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Navigating and negotiating global science: tensions in China's national science system

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ABSTRACT

This study aimed to understand the tensions in China's national science system as China is becoming a central player in global knowledge production. Publishing patterns and international co-authorship patterns of Chinese universities were utilized to analyse the dynamics and tensions in the national science system. Findings show that China's scientific publishing and collaboration behaviours are embedded in the 'centre-periphery' framework of the global science system, which stimulates conflicts between the rapid growth of English publishing and the need of developing China's local indigenous research. The Chinese national science system is increasingly stratified as it moves from the 'periphery' towards the 'centre' of the global science system. Its integration into the global science system is reliant upon a handful of top research universities and disciplines in the natural sciences and engineering. A tension lies between the universal and open nature of science and the hierarchical global science network.

KEYWORDS

Global science; national science; Chinese higher education; international collaboration; academic publishing

Introduction

The field of 'science' is comprised of a complex intermeshing of individual researchers and groups, research institutions, national science systems and a global science systems (Marginson and Wen 2019). National science systems have become connected to the global system and evolve partly in response to it. As most people still think from within the 'national container' (Shahjahan and Kezar 2013), the relationship between the national science system and the global science is often unclear. It is essential to explore the boundary between national science and global science, even though the boundary is often blurred.

Relations between the national science system and the global science system are a case-by-case matter. As China has become a global powerhouse of science and technology with the largest volume of scientific publications in the world since 2016 – 426,000 publications constituting 18.6% of all in publications in Elsevier's Scopus database (Tollefson 2018), it is chosen as a case to examine the tensions within its large national scientific system. Among many explanations such as the economic determinism and Confucius cultural determinism, one of the most important explanations for China's great jump in scientific production is China's integration into global higher education system since 1980s (Horta and Shen 2020; Wen and Hu 2019). The global intellectual and personnel exchanges allow China to come closer to the frontier of global science. China's connections with the scientific superpowers, especially the United States, largely increase the level of scientific production of China (Freeman and Huang 2015). Marginson (2022) associated China's rise in scientific production to the dual process of capacity building that integrates global science and

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national science. He referred to the development of China's science as the national/global synergy, but also mentioned that China has been only partly dependent on the global system. The tensions within China's national science system that includes academic fields, institutions, and language, can hold back the effectiveness of the synergy. With these layers patched, the global-national synergy in China's national system development is not solid. As China integrates into the global science system, the tensions within should be revisited.

In this line of research, most studies utilized a bibliometric approach that relies on English publications, which cannot accurately depict a full picture of China's national science system, as Chinese publication is an essential part of the national science system. Chinese academics, humanities, and social sciences scholars, in particular, have different research paradigms, topic preferences, and styles of writing in their Chinese and English articles (Yang, Xie, and Wen 2019). Overlooking the role of Chinese publications in analysing China's national science system would mislead our understanding of publishing behaviours and outcomes. Thus, this study seeks to extend the current understanding of the interplay between China's national science and global science by bringing in a large volume of Chinese publications and shedding light on the existence of Chinese publications in China's national science system.

Two major research questions guide this study: What are the patterns in Chinese research universities' publications and international collaborations? How do the publishing and co-authoring patterns illustrate the tensions in China's national science system since it has been engaged in the global science?

Interpretative frameworks of global science and national science

Marginson (2021) summarized four interpretative narratives of global science that include: science as a centre-periphery hierarchy; science as an arms race between competing nations; science as a global market of competing 'World-Class Universities' (WCUs); and science as an expanding cross-border network. This study adopts this framework to conceptualize the tensions within China's national scientific system in the context of global science.

First, the centre-periphery conceptualization of global science is derived from the notion that sees science as a site of relations of power which is largely determined by economic and military power (Marginson 2021). The centre-periphery structure in the global network of science acknowledges the intellectual or financial dependency within a hierarchical social system of science (Beaver and Rosen 1979). Relatedly, the hierarchical structure of science has been intensified by the global rankings of WCUs that are largely based on the Euro-American script. Ranking perpetuates the hierarchy of university firepower that shapes which knowledge carries the most authority. To reposition itself in the centre-periphery global structure, China has concentrated resources in the designated national flagship universities (Oleksiyenko 2014). Yang (2014) found that Chinese national flagship universities focus their strategic collaboration overwhelmingly on prestigious global partners, as they used to compare themselves with their prominent Western peers and are chasing after their peers in the 'centres' mainly in North America and Europe. The centre-periphery theorization is problematic by overemphasizing the binary North–South hierarchy and the Anglo-American hegemony; the global science is increasingly becoming multi-polar with the rise of Asian systems such as Singapore, South Korea, and China. The breakthrough of China to a leading global role to some extent can show the collapse of the centre-periphery model (Marginson 2021).

Scientific nationalism and scientific globalism further discuss the ways in which the nature of science and disciplinary knowledge plays a part in shaping the tensions in China's national science system. In relation to scientific nationalism, science is an arms race (Marginson 2021), utilized by nation states to promote national interests and exceed each other (Cantwell and Grimm 2018). Scientific globalism focuses on the advancement of knowledge and open science rather than on national advantage and prestige (Sá and Sabzalieva 2018). Scientific nationalism and scientific globalism not only contrast, but also coexist with one another (Lee and Haupt 2021).

Like scientific globalism, science network research is also built on the nature of science being open and universal. Science network theory grasps the fluid public good nature of knowledge (Stiglitz 1999), which flows quickly in all directions, and the self-organizing quality of science (Leydesdorff and Wagner 2008). The network framework gives attention to the 'flat' aspects of global research collaborative relations. However, the hierarchical nature of science network is also valid, nodes with either more existing connections or structural advantages tend to have more power over the new entrants. These theoretical perspectives together guide this study to synthesize how national and institutional policy, language, science, and knowledge may form the tensions between China's national science system and the global science system.

China in global science

Global versus national science in policy

Since the first decade of twenty-first century, the national research policy has changed from 'import-oriented' that features the period after the Open Door policy to 'going-out oriented,' which has a considerable impact on China's contemporary national science system. Unlike in Anglophone nations where academic governance has arguably discussed more at institutional level (Rowlands 2017), in China's context, academic governance is seen practised at party-state level as the state has stronger supervision over universities, despite a very few top research universities in China might enjoy more institutional autonomy than others.

National science policy has been encouraging English publications and international collaboration. Since the late 1990s, the Chinese government and universities have been inclined to encourage Chinese scholars to publish English papers through monetary incentives and career-related incentives (Xu 2019). International collaboration is explicitly encouraged in 'project 985' and 'Double First Class University' policies. From the 'project 985' period to 'Double First Class' period, the policy discourse has changed from 'we should build an environment that benefits international academic exchanges and scientific collaboration … collaborating with world-class universities or academic organizations' (Ministry of Education of China, MOE 2004) to 'higher education institutions should aim at world-class level … to proactively engage in the global intellectual exchanges, and thus expanding the global impact'(MOE 2018). The changing discourse in national higher education policy reflects the changing status of Chinese universities in the world and the national goal of becoming a 'leader' other than a 'follower' in global science.

The phenomenon of 'SCI/SSCI worship' can be a side effect of the national goal of promoting world-class universities and national presence in global science. The campaign against 'SCI/SSCI worship' has started in recent years in the academic community, especially in the fields of humanities and social sciences. In 2018, MOE purposed to break the 'Five only' (only scores, admissions, diplomas, publications, academic titles). In 2020, the Ministry of Science and Technology (MOST) and MOE released two policy documents that potentially set new guidelines for academic publishing, which explicitly discouraged institutions from rewarding individuals and departments based on the SCI articles they publish. Publication in top international journals (e.g. *Cell, Nature, and Science*) is still encouraged, but equal importance is attached to the domestic publications selected for the 'Action Plan for the Excellence of Chinese STM Journals,' an official list of 285 high-quality Chinese scientific journals (Li 2020).

These recent science policies encourage Chinese scholars to 'write papers on the land of our country' (MOE 2020), which signify a national policy shift from reliance on international publications. Some research universities do not offer monetary awards for international publications indexed by SCI/SSCI any longer, whereas place more weights on Chinese publications in faculty members' promotion and award selections. There might likely be a decrease in the number of papers submitted to SCI/SSCI articles or some lower quality English journals. As such, Huang (2020) thought if Chinese institutions would lessen the reliance on SCI and SSCI, the international collaboration would inevitably drop for China.

Global and national language of science

English is regarded as the global language of published science (Rijnsoever and Hessels 2011), thus having an absolutely dominant position in the global science system (Xu 2019). Global English can operate as part of both the global science system and the national system. Despite the fact that native language publications are declining in almost every country, China is an exception in that it is the largest producer of scientific publications in Elsevier Scopus, and its publications in its native language are not declining. In 2018, the number of articles written in Chinese and published on Chinese journals was 1.04 million, twice as many as those published in English journals (NBSC 2018). However, the impact of the large volume of Chinese publications on the global science system is limited, as most Chinese journals are 'unread and uncited' outside China, with narrow author distribution and readership (Feng, Beckett, and Huang 2013). The fact that language creates barriers for non-English speaking countries to exchange their knowledge in global science is undeniable (Yang, Xie, and Wen 2019).

Some scholars thought it problematic to evaluate national science through a global lens. Shin (2007) found that SSCI publications were used as the 'guiding light of social science' in South Korea, which results in the withering of indigenous social sciences. Maldonado-Maldonado and Lee (2018) asserted that prioritizing global over local interests in order to be published in English journals for some locally oriented research is problematic for research universities in the Global South. This issue is particularly salient in the social sciences and humanities and some applied science and engineering disciplines. Unlike science and engineering faculty members who are accustomed to reading the top journals, such as *Nature* and *Science,* and subsequently target them for publication, some traditional engineering disciplines, however, have a larger group of audiences in the industry who favour reading Chinese. Thus, faculty members aim to publish in high-quality international journals while maintaining close relationships with the domestic industries and concerning the local applications of scientific results. Also, for social sciences scholars, it is a practical conflict between the need to develop local research, practices, and policies and the institutional push for thinking about their presence in international/English journals (Wen and Yang 2019; Yang, Xie, and Wen 2019).

International research collaborations

International research collaboration serves as an important linkage between the national science system and the global science system. China has an international collaboration rate of 22%, compared to 39% in the US (NSB 2018). European countries have higher rates of international co-authorship, such as the United Kingdom (62%). The propensity to collaborate across borders is closely related to the national system size and trajectory. Countries with larger systems typically have lower rates of international co-authorship because of more domestic partners (NSB 2018).

Of all China's international collaboration in 2018, about 44% were collaborated with US authors. China and the US mutually benefit from the research collaboration. The US extends the global reach of China's research with its established scientific heft, and China brings financial investments to scientific research (Lee and Haupt 2020). Additionally, scholars found China's international collaboration grew fast in the fields such as physics and molecular biology (Niu and Qiu 2014), but that the scale and growth of international collaboration in the social sciences were limited, as engagement in global social sciences and humanities may depend heavily on the capacity of individual scientists to handle cross-cultural, bilingual, or multilingual communication (Oleksiyenko 2014).

Methods and data

This present research is an exploratory case study utilizing publications data and interviews. Ten Chinese research universities with the highest research performance indicated by Leiden University Ranking were sampled (Table 1).

This research collected academic publication and co-authorship data retrieved from the Web of Science (WoS) Core Collection by Clarivate Analytics and China National Knowledge Infrastructure (CNKI), the most commonly used database of Chinese academic literature. WoS covers citation-based indexes like SCI, SSCI, and A&HCI, which are frequently used in research evaluation in China. Considering that there are more than 3000 universities in China, we selected the top 10 research universities in China based on the Leiden University 2020 Rankings. All the 10 universities are among the 39 research universities in the 'Project 985,' which is a group of pioneers in China's 'building a world-class university' strategy and has a prominent position in China's higher education system. From September to November 2020, we collected the number of Chinese publications (from CNKI) and English publications (from WOS) from the top 10 universities in 2008 and 2018. Since Chinese publications are classified by 13 major categories of Chinese disciplines, while English publications are classified by WOS Subject Categories with more than 200 subject areas, we sorted all the publications into five fields: natural science, Life Science, engineering, social science, arts, and humanities. It should be acknowledged that either WoS or CNKI are not exclusive. The inclusion of works in the humanities is limited in the mostly used global sources of global science such as WoS. Secondary datasets such as China Statistical Yearbooks were also utilized to synthesize the co-authorship and citation patterns of China's academic production. Because different reports use different statistical coverage, we were careful to avoid comparisons between data from different sources.

Twenty in-depth interviews were conducted to explore the publishing patterns revealed by the data and to understand faculty members' behaviours and perspectives. Ten interviewees were from humanities and social sciences disciplines including education, sociology, history, library science, psychology, public policy, and economics; and ten interviewees were from sciences and engineering fields including mathematics, physics, energy and fuels, medicine, environmental science, materials science, and information engineering. All faculty members were recruited from the ten top universities in the data collection sample. The strategy of recruiting aims to achieve compositional diversity in terms of gender, rank, and disciplines. It should also be warranted that the purposeful sampling and snowball techniques utilized to recruit participants would limit the representation of the data.

In the semi-structured interviews, faculty members were asked to elaborate on their journal publishing experience on both Chinese and English journals, their collaboration behaviours with international scholars, and their opinions on the changing publishing policies in China. We utilized focused coding and elaborative coding methods (Saldaña 2021) to analyse the way in which faculty members make meaning of their behaviours and perspectives. By interviewing faculty members working in China's national science system, we aimed to understand the tensions from their perspectives.

Table 1. The sample of top 10 Chinese universities with the highest research performance by Leiden 2020.

University	Number of Top 5% articles (2014–2017)	Global Ranking 2020
Tsinghua University	1270	29
Zhejiang University	1092	58
Shanghai Jiaotong University	939	63
Peking University	831	49
Huazhong University of Science and Technology	693	101–150
Harbin Institute of Technology	630	101–150
Xi'an Jiaotong University	611	101–150
Fudan University	610	100
University of Science and Technology of China	602	73
Sun Yat-sen University	602	101–150

Findings

Patterns of publications in terms of publishing languages and fields

Despite the increase in English publications over the recent years, Chinese scholars published more Chinese than English articles overall (Figure 1), as China has a huge national science system in terms of scientific R&D investment, personnel, and production. However, such an overall publishing trend does not match the pattern of Chinese first-tier research universities. They have published more English articles each year than Chinese articles since 2011 (Figure 2). The increasing trend line of English publications in China should be much steeper if including the portion of English publications that were not included in WoS.

For each of the 10 universities, the past decade has witnessed a huge increase in WoS publications. The number of publications in 2018 has increased by two to three times, compared to 2008, for most universities. The number of WoS publications has increased by 703% for Xi'an Jiao Tong University. In contrast, CNKI publications have decreased by varying degrees from 7% to 48% for nine universities, except Peking University. The university saw a 3% increase in its Chinese publications, which makes it stand out among other Chinese universities with the highest research performance over the decade. Universities have been reliant on Chinese publications in 2008, whereas Chinese publications only constituted less than one-third of all universities' publications in 2018, which shows a shift towards publishing in English from Chinese in China's research universities for the past decade (Table 2).

A gap is found between the global science system and the national science system in terms of the publishing language and beyond. The increase in English publishing is associated with the national science policies and economic incentives, but the recent national policy shift from reliance upon international publications has started to change institutions and scholars' perspectives towards publishing. Interviewees thought 'SCI/SSCI worship' was problematic, but withdrawing the acknowledgement of English publications would bring more problems, because they thought a healthy academic culture has not yet been formed in most Chinese universities. As an associate professor of education explained:

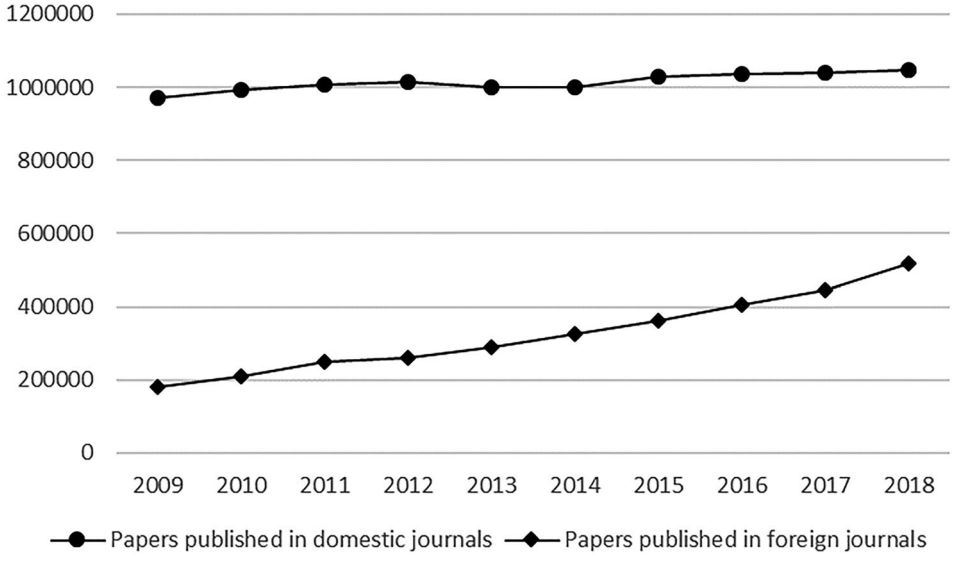

Figure 1. Papers published by Chinese research institutions/universities. Sources: Authors, China Statistical Yearbooks published by the National Bureau of Statistics of China.

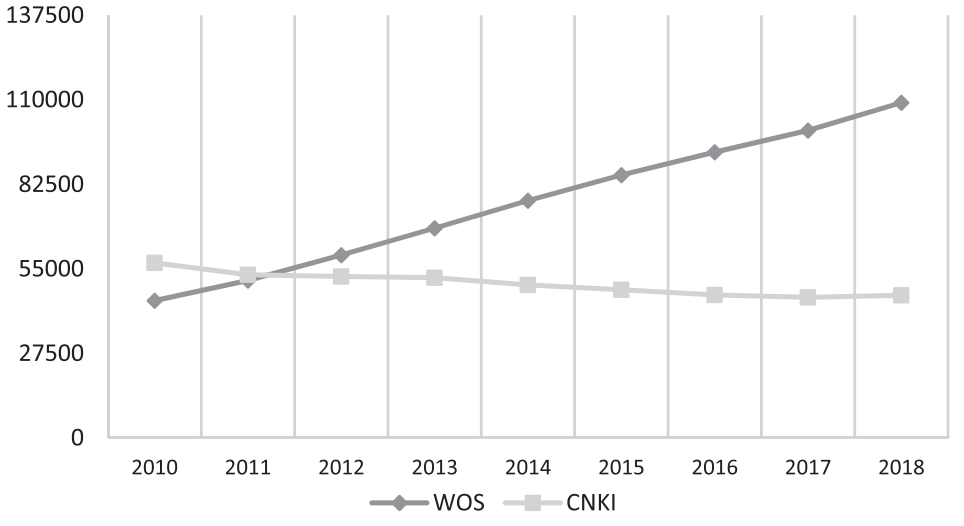

Figure 2. Trends of number of articles published by top 10 Chinese universities with highest research performance from 2010 to 2018. Sources: Authors, Web of Science and CNKI.

> SCI seems to be one of the most approachable metrics for young faculty members, other criteria such as academic titles, qualifications, grants, or backgrounds are even harder to obtain. The problem is not that the SCI is regarded as a gauge, but the ways in which the gauge can be fairly used.

One mathematics faculty member similarly identified the problem of the ways in which the SCI standards can be used in evaluation. He elaborated, 'It is unclear how English publications should be assessed, for example, a few disciplines recognized a list of Chinese and English journals according to their disciplinary natures to complement the Q index problem of SCI.'

This study found that the disciplinary differences existed in the overall patterns of China's publications collected by WoS and CNKI. China's large share of publications in global science was mainly contributed by its publications in the fields of the natural sciences, including physics, chemistry, mathematics, geography, and astronomy. In 2018, the number of natural science articles published by Chinese scholars collected by WoS was 1.6 times that of articles on CNKI. For engineering and life sciences articles, the number of English articles is about one-third of that of Chinese articles. For the social sciences and arts and humanities, the number of English articles is very small (Table 3). Among the ten universities in the sample, the discipline imbalance is even more extreme. The English/Chinese ratio of publications is the largest in the natural sciences, followed by engineering[1] (Table 4).

Table 2. The changes in the number of publications in CNKI and WOS for the ten universities.

	2008			*2018*			*Increase rom 2008–2018*	
University	WOS	CNKI	CNKI/WOS	WOS	CNKI	CNKI/WOS	CNKI	WOS
THU	5404	7222	134%	14,266	6695	47%	−7%	164%
PKU	5223	7147	137%	16,244	7393	46%	3%	211%
SJTU	4814	6794	141%	14,594	5475	38%	−19%	203%
FDU	3089	5235	169%	9273	4250	46%	−19%	200%
ZJU	6591	8880	135%	15,699	5722	36%	−36%	138%
HUST	3344	7270	217%	7805	3760	48%	−48%	133%
HIT	2813	5548	197%	6204	2924	47%	−47%	121%
XJTU	1076	4150	386%	8636	3732	43%	−10%	703%
USTC	2172	2370	109%	4724	2181	46%	−8%	117%
SYSU	3387	4649	137%	11,620	4310	37%	−7%	243%

Sources: Authors, Web of Science and CNKI.

Table 3. The number of China's total WoS and CNKI publications by fields.

	Chinese papers 2018 (CNKI)	English papers 2018 (WOS)	English/Chinese Ratio
Natural sciences	143,795	226,463	1.57
Life Sciences	617,839	202,543	0.33
Engineering	1,043,411	370,785	0.36
Social Sciences	912,921	30,458	0.03
Arts and Humanities	329,399	4969	0.02
Total	3,047,365	835,218	/

Sources: Authors, Web of Science and CNKI.

Faculty members in S&E fields thought their fields were globalized, so using global academic language helped to expand their academic impact. Some engineering faculty members thought it important to publish in Chinese journals, especially for the applied research that can be helpful for relative industries in China. An assistant professor in medicine mentioned that engineers and technicians working in the industry mainly read Chinese and barely read SCI articles, so publishing on Chinese journals is essential for the practical use of research.

Moreover, the research evaluation stimulated by the idea of world-class university as a contest, utilizes English publication as an important criterion for university academic reputation. As a result, the quality and impact of Chinese journals is decreasing and lagging far behind English journals. Scholars tend to write their best research ideas and results into English manuscripts other than Chinese. However, the high-quality and low-quality English publications are intermingled.

A few faculty members in the social sciences and humanities thought academic writing was untranslatable between Chinese and English, which made local and insightful work lack international visibility. A faculty member in library science explained, 'The depth in native language is irreplaceable. For bilingual scholars, the language obstacle is still valid. The most insightful articles are not suitable for publishing in SSCI journals.' As such, profound and insightful work targets Chinese journals, whereas some of the work will be reshaped into introductory and simple pieces targeting English journals. As an education faculty member said, 'Many Chinese scholars' theories, no matter if classic, are grounded in Chinese soil, which is hard to be comprehended by foreigners. Opinions that thrive in the Chinese context can only be accepted by the West when compared to Western concepts.' Another faculty member in education related to her research on Chinese migrant children's education and thought the English version of her publication was on a surface level, as she needed to introduce a Chinese context to the global academic audience.

Patterns of Chinese research universities' international collaboration

The fact that the discussion over international collaboration in literature and in this study is all based on English publications reflects the dominated role of English for cross-border research and the limited international collaborations in Chinese database. In terms of global co-authorship, the US–China linkage is the thickest in volume. The United States is the top international collaborator for each of the 10 universities in the sample. Other countries or regions that Chinese universities collaborated most with included the United Kingdom, Australia, Germany, Taiwan, Canada, Japan, France, Italy, and South Korea.

Table 4. The number of China's top 10 universities' WoS and CNKI publications by fields.

	Chinese papers 2018 (CNKI)	English papers 2018 (WOS)	English/Chinese Ratio
Natural sciences	9003	54,965	6.11
Engineering	18,520	43,526	2.35
Social Sciences	16,044	3718	0.23
Humanities	6038	583	0.10
Total	102,792	49,605	/

Sources: Authors, Web of Science, and University Research Achievements Analysis of CNKI: http://www.usad.cnki.net/.

As the past literature found, the propensity to collaborate across borders can be affected by national system size and trajectory. In 2016, China's rate of collaboration was a modest 20.3% whereas US is 37%. For the top 10 Chinese research universities of this research, the proportion of all papers that were internationally co-authored was about 30%, 10% higher than the average of China (Table 5). Compared with US prestigious universities, Chinese first-tier universities' international co-authorship rate is still low. For example, universities such as Harvard and UCLA have more than 50% coauthored papers of all are global coauthored papers during 2014–2017 (Marginson and Wen 2019).

The increase in the international collaboration in the Chinese top research universities was related to faculty members' choices of collaborators. They noted that such factors as academics' social capital, academic specialty, and global academic impact affect their choices of international collaborators. Past literature and interviewees' narratives both show that scholars tend to work with their overseas PhD or post-doc advisors, or collaborate with foreign scholars whom they had previously connected with during their short visits or conferences (Shen 2018). This type of collaboration is found often built between foreign senior scholars and Chinese junior scholars. Chinese young scholars, though having overseas study or work experience, need someone who can 'hold the wheel' due to their experience in the field and 'in navigating the global publishing industry.'

University often evaluates an applicant's potential in establishing international collaboration ties by their backgrounds. A faculty member in physics elaborated:

> My university requires one publication for applicants who obtained their doctorate degrees from prestigious overseas universities, two publications for those either having a prestigious domestic degree or some overseas experience, but three for those with a domestic degree. Can athletes from developed countries run one lap less in the Olympics?

Complementary academic specialties appeared to be additional important factors for Chinese scholars in choosing with whom to collaborate with. A medicine faculty member stated that a collaborator's global impact and academic capability was his primary concern. Overall, faculty members thought that an ideal collaborator is an international scholar who has similar research interests, complementary methods and resources, and great impact in the field. Chinese universities encourage scientists to extend their impact to 'periphery' nations and regions by 'going-out' strategy, but in fact more energies in international collaboration in China have been spent on building the connections with the scholars in the 'centre' of global science.

Additionally, the citation patterns across nations reveal that the impact of Chinese scholars' work is limited compared to the US. As the citation indexes illustrate (Table 6), the citation frequency of Chinese authors' English publications by other major countries and regions is less than that of Chinese authors citing publications from other countries and regions, except for India. The academic exchanges between China, South Korea, and Taiwan are more egalitarian, while the academic

Table 5. Proportions of all papers that are internationally coauthored by top 10 Chinese universities over the three periods.

	Proportion of all papers (unweighted) that are internationally co-authored (%)			Increase	
Chinese top Rus	2007–2010	2011–2014	2015–2018	2007–2010 and 2011–2014	2011–2014 and 2015–2018
THU	24.30	31.40	36.40	7.10	12.10
PKU	34.20	36.70	37.40	2.50	3.10
SJTU	22.20	27.70	31.10	5.50	8.90
FDU	30.20	30.50	30.40	0.30	0.20
ZJU	23.40	27.50	30.90	4.10	7.50
HUST	20.10	24.60	27.50	4.50	7.50
HIT	18.30	25.20	27.30	6.90	9.00
XJTU	24.00	27.60	28.80	3.60	4.80
USTC	26.90	32.10	32.50	5.20	5.60
SYSU	24.10	26.70	30.10	2.60	5.90

Sources: CWTS Leiden Ranking 2020.

Table 6. Relative citation index, by selected country or region: 2014.

	Country/Region	A = China citing other country/ region	B = China cited by other country/ region	C = USA citing other country/ region	D = USA cited by other country/ region	B/A Cited/ Citing Index of China	D/C Cited/ Citing Index of USA
North America	United States	0.8	0.31	2.93	2.93	0.39	N/A
	Canada	0.69	0.37	1.15	1.49	0.54	1.30
Europe	France	0.55	0.32	0.76	1.16	0.58	1.53
	Germany	0.63	0.31	0.88	1.18	0.49	1.34
	United Kingdom	0.61	0.3	1.13	1.29	0.49	1.14
Asia	China	2.73	2.73	0.31	0.8	N/A	2.58
	India	0.58	0.86	0.2	0.65	1.48	3.25
	Japan	0.65	0.47	0.5	1.04	0.72	2.08
	South Korea	1.11	0.86	0.49	1	0.77	2.04
	Taiwan	0.96	0.91	0.39	0.98	0.95	2.51

Sources: Authors, National Science Board, NSB. S&E Indicators 2018.

Note: Relative citation index normalizes cross-national citation data for variations in relative size of publication output. The index is calculated as the frequency of the country's citing (or being cited by) China / the average frequency of citing (or being cited by) China.

exchanges between China and the US, the UK, Canada, and Germany are skewed. Researchers from the US, Canada, and the UK most frequently cited researchers from only two countries' researchers (NSB 2018). Thus, seeking international collaboration to expand global impact is a response to the limited global impact of Chinese scholars' publications in general. An energy and fuels professor said, 'I would seek to collaborate with international scholars who can publish on top journals such as Nature and Science.' The international coauthored research usually has much more citations. The directionality of citations and the choice of international collaborators not only suggest the status of China's published science in global science system, but also reflect the gaps between the goal of 'going-out' and the actual collaborating behaviours.

Discussion

This research has identified several patterns of publishing and co-publishing behaviours of China's science system, from which several tensions within the national science system are revealed.

From the perspective of centre-periphery theory, there has been a rising trend of publishing in English for China's top research universities in the recent decade, which shows the increasing centrality of China's science in global science network. China is moving closer to the 'centre' in terms of the volume of publications. However, our findings illustrate that China's international cooperation level is much lower than its counterparts in the US and that it shows China's attractiveness as an international research collaborator is still limited. Chinese scholars are also cited much less than Chinese scholars cite scholars from other countries.

The international collaboration patterns and citation patterns found in this study show the existing centre-periphery structure of the global science network. Partner seekers pursue a higher status match in local and global university rankings, which marginalize the lower strata of partakers (Slaughter and Rhoades 2004). Chinese scholars seek to collaborate with overseas scholars to extend their global impact, which acknowledges the 'centre' positions of overseas collaborators and the relatively 'periphery' status of Chinese researchers in the global collaboration network.

The open nature of science may alleviate the tensions between national science and global science in that it allows scientists to gain more access to collaborators and knowledge. However, the findings acknowledge the hierarchical structure of global science network, which contributes to the stratification of universities and disciplines in China's national science system. It suggests a tension that lies in the relationship between the universal and open nature of science and the hierarchically nested global science network.

As China is integrating into global science system, more tensions in national science system are stemmed from the university and disciplinary stratifications. For one, China's rise in global science has been reliant upon a few research universities. The national goal of promoting international publications and collaborations in China seems to only apply to and benefit a handful of top research universities that enjoy preferable institutional autonomy and resources, which creates more tensions within the national science system of China. As Oleksiyenko (2014) found, China focused on its designated 'Ivy League' universities to move its position towards the 'centre' of global science. These universities received preferable funding resources and enjoyed a greater level of institutional autonomy, which further expands the discrepancy between a small amount of Chinese top research universities and the rest of Chinese universities (Marginson, Wen, and Hu 2017).

The finding is also consistent with the theory that sees global science system as a contest of world-class universities. Chinese research universities actively benchmark international top universities and seek partnerships with internationally renowned universities, laboratories and professors. Second-tier and third-tier institutions try to mimic the first-tier universities to acquire more resources. The severe domestic competitions and stratifications will do harm to the ecological development of China's national science system and the higher education system. Moreover, the 'Matthew effect' triggered by the internationalization agenda seems to extend to faculty members. Faculty members who are 'internationalists' involving in international research collaboration (Kwiek 2020) would gain more resources that lead to more international collaboration and recognition, given the research policy and reward systems (Qiu and Mao 2019).

For another, the structured global science network and the agency of language shapes which knowledge carries the most authority. The global status of China's NS&ENG legitimates the local status of these fields and brings them more local prestige and concomitant resources, which causes tensions among fields and departments. It is problematic to evaluate local science through a lens of global science (e.g. Maldonado-Maldonado and Lee 2018), but the fact is the integration into global science promoted by China's academic governance has generated tensions especially for disciplines that are more indigenous and local based such as some traditional engineering and humanities and social sciences. The national research policy puts those disciplines in an awkward position as they do not integrate into the global science system at the same pace as their counterparts in fields of sciences and technology due to the nature of the disciplinary knowledge. Due to the differences between Chinese and Western ideologies and research paradigms, Chinese HSS scholars aim to publish more in international journals and to conform to foreign topics rather than develop indigenous ideas (Wen and Yang 2019). Moreover, using English as the preferable research language creates tensions between faculty members who only write in Chinese and those who publish English articles. The recruiting policy that requires overseas educational and work experience and English publications also exacerbates the tensions between domestically trained faculty members and returnee scholars in China's national science system.

Scientific nationalism and scientific globalism coexist with one another in China's national science system. China's national science system, on one hand, is strongly led by the government and thus it is required to contribute to economic and social development; on the other, it is a 'Post-Confucian system' which also responds to Western modernization (Marginson 2011). The academic governance in such a national science system has the goal of promoting national scientific excellence, economic competitiveness, and the soft power of China. On the other, we found the goal of China's national science policy is consistent with the growing trend of international publications and collaborations, the finding of which provides another layer to Wagner, Park, and Leydesdorff's (2015) findings suggesting the growth of international collaboration is decoupled from the goals of national science policies. Since the Open Door Reform, China has been embracing the concept of scientific globalism and will continue to participate in the global science system (Vogel 2011). International collaboration contributes to the capacity building of national science by extending China's academic reach and impact in global science (Marginson 2022).

Although international collaboration is often driven bottom-up by scientists due to the open nature of science and the prevailing logic of the scientific globalism in global science system, even in the times of unprecedented changes and geopolitical tensions (Lee and Haupt 2021), the de-globalization and nationalism tide, especially the science and technology 'decoupling' between China and the US, would likely cast a shadow on the international collaboration in many forms for both countries and even the global science landscape, considering the two nations are the largest scientific research producers. Due to global health crises and geopolitical changes, as Marginson and Yang (2020) noted, while China–US relations have been instrumental in building science in China, a partial decoupling is in prospect. The choice of international collaborators might have been gradually changing for Chinese scientists, which will also affect the scientific production and knowledge flows. Strelcova's (2021) research shows China's endeavour in collaborating with European countries and countries alongside the Belt and Road. Future studies could use longitudinal data to study institutional collaborative patterns in a dynamic network that changes over time.

Conclusion

This paper discusses the tensions in the national science system for an emerging scientific powerhouse that is actively engaging the global science system. Tensions lie in the relations between the academic governance and academic cultures, between the agenda of internationalization and the stratification of the higher education system, and between the universal and open nature of science and the hierarchically nested global science network. The global/national synergy has contributed to the development of the national science system of China, but the tensions within the system have been hindering the functioning of the synergy.

The top research universities benefited the most from the global/national synergy, leaving much of the universities in the national science system staying at the periphery of the global science system. China's integration into the global science system is also reliant on a few natural sciences and engineering disciplines. The hierarchical structure of disciplines has extended to China's national academic governance, which created the obstacle for Chinese social sciences and humanities to achieve global visibility and develop by exchanging with the global science system.

A national science system can be viewed as an ecosystem including various stakeholders and participants (Baumberg 2018), within which the tensions revealed should be warranted for the ecological development of China's national science system and the higher education system. Chinese higher education will need to find ways to develop a successful formula for higher education policy and governance that provides full space for plurality of knowledge, ideas and approaches; value indigenous as well as global knowledge; and bring the resulting distinctive Chinese knowledge to the world.

This study engages local and global audiences by illuminating the ongoing changes and tensions in national science and higher education with China's rising visibility in global science. In recent years, emerging economies in East Asia and other regions have not only integrated into the global science system through active internationalization strategies, but also built their own national science system with the help of the resources of the global science system. China serves as an example that shows how emerging economies envision WCUs and global science production. Developing economies and their universities that are trying to achieve status in global science can utilize China's case to reflect on their own. This study also opens several discussions on academic governance from scholars' accounts, such as publication incentive policy, promotion policies and so forth. The findings can help policymakers and university leaders when they set up agendas and policies on the allocation of research resources, knowledge production, faculty member evaluations, and so forth. In addition, China is seen as playing an increasingly important role in the global science system due to the rapidly growing number of papers in STEM subjects. This study attempts to explore the complex tension behind the rapid growth of the total number of papers published in different disciplines, such as the number of citations and co-authors, to make a more accurate analysis of China's position in the global science system.

Note

1. The data sources for Tables 3 and 4 are different, as there is not a category for life sciences in the 10 universities' data. CNKI database uses the Chinese discipline system, in which biology is included in natural sciences.

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