An Analysis of the Connection between Researchers' Productivity and their Co-authors' Past Attributions, including the Importance in Collaboration Networks[1]

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Abstract
Many studies have analyzed the "synchronic" correlation of properties, i.e., the correlation of properties in the same period, between authors and their co-authors. However, the "diachronic" correlation of properties, i.e., the correlation between their subsequent and precedent activity, has not yet been sufficiently studied using quantitative methods. This study pays attention to not only productivity but also the importance in the collaboration network as a measure of the researcher's activity, and clarifies whether there is any connection between (i) the researcher's activity subsequent to a collaboration and (ii) the collaborator's precedent activity, aiming at deriving knowledge about the diachronic effect of collaborators. The targets analyzed in this study are the newcomers who had first appeared in the domain of computer science in 1998 and their co-authors. The results show very little correlation between the subsequent activity of newcomers and the preceding activity of their co-authors. However, there are significant differences in the co-author's precedent activity between the newcomers who have published no papers after their first publication (those who have not become visible researchers) and the newcomers who have published at least one paper after then (those who continue to produce papers).

Keywords
co-authorship network; research collaboration; research productivity; educational effect

Introduction

There have been a large number of studies that analyze the correlation of properties between authors and their co-authors, some focusing on the productivity of papers and others on affiliation, age, and sex, etc (e.g., Kretschmer, 1994; 1997; Kretschmer & Gupta, 1998; Kundra & Kretschmer, 1999; Bahr & Zemon, 2000). These studies mainly examined the synchronic correlation between these properties (both are of the same period). However, the diachronic correlation of properties, that is, the correlation between their subsequent and precedent activity, has not yet been sufficiently studied using quantitative methods. This study pays attention to not only productivity but also the importance in the collaboration (co-authorship) network as a measure of the researcher's activity, and clarifies whether there is any connection between the researcher's activity subsequent to a collaboration and the collaborator's (co-author's) precedent activity, aiming at deriving knowledge about the diachronic effect of collaborators.

In recent years, certain factors, such as the specialization of researchers and the growth of interdisciplinary fields, have caused researchers to collaborate (Cason, 1992; Andersson & Persson, 1993; Bird, 1997; Bordons & Gómez, 2000). Networking and communication through collaborating and publishing co-authored papers seem to have had very large effects on the research activity under

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such situations. In particular, for new researchers who have not yet established their research styles and methods due to their having just emerged into their academic field, collaborators (co-authors) are considered to have significant effects on their future careers as researchers. From the viewpoint of productivity, for instance, Bindon (1981), Long & McGinnis (1985), and Fonseca, Velloso, Wofchuk & Meis (1998) have described the influence of supervisors or mentors on their students. Long & McGinnis (1985) noted that the performance of mentors collaborating with their students increases the students' later publications and citations. Bindon (1981), on the other hand, noted that academic association with the staff of an industrial research institute during graduate research has a positive impact on student careers in industry.

For example, it serves following purposes to clarify the correlation between the researcher's activity "subsequent" to a collaboration and the collaborator's "precedent" activity; (1) to give information used in choosing one's collaborators, and (2) to predict the effect of education in training students as researchers (in domains where graduate students generally publish co-authored papers with their supervisors in the process of education). We examine the co-author's activity from the viewpoint of not only productivity but also the importance in the co-authorship network.

This paper is organized as follows. First we describe the target domain and the source data, and then, after explaining our methodology, we show and discuss the results of our experiments examining the diachronic correlation of properties between authors and their co-authors.

Data

We selected computer science as the target domain. Because, in this domain, research collaboration is very active, one should take into account collaboration networks in the analysis of researchers' performance. As we mentioned above, the effect of collaborators is considered to be presented especially to researchers in the early stages of their careers. So, we targeted those who had published a paper for the first time in a core journal of this domain as the first author, that is, newcomers who had just entered this domain as full-fledged researchers, and examined the correlation between the activity of the newcomers subsequent to their emergence and the activity of their collaborators precedent to the emergence of the collaborating newcomers.

In many cases of co-authorship, at least in computer science, the last author (the author whose name is listed last in co-authorship credits) plays the role of supervisor or mentor considered to have a large impact on the collaborators. For instance, Liang et al. (2001) and Liang, Liu & Rousseau (2004) reported typical name order patterns found in co-authored papers in which the student's (or younger researcher's) name preceded that of the supervisor (or elder researcher). Yoshikane, Nozawa & Tsuji (2006) also observed that the last author often has a special function in the collaboration network of computer science. Thus, this study focused on the last author as the most important collaborator.

The data used for measuring the productivity of the researcher and for observing the co-authorship network were extracted from the *SCI* (*Science Citation Index*) CD/DVD-ROM version, provided by Thomson Scientific. The *SCI* evaluates the quality of journals with qualitative criteria based on peer review and citation analysis (Testa, 2004) and selects only the core journals that satisfy the criteria. We regarded the journals selected by the *SCI* and classified in the category of "computer science, theory & methods" in the list of source publications arranged by subject category, which is given on the Thomson Scientific web site: http://www.thomsonscientific.com/cgi-bin/jrnlst/jlsubcatg.cgi?PC=K, as the core journals in the domain of computer science.[2] This category includes 37 journals (e.g., *Journal of Algorithms*).

The researchers to be analyzed are the newcomers who appeared in the domain of computer science (i.e., published their first papers in this domain) in 1998, and the last authors listed on those

[2]. The area of application is also active in computer science. However, as the core of computer science is considered to be the theoretical area, we chose the category of "theory & methods."

newcomers' first papers. This study defines a newcomer in 1998 as one who published a paper (the "document type" of which is "article" in the *SCI*) as the first author in one of the core journals in 1998 and had not published a paper in the same domain for the preceding 7 years from 1991 to 1997. Moreover, we selected the newcomers who published only one paper (co-authored paper) in 1998 in order to obtain homogenous samples. In order to observe those newcomers' activity subsequent to 1998 and their co-authors' activity precedent to 1998, we extracted the bibliographic data of all of the papers published in the 37 journals between 1991 and 2005 (i.e., the 7 years preceding and 7 years subsequent to 1998) from the database.

It is necessary to identify authors' names, that is, to distinguish the same name for physically different persons and to integrate different names for the same person, when collecting data from bibliographic databases. For identifying authors' names, there are methods such as using information which serves to distinguish authors (e.g., affiliation) and integrating a pair of names which differ only in the existence of a middle name(s) (e.g., Hayashi & Tomizawa, 2006). However, in the *SCI*, authors do not necessarily correspond one-to-one with affiliations in credits. Besides, in some cases an author has two (or more) affiliations, and in others there is no description about affiliations. Unfortunately, descriptions in the *SCI* are not always sufficient to strictly identify authors. As for the most productive authors, we carefully checked the authors' affiliations, recognizing the above limitations. Furthermore, we integrated pairs of names which are distinguished only by the existence of a middle name(s) or by differences in the use of upper and lower case letters.[3]

Table 1. Basic quantities of the data.

NP	*TA*	*DA*	A_{av}	P_{av}	DA_{new}
29820	69240	34374	2.32	2.01	641

Table 1 shows the basic quantities of the data: the number of papers, *NP*; the total number of author tokens, *TA*; the number of different authors, *DA*; the average number of authors per paper, A_{av} (= *TA*/*NP*); the average number of papers per author, P_{av} (= *TA*/*DA*); and the number of newcomers in 1998, DA_{new}. The number of newcomers fulfilling the above conditions is 641.

Methodology

Indices

The number of papers published for 7 years subsequent to 1998 (from 1999 to 2005) is used as an indicator to observe the productivity of newcomers subsequent to their emergence into the domain. For counting the number of papers of newcomers, we adopt the complete count, the adjusted count, and the straight count. *CMP* (the complete count), *ADJ* (the adjusted count), and *FST* (the straight count) represent the number of papers *of newcomers* measured by each method, respectively. *ADJ*, which is normalized by the number of co-authors, is referred to examine the productivity considering the proportion of contribution in research collaboration, while *FST*, which is defined as the number of papers published as the first author, is referred to examine the productivity as the leader of research.[4]

[3]. We processed 2,179 variants of names. Although it is possible that authors with a middle name and without it are different persons, we assume that the same first and family names, without regard to presence of a middle name(s), represent the same person in almost all cases. If more than one author with a different middle name(s) (e.g., W. B. Mao and W. H. Mao) matched an author without a middle name (W. Mao), we regarded each of them (W. B. Mao, W. H. Mao, and W. Mao) as different persons.

[4]. This is based on the assumption that the first author designs the whole research as the leader and plays the special role, which is different from other co-authors' roles. We can consider this assumption to be valid, at least to some extent, because there are guidelines endorsing it in computer science (Zobel, 1999).

On the other hand, as for the past activity of the newcomers' collaborators (the last authors in the newcomers' first papers), this study measures both the productivity and the importance in the co-authorship network for 7 years preceding to 1998 (from 1991 to 1997). For counting the number of papers of the collaborators, we adopt the complete count, the adjusted count, the straight count, and furthermore the last author count which we define as the number of papers published as the last author. *SCMP* (the complete count), *SADJ* (the adjusted count), *SFST* (the straight count), and *SLST* (the last author count) represent the number of papers *of the collaborators* measured by each method, respectively. *SLST* is referred to examine the productivity as the supervisor or coordinator.

The global structure of the network as well as direct relations between authors should be considered when observing the importance in the co-authorship network because information, knowledge, or connections spread beyond direct ties. We assume the following network model, for setting the indices to measure the importance of the newcomers' collaborators.

- Assuming directed graphs where the ties are oriented from co-authors to the first author for each paper.
- Assuming weighted graphs where the strength of co-authorship relations is taken into account.

As indices of direct relations, we use indegree SD_{in} and outdegree SD_{out} in this model, that is, the number of researchers who have published co-authored papers in which the target researcher is the first author and the number of researchers who have published co-authored papers as the first author with the target researcher.

As for indices of the importance in the global structure including indirect ties, we use SC_l and SC_f by which the importance as the leader and that as the co-operator (supporter) are measured, respectively. Yoshikane, Nozawa & Tsuji (2006) proposed SC_l and SC_f, modifying the HITS (Hyperlink-Induced Topic Search) algorithm (Kleinberg, 1998). The two indices are obtained by applying the following substitutions (followed by normalization).

$$SC_l(n_i) = \sum_{j=1}^{g} a_{ij} SC_f(n_j) \qquad (1)$$

$$SC_f(n_i) = \sum_{j=1}^{g} a_{ji} SC_l(n_j) \qquad (2)$$

where g represents the number of nodes in the network, that is, the number of researchers in the domain. a_{ij} represents the value in cell (i, j) of the adjacency matrix A of the co-authorship network, and is equal to the relationship strength of the tie oriented from n_j to n_i, that is, the number of co-authored papers where n_i is the first author and n_j is his co-author. The value of diagonal cells a_{ii} is 0.

Here, we assume the mutual dependency that "a researcher who assists important leaders plays an important role as the co-operator, and a researcher who organizes important co-operators plays an important role as the leader". In the formulas (1) and (2), by repeating recursive substitution, the global structure of the co-authorship network is reflected in the importance of each researcher.

This study refined the calculation of $SC_l(n_i)$ and $SC_f(n_i)$ by normalizing a_{ij} (the relationship strength) according to the number of authors of each co-authored paper, considering that the relationship among authors of a paper become less intimate as the number of co-authors increases. After assigning 1 to $SC_l(n_i)$ and $SC_f(n_i)$ as the initial value, we calculate $SC_l(n_i)$ and $SC_f(n_i)$ by recursively repeating substitution and normalization of vectors. (Substitution and normalization are repeated 10 times.)

Among the four indices considering the co-authorship network, SD_{in} and SC_l correspond to the importance as the leader (the first author), while SD_{out} and SC_f correspond to that as the co-operator

(other co-authors). Also, SD_{in} and SD_{out} take into account only direct relations, while and SC_l and SC_f take into account the global structure of the network.

Analysis of Correlation
We examine the correlation between (i) the productivity of newcomers subsequent to their emergence into the domain and (ii) the activity of their co-authors precedent to it, with following two viewpoints.

1. Is there a positive correlation between the productivity of newcomers and the past activity of their co-authors?
2. Is there any difference in the co-author's past activity between the newcomers who have published no papers after their first publication (those who have not become visible researchers) and the newcomers who have published at least one paper after then (those who continue to produce papers)?

It is meaningful to examine with respect to not only the first viewpoint but also the second one when this analysis is applied, for example, to the prediction of educational effects. Even if a researcher has published only a few papers, he might be good in research quality. Therefore, in some cases, one makes much of the ability to continue to produce papers as a researcher regardless of the quantity of papers.

Regarding the first viewpoint, we calculate the correlation coefficients between the family of indices to evaluate the productivity of newcomers subsequent to their emergence into the domain {*CMP*, *ADJ*, *FST*} and that to evaluate the activity of their co-authors precedent to it {*SCMP*, *SADJ*, *SFST*, *SLST*, SD_{in}, SD_{out}, SC_l, SC_f}. As these indices are expected to follow not the normal distribution but the power law distribution,[5] we adopt the Spearman's rank-order correlation coefficient.

Regarding the second viewpoint, we compare the newcomers whose value of *CMP* equals 0 (*CMP* = 0) and those whose value of *CMP* is greater than 0 (*CMP* > 0), with regard to the mean value for each of indices to evaluate the activity of their co-authors {*SCMP*, *SADJ*, *SFST*, *SLST*, SD_{in}, SD_{out}, SC_l, SC_f}, and test the significance of the difference between the two groups by the Wilcoxon rank sum test.

Results and Discussion

Correlation for All
The results of calculating the correlation coefficients between the productivity of the 641 newcomers subsequent to their emergence into the domain {*CMP*, *ADJ*, *FST*} and the activity of their co-authors precedent to it {*SCMP*, *SADJ*, *SFST*, *SLST*, SD_{in}, SD_{out}, SC_l, SC_f} are shown in Table 2. All of the values of the correlation coefficients are between 0.02 and 0.09, that is to say, very little positive correlation is observed for all the combinations of the former and latter families of indices.

The number of papers as the first author for newcomers (*FST*) has "relatively" high correlation with the same type of index for their co-authors (*SFST*). The newcomer's productivity as the leader might be slightly affected by the same ability of his co-author. As for the number of papers, including all papers published as a co-author, of newcomers (*CMP* and *ADJ*), it is the importance as the co-operator (supporter) in the global structure of the collaboration network (SC_f) that has the highest correlation among the indices to evaluate the past activity of their co-authors.

[5]. This is expected from Lotka's law (Lotka, 1926), for example.

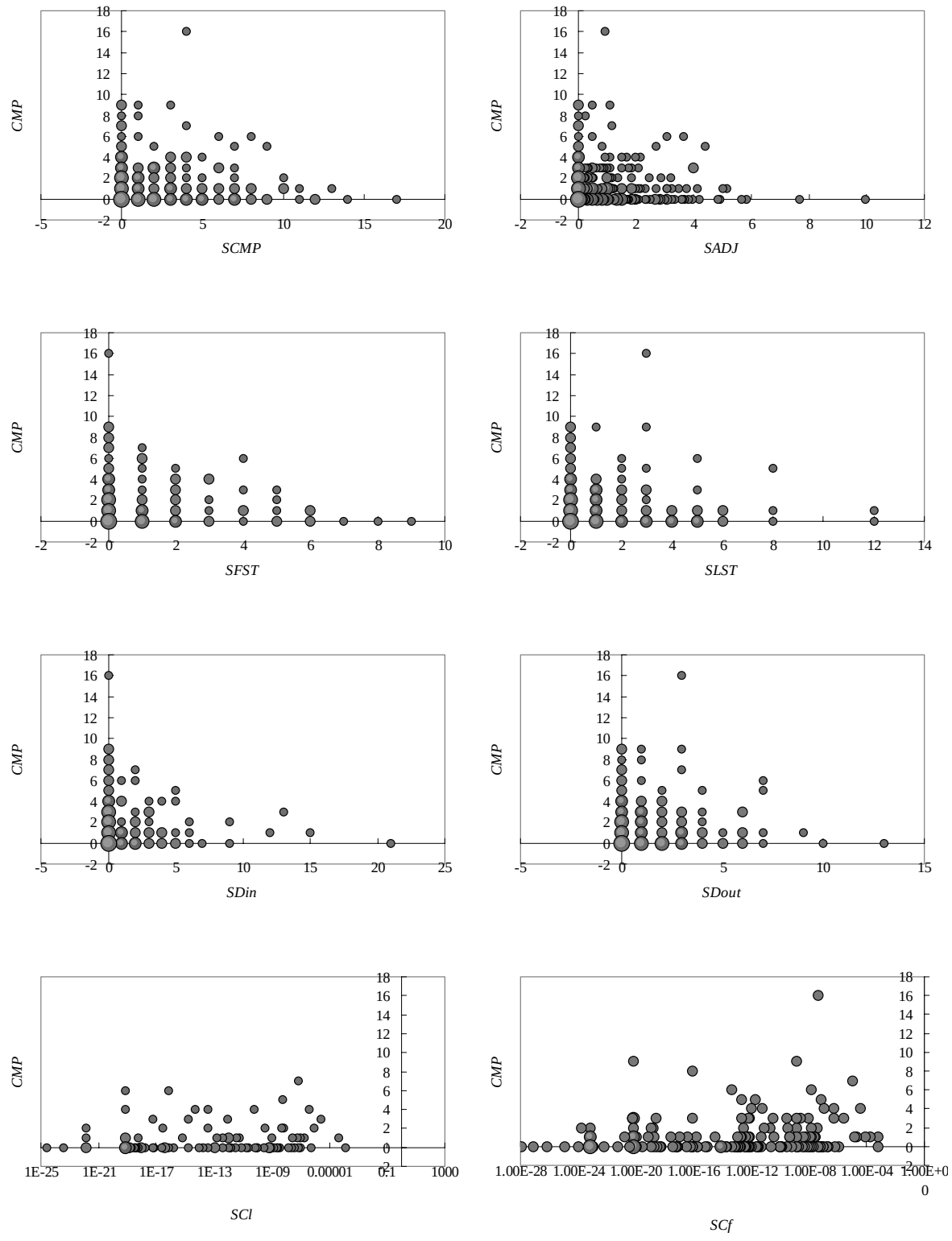

Figure 1: Bubble charts of the number of papers of newcomers against the indices for their co-authors.

However, the values of the correlation coefficients between them are not "absolutely" high.[6] Also, no distinct correlation is found in the scatter chart for each combination of the indices. The scatter charts (the bubble charts where the size of the bubbles expresses the frequency) of the number of papers of newcomers (the complete count), i.e., *CMP*, against the eight indices for their co-authors, i.e., *SCMP*, *SADJ*, *SFST*, *SLST*, SD_{in}, SD_{out}, SC_l, and SC_f, are shown as examples in Figure 1.

Table 2. Correlation between the subsequent productivity of newcomers and the precedent activity of their co-authors.

	CMP	*ADJ*	*FST*
SCMP	0.085	0.083	0.079
SADJ	0.083	0.082	0.079
SFST	0.046	0.049	0.084
SLST	0.046	0.041	0.020
SD_{in}	0.020	0.020	0.050
SD_{out}	0.072	0.067	0.050
SC_l	0.021	0.020	0.051
SC_f	0.090	0.084	0.073

As regards other domains, for instance, Long & McGinnis (1985) reported a positive correlation between the productivity, i.e., the number of papers, of mentors and that of their collaborating students in biochemistry, while some studies reported that the productivity of mentors is not directly related to their teaching effectiveness (e.g., Rushton, Murray & Paunonen, 1983). The results of this study show that, in computer science, neither the researchers' productivity nor their importance in the collaboration network is necessarily related with the subsequent productivity of their collaborators. Computer science is a relatively new domain. It may be assumed that the effect of collaborators on newcomers is weaker in this domain than in more traditional domains, such as biochemistry.

Differences between the Two Groups

Among the 641 newcomers, 232 newcomers have produced at least one paper subsequent to their emergence into the domain (*CMP* > 0) while the remaining 409 have produced no papers subsequent to then (*CMP* = 0). Table 3 shows the correlation coefficients between the subsequent productivity of the 232 newcomers (*CMP* > 0) and the precedent activity of their co-authors. The correlation coefficients, with the exception of that between *FST* and SC_l, become lower if excluding the 409 newcomers who have produced no papers after their first publication (*CMP* = 0) in the calculation (compare Table 3 with Table 2). It can be supposed that the past activity of co-authors is related to whether newcomers do/can not produce a paper after their first publication, rather than to how many papers they produce.

[6]. The "synchronic" correlation after the emergence of newcomers, that is, the correlation between the newcomers' productivity from 1999 to 2005 and the co-authors' activity during the same period, is somewhat high (around 0.3). It seems to be due to the fact that some of newcomers have been continuing to collaborate and to publish co-authored papers with the same co-authors after then.

Table 3. Correlation between the subsequent productivity of newcomers (*CPM* > 0) and the precedent activity of their co-authors.

	CMP	*ADJ*	*FST*
SCMP	0.020	0.007	0.051
SADJ	0.005	0.002	0.046
SFST	0.011	0.031	0.106
SLST	0.040	0.008	-0.016
SD_{in}	0.016	0.015	0.094
SD_{out}	0.047	0.011	0.023
SC_l	0.015	0.013	0.094
SC_f	0.077	0.034	0.061

Next, we compared the two groups of newcomers, i.e., the 409 newcomers who did not continue to produce a paper subsequent to their emergence into the domain (*CMP* = 0), and the 232 newcomers who did produce at least one additional paper subsequent to that point in time (*CMP* > 0), in terms of their co-authors' past activity. The means of the indices for each group are shown in Table 4. The co-authors of the latter group show higher values for all indices except for SC_l. The value of the latter group is about 2.8 times as high as that of the former group for SC_f, and about 1.3 times for the other indices. In particular, for *SCMP* and *SADJ*, which represent the productivity where roles in co-authored papers (the first author, the last author, or other co-authors) are not taken into account, and for SC_f, which represents the importance as co-operators in the global structure of the networks, the co-authors of the latter group show significantly higher values than those of the former group ($p < .05$).

There are three indices which represent the level of activity and importance as the co-operator, that is, *SLST*, SC_{in}, and SC_f. Among them, only SC_f shows a significant difference between the two groups of newcomers. SC_f is the index that also reflects the importance of researchers assisted by the target researcher, and it represents "the achievements of the target researcher in assisting researchers who are actively performing research as the leader". It is implied that such achievements (or experiences) of researchers affects the productivity of their collaborating newcomers.

Table 4. Comparison of the two groups of newcomers in terms of their co-authors' past activity.

	CMP > 0	*CMP* = 0
SCMP	*1.51	*1.17
SADJ	*0.63	*0.52
SFST	0.49	0.38
SLST	0.70	0.59
SD_{in}	0.59	0.42
SD_{out}	0.88	0.65
SC_l ($\times 10^7$)	2.04	3.50
SC_f ($\times 10^6$)	*3.99	*1.43

*significant ($p < .05$)

Conclusions

This study analyzed the correlation between the productivity of newcomers subsequent to their emergence into a new domain and the precedent activity of their co-authors with the aim to derive knowledge about the effect of collaborators on their collaborating partners. Very little correlation was

observed between the number of papers of newcomers and the past activity of their co-authors. On the other hand, whether the newcomers continued or ceased producing papers was related to the past activity of their co-authors. It is possible that, newcomers are helped to successfully start their careers as researchers by having the opportunity of touching the information, knowledge, and connections which their collaborators possess, though whether the newcomers can perform actively is mainly determined by other factors, such as their own effort and motivation (Frieze, Knoble & Mitroff, 1980), rather than the effect of their collaborators.

Some of the newcomers in this study may have been researchers who had temporarily moved from a related domain to the computer science domain searching for an opportunity for publication, and therefore they may not have intended to continue producing papers in the same domain. If we had excluded them from our data, then we could have possibly observed more clearly the characteristics of the newcomers who really intended to go on to careers in the computer science domain.

We focused on the productivity of papers in this study. The correlation from other viewpoints, such as the topics dealt with in papers, should be also examined in further studies in order to clarify the effect of collaborators in further detail.

References

Andersson, A. E. & Persson, O. (1993). Networking scientists. *Annals of Regional Science*, 27(1), 11-21.

Bahr, A. H. & Zemon, M. (2000). Collaborative authorship in the journal literature: Perspectives for academic librarians who wish to publish. *College & Research Libraries*, 61(5), 410-419.

Bindon, G. (1981). Output measures of cooperative research: The case of the Pulp and Paper Research Institute of Canada. *Scientometrics*, 3(2), 85-106.

Bird, J. E. (1997). Authorship patterns in marine mammal science, 1985-1993. *Scientometrics*, 39(1), 99-105.

Bordons, M. & Gómez, I. (2000). Collaboration networks in science. In B. Cronin & H. B. Atkins (Eds.), *Web of Knowledge: A Festschrift in Honor of Eugene Garfield* (pp. 197-213). Medford: Information Today.

Cason, J. A. (1992). Authorship trends in poultry science, 1981 through 1990. *Poultry Science*, 71(8), 1283-1291.

Fonseca, L., Velloso, S., Wofchuk, S. & de Meis, L. (1998). The relationship between advisors and students. *Scientometrics*, 41(3), 299-312.

Frieze, I. H., Knoble, J. M. & Mitroff, I. I. (1981). American university students' beliefs about success in science: A case study. *Scientometrics*, 3(2), 115-126.

Hayashi, T. & Tomizawa, H. (2006). Restructuring the Japanese national research system and its effect on performance. *Scientometrics*, 68(2), 241-264.

Kleinberg, J. M. (1998). Authoritative sources in a hyperlinked environment. In *Proceedings of 9th Annual ACM-SIAM Symposium on Discrete Algorithms* (pp. 668-677). New York: Association for Computing Machinery.

Kretschmer, H. (1994). Coauthorship networks of invisible-colleges and institutionalized communities. *Scientometrics*, 30(1), 363-369.

Kretschmer, H. (1997). Patterns of behaviour in coauthorship networks of invisible colleges. *Scientometrics*, 40(3), 579-591.

Kretschmer, H. & Gupta. B. M. (1998). Collaboration patterns in theoretical population genetics. *Scientometrics*, 43(3), 455-462.

Kundra, R. & Kretschmer, H. (1999). A new model of scientific collaboration Part 2: Collaboration patterns in Indian medicine. *Scientometrics*, 46(3), 519-528.

Liang, L., Kretschmer, H., Guo, Y. & Beaver, D. (2001). Age Structures of scientific collaboration in Chinese computer science. *Scientometrics*, 52(3), 471-486.

Liang, L., Liu, J. & Rousseau, R. (2004). Name order patterns of graduate candidates and supervisors in Chinese publications: A case study of three major Chinese universities. *Scientometrics*, 61(1), 3-18.

Long, J. S. & McGinnis, R. (1985). The effects of the mentor on the academic career. *Scientometrics*, 7(3), 255-280.

Lotka, A. J. (1926). The frequency distribution of scientific productivity. *Journal of the Washington Academy of Sciences*, 16(12), 317-323.

Rushton, J. P., Murray, H. G. & Paunonen, S. V. (1983). Personality, research creativity, and teaching effectiveness in university professors. *Scientometrics*, 5(2), 93-116.

Testa, J. (2004). The Thomson Scientific journal selection process. Retrieved November 16, 2006 from: http://scientific.thomson.com/free/essays/selectionofmaterial/journalselection/.

Yoshikane, F., Nozawa, T. & Tsuji, K. (2006). Comparative analysis of co-authorship networks considering authors' roles in collaboration: Differences between the theoretical and application areas. *Scientometrics*, 68(3), 643-655.

Zobel, J. (1999). Guideline on Research Practice in Computer Science. Retrieved November 20, 2006 from: http://goanna.cs.rmit.edu.au/~jz/conduct.html.