

**International Mentorship and Research Collaboration:
Evidence from European-Trained Chinese PhD Returnees**

Jin JIANG¹ and Wenqin SHEN²

¹School of Graduate Studies, Lingnan University, Hong Kong, China

Email: jjiang@LN.edu.hk.

²Wenqin SHEN

Graduate School of Education, Peking University, Beijing 100871, China

E-mail: shenwenqin@pku.edu.cn.

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Abstract

Drawing on a unique dataset that combines returnees' survey data and their information on research publications extracted from the Scopus database, this study systematically examines whether and how international doctoral mentorship for Chinese students in European countries promotes research collaboration before and upon the return of these Chinese PhDs to China. The results show that a considerable proportion of European-trained Chinese PhD returnees had co-authorship with their supervisors during their PhD study, and most of them maintained this research partnership after returning to China. In addition to the co-authorship during doctoral study, some individual characteristics (e.g., gender and marital status) and organizational factors (e.g., country of doctoral study and current work unit) were also found to contribute to international research collaboration upon the return to China of these Chinese PhD holders. This study sheds new light on the mobility and research collaboration of international students and provides policy implications for promoting Sino–foreign student exchange and research collaboration.

Keywords

mentorship, co-authorship, international research collaboration, Sino–European relationships, PhD returnee

Jin JIANG

School of Graduate Studies, Lingnan University, Hong Kong, China

Email: jjiang@LN.edu.hk.

Wenqin SHEN (✉)

Graduate School of Education, Peking University, Beijing 100871, China

E-mail: shenwenqin@pku.edu.cn.

Introduction

The Sino–European relation is one of the most important diplomatic relations in the world today, and it is considered to be an emerging axis in world affairs (Shambaugh, 2004). In the field of higher education, cooperation between China and Europe can be traced back to the Republic of China (Kreissler, 2014) when a large number of Chinese students went to France, Germany, the United Kingdom, and other European countries for further study (Bailey, 1988). In the early 1950s, China implemented a one-sided policy in diplomacy. While forming an alliance with the Soviet Union, China also joined the communist bloc and established diplomatic relations with communist countries, such as Hungary, East Germany, the Czech Republic, and Poland. Before the Cultural Revolution, China and these countries maintained relatively close educational exchanges.

In the same period, non-communist countries such as Switzerland, Denmark, and the Netherlands began to establish diplomatic relations with China. In 1954, Britain agreed to exchange a *chargé d'affaires* with China. Among the developed countries, European countries were the first to establish diplomatic relations with China. After the formal establishment of diplomatic relations, China and European countries gradually established economic, cultural, scientific, and educational exchanges. For example, China and Denmark signed cultural exchange agreements and exchanged students in the 1950s (Bertelsen, Du, & Søndergaard, 2016). After the establishment of diplomatic relations with China in 1964, France signed an agreement with China on educational and cultural exchanges. In the first four years before the Cultural Revolution, approximately 150 Chinese students studied in non-communist European countries, such as France, Switzerland, and the United Kingdom (Fraser, 1969). After the outbreak of the Cultural Revolution in 1966, the collaboration and exchange of higher education between China and Europe was interrupted. After reform and opening up, especially after the end of the Cold War, the China–Europe relations entered a period of rapid development. In May 2005, the EU and China signed a joint declaration to set the context for cooperation, stating that both sides should support research mobility between European and Chinese academia (Pinna, 2009:516).

An important area of Sino–European cooperation and exchange is higher education, especially doctoral education. At the beginning of reform and opening up, not enough students in China were going abroad to pursue postgraduate degrees. By 1982, when the undergraduate students admitted in 1978 began to graduate, the pool of students began to become sufficient. In 1981–1982, the Chinese government planned to send 1,000 Chinese students to study for doctoral degrees abroad. In 1983, another 1,000 students were selected, and many of them were sent to European countries (Hayhoe, 1984). In 2007, the China Scholarship Council (CSC) launched a public-sponsored doctoral student mobility program. With the support of the CSC, the number of Chinese students pursuing doctoral degrees in Europe has grown rapidly. In 2015 alone, the China Scholarship Fund subsidized more than 1,905 students studying for doctoral degrees in Europe (China Scholarship Council, 2016).

In the field of diplomatic history and international relations, China–EU relations have attracted growing research attention (e.g., Nee & Stark, 1989; Lüthi, 2014; Albers, 2016). However, the literature on educational relations between China and Europe is relatively limited, with the related work of Ruth Hayhoe in the 1980s being one of only a few examples (Hayhoe, 1984, 1985a, 1985b, 1986, 1987). In her studies, Hayhoe (1985b) explained the transfer of knowledge in Sino–European cooperation in higher education, and she (1987) also mentioned the possible cultural imperialism in Sino–European higher education cooperation. However, only a handful of scholars have continued to advance along this research line. Despite Pinna (2009) outlining some of the cooperation projects between China and Europe in higher education, such as the European Research Center and the Erasmus Mundus Project, the empirical analysis of the Sino–European cooperation in higher education is still rare, and the research on doctoral education cooperation between China and Europe is even rarer (Shen, Liu, & Chen, 2017).

Meanwhile, the literature on Sino–European scientific cooperation is increasing. Most of these studies use bibliometric methods to analyze the network structure of the scientific cooperation between China and European countries (Wang, Wang, & Philipsen, 2017). Research about Sino–European research collaboration in the field of food and agricultural science explains that the average impact of China–UK collaborative publications is higher than that of the domestic publications of either country; such a finding implies that cooperation is beneficial to both countries (Zhou, Zhong, & Xu, 2013). Research on Sino–German research collaborations indicates that both countries, especially China, benefit from bilateral collaboration in terms of raising the productivity and impact of publications (Zhou & Bornmann, 2015). Research on Sino–European scientific cooperation also demonstrates that academic collaborations between China and the EU 28 members have been mainly set up by Chinese researchers (Wang & Wang, 2017). However, these studies do not analyze the role of education or studying abroad in shaping Sino–European scientific research cooperation.

Against the background outlined above, we observe that the existing literature on Sino–European higher education cooperation and research cooperation is divided. We attempt to link the two research streams together by analyzing the contributions of China–EU higher education cooperation (in terms of doctoral training) to the promotion of Sino–European research cooperation. This article is aimed at filling in the gaps in the above aspects through the case of European-trained Chinese PhD returnees. Specifically, we examine whether and how international doctoral mentorship for Chinese students in European countries promotes research collaboration before and upon the return of these Chinese PhDs to China.

Doctoral study abroad is perceived as an important way to build international research networks for future collaborations (Eduan, 2017). Wagner, Bornmann, and Leydesdorff (2015) indicated that collaboration networks formed during education may continue after the students have returned to China and contribute to international co-authorship in research articles. Another survey of more than

8,000 scientists in the Asia-Pacific region also found that PhD training and post-doctoral positions contribute to the formation of networks and collaborations (Turpin et al., 2008). However, they did not analyze how this mechanism works, and they did not use bibliometric data to verify this relationship. In recent years, a growing number of Chinese students have been pursuing doctoral degrees in Europe. Have these Chinese doctoral students established research partnerships with their doctoral supervisors during their studies? If so, have these partnerships continued after the students' return to China? What are the factors that affect the establishment and continuation of scientific research cooperation? These research questions are the main focus of this work.

Sino-European Collaboration in PhD Training

In 2007, China's Ministry of Education and Ministry of Finance established a program called the National Development High-Level University Public-Sponsored Postgraduate Student Scheme. This program aimed to "implement the state's strategies of achieving national prosperity with science, education, and talents, and expedite the training of high-level talents" (Ministry of Education, 2007). The program was managed by the CSC and was named the CSC scholarship.

In 2016, the CSC program supported 3,085 students to pursue doctoral degrees abroad, and another 5,582 doctoral students were funded for research visits abroad during their studies. The number of students who went to European universities for doctoral degrees was the highest, with 697 and 394 of them going to Germany and the UK, respectively; these values account for 22.59 % and 12.77 % of the total number of doctoral candidates. Most of the joint training doctoral students studying in North America, with 3,253 or 58.28 % going to the US (Table 1).

Table 1 Overseas PhD Program per Country Funded by the CSC in 2016

Country	Supervision by host university	Joint supervision between sending and host universities
European countries		
Germany	697	250
UK	394	332
Netherlands	318	117
France	242	127
Belgium	105	71
Sweden	103	60
Spain	73	26
Denmark	56	62
Italy	48	47
Switzerland	32	63
New Zealand	26	23

Ireland	25	9
Finland	22	20
Norway	12	19
Austria	8	14
Czech	2	4
Hungary	1	1
Poland	0	3
Portugal	0	3
Greece	0	2
Subtotal	2,164	1,253
Asian countries		
Japan	210	170
South Korea	45	15
Singapore	7	129
Thailand	2	1
Subtotal	264	315
Other countries		
Russia	204	18
USA	165	3,253
Australia	163	316
Canada	117	411
Israel	6	16
Belarus	2	0
Total	3,085	5,582

Source: CSC, 2016.

Overseas Learning Experience and International Research Collaboration: Individual Characteristics and Organizational Effect

Hayhoe (1987) pointed out that a firm framework for cultural interaction between China and developed countries has not yet been developed. Until now, we still lack a recognized theoretical framework to analyze international cooperation in education. In this study, we examine whether and how individual factors, such as gender and ethnicity, and organizational factors, such as characteristics of the host country and university, affect international mentoring collaboration in terms of co-authorship in research publications. In addition to the international mentoring co-authorship during doctoral study, we also examine whether this international research partnership continue upon the return of PhD graduates to China.

International Mentoring Co-Authorship

The collaboration between supervisors and doctoral students is a special type of scientific research cooperation. Bozeman and Corley (2004) distinguished six types of scientific collaboration strategies, one of which is mentorship wherein mentors are motivated to help junior colleagues and graduate students by collaborating with them. Some scholars in Spain have analyzed the research cooperation relationship between scholars engaged in postdoctoral research abroad and their host supervisors and found that 53.8 % established scientific research cooperation relations with host supervisors during their overseas studies. Moreover, the longer the scholars are in foreign countries, the higher the probability of publishing papers with host supervisors. They used the term international mentoring co-authorship for the collaboration between postdoctoral scholars and host supervisors (Andújar, Cañibano, & Fernandez-Zubieta, 2015).

In the international mentorship and research collaboration, ethnicity is found to play an important role. Bozeman and Corley (2004) found that some scholars tend to cooperate with scholars from the same country who are fluent in their own languages. They call it the cooperation strategy of a nationalist. Murakami (2014) analyzed whether scientists who had gone abroad have continued to collaborate with foreign scientists after returning to Japan. He found that ethnicity is an important factor and that the collaborative network between returnees and overseas Japanese scientists is easy to maintain. In the Sino–foreign scientific research cooperation, the role of ethnicity seems to be crucial. Wang et al. (2013) found that a large part of China’s international collaborative papers in 2010 were co-authored with Chinese scientists abroad. In international papers published in cooperation with the US, this proportion reached 65 % in the same year. A case study based on nanoscience found that China–US collaboration in nanotechnology mainly occurs between Chinese and Chinese-American scientists (Wang et al., 2012). Therefore, we suggest that the establishment and maintenance of international mentoring co-authorship is influenced by the ethnicity of the PhDs and their doctoral mentors. Specifically, we propose the first set of hypotheses as follows:

Hypothesis 1.1: Chinese PhD returnees are more likely to co-author with Chinese mentors *during doctoral study*.

Hypothesis 1.2: Chinese PhD returnees are more likely to co-author with Chinese mentors *after returning to China*.

In addition, based on our earlier discussion on international mentoring co-authorship, we suggest that co-authorship between PhDs and their supervisor during doctoral study increases the probability of their further collaboration after the PhDs graduate. Therefore, we propose the following hypothesis:

Hypothesis 2: Chinese PhD returnees with co-authorship with their mentor during doctoral study, are more likely to have the research collaboration after returning to China.

Individual Characteristics and Organizational Factors

In addition to the mentorship, researchers' basic characteristics, and the organizational factors of universities of their study and work are important. In particular, the role of a gender in research collaboration draws research attention. Some studies stated that men in general have more research collaborations than women (Cole & Zuckerman, 1984; Bozeman and Corley, 2004). But another study found that men and women researchers in the US are found to differ in research collaborations. Women academic researchers have more collaborators than men, and they are more likely to adopt instrumental and experience-based strategies; meanwhile, men are more oriented to mentoring strategies (Bozeman, & Gaughan, 2011). Other literature on gender and doctoral education indicates that female doctoral students have lower academic output during their doctoral studies than male doctoral students (Fox, 2004), and that they receive less attention and resources in academic supervision than men (Wong & Sanders, 1983). Although little is known about the gender differences in international research collaborations, we could draw on previous discussion about the advantages of male researchers and doctoral students in productivity and research collaboration, and propose the hypothesis as follows:

Hypothesis 3.1: Compared with male Chinese PhD returnees, female returnees are less likely to co-author with supervisors *during doctoral study*.

Hypothesis 3.2: Compared with male Chinese PhD returnees, female returnees are less likely to co-author with supervisors *after returning to China*.

Many studies have pointed out that organizational factors play an important role in research cooperation (Shen, 2016; Oleksiyenko, 2013). In this article, we focus on the impact of two organizational factors on international cooperation: the country of study and the unit of employment. Language is one of the main obstacles in international cooperation. English is the lingua franca of today's academia, so English-speaking countries may have some advantages in international cooperation. Therefore, the current study proposes the hypothesis as follows:

Hypothesis 4.1: Compared with those studying in non-English speaking countries, Chinese PhD returnees from English-speaking countries are more likely to co-author with supervisors *during doctoral study*.

Hypothesis 4.2: Compared with those studying in non-English speaking countries, Chinese PhD returnees from English-speaking countries are more likely to co-author with supervisors *after returning to China*.

This study also examines whether PhD returnees will continue the research collaboration with their supervisors after returning to China. Most of PhD returnees worked in universities after returning to

China, but some also entered the research centers of the Chinese Academy of Sciences, enterprises, and government departments. Compared with PhD returnees who are employed in other units, PhD returnees who are employed in colleges and universities (especially in Project 985/211 universities) will face greater pressure to publish, and therefore have a stronger incentive to maintain existing international cooperation. Therefore, we propose the last hypothesis as follows:

Hypothesis 5: Compared with PhD Returnees working outside of the university system, PhD returnees who worked in college and universities have a higher probability of co-author with supervisors after returning to China.

Methodology

Data

The data of this study is based on a questionnaire survey on an entire group of 2,052 PhD returnees supported by the CSC. The survey was conducted in 2014 and covered issues related to the returnees' overseas doctoral learning experience, their career development upon their return, and their demographic characteristics and socioeconomic background. We received 441 valid questionnaires and extracted a subsample of 266 European-trained PhD returnees.

As previous studies on academic outputs based on self-reported survey data show (e.g., Baruffaldi & Landoni, 2012; Shin et al., 2014), the information on research publications may not be accurate. Individuals might have exaggerated or under-reported the numbers of their publications, or they might have simply mistaken or misremembered the accurate numbers. More importantly, the researchers could not easily ensure that the self-reported numbers of publications consistently shared similar qualities to reflect the respondents' scholarship in the whole sample.

Our survey data have an advantage to overcome this challenge. Supported by the CSC, the survey collected the detailed information of respondents, such as their names and those of their supervisors, the university where they graduated, and their current work unit. On the basis of this information, we matched the survey data with the information on their research publications (including co-authorship with supervisors before and after their return) extracted from the Scopus database. As Scopus is the largest abstract and citation database of peer-reviewed literature and covers scientific journals, books, and conference proceedings¹, the returnees' information on publications extracted from the database is accurate and of high quality.

¹ See details about the Scopus database on its official website: <https://www.elsevier.com/solutions/scopus>.

Variables and Statistical Models

Co-authorship in academic publications is a common way to measure international research collaboration (Melin & Persson, 1996), and it is the same approach adopted in this study. The dependent variables are two dummy variables measuring whether returnees co-authored with their supervisor in research publications during their doctoral study (first dependent variable) and upon their return to China (second dependent variable). According to the CSC, awardees of the CSC scholarship are required to return to China soon after their graduation from PhD programs abroad. Our two dependent variables could effectively capture the information of the returnees' international mentoring authorship before and after graduation and upon their return to China.

Several variables were used to capture the European-trained returnees' overseas learning experience. Their majors during their doctoral study were measured by a dummy variable of science stream (i.e., agronomy, engineering, science, and medicine) and non-science stream (i.e., management, economics, pedagogy, philosophy, law, literature, and history). We also included dummy variables on whether they studied in the top 500 universities and whether their universities were located in an English-speaking country. The main characteristics of the returnees' doctoral supervisors were measured by their Chinese ethnicity and whether they are full-time professors in the host universities. We used several dummy variables to measure the returnees' current work units with the reference group referred to as a Project 985/211 university²: working in a non-211 university, a research institute of the Chinese Academy of Science (CAS) system, a firm, or other units. We also controlled the demographic variables of the returnees, including gender (a dummy variable, with "female" as the reference group), age, and marital status (a dummy variable, with "single" as the reference group).

As the dependent variables of this study were dummy variables, multivariate logistical regression models were used to analyze the factors contributing to co-authorship between returnees and their supervisors. Odd ratios are provided in the result tables for an easy interpretation of the findings.

² Project 211 was initiated in 1995 by the Ministry of Education (MOE) of the People's Republic of China with the aim to establish around 100 leading universities in China. A total of 114 universities (116 if taking into account two branches of two universities in different provinces) have been classified under Project 211. See the details about the Project on the website of MOE: http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/moe_846/200804/33122.html. Project 985 is a national project to develop several top universities in China into world-class institutions. The project started in 1998, and 39 leading universities have been members of the project since. See details on the website of MOE: <http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/s6183/201112/128828.html>.

Results

Learning Experience in European Countries

The European-trained PhD returnees in our analysis sample are those who received the State Scholarship Fund from the CSC for overseas PhD study and then returned to China after their graduation. According to our descriptive statistics, a majority of these PhD returnees (87 %) studied science stream majors, including engineering, science, medicine, and agronomy; more than 60 % of them attended top 500 universities worldwide; and around 20 % stayed in an English-speaking country for their PhD study (Table 2).

Table 2 Descriptive Statistics ($N = 266$)

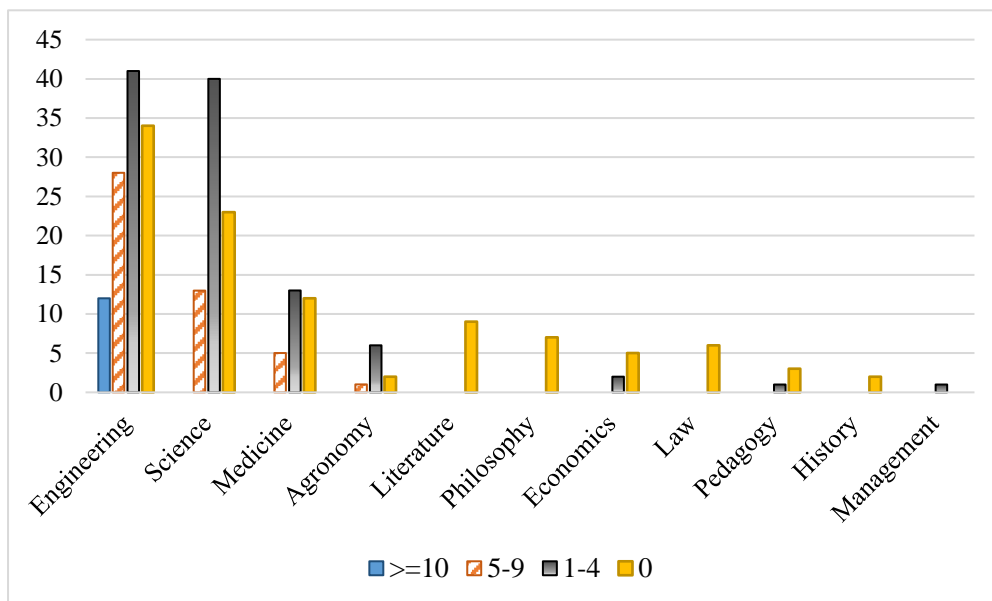
Variable	Mean	Std. Dev.	Min	Max
Co-authored with supervisor after graduation (ref. = no)	0.500	0.501	0	1
Co-authored with supervisor during PhD study	0.613	0.488	0	1
Gender (ref. = female)	0.579	0.495	0	1
Age	30.594	2.313	24	42
Marital status (ref. = single)				
Married	0.556	0.498	0	1
Major in science stream (ref. = non-science)	0.865	0.343	0	1
A top 500 university (ref. = no)	0.639	0.481	0	1
English-speaking country (ref. = non-English)	0.195	0.397	0	1
Ethnicity of supervisor (ref. = non-Chinese)	0.135	0.343	0	1
Professorship of supervisor (ref. = non-full-time professor)	0.865	0.343	0	1
Current work unit (ref. = 985/211 university)				
Non-211 university	0.154	0.362	0	1
Research institute of the CAS System	0.060	0.238	0	1
Firm	0.128	0.335	0	1
Others	0.177	0.382	0	1

Regarding the characteristics of the doctoral supervisors, around 20 % are ethnic Chinese, with most of them having full professorship in their host universities (87 %). More importantly, 61 % of the PhD returnees co-authored with their supervisors during their doctoral study. Table 2 also presents the basic characteristics of the PhD returnees and the summary statistics of their current work units.

International Mentoring and Co-Authorship during PhD Study

In doctoral study, supervisors are responsible for guiding students in their studies and academic research. Co-authorship in research publications between supervisors and students is an important approach in research collaboration. In fact, whether the returnees co-authored with their supervisors during their study varies substantially by majors. Figure 1 shows the number of PhD returnees' publications co-authored with their supervisors during their PhD study. Given the large number of returnees studying in science stream majors, such returnees were more productive with their supervisors than those majoring in a non-science stream. In particular, 12 returnees with an engineering major produced more than 10 academic publications with their supervisors during their PhD study, whereas returnees with majors in literature, philosophy, law, and history did not co-author with their supervisors during their study.

Figure 1 Number of Publications of PhD Returnees Co-Authored with Their Supervisors during Their Study, by Major ($N = 266$)



Drawing on logistic regression models, we further examine the factors that contribute to the European-trained PhD returnees' co-authorship with their supervisors during their doctoral study. Table 3 shows that the demographic characteristics of the returnees (such as gender, age, and marital status) do not have any statistically significant effect on the likelihood of co-authorship (Model 1 of Table 3). Hypothesis 3.1 about the gender difference in co-authorship during doctoral study is thus not supported.

Table 3 Odds Ratios from Logistic Regression Models Predicting Collaborations with Doctoral Supervisors during PhD Study ($N = 266$)

	(1)	(2)	(3)	(4)
Gender (ref. = female)	1.417 (0.369)	0.920 (0.271)	0.901 (0.267)	0.896 (0.266)
Age	5.036 (4.806)	4.914 (5.149)	5.208 (5.481)	5.009 (5.289)
Age squared	0.973 (0.015)	0.974 (0.016)	0.973 (0.016)	0.974 (0.016)
Marital status (ref. = single)	1.402 (0.377)	1.569 (0.463)	1.611 (0.482)	1.621 (0.487)
Married		21.406*** (12.659)	21.658*** (12.805)	21.894*** (12.993)
Major in science stream (ref. = non-science)		2.499* (1.038)	2.559* (1.073)	2.691* (1.171)
English-speaking country (ref. = non-English)			0.844 (0.257)	0.845 (0.257)
A top 500 university (ref. = no)				
Professorship of supervisor (ref. = non-full professor)				1.189 (0.496)
Ethnicity of supervisor (ref. = non-Chinese)				0.908 (0.383)
Pseudo R -squared	0.0305	0.158	0.159	0.160

Note: Constant is not shown for parsimony. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Consistent with the descriptive statistics in Table 2, returnees in science stream majors are more likely than their counterparts to co-author with their supervisors in research publications (Model 2). The results are robust after conditioning on returnees' demographic characteristics and their international learning experience (Models 3 and 4).

In addition, studying in an English-speaking country increases the possibility of co-authorship (Models 2–4) while the ranking of the returnees' university has no significant effect (Models 3–4). The findings support Hypothesis 4.1 that Chinese PhD returnees from English-speaking countries are more likely to co-author with supervisors during doctoral study, while comparing with those studying in non-English speaking countries.

Interestingly, the effects of the main characteristics of supervisors are not statistically significant. A supervisor's Chinese ethnicity or full professorship does not increase the likelihood of co-authorship with students (Model 4). It means that the finding does not support Hypothesis 1.1 about the positive effect of Chinese ethnicity of mentors on co-authorship with Chinese PhD students. The same ethnicity of PhD students and their mentors in Chinese provide the advantage of communication without

language barrier, as they usually speak Chinese. However, we suggest that this advantage may not be significant for the PhD student during doctoral study. Because they could have various ways to discuss their research with their mentors, such as regular face-to-face meetings, in-class or after class discussion. In particular, the PhD returnees in our analysis sample were government scholarship awardees after a competitive selection process, they may be proactive in working with their mentors regardless the ethnicity of their mentors. We suggest this is the possible reason for the insignificant effect of the Chinese ethnicity of mentors on the co-authorship during PhD returnees' doctoral study.

Continuity of Co-Authorship upon Return

We further examined whether the co-authorship between returnees and their supervisors continued upon the returnees' return to China. The descriptive statistics of our analysis sample in Table 4 shows that the PhD returnees in science stream majors have a large percentage of co-authorship with supervisors, ranging from 40 % to 67 % on the basis of majors. By contrast, the returnees in some non-science stream majors, such as literature, law, pedagogy, history, and management, did not co-author with their supervisors in research publications after graduating and returning to China.

Table 4 European-Trained PhDs' Co-Authorship with Supervisors upon Return (%)

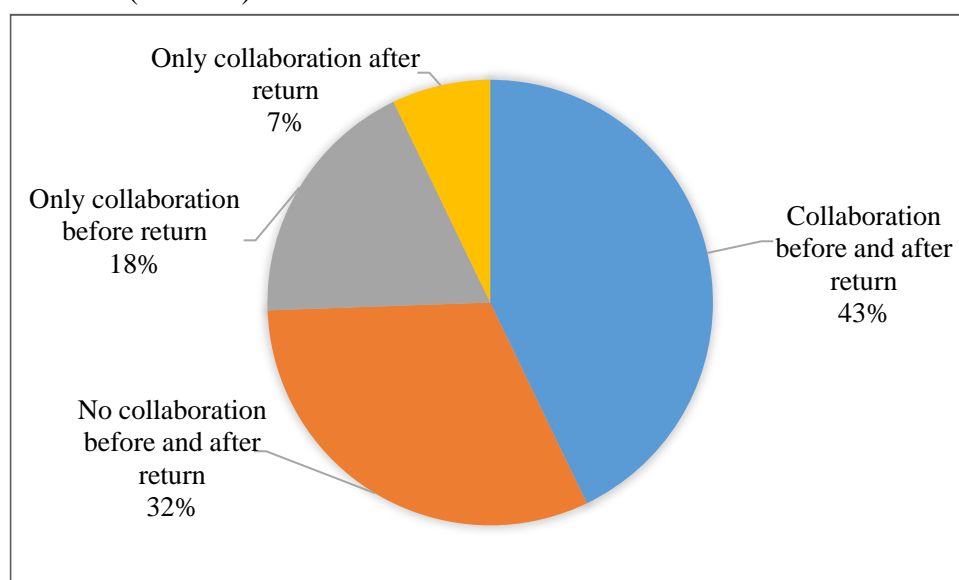
Major	Co-authored with supervisors	Did not co-author with supervisors
Science stream		
Agronomy (9)	66.67	33.33
Engineering (115)	60.87	39.13
Science (76)	53.95	46.05
Medicine (30)	40.00	60.00
Non-science stream		
Economics (7)	42.86	57.14
Philosophy (7)	14.29	85.71
Literature (9)	0	100
Law (6)	0	100
Pedagogy (4)	0	100
History (2)	0	100
Management (1)	0	100

Note. The sample size is 266, and the number of cases in each major is indicated in parentheses.

Tables 2 and 3 show that whether the European-trained returnees co-authored with their supervisors during their doctoral study relates to the returnees' majors and the speaking language of the host country. We extend the analysis to determine whether the returnees co-authored with their doctoral supervisors after their return to China.

Figure 2 presents the distribution of co-authorship groups between returnees and their supervisors before graduation and upon their return to China. More than 60 % of the returnees had co-authorships with their supervisors in research publications before their graduation. During the survey period, 43 % of the returnees maintained these co-authorships upon their graduation and return to China; 18 % did not co-author with their supervisors after their graduation. Interestingly, a small percentage (7 %) of returnees formed research partnerships with their supervisors upon their graduation despite not co-authoring with their supervisors before graduation. Around 30 % of the returnees did not co-author with their doctoral supervisors before graduation or after their return to China. The descriptive statistics provide support for Hypothesis 2 about the continuity of mentor–student co-authorship after the Chinese PhDs return to China.

Figure 2 PhD Returnees’ Collaboration with Doctoral Supervisors before Graduation and after Return to China ($N = 266$)



Logistic regression models were employed for further analysis of the returnees’ co-authorship with their supervisors upon their graduation and return to China. Table 5 shows the odds ratios from the models based on the returnees’ demographic characteristics, PhD majors, and host universities. The male and married returnees were more likely to work with their supervisors on publications after their graduation (Models 1 and 2), whereas age did not have any significant effect.

Table 5 Odds Ratios from Logistic Regression Models Predicting Collaboration with Doctoral Supervisors after Graduation: Basic Models ($N = 266$)

	(1)	(2)	(3)
Gender (ref. = female)	2.484*** (0.645)	1.960* (0.541)	1.993* (0.557)
Age	1.666	1.216	1.184

	(1.374)	(1.126)	(1.095)
Age squared	0.991	0.997	0.998
	(0.013)	(0.015)	(0.015)
Marital status (ref. = single)	1.996**	2.194**	2.154**
Married	(0.534)	(0.616)	(0.612)
Major in science stream		11.136***	11.051***
(ref. = non-science)		(6.467)	(6.421)
English-speaking country (ref. = non-English)		2.157*	2.128*
		(0.795)	(0.786)
A top 500 university (ref. = no)			1.126
			(0.325)
Pseudo <i>R</i> -squared	0.0538	0.130	0.130

Note: Constant is not shown for parsimony. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In fact, the gender difference is large in returnees' co-authorship with their supervisors upon their return to China. In our analysis sample, 59 % of male returnees had co-authored publications with their supervisors after their return; the percentage for female returnees is only 38 %. Model 5 of Table 6 shows that male returnees are almost three times more likely than their female counterparts to co-author with their supervisors upon their return to China, with their PhD learning experience considered (Hypothesis 3.2 is supported). Comparing with the insignificant gender difference (Model 4 of Table 3) during doctoral study, the significant disadvantage of female in the research collaboration after returning to China may relate to the gender-biased expectation and family division of labor for females, and/or insufficient research support for female scholars. The actual mechanisms need further research.

Table 6 Odds Ratios from Logistic Regression Models Predicting Collaboration with Doctoral Supervisor after Graduation: Effects of Supervisor, Co-Authorship Experience, and Work Units

	(1)	(2)	(3)	(4)	(5)
Gender (ref. = female)	1.993*	2.002*	2.530**	2.552**	3.243***
	(0.557)	(0.566)	(0.807)	(0.826)	(1.145)
Age	1.184	1.303	0.722	0.849	0.618
	(1.095)	(1.245)	(0.690)	(0.849)	(0.648)
Age squared	0.998	0.996	1.006	1.004	1.008
	(0.015)	(0.015)	(0.015)	(0.016)	(0.017)
Marital status	2.154**	2.054*	2.073*	1.939*	1.980*
Married (ref. = single)	(0.612)	(0.591)	(0.659)	(0.625)	(0.675)
Major in science stream (ref. = non-science)	11.051***	9.715***	3.631*	2.915	3.553
	(6.421)	(5.651)	(2.306)	(1.867)	(2.324)
English-speaking country (ref. = non-English)	2.128*	1.902	1.634	1.372	1.228
	(0.786)	(0.734)	(0.683)	(0.593)	(0.557)
A top 500 university (ref. = no)	1.126	1.124	1.264	1.272	1.235
	(0.325)	(0.327)	(0.408)	(0.415)	(0.435)
Professorship of supervisor (ref. = no)		1.027	0.965	0.886	0.525

= non-full professor)	(0.416)	(0.432)	(0.411)	(0.268)
Ethnicity of supervisor (ref. = non-Chinese)	2.507*		3.342*	4.816**
	(1.099)		(1.686)	(2.844)
Co-authorship during study (ref. = no)		8.969***	9.725***	11.673***
		(3.118)	(3.484)	(4.650)
Current work unit (ref. = 985/211 university)				
Non-211 university				2.085
				(1.000)
Research institute of the CAS system				0.149**
				(0.105)
Firm				0.183**
				(0.099)
Others				0.782
				(0.349)
Pseudo <i>R</i> -squared	0.130	0.143	0.258	0.276
				0.337

Note: Constant is not shown for parsimony. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Consistent with the results of predicting co-authorship during doctoral study, studying a science stream major and in an English-speaking country significantly increase the likelihood of co-authorship after graduation (Models 2 and 3). Meanwhile, whether the host university is a top worldwide university did not have any statistical impact on co-authorship (Model 3).

Table 6 shows the effects of supervisor, previous co-authorship experience, and work unit on co-authorship upon graduation. Model 1 repeats Model 3 of Table 5 for easy comparison. We add the characteristics of doctoral supervisors in Model 2 and show that the Chinese ethnicity of the supervisor increases the likelihood of co-authorship between the supervisor and the returnee, whereas the supervisor's full professorship does not. The significant effect of Chinese mentor on the co-authorship after PhDs return to China supports Hypothesis 1.2. The possible reason is that the maintenance of the research collaboration with doctoral mentor is challenging after the PhDs return to China, as PhD returnees could not have regular face-to-face meetings and discussions with their mentors as they did during doctoral study. Due to the Confucian tradition, Chinese have been affected by the common notion that "teacher for one day, father forever." Chinese PhDs and their Chinese mentors are thus more likely to maintain the relationship and research ties, despite the PhDs return to China after graduation.

More importantly, Model 3 shows that returnees who have co-authorship experience with their supervisors during their doctoral study are more likely than counterparts to continue the co-authorship after their graduation. The effects of the co-authorship experience and supervisor's ethnicity are robust in Model 4, controlling both effects as well as returnees' demographics, majors, host country and university. Specifically, a returnee having a Chinese supervisor is 3.3 times more likely to co-author

than his/her counterpart. Similarly, a returnee having co-authorship experience with his/her supervisor is 9.7 times of his/her counterpart in the likelihood of co-authorship. The evidence supports Hypothesis 2 about the important role of co-authorship during doctoral study.

As the research publications are mainly in English, language usually becomes a barrier for Chinese returnees. A returnee having his/her doctoral study in a non-English speaking country is embedded in an environment of his/her second or even third language, which may create a barrier for collaboration in English research publications. The comparison between Model 1 and Models 2–4 reveals interesting findings about language barrier in research co-authorship in terms of the speaking language of the returnees' host country.

On the one hand, the variable of English-speaking country (ref. = non-English speaking) is statistically positive in Model 1 and becomes small and insignificant in Model 2 with the significant effects of the supervisor's ethnicity. The disadvantage posed by a host university in a non-English speaking country could become insignificant in co-authorship if the European-trained returnee has a Chinese supervisor. In fact, having a Chinese supervisor increases the likelihood of co-authorship after graduation but not during doctoral study (Model 4 of Table 3). Returnees studying in a non-English speaking country may be embedded in the non-English speaking environment, but they are not greatly affected by this environment upon their return to China after graduation. In addition, the returnees with Chinese supervisors are more likely than others to stay in touch with the supervisors after graduation and collaborate for research publication.

On the other hand, Models 1 and 3 show that the advantage of studying in an English-speaking country in co-authorship becomes insignificant after controlling for the co-authorship experience during doctoral study. As the variable of the English-speaking country positively predicts the co-authorship before graduation (Models 2–4 of Table 3), but not upon graduation (Model 4 of Table 6), we suggest that the advantage of studying in an English-speaking country in co-authorship after graduation (Model 4 of Table 6) is mainly mediated by co-authorship before graduation (Models 2–4 of Table 3). Thus, studying in an English-speaking country increases the returnees' likelihood of co-authoring with their supervisors during their doctoral study. Such likelihood exerts a positive impact on co-authorship after graduation. Therefore, the findings do not support Hypothesis 4.2 about the effect of studying in an English-speaking country on co-authorship after PhDs returning to China.

The last model of Table 6 shows the effects of the current work unit on co-authorship upon graduation and return to China. We found that returnees working in a research institute of the CAS system or a firm are less likely to collaborate with doctoral supervisors for research publication than those working in a leading university of Projects 985/211. This result may be related to the assessment criteria differing across leading universities, research institutes, and firms. Leading universities in China usually emphasize the promotion of international research collaboration and publication with the aim

of earning high rankings in the global university league (Deem, Mok, & Lucas, 2008); this objective motivates the returnees in these universities to seek more research collaboration relative to their counterparts working in firms or research institutes of the CAS system.

Discussion and Conclusions

Drawing on a unique data set combining returnees' survey results and their publications in the Scopus database, this study examines the European-trained PhD returnees' overseas learning experience and their co-authorship with supervisors before and upon their return to China. Our research yields five main findings and related policy recommendations for Sino–European research collaboration.

First, the Chinese ethnicity of doctoral supervisors does not increase the likelihood of co-authoring returnees during PhD study, but it affects the co-authorship upon returnees' return to China. This finding echoes the important role of international scholars of Chinese descent in promoting China's international scientific research cooperation (Jin et al., 2007). On the other hand, the strong ethnic bond is not necessarily beneficial to the breadth and quality of international cooperation. In fact, academic papers by authors of multiple ethnicities on average have generally more citations than those papers by authors of the same ethnicity. Thus, ethnic diversity could probably exert considerable impact on research citation (Freeman & Huang, 2014). Therefore, policy makers should pinpoint and solve the obstacles hindering collaboration in publications between PhD returnees and their non-Chinese supervisors.

Second, more than 60 % of the European-trained PhD returnees had co-authorship with their supervisors before and/or after their return to China. In addition, most of the international mentoring co-authorships established during the doctoral study were maintained upon the returnees' return to China. Among the returnees who did not form any research partnerships with their supervisors during their PhD study, only a small percentage started co-authorships with their doctoral supervisors upon their return to China. This result may be related to the complexity of research collaboration, which usually involves the time-consuming process of getting to know collaborators and working with one another.

These findings have important implications for Sino–European research collaboration. Sponsoring Chinese students studying in European countries for PhD programs does not only increase the mutual understanding between China and European countries. More importantly, European-trained returnees could bring in solid and concrete research collaboration through their co-authorship with their supervisors. The continuity of this international mentoring and co-authorship with returnees implies the importance of establishing research collaboration and publication mentorship with supervisors during returnees' doctoral study.

Third, returnees studying in an English-speaking country are more likely to co-author with their supervisors upon their return. Such advantage is mainly mediated by co-authorship before graduation. Thus, studying in an English-speaking country increases returnees' likelihood to co-author with their supervisors during their doctoral study, which further affects the research partnership after the returnees' return to China.

Fourth, organizations have an effect in returnees' co-authorship, that is, those working in the research institutes of the CAS system are less likely to co-author with their supervisors upon return than those working in leading universities. On the one hand, this result may be related to the strong motive of leading universities to promote international collaboration and research publication in pursuit of the goal of a high ranking in the global university league (Deem et al., 2008). On the other hand, the bureaucratic management of the CAS system may also have a negative effect on international research co-authorship. One PhD returnee working in a research institute of the CAS system told us in an in-depth interview that he did not co-author with his doctoral supervisor because only scholars who are professors can apply for funding for international collaboration.

Finally, gender difference is also found in returnee-supervisor co-authorship upon the returnees' return despite such difference being insignificant during their PhD study. With regard to the respondents' PhD learning experience, male returnees were three times more likely than their female counterparts to co-author with their supervisors upon their return to China. Further study is required to examine whether and how such a large gender difference relates to gender role differentiation in marriage and parenthood or in other related factors.

This study contributes to the literature by linking the research on international PhD mobility and research collaboration. Earlier studies on student mobility usually focus on the mobility of undergraduate students or mixed study levels of students. Little attention has been paid to the internationalization of postgraduate education and its impacts on research collaboration, including international co-authorship and other international research benchmarks (Knight & de Wit, 2018). To our best knowledge, this research is one of the first attempts to investigate international mentoring co-authorship and research collaboration between doctoral supervisors and PhD students. International research collaboration is seen as one of the key driving forces of the rapid development of Chinese research (Freeman & Huang, 2015). Our study sheds new light on how such international collaboration has been developed and how international learning plays a role in such collaboration.

In addition, our data address a main challenge in previous studies based on the self-reported data on research publication by merging the survey data with concrete publication information extracted from the Scopus database. The use of such data ensures that the returnees' information on publications in our analysis are accurate and of high quality. To our knowledge, this work is the first attempt to collect detailed data about Chinese PhD returnees supported by the CSC. Nevertheless, we are aware of

potential data limitations. For instance, the returnees of our sample are possibly self-selective in answering the questionnaire of this study. Those with good careers upon returning from their PhD study are more likely than their counterparts to join the survey. Future studies would benefit from the collection of inclusive data.

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