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Article

Comparing the collaboration networks and productivity of China-born and US-born academic scientists

Eric Joseph van Holm [1,*], Yonghong Wu [2] and Eric W. Welch [3]

[1]Center for Science Technology and Environmental Policy Studies, School of Public Affairs, Arizona State University, 411 N Central Avenue, Phoenix, AZ 85004, USA, [2]Department of Public Administration, University of Illinois at Chicago, 412 South Peoria Street, Chicago, IL 60607, USA, [3]Center for Science Technology and Environmental Policy Studies, School of Public Affairs, Arizona State University, 411 N Central Avenue, Phoenix, AZ 85004, USA

*Corresponding author. Email: evanholm@asu.edu

Abstract

Chinese scientists constitute the largest group of foreign-born tenure-track faculty in science and engineering (S&E) fields in the USA, and have become a target of recent Chinese government efforts seeking to attract them back to China. This study examines the differences of collaboration networks between Chinese scientists and US-born scientists working in the USA. The findings show significant differences in the size, composition, and role of collaboration networks of Chinese scientists, and how these networks differently impact their productivity. The networks of scientists born in China are smaller, more dispersed, and less communicative. However, despite those networks and less benefit from traditional research resources, Chinese scientists appear to be more productive than their American colleagues are. The study improves understanding of this important group in the USA's research enterprise and also provides insights for science policy.

Key words: collaboration network; higher education; Chinese scientists; scientific production; culture.

1. Introduction

Asian-born faculty held roughly 17 per cent of all full-time US science and engineering (S&E) faculty positions in 2014, and of those, Chinese scientists make up one of the largest groups (National Science Board 2016). China has long permitted an outflow of scientists and students to Western countries and has encouraged transnational networks to increase return knowledge flows (Welch and Zhen 2008). These national efforts have allowed China to make the largest gains in publishing among the BRICS, and their scientists have had a particularly substantial growth in co-authoring with the USA since the beginning of the 21st century (Bornmann et al. 2015). For developing countries, the building of international research collaborations is vital because of the productivity gains they generate for domestic scientists (Jonkers and Tijssen 2008; Shin and Cummings 2010).

The encouragement of international partnerships has been part of a strategy that has seen China increase investment in its science and technology system rapidly for over a decade. For example, as shown in Figure 1, China's gross domestic expenditure on R&D as a percentage of the nation's GDP has more than doubled since 2000 with no signs of slowing. Other statistics, such as China's production of patent submissions as reported in the World Intellectual Property Organization Statistics Database have also demonstrated year-on-year increases to the point that some of the production statistics are higher than the USA.

As China attempts to transition toward an innovation-driven economy, its science and technology policy has been shifting to encourage originality and autonomy in research. The rise in expenditures and production belies a significant increase in demand for skilled and talented personnel, one source of which is the US university system. Chinese scientists working in US academic research institutions have become a target of government policies seeking to attract them to return to China. For instance, in 2009 China launched the *Thousand Talents Program* aiming to recruit global talent by offering generous personal compensation and lab funding. This program was the first of a variety of similar programs in China designed to attract top scientists from abroad, particularly from the USA, raising the potential issue of a 'reverse brain drain' if successful. The policy is well founded, as Chinese scientists returning from abroad have been shown to be more productive, partially as a result of the collaborative relationships developed while in the USA (Jonkers and Tijssen 2008).

The potential loss of Chinese scientists and those from other countries poses a serious concern for the continued competitiveness

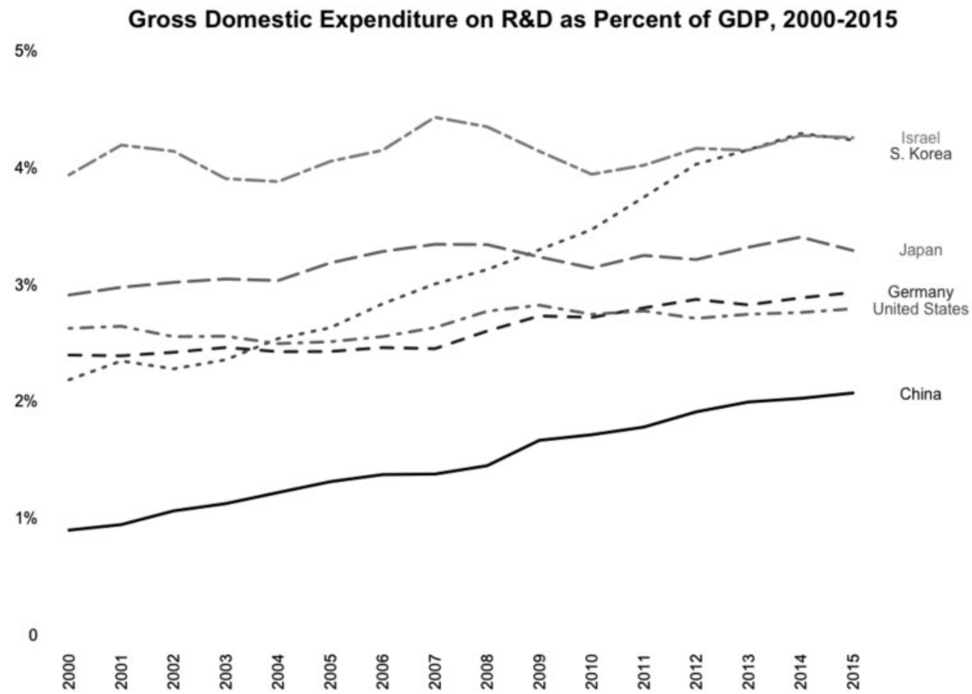

Figure 1. Gross domestic expenditure on R&D as percentage of GDP, 2001–2012. *Source*: Main Science and Technology Indicators, OECD.

of the USA's science and technology system. As US universities are strategically investing to attract and train the next generation STEM workforce for the country (Gunn and Mintrom 2013; Stromquist 2007), in a period of global competition for talent (Altbach 2005; Foote et al. 2008) and observing ongoing national discussions concerning immigration (Hopkins 2010; Freeman 2005), it is essential to improve understanding about the characteristics, experiences, and contributions of the largest foreign-born segment of the US STEM workforce. Improved knowledge will help policymakers and universities to recognize areas of weakness and design solutions that improve the work environment, and thereby the long-term competitiveness of the US STEM workforce.

Despite their importance to American science and technology and the increasing competition for their talents, little is known about the differences between Chinese scientists working in the USA as compared with their US-born counterparts. Are Chinese scientists embedded in collaboration networks similar to those of US-born scientists? Do the collaboration networks play an equally important role in the productivity and career of China-born scientists as their US-born colleagues? This article addresses these questions and others within an integrated social and human capital framework. In particular, we examine the collaboration networks of Chinese academic scientists working in the US higher education institutions and how collaboration networks contribute to Chinese scientists' productivity and career development as compared with their US-born colleagues.

We first compare the collaboration networks (size and composition) of Chinese and US-born scientists before examining how different human and social capital characteristics predict key research outputs and whether Chinese scholars depend on distinctive types of resources and structures than their US-born counterparts. Understanding the unique needs of Chinese scientists, who form a significant portion of foreign-born academic scientists in US S&E fields and are receiving significant pressure and opportunity to return home, is critical to the continued competitiveness of American science and technology. By focusing on Chinese scientists in isolation from other nations our analysis is able to fully utilize the sizable literature on cultural differences between the USA and China to formulate more specific hypotheses, rather than treat all foreign scientists as a cultural monolith.

This study improves the understanding of the relationships among collaboration networks, resources, research activities, and productivity outputs of Chinese faculty researchers. The findings shed light on whether there are cultural distinctions that create opportunities for recruitment and retention, recognizing that both the US and China are likely to benefit from better knowledge about the structures and behaviors of this group. The study will also provide insights into how effective the current Chinese government recruitment efforts might be and what factors may be important for US universities and science policy to consider.

2. Literature and hypotheses

Scholars generally support the view that an individual's research capacity is generated by the accumulation of scientific and technical human capital, which includes both human capital endowments such, as formal education and training, as well as social relations and network ties (Bozeman and Corley 2004). From a social network perspective, individuals' participation in career-related networks enhances opportunities for advancement by increasing the amount and quality of resources accrued by the networked individual (Granovetter 1973, 1983; Burt 1992, 2005; Renzulli et al. 2000). The social capital gained through participation in collaborative networks can take many different forms. Resources such as knowledge, expertise, and equipment are often shared within networks and introductions to additional collaborators may be provided through collaborative ties (Bozeman et al. 2001). Therefore, access to and participation in collaborative teams has important implications for productivity and career development of academic scientists (Ibarra and Deshpande 2007).

Academic scientists from different cultures and countries are motivated to develop effective collaboration network structures to obtain resources, opportunities, prestige, and visibility from their direct or indirect ties to colleagues (Fox and Faver 1984; Hafernik et al. 1997; Katz and Martin 1997; Melin 2000). In this article, we focus on how different cultural backgrounds influence the size and shape of collaboration networks among university scientists. While the networks and careers of foreign-born coworkers in an academic context have been understudied, the management literature has examined how cultural differences affect the work behavior and outcomes of foreign employees. In a landmark study, Hofstede (1980, 2003) developed the culture value framework, in which culture is defined as 'the collective programming of the mind which distinguishes the members of one human group from another' (Hofstede 1980: 25). Based on his study of foreign employees working in IBM, Hofstede found that national culture is an important determinant of employees' workplace behaviors, attitudes, and working outcomes, a finding which has been corroborated repeatedly in subsequent empirical studies (Kirkman et al. 2006; Smith and Bond 1999).

Cultural differences have been found in academic settings as well. Collins (2008) and Munene (2014) found that foreign faculty commonly has feelings of isolation and loneliness, often due to perceived cultural differences and institutional policies with regard to workloads and teaching requirements. Kim et al. (2011) found lower levels of satisfaction among foreign faculty, owing to their discomfort in the American higher education system. Despite widespread feelings of isolation, foreign-born faculty is frequently more productive than their US-born colleagues (Mamiseishvili and Rosser 2010).

It is well established that Chinese culture is characterized by collectivism in contrast to the individualism that is a core value of Western cultures (Hofstede 2003; Lockett 1988). For instance, compared to their American counterparts, Chinese professionals have been found to be more likely to use familial norms in their professional relationships (Chua et al., 2009). As summarized by Yang (1988), the familial collectivism rooted in Chinese culture is characterized by mutual dependence, hierarchical power structure, dominance of family interaction over other relationships, and preference for extended family structure. Those defining features influence the development and structure of Chinese professional relationships in the homeland and abroad.

Although most studies have been conducted in the private and non-profit sectors, we expect that similar cultural differences will be evident in the academic setting. Informed by Hofstede's culture value theory and subsequent empirical studies, we establish three overarching hypotheses to explain how networks and productivity of China-born and US-born scientists' may diverge due to cultural differences.

2.1 Network structure

One important indicator of social capital (but certainly not the only one) is the size of an individual's network (Wasserman and Faust 1994). A larger network can imply access to and availability of more resources and increase the possibility of receiving diverse information (Greve 1995) and has been shown to benefit scientists (Birley 1985; Nicolaou and Birley 2003). In US universities, foreign scientists may have more difficulty enlarging their collaboration networks than US-born scientists because of language or cultural barriers (Collins 2008; DiTomaso et al. 1993; Loo 1985). In addition, homophily or the 'similar-to-me effect' could further constrain development of collaboration networks of foreign scientists (Ibarra 1995; Cox 1993). Therefore, we expect US-born scientists to have larger collaboration networks than Chinese scientists.

Another way to examine collaboration structure is to capture the propensity of scientists to collaborate with people working outside their home institutions. Scholars have found that people tend to collaborate with those who are geographically more proximate, for example, due to the transaction costs associated with communication of complex ideas across large distances (Bozeman and Corley 2004; Cummings and Kiesler 2007; Landry et al. 1996; Mora-Valentin et al. 2004). The collaboration pool of US-born scientists is larger than Chinese scientists in the USA, who are typically dispersed across states and institutions. As a result, Chinese scientists' networks are likely to extend beyond their own institutions as they seek collaborators with same or similar cultural background, whereas native scientists would not be constrained by such considerations. Hence, we expect that Chinese scientists in US universities are more likely to collaborate with people outside their home institutions than US-born scientists.

Further dispersing their networks, Chinese scholars are likely to have collaboration networks that extend internationally. The development of international collaborations are a vital reason that countries encourage outflows of scientists, and such home linkages have been shown to be an important predictor of return migration (Baruffaldi and Landoni 2012). Working with scientists at international institutions is another way for foreign scholars to seek homophily by working with individuals from their native country. In addition, because creating transnational partnerships has been a target of Chinese policy, scientists in both contexts will have reasons to seek such collaborations (Welch and Zhen 2008). Therefore, we also predict that Chinese scientists will have a larger share of their networks at foreign institutions.

H1a: Chinese scientists will have a smaller collaboration network than US-born scientists.

H1b: Chinese scientists will have a higher proportion of network ties outside their institution than US-born scientists.

H1c: Chinese scientists will have a higher proportion of network ties in foreign institutions than US-born scientists.

2.2 Network composition

We also examine three other network characteristics: closeness, length of relationship, and hierarchy. Closeness refers to the perceived emotional closeness of the scientists with other individuals in the network. It is often measured using frequency of communication or whether an individual is considered to be a close personal friend. Close ties are highly trusted and are therefore generally reliable sources of resources and advice. Close collaboration ties are more likely to provide academic scientists with needed research inputs, nominations, introductions, or funding necessary to establish a career and ensure advancement. While native and foreign scientists both depend upon close ties, Chinese scientists are expected to be more dependent on a small set of highly trusted collaborators given their norms of familial collectivism. Chinese professional relationships tend to be a mixture of family and non-family, personal and impersonal, and expressive and instrumental characteristics (Chen et al. 2013). The empirical study by Chua et al. (2009) corroborates the intertwining of affect-based and cognition-based trust in the professional networks of Chinese. These familial-ties may contribute to

Chinese scientists developing longer-lasting connections with their collaboration networks. In particular, Chinese scientists may be more likely to remain attached to other scholars they met early in their careers, particularly during their transition to a foreign culture.

The proportion of senior ties in the network measures the likelihood that scientists work with colleagues at different ranks, relative to their own rank. One core feature of Chinese familial collectivism is hierarchical power structure (Yang 1988) so there is a greater value placed on seniority in professional relationship than in American culture (Hofstede 1980). Instead, the egalitarian American culture emphasizes friendship ties as much as other types of relationships.

As previous studies indicate, foreign-born scientists in the USA usually face more strict selection process in each stage of their career paths, including graduate program application, job market application, tenure process, and research grant application (Choi 1995). Given the strict selection process, Chinese scientists are motivated to seek assured access to resources through collaboration or mentoring relationships with senior scientists who are more visible and have more established reputations. In many cases, the senior scientists could also be strong collaboration ties that are highly trusted and maintained over long periods of time. As access to resources is a primary motivation of collaboration (Fox and Faver 1984; Hafernik et al. 1997; Katz and Martin 1997; Melin 2000), it is likely that Chinese scientists will work more with scholar's senior to them.

H2a: Chinese scientists will have closer ties with their collaborators than US-born scientists.

H2b: Chinese scientists will have a larger proportion of long-term collaboration network ties.

H2c: Chinese scientists will have a larger proportion of their collaboration network ties with seniors than US-born scientists.

2.3 Productivity

Research has found foreign faculty to be more productive than their US-born colleagues (Mamiseishvili and Rosser 2010), but scant research has investigated how they utilize their networks or resources in their work. Kim et al. (2011) studied how work satisfaction impacted the research productivity of foreign faculty, finding them to be both more productive and less satisfied with their jobs. However, the analysis did not find a relationship between the two variables for foreign faculty, a relationship the analysis could not entirely explain.

Given the well-accepted importance of collaborative networks in forming academic opportunities and outcomes (Chubin et al. 1990), it is reasonable to expect that the smaller networks of Chinese scientists may impede their research productivity. On the other hand, Chinese scientists may benefit from smaller, more trusted networks of close senior collaborators. It is also possible that Chinese scientists may not utilize their networks as productively as their US-born colleagues because of cultural and language barriers or because of the geographic dispersal of their collaborators. Does a superior leveraging of one's network and resources explain a portion of the longstanding gap in productivity rates between foreign and US-born scientists? While far more exploratory that those analyzing differences in network structure, we predict that China-born scientists will demonstrate higher rates of return from their networks and resources.

H3: Network and research resources will increase the productivity of China-born scientists more than US-born scientists.

Data and method

The analysis first compares the collaboration networks (structure and composition) between the two groups to test H1a:c and H2a:c. The article then applies regression analysis to understand how different human and social capital characteristics predict key research outputs and whether Chinese scientists leverage resources and structures differently than their US-born counterparts (H3).

The article uses data collected in 2012 for an NSF-funded national study to examine the role of professional and collaboration networks for career outcomes including production, advancement, and mobility. The survey was specifically designed to investigate the professional networks of women and underrepresented minorities in STEM fields, as compared to their male and white counterparts. Data were collected based on a nationwide survey of 9,925 tenured and tenure-track academic scientists in four STEM fields—biology, biochemistry, civil engineering, and mathematics. The sample frame included most well recognized institution types such as research intensive, research extensive, master comprehensive, liberal arts colleges, women's colleges, and historically black colleges and universities. With respect to the fields included, the respondents are representative of the tenure and tenure-track faculty working in research-intensive and extensive universities.

The survey collected ego-centric network data through name-generating social network questions where respondents identified colleagues in several categories: close research collaborators, people with whom they discuss teaching issues, and scientists from whom they seek career-related advice, etc. Named individuals were then the focus of additional questions regarding the nature of the relationship and the resources exchanged.

The response rate for the survey was 40.4 per cent resulting in a total of 4,196 valid responses, 2,245 of which self-identified as US-born scientists while 183 foreign-born scientists identified China as their country of origin. Among the 1,917 respondents who work in research-intensive and extensive institutions in the USA, 879 are US-born scientists and 126 are born in China (China is identified as the country of origin). Owing to the representativeness of the survey, the sample size provides sufficient variation to discern verifiable distinctions between scientists born in China and the USA.

Taking advantage of the survey data, we are able to develop several collaboration network variables to test our hypotheses. First, we use the total number of research collaborators to measure the size of a collaboration network (H1a). Second, we differentiate collaboration ties by a number of criteria: percentage of collaboration ties outside institution (H1b), percentage of collaboration ties at foreign institutions (H1c), percentage of collaboration ties with daily or weekly contact (H2a), percentage of collaboration ties to individuals met during graduate school (H2b), and percentage of collaboration ties to senior scholars (H2c). Table 1 presents some descriptive statistics for the collaboration network variables.

The descriptive statistics in Table 1 evidence substantial variation in the measures of network structure. To remind the reader, we hypothesized that Chinese academic scientists will have smaller collaboration networks, a higher proportion of external and foreign collaborators, closer and longer ties with collaborators, and a larger proportion of connections with senior faculty than the US-born scientists. The mean statistics show that Chinese scientists' networks appear to be smaller, less close, more external, long-lasting, and hierarchical. These preliminary findings provide initial support for five hypotheses (H1a, H1b, H1c, H2d, and H2c) but do not support H2a.

Table 1. Network characteristics across groups of academic scientists

Statistic		*N*	Mean	St. Dev.	Min	Max
Total ties	US-born	830	3.91	2.27	0	8
	Chinese	115	3.36	2.15	0	8
Outside institutions (%)	US-born	830	0.33	0.18	0.00	1.00
	Chinese	115	0.41	0.22	0.00	1.00
Foreign institutions (%)	US-born	830	0.04	0.08	0.00	0.75
	Chinese	115	0.09	0.15	0.00	1.00
Close contact (%)	US-born	830	0.42	0.21	0.00	1.00
	Chinese	115	0.28	0.21	0.00	1.00
Met graduate students (%)	US-born	830	0.08	0.13	0.00	1.00
	Chinese	115	0.22	0.23	0.00	1.00
Senior scholars (%)	US-born	830	0.47	0.28	0.00	1.00
	Chinese	115	0.71	0.25	0.00	1.00

Note: The statistics are based on a sample of 955 academic scientists who work in research-intensive or extensive institutions in the USA with identifiable country origin.

Table 2. Descriptive Statistics—analysis of network characteristics

Statistic	*N*	Mean	St. Dev.	Min	Max
Total ties	955	3.81	2.26	0	8
Outside institutions	955	0.34	0.19	0.00	1.00
Foreign institutions	955	0.05	0.09	0.00	1.00
Close contact	945	0.40	0.21	0.00	1.00
Met as graduate students	955	0.10	0.16	0.00	1.00
Senior scholars	955	0.50	0.29	0.00	1.00
Group dummy (Chinese = 1)	955	0.13	0.33	0	1
Gender (female = 1)	955	0.52	0.50	0	1
Marital status (married = 1)	952	0.86	0.35	0	1
Institution type (research intensive = 1)	955	0.44	0.50	0	1
Admissions Rate	951	0.62	0.21	0.07	1.00
Associate professor	955	0.33	0.47	0	1
Full professor	955	0.41	0.49	0	1
PhD from Non-US University	953	0.04	0.20	0	1
Held Postdoc	955	0.21	0.41	0	1
Biochemistry	955	0.25	0.43	0	1
Civil Engineering	955	0.19	0.39	0	1

Note: The statistics are based on a sample of 955 US-born and Chinese academic scientists who work in research-intensive or extensive institutions in the USA.

However, bivariate differences of means may be explained by other factors. Hence, it is important to consider a broader set of explanatory variables as part of regression equations that explore differences in network structure between Chinese and US-born scientists. Along with a group dummy for country of origin (Chinese = 1), other explanatory factors include demographic variables such as gender and marital status. In addition, we control for the type of institution (research intensive or extensive) the faculty works at as well as the admissions rate for undergraduates to control for the selectivity of the university. The admissions rate was collected for each institution from The Integrated Postsecondary Education Data System for 2012. In addition, the individual's academic rank is included as longer careers should provide scientists opportunities to extend and broaden their networks. We also include whether the respondent earned their doctorate at a USA institution or ever held a postdoctoral fellowship as these may also influence the types of collaborators with which they have come into contact. Finally, we control for which of the four fields (biochemistry, civil engineering, math, or biology) they are employed in. Descriptive statistics for these variables are shown in Table 2.

As is well recognized in the literature, collaboration networks play an important role in productivity and career advancement of academic scientists through establishing access to knowledge and resources critical to academic research. We use the number of peer-reviewed articles published and the number of grant proposals accepted over the past two years as measures of faculty productivity. We measure the size of professional networks with three variables to capture discrete effects, specifically the total number of collaborators, the percentage of close research collaborators, and the percentage of foreign collaborators. To examine if the effect of network characteristics are different for Chinese and US-born scientists, we include the interaction terms of all three network variables with the group dummy variable. Larger (Lee and Bozeman 2005), closer (Bozeman and Corley 2004), and more international networks (Jonkers and Tijssen 2008; Shin and Cummings 2010) have been shown to have positive effects on productivity in the past, but it is unclear how these will differentially impact scientists born in China and the USA.

We also control for other factors that may contribute to the faculty publication and grant-seeking productivity. First, we measure accumulated research capacity as the number of years of employment after the first tenure track position. Scientists should improve as their careers mature; however, we also include a squared term because motivation may wane following the successful acquisition of full tenure.

In addition to the length of their career, scientists' access to research-related resources and research efforts are also important determinants of productivity. We control for tangible resources in terms of facility, equipment, and research assistants using the type of institution (research intensive = 1; research extensive = 0) and the number of research assistants supervised in the past year. In general, faculty in research-intensive institutions have better access to research facility and equipment than faculty in research extensive institutions. In addition, we measure faculty research efforts by the number of hours spent on research in a typical week.

In order to understand how Chinese scientists utilize resources differently than Americans, we also include interactions for the number of hours spent on research and the number of research assistants. We include those interactions, along with the three described above for network characteristics in separate regressions in order to avoid overfitting the model because China-born scientists comprise only 13 per cent of the final sample. Thus, with two productivity measures and five interaction terms, we measure network and resource effects on productivity over ten regressions in total.

Table 3 presents descriptive statistics for the variables used in the analysis of network characteristics and productivity.

3. Results

The results are presented in two parts. In the first section, we examine the differences in network structure between China-born and US-born respondents. In the second section, we examine how network structure impacts the production of papers and grant proposals, and whether there are differences in the effect for US-born and China-born faculty.

3.1 Differences in network structure of China and US-born scientists

We first conduct analysis of network characteristics on a sample of 955 US-born and Chinese academic scientists who work in research-

Table 3. Descriptive Statistics—analysis of productivity measures

Statistic	*N*	Mean	SD	Min	Max
Peer-reviewed articles last two years	916	5.67	8.75	0	150
Research grants awarded last two years	818	1.72	2.72	0	50
Group dummy (Chinese = 1)	955	0.13	0.33	0	1
Total number of collaboration ties	955	3.81	2.26	0	8
Close collaboration ties	945	0.40	0.21	0.00	1.00
Foreign collaboration ties	955	0.05	0.09	0.00	1.00
Years since first tenure track position	921	14.50	11.19	0	51
Institution type (research intensive = 1)	955	0.44	0.50	0	1
Number of research assistants in past year	887	2.69	2.90	0	17
Weekly hours spent on research	940	23.46	13.58	0.00	78.40
Biochemistry	955	0.21	0.41	0	1
Civil Engineering	955	0.25	0.43	0	1
Math	955	0.19	0.39	0	1

Note: The statistics are based on a sample of 955 academic US-born and Chinese scientists who work in research-intensive or extensive institutions in the USA.

intensive and extensive institutions in the USA. We use a group dummy variable to differentiate the two groups (Chinese = 1). As discussed in the prior section, six network variables are used as dependent variables, specifically the total number of collaboration ties, percentage of collaboration ties at outside institutions and foreign institutions, percentage of collaboration ties with daily or weekly contact, percentage of collaboration ties met during graduate school, and percentage of collaboration ties to seniors. The total number of collaboration ties is a count variable, and its distribution is over-dispersed, so we use a negative binomial regression with a model that includes gender, marital status, type of institution, field, rank, length of career, and the group dummy. The other dependent variables are measured in percentages, and we use Ordinary Least Squares (OLS) regression (with robust standard errors) on the same set of explanatory variables. The statistical results are presented in Table 4.

The regression results continue to support five out of six hypotheses regarding network characteristics of Chinese scientists as compared with US-born scientists. In particular, the estimated effect of the group dummy is statistically significant at the 1 or 5 per cent level and in the expected direction on the total number of collaboration ties (negative; H1a), percentage of collaboration ties outside institution (positive; H1b), percentage of collaboration ties to foreign institutions (positive; H1c), percentage of collaboration ties met as graduate students (positive; H2b), and percentage of collaboration ties to seniors (positive; H2c). However, the estimate of the group dummy is statistically significant but negative for the percentage of collaboration ties with daily or weekly contact. This unexpected finding, which is contrary to the direction of hypothesis H2a, may either be because Chinese scientists have fewer close ties to collaborators or they are less communicative with their collaborators. Whether this result is a function of communication style or closeness should be examined further in the future, perhaps through interviews.

There are other important findings with the independent variables studied. For instance, gender and marital status seem irrelevant to the collaboration network characteristics, except in one case: females are significantly less likely to have collaboration ties with others at foreign institutions.

Academic scientists working in research-intensive institutions have smaller network sizes and fewer ties with scholars in foreign institutions, with individuals they met as graduate students, or with senior scholars. However, they maintain more frequent contact than those in research extensive institutions.

Field of research does make for some difference in network characteristics. For instance, mathematicians have a smaller number of research collaborators than those in biology. In addition, biochemists and civil engineers are significantly less likely to have foreign collaborators, while this is more common for faculty in math. Mathematicians also are the most likely to have weekly contact with their networks.

Higher ranked faculty and faculty with longer careers tend to have more network ties and a higher proportion of external ties, but fewer ties to those they met at graduate school and to those at a higher rank. Those findings likely reflect lifecycle realities for scientists, as maintaining contact becomes more difficult over time and because it is more challenging to find senior scholars to partner with as they themselves become more senior.

3.2 Network determinants of productivity for Chinese and US-born scientists

To explore how professional networks and research resources affect faculty production, we focus on the number of peer-reviewed articles published and the number of grant proposals that were awarded in the past two years. We expect that both of these productivity variables will be explained by the structure and composition of scientists' research network, as well as several other control variables such as (1) the number of years since the first tenure track position, (2) type of institution, (3) the number of research assistants supervised in the past year, and (4) the number of hours spent on research in a typical week. The group dummy (Chinese = 1) is also interacted with the network variables, the number of research assistants, and the hours spent on research in order to test whether culture impacts how scientists utilize these resources. Because the two productivity variables are measured as counts (number of articles and grant submissions) and because their distributions are over-dispersed, we use negative binomial regression. The estimation results are presented in Tables 5 and 6.

The descriptive statistics shown earlier in Table 3 demonstrated that faculty in this sample produced approximately six articles and just under two research grants over the previous two years.

Table 4. Statistical results—analysis of network characteristics

	Dependent variable:					
	Total ties	Outside institutions	Foreign institutions	Close contact	Met as graduate students	Senior scholars
	Negative binomial	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
Group dummy (Chinese = 1)	−0.153**	0.085***	0.025**	−0.139***	0.142***	0.163***
	(0.069)	(0.023)	(0.012)	(0.023)	(0.025)	(0.026)
Gender (female = 1)	0.010	0.017	−0.022***	−0.027**	0.008	0.038**
	(0.040)	(0.013)	(0.006)	(0.014)	(0.011)	(0.016)
Marital status (married = 1)	0.064	−0.017	−0.010	0.012	0.014	0.011
	(0.055)	(0.018)	(0.008)	(0.019)	(0.014)	(0.021)
Institution type (research intensive = 1)	−0.120***	0.009	−0.016***	0.059***	−0.006	−0.012
	(0.040)	(0.013)	(0.006)	(0.013)	(0.010)	(0.016)
Admissions Rate	−0.010	−0.024	−0.004	0.032	−0.016	−0.039
	(0.094)	(0.028)	(0.014)	(0.033)	(0.024)	(0.038)
Associate professor	0.008	−0.062***	0.018**	0.006	−0.036**	−0.171***
	(0.053)	(0.016)	(0.008)	(0.018)	(0.015)	(0.019)
Full professor	0.144***	−0.070***	0.027***	0.010	−0.046***	−0.380***
	(0.049)	(0.016)	(0.007)	(0.018)	(0.016)	(0.020)
PhD from Non-US University	0.111	−0.107***	0.074***	0.021	−0.029	−0.018
	(0.092)	(0.031)	(0.027)	(0.031)	(0.037)	(0.042)
Held Postdoc	0.026	0.057***	0.027***	−0.070***	0.018	0.066***
	(0.052)	(0.016)	(0.007)	(0.018)	(0.013)	(0.020)
Biochemistry	−0.005	−0.005	−0.015**	0.030*	−0.010	0.010
	(0.052)	(0.016)	(0.007)	(0.017)	(0.012)	(0.020)
Civil Engineering	0.048	−0.027	−0.014*	0.017	0.025	0.021
	(0.059)	(0.018)	(0.008)	(0.020)	(0.015)	(0.023)
Math	−0.140**	0.015	0.019*	0.052***	0.033**	−0.003
	(0.062)	(0.019)	(0.010)	(0.020)	(0.016)	(0.024)
Constant	1.280***	0.362***	0.038**	0.393***	0.087***	0.639***
	(0.107)	(0.035)	(0.015)	(0.037)	(0.032)	(0.041)
Observations	946	946	946	937	946	946
R^2		0.094	0.114	0.121	0.128	0.382
Adjusted R^2		0.082	0.103	0.110	0.117	0.374
Log Likelihood	−2,084.073					
theta	11.079***					
	(2.231)					
Akaike Inf. Crit.	4,194.145					
Residual Std. Error		0.183 (df = 933)	0.088 (df = 933)	0.200 (df = 924)	0.151 (df = 933)	0.230 (df = 933)
F-Statistic		8.076*** (df = 12; 933)	10.050*** (df = 12; 933)	10.595*** (df = 12; 924)	11.426*** (df = 12; 933)	47.999*** (df = 12; 933)

Note: * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$.

Scientists born in China account for roughly 13 per cent of the faculty in the sub-sample. In addition, scientists in this sub-sample reported an average of just under four collaborators, 14 years of academic experience, just under three research assistants, and 44 per cent were from research-intensive institutions.

Results for the full model predicting publication rates are in Table 5. The group dummy variable is statistically significant and positive indicating that China-born scientists as a group produce more peer-reviewed publications than US-born scientists, holding the structure and composition of the networks constant. In addition, statistical results show that the number of collaboration ties contributes to faculty productivity with regard to publications. Larger networks allow for greater specialization and the sharing of more resources, and these results further confirm network's importance to research output. However, the closeness of the network has the opposite effect when holding all else constant. The percentage of collaborators at foreign institutions also reaches significance across the models and is positive, indicating that broader geographic networks also aid a scientist's productivity.

Longer experience in a tenure track job results in more publications on average, but the negative coefficient on the squared term indicates these gains decrease over time. The number of research assistants supervised and number of hours spent on research both have a positive effect on peer-reviewed publications, demonstrating again how resources can impact productivity across the sample. There are few meaningful differences in the publication rates based on field; while the comparison group, biology, is generally the most productive the differences are only statistically significant when compared with faculty in math.

Table 5. Analysis of Network and Resources on Publications

	Dependent variable:				
	number of publications in past two years				
	(1)	(2)	(3)	(4)	(5)
Group dummy (Chinese = 1)	1.004***	0.723***	0.572***	0.236*	0.834***
	(0.178)	(0.169)	(0.112)	(0.141)	(0.234)
Total number of collaboration ties	0.104***	0.083***	0.080***	0.084***	0.078***
	(0.016)	(0.014)	(0.014)	(0.014)	(0.014)
Close collaboration ties	−0.399**	−0.340**	−0.458***	−0.451***	−0.454***
	(0.158)	(0.171)	(0.159)	(0.159)	(0.160)
Foreign collaboration ties	1.538***	1.467***	1.865***	1.491***	1.470***
	(0.344)	(0.347)	(0.401)	(0.347)	(0.347)
Years since first tenure track position	0.061***	0.063***	0.064***	0.061***	0.063***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Years since first tenure track position squared	−0.001***	−0.002***	−0.002***	−0.001***	−0.002***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Institution type (research intensive = 1)	−0.019	−0.011	−0.018	−0.010	−0.007
	(0.067)	(0.067)	(0.067)	(0.067)	(0.067)
Number of research assistants in past year	0.055***	0.056***	0.058***	0.048***	0.058***
	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)
Weekly hours spent on research	0.023***	0.025***	0.025***	0.024***	0.026***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Biochemistry	−0.072	−0.104	−0.103	−0.095	−0.111
	(0.083)	(0.083)	(0.083)	(0.083)	(0.083)
Civil engineering	−0.129	−0.113	−0.105	−0.101	−0.101
	(0.084)	(0.084)	(0.084)	(0.084)	(0.084)
Math	−0.204**	−0.202**	−0.180*	−0.198**	−0.219**
	(0.098)	(0.099)	(0.099)	(0.098)	(0.099)
Interaction – Chinese-total ties	−0.152***				
	(0.041)				
Interaction – Chinese-close ties		−0.820*			
		(0.457)			
Interaction – Chinese-foreign ties			−1.418*		
			(0.764)		
Interaction – Chinese-research assistants				0.076**	
				(0.032)	
Interaction – Chinese-research hours					−0.012*
					(0.007)
Constant	0.188	0.201	0.235	0.285*	0.230
	(0.146)	(0.150)	(0.146)	(0.146)	(0.148)
Observations	817	817	817	817	817
Log Likelihood	−2,147.556	−2,152.791	−2,152.954	−2,152.071	−2,153.393
theta	1.883***	1.850***	1.845***	1.856***	1.843***
	(0.124)	(0.121)	(0.121)	(0.122)	(0.121)
Akaike Inf. Crit.	4,323.113	4,333.581	4,333.909	4,332.143	4,334.786

Note: *P < 0.1; **P < 0.05; ***P < 0.01.

However, the above discussion of networks and resources overlooks the ways that networks and resources may impact Chinese and US-born scientists differently; the interaction terms allow us to test our third hypothesis and observe whether there are dissimilar effects. All three network variables tested had significantly different effects for the two groups. Specifically, having larger networks and more foreign ties had a positive effect overall for both groups, but is less beneficial for China-born scientists than their US-born colleagues. In addition, China-born scientists with closer networks face a larger negative effect, holding all else constant.

The interaction term for the number of hours spent on research in a week is also negative, indicating that every extra hour spent on such activities has less of a return for China-born scientists than those born in the USA. Conversely, the models indicate that China-born scholars receive a larger benefit from additional research assistants than their US-born colleagues.

In general, the effect of the network and resource variables on grants awarded is similar to peer-reviewed publications. However, the dummy variable for whether the individual was born in China is only significant in one analysis, that being when including the interaction for the number of research assistants. The interaction term of the group dummy with the number of research assistants is statistically significant and negative, suggesting that the effect of the additional assistants depends on the country of origin-such support is utilized more productively by US-born scientists than their China-born counterparts.

The share of close collaboration ties has a slightly significant and positive effect on grant submission. However, the percentage of

Table 6. Analysis of network and resources on grants

	Dependent variable:				
	Number of grants awarded in past two years				
	(1)	(2)	(3)	(4)	(5)
Group dummy (Chinese = 1)	0.213	0.165	0.125	0.305**	0.102
	(0.221)	(0.189)	(0.122)	(0.143)	(0.246)
Total number of collaboration ties	0.126***	0.122***	0.122***	0.122***	0.123***
	(0.021)	(0.019)	(0.019)	(0.019)	(0.019)
Close collaboration ties	0.575*	0.588	0.572*	0.576*	0.571
	(0.348)	(0.388)	(0.345)	(0.346)	(0.347)
Foreign collaboration ties	−1.335***	−1.341***	−1.362**	−1.408***	−1.348***
	(0.474)	(0.475)	(0.554)	(0.479)	(0.475)
Years since first tenure track position	0.007	0.008	0.007	0.008	0.007
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Years since first tenure track position squared	−0.0004	−0.0004	−0.0004	−0.0004	−0.0004
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Institution type (research intensive = 1)	−0.171	−0.170	−0.170	−0.175	−0.171
	(0.118)	(0.117)	(0.118)	(0.117)	(0.117)
Number of research assistants in past year	0.082***	0.082***	0.082***	0.087***	0.082***
	(0.013)	(0.013)	(0.013)	(0.014)	(0.013)
Weekly hours spent on research	0.017***	0.018***	0.018***	0.018***	0.017***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Biochemistry	−0.295***	−0.301***	−0.300***	−0.299***	−0.300***
	(0.114)	(0.113)	(0.113)	(0.113)	(0.113)
Civil Engineering	0.353***	0.354***	0.355***	0.354***	0.355***
	(0.118)	(0.117)	(0.117)	(0.117)	(0.117)
Math	−0.400**	−0.398**	−0.399**	−0.407***	−0.397**
	(0.157)	(0.157)	(0.158)	(0.157)	(0.157)
Interaction – Chinese-total ties	−0.022				
	(0.049)				
Interaction – Chinese-close ties		−0.119			
		(0.521)			
Interaction – Chinese-foreign ties			0.064		
			(1.037)		
Interaction – Chinese-research assistants				−0.050**	
				(0.024)	
Interaction – Chinese-research hours					0.001
					(0.007)
Constant	−0.887***	−0.886***	−0.876***	−0.894***	−0.873***
	(0.198)	(0.200)	(0.198)	(0.196)	(0.198)
Observations	738	738	738	738	738
Log Likelihood	−1, 200.992	−1, 201.056	−1, 201.074	−1, 200.307	−1, 201.071
theta	2.380***	2.381***	2.380***	2.394***	2.380***
	(0.285)	(0.285)	(0.285)	(0.288)	(0.285)
Akaike Inf. Crit.	2,429.984	2,430.111	2,430.148	2,428.614	2,430.143

Note: *P < 0.1; **P < 0.05; ***P < 0.01.

foreign ties again has a strongly negative effect in the second set of regressions, the opposite finding from when studying publication rates. There are strong differences for different fields with regard to grant proposals; being a faculty member in civil engineering appears to increase one's rate of grant awards, while math and biochemistry both had fewer grants awarded than biology. That result is logical considering the differing availability and importance of grants between fields.

Conclusion

Overall, the findings suggest important implications for science policy, particularly as they relate to the potential for a Chinese brain drain. As a group, they are found to be more productive than US-born colleagues. This is impressive given that Chinese scientists possess smaller networks and do not leverage their collaboration networks as effectively as their US counterparts. In addition, China-born scientists do not benefit as much from certain network resources such as collaboration ties from foreign institutions. Why this is so is not clear, but the lower level of communication frequency in the networks of Chinese scientists may provide some indication. It is possible that Chinese scientists collaborate differently than US-born scientists; they may as a group have a more consistent norm about work effort and be more self-reliant than their US-born colleagues. The findings are only suggestive, but it seems that Chinese scientists are members of smaller, less communicative networks with heavy ties to their birth-country. Their networks are more dispersed and they appear to be more self-reliant, even as they benefit substantially from graduate students. Whether the findings have identified a certain degree of unwelcomed cultural isolation or an issue of cultural preference is not clear in this analysis.

There is growing evidence that cultural differences are reflected in network and research habits for scientists in the USA. Kim et al. (2011) showed that workplace satisfaction was far less important to foreign faculty than their US colleagues. Here, we show that not only are there significant differences in how China-born scientists structure their networks, but that resources such as network size, international collaborations, the number of research assistants, and hours spent on research have less of a positive effect on their productivity. As foreign-born faculty become more central to the USA's higher education system, it is critical to understand what motivates their workplace performance and what resources to provide in order to maximize their efficiency. While the present analysis has been unable to identify what support is best to give China-born and all foreign-born scientists that question warrants further study.

From a policy perspective, it appears that Chinese scientists are less embedded in scientific networks, particularly local ones, and may be more isolated. While not examined here, lower levels of embeddedness may also result in lower levels of satisfaction, career enjoyment, and professional comfort. If true, the different network structures may indicate that Chinese scientists are more mobile and more willing to move than their US-born counterparts, particularly if they are recruited through Chinese national efforts such as the *Thousand Talents Program*.

Of particular interest is the negative effect of international collaboration on grant submissions for both groups. The survey did not identify where international collaborators resides, but it is reasonable to predict many of these linkages are to the researcher's country of origin in the case of China-born scientists. The results stand in contrast to the benefits of international collaboration shown in past literature to scientists employed in China and South Korea, and evidence the importance of context in network effects. While there are numerous benefits to international research, both at the individual and institutional level, these concerns should be weighed in regards to the burdening of faculty, for whom productivity is critical to their career advancement.

Nevertheless, it is possible to conclude from this analysis that there are further opportunities for research and policy to investigate the propensity of Chinese scholars to respond to China's new recruiting programs. We can offer two possible concluding scenarios based on the analysis conducted. One scenario is that Chinese scientists have simply carved out a culturally identifiable niche in a flexible US university system. Within that system, they are able to form network structures and establish research contexts that fit their needs and interests, particularly staying connected to foreign scientists, and enable them to be productive. A second scenario is that Chinese scientists are relatively marginalized. They are not well embedded in networks and the resources they obtain do not provide them with productivity advantages. In particular, we see in the negative coefficients for the interactions of research hours and graduate assistants that these resources are not as beneficial to Chinese scientists as the US-born. Rather, they are treated by the US S&T system in ways that have required them to be more self-reliant.

This study does not resolve whether Scenario 1 or 2 dominates. Rather it raises the question about whether Chinese scientists in US research universities are vulnerable to recruitment by China for reasons that go beyond simply returning to their national origin. Both the USA and China would benefit from greater attention to potential institutional sources of opportunity and bias within the structure of science. Competition for valuable human resources will continue to be of significant interest to S&T policymakers over the coming decades and nowhere will it be greater than between the USA and China. Further application of this approach is not only important for the case of Chinese scientists in the USA, but for other foreign-born groups as well.

References

Altbach, P. (2005) 'Academic Challenges: The American Professoriate in Comparative Perspective'. In: *The Professoriate*, pp. 147–65. Dordrecht: Springer.

Baruffaldi, S. H., and Landoni, P. (2012) 'Return Mobility and Scientific Productivity of Researchers Working Abroad: The Role of Home Country Linkages', *Research Policy*, 41/9: 1655–65.

Birley, S. (1985) 'The Role of Networks in the Entrepreneurial Process', *Journal of Business Venturing*, 1/1: 107–17.

Bornmann, L., Wagner, C., and Leydesdorff, L. (2015) 'BRICS Countries and Scientific Excellence: A Bibliometric Analysis of Most Frequently Cited Papers', *Journal of the Association for Information Science and Technology*, 66/7: 1507–13.

Bozeman, B., and Corley, E. (2004) 'Scientists' Collaboration Strategies: Implications for Scientific and Technical Human Capital', *Research Policy*, 33/4: 599–616.

——, Dietz, J. S., and Gaughan, M. (2001) 'Scientific and Technical Human Capital: An Alternative Model for Research Evaluation', *International Journal of Technology Management*, 22/7–8: 716–40.

Burt, R. S. (1992) *Structural Holes Versus the Social Structure of Competition.. Cambridge*, MA: Harvard University Press.

—— (2005) *Brokerage and Closure: An Introduction to Social Capital*. Oxford: Oxford University Press.

Chen, C. C., Chen, X. P., and Huang, S. S. (2013) 'Chinese Guanxi: An Integrative Review and New Directions for Future Research', *Management and Organization Review*, 9/1: 167–207.

Choi, H. (1995) *An International Scientific Community: Asian Scholars in the United States*. Westport, CT: Praeger.

Chua, R. Y. J., Morris, M. W., and Ingram, P. (2009) 'Guanxi vs. Networking: Distinctive Configurations of Affect- and Cognition-Based Trust in the Networks of Chinese vs. American Managers', *Journal of International Business Studies*, 40/3: 490–508.

Collins, J. M. (2008) 'Coming to America: Challenges for faculty coming to United States' universities', *Journal of Geography in Higher Education*, 32/2: 179–88.

Chubin, D. E. and Hackett, E. J. (1990) 'Peerless science: Peer review and US science policy', Albany, NY: State University of New York Press.

Cox, T. (1993) *Cultural Diversity in Organizations: Theory, Research and Practice*. San Francisco: Berret-Koehler.

Cummings, J. N., and Kiesler, S. (2007) 'Coordination Costs and Project Outcomes in Multi-University Collaborations', *Research Policy*, 36/10: 1620–34.

DiTomaso, N., Farris, G. F., and Cordero, R. (1993) 'Diversity in the Technical Work Force: Rethinking the Management of Scientists and Engineers', *Journal of Engineering and Technology Management*, 10/1–2: 101–27.

Foote, K. E., Li, W., Monk, J. et al. (2008) 'Foreign-Born Scholars in US Universities: Issues, Concerns, and Strategies', *Journal of Geography in Higher Education*, 32/2: 167–78.

Fox, M. F., and Faver, C. A. (1984) 'Independence and Cooperation in Research: The Motivations and Costs of Collaboration', *The Journal of Higher Education*, 55/3: 347–59.

Freeman, G. P. (2005) 'Political Science and Comparative Immigration Politics', In: Morawska, E., and Bommes, M. (eds), *International Migration Research: Constructions, Omissions and the Promises of Interdisciplinarity*, pp. 111–28. London, UK: Routledge.

Granovetter, M. (1973) 'The Strength of Weak Ties', *American Journal of Sociology*, 78/6: 1360–80.

——— (1983) 'The Strength of Weak Ties: A Network Theory Revisited', *Sociological Theory*, 1: 201–33.

Greve, A. (1995) 'Networks and Entrepreneurship: An Analysis of Social Relations, Occupational Background, and Use of Contacts During the Establishment Process', *Scandinavian Journal of Management*, 11/1: 1–24.

Gunn, A., and Mintrom, M. (2013) 'Global University Alliances and the Creation of Collaborative Advantage', *Journal of Higher Education Policy and Management*, 35/2: 179–92.

Hafernik, J. J., Messerschmitt, D. S., and Vandrick, S. (1997) 'Collaborative Research: Why and How? ', *Educational Researcher*, 26/9: 31–5.

Hofstede, G. (1980) *Cultures Consequences: International Differences in Work-Related Values.* Beverly Hills, CA and London: Sage Publications, Inc.

——— (2003) *Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations*. London: Sage Publications, Inc.

Hopkins, D. J. (2010) 'Politicized Places: Explaining Where and When Immigrants Provoke Local Opposition', *American Political Science Review*, 104/1: 40–60.

Ibarra, H. (1995) 'Race, Opportunity, and Diversity of Social Circles in Managerial Networks', *Academy of Management Journal*, 38 /3: 673–703.

———, and Deshpande, P. (2007) 'Networks and Identities: Reciprocal Influences on Career Processes and Outcomes', in Gunz H. and Peiperl M. (eds.) *Handbook of Career Studies*, pp. 268–283. Thousand Oaks, CA: SAGE Publications, Inc.

Jonkers, K., and Tijssen, R. (2008) 'Chinese Researchers Returning Home: Impacts of International Mobility on Research Collaboration and Scientific Productivity', *Scientometrics*, 77/2: 309–33.

Katz, J. S., and Martin, B. R. (1997) 'What is Research Collaboration?', *Research Policy*, 26/1: 1–18.

Kim, D., Wolf-Wendel, L., and Twombly, S. (2011) 'International Faculty: Experiences of Academic Life and Productivity in U.S. Universities', *The Journal of Higher Education*, 82/6: 720–47.

Kirkman, B. L., Lowe, K. B., and Gibson, C. B. (2006) 'A Quarter Century of "Culture's Consequences": A Review of Empirical Research Incorporating Hofstede's Cultural Values Framework', *Journal of International Business Studies*, 37/3: 285–320.

Landry, R., Traore, N., and Godin, B. (1996) 'An Econometric Analysis of the Effect of Collaboration on Academic Research Productivity', *Higher Education*, 32/3: 283–301.

Lee, S., and Bozeman, B. (2005) 'The Impact of Research Collaboration on Scientific Productivity', *Social Studies of Science*, 35/5: 673–702.

Lockett, M. (1988) 'Culture and the Problems of Chinese MANAGEMENT', *Organization Studies*, 9/4: 475–96.

Loo, C. M. (1985) 'The 'Biliterate' Ballot Controversy: Language Acquisition and Cultural Shift Among Immigrants', *International Migration Review*, 19/3: 493–515.

Melin, G. (2000) 'Pragmatism and Self-Organization Research Collaboration on the Individual Level', *Research Policy*, 29/1: 31–40.

Mamiseishvili, K. and Rosser, V. J. (2010) 'International and citizen faculty in the United States: An examination of their productivity at research universities', *Research in Higher Education*, 51/1: 88.

Munene, I. I. (2014) 'Outsiders Within: Isolation of International Faculty in an American University', *Research in Post-Compulsory Education*, 19/4: 450–67.

Mora-Valentin, E. M., Montoro-Sanchez, A., and Guerras-Martin, L. A. (2004) 'Determining Factors in the Success of R&D Cooperative Agreements Between Firms and Research Organizations', *Research Policy*, 33/1: 17–40.

National Science Board (2016) *Science and Engineering Indicator*. Arlington: National Science Foundation.

Nicolaou, N., and Birley, S. (2003) 'Social Networks in Organizational Emergence: The University Spinout Phenomenon.', *Management Science*, 49/12: 1702–1725.

Renzulli, L. A., Aldrich, H., and Moody, J. (2000) 'Family Matters: Gender, Networks, and Entrepreneurial Outcomes', *Social Forces*, 79/2: 523–46.

Shin, J. C., and Cummings, W. K. (2010) 'Multilevel Analysis of Academic Publishing Across Disciplines: Research Preference, Collaboration, and Time on Research', *Scientometrics*, 85/2: 581–94.

Smith, P. B., and Bond, M. H. (1999) *Social Psychology Across Cultures*. Boston: Allyn & Bacon.

Stromquist, N. P. (2007) 'Internationalization as a Response to Globalization: Radical Shifts in University Environments', *Higher Education*, 53/1: 81–105.

Wasserman, S., and Faust, K. (1994) *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge University Press.

Welch, A. R., and Zhen, Z. (2008) 'Higher Education and Global Talent Flows: Brain Drain, Overseas Chinese Intellectuals, and Diasporic Knowledge Networks', *Higher Education Policy*, 21/4: 519–37.

Yang, C. F. (1988) 'Familialism and Development: An Examination of the Role of Family in Contemporary China Mainland, Hong Kong, and Taiwan', In Sinha, D. and Kao, H. S. R. (eds), *Social Values and Development: Asian Perspectives*, pp. 93–123. Thousand Oaks, CA: Sage.