. Publication activities of China and Singapore in economics & business administration are all above the average. Japan is an exception among Asian countries in this regard.

The overall trends in the three major fields under study mirror the situation in all social sciences files combined. The citation impact of the EU-15 in the three main fields...
corresponds to their activity index: psychology has above-average AI and receives the highest citation impact.

Asian countries have not yet reached the standard set by the USA. China, South Korea, and Singapore share similar citation patterns which correspond to their publication activities. These countries have relatively higher citation impact in economics and business and test citation impact in psychology. Japan was an exception with a similar pattern to that of the EU-15: they have the highest citation impact in psychology.

Discussion

Many factors may affect the development of social sciences. Except internal theoretical and practical issues, other factors such as academic level of researchers, social and cultural environment, economical and political systems are also critical to the development of social sciences. Regarding to China’s low international visibility, we summarized the following possibilities:

(1) The attribution of national orientation of social sciences

Social Sciences mainly focus on domestic social, political, and economical issues. Relevant research outputs are usually applicable in a target country or region, and therefore can be only valuable for and published in that country or region. Undoubtedly, research in social sciences is very active in China: the fact that there are around 3000 journals in humanities and social sciences can be a proof. The low world share of publications or citations may imply that Chinese social scientists are less active in international community.

(2) Ideological difference between China and the West

Compared to natural sciences, the methods in the social sciences are more difficult. Research in the sciences is less sensitive to official political ideologies. By contrast, social sciences are often directly related to ideology and more intervened and controlled by rulers. In a socialist country like China the influence of the official ideology on research in disciplines like philosophy, political sciences, law, but also sociology, and psychology is perceptible. This might be considered one reason for the ‘phase shift’ in the growth of Chinese social sciences literature.

(3) The separated administration systems for natural sciences and social sciences

Nowadays, cross-disciplinary research becomes increasingly important. To some extent, collaboration between natural sciences and social sciences may affect research output. In China, two top organizations are engaged in the administration of R&D: the Ministry of Science and Technology (MOST) is responsible for R&D in natural sciences and technology; while the R&D in social sciences is managed by the National Planning Office of Philosophy and Social Sciences (NPOPSS). Such separated management system may hinder collaboration between natural and social sciences.
(4) Evaluation system for research performance

In the evaluation system for researchers in natural sciences, publications in the SCIE/SSCI take a high score, which stimulates researchers to publish in journals included in the SCIE/SSCI. In some research institutes, international and domestic journals are treated differently. Publications in international journals which are not included in the SCIE/SSCI can still get higher score than those in domestic journals. This extremely stimulates Chinese researchers to publish internationally. Nevertheless, in the evaluation system in social sciences, very few institutions treat publications as those in the natural sciences. In other words, there are no measures to stimulate social scientists to publish internationally.

Based on the following facts, we think that China has potential to raise its international visibility in social sciences:

- China has a huge reservoir of researchers. Chinese higher education institutions have been producing human resources continuously [MOE, 2007A]. In addition, more and more Chinese scholars and doctorate students are sent abroad. These internationally trained scholars help to narrow the gap between China and international community.
- The growing international collaboration improves the knowledge level of Chinese scholars and helps Chinese researchers to better merge into international community. Such collaboration may also help international community better understands China as well.
- Statistics from the Ministry of Education of China (MOE) shows that China’s investment in R&D in humanities and social sciences keeps growing [MOE, 2007B].
- As a major language in the SSCI and an important communication tool with international community, English proficiency may help to raise a country’s international visibility. Chinese education sector highlights English language education from primary schools to universities. English has the same weight as other major basic courses like Chinese language and mathematics in evaluating students’ performance.

We would like to thank Prof. Loet Leydesdorff from the University of Amsterdam for his original idea of writing a paper about China’s publication activity in the social sciences. Thanks are due to Prof. Wu Yishan from the Institute of Scientific and Technical Information of China. Prof. Wu expressed his viewpoints on China’s low visibility in the SSCI. Finally, we also wish to thank Balázs Schlemmer for his creative assistance in preparing the ‘scientopographical’ maps of this paper.


**Appendix**

**List of fields selected for the study**

<table>
<thead>
<tr>
<th>Main field</th>
<th>Subfield</th>
<th>ISI subject category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social, political &amp; communication sciences</td>
<td><em>Policy, Planning and Development</em></td>
<td>International relations, Political science, Public administration, Planning &amp; development</td>
</tr>
<tr>
<td></td>
<td><em>Education &amp; Information Science</em></td>
<td>Communication, Education &amp; educational research, Education, scientific disciplines, Education, special, Information science &amp; library science</td>
</tr>
<tr>
<td>Sociology &amp; Anthropology</td>
<td></td>
<td>Anthropology, Ethnic studies, Family studies, Sociology, Women’s studies</td>
</tr>
<tr>
<td>Community &amp; Social Issues</td>
<td></td>
<td>Demography, Social issues, Social sciences, interdisciplinary, Social sciences, biomedical, Social work</td>
</tr>
<tr>
<td>Psychology</td>
<td><em>Psychology &amp; Psychiatry</em></td>
<td>Psychology, biological, Psychology, clinical, Psychology, educational, Psychology, developmental, Psychology, applied, Psychology, Psychology, multidisciplinary, Psychology, psychoanalysis, Psychology, mathematical, Psychology, experimental, Psychology, social, Psychiatry</td>
</tr>
</tbody>
</table>

*Scientometrics*
A Comparison Between the China Scientific and Technical Papers and Citations Database and the Science Citation Index in Terms of Journal Hierarchies and Interjournal Citation Relations

Ping Zhou
Institute of Scientific and Technical Information of China, 15 Fuxing Road, Beijing 100038, People’s Republic of China, and Amsterdam School of Communications Research, University of Amsterdam, Kloveniersburgwal 48, 1012 CX Amsterdam, The Netherlands. E-mail: zhoup@istic.ac.cn

Loet Leydesdorff
Amsterdam School of Communications Research, University of Amsterdam, Kloveniersburgwal 48, 1012 CX Amsterdam, The Netherlands. E-mail: loet@leydesdorff.net

The journal structure in the China Scientific and Technical Papers and Citations Database (CSTPCD) is analyzed from three perspectives: the database level, the specialty level, and the institutional level (i.e., university journals vs. journals issued by the Chinese Academy of Sciences). The results are compared with those for (Chinese) journals included in the Science Citation Index (SCI). The frequency of journal–journal citation relations in the CSTPCD is an order of magnitude lower than in the SCI. Chinese journals, especially high-quality journals, prefer to cite international journals rather than domestic ones; however, Chinese journals do not get an equivalent reception from their international counterparts. The international visibility of Chinese journals is low, but varies among fields of science. Journals of the Chinese Academy of Sciences have a better reception in the international scientific community than university journals.

Introduction

With the continuous development of the Chinese economy, the scientific production of China also is experiencing notable growth. Take scientific publications as an example: The percentage of the world share of Chinese publications increased exponentially during the period 1993–2004 (Jin & Rousseau, 2004; Zhou & Leydesdorff, 2006). This increase advanced China’s position from 17th in 1993 to 5th in 2004 (ISTIC, 1998); however, the number of citations received by Chinese publications is low. In 2004, China ranked only 14th on this indicator (ISTIC, 2005). Although this is a large advancement compared to the 18th position in 2003, the performance of China in terms of publications and citations is not yet compatible.

To investigate the reasons for these relatively low citation rates, it theoretically would be interesting to compare Chinese articles with their Western counterparts as matched pairs in terms of their quality and the number of citations received; however, it is difficult to assess quality independent of citation rates, and a critical problem is that articles can be cited for a variety of reasons. Some authors cite articles to place their contributions in relevant discussions, some references serve as summaries, and others are used as additional warrant of the knowledge claims (Leydesdorff & Amsterdamska, 1990). Although finding matched pairs of articles for the comparison thus may be virtually impossible, comparison at an aggregated level, such as at the level of nations or journals, is feasible.

In addition to the intrinsic quality of articles, other factors such as language and the availability of the journal online may affect the visibility of a journal. No research has been done about the visibility of Chinese journals as a possible cause for the low citation rates. We use routines developed by one of the authors of this article in the context of the international set of the ISI journals (Leydesdorff & Cozzens, 1993) for studying the position and visibility of Chinese journals. The visualizations are based on using Pajek. Citation data are collected from the China Scientific and Technical Papers and Citations Database (CSTPCD) and the Science Citation Index (SCI), respectively.
Since its first publication in 1964, the SCI has been widely used by universities, research institutions, and individuals to evaluate research output. In 2003, 5,907 journals from various countries were included as sources of the SCI. To some extent, the SCI data can represent a country’s scientific production (Sivertsen, 2003); however, it cannot provide the full panorama of a country’s scientific output, especially not when the official language is not English. Inclusion in the SCI has been debated in terms of national, language, and disciplinary biases. For example, Van Leeuwen, Moed, Tijssen, Visser, and Van Raan (2001) argued that the language bias of coverage can have consequences for international comparisons of national research performance.

In 2003, 4,497 scientific journals were published in mainland China (Ren, 2005). Among these, only 67 were included in the SCI of that year (i.e., ~1.5%). Thus, it is imperative for China—a large country that has 5,000 years of history and a tradition of nurturing science and education—to formulate a database for the purpose of evaluating its scientific outputs. The CSTPCD, a database similar to the SCI, was set up in 1988 with the support of the Ministry of Science and Technology. The Institute of Scientific and Technical Information of China (ISTIC) has carried out and developed the project ever since, making the CSTPCD widely used by research institutions, scientific management organizations, and individual scientists to measure their research output (Wu et al., 2004).

When the database was first established in 1988, only 1,189 journals were included; 15 years later (2003), this number has increased to 1,576 journals. The annual news conference on the statistics of Chinese scientific publications and citations—held by the ISTIC—has been an important event in the Chinese science community. The results are published by major Chinese media such as China Central Television Station and Chinese S&T Daily.

The Chinese Science Citation Database (CSCD) is another database similar to the CSTPCD. This database is produced by the Documentation and Information Centre of the Chinese Academy of Sciences (DICCAS), and covered 1,046 journals in 2001 (Jin & Wang, 1999). Leydesdorff and Jin (2005) used the CSCD to map Chinese journal–journal citation relations.

In the current study, we used the CSTPCD as the data source. Among the issues we wished to examine are the following:

• The similarities and differences between the domestic and the international databases. Although both the SCI and the CSTPCD are widely used for research evaluation in China, and comparative studies on the two databases were done before (Liang, Wu, & Li, 2001; Liang, 2003), we wish to explore this issue from the perspective of evaluating the databases using scientific journals as units of analysis.

• To classify journal hierarchies and layers of communication in Chinese and international journals, the aggregated journal–journal citation relations in the two databases provide information about disciplinary similarities and citation preferences among journals. Different journals have different citation impacts, and some journals are cited more frequently than are others. This information can be used to classify journal hierarchies and layers of communication.

• Comparative studies at the journal level may help us to reach the aforementioned objectives.

**Methods and Materials**

To visualize aggregated journal–journal citations, we used a series of previously developed routines for analyzing journal–journal citation relations and the software package Pajek (available: http://vlado.fmf.uni-lj.si/pub/networks/pajek/). The aggregated journal–journal citations can be considered as a huge matrix of citing and cited journals, respectively. This matrix is asymmetrical and overwhelmingly empty. Scientific journals tend to cite one another in dense clusters that represent specialties (Leydesdorff, 2004). Some (e.g., interdisciplinary) journals cite and are cited across different fields, but the majority of the journals are embedded in a specialized publication and citation structure (Narin, Carpenter, & Berlt, 1972). In other words, the matrix is nearly decomposable into specialty structures (Simon, 1973).

The classification of journals into their local densities has not been a sine cura (Doreian & Fararo, 1985; Leydesdorff, 1986; Tijssen, de Leeuw, & van Raan, 1987). Although the densities reflecting specialties are reproduced from year to year, the decomposition in each year is sensitive to the choices of the various parameters involved, such as the seed journal(s) for collecting a citation environment, the threshold levels, similarity criteria, and the clustering algorithm. In other words, the vectors of the journal distribution span a multidimensional space in which “clouds” can be distinguished, but the delineation of these clouds remains fuzzy at the edges (Bensman, 2001) and varies with the perspectives chosen by the analyst.

Leydesdorff and Cozzens (1993) developed a series of routines that generate aggregated journal–journal citation matrices on the basis of a seed journal or a set of seed journals. For this study, we modified these routines to differentiate between the journal environments in the citing and cited dimensions. These two environments can be very asymmetrical for the same journal found in the international database or in the Chinese database. As we will demonstrate later, some journals are heavily cited domestically, but cite only internationally. The new routines generate an aggregated journal–journal citing network that includes only journals that are cited by the seed journal above a certain threshold (e.g., 1% of its total citing) while a cited network covers journals that cite the seed journal above the threshold (i.e., 1% of its total cited).

The various citation matrices are imported into SPSS for factor analysis, and read into Pajek for the visualization. The matrices were normalized using the cosine as the similarity measure (Salton & McGill, 1983). As a similarity measure, the cosine is equivalent to the Pearson correlation coefficient (Jones & Furnas, 1987), but it has advantages in the case of sparse matrices (Ahlgren, Jarneving, & Rousseau, 2003). For the purpose of the visualization, it is convenient that the
cosine provides us with positive values only while one also expects negative values in a Pearson correlation matrix. The Pearson correlation remains the analytical instrument for finding the eigenvectors of the network (e.g., by using factor analysis) while the cosine is the appropriate measure for mapping and visualizing the vector space. The figures included in this study only exhibit cosine values $\approx 0.2$.

Data sources originated from the 2003 aggregated journal–journal citation databases of the CSTPCD and the corresponding Journal Citation Report (JCR) 2003 of the SCI. The results are described in three subsections: The first provides descriptive statistics about the CSTPCD in comparison with the SCI; the second subsection shows comparative results with the SCI in fields such as general science, biology, and material science; and in the third subsection, we use these methods to compare the citation status of institutional journals with an origin at a Chinese university and the Chinese Academy of Sciences, respectively.

Results

The CSTPCD and the SCI

Table 1 contains several terms which can be derived from the two databases. Based on the original data of the CSTPCD or the SCI, we create two databases for both the CSTPCD and the SCI. The first two databases contain fields such as journal names, number of citations received, and number of references. By aggregating data in the fields of the number of references and the number of citations received, respectively, one can obtain the “total number of references” and the “total number of citations received” in one database. For the “sum of journal–journal relations,” two other databases were generated with aggregated information of citations among each two journals.

Among the 1,576 journals in the CSTPCD, 157,659 citation relations are maintained; that is, 6.3% of the 2,483,776 (1,576$^2$) possible relations. The corresponding figure is 2.8% for the SCI in the year 2003. These figures show that the percentage of actual journal–journal citation relations over the possible number of journal–journal relations is very low (Table 1).

In the CSTPCD, the mean of the journal–journal citation relations per journal is 364 ($573,543 / 1,576$) while that for the SCI is 2,980 ($17,604,594 / 5,907$). In other words, journal–journal citation relations are expected to occur in the SCI eight times ($2980 / 364$) more than that in the CSTPCD. With regard to the average number of references per journal, the corresponding figures for the CSTPCD and the SCI are 1,417 ($2,233,524 / 1,576$) and 4,055 ($23,953,246 / 5,907$), respectively. Thus, the figure of the SCI is approximately three times ($4,055 / 1,417$) that of the CSTPCD.

Among the 1,576 journals covered by the CSTPCD in 2003, 29 were published in English, and the remainder ($n = 1,547$) journals were published in Chinese; however, some of the journals published in Chinese provided abstracts in English. The SCI covered 5,907 journals in 2003, of which only 67 Chinese journals are included (1.13%). Among these 67 Chinese journals, 22 are published in Chinese and 45 are in English.

Comparison at the Level of Specialties

We selected journals in general science, material science, and the life sciences to compare citing and cited environments in both the international and domestic databases. Journals in general science aim to cover publications in various existing disciplines; our objective was to test whether this also is the case for Chinese journals. According to a report of the DICCAS (2004), material science and mathematics are the fields in which China performs best while the life sciences lag behind.

In general, the criteria for selecting sample journals were the following:

- A journal is included in both the CSTPCD and the SCI. In the case of the analysis of journals in material science and the life sciences, we use this criterion.
- Some Chinese journals have both a Chinese and an English edition. The Chinese editions of this kind of journal are usually included in the CSTPCD since the database is mainly focused on publications in Chinese while the SCI only covers the English editions of this type of journal (Ren & Rousseau, 2004). Journals under discussion in this article which fulfill this criterion are the Chinese Science Bulletin (CSB), Science in China Series C, Science in China Series E, and the Journal of the University of Science and Technology Beijing. In these cases, we use Chinese editions in the CSTPCD and their English editions in the SCI for the analysis.

Journals in general science. We selected the CSB as the subject of study since this is considered the most important journal in Chinese general science. According to statistics of the ISTIC (2004), the Chinese edition of this journal (CSB-C) ranked first in the general science class with an impact factor of 0.891 in the CSTPCD in 2003. The journal is published in two independent editions, in Chinese (the CSB-C) and in English (the CSB-E), respectively. The CSB-E had an impact factor of 0.593 in the SCI in 2003 (JCR 2003). Note that the two-edition publication mechanism of some Chinese journals can cause errors in assigning citations. For example, a citation is sometimes attributed to the CSB-E...
Citation environment of the CSB-C in the CSTPCD: Citing pattern. The CSB-C had a total of 11,506 references in 2003, among which 1,605 were provided to 284 journals included in the CSTPCD. This means that articles in the CSB-C give only 14% of their references to journals covered by the CSTPCD. When the threshold is set at the convenient value of 1% (given the expectation of a Lotka distribution), there would be no other CSTPCD journals included in the citing environment of the CSB-C except CSB-C itself. In other words, no other journals included in the CSTPCD received 1% of the CSB-C’s total citations. This means that almost half (44%) of the 1,576 total journals included in the CSTPCD had cited the CSB-C, providing 3,958 citations. This indicates the high visibility of the CSB-C among Chinese scientific and technological journals. The visibility of the CSB-C matches its reputation as an important journal in general science. According to ISTIC’s statistics, the journal’s impact factor ranks first among journals in general science in 2003 (ISTIC, 2004).

To analyze which fields have a close citation relation with the CSB-C, we collected the cited environment of the CSB-C by setting the threshold as 1% (Figure 1). Each of the 10 journals included in this cited environment comprised a number of citations of more than 1% of the total number of citations of the CSB-C. Among these, seven were from geology, two from general science (including the CSB-C itself), and one from geography. Thus, we may conclude that the main impact of the CSB-C is in the geosciences.

Although the CSB-C is a general science journal, its citation reception is mainly in the geosciences. The journal has a high visibility among Chinese S&T journals, but authors prefer international journals as sources for citations when publishing in the CSB-C. Does the CSB-C receive the same return from its international counterparts? We selected the CSB-E to explore this question.

Citation environment of the CSB-E in the SCI: Citing pattern. The CSB-E cited a total of 1,168 journals two or more times in 2003, and cited another 2,399 journals only once, generating 12,082 citations in total (JCR, 2003). Among these journals, 775 journals are included in the SCI and are cited two or more times (8,210 citations total). This means that at least 68% of the references by the CSB-E are given to international journals. International journals would then account for approximately 86% of the total references of the CSB-C.1

The CSB-C cited 125 journals only once; 49 journals were cited twice and 34 journals three times. In other words, 73% of the 284 journals were cited by the CSB-C less than four times. Journals that obtain higher numbers of citations in the CSB-C were the CSB-C itself (n = 332), Science in China D (Chinese ed.; n = 98), Quaternary Sciences (n = 49), Acta Petrologica Sinica (n = 45), and Science in China B (n = 43). Except the CSB-C—a general science journal—and Science in China B—a chemistry journal—these journals were classified by ISTIC as belonging to the geosciences.

1It is possible that the CSB-C cited some journals that were not included in the CSTPCD, but this number would not play a key role since the database covers most of the Chinese journals with sufficient quality.
in the CSB-E tend to cite journals included in the SCI. Consequently, international journals have a very significant citation impact on Chinese authors who publish articles in the CSB-E. Among the journals cited more frequently by these authors, leading and general science journals prevail (Figure 2).

Citation environment of the CSB-E in the SCI: Cited pattern. The CSB-E was cited 2,302 times in 2003, among which 1,900 citations were from 248 journals that were included in the SCI and provided two or more citations. The 46 Chinese journals that were included in the SCI and cited by the CSB-E two or more times made a total of 1,091 citations, with a share of 47% of the 2,302 citations. International journals account for 33% of the 2,302 citations. Among the 46 Chinese journals, 25 are published in English with a share of 33% of the 2,302 citations, and the contribution of the 21 journals in Chinese is 14%. The rest (18%) of the citations were from journals that cited the CSB-E only once or were from journals with ambiguous information in the SCI database about their national origin. This means that the CSB-E is mostly cited by Chinese journals (Table 2).

The CSB-E was cited by journals in various disciplines, but most of the journals citing the CSB-E are Chinese journals; all journals that contributed more than 1% of the total number of citations of the CSB-E were from China (Figure 3).

In summary, the CSB-C is considered as an important journal in China, with the highest impact factor (0.891) among journals included in the CSTPCD in the category of general science in 2003; however, in terms of international visibility, Chinese journals in this field still have a long way to go. With an impact factor of 0.593, the CSB-E ranked only 18th among the multidisciplinary journals included in the SCI 2003. Nature’s impact factor of 30.979 is more than 52 times that of the CSB.

Although the two editions of the CSB contain the same articles, they seem to have a different disciplinary impact in terms of their citation relations. The impact of the Chinese edition is mainly focused on the geosciences while the

<table>
<thead>
<tr>
<th>Journal</th>
<th>Chinese journals</th>
<th>International journals</th>
<th>Other journals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese Science Bulletin (English ed.)</td>
<td>47%</td>
<td>33%</td>
<td>20%</td>
</tr>
<tr>
<td>Journal of Inorganic Materials (Chinese ed.)</td>
<td>56%</td>
<td>19%</td>
<td>25%</td>
</tr>
<tr>
<td>Journal of Materials Science &amp; Technology (English ed.)</td>
<td>21%</td>
<td>46%</td>
<td>23%</td>
</tr>
<tr>
<td>Science in China Series C-Life Science</td>
<td>38%</td>
<td>30%</td>
<td>22%</td>
</tr>
<tr>
<td>(English ed.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Journal of University of Science and Technology Beijing</td>
<td>64%</td>
<td>11%</td>
<td>25%</td>
</tr>
<tr>
<td>Science in China Series E</td>
<td>38%</td>
<td>22%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Note. The title “Other journals” indicates those that cited the object journal only once or those with unclear information.
English edition behaves more like a multidisciplinary journal when evaluated in terms of its citation patterns.

**Journals in material science.** Here, we will examine two Chinese journals: the *Journal of Inorganic Materials (JIM)* and the *Journal of Materials Science & Technology*. The *JIM* is published in Chinese. We chose this journal for comparison because it is covered by both the *CSTPCD* and the *SCI* in 2003. The *Journal of Materials Science & Technology* is published in English and is covered only by the *SCI*; the *CSTPCD* mainly covers journals in Chinese. We include this English-language journal in the study to assess whether the use of one language or the other influences a journal’s visibility.

**Citation environment of the JIM in the CSTPCD: Citing pattern.** The *JIM* had 3,279 references in 2003, among which 407 citations are provided to 122 journals in the *CSTPCD* (12%). As authors tend to consult research output published in relatively high-quality journals, we conjecture that the remaining 2,872 (3,279 - 407) references were given to international journals instead of domestic journals not covered by the *CSTPCD*. In this case, the international journals would account for 88% of the number of references of the *JIM*.

The journal that was mainly cited by the *JIM* (93 of 407 times) is the *JIM* itself. The *Journal of the Chinese Ceramic Society* had the second highest number of references (25) from the *JIM*. This means that the *JIM* mainly cites journals in material science. Seventy journals are cited only once. When the threshold is set at 1%, no other journals in the *CSTPCD* are included in the citing environment of the *JIM*, except the *JIM* itself. In summary, authors publishing in the *JIM* hardly cite domestic journals.

**Citation environment of the JIM in the CSTPCD: Cited pattern.** Even though authors in the *JIM* show little citation interest in its domestic counterparts, its visibility among Chinese journals is high. In 2003, 212 journals in the *CSTPCD* cited the *JIM*, generating 896 citations. There are 20 domestic journals in the cited environment of the *JIM* when the threshold is set at 1% (Figure 4). This means that the *JIM* has high visibility in domestic material science and other relevant fields.

**Citation environment of the JIM in the SCI: Citing pattern.** The *JIM* had 2,788 total references recorded in the *SCI* in 2003, which cited 170 journals that are covered by the *SCI* for a total of 2,249 times (Each of the 170 journals was cited at least twice.) Figure 5 is obtained when the threshold is set at 1%. Among the 20 journals cited by the *JIM*, the only Chinese journal cited was the journal itself; however, the journal that was cited the most (242 times) was the *Journal of the American Ceramic Society*.

**Citation environment of the JIM in the SCI: Cited pattern.** In 2003, the total number of citations of the *JIM* was 346. Thirty-nine journals included in the *SCI* cited the journal two or more times, providing 259 citations to the journal. This is 75% of its total number of citations. The Chinese journals accounted for 56% of this share and international journals for 19% (Table 2). Of the 56% citation contribution of Chinese journals, 8% was provided by 7 English editions, and 48% was provided by 11 Chinese editions. Therefore, the international visibility of the *JIM* is mainly among Chinese journals, and the journals published in Chinese provided the major citation contribution to the *JIM*. When the threshold is set at 1%, 15 journals are included in the cited environment of the *JIM*, but only 4 were international journals; the other 11 journals were Chinese (Figure 6).

The previous analysis shows that authors in the *JIM* prefer to cite articles in international journals; however, the journal under study does by far not obtain an equal return from its international counterparts.
Cited environment of Chinese journals published in English in the SCI. Since the JIM is published in Chinese, the language barrier may block international scientists from becoming acquainted with its content. Therefore, we chose another journal that also is in material science, but published in English: the Journal of Materials Science & Technology (JMST), in order to assess whether language indeed functions as an obstacle.

The JMST was cited 318 times in 2003, among which 211 citations were provided by 43 journals included in the SCI and citing the JMST two or more times. These journals accounted for 67% of the total number of citations, among which 21% was from six Chinese journals, and 46% was from international journals (Table 2). Of the 21% share contributed by the six Chinese journals, 12% was from four English-edition journals, and 9% was from two Chinese-edition journals. The international share of number of citations of the JMST was substantially higher than that of the JIM (19%).

In 2003, there were 23 journals in the cited environment of the JMST in the SCI when the threshold is set at 1%, comprised of 18 international journals and 5 domestic ones. In addition to higher visibility among international journals, the JMST also is integrated with international journals in the graph (Figure 7).

Whether they are published in Chinese or in English, Chinese journals in material science have some international visibility; however, the language factor does affect the connectivity of Chinese journals in the disciplinary network. The international visibility of the two journals in material science demonstrates the difference: The shares of citations from international journals were 19 and 46%, respectively, for the Journal of Materials Science (in Chinese) and the JMST (in English). Furthermore, the journal in English is
incorporated in the graph of its international counterparts while the other is not.

**Journals in the life sciences.** As mentioned earlier, China’s performance in the life sciences is assessed to be of lower quality when compared to other fields of science, such as mathematics and material science (DICCAS, 2004). We chose a journal that is covered by both the CSTPCD and the SCI to compare the citations or references of journals in this field: the *Science in China Series C-Life Sciences*. This journal has two independent publication editions: The Chinese edition is included in the CSTPCD, and its English edition is covered by the SCI. In this case, the English edition is a duplication of the Chinese one; the CSTPCD includes only the Chinese edition while the SCI covers the English edition (Ren & Rousseau, 2004).

**Citation environment of the Science in China Series C-Life Sciences in CSTPCD: Citing pattern.** The *Science in China Series C-Life Sciences* (SCSC-C for the Chinese edition) had a total of 1,641 references in 2003, but only 63 journals in the CSTPCD received 157 references from this total (10%). This means that 90% of the references of the SCSC-C were given to journals not included in the CSTPCD. As the CSTPCD already has covered most of the important Chinese S&T journals, we conjecture again that the other 90% of references are attributed to international journals. Of the 10% (n = 157) Chinese references, 23 were given to the CSB and 17 to SCSC-C itself. Other journals received less than a 1% share of the total citations.

**Citation environment of the SCSC-C in CSTPCD: Cited pattern.** Although authors in SCSC-C have little interest in citing domestic journals, the journal’s visibility in the domestic community is high. The journal was cited by 135 journals included in the CSTPCD for a total of 282 times, and 25 of these journals satisfied the condition that each contributes to the citations more than 1% (Figure 7). The SCSC-C gave its highest number of references (n = 23) to the CSB, and the CSB gave the same return to the SCSC-C by contributing the highest number of citations (n = 27) to the SCSC-C. Figure 8 shows that most of these 25 journals are from the life sciences.

**Citation environment of the Science in China Series C-Life Sciences in the SCI: Citing pattern.** The English edition of the *Science in China Series C-Life Sciences* (SCSC-E) had a total of 1,522 references in 2003; 168 journals in the SCI were cited by SCSC-E for two or more times. These 168 journals accounted for 1,115 references (73%). Fourteen journals satisfy the condition that each of them provides at least 1% of the total citations of the SCSC-E (Figure 9).

Journals that achieved the first four highest numbers of references from the SCSC-E include the *Journal of Biological Chemistry*; the *Proceedings of the National Academy of Sciences, USA; Science*; and *Nature*. Except the CSB and the SCSC-E itself, the other 12 journals which are heavily cited by the SCSC-E are international. This shows that authors in the SCSC-E prefer to cite articles published in international journals instead of making references to articles published in domestic journals.

**Citation environment of the Science in China Series C-Life Sciences in the SCI: Cited pattern.** Among the number of citations provided by journals that cited the SCSC-E at least twice in 2003, 38% were from Chinese journals, and 30% were from international journals (Table 2).
When the threshold was set at 1%, 15 journals were included in the cited environment of the SCSC-E. Of these 15 journals, 7 are international. Most of the journals citing the SCSC-E are from the life sciences (Figure 10).

The citation pattern of the *Science in China Series C-Life Science* shows that this journal's authors, when choosing citations, favor international journals instead of domestic ones. The journal has high domestic visibility, although its international visibility is low. Compared to journals in material science, the international visibility of journals in the life sciences is lower than that of journals in the material sciences (Table 2).

**Institutional Journals**

Among the Chinese S&T journals, more than half (63%) are institutional. They are either based in Chinese universities or in the Chinese Academy of Sciences (CAS). The percentage share of university-based journals is 45% and that of the CAS is 18% (Ren, 2005). In this section, we compare...
the citation patterns of journals from these two types of institutions.

To maintain the comparative nature of the study, journals were selected using the following criteria: (a) The journals are from a university and the CAS, respectively; (b) they are in the same or similar fields; and (c) they are to be included in both the CSTPCD and the SCI. Only three Chinese university journals were covered by the SCI in 2003; using the criterion that the university journal and the CAS journal should be in the same or at least similar fields, we found two journals that satisfy these conditions: (a) the Journal of the University of Science and Technology Beijing and (b) the Science in China Series E-Technological Sciences. The latter journal is issued by the CAS. Both journals have Chinese and English editions; the Chinese editions are included in the CSTPCD, and the English editions are covered by the SCI.

Both journals belong to the multidisciplinary category within the classification system provided by the ISTIC staff and are classified as engineering. These two journals have two independent language editions: one in Chinese and another in English. We studied their domestic visibility through the Chinese editions, and the international relations through the citation patterns of their English editions in the SCI. This design enables us to compare their citation patterns and visibility at home and abroad, respectively.

Performance in the domestic environment. In 2003, the Journal of the University of Science and Technology Beijing (Chinese ed., JUSTB-C) was cited 311 times by 15 journals included in the CSTPCD. Most of the reference-providing journals were in material science; more specifically, metallurgy and metallurgical engineering. In other words, the JUSTB-C is mainly cited by journals in metallurgy and metallurgical engineering (Figure 11).

The Science in China Series E (Chinese ed., SCSE-C) was cited 362 times by 23 journals in the CSTPCD. There were eight more journals in the cited environment compared to the JUSTB-C; however, the journals citing the SCSE-C are mainly in computer science and engineering (Figure 12). Journals in other disciplines such as general science, chemistry, physics, mathematics, and so on, also were present in the cited environment. Therefore, the SCSE-C behaves and is cited more as a multidisciplinary journal with a focus on computing and engineering. Both of the two journals have visibility among domestic journals.

International visibility: The Journal of the University of Science and Technology Beijing (English ed., JUSTB-E). The cited environment of the JUSTB-E in the SCI contained 13 journals when the threshold is set at 1%, among which 5 were international and 8 are Chinese journals. The journal had 145 total citations, among which only 19 (9%) were within-journal citation (44%). International journals covered by the SCI contributed to 11% of its total while Chinese journals in the SCI contributed 64% (Table 2). Thus, Chinese journals made the major contribution in citing the JUSTB-E. These data show that the citation impact of the JUSTB-E happened mainly among Chinese journals. Furthermore, the journal contained a high rate of within-journal citations and obtained low international visibility.

International visibility: The Science in China Series E (English ed., SCSE-E). There are 20 journals included in the cited environment of the SCSE-E; among them are 8 international journals and 12 domestic ones when the threshold is set at 1%. The journal had 210 total citations, among which only 19 (9%) were within-journal citations. This figure is much less than that of the JUSTB (44%). Of the
210 citations, 60% was provided by journals covered by the SCI, among which 38% was from Chinese journals and 22% from international ones.

Compared with the JUSTB, the SCSE performs better in terms of citations by other journals in the SCI since the SCSE had less within-journal citations and a higher international visibility.

**Conclusions**

Comparison between the two databases, the SCI and the CSTPCD, shows that the average number of citations per journal in the CSTPCD is much less than that of the SCI. Chinese authors publishing articles in journals in the CSTPCD make less reference to articles in journals than do authors publishing articles in journals covered by the SCI.
High-quality international journals have a higher elevated rank in the hierarchy than do their Chinese counterparts. Authors who publish in high-quality Chinese journals prefer to cite articles in international journals instead of domestic ones. For some high-quality journals, no domestic journals are included in the citation graph when the threshold is set at 1% of their citing environments; however, this tendency does not affect the domestic visibility of these journals. The domestic visibility of high-quality journals in terms of citations is high.

Although authors in Chinese journals prefer to cite articles in international journals over domestic ones, their international counterparts do not provide the same return: The international visibility of Chinese journals is low (Liu, 1993; Ren & Rousseau, 2002). The international visibility of Chinese journals differs among disciplines. Among journals in general science, material science, and life sciences, journals in material science have a relatively higher visibility while journals in the life sciences have the lowest visibility. This reflects the relative strength of China in these fields.

Language is an important factor that affects a journal’s visibility. Both Chinese university journals and CAS journals have high domestic citation rate. The international visibility of the CAS journals is higher than that of university journals. Journals in the general sciences are supposed to entertain citation relations with journals in a range of fields. The English edition of the CSB has this characteristic; however, the Chinese edition of CSB focuses more on the geosciences in terms of its citation patterns.

Among the journals included in the SCI and studied in this article, the English edition of the JUSTB has the highest self-citation rate (44.1%); the self-citation rate of the JMST was the lowest (7.9%). Of the journals included in the CSTPCD and studied in this article, the Chinese edition of the JUSTB also has the highest self-citation rate while the SCSC (Chinese ed.) has the lowest (6.0%) (Table 3). These figures show that the visibility of the university journal is low in both the domestic and international scientific communities. The Chinese edition of SCSC has high visibility among domestic journals. Journals in material science have the highest international visibility.

Policy Implications

The low visibility of Chinese journals affects the expected number of citations of the articles published within them. As Chinese journals are important channels for Chinese scientists to publish their research results, increasing the visibility of Chinese journals may help to raise the impact of Chinese articles. With the wide influence of the SCI in the evaluation of scientific output, inclusion in the SCI already has become a major objective among editorial boards of Chinese journals; however, our analysis shows that inclusion in the SCI does not necessarily lead to an increase in visibility. More needs to be done to increase this visibility, especially in terms of efforts from both scientific authors and editorial boards.

Implications Relevant to Chinese Authors

Many factors may affect a journal’s visibility. Among them, the intrinsic quality of the articles eventually may play a key role. A highly cited article is usually creative, original, and makes unique contributions to the relevant fields. The poor citation performance of Chinese articles is one of the important causes of the low visibility of Chinese journals. Among reasons that might lead to the low citation performance of Chinese articles are low journal access, poor research quality, emphasis on narrow applications, and selection of research areas outside the mainstream of the communication. The Chinese scientific community already has noticed the low citation performance of Chinese articles and has made some efforts to change the situation (e.g., ISTIC, 2005).

When an excellent piece of research has been completed, the ability to organize an article in proficient English becomes a very important factor since English is a major language in international scientific communication. In general, a journal’s visibility relies on the authors who are publishing articles within it. Authors need to enhance not only their academic competence but also their ability to organize articles in English (Ren, 2004).

The analysis at the level of databases shows that Chinese journals have fewer citations (i.e., either number of references or number of citations) per article than that of international ones. This may have the following implications:

- Chinese authors seem to read less literature than do their international counterparts; this may cause Chinese authors to know less about what is occurring in their relevant fields. Being well-informed is helpful for research. If one does not know or knows little about the evolution of his or her
research interests, one might conduct research that already has been done or partly been done by others, resulting in a misuse of time and money.

• Compared to their international counterparts, Chinese authors have less access to international or even domestic journals, which results in fewer chances to read relevant articles. Among the reasons that can cause such a situation, capital shortage is critical for an institution when one has to decide how much and to which literature one subscribes. Compared to the Chinese rates, prices of international journals are very high, and only a few Chinese research institutions or libraries can afford these charges. Even those institutions that can afford a subscription to international journals may have to make choices among interesting literature because of financial shortages. In addition, many researchers in China complain that the number of international journals to which their institutions subscribe is too small (Ning, 2002). Take the subscription to the SCI as an example. Among the 1,396 regular higher education institutions in China, 41 (2.9%) purchased the SCI database in 2004 (according to the SCI office in China). Accessibility of journals published in China is better than that of international ones; however, many institutions are still puzzled by a shortage of funding. There are three national journal databases providing online services relevant to Chinese scientific publications, but all of them supply service only to users who pay subscription rates. When an institution is not a subscribed user of such Web servers, researchers in the institution will face access problems.

• Financial problems also puzzle the editorial boards of Chinese journals. To publish more articles within a limited number of pages, editorial boards require authors to limit the number of cited references. Furthermore, authors are forced to cut references in their articles to publish more content.

Suggestions to the Editorial Boards of Chinese Journals

With Chinese universities and research institutes encouraging scientists to publish in international journals, especially in journals covered by the SCI, Chinese journals face fiercer competition in absorbing articles of sufficient quality from Chinese authors (Jin & Rousseau, 2004). On the one hand, Chinese journals stand in a disadvantageous position when competing with their international counterparts because of journal quality and international visibility; on the other hand, such an unfavorable situation forces Chinese journals to improve or reform for survival. This also can be considered as an opportunity for editorial boards to raise the quality of their journals.

The Chinese government already has made a decision to provide some Chinese journals with financial support to help them increase their international visibility (Jia, 2004). But financial aid is not enough to raise a journal’s visibility, especially if such financial support reaches only a small number of journals. More efforts need to be made by editorial boards. In addition to absorbing high-quality articles, the following measures might be helpful in improving a journal’s visibility:

• Increasing accessibility for international readers. Journal articles need to be readable before they can be cited. When a journal is easily accessible, the possibility of being cited will increase. To realize this target, Chinese journals need to provide electronic editions to make the content easily accessible through the Internet or specific portals. Until now, there are three national journal databases providing online services relevant to scientific journal publications, and all of these operate commercially (Ren, 2005). But only one of the three databases—the China National Knowledge Infrastructure (www.global.cnki.net)—provides services in English. The other two do not provide English versions and therefore limit their target users to Chinese readers. For the English database Web site, more promotional work is needed to make international scientific readers aware of its availability.

• Open access. Even though the China National Knowledge Infrastructure provides an English service, its commercial mechanism may prevent international readers from accessing its data since most international scientists are not paying users. Open access may eliminate this barrier in terms of accessibility.

• Publication of an English edition of the journal. Even though international readers can access Chinese journals, the use of the Chinese language may prevent them from understanding the content of the articles. Using the Chinese language does affect an article’s visibility, and provision of an English version would help to improve visibility.

• Cooperation with international publishers and online journal database providers. International publishers have deliberate strategies for promoting their journals while online journal providers give direct access to academic researchers. If a Chinese journal is covered by an international journal database, the chance of being read by international researchers will be increased considerably. If made free of charge, universities in other countries may be eager to add Chinese journal collections to their open-access databases.

Acknowledgments

We are grateful to the statistics team of the Institute of Scientific and Technical Information of China (ISTIC) for supplying relevant data, especially Ma Zheng for providing us with the aggregated journal–journal citation data according to the specification. Wu Yishan offered suggestions for the implications relevant to Chinese scientific authors. We also thank the anonymous referees for their suggestions.
Chapter 9

Visualization of the citation environments in the CSTPCD journal set


1. Introduction

The aggregated journal-to-journal citations provided by databases like the *Journal Citation Reports* (JCR) and the *China Scientific and Technical Papers and Citation Database* (CSTPCD) can be considered as a huge matrix of cited and citing journals. The matrix is asymmetrical and overwhelmingly empty. Scientific journals tend to cite one another in dense clusters which represent specialties. However, some (e.g., interdisciplinary) journals cite and are cited across different fields (Narin et al., 1972). There are also hierarchies spanning fields at lower levels (Doreian 1986; Doreian & Fararo, 1985). While the majority of the journals remain embedded in one or more specialized publication and citation structures, the matrix thus is nearly decomposable (Simon, 1973).

Decomposition of journals based on their citation relations remains sensitive to the choices of the various parameters involved, such as the seed journal(s) for collecting a citation environment, the threshold levels, similarity criteria, and the clustering algorithm. In other words, the vectors of the journal distribution span a multi-dimensional space in which clouds can be distinguished, but the delineation of these clouds at the edges remains fuzzy (Bensman, 2001) and varies with the perspectives chosen by the analyst (Leydesdorff & Cozzens, 1993; McKain, 1991). Particularly, if one wishes to construct a baseline against which to measure change, the distinctions among variations, measurement errors, auto-correlations in the data, and structural change may become too uncertain to be meaningful (Leydesdorff, 1991; 2002).

Based on analyzing citation networks of journals, Leydesdorff and Cozzens (1993) started to classify specialties based on journal citation relations. In later years, Leydesdorff further developed this method and made journal citation networks visible by applying SPSS and Pajek. Leydesdorff’s method needs to select a “seed journal”. A seed journal is a target journal. A network that is composed of journals cited by the seed journal is named as a citing network; a network that is formed by journals citing the seed journal is called a cited network. A journal can appear in many citation networks. When a journal is used as a seed journal, the corresponding network is called this journal’s core citation network.

The citation networks of Chinese journals covered by the CSTPCD from 2003 to 2006 are available from the Internet. Interested users just need to follow the manual ([http://users.fmg.uva.nl/lleydesdorff/istic03/manual.htm](http://users.fmg.uva.nl/lleydesdorff/istic03/manual.htm)) to get visible citation networks of relevant Chinese journals.

2. Materials and methods

2.1 Materials
The data source is from the citation data of Chinese journals included in the CSTPCD and is processed by a set of routines developed by Leydesdorff. The Pajek which is free for academic research is used for visualization. The download address of Pajek is at: http://vlado.fmf.uni-lj.si/pub/networks/pajek/ 

2.2 Methods

Scientific journals cite each other forming an aggregated journal-journal citation matrix. These matrices contain interesting information like disciplinary similarities and journal hierarchies. One can normalize the matrices by using the cosine as the similarity measure (Salton & McGill, 1983). Salton’s cosine is equivalent to the Pearson correlation coefficient (Jones & Furnas, 1987), but its non-parametric character has advantages in the case of sparse matrices (Ahlgren et al., 2003). For the purpose of the visualization, it is convenient that the cosine provides us with positive values only, while Pearson correlation matrix also generates negative values. We will use the cosine between two vectors to measure similarities between the distributions of various journals included in a citation environment.

Through the routines one can obtain ‘citing’ and ‘cited’ matrices for each journal. In order to generate a citation matrix, we need first to select a journal – a seed journal – to run the routines. A ‘citing’ matrix gathers journals that are cited by authors in the seed journal, while a ‘cited’ matrix is composed of journals whose authors cite the seed journal. Each journal citing or being cited to the extent of more than one percent is drawn into the matrix (Leydesdorff & Cozzens, 1993). The matrices are in ASCII format and can be read directly into Pajek. Cosine values below 0.2 were suppressed in order to enhance the interpretability of the visualizations.

In a Pajek picture, thickness of lines between nodes (i.e., journals) corresponds to the cosine value. A thick line implies that the citation patterns of the journals at the two ends are similar; if a line is thin, the similarities of the citation patterns between the two journals are weak. Since journals in the same discipline are expected to have similar citation patterns, journals linked by thick lines and in strong components can be classified into the same disciplinary category. If journals are not connected by lines, these journals are expected to belong to different disciplines.

The size of the nodes reflects the percentage contribution to the citations in a matrix—citing or cited, respectively. The grand sum of the citation matrix $N (= \sum C_{ij})$ is used as the basis for the normalization of the citation contributions. Each journal contributes with its margin total $C_i (= \sum c_i)$ as a grand sum. In a local citation environment, a journal’s contribution can be defined by this $C/N$ ratio. This ratio determines the size of nodes. By distinguishing between the vertical size of a node and the horizontal one, a second parameter can be used to indicate this percentage after correction for within-journal (self-)citations (Price, 1981; Noma, 1982). Thus, one is able to visualize how much a journal is dependent on an inner circle of authors citing one another by inspecting the shape of the nodes. Note that within-journal citations can be both self-citations of authors and citations among authors publishing in the same journal. To make it clearer, in a citation diagram the shapes of nodes are consequently an ellipse in which the vertical and horizontal radii are different. The vertical radius of the ellipse indicates a journal’s citation share in a specific environment, while the horizontal radius of a node informs us about a journal’s share when within-journal citations are excluded.
In a ‘citing’ environment, the vertical radius represents the collective behaviour of authors in a journal in terms of percentage share of references in a local environment, while the horizontal radius represents a citation activity which maps whether authors in a journal are active in referring to other journals in the same environment. The longer a journal’s horizontal radius, the more active authors in a journal would be in citing other journals.

In a ‘cited’ environment, the vertical radius represents a journal’s citation impact, while the horizontal radius represents a journal’s citation impact to other journals (or foreign citation impact) after correction for within self-citations. A longer horizontal radius means a stronger local citation impact. The difference between the vertical and horizontal radii of the ellipse indicates the extent of a journal’s within-journal citations. If the difference is big, the ellipse would be narrow. This indicates that the journal has a relatively large share of within-journal citations. On the contrary, if the difference is zero, the ellipse becomes a circle. This implies that the journal has no within-journal citations.

The narrower an ellipse, the more severe the effect of within-journal citations would be. When an ellipse becomes a vertical line in a reference environment, authors in a journal have little interest in referring to other journals in this environment. If such a degenerated ellipse appears in a cited environment, a journal has little foreign citation impact in this environment.

The visualization is based on the algorithm of Kamada and Kawai (1989) as it is available in Pajek. This algorithm represents the network as a system of springs with relaxed lengths proportional to the edge length. Nodes are iteratively repositioned to minimize the overall ‘energy’ of the spring system using a steepest descent procedure. (The procedure is analogous to some forms of non-metric multi-dimensional scaling.) A disadvantage of this model is that unconnected nodes may remain randomly positioned across the visualization. Since we use the symmetrical cosine-matrices as input for the visualizations, the graphs are not directed.

Using the routines mentioned above, all journals covered by the CSTPCD in 2003 were mapped in terms of the cosines among the vectors of the journals in the environments of each seed journal. These matrices are available online at http://www.leydesdorff.net/. The relevant environment for each journal was determined by including all journals which cite or are cited by the journal under study to the extent of one percent of its citation rate in the respective dimension (He & Pao, 1986; Leydesdorff, 1986). This generates sets of the order of 10-50 journals, but we shall see that in the case of highly skewed distributions (for example, only within-journal citations) this procedure does not work.

3. Results

In order to make the analysis and results representative, we mainly select two sets of journals. The first set is for comparison among mono-disciplinary and multidisciplinary journals, and the second set is for comparison between Chinese and international journals. For mono-disciplinary journals we selected the Journal of Materials Engineering (JME). Another journal, Science in China B which is a chemistry journal, is selected to show some specific situation happened in mono-disciplinary journals. The Chinese version of Chinese Science Bulletin (CSB-C) is selected to represent multidisciplinary journals. The English version of Chinese Science Bulletin (CSB-E) is selected for international comparison with Science.
3.1 Citation environments of mono-disciplinary journals – the *Journal of Materials Engineering*

The core cited network

Table 1 lists the cited data of the *Journal of Materials Engineering* (*JME*) in some journals’ core cited environments. The data shows that a journal may have different *C/N* values in different cited environments, which implies that *C/N* ratio can only be meaningful in a specific environment.

<table>
<thead>
<tr>
<th>Seed Journal</th>
<th>Citations Received</th>
<th>N</th>
<th>Vertical Radii - C/N (%)</th>
<th>Horizontal Radii - C/N (%)</th>
<th>Self-citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>材料工程 (<em>JME</em>)</td>
<td>184</td>
<td>5,524</td>
<td>3.3</td>
<td>3.0</td>
<td>18</td>
</tr>
<tr>
<td>金属学报 (<em>Acta Metallurgica Sinica</em>)</td>
<td>138</td>
<td>5,638</td>
<td>2.4</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>材料导报 (<em>Materials Review</em>)</td>
<td>129</td>
<td>4,563</td>
<td>2.8</td>
<td>2.4</td>
<td></td>
</tr>
</tbody>
</table>

All journals in the cited environment of the *JME* are in materials science (Figure 1). The horizontal radius of the *Acta Metallurgica Sinica* (*AMS*) and *The Chinese Journal of Nonferrous Metals* (*CJNM*) are longer than those of other journals in Figure 1, which implies that the two journals have larger share of citations and, therefore, higher citation impact in the network. The difference between horizontal and vertical radius of other journals in the network are big, which means that these journals have heavy self-citations.

![Figure 1. The core cited environment of the *Journal of Materials Engineering* (cosine ≥ 0.2. Size of nodes:2).](image)

Through thickness of lines and links between journals, one can, to some extent, tell disciplinary similarities of journals based on their citation behavior. But for a better judgement, factor analysis is needed. Table 2 is the rotated component matrix of journals in the core cited environment of the *JME*. The factor loadings of *JME*, the *Materials Review*, the *Journal of Materials Science and Engineering*, the *Aerospace Materials & Technology*, and
the *Journal of Aeronautical Materials* are close, which means these journals have disciplinary similarities. The same applies to the *Transactions of Materials and Heat Treatment*, the *Heat Treatment of Metal*, and *Materials for Mechanical Engineering*.

<table>
<thead>
<tr>
<th>Journals</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>JME</td>
<td></td>
</tr>
<tr>
<td>Materials Review</td>
<td>.921</td>
</tr>
<tr>
<td>Journal of Materials Science and Engineering</td>
<td>.904</td>
</tr>
<tr>
<td>Aerospace Materials &amp; Technology</td>
<td>.864</td>
</tr>
<tr>
<td>Journal of Aeronautical Materials</td>
<td>.754</td>
</tr>
<tr>
<td>Transactions of Materials and Heat Treatment</td>
<td>.550</td>
</tr>
<tr>
<td>Materials for Mechanical Engineering</td>
<td>.550</td>
</tr>
<tr>
<td>Foundry</td>
<td>.901</td>
</tr>
<tr>
<td>Special Casting &amp; Nonferrous Alloys</td>
<td>.850</td>
</tr>
<tr>
<td>Hot Working Technology</td>
<td>.486</td>
</tr>
<tr>
<td>Materials Science and Technology</td>
<td>.138</td>
</tr>
<tr>
<td>Titanium Industry Progress</td>
<td>-.159</td>
</tr>
<tr>
<td>Acta Metallurgica Sinica</td>
<td>.107</td>
</tr>
<tr>
<td>China Metallurgica Sinica</td>
<td>.176</td>
</tr>
<tr>
<td>Journal of the Chinese Ceramic Society</td>
<td>.110</td>
</tr>
<tr>
<td>Journal of Northwestern Polytechnical University</td>
<td>.124</td>
</tr>
<tr>
<td>Ordnance Material Science and Engineering</td>
<td>.189</td>
</tr>
<tr>
<td>Acta Materiae Compositae Sinica</td>
<td>.101</td>
</tr>
<tr>
<td>China Surface Engineering</td>
<td>.153</td>
</tr>
<tr>
<td>China Plastics</td>
<td>-.137</td>
</tr>
<tr>
<td>Materials Protection</td>
<td>.124</td>
</tr>
<tr>
<td>Rare Metal Materials and Engineering</td>
<td>-.133</td>
</tr>
<tr>
<td>Chinese Journal of Rare Metals</td>
<td>.924</td>
</tr>
</tbody>
</table>

**The core citing environment**

Only two journals, the *JME* and the *金属学报 (Acta Metallurgica Sinica)* are included in the core citing environment of the *JME* (Figure 2). The ellipse size of *Acta Metallurgica Sinica* is larger than that of the *JME*, indicating that the *Acta Metallurgica Sinica* provides more reference than the *JME*. Both journals contain heavy self-citations. The fact that the *JME* cites a few journals implies that the journal is not active in citing other journals in the CSTPCD.
3.2 Isolated journals in a citation environment

Isolated journals may appear in a citation environment. This situation will be investigated by using the *Science in China B (SCB)* as a seed journal. In the cited environment of the *SCB*, there are no lines linking the journal 冰川冻土 (*Journal of Glaciology and Geocryology*) and other journals in the environment (Figure 3), meaning this journal has poor citation similarities with other journals. The cited matrix of the journal (Table 3) tells that the cited pattern of the *Journal of Glaciology and Geocryology* is different from those of the other journals. The upper-left side and the bottom side of Figure 3 are clusters of chemical journals. The upper-right side gathers multi-disciplinary journals. The other two journals on the left and right side are journals in geosciences. The 冰川冻土 (*Journal of Glaciology and Geocryology*) has slight similarities with these journals but such similarity is not as strong as those journals within a cluster.
Table 3. The cited matrix of the Science in China B.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>332</td>
<td>17</td>
<td>43</td>
<td>98</td>
<td>2</td>
<td>8</td>
<td>30</td>
<td>21</td>
<td>3</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>B</td>
<td>56</td>
<td>44</td>
<td>15</td>
<td>16</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>13</td>
<td>0</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>0</td>
<td>30</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>118</td>
<td>6</td>
<td>33</td>
<td>310</td>
<td>0</td>
<td>2</td>
<td>42</td>
<td>5</td>
<td>4</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>E</td>
<td>10</td>
<td>1</td>
<td>12</td>
<td>0</td>
<td>117</td>
<td>53</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>18</td>
<td>0</td>
<td>17</td>
<td>0</td>
<td>54</td>
<td>262</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>20</td>
<td>3</td>
<td>12</td>
<td>52</td>
<td>0</td>
<td>0</td>
<td>210</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>H</td>
<td>40</td>
<td>15</td>
<td>47</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>451</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>26</td>
<td>4</td>
<td>12</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>475</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>J</td>
<td>16</td>
<td>5</td>
<td>11</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>13</td>
<td>17</td>
<td>136</td>
<td>0</td>
</tr>
<tr>
<td>K</td>
<td>36</td>
<td>3</td>
<td>16</td>
<td>62</td>
<td>0</td>
<td>0</td>
<td>58</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>39</td>
</tr>
</tbody>
</table>

Note:
A: 科学通报 (Chinese Science Bulletin)
B: 自然科学进展 (Progress in Natural Science)
C: 中国科学 B (Science in China B)
D: 中国科学 D (Science in China C)
E: 物理化学学报 (Acta Physico-Chimica Sinica)
F: 化学学报 (Journal of the Chinese Chemical Society)
G: 地质论评 (Geological Review)
H: 大气科学 (Chinese Journal of Atmospheric Sciences)
I: 冰川冻土 (Acta Geologica Sinica)
J: 地理学报 (Acta Geographica Sinica)
K: 高校地质学报 (Geological Journal of China Universities)

3.3 Core citation environments of multi-disciplinary journals

3.3.1 The Chinese Science Bulletin (科学通报)

The core cited environment

In the core cited environment of the Chinese Science Bulletin (科学通报, CSB), the CSB, Science in China D (中国科学 D), and Acta Petrologica Sinica (岩石学报) have higher citation impact (Figure 4). In addition, the foreign citation impact of these journals is also high.
As the CSB is a multi-disciplinary journal, publications in this journal are supposed from different fields, and therefore having citation impact in various fields. But the fact is that journals citing the CSB are mainly from geoscience. In other words, citation impact of the CSB mainly happens in geoscience.

**The core citing environment**

The core citing environment of the CSB does not contain any other journals included in the CSTPCD when the threshold is set at 1%. In other words, the CSB only cites itself. Furthermore, the CSB is not interested in citing domestic journals. This situation happened to the JME as well.

What kind of journals are the JME and the CSB interested in? When it is impossible to find an answer in a domestic citation database (i.e., the CSTPCD) we have to shift to an international one, the Science Citation Index Expanded (SCIE). Although the JME is not covered by the SCIE, the English version of the CSB is covered. Figure 5 shows that international journals, especially Science and Nature, are the major sources cited by the English version of the CSB.

*Figure 4.* The core cited environment of the *Chinese Science Bulletin* (cosine ≥ 0.2, node size: 2)
Figure 5. The core citing environment of the English version of *Chinese Science Bulletin* (cosine ≥ 0.2, node size = 2).

The CSB, Science, and Nature are multidisciplinary, but the citing patterns of Science and Nature are similar, while the CSB is isolated in its own core citing environment. This indicates that Science and Nature are similar in terms of citing pattern as typical multidisciplinary journals, while the CSB is not. This corresponds to the result of the core cited environment of the Chinese version of the CSB (Figure 4): the CSB is mostly cited by journals in geoscience.

In addition, Figure 5 tells that Science and Nature have similar number of references since they have analogical size of vertical radius. Both journals have certain amount of self-citations, but the ratio is less than that of citing other journals. Another Chinese journal, the *Journal of Geophysical Research*, in Figure 5 is notable because of its distinct ratio of self-citations. Compared to other journals in the core citing environment of the CSB, 1) the CSB has much fewer references; 2) geoscience journals have higher ratio of being cited by the CSB.

3.3.2 Science

*The core cited environment*

Journals mainly cited by Science are the *Journal of Biological Chemistry*, the *Proceedings of the National Academy of Sciences of the United States of America*, and the *Journal of Geophysical Research*. This indicates that Science has citation impact in multidisciplinary fields with specific impact in biochemistry and geosciences (Figure 6). In the core cited environment of Science, both the *Proceedings of the National Academy of Sciences of the United States of America* and Science have high citation impact, while the *Journal of Geophysical Research* has severe self-citations.
The core cited environment of *Science* (cosine \(\geq 0.2\), node size = 10).

**The core citing environment**

In addition to be multidisciplinary, *Science* has special focus on physics, geophysics, astrophysics, and biochemistry. There are eight journals in the core cited environment of *Science*. Except multidisciplinary journals, journals in other fields like physics, geophysics, astrophysics, and biochemistry are also included (Figure 7). This implies that authors in *Science* do from various fields.
The citing and cited environments of *Science* shows that, except to be multidisciplinary, *Science* has special focus on biochemistry, physics, geophysics, and astrophysics.

Both Chinese domestic and international multidisciplinary journals have multi-disciplinary activity in terms of providing references: journals from different fields are included in their core citing environment. But with respect to citation impact, they tend to be more cited by journals from certain fields in addition to multidisciplinary journals. The Chinese multidisciplinary journals have notable citation impact in geosciences while the international journals have notable impact in biochemistry and geosciences.

### 4. Discussion and conclusions

Since there is no limit of citation years, journals published earlier may have more chances to be cited therefore get higher C/N ratio in a citation environment. Take Figure 1 for example, the *Acta Metallurgica Sinica* and the *Acta Metallurgica Sinica* are in the same field, but the former was established in 1956 and has the highest C/N ratio, while the latter was established in 1991 and has lower C/N ratio. The same situation applies to two journals in Figure 4: the *Chinese Science Bulletin* established in 1950 and the *Progress in Natural Science* established in 1990. Both journals are multidisciplinary. The former was established 40 years ahead of the latter. But establishing year is not the only factor deciding a journal’s C/N ratio. In Figure 4, the *Acta Petrologica Sinica* (岩石学报) and the *Acta Geologica Sinica* (地质学报) are in the same field – geology. The former was established in 1985, which is 63 years later than that of the latter. But the former has higher C/N ratio. Bensman and Wilder (1998) provided evidence that total citations correlate with perceived quality of journals more than the Impact Factors. Therefore, the C/N ratio is more rational for journals with similar SIZE. If the size of journals differs extraordinarily, the C/N ratio cannot be applied in evaluating journals.

Cosine can be used to measure similarities of journals’ citation pattern, therefore to help classify journal disciplines. Such similarities can be visualized by Pajek. When it is difficult to classify journals, factor analysis will help.

Chinese journals favour international counterparts while making references. Top Chinese journals are well-received in domestic community. Compared to international journals, Chinese journals provide fewer references. Multidisciplinary journals act multi-disciplinarily while providing references. In terms of citation impact, multi-disciplinary journals do impact multi-disciplinarily, in the meantime, with specific impact in certain fields.
Chapter 10

The citation impacts and citation environments of Chinese journals in mathematics

PING ZHOU,a,b LOET LEYDESDORFFb

a Institute of Scientific and Technical Information of China, Beijing (P. R. China)
b Amsterdam School of Communications Research (ASCoR), University of Amsterdam, Amsterdam (The Netherlands)

Scientometrics, Vol. 72, No. 2 (2007) 185–200
Reprinted with permission of the publisher

Based on the citation data of journals covered by the China Scientific and Technical Papers and Citations Database (CSTPCD), we obtained aggregated journal-journal citation environments by applying routines developed specifically for this purpose. Local citation impact of journals is defined as the share of the total citations in a local citation environment, which is expressed as a ratio and can be visualized by the size of the nodes. The vertical size of the nodes varies proportionally to a journal’s total citation share, while the horizontal size of the nodes is used to provide citation information after correction for the within-journal (self-) citations. In the “citing” environment, the equivalent of the local citation performance can also be considered as a citation activity index. Using the “citing” patterns as variables one is able to map how the relevant journal environments are perceived by the collective of authors of a journal, while the “cited” environment reflects the impact of journals in a local environment. In this study, we analyze citation impacts of three Chinese journals in mathematics and compare local citation impacts with impact factors. Local citation impacts reflect a journal’s status and function better than (global) impact factors. We also found that authors in Chinese journals prefer international instead of domestic ones as sources for their citations.

Introduction

In recent years, the percentage world share of scientific publications of the P. R. of China has increased exponentially (ZHOU & LEYDESDORFF, 2006). This trend is
expected to continue since the Chinese government plans to invest more in science. A recently issued medium and long-term plan on scientific and technological development requires that Chinese central and local government investments in science and technology increase faster than China’s economic growth rate (Jia, 2006). This strategy issued by the State Council of China will increase annual investment in R&D to 900 billion Yuan (US$112 billion) in 2020. This would boost the proportion of China’s gross domestic product spent on R&D from today’s 1.3% to 2.5%.

With this emphasis on S&T of the Chinese government, Chinese scientific journals will play increasing roles in scientific communication. However, as important communication channels for Chinese scientists, Chinese journals face fierce competition by their international counterparts. High-quality papers written by Chinese authors are usually submitted to international journals included in the SCI instead of domestic journals, because papers published by Chinese scientists in the SCI source journals can bring substantial rewards, such as professorships, research grants, and even housing (Jia, 2005). In order to improve the situation and help Chinese journals raise their qualities, the Chinese government has launched a campaign to boost Chinese journals. At the heart of the campaign is a new fund that will provide financial support to 300 to 500 scientific journals of the country. In addition, the government will encourage Chinese researchers to publish their results in domestic – rather than international – journals, and to place their results in free archives (Jia, 2005).

Since the campaign aims at supporting journals selectively, the policy question of how to evaluate journal quality becomes critical. Some may recommend selecting journals with higher impact factors in the same field and included in the SCI, the China Scientific and Technical Papers and Citations Database (CSTPCD), a database produced by the Institute of Scientific and Technical Information of China (ISTIC), or the Chinese Science Citation Database (CSCD), a database produced by Chinese Academy of Sciences (CAS) (Jin & Rousseau, 2004). Using such solutions to evaluate journal quality raises the following two problems: 1) journals with different citation patterns (i.e., disciplinary attribution) might be artificially classified as the same discipline; comparison among such journals is inappropriate; 2) Deliberate interventions by editors may weaken the objectivity of impact factors (Begley, 2006).

By using the routines introduced below, we hope to provide approaches for the Chinese government in the campaign of raising the quality of Chinese journals. The study focuses on two issues: disciplinary classification and local impact. We will compare the results achieved by using our routines with the results obtained with the currently available methods: inductive classifications and impact factors.
Materials and methods

Materials

In China, there are two databases engaged in the statistics of scientific publications. One is the China Scientific and Technical Papers and Citations Database (CSTPCD), and the other is the Chinese Science Citation Database (CSCD). In this study, we use the CSTPCD as the major data source. The CSTPCD was set up in 1988 analogously to the Science Citation Index (SCI) with the support of the Ministry of Science and Technology of China. The Institute of Scientific and Technical Information of China (ISTIC) has carried out and developed the project ever since, making the CSTPCD widely used by research institutions, scientific management organizations, and individual scientists to measure their research output (Wu et al., 2004). When the database was first established in 1988, only 1,189 journals were included. Fifteen years later (2004), this number had increased to 1,608 journals. This corresponds to a share of approximately 36% of the scientific journals published in China (Ren, 2005). Based on the CSTPCD, ISTIC publishes the Chinese S&T Journal Citation Reports (CSTJCR) annually, which is similar to the Journal Citation Reports (JCR) published by Institute of Science Information (ISI). We also use the Science Citation Index (SCI) to analyze the citation patterns of some Chinese journals in the international environment. We use data from 2003 and 2004, respectively. Routines that were recently further developed by us are used to extract matrices of journals that have either citing or cited relations (Zhou & Leydesdorff, 2007). In order to visualize citation relations among journals, we use the visualization program Pajek which is available at http://vlado.fmf.uni-lj.si/pub/networks/pajek/.

Methods

Scientific journals cite each other forming an aggregated journal-journal citation matrix. These matrices contain interesting information like disciplinary similarities and journal hierarchies. One can normalize the matrices by using the cosine as the similarity measure (Salton & McGill, 1983). Salton’s cosine is equivalent to the Pearson correlation coefficient (Jones & Furnas, 1987), but its non-parametric character has advantages in the case of sparse matrices (Ahlgren et al., 2003). For the purpose of the visualization, it is convenient that the cosine provides us with positive values only, while the Pearson correlation matrix also generates negative values. We will use the cosine between two vectors to measure similarities between the distributions of various journals included in a citation environment.

Through the routines one can obtain ‘citing’ and ‘cited’ matrices for each journal. In order to generate a citation matrix, we need first to select a journal – seed journal – to
run the routines. A ‘citing’ matrix gathers journals that are cited by authors in the seed journal, while a ‘cited’ matrix is composed of journals whose authors cite the seed journal. Each journal citing or being cited to the extent of more than one percent is drawn into the matrix (LEYDESDORFF & COZZENS, 1993). The matrices are in ASCII format and can be read directly into Pajek. Cosine values below 0.2 were suppressed in order to enhance the interpretability of the visualizations.

In the Pajek picture, the width of the lines between nodes (i.e., journals) corresponds to the cosine value. If a line is thick, it indicates that the citation patterns of the journals at the vertices are similar; if a line is thin, the similarities of the citation patterns between the two journals are weak. Since journals in the same discipline can be expected to have similar citation patterns, journals linked by thick lines and in strong components can be classified into the same disciplinary category. If journals are not connected by lines, these journals can be expected to belong to different disciplines.

The size of the nodes reflects the percentage contribution to the citations in a matrix – citing or cited, respectively.1 The grand sum of the citation matrix \( N (= \sum c_{ij}) \) is used as the basis for the normalization of the citation contributions. Each journal contributes with its marginal total \( C_i (= \sum c_i) \) to the grandsum. In a local citation environment, a journal’s contribution can be defined by this \( C_i/N \) ratio. This ratio will be used for determining the size of nodes. By distinguishing between the vertical size and the horizontal one of a node, a second parameter can be used to indicate this percentage also after correction for within-journal (self) citations (PRICE, 1981; NOMA, 1982). Thus, one is able to visualize how much a journal is dependent on an inner circle of authors citing one another by inspecting the shape of the nodes. Note that within-journal citations can be both self-citations of authors and citations among authors publishing in the same journal. In a citation picture, the shapes of nodes are consequently an ellipse in which the vertical and horizontal radii are different. The vertical radius of the ellipse indicates a journal’s citation share in a specific environment, while the horizontal radius of a node informs us about a journal’s share when within-journal citations are excluded.

In a ‘citing’ environment, the vertical radius represents the collective behaviour of authors in a journal in terms of percentage share of references in a local environment, while the horizontal radius represents a citation activity which maps whether authors in a journal are active in referring to other journals in the same environment. The larger a journal’s horizontal radius, the more active authors in a journal would be in citing other journals.

In a ‘cited’ environment, the vertical radius represents a journal’s citation impact, while the horizontal radius represents a journal’s citation impact to other journals in a local citation environment after correction for within self-citations. A larger horizontal

---

1 Because the ISI suppresses the single relations by summing them under the category ‘all others’, the citation matrix includes all citations above one. However, all citations, including single citations, are included in citation matrices from the CSTPCD.

*Scientometrics 72 (2007)*
radius means a stronger local citation impact. The difference between the vertical and horizontal radii of the ellipse indicates the extent of a journal’s within-journal citation. If the difference is large, the ellipse will be narrow. This indicates that the journal has a relatively large share of within-journal citations. However, if the difference is zero, the ellipse becomes a circle. This implies that the journal has no within-journal citations.

The narrower an ellipse, the more severe the effect of within-journal citations would be. When an ellipse becomes a vertical line in a reference environment, authors in a journal have little interest in referring to other journals in this environment. If such a degenerated ellipse appears in a cited environment, a journal has little citation impact to other journals in this environment.

The visualizations are based on the algorithm of Kamada & Kawai (1989) as it is available in Pajek. This algorithm represents the network as a system of springs with relaxed lengths proportional to the edge length. Nodes are iteratively repositioned to minimize the overall ‘energy’ of the spring system using a steepest descent procedure. (The procedure is analogous to some forms of non-metric multi-dimensional scaling.) A disadvantage of this model is that unconnected nodes may remain randomly positioned across the visualization. Since we use the symmetrical cosine-matrices as input for the visualizations, the graphs are not directed.

Using the routines mentioned above, all journals covered by the CSTPCD in 2003 and 2004 were mapped in terms of the cosines among the vectors of the journals in the environments of each seed journal. These matrices are available online at http://www.leydesdorff.net/istic04. The relevant environment for each journal was determined by including all journals which cite or are cited by the journal under study to the extent of one percent of its citation rate in the respective dimension (He & Pao, 1986; Leydesdorff, 1986). This generates sets of the order of 10-50 journals, but we shall see that in the case of highly skewed distributions (for example, only within-journal citations) this procedure does not work.

Results

Since China’s performance is most pronounced in the field of mathematics (DICCAS, 2004), journals in this field can be expected to provide us with the clearest pictures of how citation behavior may differ in domestic and international contexts. We selected a journal that has the highest impact factor in the category of mathematics classified by ISTIC in 2004, and compare the results with those for a journal with a much lower impact. We will explore the two issues of classification and impact through analyzing citation performance of the relevant citation environments of these journals in 2003 and 2004.
Citation patterns in the domestic environment

Cited patterns of JME and AMS-C. According to the CSTJCR 2004, the Journal of Mathematics Education which is published in Chinese with the Chinese title (we will call it JME below for convenience) has the highest impact factor (0.84) among journals in the category of mathematics. Another journal, the Acta Mathematica Sinica, is also published in Chinese with the Chinese title of (we will call it AMS-C as abbreviation). The impact factor of AMS-C is 0.30, ranking the fifth in the same category of JME. The titles indicate already that the two journals may have different functions for the development of the discipline.

a. The cited pattern of JME

Figures 1 and 2 provide visualizations of the citation impact environments of JME in 2003 and 2004, respectively. In Figure 1, five journals cited JME but these journals’ citation patterns are so different that there are no lines drawn between the vertices. This means that the citation patterns are not correlated. The ellipse of JME is very narrow, indicating that the journal has very heavy within-journal citations. In fact, the five journals in Figure 2 provided 259 references to JME, among which 239 were from JME itself. This corresponds with a share of 92%.

In 2004, one more journal is included in the citation impact environment of JME. The ellipse of JME has become even narrower than in 2003, which means that the share of within-journal citations increased. In 2004, JME was cited to a total of 284 times among which 273 (96%) were provided by papers in JME itself.

The two figures show convincingly that most of the citations to JME are from the journal itself, which implies that authors in the journal are not active in citing other journals. The other journals in its citation impact environment are university journals.

Figure 1. Citation impact environment of Journal of Mathematics Education in 2003 (CSTPCD, threshold = 1%; cosine ≥ 0.2)

Scientometrics 72 (2007)
Most of the university journals are from normal universities. The impact factors of these journals are very low, with ranks ranging from 58th to 84th among the 84 journals in the category of mathematics. University journals are multidisciplinary, publishing articles in various fields (JIN & LEYDESDORFF, 2005). Articles published in university journals and citing JME are in the field of mathematics. Thus we may conclude that the citation impact of JME is mainly within the journal, with a weak impact to normal university journals that publish articles in mathematics. This accords with the journal’s title which emphasizes mathematical education.

b. The cited pattern of AMS-C

Figure 3 provides a visualization for the citation impact environment of AMS-C in 2003. Twenty-eight journals contribute to the total citation of AMS-C in this year for at least one percent.
Journals in the center of the figure are linked by lines that are thicker than those among other journals. This means that the citation patterns of the journals in the center are similar. Therefore, these journals can be classified as belonging to the same discipline, i.e., mathematics in this case. In fact, all these journals have ‘mathematics’ in their titles. Journals in the periphery are university journals.

In Figure 3, the node that visualized AMS-C is a full circle, indicating that the within-journal citations of AMS-C in 2003 are zero. In addition, the node size of AMS-C is the largest in the figure, indicating that this journal has the highest local citation impact in its citation impact environment. The citation impact of AMS-C is distributed among mathematical journals and university journals.

The citation impact of the journal of AMS-C changed slightly in 2004 (Figure 4). In addition to one more journal joining the citation impact environment, the node of AMS-C is no longer a full circle: the difference between the horizontal and vertical radii is more pronounced than in Figure 3. This indicates that there are some within-journal citations in 2004. Nonetheless, AMS-C still had the highest citation impact in the citation impact environment of AMS-C. The impact of AMS-C in terms of fields is similar to 2003. Journals linked by thick lines and gathered in the core are in mathematics, while university journals are distributed in the periphery.

Both JME and AMS-C are classified by the ISTIC as journals in mathematics. If we use impact factors as indicators for the comparison, JME, with an impact factor of 0.84,
would rank higher than AMS-C which had an impact factor of 0.30. However, when we analyze their cited performances in relevant local environments, the impact of AMS-C is considerably higher than JME, for the following two reasons:

1) There are many more journals citing AMS-C than citing JME. In other words, AMS-C is more widely recognized among authors in other journals;

2) AMS-C influences more journals and more fields than JME does. The major impact of AMS-C is in mathematics journals, in addition to university journals.

From Figures 1, 2, 3 and 4 one can find interesting information: JME and AMS-C did not appear in each other’s citation environments. As the journal that had the highest impact factor in the field of mathematics, JME had no citation impact to AMS-C whose impact factor ranked lower (the fifth in the same category of mathematics). Additionally, JME has a weak citation impact on normal university journals.

Citing patterns of JME and AMS-C.

a. Citing patterns of JME

When the threshold is set at one percent, no other journals covered by CSTPCD are included in the reference environment of JME in either 2003 or 2004, except JME itself. This indicates three possibilities: 1) most of the references of JME were provided to itself; 2) journals cited by JME were not covered by the CSTPCD; and 3) combination of possibilities 1) and 2). The cited pattern of JME showed already that this journal has very heavy within-journal citation rates (Figures 1 and 2).

Upon closer inspection of the citation patterns, we found that JME cited only two journals covered by the CSTPCD. These two journals are JME itself and the Journal of Liaoning Normal University. Of the 274 references provided by JME to these two journals, 273 were within-journal citations. Only one reference was made to the Journal of Liaoning Normal University. Since the share of the Journal of Liaoning Normal University in the total number of references of JME is less than one percent, the Journal of Liaoning Normal University does not appear in the reference environment of JME.

Authors in JME provided 685 references in 2004. In addition to the 273 references to the journal itself and one reference to another Chinese journals, the other 411 references were given to articles in international journals. In other words, the percentage of references of JME provided to international journals and JME itself journals are 60% and 40%, respectively. The citation impact of international journals on articles in JME is much larger than the impact of domestic journals.

In 2003, JME provided 555 references to journals, of which 245 were to domestic journals and 310 were to international journals. Among the 245 references, only 6 were given to five other domestic journals. The share of within-journal citations of JME in the domestic environment was 98%. International journals and JME itself accounted for 56% and 43% of the total references in articles published in JME during 2003.
In summary, authors in JME have little interests in referring other journals in the domestic environment except JME itself. This journal has very heavy within-journal citations. However, international journals are favorite among authors in JME in terms of making references.

b. Citing patterns of AMS-C

In addition to AMS-C itself, only two other Chinese journals covered by the CSTPCD, but published in English, were included in the reference environment of AMS-C in 2003 (Figure 5).

The English edition of Acta Mathematica Sinica is published by the same editorial board as Acta Mathematica Sinica, but the articles are different. We will abbreviate the English journal of Acta Mathematica Sinica as AMS-E. In Figure 5, the ellipse of AMS-C is almost a perfect circle and this vertex has the largest radius in the graph. This result teaches us four things:

1) The lines among the three journals in Figure 5 are thick, indicating that these journals have very similar patterns in providing references. Citation patterns of AMS-C and AMS-E are the most similar, since the line between these two journals is the thickest;

2) There are virtually no within-journal citations in AMS-C since the node shape of AMS-C is a circle;

3) In its local reference environment, AMS-C is the most active journal in terms of making references to other journals;

---

2 In China, some journals are published in two languages, Chinese and English, but the English version is just a translation of the Chinese one.
4) Both *Acta Mathematica Sinica* and *Chinese Annals of Mathematics Series B* have large shares of within-journal citations in this environment since the two ellipse are very narrow.

In order to check these conclusions, we ran the routines also using 2004 data. While we found that AMS-C did not provide any references to itself in 2003, some changes happened in the citing pattern of AMS-C in 2004. In this year, authors in AMS-C provided 112 references to journals covered by the CSTPCD, among which 49 were within-journal citations. The total number of references of AMS-C, however, was 1,209 in 2004. Journals covered by the CSTPCD just took a share of 9% of the references of AMS-C, while international journals accounted for the remaining 91% of the references.

In the domestic science community, the citing activity of the two journals shows that JME mostly cited itself, while AMS-C is active in providing references to other journals, especially in 2003 when the journal did not provide a single reference to itself. AMS-C changed its citing pattern in 2004 a little bit by referring more often to articles published within it. However, within-journal citations do not constitute a large share of the total references in AMS-C. This share is just 9%. Authors in both JME and AMS-C prefer international journals in terms of making references. Over half of the references in JME are to international journals while this number is even higher for AMS-C (91% in 2004).

The citing patterns of the two journals show that international journals have a larger influence on Chinese journals than domestic ones. In the above analysis, international journals took 91% of the total references of AMS-C in 2004, while JME provided 40% of its total references to its international counterparts in that same year. Authors in AMS-C prefer citing internationally even more than authors in JME.

**Comparison of citation patterns in domestic and international environments**

In order to make the comparison more complete, we also selected *Acta Mathematica Sinica English Series* (AMS-E) as a seed journal. AMS-E is covered by both the CSTPCD and the SCI. Figures can thus be produced by using the journal as a seed in the two databases similarly.

Cited patterns in the two databases. In the domestic environment, AMS-E is not only visible among mathematic journals, but is also cited in articles which are published in university journals. In the domestic citation impact environment of AMS-E, AMS-C has the highest local citation impact since the node of AMS-C is the largest (Figure 6). In Figure 4 (above), the local impact of AMS-C was also the largest. With regards to JME, the journal that has the highest impact factor among mathematic journals in 2004, does not appear in either of the two figures. This means that JME cites neither AMS-C nor AMS-E.
In the international citation impact environment of AMS-E, AMS-E is integrated with its international counterparts. In other words, AMS-E has international visibility. Nevertheless, the nodes of Chinese journals in the international environment are invisible (Figure 7), which implies that the local international impact of Chinese journals is weak.
Citing patterns in the two databases. Using the CSTPCD, only two journals are in the reference environment of AMS-E in 2004; that is: the journal itself and its counterpart in Chinese, AMS-C (Figure 8). Of the 1,273 references to journals, 81 were to domestic journals in the CSTPCD with a share of 6%. AMS-E did not cite JME, although JME had the highest impact factor in 2004 in the category of mathematics.

Figure 8. Domestic reference environment of the Acta Mathematica Sinica English Series in 2004 (CSTPCD, threshold = 1%; cosine $\geq 0.2$)

Figure 9 provides the reference environment of the same journal (AMS-E) in the international environment based on the SCI. AMS-E cites more international journals than domestic ones in 2004. Except AMS-E and Science in China Series A (a Chinese journal in mathematics), all the others are international journals. It is clear that authors in AMS-E favor international journals included in the SCI for making references. AMS-E gives 94% of its references to international journals. Compared to international journals, authors in Chinese journals make less references since the node sizes of the two Chinese journals are very small while those of most international journals are relatively large.

In other words, Chinese journals in mathematics have a citation impact on both domestic and international journals. In the domestic environment, the citation impact can be seen among domestic mathematics journals and university journals. The local
citation impact of AMS-C is the highest. In the international environment, however, the impact of Chinese mathematics journals is lower than that of their international counterparts.

Chinese authors in mathematics favor international journals included in the SCI for making references. Compared to their international counterparts, Chinese journals provide less references. Although JME has the highest impact factor among domestic journals in mathematics, there is no mutual citation interests between JME and the two language versions of AMS. This may imply that the research interests of authors in JME are not relevant to papers in AMS-C and AMS-E, and vice versa. This might be because JME is a journal in mathematics education, while AMS-C and AMS-E focus on research in mathematics.

Conclusions and discussions

In this study, we analyzed citation patterns of three Chinese journals in mathematics. These are the Journal of Mathematics Education and the Chinese and English versions of Acta Mathematica Sinica (labeled as AMS-C and AMS-E respectively).

Although the Journal of Mathematics Education (JME) has the highest impact factor in 2004 in the category of mathematics in the CSTJCR, the citation impact of JME is mainly within the journal itself. Its weak impact on other journals is limited to university journals whose impact factors are low. As a journal with the highest impact factor in the category of mathematics, JME has no citation impact on the group of journals classified as mathematics journals. Furthermore, JME does not appear in either the reference environments or citation impact environments of the two language versions of AMS, and vice versa.

Acta Mathematica Sinica (AMS-C) has the highest local citation impact in the field of mathematics although its global impact factor is much smaller than that of JME. In addition to university journals, AMS-C is well recognized by Chinese authors in mathematics. In the domestic environment, the two language versions of AMS, especially AMS-C, have impact on other mathematic journals while JME’s impact is limited to itself with a weak impact on normal university journals. AMS-E has visibility in the international environment, but its citation impact is weak compared to its international counterparts.

Both JME and the two language versions of AMS favor international journals for making references. Although authors in JME prefer to cite articles in this journal itself, it gave 60% of its total references to international journals in 2004. International journals take an even higher share of references in AMS-C than in JME. This number was 91% in 2004.
Compared to AMS-C, the communication dimension of JME is much narrower. On the one hand, AMS-C is more active in providing references to other journals. On the other hand, AMS-C is more recognized by other journals including international ones. According to its title, JME is a journal in mathematics education. Our analysis also shows that JME does not have citation impact on mathematics journals but does have citation impact on university journals, especially journals of normal universities which mainly provide higher education to future teachers. Therefore, perhaps it is better to put JME into a category of education science. However, there is no such category available in the CSTJCR.

As an important journal engaging in higher education of mathematics, JME mainly serves for knowledge transfer, while AMS-C plays more a role in knowledge generation. A journal which is important for knowledge transfer has a higher impact factor than that of a journal which is central for knowledge generation in the same field.

In the category of mathematics in the CSTJCR, JME is the unique non-university journal for education. This situation makes JME an important communication platform and, therefore, an important reference source for articles in mathematics education. In other words, papers in mathematics education swarm into JME for publication. In the meantime, papers in JME become major reference sources of papers published in the journal, causing heavy within-journal citations.

The above analysis shows that evaluating a journal’s quality is not a simple task (LEYDESDORFF, 2006). In addition to global impact factors, other elements like local citation impact and the specific role of a journal should be considered. Peer review is another important approach for this purpose. Furthermore, it is inappropriate to compare journals serving different functions. JME has the highest impact factor, but its citation impact on other journals is very weak. Although the impact factor of AMS-C is less than that of JME, AMS-C’s citation impact on other scientific journals is the largest in its local citation impact environment.

The fact that Chinese authors favor international journals may indicate that they assess the quality of articles published in Chinese journals as less then those published in international journals. Hence, improving the quality of Chinese papers and journals is still a hard task for relevant players including authors, the government, and editorial boards.

*  

We would like to thank the statistics team of the Institute of Scientific and Technical Information of China, especially Ma Zheng, for providing us with relevant data.
Chapter 11

Analysis on the citation environments of Chinese journals in computer science


1. Introduction

In 2003, the China Scientific and Technical Papers and Citations Database (CSTPCD) covered 1,576 journals, among which 2,233,524 citing relations and 570,384 cited relations had happened. It is a hard task to find out journals that have citation relations manually. With the routines developed by Leydesdorff and Cozzens (1993) and later on improved by Leydesdorff, such kind of problems can be solved. A user only needs to select a journal s/he is interested in and runs the routines, a set of journals that have citing or cited relations with the seed journal would be collected automatically. The Pajek is used for the visualization.

We name the journal to be selected or interested in as a seed journal. The network of journals that are cited by the seed journal is called a citing network, while that of journals citing the seed journals is called a cited network. A journal may appear in different citing or cited networks. The citing/cited network of a seed journal is called the journal’s core citing/cited network.

Scientific journals cite each other forming an aggregated journal-journal citation matrix. These matrices contain interesting information like disciplinary similarities and journal hierarchies. One can normalize the matrices by using the cosine as the similarity measure (Salton & McGill, 1983). In a Pajek picture, thickness of lines between nodes (i.e., journals) corresponds to the cosine value. If a line is thicker, it indicates that the citation patterns of the journals at the vertices are similar; if a line is thinner, the similarities of the citation patterns between the two journals are weaker. Since journals in the same discipline can be expected to have similar citation patterns, journals linked by thick lines and in strong components can be classified into the same disciplinary category. If journals are not connected by lines, these journals can be expected to belong to different disciplines. In order to better delineate citation relations among journals, only lines with cosine $\geq 0.2$ are shown in Pajek pictures.

The percentage share of citing/cited counts of a journal in a specific citing/cited network ($C_{ij} / N$) is used to measure the performance of a journal in a specific citing/cited network. A journal may appear in different citing/cited networks therefore may have different $C_{ij} / N$ ratios. Since threshold is set at 1% in this paper, only journals with $C_{ij} / N > 1\%$ can be included in a specific network. In a citing (or cited) network $C_{ij}$ represents the times of journal $i$ citing (or being cited by) journal $j$. $N$ is the total number of citations happened among journals in a citing/cited matrix. To make it clear, in a citing environment, $N$ is the total number of citing counts made among journals in a citing matrix; and in a cited network, $N$ is the total number of citations happened among journals in a cited matrix. The calculation of $N$ can be expressed as:
\[ N = \sum C_{ij} \]

It is obvious that the value of \( C_{ij}/N \) is different from that of the impact factor (IF) because of the different perspectives. In a specific year, a journal may have different \( C_{ij}/N \) values in different local citing/cited networks but only one IF.

Citation behavior of journals can be divided into two types: within-journal citations and foreign citations. As there are debates about the role of within-journal citations, we calculate a journal’s \( C/N \) ratio separately. One is based on a journal’s total citing/cited counts and the other only counts on foreign citing/cited rates. In a citing/cited network, each journal is represented by a node. The size of a node is decided by the lengths of vertical and horizontal radii. The vertical radius is the ratio of the overall citing/cited counts to the total citing/cited counts, and the horizontal radius is the ratio of foreign citing/cited counts to the total citing/cited counts. The closer a node’s vertical and horizontal radii are the less within-journal citations exist. This phenomenon implies that the journal is active in referring other journals in a citing network. If this happens in a cited network it means that the journal has higher citation impact to other journals. If a node’s vertical radius equals to its horizontal radius, the corresponding journal does not have within-journal citations at all. On the contrary, if a node’s vertical radius is much longer than the horizontal one, it means the journal has remarkable within-journal citations and therefore less active in referring other journals in a citing environment. If this happens in a cited environment, this phenomenon means the journal’s foreign citation impact is weak. When a node’s horizontal radius is zero, the corresponding journal only has within-journal citations.

In this study, two Chinese journals with the highest impact factors (IF) in the category of computer science in the CSTPCD are selected. The first one is the 软件学报 (Journal of Software, in abbreviation JS) and the second one is 计算机学报 (Chinese Journal of Computers, in abbreviation CJC). The IFs of the JS and the CJC are 0.919 and 0.921 respectively in 2004. The two IFs are very close. Comparison analysis will be done for the citing/cited networks of the two journals in 2003 and 2004.

2. Results

2.1 Citation networks of the Journal of Software

The core citing network

Figure 1 is the citing network of the Journal of Software (JS) in 2003. The JS had 3,780 journal references in total. Of the journals referred by the JS, 45 are included in the CSTPCD and have been cited by 417 times. The majority of the references of the JS, which are 3,780 – 417 = 3,363 or 89% of the total are referred to either international or domestic journals which are not included by the CSTPCD in 2003. As the CSTPCD covers most important domestic S&T journals and important journals receive more citations, we conjecture that most of the rest 3,363 references are made to international journals. This situation applies to citation environments analyzed in the latter cases.
Of the 417 references, 169 are within-journal citations of the JS. When the threshold is set as 1%, only the Chinese Journal of Computers (CJC) is included and has been cited for 86 times by the JS. The two journals took 61% of the JS’s domestic references. Therefore the CJC is the most favorable foreign journal of the JS in terms of providing references in 2003. Both journals have apparent within-journal citations.

In 2004, the JS had provided 2,628 journal references, which is much less than that in 2003. 260 references are provided to 32 journals covered by the CSTPCD. Compared to 2003, the JS cited fewer domestic journals in 2004. For the same reason discussed above, most of the rest 1,338 (=2,628 – 260) references (i.e., 90%) are provided to international journals. When threshold is set as 1%, three journals appear in the citing network of the JS, which are the Journal of Software, Chinese Journal of Computers, and the Journal of Computer Research and Development. Namely, the JS dispersed its reference focus to one more journals, although the total number of domestic journals being cited is reduced dramatically. The JS provided 60% of its domestic references to the three journals. Compared to 2003, the JS has less within-journal citations in 2004. Among the three journals, within-journal citations in the 计算机研究与发展 (Journal of Computer Research and Development) is more apparent (Figure 2).
Figure 2. The core citing network of the 软件学报 (Journal of Software) in 2004 (threshold = 1%, cosine ≥ 0.2).

The core cited networks

Although citing few domestic journals, the JS is well-received by other domestic journals. In 2003, the JS received 1,391 citations. In its core cited network, the JS was cited 892 times by 15 journals, which is 56% of the total. Of the 15 journals, the Computer Engineering and Applications cited the JS the most with 200 times. The number of within-journal citations of the JS is also rather high (169 times). Table 1 lists detailed citation information of the 15 journals.

The JS has the largest citation impact in its core cited network. The other journals which have notable citation impact are the Computer Engineering and Applications (计算机工程与应用), the Journal of Computer Research and Development (计算机研究与发展), and the Chinese Journal of Computers (计算机学报) (Figure 3). The citation impact of the Computer Engineering and Applications in this network is an exception which will be discussed in the conclusion part.
Table 1. The cited matrix of the *Journal of Software* in 2003.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>94</td>
<td>16</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>11</td>
<td>121</td>
<td>6</td>
<td>3</td>
<td>29</td>
<td>5</td>
<td>39</td>
<td>5</td>
<td>29</td>
<td>16</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>12</td>
<td>165</td>
<td>13</td>
<td>16</td>
<td>5</td>
<td>18</td>
<td>5</td>
<td>19</td>
<td>9</td>
<td>1</td>
<td>16</td>
<td>10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>6</td>
<td>11</td>
<td>3</td>
<td>167</td>
<td>81</td>
<td>10</td>
<td>2</td>
<td>8</td>
<td>46</td>
<td>65</td>
<td>0</td>
<td>22</td>
<td>37</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>169</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>86</td>
<td>25</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>10</td>
<td>44</td>
<td>9</td>
<td>51</td>
<td>70</td>
<td>163</td>
<td>28</td>
<td>51</td>
<td>68</td>
<td>84</td>
<td>17</td>
<td>110</td>
<td>51</td>
<td>53</td>
<td>17</td>
</tr>
<tr>
<td>G</td>
<td>2</td>
<td>28</td>
<td>10</td>
<td>5</td>
<td>27</td>
<td>6</td>
<td>211</td>
<td>2</td>
<td>30</td>
<td>16</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>10</td>
<td>18</td>
<td>1</td>
<td>26</td>
<td>24</td>
<td>45</td>
<td>9</td>
<td>201</td>
<td>16</td>
<td>36</td>
<td>6</td>
<td>68</td>
<td>32</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td>45</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>81</td>
<td>24</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>J</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>26</td>
<td>5</td>
<td>11</td>
<td>0</td>
<td>25</td>
<td>147</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>K</td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>13</td>
<td>30</td>
<td>18</td>
<td>2</td>
<td>13</td>
<td>6</td>
<td>11</td>
<td>13</td>
<td>30</td>
<td>10</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>20</td>
<td>84</td>
<td>30</td>
<td>115</td>
<td>200</td>
<td>87</td>
<td>53</td>
<td>76</td>
<td>141</td>
<td>182</td>
<td>10</td>
<td>506</td>
<td>83</td>
<td>41</td>
<td>18</td>
</tr>
<tr>
<td>M</td>
<td>1</td>
<td>21</td>
<td>1</td>
<td>71</td>
<td>119</td>
<td>32</td>
<td>11</td>
<td>12</td>
<td>115</td>
<td>81</td>
<td>14</td>
<td>37</td>
<td>120</td>
<td>32</td>
<td>3</td>
</tr>
<tr>
<td>N</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>18</td>
<td>27</td>
<td>29</td>
<td>7</td>
<td>17</td>
<td>26</td>
<td>35</td>
<td>2</td>
<td>51</td>
<td>20</td>
<td>81</td>
<td>2</td>
</tr>
<tr>
<td>O</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>14</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>2</td>
<td>16</td>
<td>12</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

**Note:**
- A — 武汉大学学报信息科学版
- B — 中国图象图形学报
- C — 系统仿真学报
- D — 计算机科学
- E — 软件学报 (Journal of Software)
- F — 计算机工程
- G — 计算机辅助设计与制造学报
- H — 计算机辅助设计与制造学报
- I — 计算机学报 (Journal of Computer Science)
- J — 计算机研究与发展
- K — 计算机工程与设计
- L — 计算机工程与设计
- M — 小型微型计算机系统
- N — 计算机应用
- O — 计算机工程与科学

Figure 3. The core cited network of the *Journal of Software* in 2003 (threshold = 1%, cosine ≥ 0.2).
In 2004, the citation impact of the *JS* had been increased since two more journals are included in its core cited network. The two journals are 微电子学与计算机 and 计算机集成制造系统-CIMS (Figure 4).

![Figure 4](image-url)  
*Figure 4. The core cited network of the *Journal of Software* in 2004 (threshold = 1%, cosine ≥ 0.2).*

Compared to 2003, the *JS* has less within-journal citations and still keeps the position of the highest citation impact in its core cited network in 2004. The other three journals with notable citation impact in 2003 keep their high citation impact in 2004. The three journals are the *Computer Engineering and Applications* (计算机工程与应用), the *Journal of Computer Research and Development* (计算机研究与发展), and the *Chinese Journal of Computers* (计算机学报).

While receiving more citation rates (i.e., 1598), the *JS* largely reduced its within-journal citations in 2004. The 73 within-journal citations in 2004 is less than half of that (i.e., 169) in 2003. This implies that the foreign citation impact of the *JS* has been increased remarkably. The *Computer Engineering and Applications* (计算机工程与应用) is still the first citer of the *JS*. The cited matrix of the *JS* is listed in Table 2.

Only a few Chinese journals are referred by the *Journal of Software* (*JS*). But the *JS* has extended its focus in terms of citing domestic journals from two to three. Within-journal citations exist in the *JS* but have been notably reduced from 2003 to 2004. International journals are the most favourite in terms of making references. A majority number of references of the *JS* are provided to international journals. This implies that the authors of the *JS* emphasize more on learning from their international counterparts, or, international output has higher impact to Chinese authors in the *JS*. In the domestic community, the *JS* has the highest citation impact.
### Table 2. The cited matrix of the *Journal of Software* in 2004.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27</td>
<td>20</td>
<td>15</td>
<td>1</td>
<td>10</td>
<td>19</td>
<td>22</td>
<td>4</td>
<td>14</td>
<td>21</td>
<td>24</td>
<td>4</td>
<td>30</td>
<td>16</td>
<td>16</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>192</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>21</td>
<td>10</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>21</td>
<td>83</td>
<td>3</td>
<td>1</td>
<td>18</td>
<td>3</td>
<td>16</td>
<td>2</td>
<td>18</td>
<td>9</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>20</td>
<td>25</td>
<td>243</td>
<td>4</td>
<td>24</td>
<td>11</td>
<td>21</td>
<td>5</td>
<td>25</td>
<td>22</td>
<td>2</td>
<td>19</td>
<td>8</td>
<td>7</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>22</td>
<td>8</td>
<td>5</td>
<td>104</td>
<td>75</td>
<td>13</td>
<td>8</td>
<td>13</td>
<td>58</td>
<td>57</td>
<td>1</td>
<td>28</td>
<td>16</td>
<td>12</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>12</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>73</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>45</td>
<td>39</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>9</td>
<td>32</td>
<td>41</td>
<td>16</td>
<td>41</td>
<td>89</td>
<td>137</td>
<td>30</td>
<td>49</td>
<td>68</td>
<td>87</td>
<td>10</td>
<td>121</td>
<td>46</td>
<td>41</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>8</td>
<td>26</td>
<td>7</td>
<td>5</td>
<td>43</td>
<td>3</td>
<td>215</td>
<td>2</td>
<td>41</td>
<td>17</td>
<td>4</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>4</td>
<td>34</td>
<td>44</td>
<td>9</td>
<td>31</td>
<td>54</td>
<td>85</td>
<td>21</td>
<td>304</td>
<td>50</td>
<td>61</td>
<td>4</td>
<td>108</td>
<td>45</td>
<td>30</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>J</td>
<td>0</td>
<td>25</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>40</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>73</td>
<td>20</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>K</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>12</td>
<td>48</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>40</td>
<td>96</td>
<td>0</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>5</td>
<td>12</td>
<td>5</td>
<td>1</td>
<td>16</td>
<td>38</td>
<td>61</td>
<td>9</td>
<td>36</td>
<td>28</td>
<td>34</td>
<td>35</td>
<td>64</td>
<td>20</td>
<td>31</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>M</td>
<td>12</td>
<td>81</td>
<td>100</td>
<td>28</td>
<td>78</td>
<td>236</td>
<td>107</td>
<td>47</td>
<td>56</td>
<td>138</td>
<td>153</td>
<td>20</td>
<td>548</td>
<td>73</td>
<td>41</td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>N</td>
<td>3</td>
<td>30</td>
<td>17</td>
<td>5</td>
<td>53</td>
<td>93</td>
<td>18</td>
<td>13</td>
<td>8</td>
<td>86</td>
<td>111</td>
<td>0</td>
<td>26</td>
<td>136</td>
<td>3</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>O</td>
<td>4</td>
<td>28</td>
<td>25</td>
<td>13</td>
<td>26</td>
<td>56</td>
<td>75</td>
<td>20</td>
<td>30</td>
<td>42</td>
<td>44</td>
<td>13</td>
<td>86</td>
<td>30</td>
<td>68</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>P</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>10</td>
<td>8</td>
<td>23</td>
<td>8</td>
<td>15</td>
<td>4</td>
<td>9</td>
<td>10</td>
<td>1</td>
<td>18</td>
<td>11</td>
<td>4</td>
<td>146</td>
<td>0</td>
</tr>
<tr>
<td>Q</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>2</td>
<td>11</td>
<td>25</td>
<td>23</td>
<td>3</td>
<td>8</td>
<td>15</td>
<td>28</td>
<td>2</td>
<td>19</td>
<td>19</td>
<td>3</td>
<td>1</td>
<td>18</td>
</tr>
</tbody>
</table>

**Note:**
- A – 微电子学与计算机
- B – 电子学报
- C – 中国图象图形学报
- E – 计算机科学
- F – 计算机工程
- G – 计算机工程
- H – 计算机应用研究
- I – 计算机科学
- K – 计算机工程
- L – 计算机工程
- M – 计算机工程与应用
- O – 计算机应用
- Q – 计算机工程与科学
- D – 系统仿真学报
- J – 仿真学报 (Journal of Software)
- F – 计算机辅助设计与图形学学报
- H – 计算机辅助设计与图形学学报
- K – 计算机辅助设计与图形学学报
- L – 计算机辅助设计与图形学学报
- M – 计算机辅助设计与图形学学报
- O – 计算机辅助设计与图形学学报
- P – 计算机辅助设计与图形学学报

### 2.2 The citation network of the *Chinese Journal of Computers*

**The core citing network**

Similar to the *JS* the *Chinese Journal of Computers (CJC)* also favors international journals while making references. In 2003, the *CJC* had 3,244 references in total of which only 317 were made to 62 Chinese journals covered by the *CSTPCD*. Most of the rest 2,927 (= 3,244 – 317), which is 90% of the total, were referred to international journals.

Of the 317 domestic references, 81 are within-journal citations of the *CJC*. When threshold = 1%, only the *JS* is in the core citing network (Figure 5). In domestic community, the *JS* and the *CJC* favours each other in terms of providing references. Or, we may say that the two journals are ranked the highest quality by Chinese domestic scholars in this field.

Figures 1 and 5 are similar but are obtained with different journals as the seed. Both journals have notable within-journal citations. In terms of citing activeness, the *JS* is more active in providing references than the *CJC*.
In 2004, the CJC had 3,060 references, among which 281 were made to 57 journals covered by the CSTPCD. Most of the rest 2,779 (= 3,060 – 281) references, which is 91% of the total, were provided to international journals. Compared to 2003, the CJC increased its citations to international counterparts.

Journals included in the citing network of the CJC were the same (i.e., the CJC and the JS) in 2003 and 2004. The JS was still the first domestic journal to be cited by the CJC (Figure 6). The citing activeness of the CJC had been increased to the level of the JS.

Figure 5. The core citing network of the Chinese Journal of Computers in 2003 (threshold = 1%, cosine ≥ 0.2).

Figure 6. The core citing network of the Chinese Journal of Computers in 2004 (threshold = 1%, cosine ≥ 0.2).

The core cited network
Table 3. The core cited matrix of the *Chinese Journal of Computers* in 2003.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
<td>22</td>
<td>5</td>
<td>9</td>
<td>16</td>
<td>10</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>14</td>
<td>9</td>
<td>16</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>132</td>
<td>7</td>
<td>0</td>
<td>4</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>15</td>
<td>12</td>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>22</td>
<td>121</td>
<td>6</td>
<td>3</td>
<td>29</td>
<td>5</td>
<td>39</td>
<td>11</td>
<td>5</td>
<td>29</td>
<td>16</td>
<td>10</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>9</td>
<td>12</td>
<td>165</td>
<td>13</td>
<td>16</td>
<td>5</td>
<td>18</td>
<td>3</td>
<td>5</td>
<td>19</td>
<td>9</td>
<td>16</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>25</td>
<td>11</td>
<td>3</td>
<td>167</td>
<td>81</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>8</td>
<td>46</td>
<td>65</td>
<td>22</td>
<td>37</td>
<td>9</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
<td>20</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>169</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>86</td>
<td>25</td>
<td>2</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>2</td>
<td>16</td>
<td>44</td>
<td>9</td>
<td>51</td>
<td>70</td>
<td>163</td>
<td>28</td>
<td>28</td>
<td>51</td>
<td>68</td>
<td>84</td>
<td>110</td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>H</td>
<td>1</td>
<td>6</td>
<td>28</td>
<td>10</td>
<td>5</td>
<td>27</td>
<td>6</td>
<td>211</td>
<td>5</td>
<td>2</td>
<td>30</td>
<td>16</td>
<td>4</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>I</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>19</td>
<td>0</td>
<td>20</td>
<td>14</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>J</td>
<td>6</td>
<td>11</td>
<td>18</td>
<td>1</td>
<td>26</td>
<td>24</td>
<td>45</td>
<td>9</td>
<td>3</td>
<td>201</td>
<td>16</td>
<td>36</td>
<td>68</td>
<td>32</td>
<td>11</td>
</tr>
<tr>
<td>K</td>
<td>1</td>
<td>20</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td>45</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>81</td>
<td>24</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>0</td>
<td>11</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>26</td>
<td>5</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>25</td>
<td>147</td>
<td>0</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>M</td>
<td>6</td>
<td>71</td>
<td>84</td>
<td>30</td>
<td>115</td>
<td>200</td>
<td>87</td>
<td>53</td>
<td>40</td>
<td>76</td>
<td>141</td>
<td>182</td>
<td>506</td>
<td>83</td>
<td>41</td>
</tr>
<tr>
<td>N</td>
<td>1</td>
<td>29</td>
<td>21</td>
<td>1</td>
<td>71</td>
<td>119</td>
<td>32</td>
<td>11</td>
<td>18</td>
<td>12</td>
<td>115</td>
<td>81</td>
<td>37</td>
<td>120</td>
<td>32</td>
</tr>
<tr>
<td>O</td>
<td>1</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>18</td>
<td>27</td>
<td>29</td>
<td>7</td>
<td>8</td>
<td>17</td>
<td>26</td>
<td>35</td>
<td>51</td>
<td>20</td>
<td>81</td>
</tr>
</tbody>
</table>

**Note:**
- A - 微电子学与计算机
- B - 电子学报
- C - 中国图象图形学报
- D - 系统仿真学报
- E - 计算机科学
- F - 软件学报 (*Journal of Software*)
- G - 计算机工程
- H - 计算机辅助设计与图学学报
- I - 模式识别与人工智能
- J - 计算机应用研究
- K - 计算机学报 (*Chinese Journal of Computers*)
- L - 计算机研究与发展
- M - 计算机工程与应用
- N - 小型微型计算机系统
- O - 计算机应用

Similar to the *JS*, the *CJC* is also well-received by domestic journals although it likes to refer international counterparts. In 2003, the *CJC* had been cited for 1,234 times. In its core cited network the *CJC* received 731 citations, which is 59% of the total citations. Journals which are mostly cited by the *CJC* are 计算机工程与应用 (*Computer Engineering and Applications*) and 小型微型计算机系统 (*Journal of Chinese Computer System*). Detail cited information of the *CJC* is listed in Table 3.

In the *CJC*’s core cited network in 2003, the *JS* has the highest citation impact. Other journals including the *CJC* itself and the 计算机研究与发展 (*Journal of Computer Research and Development*) have pronounced citation impact as well. Within-journal citations in the three journals, especially in the *CJC* and the *JS* are not obvious (Figure 7).
Figure 7. The core cited network of the Chinese Journal of Computers in 2003 (threshold = 1%, cosine ≥ 0.2).

Similar to the JS whose citation impact was extended to more journals in 2004, the CJC also included two more journals in its cited network in 2004 at the same threshold (1%) (Figure 8). The two new journals included in the core cited network of the CJC are 计算机工程与设计 (Computer Engineering & Design) and 计算机工程与科学 (Computer Engineering and Science).

The JS still has the highest citation impact in the core cited network of the CJC. Other journals with remarkable citation impact also keep similar impact as those in the core cited network of the CJC in 2003. These journals are the JS, the CJC, and 计算机研究与发展 (Journal of Computer Research and Development). The citation impact of 计算机工程与应用 (Computer Engineering and Applications) increased in 2004. But within-journal citation in the Computer Engineering and Applications is also quite clear.
In 2004, the CJC had been cited for 1,370 times, which is 135 times more than that in 2003. In the meantime the within-journal citations of the CJC were reduced to 73 times. This means that the foreign citation impact of the CJC has been increased, either in terms of citation counts or the number of journals referring the CJC. The 计算机工程与应用 (Computer Engineering and Applications) is still the journal providing the most citations to the CJC (Table 4).

Similar to the JS, the CJC mainly cites international journals. In the two studied years, around 90% of the references of the CJC are provided to international journals. International journals are the main knowledge source of the CJC authors. In other words, publications of international authors have much higher impact to the CJC authors.

In the core cited network of the Chinese Journal of Computers (CJC), the journal with the highest citation impact is the Journal of Software instead of the CJC itself.
Table 4. The core cited matrix of the *Chinese Journal of Computers* in 2004.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>27</td>
<td>20</td>
<td>15</td>
<td>1</td>
<td>10</td>
<td>19</td>
<td>22</td>
<td>4</td>
<td>5</td>
<td>14</td>
<td>21</td>
<td>24</td>
<td>4</td>
<td>30</td>
<td>16</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>192</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>21</td>
<td>10</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>21</td>
<td>83</td>
<td>3</td>
<td>18</td>
<td>3</td>
<td>16</td>
<td>9</td>
<td>2</td>
<td>18</td>
<td>9</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>20</td>
<td>25</td>
<td>243</td>
<td>4</td>
<td>24</td>
<td>11</td>
<td>21</td>
<td>8</td>
<td>5</td>
<td>25</td>
<td>22</td>
<td>2</td>
<td>19</td>
<td>8</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>22</td>
<td>8</td>
<td>5</td>
<td>104</td>
<td>75</td>
<td>13</td>
<td>8</td>
<td>7</td>
<td>13</td>
<td>58</td>
<td>57</td>
<td>1</td>
<td>28</td>
<td>16</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>12</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>73</td>
<td>0</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>45</td>
<td>39</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>G</td>
<td>9</td>
<td>32</td>
<td>41</td>
<td>16</td>
<td>41</td>
<td>89</td>
<td>137</td>
<td>30</td>
<td>8</td>
<td>49</td>
<td>68</td>
<td>87</td>
<td>10</td>
<td>121</td>
<td>46</td>
<td>41</td>
<td>12</td>
</tr>
<tr>
<td>H</td>
<td>0</td>
<td>8</td>
<td>26</td>
<td>7</td>
<td>5</td>
<td>43</td>
<td>3</td>
<td>215</td>
<td>9</td>
<td>2</td>
<td>41</td>
<td>17</td>
<td>4</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>0</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>0</td>
<td>14</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>J</td>
<td>4</td>
<td>34</td>
<td>44</td>
<td>9</td>
<td>31</td>
<td>54</td>
<td>85</td>
<td>21</td>
<td>8</td>
<td>304</td>
<td>50</td>
<td>61</td>
<td>4</td>
<td>108</td>
<td>45</td>
<td>30</td>
<td>14</td>
</tr>
<tr>
<td>K</td>
<td>0</td>
<td>25</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>40</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>73</td>
<td>20</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>L</td>
<td>0</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>12</td>
<td>48</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>40</td>
<td>96</td>
<td>0</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>M</td>
<td>5</td>
<td>12</td>
<td>5</td>
<td>1</td>
<td>16</td>
<td>38</td>
<td>61</td>
<td>9</td>
<td>11</td>
<td>36</td>
<td>28</td>
<td>34</td>
<td>35</td>
<td>64</td>
<td>20</td>
<td>31</td>
<td>8</td>
</tr>
<tr>
<td>N</td>
<td>12</td>
<td>81</td>
<td>100</td>
<td>28</td>
<td>78</td>
<td>236</td>
<td>107</td>
<td>47</td>
<td>37</td>
<td>56</td>
<td>138</td>
<td>153</td>
<td>20</td>
<td>548</td>
<td>73</td>
<td>41</td>
<td>33</td>
</tr>
<tr>
<td>O</td>
<td>3</td>
<td>30</td>
<td>17</td>
<td>5</td>
<td>53</td>
<td>93</td>
<td>18</td>
<td>13</td>
<td>8</td>
<td>8</td>
<td>86</td>
<td>111</td>
<td>0</td>
<td>26</td>
<td>136</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>P</td>
<td>4</td>
<td>28</td>
<td>25</td>
<td>13</td>
<td>26</td>
<td>56</td>
<td>75</td>
<td>20</td>
<td>4</td>
<td>30</td>
<td>42</td>
<td>44</td>
<td>13</td>
<td>86</td>
<td>30</td>
<td>68</td>
<td>14</td>
</tr>
<tr>
<td>Q</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>2</td>
<td>11</td>
<td>25</td>
<td>23</td>
<td>3</td>
<td>0</td>
<td>8</td>
<td>15</td>
<td>28</td>
<td>2</td>
<td>19</td>
<td>19</td>
<td>3</td>
<td>18</td>
</tr>
</tbody>
</table>

**Note:**

A - 微电子学与计算机  
B - 电子学报  
C - 中国图象图形学报  
D - 系统仿真学报  
E - 计算机科学  
F - 软件学报  
G - 计算机工程  
H - 计算机辅助设计与图学学报  
I - 模式识别与人工智能  
J - 计算机应用研究  
K - 计算机学报  
L - 计算机研究与发展  
M - 计算机工程与设计  
N - 计算机工程与应用  
O - 小型微型计算机系统  
P - 计算机应用  
Q - 计算机工程与科学

3. Conclusions and discussion

Based on the above results the following conclusions can be made:

- in the computer science, the impact of international journals is much higher than that of Chinese domestic ones;
- the *Journal of Software* has the highest citation impact in Chinese computer field, which roughly corresponds to the value of impact factors;
- the fact that the *Journal of Software* and the *Chinese Journal of Computers* only cite each other in their core citing networks implies that the two are the most important journals in Chinese computer field;
- Chinese journals favor international journals in providing references.

In this study, the following two facts need further discussion:
As mentioned before, the Impact Factors of the *JS* and the *CJC* in 2004 are 0.919 and 0.921 respectively. The IF of the *CJC* is slightly higher than that of the *JS*. But their C/N ratios tell a different situation: in the core cited networks of either the *JS* or the *CJC*, the C/N ratio is notably higher than that of the *CJC*.

The situation of the journal *计算机工程与应用* (*Computer Engineering and Applications, CEA*) is another case. This journal has notable citation impact in the core cited networks of the two studied journals. Such variation mainly lies in the different perspectives of the two indicators.

The Impact Factor (IF) is defined as the average number of citations in a year given to those papers in a journal that were published during the two preceding years. A journal’s citation impact is normalised by both the number of publications and years of citations, namely a citation window. The strength of the IF is its independence of the ‘size’ of a journal, its comprehensibility, stability, and seemingly reproducibility. But the IF has some obvious flaws (Garfield, 2003; Pinski & Narin, 1976; Amin & Mabe, 2000). In practice, the IF is mainly applied to evaluating journals which are classified into the same category. But journal classification is still an unsolved problem since many journals, especially multi-disciplinary journals, cannot unambiguously classified into categories on the basis of their aggregated citation patterns (Leydesdorff, 2006). All sets are overlapping and fuzzy (Bradford, 1934; Garfield, 1971). For lack of an agreed-upon alternative, the subject categories established by the Institute of Science Information of Thomson Scientific are often used for “comparing like with like” (Martin & Irvine, 1983). But the ISI classifications match poorly with classifications derived from the database itself on the basis of analysis of the principal components of the networks generated by citations (Leydesdorff, 2006). When the foundation of “comparing like with like” cannot reflect the practical situation, the results based on such a foundation may bring problems.

The C/N ratio is also used to measure journal citation impact. It is defined as the share of citations received by a journal in a LOCAL cited network. All citations a journal received from journals within the local network in the studied year are counted. The normalization is based on citations happened among journals in a local network. Since a local citation network gathers journals with disciplinary similarities, comparing journals in the same citation network is more reasonable than comparing journals classified artificially. It is natural to think that journals publishing in earlier years may have more chances to be cited. But Bensman and Wilder (1998) provided evidence that total citations correlate with perceived quality of journals more than the impact factors. Therefore, comparison based on the C/N ratio is more reasonable for journal with similar SIZE. If the size of journals differs extraordinarily, the C/N ratio cannot be applied in evaluating journals.

The citation situation of the *JS* and the *CJC* further confirms the conclusion of Bensman and Wilder (1998). The establishing times of the two journals differ largely, the *JS* was in 1990 and the *CJC* was in 1978. From the perspective of establishing time, the *CJC* has more chances to be cited since it has existed 12 years earlier than the *JS*. The numbers of papers published in the two journals are similar. To some extent, the *CJC* also has some superiority since it publishes somewhat more papers than the *JS*. For example, in 2004, the *JS* published 207 papers and the *CJC* published 234 papers. Although the *CJC* has two advantages in terms of the calculation of the C/N ratio, it still has lower C/N ratio than the *JS*. Therefore, the C/N ratio is more persuasive than using the Impact Factor in measuring citation impact.
But if the size of a journal is too big than that of others to be compared, the size may cause severe bias using $C/N$ ratio to measure journal citation impact. This is exactly the case of the 《计算机工程与应用》 (Computer Engineering and Applications, CEA). In 2004, the CEA published 36 issues and around 70 papers in each issue. Therefore the total papers the CEA published in 2004 were at least 2,520. While the Journal of Software publishes 12 issues annually with 207 papers in total in the same year, which is over 10 times fewer than that in the CEA. If citations paper for the two journals were one, the CEA may receive 2,520 counts and the JS can only receive 207 counts.

One must be cautious while comparing citing activity among Chinese journals since domestic citation databases can only reflect activity among domestic journals. For journals mainly citing international counterparts, result only based their domestic core citing network may lead to a wrong conclusion. For example, both the Journal of Software and the Chinese Journal of Computers largely cite international journals, only based on their domestic core citing networks one may conclude wrongly that the two journals are not active in making references. Therefore, a complete comparison should be done based on both the domestic and international databases.

**Acknowledgement**

We are grateful for Professor Wu Yishan from the Institute of Scientific and Technical Information of China for his suggestions and comments. We also thank Mr. Ma Zheng from the same institute for providing journal citation data.
PART III

OUTCOMES
Chapter 12
Conclusions, Discussion, and Perspectives

1. Conclusions

This chapter will answer the questions raised in Chapter 1. Since the studies are based on data sources including the WoS and the CSPTCD which have coverage limitations, the conclusions ONLY reflect the dynamics of knowledge production and scholarly communication in peer-reviewed journals covered by the WoS or the CSPTCD.

1.1 China has become a major producer of scientific publications

China’s exponential growth (Figs. 1 and 2 in Chapter 4) in scientific publications is unique in the world. Along with the exponential increase of scientific publications, the citation rates of Chinese publications are increasing exponentially as well (Figure 3 in Chapter 4). Other indicators measuring the impact of publications, such as the percentage of world share of citations and the number of most highly cited publications, also demonstrate the increased status of Chinese publications (Figs. 4 and 5 in Chapter 4). Nonetheless, the overall citation impact of Chinese publications is still low because of not being well cited by international authors. The progress of citation impact of Chinese publications is much slower than that of publications. In the international scientific community, citation relations mostly happened between Chinese publications since Chinese journals have not integrated into the citation environment of international journals.

In addition to raising its holistic level in publishing scientific literature, China has put enormous energy in developing critical fields, one of which is nano-science and technology. Although China started research in this field later than other major countries like the USA, France, Germany, and Japan, its world share of publications in this field has increased rapidly. China took the second position in 2004 just behind the USA and has potential in further expanding research in this field. Such expectation is based on China’s higher world share of publications in nano-relevant fields compared with its world share of publications over the entire data set of the SCIE. The USA and the EU are the major players in this field, while China, Japan, and South Korea account for most of the remaining share (Figures 11 and 12 in Chapter 4).

The Chinese government pays unprecedented attention to the development of knowledge production and the transition to a knowledge-based economy. More than any other country in the world, funding for R&D is growing not only absolutely, but also relative to the spectacular growth in the gross domestic product (Figures 14 and 15 in Chapter 4). It is noteworthy that business investment in R&D is increasing even faster than government expenditure. This increased investment has been reflected in the output and thus one may assume an efficient coupling between input and output in scientific research. Among the countries studied, Japan has the highest GERD/GDP ratio, and its trend shows linear growth, but like most countries it spends more to maintain approximately the same share (Cozzens et al., 1990). The EU countries grow slowly in terms of this indicator, but they are still more than one percent below the
target of 3% (GERD/GDP) set by the “Lisbon” agreement. The USA’s investment is higher than that of the EU countries, but with less output in scientific publications.

China has huge human resources in science and technology. With exponentially increased funding and proper guidance of scientific policies, China’s increased momentum in knowledge production is expected to be sustainable. Our most recent study (Zhou & Leydesdorff, 2008) based on the SCIE 2007 has proved such expectation. Nowadays, the problem for China is not the production of scientific publications, but the dissemination and visibility of scientific publications in the international communication system of science.

1.2 Regional contributions are highly skewed

A few Chinese regions are very productive while the most regions are not. Regions with the most human resources usually have high national share of both publications and citations. Beijing, Shanghai, Hong Kong, and Jiangsu take the lead and Qinghai, Hainan, Macao, Ningxia, and Tibet are almost invisible in either publications or citations. Regions in the Mainland are apparently active in publishing in traditional disciplines including physics, chemistry, and mathematics. Some regions are also active in geosciences and space sciences but are not strong enough to raise China above the world average in this subject category. For historical reason, Hong Kong has its own activity pattern of being extremely active in engineering and mathematics. Compared to regions in the Mainland, Hong Kong’s publication activities in other fields are relatively balanced.

Regional Citation impact in terms of national share of citations basically corresponds to regional productivity: the leading prolific regions are also leading contributors to national citations. Relative citation impact of leading regions from the Mainland is lower than the world average. The performance of Hong Kong is best. No matter the indicators are based on production scale or on average quality, Hong Kong is always among the top.

The decline of Hong Kong in national share of publications may imply that Hong Kong has reached its potential in publishing international papers. But the situation in Chinese Mainland regions is different: they have huge reservoir of human resources and a large population of the manpower has not published internationally yet. For historical and language reasons, Chinese Mainland researchers mainly publish in domestic journals. With China’s effort of integrating into the outside world, more and more Mainland researchers will shift from publishing domestically to internationally. This trend has already been seen in China’s amazing growth in international publications, and there is no sign showing this growth trend will slow down or stop (Zhou and Leydesdorff, 2008).

Regarding to the relation between R&D and scientific publications, high R&D expenditure does not necessarily bring high output since scientific publications are only one form of R&D output. In the case of Chinese regions, high investment in R&D does have some relevance to knowledge production in publications: prolific regions usually invest more in R&D, although productivity does not well-correspond to R&D investment.
1.3 International collaboration plays an important but decreasing role

While establishing collaboration relations with more countries in science, China has strong relations with countries including the USA, Japan, the UK, Germany and Canada. Collaborations with Australia and Singapore have also been enhanced. Chinese internationally co-authored publications keep growing, but the contribution to Chinese total productivity is decreasing. This is not the case in most scientific players like the USA, the UK, Germany, Japan, etc. The fact that the growing momentum of Chinese total publications is faster than that of international ones may explain the Chinese phenomenon.

International collaboration compensates China’s disciplinary deficiency: China’s disciplinary publication activities are skewed with extreme activity in Chemistry, Physics, and Mathematics. But its activity in international collaboration is the opposite. International collaboration increases China’s citation impact in almost all scientific disciplines except that of mathematics. But the raising effect of international collaboration in many subject categories has reduced remarkably. The subjects in which China is extremely inactive, namely, clinical and experimental medicine and neuroscience and behavior, still increasingly benefit from international collaboration.

In terms of regional activeness in international collaboration, prolific regions like Beijing, Hong Kong, Shanghai, and Jiangsu are also the most active in international collaboration.

International collaboration in the social sciences has also been increased in China. The USA and Singapore are two major countries collaborating with China. Other important Chinese partners include the EU-15, Australia, Canada, and the UK. Collaboration ties with Singapore, South Korea, the USA, and the EU-15 have increased, but the collaboration relation with Japan has decreased.

1.4 China progresses slowly in the internationalization of social sciences

The world share of Chinese publications in the social sciences is very low. On the way to publishing internationally, China develops slowly with some visible changing points in 1978, 1997 and 1999 respectively. The adoption of the Opening-up Policy in 1978 had positive but limited impact on Chinese social sciences. The return of Hong Kong in 1997 has remarkable effect in increasing China’s world share. In fact, Hong Kong has become a major contributor to Chinese publications, although its role started to decline since 2005. While the rapid growth trend of the Mainland is speeding up, Hong Kong seems having reached its production potential. The year 1999 can be considered as a turning point of Chinese social sciences since publications from the Mainland increased sharply.

The development of the social sciences is slower than that in the natural sciences in China (Zhou & Leydesdorff, 2006, 2008). Although Chinese publications began to grow visibly in 1999, the gap between China and the West represented by the USA and the EU is too wide to be narrowed within a short period. Not only China, other major Asian countries including Japan, South Korea, New Zealand, Singapore, and India do not perform well in terms of internationalization. It seems that the SSCI reflects the publication performance of the West (Europe and the USA) better than
that of the East. As one of the major players in the natural sciences, Japan has a quite low world share in the social sciences. Publications from the USA and the EU-15 have higher citation impact than those from Asia. Furthermore, the world share of citations of most Asian countries including China and Japan were lower than their world share of publications. On the contrary, both the USA and the EU-15 have higher world share of citations compared to their world share of publications.

Regarding to publication activity in the three selected main fields (i.e., psychology; economics and business administration; social, political and communication sciences) in the social sciences, the USA sets the standard or world average. The EU-15 and Japan have similar patterns: both are active in publishing in psychology. China and Singapore are relatively more active in economics and business administration. Japan is an exception among Asian countries in this regard. Citation impact of the studied countries/region corresponds to their publication activities. The EU-15 and Japan have higher citation impact in psychology. China, South Korea, and Singapore share similar citation patterns with relatively higher citation impact in economics and business administration and less citation impact in psychology. But Asian countries have not yet reached the standard set by the USA.

1.5 The Chinese scholarly communication system is special

Communication among Chinese scholars is less active than that among international ones. In the domestic community, knowledge mainly flows from high-quality journals to the lower ones. High-quality international journals have a higher rank in the hierarchy than do their Chinese counterparts: knowledge flow between Chinese and international scholars are not balanced. Chinese authors mainly play as knowledge receivers while international authors play as knowledge contributors. Definitions about knowledge receiver, knowledge producer, and knowledge contributor are introduced in the third part (i.e., the Perspectives) of this chapter.

The international visibility of Chinese journals varies among disciplines. Among the selected fields including general science, materials science, mathematics, and the life sciences, journals in materials science and mathematics have a relatively higher visibility while that in the life sciences is the lowest.

Language is an important factor that affects a journal’s visibility. Both Chinese university journals and the CAS (Chinese Academy of Sciences) journals have high domestic citation rate. Both international and domestic visibilities of the CAS journals are higher than those of university journals. Journals in the general sciences are supposed to entertain citation relations with journals in a wide range of fields. But this is not always the case in Chinese journals. The English version of the CSB has this characteristic but the Chinese version of CSB has higher visibility in the geosciences.

Chinese journals with high Impact Factors (IF) do not necessarily have high local impact. Therefore, except the IF other elements like local citation impact and the specific role of a journal should be considered while conducting journal evaluation. For example, the JME (Journal of Mathematics Education) has the highest impact factor in the category of mathematics, but its citation impact on other journals is very weak. This is because most citations of the JME are within-journal citations. The local citation impact of the AMS-C (Acta Mathematica Sinica – Chinese version) is the
highest although its global impact factor is lower than that of the *JME*. It is also inappropriate to compare journals serving different functions. According to its title, the *JME* is a journal in mathematics education. This journal does not have citation impact on mathematics journals but do have citation impact on journals from educational institutions (i.e., university journals) especially journals of normal universities which mainly provide higher education to future teachers. In this situation, it is perhaps better to classify the *JME* into a subject category like education science.

To summarize, science development in China is unique: 1) Chinese knowledge production keeps exponential growth and there is no sign showing the increasing speed will slow down; 2) While having the publication characteristics of that of the formal socialist countries with extreme activity in chemistry and physics, the Chinese publication system is also very active in mathematics. 3) The Chinese pattern of international collaboration is different from most of those advanced countries: national share of international coauthored publications goes down while that of most countries grows up. But international cooperation helps raise China’s international visibility and impact; 4) Regional contributions to China’s knowledge production are highly skewed, which corresponds to the estimation of Cole and Cole (1972) about the productivity of scientists if we change the analytical unit from individual scientist to individual Chinese regions. The estimation of Cole and Cole (1972) is “roughly 50% of all scientific papers are produced by approximately 10% of the scientists”.

Being a leading nation in terms of publications in the natural sciences, China progresses slowly in the internalization of social sciences. The internationalization speed of Chinese social sciences is much slower than that of the natural sciences in China. But because of the coverage limit of the *SSCI* and the close tie between social sciences and the national, cultural, social, and political environment, publication in the social sciences can be very local or national. Therefore the current results which are based on an international database cannot tell the overall situation about China’s research in the social sciences. It is necessary to analyze Chinese domestic publication databases in the social sciences so as to better understand the Chinese situation in this regard. Unfortunately, data was lacking during the period of this dissertation research so that I was not able to analyze the Chinese domestic publication activity in the social sciences.

The Chinese government pays unprecedented attention to the development of knowledge production and the transition to a knowledge-based economy. More than any other country in the world, funding for R&D is growing not only absolutely, but also relative to the spectacular growth in the gross domestic product. Business investment in R&D increases even faster than government expenditure.

Compared to their international counterparts, Chinese scholars are less active in communicating through scientific literature since they provide fewer references in their publications. In the domestic community, knowledge mainly flows from high-quality journals to the lower ones. High-quality international journals have a higher rank in the hierarchy than do their Chinese counterparts: knowledge flows mainly from international scholars to Chinese scholars. Knowledge produced by Chinese scholars is not well-received by the international community. Chinese authors mainly play as knowledge receivers while international authors play as knowledge contributors.
2. Discussion

As the dissertation is based on a bibliometric methodology, it is necessary to introduce some basic knowledge about bibliometrics and clarify the merits and flaws in terms of bibliometric application so as to help readers better understand relevant results and conclusions.

2.1 Brief knowledge about bibliometrics

Since its emergence in the late 60s of last century, bibliometrics has become increasingly important in science policy and research management. The term “bibliometrics” was first defined by Pritchard (1969) as “the application of mathematical and statistical methods to books and other media of communication”. In the same year, Nalimov and Mulchenko (1969) proposed another term – scientometrics. They defined scientometrics as “the application of those quantitative methods which are dealing with the analysis of science viewed as an information process”. Although bibliometrics has wider coverage than scientometrics according to their respective definitions, both terms are almost used as synonyms (Glänzel, 2008a) in the bibliometric/scientometric community.

Modern bibliometrics is mostly based on the work of Derek J. de Solla Price and Eugene Garfield. The former adopted a new element in the historiography and sociology of science in the course of examining the major transformation of science as prefigured in his book: *From Little Science to Big Science* (Price, 1963). The latter invented the *Science Citation Index*, and founded the Institute for Scientific Information (ISI) which produces the *Web of Science (WoS)* and the *Journal Citations Report (JCR)* (Garfield, 1979).

Books, monographs, theses, and papers in serials and periodicals are the units of analysis in bibliometrics. Since certain standards are postulated for scientific papers published in refereed scientific journals, such units proved to be the unit of analysis most suitable for scientometric studies (Glänzel, 2008a). As an inter-disciplinary instrument, scientometrics originates from the information sciences. The original purpose was to improve bibliographic databases and to extend information services. After about 40 years’ development, the most important task of scientometrics has become serving for science policy and research management. Journal publications, (co-)authors, references, and citations are basic objects of scientometric study.

The ISI’ *Web of Science (WoS)* is the most commonly used data source and contains three important databases: the *Science Citation Index Expanded (SCIE)*, the *Social Science Citation Index (SSCI)*, and the *Arts & Humanities Citation Index (AHCI)*. The *Science Citation Index (SCI)* has two versions: the *SCI CD-ROM* and *SCI Expanded (SCIE)*. The *SCI CD-ROM* is simply called the *SCI*. The *SCIE* is the web version of the *SCI* and covers more journals than the CD-ROM version. The *SCI* was created by Eugene Garfield in 1963 and has become the most generally accepted source in the scientometric community. The ISI’s other database relevant for this study is the *Journal Citation Reports (JCR)* which are derived annually from the citation databases. The *JCR* is also used as an indirect subject assignment of individual publications. Journals in the *JCR* are assigned to various subjects. For
example, if a journal is assigned to the subject of chemistry, all publications in this 
journal are assigned to the same subject, which is chemistry.

In 2004, the Dutch publisher Elsevier established the SCOPUS which has similar 
functions as the corresponding databases of the WoS. Since the late 80s of last century, 
two Chinese science citation databases and one social science citation database were 
established successively. The first database, the China Scientific and Technical 
Papers and Citations Database (CSTPCD), was set up in 1987 by the Institute of 
Scientific and Technical Information of China. By 2006, China has around 5000 S&T 
journals and 3000 journals in the social sciences and humanities. The CSTPCD 
covered 1723 S&T journals in 2007. In 1989, the Documentation and Information 
Center of the Chinese Academy of Sciences (DICCAS) constructed a similar database 
– the Chinese Science Citation Database (CSCD). The CSCD covered 1083 journals 
in 2007 (CSCD, 2008). Two databases in the social sciences and humanities are seen 
in China.

The first Chinese citation database in the social sciences – the Chinese Social Science Citation Index (CSSCI) was established in 2000 by Chinese Social Sciences Research Evaluation Center affiliated to Nanjing University. The CSSCI covers 680 journals in the period 2007 (CSSCI, 2008). Another database entitled the Chinese Humanities and Social Science Citation Database (CHSSCD) is produced by the Centre for Documentation and Information attached to the Chinese Academy of Social Sciences. The first citation database of the CHSSCD appeared in 2000 (Zhou, 2002). The CHSSCD covered 662 journals in 2001. In terms of social visibility, the CSSCI is better known than the CHSSCD. All the Chinese databases have similar structures as their international counterparts, but are based on Chinese domestic journals.

With the development of science, the demand of supplementing the assessment of 
research with quantitative methods and linking research funding to performance 
indicators increases. Such requirement promotes scientometrics to evolve from a sub-
discipline of information science to an inter-disciplinary specialty (Glänzel, 2008b). 
Library and information science is the foundation of bibliometrics/scientometrics. 
Mathematics is the critical tool for constructing bibliometric indicators and models. 
Sociology of science lays theoretical ground for scientometrics. Scientometrics can 
also be used for studying the sociology of science (Elkana et al., 1978; Leydesdorff, 
1986, 1998; Wouters, 1999). Social network analysis like citation analysis and 
betweeness centrality among journals has become an important practice in 
scientometrics (Otte & Rousseau, 2002; Leydesdorff, 2007a; Leydesdorff, et al., 
2008a; Park & Leydesdorff, 2009; Zhou & Leydesdorff, 2007a; Zhou & Leydesdorff, 
2007b).

Present bibliometrics can be divided into three sub-areas (Glänzel, 2008a): 1) 
Bibliometrics for bibliometricians. This is the domain of basic bibliometric research 
focusing on methodological exploration; 2) Bibliometrics for scientific disciplines. 
This domain can be considered as an extension of science information by metric 
means. There is a joint borderland with quantitative research in information retrieval. 
3) Bibliometrics for science policy and research management. This is the most 
important domain in bibliometrics which focuses on national, regional, and 
institutional structures of science and their comparative presentation.
After several decades of development, institutions engaged in scientometric research and education have been established in many countries. Here I just list some of them: the Institute of Science Information (ISI) in the USA, the Information Science and Scientometrics Research Unit at the Hungarian Academy of Sciences, The Center for Science and Technology Studies (CWTS) in The Netherlands, the Steunpunt O&O Indicatoren (SOOI) in Belgium, the National Institute of Science, Technology and Development Studies (NISTADS) in India, and so on. Since journals, professional societies, and international conferences are important indicators to determine if a new field is viable, let me provide information about the development of scientometrics. The first journal was founded in 1978 with exactly the name of the field – *Scientometrics*. Other journals pertinent to scientometrics include the *Journal of Informetrics*, the *Research Evaluation*, the *Journal of American Society for Information Science and Technology (JASIST)*, and so on. In 1993, the International Society for Scientometrics and Informetrics (ISSI) was founded with members all over the world. In addition, the ISSI has its own publications – the *ISSI Newsletter* which is published monthly and provides a communication channel for scientometricians or informetricians. Important international conferences pertinent to scientometrics include the International Conference on Scientometrics and Informetrics organized by the ISSI biennially since 1987 and the biennial Conference on Science & Technology Indicators organized by the Centre for Science and Technology Studies (CWTS) in Leiden.

The development and consummation of data sources and the rapid progress in computer science and technology accelerates the development of this field of studies. Nowadays, bibliometrics has played an important role in science policy and research management. Significant compilations of science indicators, such as the Science and Engineering Indicators of the National Science Board of the U.S.A. and the European Reports on S&T Indicators, heavily rely on publication and citation statistics and other more sophisticated scientometric techniques. Furthermore, some governments have embraced scientometrics with great expectation for the purpose of research evaluation. The British government announced that a new framework for assessing and funding university research would be introduced following the completion of the research assessment exercise in 2008, intending to replace their current method for determining the quality of university research – the UK Research Assessment Exercise (RAE) (Universities UK, 2007). Metrics, rather than peer-review, will be the focus of the new UK system and it is expected that bibliometrics will provide the central indices for quality in this system.

In the Flemish region of Belgium, science policy has evolved very much into the direction of scientometric-based evaluation and allocation rules. Two mechanisms, the BOF and the IOF, rely heavily on bibliometric analysis. The BOF (i.e., the Bijzonder Onderzoeksfonds) mechanism distributes R&D funding to universities for basic research. The IOF (i.e., Industrieel Onderzoeksfonds) mechanism provides funding to universities for industry-relevant research. In order to better serve the bibliometric-based evaluation mechanisms, a specific organization, the Steunpunt O&O Indicatoren (SOOI), has been established since 2002. The SOOI is an interuniversity consortium with participation of all Flemish universities (K.U.Leuven, UGent, VUB, UA and UHasselt). The K.U. Leuven is responsible for indicators on research output and innovation. Ghent University focuses on Human Resources in Research (doctorates, doctoral careers and researchers’ mobility). The other three
Flemish universities (the Free University of Brussels, the University of Antwerp and the University of Hasselt) are partners in the project.

Some other countries also partly adopt bibliometric analysis in R&D allocation. For example, the link between research funding and quantitative performance measures has existed in Australian universities for a decade (Butler, 2004). In 2005, the Norwegian government introduced an output indicator for scholarly publications in the funding formula for the basic funding of research in the Higher Education Sector (Siversen, 2008). In the European Commission Bibliometric indicators also figure prominently in the Seventh Research Framework Program (FP7).

2.2 Problems in bibliometrics

While playing increasingly significant roles in S&T policy making and research evaluation, bibliometrics has faced more challenges. As mentioned before, bibliometrics was originated for improving the use of bibliographic databases and extending information services (Glänzel, 2008). The new application in research evaluation brings bibliometrics more challenges in addition to some flaws already exist (Edge, 1979; Chapman, 1989; MacRoberts & MacRoberts, 1986, 1989, 1996; Leydesdorff, 2007c). Caution should be taken while applying bibliometrics to assess research performance and assign research fund. Major problems of bibliometrics are generalized below.

2.2.1 The coverage limit of relevant data sources

Commonly used data sources in bibliometric community are the WoS in the USA and the SCOPUS in The Netherlands. These data sources mainly include publications in peer-reviewed scientific journals and conference proceedings. But not all peer-reviewed journals and conference proceedings are included. In addition, other forms of literatures such as books and none peer-reviewed journals are not covered. When some fields publish heavily in literatures are not included in the WoS or SCOPUS, scientometric results based mainly on journals can be severely biased (Figure 1).
Peer-reviewed journals and conferences are the major communication channels for most fields. But situation in the social sciences and arts and humanities are exceptional since more communication channels exist. In some traditional scientific fields such as mathematics, chemistry, physics, and biology, the share of peer-reviewed journals take more than half of the overall publication types. In other fields especially the applied sciences, the engineering sciences, the social sciences, and computer and information sciences, the shares of peer-reviewed journals are much less than other publication types like conference proceedings (Figure 2). Therefore, bibliometric results based on peer-reviewed journals can be more representative for the natural sciences than for the social sciences, arts and humanities, and computer and information science.

Another problem of these data sources is the language bias. First, language biases play an important role in the comparison and evaluation of national science systems (Leeuwen et al., 2001). For instance, the WoS databases contain very few non-English journals. Such coverage favours English speaking countries like the USA, the UK, and Canada. While the USA and the UK have barely any publications in other than English-language journals, but countries like Germany, France, and Switzerland still have significant number of publications in languages other than English. The Chinese situation is more exceptional. This country has around 5000 S&T journals among which majority are in Chinese. In 2006, the Chinese database the CSTPCD covered 1723 journals in which 407,808 papers were published (ISTIC, 2007). But only 76 Chinese journals were covered by the SCIE in 2007. Therefore, what one can get from the ISI databases is the internationalization of a nation in science.

2.2.2 Problems in citations
What are citations? The fact that there are a lot of definitions about the meaning of citations suggests that citations are complicated. Cozzens (1989) claims that citations are the result of two systems underlying the conduct of scientific publication, one a “reward” system and the other “rhetorical”. The first kind has the meaning most often associated with a citation – an acknowledgement that the citing paper has “intellectual debt” to the cited. The second, however, has a meaning quite different – a reference to a previous paper that explains some result, perhaps not a result of the cited author at all. Such kind of rhetorical citations is merely a way to carry on a scientific conversation, not establish intellectual indebtedness. Leydesdorff defines citations as references to other textual elements from the perspective of the citing article (Leydesdorff, 1998). Glänzel and Schoepflin (1999) interpreted citations as “one important form of use of scientific information within the framework of documented science communication” (1999).

Citations involve two major processes: the citing process of scientific authors and the process of inverting citation to the cited side. Both processes lack theoretical grounding. Since the citing behaviour of authors has a direct relationship to the value of citation analysis, citation analysis must be accounted for in terms of the citation behavior of authors. Merton (1977) first explained references in terms of the norms of science as “citations and references operate within a jointly cognitive and moral framework”. But reasons for making citations vary extensively. A proper and satisfactory theory of citing is still lacking (Cronin 1981, 1984; Cozzens 1981, 1985, 1989; Luukkonen 1990; Luukkonen 1997; Leydesdorff, 1987, 1998). Citation analysts invert the citation matrix to the cited side (Wouters, 1999). This inversion is a large step which requires theoretical justification.

Citation analysis examines the frequency, patterns and graphs of citations in published literatures. A basic assumption in citation analysis is that “all citations are equal” (Smith, 1981), which makes it possible to add citation frequency of a given article. Based on individual articles, citation frequencies of individual researchers, research groups or institutions, journals, countries, or disciplines can also be summed up at higher levels of aggregation. Nowadays, citation frequencies have become important indicators in research evaluation. Citation frequency is so important that it may affect researchers’ income or career promotion. Because of this significance, citations are compared as the “currency of science” (Wouters, 1999). Results of citation analysis may also affect the allocations of research funds.

Is every citation equal? Can citation frequencies (or counts, or rates) really measure quality? Let us first check why scientists make citation so as to answer the first question. Garfield and Weinstock (Garfield, 1964; Weinstock, 1971) summarized the following 15 reasons for why scientists refer others’ work:

- Paying homage to pioneers,
- Giving credit for related work (homage to peer),
- Identifying methodology, equipment, etc.,
- Providing background reading,
- Correcting one’s own work,
- Correcting the work of others,
- Criticizing previous work,
- Substantiating claims,
➢ Alerting to forthcoming work,
➢ Providing leads to poorly disseminated, poorly indexed, or uncited work,
➢ Authenticating data and classes of facts – physical constants, etc.,
➢ Identifying original publications in which an idea or concept was discussed,
➢ Identifying original publications or other work describing an eponymous concept or term,
➢ Disclaiming work or ideas of others (negative claim),
➢ Disputing priority claims of others (negative homage).

It is clear that citing others’ work can be various reasons. The relation between the citing and cited works can be positive, neutral, or negative. For instance, reasons 1-4 can be considered as positive while list 5-7, 14 and 15 are negative. Citations are not equal even cited literatures contribute positively to the citing work, because the extent of contribution of different cited literatures may also differ. Therefore considering each citation the same in terms of values lacks empirical grounding. But citations can be treated equally if they are considered as use of information, no matter the relation between the citing and cited literatures is positive, negative, or neutral.

Nevertheless, it is still worth of discussing if the expression “all citations are equal” can really reflect the practical situation. In scientific papers, all cited literatures only appear in the reference list once no matter how many times they appear in the text of a citing paper. In other words, some cited publications are used more than once in the same citing paper but are treated the same as those only appear once: both types of publications are counted as ONE citation. Till now, this problem has not been solved yet.

Can citations be used to measure quality? The fact that citation relation between citing and cited papers can be positive, neutral, or negative implies that citations do not necessarily point to quality. Regarding to citation frequencies, a less frequently cited paper does not necessarily have lower quality. In addition to a paper’s quality, many other factors including time and disciplinary attribution may affect a paper’s citation counts. A less frequently cited or uncited paper may only tell that the paper is less or not accepted by the community by the moment the citation counts are calculated. Just as Braun and his colleagues remarked:

“(I)f a paper receives 5 or 10 citations a year throughout several years after its publication, it is very likely that its content will become integrated into the body of knowledge of the respective subject field; if, on the other hand, no reference is made at all to the paper during 5 to 10 years after publication, it is likely that the results involved do not contribute essentially to the contemporary scientific paradigm system of the subject field in question” (Braun, et al., 1985).

Citations analysis involves complex processes. In addition to different reasons and roles of citations in a specific citing paper, other factors especially in the processes of providing references and indexing citations, may also affect the result of citation analysis. Scientists cite others work by listing them in a reference list. This referring process may result in misrepresentation. A scientist may refer to nonexistent papers just because of typing wrong page number or year or making spelling mistakes. While making references, authors may cite sources only known through intermediary
publications. This may cause irrelevant sources be counted as citations and therefore misrepresent intellectual influence. Misrepresentation may also appear when senior researchers systematically over-cite the work of their students and young colleagues so as to “put them on the intellectual map”, thus indirectly enhancing their own standing and inflating the influence of young and less well-known scientists (Zuckerman, 1987).

Citation assignment for co-authored publications is another problem. Credit assignment to coauthors is difficult, even coauthors themselves are hard to agree on what led them to particular ideas or who did what, let alone specifying their scientific influences (Zuckerman, 1987). Sometimes, over-inclusion and under-inclusion also occur in co-authored publications. Some scientists maybe included in papers which they do not have any contribution, while some less well-known and junior contributors might not appear. It also happens that some prominent scientists decide not to show the name in coauthored papers although they do contribute to the research. Citation indexing workers produce citations by inverting the citation matrix to the cited side. Citation analysts collect data from large amount of citation data. Each process may bring errors (Smith, 1981; Egghe & Rousseau, 1990), which is the main reason that cleaning up the datasets is common practice in scientometric community.

The value of author self-citations is another disputed topic since author may cite their own publications on purpose so as to construct their professional credibility (Hyland, 2003) even if those works are not relevant to the present one. But authors may also cite their former work because of relevance. Glänzel and his colleagues confirm the positive role of self-citations with mathematic formulation and conclude that self-citation based indicators are valuable supplementary measures that can be used both in informetrics and research evaluation (Glänzel et al., 2004).

Although there is no unified statement about what citation can measure, bibliometricians frequently use citation indicators to measure (citation) impact at high aggregated (i.e., national or regional) levels. Major indicators pertinent to citations include absolute and relative indicators. For absolute indicators there are citation counts and share of citation counts. Relative indicators include Mean Observed Citation Rate (MOCR), Mean Expected Citation Rate (MECR), Field Expected Citation Rate (FECR), Normalized Mean Citation Rate (NMCR), Relative Citation Rate (RCR), High-impact Activity, and High-impact Attractivity. Detail information about these indicators can be found in Chapter 3.

2.2.3 Problems in ranking

Nowadays, bibliometric indicators are applied in various rankings such as university ranking, journal ranking, and even research individual ranking. According to Glänzel and Debackere (2009), ranking is positioning comparable objects on an ordinal scale based on a (non-strict) weak order relation among (statistical) functions of, or a combination of functions of measures or scores associated with those objects. The so-called “statistical functions” are bibliometric indicators. Normally, a ranking result is based on different indicators which represent various aspects of quality. A combination of these indicators forms a composite indicator which determines the relative positions of objects in a compared set. But the use of composite indicators can
be problematic. Glänzel and Debackere (2009) list the following most significant problems.

- Possible interdependence of components,
- Altering weights can result in different ranking,
- Results might be obscure and irreproducible,
- Random errors of statistical functions are usually ignored,
- The multi-dimensional space is crashed into linearity.

In the following text, I will discuss problems in applying bibliometric indicators in different rankings.

**University ranking**

A university is an institution of higher education and research, which grants academic degrees in a variety of subjects. Since bibliometric results are based on large amount of data, a bottom line is to ensure the correctness of data collection and data processing (i.e., correct institutional assignment). Application of sound methodology is also critical. Because of the diversification of universities, even multi-disciplinary research and education institutions have usually more specific research profiles. Therefore comparison should be done among those with similar research profiles. In order to obtain a more realistic comparison, Glänzel and Debackere (2009) suggest apply standardized indicators.

**Journal ranking – the Impact Factor**

The IF was originally designed by Garfield (1972) for journal evaluation. It is defined as the average number of citations in a year given to those papers in a journal that were published during the two preceding years. Major problems arise from the IF can be the following:

- The calculation of the impact factor in the *Journal Citation Index* is not exactly the identification of the impact factor. Many journals publish non-substantive items such as letters or editorials which are seldom cited. These items are not counted in the denominator of the impact factor. But these items are sometimes cited and these citations are counted in the numerator. This makes the IF is not precisely the average citations per article.
- The citation data source providers may make mistakes while integrating data for the calculation of the Impact Factor. Rossner and his colleague (2007) found that in the *JCR* of the ISI there were numerous incorrect article-type designations. Many articles that the authors consider “front matter” were included in the denominator. The total number of citations for each journal was substantially fewer than the number published on the *JCR* website.
- The two-year citation window which was originally set for biochemistry and molecular biology (Garfield, 2003) can not reflect variations of citation patterns of journals in different fields since publications in different fields have different citation culture.
- Even within the same discipline, exogenous variation also exists among journals mainly publishing reviews, research articles, and letters. Review journals tend to have higher impact factors (Pinski & Narin, 1976).
- The normalization with journal size gives small journals a better chance of selection (Leydesdorff, 2008). As citations are dynamic and therefore IF varies
from year to year. The variation tends to be larger for smaller journals. For journal publishing fewer than 50 articles, the average change in the IF from 2002 to 2003 was nearly 50% (Amin & Mabe, 2000).

- Journals publishing articles in languages other than English will likely receive fewer citations because a large portion of scientific community cannot (or do not) read them.

The above list of flaws of the impact factor does not mean that the IF is useless. But it is necessary to be cautious while applying the IF to research evaluation. For alternatives, some researchers have proved that total citations correlate with perceived quality of journals more than impact factors (Bensman & Wilder, 1998; Leydesdorff, 2007b). Some organizations extend the citation windows in their evaluation work. The Information Science and Scientometrics Research Unit (ISSRU) of the Hungarian Academy of Sciences and the Research Association for Science Communication and Information (RASCI) in Germany use three-year or four-year citation windows (Glänzel, 2008a).

In addition to ranking journals, impact factor is also used to compare individual papers, people, programs, or even disciplines. For example, some universities classify journals into various levels according to their IF values and assign different scores to journals at different levels. A paper’s score is dependant on which journal it is published. There are two serious problems in understanding the IF. First, Papers in the same journal do not equally receive citations. A paper in a journal with high impact factor does not assure the paper receiving high citation counts because the distribution of citation counts for individual papers in a journal is highly skewed (Seglen, 1996; Garfield, 1987). Adler and his colleagues (2008) prove that around 70% of articles in the Proceedings of the American Mathematical Society (PAMS) in 2000-2004 received no citations in 2005, only a few receive 3 citations. In another journal, the Transaction of the American Mathematical Society (TAMS), over 50% articles received no citations while a few articles receive 12 citations. Second, papers published in journals in the same field with different impact factors does not mean the one in the journal with higher impact factor receives higher citations than the one in the journal with lower impact factors. If one ranks papers according to their journal impact factors, the probabilities of being wrong would be 62% (Adler, et al., 2008). Therefore, using impact factors to evaluate articles or their authors makes no sense and can be dramatically misleading.

If one does want to evaluate papers or their authors with citations, counting citations of those papers would be more reliable. But this is under the condition that the compared objects are in the same field and publication years should be the same, since citation culture varies in different disciplines and citation counts may change at anytime. Earlier publications may have more chances to be cited. For papers in the same field and publishing in the same year and receiving no citations, the impact factors of their publishing journals can be used for evaluation.

**Individual ranking – the h-index**

The Impact Factor (IF) is used for ranking journals and papers and h-index is mainly for ranking scientists. The h-index was proposed by Hirsch as an indicator for evaluation of researchers. It is defined as the highest rank of a scientist’s list of
publications such that the first h publication received at least h citations (Hirsch, 2005). The h-index can be extended to any set of documents (Braun, et al., 2006). Unlike the impact factor, the h-index cannot decrease for a given set of documents and can thus be considered as an accumulating indicator for lifetime achievement in the case of individual scholars. Glänzel (2006a) has found strong relation between both number of papers published and citations received with h-index for practically all Paretian distributions. While having some advantages in evaluating individuals (Glänzel, 2006b), the h-index also has the following shortcomings (Glänzel, 2006b, 2008a) because it

- puts new comers at a disadvantage since both publication output and citation counts of new comers will be relatively low;
- allows scientists rest on their laurels since the citation counts might increase even if no new papers are published;
- does not show decay in a scientist’s career;
- is not independent of subject-specific communication behaviour and cannot be normalized in a similar manner as other publication- or citation-based indicators;
- causes problems in finding appropriate reference standards for comparison even in the same subject field;
- puts small but highly-cited paper sets at a disadvantage because h-index cannot exceed the number of publications.

Based on h-index, a series of indices were suggested (Hirsch, 2005; Egghe, 2006a, b; Jin, 2006; Jin, et al., 2007; Burrell, 2007; Kosmulski, 2006). But mathematical sophistication alone cannot increase the validity of an indicator used in processes of research evaluation (Leydesdorff, 2008).

2.2.4 Problems in field classification

“Comparing like with like” (Martin & Irvine, 1983) has become a common sense in scientometric community. In other words, comparisons can be meaningful only when they are made within the same field and for comparable units of analysis. But this involves another problem: field classification is still an unresolved issue in scientometrics. Till now, no perfect field classifying schemes have been established. The common practice in field classification is based on journals. But journal cannot unambiguously be classified into categories on the basis of their aggregated citation patterns (Leydesdorff, 2008). All sets are overlapping and fuzzy (Bradford, 1934; Garfield, 1971; Bensman, 2007).

For lack of an agreed-upon alternative, the ISI subject categories are often used for comparison study. The ISI Subject Categories, however, are not suited for detailed evaluation (Leydesdorff & Rafols, 2008). According to the evaluation of Pudovkin and Garfield (2002), in many fields these categories are sufficient, but they then admit “in many areas of research these ‘classifications’ are crude and do not permit the user to quickly learn which journals are most closely related” (p. 1113). Boyack et al. (2005) estimated that the attribution is correct in approximately 50% of the cases across the file, but may be as high as 80% in some of the core fields (Boyack, personal communication, 14 September 2008). Leydesdorff and Rafols (2008) claim that the ISI Subject Categories can be used for statistical purposes—the factor
analysis for example can remove the noise—but not for the detailed evaluation. In the case of interdisciplinary fields, problems of potentially erroneous classifications can be expected.

In general, the existence of flaws and shortcomings in the application of bibliometrics implies that this specialty badly needs theoretical grounding. “We still have a theoretically underdeveloped understanding of what these bibliometric data actually mean. The continuous call for a theory of citation in quantitative science studies is itself indicative of the urgency to explore more systematically the relations between the use of scientometric methods and qualitative approaches in STS” (Leydesdorff, 1987).

2.3 What bibliometrics can and cannot do

Listing the problems in bibliometrics does not mean that bibliometrics is useless but does mean that we should be cautious while applying bibliometric indicators in research evaluation and that there are a lot of work to be done to make bibliometrics a well-established specialty.

The existing citation databases contain rich information about science, which ensures bibliometric study the following values:

- to master scientific information flood at overall or disciplinary levels;
- to monitor, describe, and model the production, dissemination, and use of knowledge;
- to map scientific collaboration at individual, institutional, regional, and national levels;
- to discover the emergence of or predict new scientific field or sub-field;
- to help policy makers in terms of understanding the development and trend of world science and national scientific strength and weakness so as to make feasible national scientific policy;
- to provide quantitative references for research evaluation and assignment of research funding.

In research evaluation practice, bibliometric results are suggested to be combined with those of peer-reviewed. The former is considered as objective and quantitative and the latter is subjective and qualitative. They two instruments are expected to compensate with each other so as to make evaluation results more reasonable and to ensure research funding more effective.

The reason for not only relying on peer review is because peer review has flaws as well (Cole, et al., 1977; Cole, et al., 1981; Martin & Irvine, 1983). The main problem of peer review is that the evaluation process is affected by many non-scientific issues. In their study on the evaluation procedures of the US National Science Foundation (NSF), Cole and his coauthors found that applicants from high ranking departments were rated lower by reviewers from high ranking departments than they were by reviewers from lower ranked departments, and an applicants past performance which is one of the most important criteria in the NSF procedure had only a marginal influence upon the probability of his or her proposal being granted (Cole, et al., 1977). Martin and Irvine (1983) considered peer review as a method “based on individual
scientists’ perceptions of contributions by others to scientific progress, perceptions arrived at through a complicated series of intellectual and social processes, mediated by factors other than the quality, importance or impact of the research under evaluation”. They summarized three major problems of using peer reviewed outcomes in a policy context: 1) evaluators may be influenced by political and social pressures within the scientific community, such as the possible implications of their judgments for their own work and that of their colleagues; 2) peer reviewers tend to evaluate in terms of their own research interests, and may not possess all the knowledge that is needed to form a balanced judgment; 3) peers tend to conform to conventionally accepted patterns of belief, and may, for instance, be influenced by a scientist’s reputation rather than his or her actual contribution to scientific progress. The relation between peers and scientists being reviewed may affect peers to make an objective and fair judgment.

Various studies have demonstrated strong correlation between results of citation analysis and peer review (Oppenheim, 1995, 1997; Bair & Oppenheim, 1994; Liu, 1994; Seng & Eillet, 1995; Ajibade & East, 1997; Hemlin, 1996; Zhu, et al., 1991). Holmes and Oppenheim (2001) even used citation analysis to predict the outcome of the 2001 Research Assessment Exercise (RAE) of the UK for the field of library and information management.

Bibliometrics is sometimes misunderstood in terms of its role in research evaluation. It is necessary to clarify what bibliometrics can not do. As mentioned before, bibliometrics aims at 1) building more quantitatively robust models of the development of the sciences, technology, and innovation (Elkana et al., 1978); and 2) using the variables in these models as indicators for performance measurement (Martin & Irvine, 1983; Martin, 1996). In terms of research evaluation, both bibliometrics and peer review are needed. The two tools compensate and cannot replace each other. Bibliometrics is designed to measure research performance not research results. Research results can be better assessed by peer review (Glänzel, 2006c).

For the purpose of my research, the language bias does not pose an analytical problem given the research questions. The focus is on the knowledge production and the translation of the Chinese S&T capacity into the international arena. The latter is partly operationalized as publications in English. Publications of Chinese authors in languages other than Chinese and English (e.g., in Russian) have not been considered. Given this research question, representation of journals in Chinese within the international databases are also found, and although this can obviously be considered as an underrepresentation of the Chinese potential which signals the danger of the relative isolation of publications in the Chinese language despite their inclusion in the ISI databases. Of course, the Chinese percentage world share of publications and citations in this database would increase further if more Chinese journals were included, but for the purpose of my research the possible underrepresentation only strengthens the conclusions about the emergence of China as a leading nation in science.

The disciplinary bias of the SCI in favor of biomedicine and the life sciences is a more important reason for concern. Park et al. (2005) signaled that the research portfolio of the Netherlands is much more compatible with the journal portfolio of the SCI than
that of South Korea. The authors conclude that this might have a considerable effect when comparing these two countries using this database. Consistent with these earlier studies, my study also shows that the Chinese portfolio different from those of the Western countries because of the strong activity in chemistry, physics and mathematics. If more journals in these disciplines are included in the SCI, the visibility of China would be higher. This effect may also partly explain the enhanced visibility of China in a subset like the one constructed as “nano-relevant.”

As noted, the “nano-core” journals are more deeply integrated into the elite journal structure of the United States. These journals can be expected to have a bias in favor of accepting papers from elite institutions in the USA and in other advanced countries, and may not be easy to access by scholars from more peripheral locations. The Chinese contribution in these core journals has been increasing considerably, as has the Chinese contribution to the one percent most highly cited papers. Part of this may be the result of international collaboration with Chinese authors.

Compared to the natural and life sciences, the social sciences have some special attributions: more fragmented literature, inherently more national oriented, and relying heavily on non-journal literature like working paper series. All these points remind us be cautious in studying performance in the social sciences using bibliometric methodology. But the SSCI is valuable when statistics is based on some fields that are relatively well covered or on research that is internationally oriented. It is also persuasive to use the dataset to describe a nation’s historical development and internationalization in the social sciences.

Many factors may affect the development of the social sciences. Except internal theoretical and practical issues, other factors such as the academic level of researchers, social and cultural environment, economical and political systems are also critical to the development of the social sciences. Regarding to the Chinese case, the following factors may affect its low international visibility:

- **The attribution of national orientation of the social sciences**
  The Social Sciences mainly focus on domestic social, political, and economical issues. Relevant research outputs are usually applicable in a target country or region, and therefore can be only valuable for and published in that country or region. Undoubtedly, research in the social sciences is very active in China: the fact that there are around 3000 journals in humanities and the social sciences can be a proof. The low world share of publications or citations may imply that Chinese social scientists are less active in international community.

- **Ideological difference between China and the West**
  Compared to the natural sciences, the methods in the social sciences are more difficult. Research in the sciences is less sensitive to official political ideologies. By contrast, the social sciences are often directly related to ideology and more intervened and controlled by rulers. In a socialist country like China the influence of governor’s ideology on research in disciplines like philosophy, political sciences, law, but also sociology, and psychology is perceptible. This might be considered one reason for the ‘phase shift’ in the growth of Chinese social sciences literature.
The separated administration systems for the natural sciences and the social sciences

Nowadays, cross-disciplinary research becomes increasingly important. To some extent, collaboration between the natural sciences and the social sciences may affect research output. In China, two top organizations are engaged in the administration of R&D: the Ministry of Science and Technology (MOST) is responsible for R&D in the natural sciences and technology; while the R&D in the social sciences is managed by the National Planning Office of Philosophy and Social Sciences (NPOPSS). Such separated management system may hinder collaboration between the natural and the social sciences at the highest administrative level.

When co-authorship relations are normalized, China appears to have become well integrated into the Asian-Pacific region in the natural sciences during the 1990s (Wagner and Leydesdorff, 2005). Some authors have recommended normalizing S&T indicators in terms of the size of the respective populations. In the case of China as a developing nation, such a per capita normalization would have dramatic effects, and the phenomena to which I wished to draw attention would completely disappear. The size of the scientific community in a nation could be considered as another factor. A large scientific community may lead to a relatively large within-country citation rate, while scholars in small nations may have to rely more on international colleagues. A correction of the citation rates of the USA or China for the within-country citations, however, would have very large effects on the citation indicator (Seglen, 1997). This indicator would have a meaning in terms of the networking of international collaboration and influence more than in terms of national performance.

3. Perspectives

3.1 Theoretical implications

China has become a major producer of scientific publications. But its citation impact is still low. Here I use citations per publication \((c/p)\) to delineate the citation performance of Chinese publications. A three-year citation window is applied. Table 3 lists the \(c/p\) (i.e., the number of citations divided by the number of publications) received by papers published in 1994 and 2004. In ten years, the \(c/p\) ratios of all the selected countries have increased, among which China achieved the least growth.

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>UK</th>
<th>GERMANY</th>
<th>FRANCE</th>
<th>JAPAN</th>
<th>CHINA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>2.09</td>
<td>1.93</td>
<td>1.60</td>
<td>2.05</td>
<td>1.38</td>
<td>1.44</td>
</tr>
<tr>
<td>2004</td>
<td>6.80</td>
<td>6.07</td>
<td>5.80</td>
<td>5.19</td>
<td>4.40</td>
<td>3.15</td>
</tr>
<tr>
<td>Increases of (c/p)</td>
<td>4.71</td>
<td>4.13</td>
<td>4.20</td>
<td>3.14</td>
<td>3.02</td>
<td>1.71</td>
</tr>
</tbody>
</table>

Why are not only foreign but also Chinese authors less active in citing Chinese publications? A new term “knowledge contributor” may help in delineating the Chinese phenomenon. In a journal-based communication system, authors play three roles as knowledge producers, knowledge contributors, and knowledge receivers. A knowledge producer is the one who publishes papers while a knowledge contributor is the one whose publication is used or cited. Usefulness is the key to decide if one is knowledge producer or contributor. A knowledge producer does not necessarily
become a knowledge contributor. Only when a producer’s publication is cited can the author become a knowledge contributor. With this context, a strong academic country is not only a leading knowledge producer, but also a leading knowledge contributor. A knowledge receiver cites knowledge from other literature by placing references in his/her reference list.

In terms of indicators for the three types of players in scholarly communication, either numbers or share of publications can be used for a knowledge producer; normalized citations, i.e., citations per publications can measure knowledge contributions; and number of references listed in publications can be applied to measure a knowledge receiver. China is a big knowledge producer but not an influential knowledge contributor.

3.2 The Chinese way of knowledge production

The Chinese way of knowledge production is unique in terms of its rapid and continuous growth during the last 30 years. Such remarkable achievement can be attributed to two major causes: the exceptional growth in economy and the timely adjustment of science management. Since 1978 when the Opening – up Policy was adopted, science management has experienced three stages (Rednet, 2008):

*Recovery and reconstruction (1978 – 1985)*

Various levels of scientific administrative departments and research institutes which were damaged during the Cultural Revolution were recovered or established, and a series of scientific policies was put forward. But for historical reason, scientific administration in this stage was still central planning: research and funding was assigned by the central government. Research institutes did not need to worry about their budgets nor did it matter whether they did a good job or not. This led to a situation in which low-level and low-efficiency research was very common in the Chinese academic community.

*Competition and marketization (1985 – 1993)*

The low efficiency in scientific research had caused wide complaints and requirement for further institutional reform became fierce. Scientific administration in this stage aimed at importing competitive mechanisms into scientific administration and encouraging communication between academic institutes and industrial sectors. To some extent, academic institutes had more space in making their own research plans. This provided more freedom for academic institutes on the one hand. But it also made institutes more short-sighted because of budget problems: they do research for money.

*Adjustment and innovation (1993 – )*  

The environment of knowledge production has been further improved since 1993. China has taken important actions to improve the development and management of science and technology. A series of important programs and laws have been carried out. For example, the “211 Program” adopted in 1993 and the “Knowledge Innovation Program” carried out in 1998 aim at supporting national research base. The former is for universities and the latter supports research in the Chinese Academy of Sciences.

In order to keep a stable research force and, in the meantime, encourage competition, China has adjusted its funding policy: from simply funding research projects to the combination of supporting both projects and construction of research base. Funding manners have been diversified. In addition to enhancing financial support to basic research, China established technological innovation projects for industries. For example, some industrial R&D centers in some large scale enterprises were funded by the government.

In this stage, the Chinese way of knowledge production has some signs of the Triple Helix. University spin-off firms, tri-lateral initiatives for knowledge-based economic development, government laboratories, and academic research groups appear and play increasingly important role in China’s project of constructing an innovative country.

In terms of the model of Triple Helix, Chinese knowledge production in science has entered the same stage as that of the some scientific leading nations. This means that China and the other leading scientific nations compete at the same level. Why, then, does China grow faster than its international counterparts in knowledge production? The following factors may help to explain this:

1) Continuous and increasing investments in R&D. More than any other country, China’s R&D investments are growing not only absolutely but also relatively to the spectacular growth in GDP;
2) The huge reservoir of human resources. In addition to the domestically trained researchers, growing numbers of oversea Chinese PhDs have returned to China. Enlarged and enhanced international collaborations help Chinese scholars merge more easily and therefore more actively into the knowledge production at the global level;
3) Research evaluation mechanism. Publications and especially international publications have become an important indicator for evaluating Chinese researchers since the 80s of last century. Publishing a certain quantity of papers has become a must for researchers. Publishing in international journals receives higher score than publishing in domestic journals.

In general, China’s growing momentum in knowledge production will most likely continue. But the gap between the natural sciences and the social sciences will exist and may be enlarged since the speed and starting points of the two are very different.

3.3 The Chinese way of scholarly communication

The Chinese system of scholarly communication is special compared to the international ones: Chinese researchers are less active in providing references to the publications of other scholars and mainly play a role as knowledge receivers in relation with their international counterparts.
Journal can less easily be accessed in China than in Western countries. This hinders Chinese scholars from knowing updated research output and therefore unable to cite recent literature in their publications. Lacking updated academic information may cause Chinese researchers to do studies that have already been finished by others. To many researchers, accessing domestically published literature is a problem, let alone the international ones. With increased financial support, such accessibility has been solved in some academic institutes, but is still a problem for many researchers.

Even if accessibility is not a problem, the reading habit and poor English language proficiency of some Chinese researchers may affect the efficiency of communication. Knowing what others are doing or have done has not penetrated into the academic life of some Chinese researchers. In order to force researchers to read more, some Chinese journals require that a paper must contain a certain number of references. Some journals even require that the share of international references must be at least 40% of the total. This policy reflects the important role of international publications in Chinese scholarly communication, and may explain, to some extent, why Chinese authors are less cited than citing in the international communication system.

In the past, Chinese journals did not wish references to be included because of the special censorship of Chinese publications. While registering in the General Administration of Press and Publications (GAPP), Chinese journals are required to indicate how many pages are included in one issue. One is not allowed to surpass this number of pages in later publishing activity. Chinese journals charge authors who publish papers. The cost is calculated in terms of the number of pages. In order to publish more papers so as to earn more money, some journals only allow a certain number of references because of the page limit. Some journals even omitted references. This situation began to change and some Chinese journals shifted from limiting to requiring references. No matter what journals require about the number of references, such artificial involvement may distort the evaluation when using bibliometric methods to measure citation impact of either journals or publications.

To sum up, the Chinese communication system is moving towards the international one. But a gap still exists. A comparison of references per Chinese publications shows that more documents are cited in Chinese publications after ten years’ development (Table 12-1). The gap between China and the West is narrowing but still exists (Table 12-2).

<table>
<thead>
<tr>
<th>Table 1. References per Chinese article (SCIE data)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1996</strong></td>
</tr>
<tr>
<td>Chemistry, Multidisciplinary</td>
</tr>
<tr>
<td>Materials Science, Multidisciplinary</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. References per article of some countries (SCIE data)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
</tr>
<tr>
<td>Chemistry, Multidisciplinary</td>
</tr>
<tr>
<td>Materials Science, Multidisciplinary</td>
</tr>
</tbody>
</table>
Learning from the West is still the main stream in China even though this country is advanced in fields like nano-science and nano-technology. While international collaboration keeps increasing and with more and more overseas Chinese scholars’ returning, China’s role of a knowledge receiver will change. A communication balance between Chinese and the international community can be expected in the future.

3.4 Further studies

Based on the fact that Chinese authors favour publications of their international counterparts and the raise of the new term ‘knowledge contributor’, it would be interesting to figure out who are the major knowledge contributors in knowledge production in the world. Comparative analysis on the difference between knowledge producers and knowledge contributors and exploring reasons behind may come out some interesting implications. It is also worthwhile to investigate the distribution of lowly- or un-cited publications in terms of regions and disciplines and to explore the knowledge base of Chinese scientific community with further investigation into fields. Furthermore, exploring the possibility of increasing the efficiency of scholarly communication would be an interesting topic of relevant players in scholarly communication. The skewed productivity among Chinese provinces hinders regional development when knowledge has become a base of economy. How to reduce the gap between the developed and undeveloped regions would be a nice research project. Further study on Chinese scholarly communication in the social sciences based on a Chinese domestic database can compensate the incompleteness of the present study included in the dissertation.


Chapter 13

Policy implications

China has achieved amazing progress in production of scientific knowledge. But this country’s citation impact is not proportionate to the rapid growth of its scientific publications: the citation impact of Chinese publications is still low. Such a sharp contrast requires adjustment of a wide range of issues pertinent to knowledge production and scholarly communication.

Knowledge production contains different stages including generating a research project, gathering funding and research resources, conducting research, publishing research results, and evaluating research performance. Each stage involves communications between pertinent actors in knowledge production. Ideal communications promote knowledge production not only quantitatively but also qualitatively. The Chinese case implies that improving quantitative production is relatively easier than encouraging qualitative production. The fact that scientific advanced countries including the USA, Japan, and the EU nations have both high share of publications and high citation impact indicates that there are spaces for China to improve its present situation. This chapter is dedicated to this purpose with policy implications specially made for different actors in knowledge production and scholarly communication. Implications which can be useful for two or more actors are put together.

1. For government agencies, research institutions, and authors

Enhance qualitative research

The innovativeness and quality of research are usually positively correlated. Innovative research, such as a breakthrough discovery, a new theory or method, may have more chances to be cited. This is an easy and difficult issue: easy to be understood but difficult to realize. The fact that China produces the second highest number of publications but has relatively low citation impact and Chinese scientists mainly absorb knowledge from foreign publications implies that Chinese publications are less innovative at a holistic level compared to the international ones. In other words, some Chinese publications are less useful or even useless. This situation implies that some R&D resources have been wasted, which is against the cost-effective principles for research funding. It is high time for relevant players to explore solutions which encourage innovative research. China should realize that it has finished the catching-up task in increasing quantitative production of scientific knowledge and should focus more on qualitative production.

Strengthen collaboration

International collaboration is a double-win practice. All participants get benefit from such kind of activity with an intention of making up their own deficiency by leaning or using others’ strong points. In addition, international collaboration is advantageous for:

- the emergence of new ideas,
- enlarging communication network, and
- raising international visibility.
In the Chinese case, international collaboration not only helps Chinese scientists improve their research skills and expand their perspectives, but also enlarges their communication networks. When a cooperation project is finished, Chinese scientists should remain in close touch with their international counterparts to ensure regular communication and perhaps next collaboration.

The development of Chinese international collaboration is reflected by the growth of internationally coauthored publications. But compared to the rapid growth of China’s total publications, the share of internationally coauthored publications is declining while those of most leading nations are increasing. This implies that Chinese international collaboration does not keep in pace with its overall activity in knowledge production. There are still spaces to improve in this regard. Up to now, China only has strong collaboration with the USA, Japan, Australia, and Singapore. In addition to further strengthening collaboration with these countries, possibility of extending collaboration with the European Union and its member nations, especially the UK, Germany, and France, Existing collaborated countries can also be explored.

Except strengthening international collaboration at an overall level, disciplinary variation should also be taken into account. Special supports may give to fields that are critical in national strategies and people’s livelihood and in which China is less active.

Domestic collaboration is important as well. Nowadays, knowledge plays increasingly important role in promoting economic development. The skewed distribution of knowledge productivity among Chinese regions may block the development of the less productive regions. Encouraging regional collaboration would help to reduce the gap between the poor and well developed regions and improve the knowledge infrastructure in the poorer regions. Regions with weak activity in certain fields may collaborate with those with strong activity. For example, Beijing, Shanghai, and Hong Kong are relatively active in engineering science and can be good partners for regions who want to enhance research activity in this subject category.

Establish scholarly communication networks

In addition to formal communication channels like academic journals and conferences, informal communication like workshops or seminars, blogs, and email links are also important. The international scientific community has provided good models. Take the email communication in scientometric community for example, the American Society for Information Science and Technology has established a Virtual Special Interest Group – the SIGMETRICS which is a listserv discussion group that covers bibliometrics and informetrics, but also metrics as related to the design and operation of Digital Libraries and other information systems interpreted broadly. Through the SIGMETRICS registered scholars can easily communicate thoughts, opinions, and announce their publications.

2. For government agencies and academic institutions

Provide better access to academic media

Compared to their international counterparts, Chinese authors have less access to international or even domestic journals, which results in Chinese scholars have fewer chances
to read relevant articles. Among the reasons that can cause such a situation, capital shortage
is critical for an institution when one has to decide how much and which literature should be
subscribed. Compared to the Chinese rates, price of international journals is very expensive.
Only a few Chinese research institutions or libraries can afford to subscribe. Even those
institutions that can afford international journals may have to make choices among interesting
literature because of financial shortages. In addition, many researchers in China complain that
the quantity of international journals their institutions subscribe is too small (Ning, 2002).

Construct a more feasible evaluation system

The end of the 80’s of last century can be considered as the watershed of Chinese knowledge
production because the Science Citation Index (SCI) was induced into Chinese research
evaluation system. Before the SCI was applied in research evaluation, the number of Chinese
publications in the SCI was very low. I just checked publications of China and Belgium in
1985 and found that Chinese number of publications (3,384) was lower than Belgian (5,155).
But ten years later in 1995, Chinese publications were increased to 12,535 while Belgium
published 8,292 papers. In ten years, Chinese publications grow by 3.7 times while that of
Belgium increased just by 1.6 times.

Design and selection of indicators for research evaluation play significant role in determining
the quality of knowledge production. Current evaluation schemes executed by Chinese
academic institutions encourage publishing in the SCIE/SSCI journals and mostly (even only)
emphasize on quantitative production, which is an important factor causing Chinese
publications increase rapidly. Papers published in domestic journals included in a Chinese
domestic citation database like the CSTPCD and papers published in journals covered by
international databases like the SCIE/SSCI are treated differently. The SSCI/SCIE papers
receive a much higher score than those in the CSTPCD. Journal impact factors instead of
citations received by a specific paper matter very much in research evaluation. Papers
published in the same SCIE/SSCI journal are treated the same no matter how many different
citations are received by these papers. Such evaluation methodology encourages researchers
focus more on quantitative instead of qualitative publishing. As discussed in Chapter 12, not
all journals covered by the WoS are of high quality and not all papers published in the same
journal are necessarily of the same quality.

Not only different fields should be treated differently. Variation among research in the same
field should also be considered. For example, some high-quality research may take years to
be finished and may not be able to publish within an evaluation period. Some research results
cannot be published because of intellectual property or security reasons. A good evaluation
system should consider every specific situation. Solely counting number of publications may
discourage scholars to conduct research of high quality but less productivity and may also
result in short-sighted studies.

It must be recognized that a well-established research evaluation system is not only
significant to the quality of knowledge production, but also critical to the development even
survival of Chinese academic journals. The current evaluation system results in high-quality
papers publishing in the SCI/SSCI journals. This may bring two bad effects. First, it reduces
the accessibility of Chinese researchers to new and high-quality knowledge. On the one hand,
many academic institutions cannot afford subscribing international journals because of their
unaffordable cost. Even though some institutions can subscribe international journals, a
considerable number of Chinese researchers cannot know what have been done by their
counterparts because most of the SCI/SSCI journals are in English and a large population of Chinese researchers’ English ability is rather poor. Second, publishing internationally may make the quality and impact of domestic journals worse since only poor quality papers are submitted to domestic journals. There are some Chinese journals covered by the SCI/SSCI. But the number is very small. In addition, current Chinese research standard values Chinese SCI/SSCI journals less than international SCI/SSCI journal. If an author feels his/her paper is high quality, the first journal he/she would think about is international not domestic one.

3. For government agencies and journal editors

Improve the quality of journals

Chinese journals are by far still the main channels for Chinese scientists to communicate with their international counterparts. High-quality journals need high-quality papers. Absorbing high-quality papers, especially papers produced by influential scientists may improve a journal’s quality. Realizing the relatively low quality and low international attractiveness of Chinese journals, relevant Chinese government agencies have carried out some measures by providing financial support to some selected journals. At the national level are the GAPP’s ‘Journal Phalanx of China’, the Ministry of Science and Technology (MOST)’s ‘Development Strategy Research for Competitive S&T Journals’, and the National Natural Science Foundation (NSFC)’s ‘Key Academic Specific Found’. But solely providing financial support does not solve the critical problem that most high quality papers go to the SCI/SSCI journals because of current research evaluation measures.

4. For journal editors

The low visibility of Chinese journals affects the expected citations of the articles published in them. As Chinese journals are still important channels for Chinese scientists to publish their research output, increasing the visibility of Chinese journals may help to raise the impact of Chinese articles. With the wide influence of the WoS in the evaluation of scientific output, inclusion in the WoS already has become a major objective among editorial boards of Chinese journals. However, inclusion in the WoS does not necessarily lead to an increase in visibility. More needs to be done to increase this visibility, especially in terms of efforts from both academic authors and editorial boards. The following issues are worth trying:

Increase accessibility for international readers

Journal articles need to be readable before they can be cited. When a journal is easily accessible, the possibility of being cited will increase. To realize this target, Chinese journals need to provide electronic editions to make the content easily accessible through the Internet or specific portals. Till now, there are three national journal databases providing online services relevant to scientific journal publications, and all of these operate commercially (Ren, 2005). The three online journals providers are: the China National Knowledge Infrastructure (CNKI), China Online Journals (COJ), and the VIP. The former two provide both Chinese and English versions while the VIP only has Chinese version. Both the CNKI and the COJ has several international users but the number is too small to achieve impressive change. More promotional work has to be done so as to enlarge international subscribers.

Provide open access
The commercial mechanism of the three online journals providers may prevent both domestic and international readers from accessing its data since most international scientists are not paying users. Open access may eliminate this barrier in terms of accessibility.

*Publish an English version*

The use of the Chinese language may prevent international readers from understanding the content of the articles. Using the Chinese language does affect an article’s visibility, and provision of an English version would help to improve visibility. Some Chinese journals, for example, the *Chinese Science Bulletin* and the series of Science in China, have had both Chinese and English versions.

*Cooperate with international publishers and online journal database providers*

International publishers have deliberate strategies for promoting their journals. Online journal providers give direct access to academic researchers. If a Chinese journal is covered by an international journal database, the chance of accessing international readers will be increased considerably.

5. For scientific authors

Authors are the original producers of scientific publications. Except enhancing knowledge required for corresponding research, pursuing innovative research, and seeking chances of international collaboration, the following two suggestions may also help.

*Be more active in informal communication*

By informal communication, I mainly point to reading published literatures and exchanging information and thoughts with peers. Innovative research is based on strong knowledge background which includes both education background and knowing the state-of-the-art. For the latter factor, reading publications by peers and communicating with both domestic and international counterparts may help. The fact that Chinese authors provide fewer references may indicate that they read fewer literatures than do their international counterparts. This may result in Chinese authors knowing less about what has happened in their fields. A good reading habit may also help to communicate regularly with domestic and international counterparts. Being well-informed is helpful for research. A good research idea may come from reading others’ output. If a researcher does not know or knows little about the evolution of his or her research interests, he/she might conduct research that has already been done or partly been done by others, resulting in a misuse of time and money.

*Improve English proficiency*

As an international language, English is a bridge for formal or informal communication and international collaboration. Most scholarly communication media covered by international citation data sources are in English. English writing ability is essential for publishing internationally. It is true that there are a few Chinese journals published in Chinese language and are included in international data sources like the WoS and the SCOPUS. But publications in these journals are hard to be known therefore impossible to be cited by international audience because of the language barrier.
Bibliography


(Source titles of the CSCD in 2007-2008). Available at:
http://sdb.csl.ac.cn/cscd_source.html.

(Announcement on the source titles of the CSSCI IN 2008-2009). Available at:

Davies, K. (2003). China’s economy: still some way to go. Available at:
way to go.html.

Delamont, S. (1989), Citation and social mobility research: self-defeating behaviour,
Sociological Review, 37 (2) : 332–337.

DICCAS (2004), China in World Science. Beijing: Library of the Chinese Academy of
Sciences. p. 29.

Dong, JQ. (1999), The development of Chinese social sciences. In: Review and Forecast:
Chinese Social Sciences in the 21st Century (中国社会科学的形成和发展，回顾与展望：

American Society of Information Science, 36, 28-37.

Doreian, P. (1986). A Revised Measure of Standing of Journals in Stratified Networks,
Scientometrics 11, 63-72.


7879-7597-4.

History of Science, 17 (2), 102-134.

Egghe, L. & Rousseau, R. (1990), Introduction to Informetrics. Quantitative Methods in
Library, Documentation and Information Science, Elsevier, Amsterdam.


Metric of Science: The Advent of Science Indicators. Wiley, New York.


Glänzel, W., Danell, R. & Persson, O. (2003), The decline of Swedish neuroscience - decomposing a bibliometric national science indicator, Scientometrics, 57 (2), 197-213.


Hicks, D. (1999), The difficulty of achieving full coverage of international social science literature and the bibliometric consequences, Scientometrics, 44 (2) : 193–215.


Indicators for the knowledge-based economy: A comparison between South Korea and The Netherlands. Scientometrics 65 (1), 3–27.


JCR 2003; Journal Citation Reports of the Science Citation Index. Philadelphia.


Jin, B., Leydesdorff, L., 2004. A Comparison of the Aggregated Journal Citation Structures in the Chinese Science Citation Database and the Science Citation Index. Paper presented at the Eighth International Conference on Science and Technology Indicators. Leiden, 23–25 September.


Jin, Bihui, L. Leydesdorff (2005), 中国科技期刊引文网络：国际影响和国内影响分析 (Citation networks of Chinese S&T journals: analysis on international and domestic influence), 中国科技期刊研究 (Chinese Journal of Scientific and Technical Periodicals), 16 (2) : 141 – 146.


Leydesdorff, L. (2002). Indicators of Structural Change in the Dynamics of Science: Entropy Statistics of the SCI Journal Citation Reportss. Scientometrics, 53(1), 131-159.


217
Leydesdorff, L. (2004c). Top-Down Decomposition of the Journal Citation Reports of the Social Science Citation Index: Graph- and Factor-Analytical Approaches. Scientometrics, 60(2), 159-180.


Leydesdorff, L., & Cozzens, S.E. (1993). The delineation of specialties in terms of journals using the dynamic journal set of the Science Citation Index. Scientometrics, 26, 133–154.


Leydesdorff, L., C. Wagner (2007), Is the United States losing ground in science? A global perspective on the world science system, Proceedings of the 11th International Conference of


O’Neill, J. (2005), Attention Europe: The BRICs are coming! Internationale Politik, 60 (5), 78-79.


Wouters, P. F. (1999), The Citation Culture, Ph D thesis University of Amsterdam. This work has been discussed, apart from in the scientific literature, in NRC HANDELSBLAD and ELSEVIER.


Xinhua Net (2007a). In the past four years, Chinese economy has jumped to the fourth from the sixth. Availble at http://news.xinhuanet.com/newscenter/2007-10/11/content_6864327.htm

Xinhua Net (2007b). 高层次留学人才回国工作不受编制户口限制(Return of high-level talents will not subject to the limitation of establishment or registered permanent residence). Available at: http://news.xinhuanet.com/edu/2007-03/29/content_5913881.htm.


Zhou, P. & L. Leydesdorff (2007b). The Citation Impacts and Citation Environments of Chinese Journals in Mathematics, Scientometrics 72(2), 185-200.


Zhou, X. (2002). 《中国人文社会科学引文数据库(CHSSCD)》的建设、应用于发展 (Construction, application, and development of the Chinese Humanities and Social Science Citation Database (CHSSCD)). 情报资料工作(INFORMATION AND DOCUMENTATION SERVICES), 4: 30-32.


