

The Influence of Homophily-Heterophily Grounded Research Collaboration on Performance

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Abstract This study aims to go beyond simply showing the increasing trend of collaboration in academia to explore what factors influence research collaboration. Assuming an affinity between the degree of homogeneity in researcher attributes and the tendency to collaborate, we examine how the degree of homogeneity in majors and shared research interests among researchers, the degree of ease of communication based on belonging to the same institution, and the social ties between collaborators based on alum relationships affect research outcomes. Using a cohort of social scientists conducting funded research, we analyze the density and strength of inter-researcher homogeneity based on their attributes and demonstrate that there is a correlation between the reputation of the journal in which a paper is published and the degree of inter-researcher homogeneity. If you want to make an impact on a journal at the ‘local’ level, it is more effective to collaborate with researchers from the same discipline. Conversely, to make a notable impact at the ‘cosmopolitan’ level, it is more efficient to work with heterogeneous researchers. We propose that a moderate level of cohesion or homogeneity among researchers,

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that is, somewhere in the middle of the homogeneity-heterogeneity continuum rather than at either end, is the optimal condition for research performance.

Keywords homophily · research collaboration · research performance · cosmopolitan and local journals · density · strength · research support policy

Introduction

In recent years, collaboration has emerged as a key term to understand and analyze complex modern society. The importance of collaboration is being emphasized in all sectors of society, and collaboration is constantly on the rise. The process by which functionally differentiated members of society achieve common outcomes through collaboration has been one of the main concerns of sociology since its inception. For example, French sociologist Emile Durkheim (1984 [1893]) presented collaboration as a key concept in modern society more than a century ago in *The Division of Labor*. According to Durkheim, social solidarity transforms from a mechanical solidarity based on homogeneity among members of society to an organic solidarity for survival among relatively heterogeneous beings as social division of labor and interdependence increase. This tendency to divide labor and cooperate is becoming more pronounced in all spheres of society, and it is no exaggeration to say that it has become a prevalent pattern.

Academia is no exception. Collaboration generally refers to individuals working together to achieve the same goal. Research collaboration, or collaborative research, refers to joint research conducted by two or more researchers to achieve the same goal of creating new scientific knowledge (Katz & Martin, 1997). It includes co-authorship, team or group research projects involving two or more researchers as co-authors, and co-citation, where authors cite each other's work. In recent years, there has been a noticeable increase in research collaboration in the natural sciences, engineering, and social sciences (Price, 1986; Wuchty et al., 2007). In particular, co-authorship is on the rise in the major fields of the social sciences, including business administration, economics, political science, and sociology (Moody, 2004). Today, research collaboration has both academic and social significance, as it goes beyond simply linking individual researchers and is recognized as an important mechanism for generating new innovative knowledge and reaching scientific consensus (Kanter, 1994; Katz & Martin, 1997; Laband & Tollison, 2000; Loan-Clark & Preston, 2002; Moody, 2004).

This study aims to explore the conditions for successful research collaboration by analyzing the relationship between researcher characteristics, research collaboration, and research outcomes. Previous studies on collaboration have focused on showing an upward trend in research collaboration or identifying the prevalence of interdisciplinary research collaboration in certain fields. What distinguishes our study from previous research is that it attempts to delve deeper into the specific characteristics of researchers who engage in research collaborations and how they facilitate collaboration. In particular, this study focuses on social scientists conducting collaborative research on funded grants in Korea and examines how homogeneity among researchers is associated with research performance. To do so, we focus on the degree of inter-researcher homogeneity and the degree of research collaboration, centered on three factors as

key functions of inter-researcher homogeneity: The degree of shared research interests, based on the degree of congruence between researchers' majors; the degree to which collaborators are affiliated with the same research institution and the resulting ease of face-to-face interaction; and alumni solidarity, intimacy, or intellectual ties, which are differentially shaped by the degree of homogeneity of the institution where the bachelor's or doctoral degree was received.

Related Literature

Background for the Expansion of Research Collaboration

Recent technological advances and macro societal changes, such as the advent of a converged society, have led to a significant increase in research collaboration. Academia is also becoming more collaborative as research becomes more complex and large-scale. In general, we can point out the following reasons for the increase in research collaboration.

First, the cost of basic research in the research environment has increased dramatically. It is not practical for a funding agency or project sponsor to provide all the research facilities, equipment, or resources that a researcher or research team might want. Therefore, it is more common than in the past for researchers to team up to conduct collaborative research in order to secure the resources needed for large-scale studies on a local, national, or global scale.

Second, the need for collaboration has increased significantly in some regions of research that require complex tools and resources, such as "big science" (Price 1986). In these fields, it has become virtually impossible for researchers to perform all specialized tasks alone, making interdisciplinary collaboration even more necessary.

Third, interdisciplinary or multidisciplinary research is growing in importance. Most scientific advances today are often the result of the integration of previously separate disciplines. Since an individual researcher cannot possess all the skills required for interdisciplinary research, recruiting and organically collaborating with relevant scholars related to the research goal is often seen as a shortcut to successful research (de Vaan, Stark, and Vedres 2015).

Fourth, the development of transportation and information and communication facilities has greatly reduced the cost of travel and communication. Reduced communication costs and improved accessibility have created conditions for better research collaboration among scholars across geographical barriers.

Co-authorship as a Specific Practice of Research Collaboration

Collaborative activity has often been an issue on what basis to measure research. In this regard, co-authorship has been widely used in academia as a basic unit for empirically capturing collaborative research activity among scholars. Collaboration or co-authorship is a form of writing in which two or more authors are responsible for creating or revising a particular work. In general, collaborative writing refers to activities in which two or more people conduct joint research on a particular topic and publish the results as an article in a journal (Laband & Tollison, 2000; Sonnenwald, 2007). Smith (1958) first proposed co-authored papers to measure

research collaboration. He conducted a study of journals in psychology over ten years from the mid-1940s to the mid-1950s and empirically verified an increase in the average number of authors per article. Price (1986) used co-authored papers to measure changes in collaboration in the natural sciences. In particular, he analyzed co-authored papers published in chemistry abstracts in the early to mid-20th century to validate Smith's claim that co-authorship was on the rise and even predicted the disappearance of single-authored papers by the 1980s based on the growing trend of collaborative research (Price 1986, 77-79).

On the other hand, some researchers have pointed out the problems that arise when co-authored papers are viewed as a form of research collaboration. For example, Hagstrom (1965) pointed out the negative aspects of co-authored papers, poignantly criticizing the tacit practice widespread in academia of granting "honorary co-author" titles to those who did not contribute or participate substantially in the writing of the paper. Despite these criticisms, it is hard to deny that using co-authorship to assess research collaboration has its utility: analyzing research collaboration based on co-authorship has the advantage of quantifying data, which allows for empirical validation.

Who Participates in Coauthorship?: The Homophily Model vs. Heterophily Model

One of the questions about the rise of co-authorship is: Who are the actors involved in co-authored papers, and what are their characteristics? More specifically, do researchers primarily involved in co-authorship activities tend to have similar characteristics, or conversely, do they tend to have heterogeneous characteristics? We will use the concepts of 'homophily' and 'heterophily' concerning this issue. In co-authorship, homophily refers to when two or more individuals share the same perception of a problem, research interests, and intellectual background. Heterophily, on the other hand, is when two or more individuals involved in co-authorship have different academic goals, specialties, or affiliations (Ibarra, 1992; Lazarsfeld and Merton, 1982 [1954]; McPherson et al., 2001).

In general, the homophily model assumes that people who share certain characteristics, such as sex, race, education level, and geography, tend to interact with each other and that individuals with closer social distance are more likely to engage in co-authorship (Kretschmer, 1997). In other words, co-authorship does not occur naturally or by chance but results from the mutual homogeneity between researchers, and the common attributes they share bring a kind of chemical bond to the collaboration (Kanter, 1994). Critical attributes of co-authors that are often discussed to create this bond include awareness of the same research question, personal compatibility (working style, writing style, priorities, etc.), relationships (especially contemporaries or alumni), same-sex, same affiliation, and geographic proximity (Hara et al., 2003).

To explain the homophily model, Granovetter's (1973) well-known concept of 'tie strength' is worth mentioning. Strong ties refer to networks of individuals who are in frequent contact. Members with strong ties tend to have dense interactions in the network, making it more cohesive and more effective in exchanging complex information. According to Powell and Grodal (2005), radical innovation or highly creative research is more likely to be based on strong ties. Researchers with strong ties build relatively stable networks directly and indirectly through their partners. However, a weakness of strong ties is that researchers with strong ties often become trapped in their inner circle and tend to be insensitive to external demands or changes.

In addition to the homophily model, Granovetter's concept of tie strength can be used effectively to explain the heterophily model. Granovetter's "The Strength of Weak Ties" has an elective affinity with the heterophily model. According to Granovetter, people with close ties are likelier to share similar information. In contrast, weak ties to out-group members may be more useful when a wide range of information is needed, such as in a job search. Taking a structural approach to Granovetter's argument, Burt (1992) uses the concept of "structural holes" in his analysis of internal promotions to explain the benefits of weak ties from a relational perspective. Indeed, weak ties can be an effective channel for acquiring new ideas or information. However, weak ties can also lead to difficulties adopting technologies or ideas developed in different contexts or cultures (Hansen, 1999; Uzzi, 1997). Therefore, ongoing communication is necessary to maximize the effectiveness of collaborative research in weak ties. Such communication enables researchers to understand the technical knowledge of the other party and the organizational, cultural, and institutional characteristics, leading to improved research performance.

According to the heterophily model, co-authorship tends to be practiced by individuals who are socially distant from each other. Rogers (2003) states that heterophily is a necessary condition for the mutual benefit of collaborative research through knowledge sharing, especially complementary knowledge. In other words, heterogeneity in fields of expertise or research is favorable for co-authorship. Co-authors from different disciplines can gain recognition for their expertise from researchers in other fields through co-authorship. Differences between theory and application, or "interdisciplinary differences in academic positions" (Hara et al., 2003, p. 962), also foster collaboration. Several studies (de Vaan, Stark, and Vedres, 2015; Uzzi & Spiro, 2005) show that cognitively heterogeneous people have produced creative results through collaboration.

Conceptual Framework and Analysis

Density and Strength

In this study, we propose the concepts of 'density' and 'strength' to measure the level of homophily between co-authors. First, 'density' refers to the degree to which researchers are homogeneous for each variable when there are two (or three) authors. Density is measured by whether the researchers who collaborated on a particular paper share the same major (homogeneity of major), are affiliated with the same research institution (homogeneity of affiliation), or earned their bachelor's or doctoral degrees from the same university (homogeneity of degree-granting institution). For example, if both authors have the same major, they are considered homogeneous regarding research interests in a paper with two authors. We can measure homogeneity between co-authors for their current affiliations and degree-granting institutions similarly. In the case of the three authors, we consider them to have a high degree of homophily in research interests if they all have the same major. If two of the three authors have the same major, we consider them to have a medium degree of homophily. On the other hand, if all three authors have different majors, we consider them heterogeneous in their research interests. The classification of homophily-heterophily using the density concept can also be applied to co-authors' current

affiliations and degree-granting institutions.

In this study, we also use the concept of “strength” of homophily. Simply put, we want to operationalize the strength of homophily as the degree to which the “densities” of the homophily measures of each of the aforementioned individual variables overlap. For example, in a two-author paper, if both authors have the same major, current affiliation, bachelor’s degree, and doctoral degree, the strength of homophily between the two researchers can be considered very high. For a three-author paper, the strength of homophily can be considered very high if the authors have the same major, current affiliation, bachelor’s degree, and doctoral degree. By categorizing the homophily between authors of co-authored papers into the dimensions of ‘density’ and ‘intensity’, we aimed to empirically verify which homogeneous aspects of researchers promote research collaboration, which in turn leads to the research outcome of publication.

Hypotheses

The main interest of this study is how the homophily model affects co-authorship activity. To this end, we hypothesized that “researchers with homogeneous backgrounds will be more active in co-authorship than those without.” More specifically, we assumed that researchers who received their degrees from the same institution, are affiliated with the same organization, and specialize in the same discipline would be more cohesive than those who do not. We also assumed that the former would form stronger bonds based on more frequent contact and common interests than the latter, facilitating research collaboration. Homophily among researchers is expected to facilitate collaboration by making it much easier to build trust, accountability, and solidarity among researchers in the early stages. In this study, we refined these assumptions into four sub-hypotheses.

Hypothesis 1: Researchers with shared research interests and homogeneous academic backgrounds are likelier to co-author academic papers than researchers with heterogeneous research interests and different academic backgrounds.

Researchers in the same or similar areas of specialization are likelier to share basic “cognitive perspectives” (Bauman and May, 2001) in selecting and approaching research topics and themes than researchers with different specializations. Thus, they are more likely to collaborate.

Hypothesis 2: Co-authorship is more likely to occur between researchers from the same institution than between researchers from different institutions.

When researchers are affiliated with the same institution, conditions are more favorable for various forms of interaction than when they are not. Frequent interactions promote mutual trust and solidarity among researchers. Researchers are more likely to collaborate under conditions that allow for intimate interactions.¹

¹ When measuring homogeneity among researchers based on current institutional affiliation, it is important to consider the size of the group. Researchers at smaller institutions may be in a more favorable position when it comes to developing mutual affinities. On the other hand, it is also possible that researchers in

Hypothesis 3: Publishing research results in the form of co-authorship in journals is more likely to occur among researchers who earned their degrees at the same institution than among researchers who earned their degrees at different institutions of higher education.

Researchers who earned their degrees (bachelor's, doctoral) at the same higher education institution may find it easier to collaborate than researchers who earned their degrees at different institutions because of their alumni bonds and shared academic style. In other words, highly cohesive groups may be more likely to collaborate among their members because they have the advantage of solid internal cohesion and good communication between members (Uzzi, 1997). On the other hand, an overly internally cohesive group may be exclusive toward those outside the group and pay relatively little attention to forming and maintaining weak ties that help them gain new information and knowledge, thereby weakening their ability to be flexible and proactive in responding to environmental changes.

Hypothesis 4: Research conducted by researchers with heterogeneous academic backgrounds is more likely to be published in cosmopolitan than local journals compared to research conducted by researchers with homogeneous academic backgrounds.

According to Merton (1968), influential people in a society or community are categorized into "local influentials" and "cosmopolitan influentials" based on the scope of influence they aspire to. The local influentials focus on being influential in their community, prioritizing the issues of their community. The global influentials, on the other hand, are more likely to be interested in issues beyond their community and seek to intervene actively. In this study, we adopt Merton's concepts of "local," "cosmopolitan," and "influence" and use the terms "local" for journals published domestically and "cosmopolitan" for international journals published by researchers around the world. Specifically, in this study, we categorized journals that publish articles representing collaborative research outcomes into local and cosmopolitan journals according to the journal's scope, level of influence, and degree of academic authority. In this regard, we note the possibility that research collaborations among researchers with heterogeneous backgrounds, i.e., researchers with different academic orientations and heterogeneous institutions where they received their degrees, may facilitate research activities that cross-disciplinary and regional boundaries, resulting in more global-level journal submissions and publications compared to research conducted among researchers with homogeneous academic backgrounds.

Data Description and Method

This study analyzes the forms and patterns of research collaboration, especially co-authorship, based on the research outputs of researchers funded by the Social Sciences Korea (SSK), a research support program in the social sciences of the National Research Foundation of Korea

these smaller groups may have a more difficult time finding collaborative partners with shared research interests within their own group. In this case, researchers may be more active in their efforts to find collaborative partners outside of their own group.

(NRF), which is essentially comparable to the National Science Foundation (NSF) in the United States. The NRF has been operating the Social Sciences Korea (SSK) research support program, a large-scale, performance-based financial support program, since 2010 to advance the social sciences in Korea. Through its support for Korean social scientists, the SSK hopes to foster many research groups that produce excellent research results in the social sciences (Chong & Kim, 2018).

We analyze the research output of researchers participating in the SSK over four years from 2013 to 2016.² We chose to analyze the data for this study from 2013 to 2016 because many environmental conditions surrounding researchers participating in the SSK program were relatively the same. Since its inception in 2010, the SSK program has recruited many new study groups for four consecutive years (number of new study groups recruited: 92 cohorts in 2010, 71 cohorts in 2011, 43 cohorts in 2012, and 23 cohorts in 2013). However, no new study groups were selected in the following three years. At the same time, from 2013 to 2016, there was a sequential yearly phase evaluation of research groups selected for the SSK program. In the context of the history of the SSK, which has been running since 2010 and will continue until 2023, the period from 2013 to 2016 was a time when the research groups were under the most identical research conditions - e.g., the size of the grant, the number of researchers in each group, and the stage at which the research was being conducted. Data collection revealed that 2,555 researchers produced 2,804 research outputs during this period. The study analyzed 2,370 articles published in national and international journals, excluding monographs, translations, and edited works.

We first coded information about the author's name, number of authors, journal name, and the author's major ('major' variable), institutional affiliation ('affiliation' variable), bachelor's ('bachelor's degree-granting institution' variable), and doctorate ('doctorate-granting institution' variable) for individual papers. We then examined the extent to which researchers who were authors of two- or three-author papers were similar based on achievement attributes. The degree to which authors share achievement attributes at the dyad level is called the "density of homophily" variable. In this study, we examined three types of homophily between researchers: first, we looked at the degree to which co-authors share research interests through academic homogeneity. Second, we looked at the degree to which co-authors are affiliated with the same institution to measure the ease of face-to-face interaction. Third, we examine alumni solidarity, affinity, and intellectual ties through the homogeneity of the higher education institutions where the co-authors earned bachelor's or doctoral degrees.

² We collected data from annual reports and phase reports submitted to the NRF by research groups participating in the SSK program. This report presents a list of research outputs produced by each research group. We first aggregated the research results to build a data set, and then verified the accuracy of the research results using an internet search function. At the same time, we obtained and verified information about the authors of the papers through the Internet in addition to the information presented in the papers. After the data cleaning process, which excluded cases with incomplete or missing information, we conducted the analysis on the remaining data. When collecting data for our study, we categorized the ratings of the journals in which the articles were published into four main categories. For overseas journals, we checked the grade of journals based on the distinction between SSCI- and Scopus-level journals and coded the data. For domestic journals, we used the classification of listed journals and candidate journals provided by the National Research Foundation of Korea to check the grade of journals and code the data.

Here, we use chi-square tests to examine how the density of homogeneity among researchers correlates with the type of journal in which the article was published, i.e., cosmopolitan (international) versus local (national). Next, for each of the two-author and three-author papers, we examine the degree of overlap between four key attributes of the researchers (major, institutional affiliation, bachelor's degree-granting institution, and doctoral degree-granting institution) and their correlation with the type of journal (cosmopolitan versus local) to see what patterns emerge. We refer to the degree of overlap between these four attributes as the "strength of homophily" variable.

Results

Single Authorship and Co-authorship

This study analyzed the research output of funded researchers over four years, from 2013 to 2016, the beginning of the SSK project. Based on the reputation and scope of the journals in which a total of 2,370 papers were published during this period, 669 papers were published in international journals, accounting for 28.2% of the total research output, while 1,701 papers were published in domestic journals, accounting for 71.8%. In quantitative terms, it can be seen that domestic journals produced more outputs by a ratio of about 3:7. At the same time, the fact that Korean researchers in the social sciences publish about 30% of their work in international journals shows that they are actively striving to be recognized on the international academic stage.

Table 1 Single authorship and coauthorship among analyzed papers

# of Authors per Paper	# of Papers	Cosmopolitan Journals	Local Journals
1	25.7% (608)	19.3% (129)	28.2% (479)
2	36.2% (858)	33.8% (226)	37.2% (632)
3	22.2% (525)	23.2% (155)	21.8% (370)
4	8.2% (195)	10.3% (69)	7.4% (126)
5+	7.8% (184)	13.5% (90)	5.5% (94)
Total # of Papers	2370	669	1701

Looking at the number of authors per paper, 608 papers were single-authored, accounting for 25.7% of all papers (see Table 1). In other words, one out of every four papers analyzed in this study was single-authored. At the same time, the remaining three were co-authored by two or more authors, with co-authorship being most prevalent among research papers based on two to three co-authors. Of the co-authored papers, 858 were written by two authors, accounting for 36.2% of the total, followed by 525 (22.2%) by three authors, 195 (8.2%) by four authors, and 184 (7.8%) by five or more authors. Several recent studies have shown that increased co-authored papers as a visible form of research collaboration is a universal trend that transcends disciplinary differences (Wuchty et al., 2007). Given the fact that researchers in the social sciences primarily drive SSK projects, the nearly 75% share of papers with two or more co-authors can be seen as evidence that SSK project researchers are much more inclined to research

collaboration than the typical social scientist.³

It is also interesting to note that there is a difference in the number of research collaborations between authors of published articles based on the type of journal: cosmopolitan versus local. In terms of frequency, the most frequent author types for articles published in local journals are two co-authors, one sole author, and three co-authors. In comparison, the most frequent author types for articles published in cosmopolitan journals are two co-authors, three co-authors, and one sole author. This suggests that cosmopolitan journals are more likely to produce research outputs based on co-authorship than local journals.

The State of Single Authorship/Co-authorship according to Specialty of Researchers

Meanwhile, we examined which majors tend to be more active in research collaboration. Focusing on the majors of the first authors of individual papers, we found that political science majors had the highest percentage of sole-authored papers, followed by sociology, law, economics, and public administration, as shown in Table 2. It's worth noting that while law ranked third in sole-authored papers, it didn't make the cut for two- and three-authored papers. This shows that due to the nature of the major, law majors are mostly conducting research in the form of sole authorship.

Table 2 Ranking of specialty and percentage based on 1st authors of individual papers

Ranking	Single-authored		Two-authored		Three-authored	
	Specialty	Percentage	Specialty	Percentage	Specialty	Percentage
1	Political science	34.5%	Economics	16.4%	Business administration	16.6%
2	Sociology	16.9%	Political science	14.2%	Economics	16.0%
3	Law	15.3%	Public administration	12.8%	School education	13.0%
4	Economics	7.9%	Sociology	10.5%	Public administration	12.8%
5	Public administration	5.8%	Business administration	9.3%	Social welfare	7.0%
6	Education	3.8%	Social welfare	6.6%	Sociology	6.1%
7	Communication	2.6%	Education	5.5%	Political science	5.3%
8	Business administration	2.6%	Psychology	4.3%	Education	4.0%
9	Philosophy	2.0%	Communication	2.7%	Communication	3.2%
10	Library and information science	1.5%	Living	2.0%	Psychology	2.9%

Note: For two- and three-author papers, we also considered the specialties of the second and third authors, but we focused our analysis on the first author's major, given that the first author's specialty tends to drive the topic and content of the paper.

³ For reference, here's one example of the extent to which co-authorship is alive and well in the Korean social science community. A study (Han and Kim 2017) analyzing the proportion of co-authorship among articles published in the Korean Journal of Sociology, the official journal of the Korean Sociological Association, found that an average of 30-40% of articles published from 2010 to 2014 were co-authored. In contrast, about 75% of articles published with SSK project support were co-authored. This difference is understood to be due to the nature of the SSK project, which emphasizes research collaboration among researchers.

There were differences in research collaboration trends across majors. Economics ranked first in two-authored papers and second in three-authored papers. Political science ranked first in single-authored papers, second in two-authored papers, and seventh in three-authored papers. Business administration ranks eighth in single-authored papers, fifth in two-authored papers, and rises to first in three-authored papers. As you can see, economics and business administration have the most robust research performance in papers with two or more authors. Meanwhile, the role of sociology and public administration is also interesting: researchers in these fields have seen their rankings fluctuate slightly depending on the number of co-authors, but they continue to have a strong presence in both solo and co-authored papers. The variation in participation by specialty, whether solo or co-authored and by the number of co-authors suggests that the nature of the discipline has some influence on the extent and manner of research collaboration.

Density of Homophily in Research Collaboration

We now examined the correlation between research performance and homophily, focusing on two- and three-author papers. First, we looked at two-author papers and found that 226 of the 858 papers were published in cosmopolitan journals and 632 in local journals. For each of these papers, we analyzed the relationship between the two authors by examining their majors, affiliations, and degree-granting institutions (Ph.D., B.A.). The results showed that the highest proportion of research collaboration was between researchers specializing in the same field: 612 (71.3%) of the 858 papers were co-authored by researchers majoring in the same field. It was followed by 387 (45.1%) papers co-authored by researchers with the same affiliation. On the other hand, the percentage of papers co-authored by researchers who received their PhD from the same university was the lowest. Overall, two-authored papers had the highest homogeneity of majors among researchers, followed by affiliation, bachelor's, and Ph.D.s.

Table 3 Homogeneity among co-authors in two-authored papers

Homogeneity Factor among Co-authors	Homogeneity (Homophily) Level among Co-authors	Total no. of Published Papers (858)	Total no. of Papers Published in Cosmopolitan Journals (226)	Total no. of Papers Published in Local Journals (632)
Affiliation	Homogeneous	45.1 (387)*	29.6 (67)	50.6 (320)
	Heterogeneous	54.9 (471)	70.4 (159)	49.4 (312)
		$X^2 = 29.6126$	$p\text{-value} < .00001$	
Institution that granted PhD	Homogeneous	7.2 (62)	11.9 (27)	5.5 (35)
	Heterogeneous	92.8 (796)	88.1 (199)	94.5 (597)
		$X^2 = 10.1995$	$p\text{-value} = .001405$	
Institution that granted BA	Homogeneous	17.1 (147)	24.3 (55)	14.6 (92)
	Heterogeneous	82.9 (711)	75.7 (171)	85.4 (540)
		$X^2 = 11.2136$	$p\text{-value} = .000812$	
Specialty	Homogeneous	71.3 (612)	66.8 (151)	72.9 (461)
	Heterogeneous	28.7 (246)	33.2 (75)	27.1 (171)
		$X^2 = 3.0577$	$p\text{-value} = .080358$	

* The numbers in front are percentage, and the numbers inside brackets are the number of papers

Then, we verified through a chi-square test what correlation homophily and density among researchers have with the type of journals where the papers were published (that is, cosmopolitan or local journals). For two-authored papers, the chi-square statistic is 3.057, and its p-value is .080358. The result is insignificant at $p < .05$. In other words, there was no significant relationship between the two variables of homogeneity of specialty and publication in cosmopolitan/local journals for two-authored papers. Whether research collaboration is done among those with the same or different specialties has no significant correlation with publishing papers in local or cosmopolitan journals. On the other hand, for homogeneity of affiliation, the university where they earned a Ph.D. and BA significantly correlated with publishing papers in local or cosmopolitan journals.

Table 4 Homogeneity among co-authors in three-authored papers

Homogeneity Factor among Co-authors	Homogeneity (Homophily) Level among Co-authors	Total no. of Published Papers (525)	Total no. of Papers Published in Cosmopolitan Journals (155)	Total no. of Papers Published in Local Journals (370)
Affiliation	3 authors homogeneous	22.9 (120)	8.4 (13)	28.9 (107)
	2 authors homogeneous	35.2 (185)	37.4 (58)	34.3 (127)
	Heterogeneous	41.9 (220)	54.2 (84)	36.8 (136)
		X² = 28.3696	p-value < 0.00001	
Institution that granted PhD	3 authors homogeneous	1.3 (7)	2.6 (4)	0.8 (3)
	2 authors homogeneous	32.2 (169)	27.1 (42)	34.3 (127)
	Heterogeneous	66.5 (349)	70.3 (109)	64.9 (240)
		X² = 4.8284	p-value = .089438	
Institution that granted BA	3 authors homogeneous	3.2 (17)	4.5 (7)	2.7 (10)
	2 authors homogeneous	49.1 (258)	42.6 (66)	51.9 (192)
	Heterogeneous	47.6 (250)	52.9 (82)	45.4 (168)
		X² = 4.3262	p-value = .114967	
Specialty	3 authors homogeneous	55.6 (292)	45.8 (71)	59.7 (221)
	2 authors homogeneous	37.3 (196)	43.2 (67)	34.9 (129)
	Heterogeneous	7.0 (37)	11.0 (17)	5.4 (20)
		X² = 10.6485	p-value = .004872	

For three-authored papers, as with two-authored papers, homogeneity of majors was the most significant of the four variables expected to reveal homogeneity among coauthors: 292 papers (55.6%) had three authors with the same major, and 196 papers (37.3%) had two of the three authors with the same major. There were only 37 papers where all three authors had different majors. Homogeneity of institutional affiliation was next, followed by a bachelor's degree. The homogeneity of the institution where the three coauthors earned their Ph.D. was the least common.

We then used chi-square tests to examine whether each of the four variables was associated with journal type. The results showed that specialty and affiliation were statistically significant. For specialty, the chi-square statistic is 10.6485, with a p-value of .004872. The result is significant at $p < .05$. Also, for affiliation, the chi-square statistic is 28.3696, with a p-value of less than 0.00001. The result is significant at $p < .05$, i.e., homogeneity of major and affiliation among coauthor researchers is significantly correlated with publication of their research results

in local or cosmopolitan journals.

On the other hand, the homogeneity of the institution where the researchers earned their Ph.D. or bachelor's degree is not statistically significant with publication in local or cosmopolitan journals. For institutions where the researcher earned a doctoral degree with a three-author paper, the chi-square statistic is 4.8284. The p-value is .089438. This result is not significant at $p < .05$. Also, for institutions where the researcher earned a bachelor's degree with a three-author paper, the chi-square statistic is 4.3262. The p-value is .114967. The result is not significant at $p < .05$.

In sum, homogeneity of affiliation and Ph.D./BA for two-authored papers influenced the type of journal in which they were published. In contrast, only homogeneity of affiliation and specialty for three-authored papers influenced publishing in a cosmopolitan or local journal. One interesting thing is that, regardless of the number of coauthors, the papers were more likely to be published in cosmopolitan journals if the researchers had different affiliations. In contrast, they were more likely to be published in local journals if the researchers had the same affiliation. Physical proximity due to the same research institution facilitates communication among researchers and increases the strength of collaboration. However, as communication among researchers has become smooth today beyond the constraints of time, space, and borders, the benefit of joint research due to the same affiliation has weakened. In contrast, the benefit of collaboration beyond borders, specialties, and regions increased, which may have led to this result.

Regarding specialty homogeneity, we found no correlation between specialty homogeneity and journal type in two-authored articles, but the opposite was true for three-authored articles. Of particular interest is that the homogeneity of specialty among the three coauthors in three-author articles was higher in articles published in local journals than in cosmopolitan journals. In contrast, articles coauthored by researchers with different specialties tended to be published in more prestigious international journals. This suggests that interdisciplinary work is more likely to receive global attention than work specializing in a single discipline. One of the most notable phenomena is that most collaborations, whether two- or three-authored, were most prominent when the discipline was moderately interdisciplinary rather than fully interdisciplinary or entirely homogeneous.

The Strength of Homophily in Research Collaboration

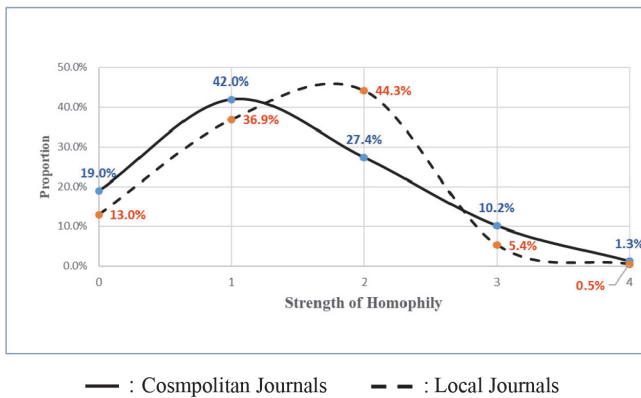
So far, we have examined correlations between researchers' shared characteristics in co-authored research collaborations, including correlations between researchers' majors, affiliations, and degree-granting institutions, and correlations between researchers' shared characteristics and the types of journals in which their papers were published. This section examines the extent to which the homogeneity of four attributes - researchers' majors, affiliations, and degree-granting institutions (bachelor's, doctoral) - exhibit multilayered coupling. We refer to the degree of multilayered coupling as the "strength" of homophily in research collaboration.

Four is the highest homogeneity strength for a two-author paper that can be expected when both authors have the same major, affiliation, and institution where they earned their doctoral and bachelor's degrees. On the other hand, if these four characteristics are completely heterogeneous between the two researchers, the combined strength is zero. When we examined 858 two-author

papers, we found that 342 (39.8%) had a combined strength of 2, followed by 328 (38.2%) with a combined strength of 1. In other words, 78% of the two-author papers had a combined strength between 1 and 2. In contrast, there were 125 (14.6%) papers with a bond strength of 0, which is a perfectly heterogeneous bond where the two researchers share no characteristics. There were only 6 (0.7%) papers with a strength of 4, the highest level of homogeneity. There were also relatively few papers with a strength of 3 (57, 6.6%).

Table 5 Homogeneity of specialty, affiliation, BA, PhD among co-authors in two-authored papers

Homogeneity of relations [strength]	Total	Cosmopolitan Journals	Local Journals
4	0.7 (6)	1.3 (3)	0.5 (3)
3	6.6 (57)	10.2 (23)	5.4 (34)
2	39.8 (342)	27.4 (62)	44.3 (280)
1	38.2 (328)	42.0 (95)	36.9 (233)
0	14.6 (125)	19.0 (43)	13.0 (82)
	100 (858)	100 (226)	100 (632)

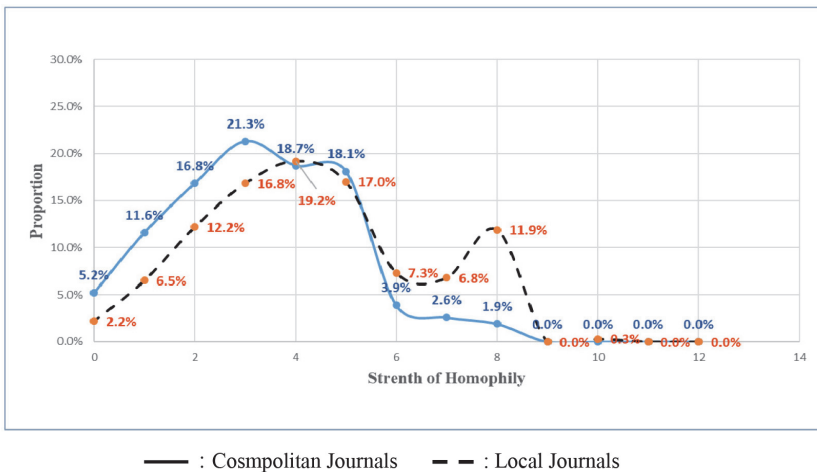


Meanwhile, as a result of examining the correlation between the type of journals where the co-authored papers are published and the strength of homogeneity, 95 out of 226 papers published in cosmopolitan journals had the strength of 1 (42.0%), taking up the greatest portion, followed by 62 papers with the strength of 2 (27.4%). On the other hand, 280 out of 632 papers published in local journals had a strength of 2 (44.3%), taking up the most significant portion, followed by 233 papers with a strength of 1 (36.9%). In sum, the strength of homogeneity among co-authors of papers published in cosmopolitan journals is lower than that of papers published in local journals.

Then, we also examined the multi-layer combination, or strength, of homogeneity in specialty, affiliation, and institution where the researchers earned their Ph.D. and BA for three-authored papers. Here, the strength of homophily is 12 when three co-authors share all four characteristics. In contrast, it is 0, or perfect heterophily, when three co-authors do not share any of the four characteristics.

Table 6 Homogeneity of specialty, affiliation, BA, PhD among co-authors in three-authored papers

Homogeneity of relations [strength]	Total	Cosmopolitan Journals	Local Journals
12	0	0	0
11	0	0	0
10	(0.2)1	0	0.3 (1)
9	0	0	0
8	9.0 (47)	1.9 (3)	11.9 (44)
7	5.5 (29)	2.6 (4)	6.8 (25)
6	6.3 (33)	3.9 (6)	7.3 (27)
5	17.3 (91)	18.1 (28)	17.0 (63)
4	19.0 (100)	18.7 (29)	19.2 (71)
3	18.1 (95)	21.3 (33)	16.8 (62)
2	13.5 (71)	16.8 (26)	12.2 (45)
1	8.0 (42)	11.6 (18)	6.5 (24)
0	3.0 (16)	5.2 (8)	2.2 (8)
Total	100 (525)	100 (155)	100 (370)



Specifically, 67.9% of the total 525 3-author papers were distributed in the strength category of 2~5 multi-layer combinations of homophily (the strength of homophily: $4 > 3 > 5 > 2$). Of these, the highest multi-layer combination (the strength of homophily) was 4, accounting for 19% (100 papers) of the 3-author papers, followed by strength three at 18.1% (95 papers), strength five at 17.3% (91 papers), and strength two at 13.5% (71 papers).

It is worth noting that each multi-layer combination of homogeneity was at most 9 in practice. While intensities as high as 12 are theoretically possible, in practice, they stop around 8 (9%, 47 papers), with a small number of papers showing intensities of 1 (8%, 42 papers) and 0 (3%, 16 papers). In other words, our study confirms that three-author papers are more likely to be based on the extent to which the researchers involved in a research collaboration share a moderate intensity of homogeneity rather than on either extreme of the homogeneity-heterogeneity continuum.

The comparison between cosmopolitan and local journals was similar to the results for two-author articles. The ranking of the strength of homophily for articles published in cosmopolitan journals was $3 > 4 > 5 > 2$, while the ranking of the strength of homophily for articles published in local journals was $4 > 5 > 3 > 2$. It means that 21.3% of the 3-author articles published in cosmopolitan journals had homogeneity strength 3, followed by homogeneity strength 4 (18.7%) and 5 (18.1%). In contrast, articles published in local journals had the largest proportion of homogeneity 4 (19.2%), followed by homogeneity 5 (17%), and homogeneity 4 (16.8%). In the end, we found that articles published in cosmopolitan journals had a lower degree of the strength of homophily among researchers than articles published in local journals.

To summarize the discussion so far, we can see that in order to increase impact and research output in journals at the local level, it is more effective to conduct collaborative research among researchers who share the same academic, professional, and regional background while it is more effective to conduct research among researchers with less homogeneous or heterogeneous attributes in order to generate research output that is of interest at the global level. At the same time, however, there is a point that should not be overlooked. These results suggest that the degree of homogeneity among researchers is not linearly related to research output but rather a non-linear relationship, specifically an inverted U-shape. Our findings are reminiscent of the paradox of over-embeddedness proposed by Uzzi (1997), albeit in a different analytic and research context. Uzzi (1997, 58) argues that ‘over-embeddedness’ is detrimental to the inflow of new information into a network because ‘redundant ties’ to the same network pattern leave no room for internal members to connect with external members who may provide insiders with innovative ideas or new information. In other words, having an appropriate level of cohesion or homogeneity among researchers is a condition for producing research that peers recognize more.

Conclusion

Research collaboration is expanding in all directions, regardless of discipline or specialty, because the gains for researchers from joint research projects and co-authorship can outweigh the losses (Katz & Martin, 1997; Loan-Clark & Preston, 2002). For example, as academic research becomes more complex, researchers are expected to have more research skills, such as theoretical knowledge and research methodologies, than ever before. When two or more researchers collaborate, they are more likely to complement each other, making research more efficient. There is also knowledge in academia that exists in the form of tacit knowledge, and research collaboration can be an effective means of sharing and transferring tacit knowledge among researchers. Researchers also have the opportunity to be more innovative and generate new perspectives and ideas by exchanging and coordinating new insights and perspectives, often through high-density interactions with other researchers, that are difficult to capture on an individual level.

As research collaboration increases, so does the number of studies exploring its trends, modalities, types, and academic implications. While most of these studies have focused on showing the time-series growth of research collaboration or its spread to various fields, this study differs from previous studies by focusing on what attributes of researchers mediate research

collaboration and how similarity or homogeneity among researchers is related to research outcomes. In other words, as we witnessed the reality that research collaboration is no longer a fad but a trend, we wanted to go beyond identifying the increasing trend of research collaboration and look deeply into the dynamics and behind-the-scenes of the collaboration process.

We could verify a few interesting facts about research collaboration in this study. First, researchers participating in mid/long-term collective research support projects such as Social Sciences Korea (SSK) produced more active co-authorship research outputs than researchers in general social sciences. This result is primarily due to the characteristics of the SSK project, which recommended researchers that share the same research interest beyond the differences in discipline, university, and region to come together voluntarily, and this led to the increase in collaborative research activities and performance among participating researchers.

Second, there was a variation in the degree of research collaboration depending on the researcher's specialty. Recently, the increase in co-authorship is generally witnessed in most fields of study, but the degree of following this trend varied depending on the character of the specialty. There are fields in which generating research output based on single authorship is the leading pattern, such as law. In contrast, there are fields in which the co-authorship of two or more researchers is more general, like economics or business administration. There are also fields in which single authorship and co-authorship were balanced, such as sociology, public administration, and political science. In other words, the diffusion of research collaboration is shown in some fields at different speeds and ranges but varies depending on the characteristics of the field.

Third, due to analyzing the correlation between homophily and the type of journals where the papers were published, joint research outcomes of researchers sharing heterogeneous attributes were more likely to be published in journals with relatively higher prestige. As a result of examining the degree of multi-layer combination among researchers' achieved attributes, researchers of two to three-authored papers published in cosmopolitan journals showed lower strength of homophily than those of papers published in local journals.

Moreover, regardless of the number of coauthors, collaborative research was most active mid-embedded rather than at the extreme ends of the homophily-heterophily continuum. It leads to the conclusion that the correlation between the strength of homophily among researchers and research performance has an inverted U-shape, which is a nonlinear relationship, rather than a linear relationship. In other words, an adequate level of cohesion or homophily among researchers is the optimum condition for the publication of collaborative research outcomes regardless of the type of journal.

One caveat to our study is that it is based on funded researchers. Studying how our findings generalize to scholars conducting research under non-funded research conditions is important. Another caveat is that our study did not explore how much a researcher's status or position at their institution might be associated with a cosmopolitan or local orientation concerning selecting partners for research collaboration. Considering the degree of homophily of researchers' positions in research collaborations and the corresponding differences in journal prestige could contribute to refining and enriching the implications of the ways and values of research collaboration in academia.

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