Published in: Proceedings of the ISSI 2007, D.Torres-Salinas & H.F. Moed (eds.)
CSIC, Madrid, pp. 427-436

The role of ethnic ties in international collaboration: the Overseas Chinese Phenomenon[1]

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Abstract
The term 'Overseas Chinese Phenomenon' is used here to refer to the fact that scientists of Chinese descent play an important role in international collaboration between mainland China and the rest of the world. In this paper, we review international collaboration between ethnic Chinese scientists in eight countries – USA, England, Germany, France, Japan, Canada, Australia, and South Korea – and colleagues in China itself. Our analysis shows that while ethnic ties play an important role as a bridge between China and the country of residence, policies of the Chinese government with respect to international collaboration and overseas Chinese reinforce the growth of ethnically based co-authorship.

Keywords
international S&T collaboration; overseas Chinese scholars; ethnic ties; government policy; ethnic collaboration index (ECI), knowledge transfer

[1]The authors thank Zhang Wang, Zhou Qiuju, Yang Liying, Yang Liangbin and Wang Dan for collecting and counting data. Research for this article has been funded by a Major State Basic Research Special Program China under grant (No 2004CCC00400) and by the US National Science Foundation (OISE-0440422).

Introduction

Since opening its doors to the outside world in 1978, China has experienced a series of organizational reforms and policy adjustments. Coincidently, a large number of Chinese students and scholars have gone abroad, studying in Western technologically developed countries, and engaging in academic exchange and scientific collaboration with international colleagues. These activities also have had a profound influence on the development of China's science and technology, including international scientific collaboration.

From the beginning of the 1990s, the number of science and technology articles published by Chinese in international periodicals has shown an exponential growth (Jin & Rousseau, 2004, 2005).[2] This increase brought China into a quantitative expansion phase (Jin & Rousseau, 2005). During the ten year period from 1996 to 2005, the doubling time of all Chinese SCI papers was 3.97 years, indicating that on average every four years the number of published articles has doubled. Among these, articles written by Chinese scientists through international collaboration show a doubling time of 3.81 years, an increase rate slightly higher than that for all Chinese SCI papers.

In 1996, Chinese international collaboration led to the publication of 3,017 papers, reaching 15,069 in 2005, a five-fold increase over ten years. The number of Chinese papers with international collaboration in 2005 alone was almost equal to the sum of all such articles published during the 1994 – 1997 period. This rapid increase in the number of international collaboration can also be observed from the fact that today, of all Chinese SCI papers, about one in four is internationally co-authored.

Many factors, both internal and external, have caused the developments mentioned above. Besides political, social and geographical reasons (Wagner et al., 2001; Wagner & Leydesdorff, 2005; Katz, 1994; Beaver, 2001; Zitt et al., 2000), we would like to add another one, namely ethnic ties. Our recent survey of Chinese-American collaborative papers in about one hundred periodicals indicates that among 3,603 such papers, 72.3% have at least one author working in the US who is either a Chinese scientist or a scientist of Chinese descent (Jin et al., 2007). This high percentage indicates that overseas Chinese living, studying or working in the United States are playing a vital role in Chinese-American scientific collaboration.

This article expands the scope of the previous investigation to eight countries – USA, Japan, Germany, England, Australia, Canada, France and South Korea – in an attempt to prove that ethnic ties play an essential role in the collaboration pattern of mainland China with other countries. As far as we know, few such studies have been performed before although we have the contribution of B.M. Webster (2004) who, in studying the impact of ethnic minority researchers on the scientific output of the UK, found that ethnic participation in British science varies across different ethnic groups, with the Chinese best represented in relation to their share in the total population. Basu and Lewison (2006) wrote an article, somewhat similar in spirit as ours, studying the output of the scientific community of Indian origin in the USA. Finally, Bassecoulard et al. (2003) studied the scientific production of Madagascar and compared this with that of Malagasy scientists in the diaspora.

Data collection and methods

Target countries

SCI data indicate that for the period from 2001 to 2005, USA, Japan, Germany, England, Australia, Canada, France and South Korea were the top eight countries in terms of the number of collaborative papers with mainland China. Table 1 lists the total number of China's collaborative papers with authors of these eight countries (collaborative articles including authors from China and another country will be referred to as "co-papers"). In 2005, the number of Chinese co-papers totaled 15,069, of which 12,101, or 80.3%, were with these eight countries. The reader may notice that the sum

[2] All data used in this article originate from the Web of Science.

(14,314 for the year 2005) of Table 1 is significantly higher because an article written in collaboration between China and two (or more) of these eight countries is counted twice (or more), namely once for each collaborating country.

Table 1. China's co-papers with its eight most important partner countries (2001-2005)

Partner country	Number of co-papers		Partner country	Number of co-papers	
	2005	2001-2005		2005	2001-2005
USA	5,722	20,815	AUSTRALIA	976	3,837
JAPAN	2,303	9,342	CANADA	1,100	3,831
GERMANY	1,377	5,622	FRANCE	832	2,935
ENGLAND	1,327	4,806	SOUTH KOREA	677	2,377

Ethnic Chinese

The term 'ethnic Chinese' in this article refers to people of Chinese descent living outside mainland China (but not in Taiwan or Singapore). They are recognized by the fact that they have a Chinese family name. They may or may not use an English first name. Ethnic Chinese will also be referred to as 'overseas Chinese'.

Data sources

All data are taken from the Web of Science, the literature type is 'article', and the time span is 2001-2005. Not all records are used however. Details are provided in the following section, where we describe how groups are constructed.

Collaboration types and groupings

The role played by overseas Chinese played in co-papers can be analyzed from several points of view. Therefore, we distinguish the following five types of co-papers.

Type A are those articles where at least one (ethnic) Chinese author has an address outside China. Some co-authors may be 'foreigners'.

Type B articles are those articles written with international collaboration but in which all Chinese authors have only addresses in mainland China. So, these articles do not involve overseas Chinese co-authors as partners, only 'foreigners'.

Type Aa are those articles where at least one ethnic Chinese author has two addresses: one in China and one in another country.

Type C are those articles where all authors are mainland and ethnic Chinese and at least one has an address in another country.

Type D are those where the first author, or the corresponding author is an overseas Chinese.

Figure 1 illustrates the relation between these five types of co-papers.

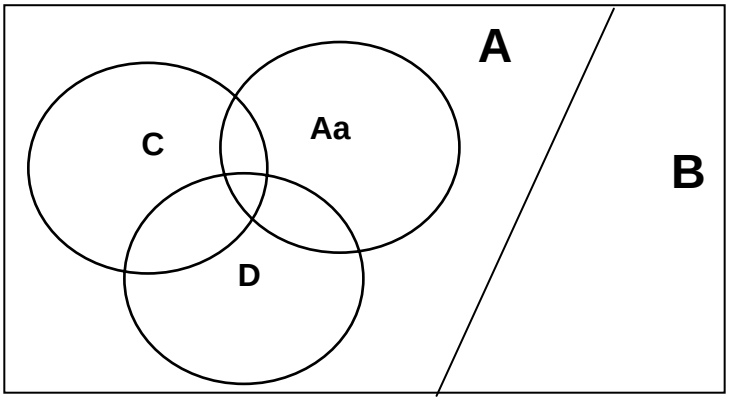

Figure 1. The five types of co-papers

From the different characteristics of the papers surveyed, we considered the following three data sets for analysis.

Set I contains a sample from all co-papers. Two factors are taken into account for determining this sample: the ability to obtain the original articles and the workload since all articles in this sample required visual inspection of the original publication. Articles included in this sample therefore had to satisfy the following three requirements: a) being included in the SCI, b) being available in the National Science Library of the Chinese Academy of Sciences, and c) leading to an adequate sample size. These restrictions are such that we were able to include all articles satisfying our requirements for all the countries other than the USA. For the USA we had to use a partial sample. This data set contains 18,879 papers. If an article involves n collaborating countries then it counts n times.

Set II consists of all type C co-papers (i.e., all authors are ethnic Chinese) involving the eight selected countries and published between 2001 and 2005. This gives a total of 11,782 items in Set II. If an article involves n collaborating countries then it counts n times.

Set III consists of all type D co-papers involving the eight selected countries and published between 2001 and 2005. Articles with more than ten authors (usually big international projects) are omitted from this set. This leads to a total of 9,836 items in which the first or corresponding author is an overseas Chinese. This number again includes double (or more) counting: if an article involves n collaborating countries then it counts n times.

Table 2. The number of items in different data set (2001-2005)

Data sets	Items		Note
Set I	18,879		Sample data
Partner countries	Total co-papers (a)	Sample data (b)	Percentage included: b/a
China with USA	20,242	5,248	25.9%
China with England	7,962	2,053	25.8%
China with Japan	9,362	3,658	39.1%
China with Germany	4,997	2,773	55.5%
China with France	2,880	1,318	45.8%
China with South Korea	2,351	1,007	42.8%
China with Canada	3,749	1,508	40.2%
China with Australia	3,729	1,314	35.2%
Set II	11,782		100 %
Set III	9,836		100 %

Observations

Type A and Type B

The occurrence of overseas Chinese among co-authors determines the distinction between type A and type B. This distinction was made by visual inspection of the published articles. In this way, through many hours of work, we were able to overcome restrictions imposed by the structure of the Web of Science.

From this data, it is possible to introduce an “ethnic collaboration index” (ECI) as the ratio of type A articles over all co-papers, an index which, of course, could in principle be calculated for other ethnic groups as well. Table 3 gives the ECI per country over the period 2001-2005.

Table 3 ECI for ethnic Chinese per country (period 2001-2005)

Country	ECI	Country	ECI	Country	ECI	Country	ECI
USA	0.721	Canada	0.551	Japan	0.475	France	0.303
Australia	0.561	England	0.481	Germany	0.403	South Korea	0.283

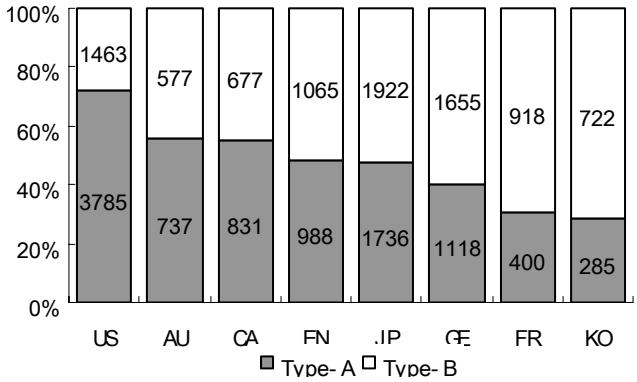

Figure 2. Illustration of the Ethnic Collaboration Index (ECI)

As further depicted in Figure 2, China's collaboration with the USA is more likely to yield Type A articles, while the majority of co-papers with Australia and Canada also are of the A type. Additional data (not included in this article), show that the overall ECI has been increasing over time, especially for the USA, England and Canada. Only Australia and Germany show an opposite trend: there the growth rate of type B articles is larger than that of type A articles, leading to a decrease in ECI.

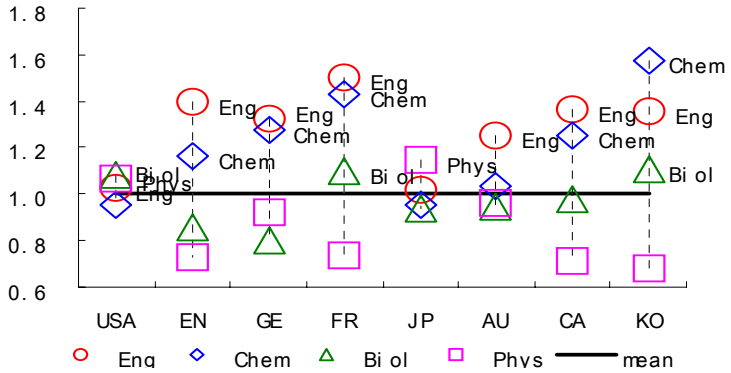

Figure 3. Relative strengths of Overseas Chinese ties in four fields

The relative number of overseas Chinese scholars in different nations and disciplines in each partner country directly affects the ECI. Here, statistics per domain were collected for the fields of physics, chemistry, biology and engineering. Figure 3 illustrates our findings. A value larger than one means that in this domain there are more co-papers with overseas Chinese than for the average of all fields. The opposite is true for a value smaller than one. We observe that engineering always (in all eight countries) has been the field in which more collaboration has occurred between Chinese scientists and their overseas Chinese colleagues than in other fields. Physics is generally weaker (except for Japan), while chemistry is generally stronger. The strength of the overseas Chinese in America and Japan is quite even over the four domains.

Type- Aa: papers by amphibious authors

The defining characteristic of Type Aa papers is that they include an overseas Chinese author who has two addresses, one is a Chinese organization address and the other is an organization address in a partner country. We will refer to such an author as an "amphibious author". In a sense an amphibious author embodies Chinese ethnic collaboration in one person.

Amphibious authors are usually experienced and accomplished scientists. They play an extremely significant role in Chinese international collaboration and in reducing scientific gaps between China and advanced countries. According to our survey (see Figure 4), this type of paper shows a considerable increase in all countries (except for Germany). The largest growth has occurred with Canada (203%), but the USA shows a high growth rate for this type of paper (186 %) as well. In 2005, Type Aa articles yielded more than 50% of all Type A articles in all countries, except England. These data prove that amphibious authors occupy a key position in the international collaboration network of China.

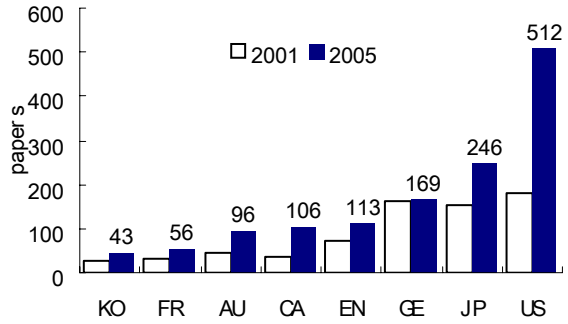

Figure 4. Type Aa articles: a comparison between the year 2000 and the year 2005

Type C

Type C articles are characterized by the fact that all authors are Chinese: some living in mainland China, some living abroad. As there are no non-Chinese authors involved, these articles suggest an independence of ethnic Chinese from their hosts. It is not clear whether this is positive or not.

Table 4. Yearly distribution and percentages of articles of Type C

Country	2001	2002	2003	2004	2005	Type C / All co-papers	
						2001	2005
US	844	945	1243	1464	1942	29.8%	34.7%
CA	75	98	138	139	132	20.8%	32.8%
AU	45	51	58	81	114	22.0%	29.2%
EN	144	215	222	301	373	12.1%	17.9%
FR	114	141	162	201	212	12.1%	13.9%
GE	103	153	215	289	356	14.6%	9.7%
JP	105	163	211	257	280	8.1%	9.1%
KO	21	23	40	57	55	7.3%	8.1%

Citation analysis of such articles (to be performed in a future article) will provide an answer. Table 4 shows that the number of type C articles has increased in absolute terms and relative to the total number of articles with at least one overseas Chinese). As seen in Table 4, this type of article is most prevalent with the United States, closely followed by Canada, and lowest in Japan and Korea.

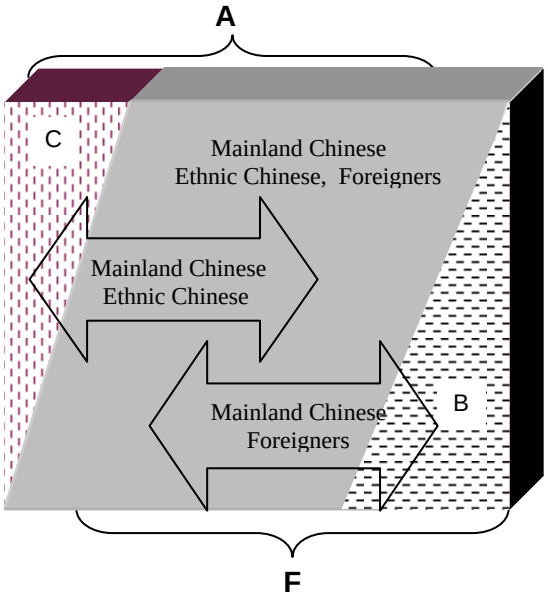

Fig.5 Another look at the relation between different types of articles

Figure 5 offers another look at the total set of co-papers. All these articles involve mainland Chinese authors, as well as authors with an address in another country. Articles in the B group do not have ethnic Chinese co-authors, while authors in the C group do not have non-Chinese co-authors. Yet, type C articles form only a minority in the total number of co-papers. Most articles involve 'foreign' co-authors as local partners, i.e. scientists who are not Chinese or of Chinese descent. If we denote them as type F, we see that they are always included in type B publications and in all type A publications which are not type C. These foreign co-authors are the mainstream partners for international collaborations with mainland China. Depending on the country between 65 and 92% (see Table 4) of all co-papers involve these local partners.

Type D articles

Table 5. Distribution of type D articles *

Country	2001	2002	2003	2004	2005	Growth between 2001 and 2005	
						Type D	all co-papers
US	707 (27.2%)	765	994	1195	1286 (26.1%)	0.82	0.90
JP	210 (16.1%)	254	262	309	333 (15.9%)	0.59	0.61
EN	118 (10.6%)	195	165	205	208 (11.6%)	0.76	0.61
CA	96 (21.1%)	126	164	197	207 (22.2%)	1.16	1.05
AU	105 (23.7%)	114	166	191	171 (20.0%)	0.63	0.93
GE	78 (17.0%)	114	155	114	132 (12.1%)	0.69	1.38
FR	32 (10.8%)	33	52	45	61 (10.4%)	0.91	0.98
KO	41 (18.6)	64	55	63	54 (10.1%)	0.32	1.43

* The figure in parentheses is the percentage of Type D articles in the total number of co-papers in that particular country.

Usually the corresponding author is the most important one. Except for certain fields (e.g., mathematics) this is often also the first author. In this section we pay special attention to the share of ethnic Chinese in this 'backbone' role. We first note that the absolute number of type D articles increased between 2001 and 2005. Yet, over this five year period, the proportion of type D articles among all co-papers shows a slight decline. When all co-papers are considered, our data show that Type D papers constitute only 19.2% of the total.

Data on Type C articles show that, among the co-papers of which all authors are Chinese (living in mainland China or in another country) a mainland Chinese collaborator is first author in about 74.3% of the cases in 2005. Only in a minority of cases (about 25.7%) is the overseas Chinese the first author. This shows that in this type of collaboration the overseas Chinese does not play the leading role, but merely acts as a bridge between China and his/her country of residence. We may conclude from this observation that ethnic Chinese is one factor of facilitating international contacts between countries.

Explanations of the observed results

Ethnic ties: A power in collaboration

On December 10, 1976, at Stockholm's concert hall, when receiving the Nobel Prize in physics, Samuel C.C Ting (Ding Zhaozhong), a scholar of Chinese descent, delivered his Nobel banquet acceptance speech in Chinese – the first time Chinese was used for such a ceremony. In this way, he hoped that the whole world would hear the voice of a "Chinese nation of science". Since China's reform and opening-up, Samuel Ting has been a regular visitor to China, leading to enhanced opportunities in scientific collaboration between China and the United States, which illustrates especially well the importance of ethnic ties.

But, as students of transnational relations are discovering, the concept of ethnic tie is not without considerable ambiguity in today's globalized world. On one hand, it points to shared identities based on language and culture. But the transnationalism which characterizes most overseas Chinese scientists is not so simple: we see the rise of bi- (or multi-) lingualism, and bi-(or multi-) culturalism further compounded by new forms of professional attachments and changes in immigration status and/or citizenship. In short, transnationalism tends to produce multiple identities.

Ethnic ties can thus be seen as a way of managing these multiple identities. As used here, we view ethnic ties as a form of "homophily," a principle which states that contact between similar people occurs at a higher rate than among the dissimilar people (McPherson et al., 2001). Thus, on one hand, we see overseas Chinese scientists drawn to established affective relations binding families, relatives, teachers, former collaborators and students together, affective orientations which can and do spill over to a broader sense of service to China's national development. On the other hand, ethnic ties are also used to advance career objectives, reputation, and prestige. In this study, we are not able to sort out the complex ways in which this happens, but it is clear from the data that ethnic ties – the *Overseas Chinese Phenomenon* – do play a very important role in China's international scientific collaborations. In this, we believe that China is not unique and look forward to further work on how, and if, ethnic ties play a role in international collaboration for other countries, such as India and South Korea.

Social basis of the Overseas Chinese Phenomenon

The 'Overseas Chinese phenomenon' in China's international collaboration in science and technology has developed from a deep social basis over many years. Chinese scientists leaving China, permanently or temporarily, are certainly influenced by Chinese traditional culture, write the same language, and have close social relations with China. These factors have constructed a social basis binding overseas Chinese to a China with which they share many characteristics. This social basis is also where the opportunity lays for overseas Chinese to carry on international collaboration with China. From the foreign country's perspective, the presence of a significant community of ethnic Chinese makes it easier to collaborate with scientists in mainland China. Without this community China's contribution to international collaboration would not be as high as it is today.

At present, there is a large number of overseas Chinese scientists located in many countries. When these scientists retain ties with their country of origin, they are able to contribute to not only the scientific welfare of their adapted country but also that of their country of origin.

Visible hands: policy effect

The appearance of the 'overseas Chinese phenomenon' in Chinese international collaboration can be attributed to another important reason, namely the vital role played by the Chinese government

(Xiang, 2005) Since the end of 1990's, the Chinese government has gradually issued a series of policy measures to attract overseas Chinese scholars. Over the years these policies are similar to a visible hand, guiding overseas Chinese scholars to join in Chinese international collaboration. The 'Overseas Chinese Phenomenon' observed in this paper can at least partially be explained by the effect of this policy.

Over the period from 1978 until the end of 2005, the total number of Chinese citizens studying abroad reached 933,400, of whom 232,900 students already returned. At present, 512,800 Chinese citizens are abroad studying, conducting collaboration research or on an academic visit (China Education and Research Network, 2006). The Chinese government has adopted many kinds of policies and measures for engaging this group of citizens to participate in scientific research with Chinese colleagues. For example, the *Fund for Distinguished Young Scholars* established by *the National Natural Science Foundation of China*, has funded 431 research projects over the period 2000-2005. Since 1997, the Chinese Academy of Sciences has incorporated the *Outstanding Talents Program* as a part of its *Hundred Talents Program*. By 2004, altogether 850 ethnic Chinese returned to mainland China through this program (Bureau of Comprehensive Planning of Chinese Academy of Sciences, 2004). In 1998 the Ministry of Education started implementing the 'Yangtze River Scholars Program', with the objective of attracting back to China a large number of outstanding young and middle-aged academic professionals, and giving them the opportunity to help China uplift the educational level of all types of institutes for higher education. In 2005, 88 scientists were appointed as short-term professors (for short courses). They came from many countries and regions, but only three of them were of non-Chinese decent. That year the United States alone provided 61 'Yangtze River Scholars'.

Conclusion and discussions

In this article we studied some aspects of China's international scientific collaboration. We believe that the observed data can be explained by two main factors: ethnic ties and the influence of government policies. We do not intend to make an analysis of government policies now, but focus on the issue of ethnic ties instead. The 'Overseas Chinese Phenomenon' refers to the fact that overseas Chinese have become a vital factor in helping Chinese scientists to establish international collaboration channels, and in finding international collaboration partners. The 'Overseas Chinese Phenomenon' in international collaboration seemingly is serving as a mechanism of knowledge transfer in the developmental process of Chinese science, and is likely to remain important even when China is fully integrated into the world of international science.

Our analysis shows that ethnic overseas Chinese play an active role in promoting international collaboration and act as bridges between China and their country of residence (permanent or temporary). Their role helps China to reduce the gaps that still exist between the country and leading developed countries. There are, however, two sides on this coin. As most co-papers involve non-ethnic Chinese from the partner country, China benefits, but developed countries benefit as well as Webster (2004) has argued. The United States of America, in particular, has been the beneficiary of the presence of 62,500 PhDs of Chinese descent working within its borders as of 2003 (US NSF, 2006). As Wagner and Juma (2005) have argued, international scientific cooperation is indeed the key to success in a globalized, networked world, and ethnic ties can be a surprisingly important mechanism in promoting that cooperation.

Is the role of ethnic ties a universal phenomenon existing in international collaboration of all or most developing countries? We hypothesize that it is, and hope that our colleagues looking at scientific development in other countries investigate this further. We even suggest that it is perhaps stronger for developing countries, but that it exists between all ethnic groups, living in a developing country or not. In this article we have shown that ethnic ties are certainly a powerful factor in contemporary Chinese international collaboration. As such it is an example of the homophily principle which states that contact between similar people occurs at a higher rate than among dissimilar people (McPherson et al., 2001).

In this article we have studied quantitative aspects of the Overseas Chinese Phenomenon. As we know, China is in a quantitative expansion phase (Jin & Rousseau, 2005) We have not addressed qualitative issues here, but it would certainly be interesting to investigate whether these collaborative articles are of high quality, if they attract more citations than the average Chinese article, which of the types discerned here attracts the most citations, and from whom. This is left for future research.

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