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Continued collaboration shortens the transition period of scientists who move to another institution

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Abstract

Scientific collaboration plays a significant role in scientists' research performance. When scientists move from one institution to another and leave the team they belong to or lead, they may continue collaborating with the former team because engaging in or building a new team takes time. In this study, we collected data from the Open Researcher and Contributor ID (ORCID) website on 2,922 scientists who published first-tier journal papers defined by the Chinese Academy of Science (CAS) before they moved to a new institution. By applying a Poisson regression model to the dataset, we explored the correlation between continued collaboration and the transition period after scientists moved, which is defined as the time span between the year of the move and the year when they published their first top-tier journal paper after moving. Our findings indicated that: (1) continued collaboration significantly shortens the transition period by 27.2%; (2) continued collaboration significantly shortens the transition period of senior scientists to a larger extent than that of junior scientists; (3) continued collaboration significantly shortens the transition period of social scientists to a larger extent than that of natural scientists; (4) the transition period is shorter after moves for scientists with higher inherent potential; and (5) there is no evidence that the transition period is associated with culture-related differences between the origin country and the destination country after the move, or whether they had lived in the destination country before.

Keywords Continued collaboration · Transition period · Global mobility · Scientists

Introduction

The mobility of scientists is an inevitable trend given increased globalization driven by the emergence of the knowledge society and knowledge economy (Bhagwati & Hamada, 1974; Xiang, 2006; D'Andrea & Gray, 2013; Daugeliene & Marcinkeviciene, 2009; Donnelly, 2009; Knight, 2011; Mayr & Peri, 2008; Meyer et al., 1997; Robertson, 2006; Saxenian, 2005; Teferra, 2005; Tung, 2008). Some scholars have argued

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that both nations and scientists benefit from mobility (Rodrigues et al., 2016). Mobility promotes the exchange of scientific, institutional, and cultural knowledge, and transferring knowledge across institutions and nations is the foundation of scientific progress (Petersen, 2018; Pettersson, 2011). It can also greatly facilitate scientific knowledge output by allowing workers to find environments in which they can maximize their skills, thereby increasing economic productivity (Fernández-Zubieta et al., 2016; Hoisl, 2007). In addition, from the perspective of job matching theory, global mobility is a method to move toward opportunity structures that better fit scientists' preferences, competencies, personality, and research profiles, allowing them to work more efficiently and thus increase their scientific productivity and impact. There is evidence that mobility increases scientists' absolute or fractional number of publications (Cruz-Castro & Sanz-Menéndez, 2010; Geuna, 2015; Jovanovic, 1979; Kato & Ando, 2013). However, some scholars have questioned the benefits of mobility by focusing on the challenges scientists face after a move, such as professional and personal dislocation and transaction costs (Azoulay, 2017). The impact of mobility on careers is more reflected in the threat to scientists' academic status and identity, and the challenge of coping with academic activities, along with their lack of cultural knowledge (Greek & Jonsmoen, 2021). The complex interplay of race and class has led some mobile scientists to define themselves as "exploited elites", which means they may be treated as lower middle class somewhere because of their ethnical background and therefore suffer some injustice (Amelina, 2013). While the career prospects and new experiences may be attractive for scientists when they move, the risks associated with mobility are still worth considering (Petersen, 2018).

Science has become increasingly reliant on teamwork over the past decades (Fortunato et al., 2018). This phenomenon can be explained by the "burden of knowledge" mechanism proposed by Jones (2009), who contended that with the development of science, the degree of specialization/knowledge barriers has increased in various fields. In addition, the burden for scientists to learn new knowledge of other fields has increased. When scientists realize that their expertise is not enough to support innovation, they choose to collaborate with others. Collaboration also plays a vital role in achieving scientific success (Bornmann, 2017; Larivière et al., 2015). Thus, scientists are becoming more collaborative, and collaborative papers are gaining more citations (Zuo & Zhao, 2018). Furthermore, studies have shown that collaboration has a positive correlation with the number of publications and impact, and these effects are more significant in international collaborations (He et al., 2009; Lee & Bozeman, 2005). However, Zhao et al. (2022) found that mobility disrupts the stability of scientists' collaboration, and can lead to a challenging transition period for scientists because of the geographic and language differences.

Scientists tend to collaborate after a move with scientists with whom they had previously collaborated due, in part, to the lower collaboration cost. Dahlander and McFarland (2013) found that compared with new relationships, continued collaboration requires fewer startup costs than a new collaboration, and the coauthors have greater trust and more effective communication. Thus, they are likely to have higher productivity and performance quality than new ties. In addition, a change in geographic location and a loss of stable coauthors can reduce the productivity of mobile researchers (Borjas & Doran, 2015). Thus, researchers often retain connections with previous collaborators to offset these global mobility problems while collaborating with researchers at their new institutions. Taking Chinese researchers in plant molecular life sciences as an example, when researchers return to China from foreign institutions, they continue to collaborate with researchers in their original institutions due to the lag period of establishing new labs and research lines. This collaboration model positively impacts their productivity in the early stages after they make a move (Jonkers & Tijssen, 2008).

The research gap is that we do not know to what extent and how continued collaboration help scientists shorten the transition period after they move from one institution to another. Here, the continued collaboration refers to continuing the ideologically collaborative relationship with previous collaborators. It is not related to whether the collaboration occurred before or after moving. There are many scenarios for continued collaboration. For example, a scientist discussed an idea with collaborators in the previous institution before the move, but the idea is implemented after the move. For another example, when scientists decide to move, they may revise the affiliation of the ready-to-submit manuscripts to the destination institution. The transition period is defined as the time span between the year of the move and the year when they published their first top-tier journal paper after moving.

In this study, we aim to address this research question by comparing the scientists who chose to continue collaboration and those who did not, and exploring the influence of continued collaboration on scientists at different career stages and in different disciplines. We collected the mobility experience and publications of nearly 3,000 scientists. The data is based on their CVs from the Open Researcher and Contributor ID (ORCID) website and the bibliographic records of the Web of Science (WoS) database. Gureyev et al., (2020) divided the mobility of scientists into four types: geography, duration, object, and profession. We used the changes of scientists' affiliations to study the global mobility caused by geographical changes (including international and domestic mobility). We built a Poisson regression model to the dataset to explore the association of continued collaboration with the transition period after scientists moved.

Literature review

Mobility implies changes in co-authorship networks (Zhao et al., 2020), which may have implications for scientists' research. Continued collaboration with previously coauthored scientists requires low search costs, even though they tend to form new collaborative relationships after moving (Zhang et al., 2018). In terms of the co-authorship networks of scientists, super ties can improve a paper's citation rate by about 17%. Here, the author defines the super tie as abnormally high collaborative strength between two scientists (Petersen, 2015). The long-term rewards of a stable partnership can offset the potential benefits of collaborating with new scientists (Petersen, 2015). Bu et al., (2018b) found that the medium–high collaboration stability has the highest average scientific impact. Although scientists' geographic location changes after moving, they still have professional ties with their previous coauthors. These social connections created by previous collaborations do not disappear entirely and significantly help scientists in their subsequent careers. Zhao et al. (2022) analyzed the extent that mobility disrupts the stability of scientists' collaboration, and the results show that tight connections in the collaboration network still exist after moving while weaker ties are broken, and the more scientists move, the more they collaborate with previous coauthors. Hence, we propose the following hypothesis:

H1 Continued collaboration is associated with a shorter transition period of scientists after they move to a new institution.

The roles that senior and junior scientists play in a team and the differences in their professionship are associated with the transition period after a scientist moves. These differences are related to their career stage. We use "junior scientist" to refer to a change from a PhD student to a faculty member in the move, and "senior scientist" refers to a scientist who remains a faculty member after the move. As the number of scientists and the size of the team continues to increase, the division of labor within the team becomes finer (Wuchty et al., 2007). Flat and egalitarian teams are more conducive to promoting the progress of junior scientists, while hierarchical teams can only improve the productivity of senior scientists in some cases (Xu et al., 2022). The division of labor among scientists is generally classified based on their characteristics, including their experience level, educational status, or social status (Guimerà et al., 2005; Shibayama et al., 2015). Therefore, senior scientists mostly assume the leader role in the team, undertaking conceptual activities such as proposing ideas and writing. In contrast, junior scientists mainly undertake extended or supporting activities that can be replaced (Haeussler & Sauermann, 2016). In this case, the social ties of junior scientists, who play a significant role in collaboration, are weaker than the social ties of senior scientists. Therefore, we propose the following hypothesis:

H2 Continued collaboration helps senior scientists to a larger extent than junior scientists in shortening the transition period after a scientist moves.

The typical transition period varies across disciplines. Researchers in the social sciences and the humanities do not form a homogeneous category in research collaboration (Larivière et al., 2006). Zhao et al. (2022) found that compared with natural science research, which highly depends on instruments and equipment, social science research is more related to people and society, so social scientists have high collaborative stability after they move. Hence, we propose the following hypothesis:

H3 Continued collaboration helps social scientists more than natural scientists in shortening the transition period after a scientist moves.

Inherent potential, or individual productivity, is closely related to the contribution and influence of scientists in their respective fields (Dennis, 1954). High productivity can increase the probability of tenure and subsequent research funding (Bertsimas et al., 2015; Stephan, 2012). Scientific achievement can be explained by the Matthew effect proposed by Merton (1968): scientists who have previously been successful are more likely to succeed again, producing increasing distinction (Bol et al., 2018). Based on this effect, a scientist with high productivity before moving is likely to obtain more favorable scientific research conditions provided by the employing affiliation after they move, thereby promoting the output of the scientific research results. Hence, we propose the following hypothesis:

H4 Higher inherent potential of a scientist is associated with a shorter transition period after a scientist moves.

Science is part of the culture, and how science is conducted largely depends on the culture-related factors in which it is practiced (Iaccarino, 2003). Scientists study the natural world through observation and experimentation, and different knowledge cultures put these empirical observations into a different, larger context (Colburn, 2000; Iaccarino, 2003). Therefore, moving to a new institution is necessary for many scientists. A long-distant geographic move allows them to reach different academic environments and experience new ways of knowledge creation and paradigm shifts (Altbach, 2007). Moving across regions also helps them stimulate creativity, nurture their social networks, and accumulate new knowledge and prestige (Cañibano et al., 2008). However, some factors may increase global mobility costs, such as occupational shocks, periods of adaptation, and stereotypes (Gopaul & Pifer, 2016). In addition, internationally recruited academics often feel isolated due to language barriers if scientists move to non-native-speaking regions (Kreber & Hounsell, 2014; Negretti & Garcia-Yeste, 2015). In addition, language and geographic proximity also influence the choice of collaborators (Larivière et al., 2006). Therefore, we propose the following hypothesis:

H5 The culture-related differences between the origin country and destination country are associated with a longer transition period.

Data and methodology

Data

In this study, the data were collected from the ORCID website and the Web of Science (WoS) database. The former provides a 16-digit identifier that is unique to each scientist to solve the problem of ambiguity of the author's name. The value of the ORCID registry is that it links both existing identifier schemes as well as publications and other research activities, crossing disciplines, organizations, and countries (Haak et al., 2012). Many scientists publish their CVs on ORCID web pages. Thus, we extracted scientists' global mobility experiences for our dataset using their CVs, which provided bibliographic records of the scientists.

We first excluded scientists whose start dates at a new institution were missing or were not accurately reported. Here, global mobility means a change in the scientists' affiliations. Considering that scientists start scientific research during their PhD studies, we removed any research activity before their PhD studies. In WoS, the authors' affiliations of the publications after 2008 are more accurate, so the records before 2008 in our dataset were also deleted. Then, we extracted scientists' affiliations from their publications in WoS to match the affiliations reported on their CVs to evaluate their research performance at each institution. If an author had more than one affiliation reported in a paper, we only used the first institution because it is, more often than not, the most recent affiliation. We treated each move of a scientist independently. For example, we included three moves in our dataset if the scientist moved three times. Our dataset included 18,752 works of 2,922 scientists and 3,222 global mobility records of them.

Table 1 Definitions of the variables

Variable name	Variable type	Annotation
Transition_period	Discrete	The time span between the move and the time that the first top-tier journal paper was published after a move
Continued_collaboration	Binary	1 if a scientist continues to coauthor with previous collaborators after the move, otherwise 0
Discipline	Count	The discipline of scientists
Career_stage	Binary	1 if a scientist is a senior scientist, otherwise 0
Linguistic_distance	Continue	The linguistic distance between countries/territories before and after the move
Geographic_distance	Continue	The geographic distance between countries/territories before and after the move
Lived_before	Binary	1 if a scientist moved to a country/territory s/he had never lived in before, otherwise 0
Inherent_potential	Discrete	The number of papers published in the affiliated institution before the move

Methods

We define *transition_period* as the time span between the year of a move and the year when the scientist published the first top-tier journal paper after a move. We built a Poisson regression model as shown in Eq. (1) to explore the relationship between the continued collaboration of scientists and their transition period after moving from one institution to another. In this model, the transition period is the dependent variable, and the variables mentioned in the hypothesis will be added to the multiple regression model one by one. The variables and definitions are shown in Table 1, and ε_i is the error term.

$$\begin{aligned}\text{transition\_period} = \; & \alpha_0 + \beta_1 \times \text{continued\_collaboration} + \beta_2 \times \text{career\_stage} + \beta_3 \times \text{inherent\_potential} \\ & + \beta_4 \times \text{geographic\_distance} + \beta_5 \times \text{linguistic\_distance} + \beta_6 \times \text{lived\_before} + \varepsilon \end{aligned} \tag{1}$$

Discipline

The discipline to which a scientist belongs. We used the papers published in the top-tier journals of the Chinese Academy of Sciences (CAS) upgraded zoning rules in 2021 (see https://www.fenqubiao.com) to determine the disciplines of scientists. The updated zoning rule introduced a new indicator called "journal transcendence index", the probability that the number of citations of a paper is greater than that of other same-topic papers selected from other journals. The new rule can eliminate the dependence on the preset discipline system and make the zoning results more robust than using impact factors. The top 5% journals are called top-tier journals of the CAS, which contain 1,125 journals that are all included by the WoS and divided into 17 disciplines (see https://github.com/Qian-Yuchen/The-CAS-top-tier-journels). Each paper is categorized into one of the six major areas of the GIPP classification system (GIPP Research Areas, 2019) at the journal level based on the corresponding relationship between the GIPP system and the CAS system. The GIPP system originated from the ~ 250 disciplines in WoS, and includes "Arts & Humanities," "Clinical, Pre-Clinical & Health," "Engineering & Technology," "Life Sciences," "Physical Sciences," and "Social Sciences." We then categorized each scientist into one of the six GIPP disciplines based on his/her publication records, which were already categorized into the GIPP disciplines. For scientists who published in multiple disciplines, we categorized them into the unique discipline in which they published most of their papers.

Career_stage

Junior or senior. The former refers to a change from a PhD student to a faculty member in the move, and the latter refers to a scientist who remains a faculty member after the move. The value is one if the scientist is a senior faculty member, otherwise zero.

Linguistic_distance

A culture-related difference variable. The official language difference between the countries/territories before and after the move. The value is between 0 and 1. The smaller the value, the smaller the linguistic distance.

Geographic_distance

A culture-related difference variable. The geographic distance between the countries/territories before and after the move. The smaller the value, the smaller the geographic distance.

Lived_before

A culture-related difference variable representing whether the scientist had previously lived in the destination country/territory before the move. If yes, the value is 0, otherwise 1.

Inherent_potential

The number of papers affiliated with the institution before the move. It should be noted that papers formally published after the move due to the lengthy review periods in some disciplines are still counted as papers from the institution before the move.

Results

Descriptive statistics

Table 2 displays the descriptive statistics of our dataset. The transition period after a move was 2.74 years, on average; 81.9% of the sampled scientists chose *continued_collaboration*. Our sample involves 80 countries/territories (66 origin countries/territories and 68 destination countries/territories). Domestic mobility accounts for 54%, slightly exceeding international mobility (46%). In domestic mobility, the top 3 types are US-US (707 times), GB-GB (257 times), and CN-CN (149 times). In international mobility, the top 3 types are CN-US (75 times), GB-US (59 times), and CA-US (41 times). The top 10 origin and destination countries/territories and the top 10 global mobility types are listed in the Appendix Table 6 and 7. The country names and their abbreviations are listed in the Appendix Table 8.

Figure 1 shows that the transition period was two years after most moves. The distribution of the transition period is approximately normal, but the values are discrete rather than continuous. Therefore, we applied a Poisson model to the regression analysis.

Table 2 Descriptive statistics

Variables	Obs	Mean	Std. Dev	Min	Max
Transition_period	3,222	2.742	1.732	0	10
Continued_collaboration	3,222	.819	.385	0	1
Career_stage	3,222	.382	.486	0	1
Inherent_potential	3,222	3.003	3.802	1	64
Linguistic_distance	3,222	.251	.372	0	1
Geographic_distance	3,222	3,011.592	4,642.731	0	19,060.355

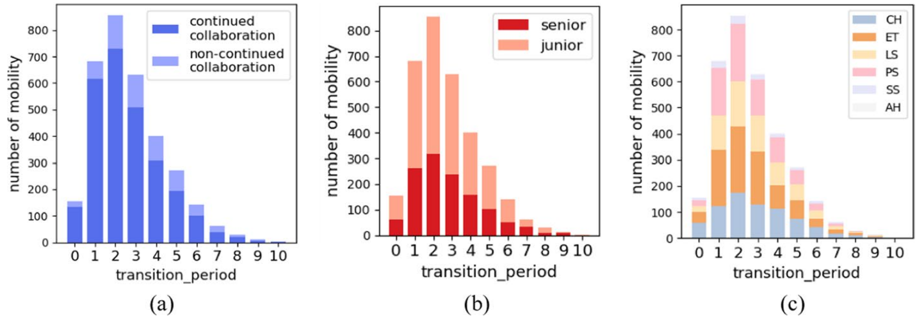

Fig. 1 Distribution of the control variables in different transition_period. **a** Continued_collaboration; **b** career_stage; and **c** discipline. *CH* Clinical, Pre-Clinical & Health, *ET* Engineering & Technology, *LS* Life Sciences, *PS* Physical Sciences, *SS* Social Sciences, *AH* Arts & Humanities

Table 3 Results of poisson regression models

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Continued_Collaboration	−0.259***	−0.330***	−0.324***	−0.324***	−0.321***	−0.318***
	(−10.12)	(−11.12)	(−10.95)	(−10.93)	(−10.82)	(−10.66)
Career_stage		−0.120***	−0.118***	−0.116***	−0.115***	−0.114***
		(−4.75)	(−4.67)	(−4.58)	(−4.52)	(−4.50)
Inherent_potential			−0.019***	−0.019***	−0.019***	−0.019***
			(−5.66)	(−5.59)	(−5.49)	(−5.44)
Linguistic_distance				−0.040	−0.003	0.012
				(−1.36)	(−0.08)	(0.33)
Geographic_distance					−0.000*	−0.000
					(−1.90)	(−1.33)
Lived_before						−0.021
						(−1.40)
Displine	Y	Y	Y	Y	Y	Y
Constant	1.268***	1.371***	1.421***	1.426***	1.429***	1.436***
	(43.99)	(38.16)	(38.52)	(38.49)	(38.55)	(38.44)
Observations	3,222	3,222	3,222	3,222	3,222	3,222

z-statistics in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$

Regression results

The results are shown in Table 3. We still use the model represented by Eq. (1). Different numbers in parentheses represent column indexes and variables are added one by one in different columns. The letter "Y" in the Discipline line represents that we fixed the effect of different disciplines. We put the dummy variables into the model separately rather than collectively to avoid potential multicollinearity issues. Scientists in the Arts & Humanities were excluded because the sample size was too small to reach statistical significance. On average, scientists' transition period was significantly shortened by 27.2% if they collaborated with previously coauthored scientists after a move, as shown in Model 6 in Table 3. Therefore,

Table 4 Grouped results of the poisson regression model

Variables	(1) Clinical, pre-clinical & health	(2) Engineering & technology	(3) Life sciences	(4) Physical sciences	(5) Social sciences	(6) Junior scientists	(7) Senior scientists
Continued_collaboration	−0.258***	−0.390***	−0.273***	−0.311***	−0.473***	−0.220***	−0.357***
	(−4.62)	(−6.56)	(−3.86)	(−4.87)	(−3.33)	(−3.59)	(−10.21)
Career_stage	−0.111**	−0.130**	−0.163***	−0.005	−0.146	–	–
	(−2.25)	(−2.52)	(−2.90)	(−0.08)	(−1.12)		
Inherent_potential	−0.006	−0.018***	−0.031***	−0.026***	−0.033	−0.027***	−0.008*
	(−0.93)	(−3.39)	(−3.50)	(−2.76)	(−0.82)	(−5.65)	(−1.77)
Linguistic_distance	0.001	−0.001	−0.000	0.000	0.000	0.000	−0.000
	(0.52)	(−0.84)	(−0.27)	(0.31)	(0.05)	(0.15)	(−0.53)
Geographic_distance	−0.000*	−0.000	0.000	−0.000*	−0.000	−0.000	−0.000**
	(−1.93)	(−0.33)	(0.38)	(−1.65)	(−0.69)	(−0.20)	(−2.34)
Lived_before	−0.012	−0.104*	0.014	0.061	0.118	−0.054	0.028
	(−0.18)	(−1.74)	(0.23)	(0.98)	(0.63)	(−1.31)	(0.59)
Discipline						Y	Y
Constant	1.339***	1.267***	1.208***	1.068***	1.315***	1.159***	1.255***
	(9.78)	(12.65)	(7.95)	(8.56)	(2.72)	(12.62)	(13.65)
Observations	747	929	671	751	124	2,001	1,239

z-statistics in parentheses

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

hypothesis H1 is supported. In addition, the inherent potential of scientists is also associated with their transition period. As the publication number increases by one publication, the transition period is reduced by 1.9%. Therefore, hypothesis H4 is supported. In Model 6, the coefficients of the variables related to the culture-related differences between the origin country and destination country are not significant. Therefore, H5 is not supported.

Table 4 shows the association between variables and the transition period in different *disciplines* and *career stages*. The coefficients of *continued collaboration* remain significant in all models. Specifically, for each discipline, the transition period decreased by 22.7%, 32.3%, 23.9%, 26.7%, and 37.7%, respectively. This finding indicates that the transition period of social scientists was shortened the most compared with that of natural scientists. Therefore, H3 is supported.

A comparison between junior scientists and senior scientists indicated that senior scientists are more reliant on collaboration with previously coauthored scientists. Continued collaboration can reduce the transition period for senior scientists by 28.4%, but only 19.7% for junior scientists. This finding verifies that senior scientists maintain long-term coauthorships (Pan & Saramäki, 2012; Petersen, 2015) and their strong social ties continue after a move. Junior scientists are beginners in their academic fields and are often "pursuers" in the collaboration relationship (Wang et al., 2017), and often conduct less important technical tasks (Larivière et al., 2016). Thus, their collaboration relationship is usually weaker ties (Bu et al., 2018a; Ke & Ahn, 2014). Therefore, they prefer to join new research groups after a move. Based on these findings, continued collaboration is more conducive to shortening senior scientists' transition period. Hence, H2 is supported.

Table 5 Results of poisson regression model for first/corresponding authors

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Continued_collaboration	−0.245***	−0.388***	−0.388***	−0.376***	−0.371***	−0.366***
	(−6.50)	(−8.28)	(−8.28)	(−8.02)	(−7.89)	(−7.76)
Career_stage		−0.204***	−0.204***	−0.199***	−0.196***	−0.193***
		(−5.24)	(−5.24)	(−5.11)	(−5.03)	(−4.96)
Inherent_potential				−0.022***	−0.022***	−0.021***
				(−4.97)	(−4.86)	(−4.82)
Linguistic_distance				0.027	0.076	0.089*
				(0.68)	(1.53)	(1.77)
Geographic_distance					−0.000*	−0.000
					(−1.67)	(−1.29)
Lived_before						−0.053
						(−1.62)
Discipline	Y	Y	Y	Y	Y	Y
Constant	1.144***	1.344***	1.344***	1.406***	1.409***	1.423***
	(25.57)	(22.90)	(22.90)	(23.32)	(23.36)	(23.37)
Observations	1,697	1,697	1,697	1,697	1,697	1,697

z-statistics in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$

Robustness check

We specifically focus on scientists who are the first authors or corresponding authors on papers, which narrowed our dataset to 6,029 works and 1,697 global mobility records of 1,571 scientists. The regression results of the sample are shown in Table 5, which are mostly consistent with the results in Table 3. Continued collaboration can significantly reduce the transition period by 30.7%. Senior scientists' transition period is 17.6% shorter compared with junior scientists. In addition, higher inherent potential before a move can also shorten the transition period. As the publication number increases by one publication, the transition period is reduced by 2.1%. This indicates that our results in Table 3 are robust.

Discussion

Continued collaboration refers to continuing the ideologically collaborative relationship with previous collaborators. It is not related to whether the collaboration occurred before or after moving. There are many scenarios for continued collaboration. Collaboration provides scientists with equipment and resources, prestige, visibility or recognition, research funding, problem-solving perspectives from their coauthors, and innovation and rigor in exchanging ideas (Bammer, 2008; Leahey, 2016). However, creating a new team and working together with other scientists in the new team toward a common goal requires considerable communication and trust (Bennett & Gadlin, 2012). For disciplines that require experimental equipment, there is also a certain lag period for establishing new laboratories and research lines (Jonkers & Tijssen, 2008). It is not hard to imagine that the collaboration cost of continuing to collaborate with previous collaborators will be lower in this case. Thus, continued collaboration significantly shortens the transition period of scientists after moving to a new institution.

In this study, the "transition period" is defined as the time span between the year of the move and the year when scientists published their first top-tier journal paper after moving. It reflects the degree to which global mobility affects scientists' research performance as measured by the number of CAS top-tier journal papers rather than psychological and emotional adaptation. However, psychological and emotional adaptation is associated with the research performance of scientists who move. For example, Morley et al. (2018) found that academics who move across national borders (migrants) may feel "otherness" as mobility can leave some scientists with a feeling of no fixed national identity. Early-career scientists may also face isolation overseas as constant moves can displace them from long-rooted networks and a sense of home and stability (Manzi et al., 2019). In this sense, global mobility highlights the emotional experiences of scientists in research collaborations. When a relationship is formed, people tend to be satisfied with and maintain the existing collaborative relationship, even if there are potentially better options (Stinchcombe, 2000).

Our research attempts to explore the influence of culture-related variables (Liu et al., 2018) on the transition period from three perspectives: linguistic distance, geographic distance, and scientists' familiarity with the destination countries/territories. Although our research does not prove that these culture-related differences extend the transition period through these variables, these factors are associated with the career of scientists after global mobility.

Language plays an essential role in scientific research. Verginer and Riccaboni (2020) show that countries with the same or similar language are more likely to be identified as the same mobility community. For example, the mobility between Brazil and Portugal is stronger, for they share the same official language. Furthermore, working in a lab without knowing the local language may be feasible, but the language challenges are more difficult in daily life (Schiermeier, 2011). Currently, English is recognized as the major language in the scientific community, and scientists in English-speaking countries or countries whose languages are similar to English have more advantages in scientific research. Scientists from non-English-speaking countries, especially junior scientists, are more likely to be affected in global mobility. The difference in language increases their difficulty in teaching and scientific research (Hsieh, 2012; Mcallum, 2017). Unfamiliar with English and lack of professional writing guidance make these scientists lack self-belief and are easily burned out and discouraged (Idrees et al., 2016). Besides, language differences can lead to lacking understanding of the cultural connotations and background (Jiang et al., 2010).

Scientists' familiarity with the countries they lived in before and their linkage with these countries make them more inclined to move back and benefit from the mobility (Baruffaldi & Landoni, 2012). Even if the mother language of scientists is English, they may still encounter language barriers after moving to other English-speaking countries which they have never been to before. This is because the same word may express different meanings or have different pronunciations in different cultures, which makes communication more difficult in some cases (Kreber & Hounsell, 2014).

Some scholars argued that geographic proximity among collaborators after a move affects collaboration (Ponds, 2007). For example, Katz (1994) found that scientific research collaboration decreases exponentially with greater distance between partners. However, others have questioned the role of geographic proximity in research collaboration (Malmberg & Maskell, 2002; Torre & Rallet, 2005) because the Internet and more affordable international transportation have allowed considerable connections to overcome geographic barriers for people (Finholt & Olson, 1997; Teasley & Wolinsky, 2001). In the world of Internet of everything (IoE), spatial distance is no longer a problem in collaboration. For instance, during the COVID-19 pandemic, universities blocked access to classrooms and laboratories, forcing faculty, staff, and students to stay home. Researchers from different universities spontaneously linked up on emerging digital platforms to tackle questions related to epidemiology, and they achieved high-quality results (Rempel, 2020). Video conferencing systems, teleconferencing platforms, and collaboration tools have facilitated work-from-home access on the computer so scientists can connect with colleagues locally and globally. Scientists can easily collaborate electronically to communicate analysis results or co-development of computational codes (Korbel & Stegle, 2020). This study indicates that the transition period is not associated with geographic differences between the origin country and destination country. The intra-regional mobility in Asia and Europe occupies a high proportion, which is consistent with the findings of Gomez et al. (2020). The number of mobility within Asia is 95, accounting for one-third of all mobility originating from Asia. For Europe, the number is 356, accounting for one-half. However, we did not find the association between mobility within transnational regions and continued collaboration. The average proportion of continued collaboration is 81.9% for all the sampled scientists in our study. The proportion for the intra-regional mobility in Asia is 83.2%, slightly higher than the average, and for the intra-regional mobility in Europe is only 76.7%, lower than the average.

Social ties are still present after a scientist moves to a new institution. Usually, the determination of social ties follows a standardized procedure asking individuals whom they consider a friend, whom they approach for professional help, or whom they communicate with regularly (Wuchty, 2009). Such social ties among scientists may be reflected in their scientific research co-authorship and are not limited by distance. In other words, there is a "peer effect" in scientific teams that extends beyond physical space to the level of thought (Wang & Barabási, 2021). For example, Azoulay et al. (2010) found that the output of coauthors dropped by 5 to 8 percent after academic "superstars" died prematurely and unexpectedly. Scientists are highly interdependent, and regardless of the distance of their coauthors, their achievements are widespread through a network of ideas and have long-term effects on scientists' careers (Wang & Barabási, 2021). Therefore, even after a move, the social ties of scientists with previous collaborators are still active and positively shorten the transition period.

Contrary to our findings, Jöns (2007) found that social scientists are rarely standardized, and their research process is very dependent on scientists' language skills, views and reading experiences, while natural scientists are more highly standardized and have intermediate products that can be easily exchanged. Therefore, social scientists are less likely to collaborate and continue this relationship compared with natural sciences. Jöns' research is based on scientists who moved during 1981–2000. But with the continuous development of the Internet, the collision of thoughts and ideas becomes easier to exchange than the intermediate research products after mobility, and social scientists often use this collaboration pattern. This pattern is more likely to be maintained and accumulated through network after global mobility, and is more stable than in natural sciences (Zhao et al., 2022). Therefore, we think that Jöns' view may no longer be applicable at present. The division of labor in scientific research increases with the number of researchers involved (Haeussler & Sauermann, 2015). Natural science research often needs more researchers, which is more standardized and the division of labor is clearer. In that case, many collaborators in natural sciences may just offer "direct" or "indirect" research support (Xu et al., 2022) in the scientific pipeline, which is replaceable and has little impact on the research output of scientists after global mobility. In summary, continued collaboration benefits social scientists more than natural scientists by shortening their transition periods after global mobility.

Another finding is that although continued collaboration shortens the transition period for junior scientists, continued collaboration after a move should not be encouraged. Research independence is a merit of scientists and should not be ignored by encouraging continued collaboration after a move. For example, after earning a PhD, scientists are supposed to conduct new research, independent of their supervisors, so new ties may be more effective. Our study revealed that the transition period for senior scientists is shortened to a

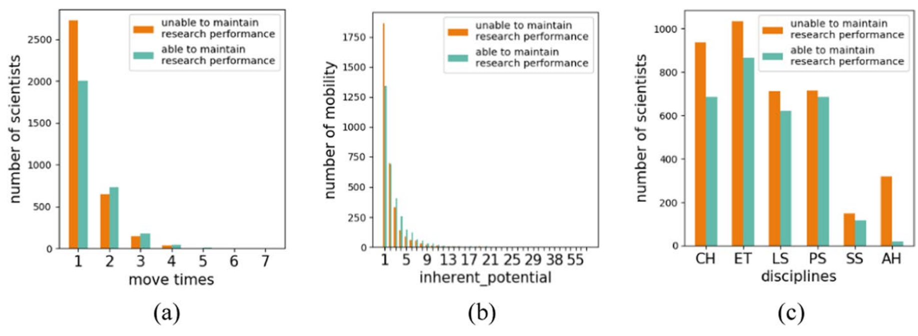

Fig. 2 Statistics on scientists'. **a** Number of move; **b** inherent_potential; **c** disciplines. *CH* Clinical, Pre-Clinical & Health, *ET* Engineering & Technology, *LS* Life Sciences, *PS* Physical Sciences, *SS* Social Sciences, *AH* Arts & Humanities

larger extent than that of junior scientists because senior scientists have stronger social ties. Thus, continued collaboration should be encouraged for senior scientists after a move.

Our study only considered scientists who moved and maintained research performance (published CAS top-tier journal articles), but many scientists who moved did not maintain their previous research performance. We compared the distribution of scientists who were able/unable to maintain their previous research performance after a move, as shown in Fig. 2. Figure 2a shows that most scientists move once or twice, and the average number of moves is 1.44 for scientists who maintained their previous research performance and 1.30 for those who did not. Figure 2b shows that scientists who maintained their previous research performance published more before the move. Figure 2c shows the disciplinary differences.

The first limitation of this study lies in the biases of the ORCID dataset. First, ORCID users skew young and certain countries are over- and under-represented (Bohannon & Doran, 2017). Second, ORCID registrants represent those who are more visible in international academia, more engaged in international communication, and more active in publishing (Zhao et al., 2020). Second, we measured scientists' transition period by the journals in which they published. However, in the humanities, it is more common to disseminate original research in books compared to in the natural sciences (Mryglod et al., 2013). As a result, our sample represents more scientists in the natural sciences, engineering sciences, and medicine than in the humanities and social sciences. Last, some crucial factors, such as funding and equipment, are not within the scope of our control variables.

Conclusion

We examined the relationship between continued collaboration and the transition period of a scientist after a move by collecting data on 2,922 scientists from ORCID and their publications in WoS and applying Poisson regression analysis. We found that continued collaboration significantly shortens the transition period by 27.2%. Compared with junior scientists, continued collaboration helped senior scientists by shortening the transition period to a larger extent. Furthermore, compared with natural scientists, continued collaboration shortened the transition period of social scientists to a larger extent. In addition, the transition period is shorter after moves for scientists with higher inherent potential. However, we did not find the association between the transition period and culture-related differences between the origin country and destination country.

Table 6 The top 10 countries/regions that scientists move in/out

No.		Abbreviation	Times		Abbreviation	Times
1	Origin countries/territories	US	901	Destination countries/territories	US	1,158
2		GB	422		GB	446
3		CN	250		CN	208
4		AU	215		AU	198
5		DE	143		DE	116
6		ES	118		CA	88
7		CA	103		JP	78
8		FR	99		DK	75
9		IT	89		ES	70
10		JP	80		SE	57

Table 7 The top 10 mobility types in domestic/international mobility

No.		Type	Times		Type	Times
1	Domestic mobility	US-US	707	International mobility	CN-US	75
2		GB-GB	257		GB-US	59
3		CN-CN	149		CA-US	41
4		AU-AU	128		DE-US	31
5		ES-ES	44		US-GB	30
6		JP-JP	42		AU-US	29
7		BR-BR	37		US-CN	29
8		DE-DE	35		FR-GB	22
9		CA-CA	35		DE-GB	20
10		IT-IT	32		ES-GB	20

Table 8 Country names and their abbreviation mentioned in the paper

Abbreviation	Country name
AU	Australia
BR	Brazil
CA	Canada
CN	China
DE	Germany
ES	Spain
FR	France
GB	United Kingdom
IT	Italy
JP	Japan
US	America

This study provides implications for research collaboration policy. Senior scientists should be encouraged to continue collaboration with previous collaborators to maintain their research performance, whereas continued collaboration for junior scientists should be encouraged with caution, so they can establish research independence.

Appendix

See Table 6, 7, 8.

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Declarations

Conflict of interest The corresponding author (Jiang Li) is member of the Distinguished Reviewers Board of Scientometrics.

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