Citation Patterns in Interdisciplinary Research Areas

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Introduction

Today, "interdisciplinary" researches are actively conducted in various domains. Researches related to multiple fields cause problems in research evaluation and how to treat them properly has been discussed (e.g., Klein, 2006). In order to argue their treatment, identification of the interdisciplinary area and objective measurement of the degree of "interdisciplinarity" are necessary.

On indices of interdisciplinarity, though there are some studies using network based indices or the number of different fields to which cited literature belongs (e.g., Porter et al., 2007; Rafols & Meyer, 2010), it is hard to say that enough investigation has been done. The characteristics of interdisciplinary areas, which have dynamic evolutionary process, are not necessarily sufficiently analyzed. In this study, firstly, indices to measure the characteristics of research areas, corresponding to three viewpoints of the variety, concentration, and recency of cited literature, are defined, then how the indices change with the change of time is followed. How interdisciplinary areas can be featured will be explored by comparing the values of the indices.

Methodology

Viewpoints and indices

Variety and concentration of the fields to which cited articles belong: (1) the number of different fields, (2) the Pratt's measure for the number of cited articles of each field, and (3) recency of cited articles: the arithmetic mean value of citation age are adopted as indices. The Pratt's measure is a concentration index used in bibliometrics, which is calculated from the following equation (Pratt, 1977).

$$P = \frac{2\lfloor((N+1)/2) - q\rfloor}{N-1}$$

where N is the number of fields, and q is obtained by the following operation: first multiplying the number of articles by a rank for each field, then calculating summation of it, and finally dividing it by the number of all articles.

Data

For three subjects of biology, geosciences, and computer science, analytical objects are selected making a pair comprising the area with higher interdisciplinarity and the one with lower interdisciplinarity. Three pairs, a pair of interdisciplinary biology (BIh) and biology (BIl), a pair of "geosciences, multidisciplinary" (GEh) and "geology" (GEl), and a pair of "computer science, interdisciplinary applications" (COh) and "computer science, theory and methods" (COl) are selected. In this study, we deem whether each area is interdisciplinary or not, on the basis of scope notes in the list of source publications arranged by subject category of the SCI (Science Citation Index). For each area, bibliographic data of articles

published from 2000 to 2007 was extracted from the SCI. Then, the fields to which articles cited by them belong were discriminated, and further the difference of the publishing year between the citing and cited articles, that is, citation age was calculated. Articles were related to fields on the basis of the subject categories of the SCI.

As the basic quantities of the six areas, the number of articles (A) and the number of cited articles whose fields were distinguished (CD) are shown in Table 1. In addition, in terms of the number of different fields to which cited articles belong (N), the Pratt's measure for the number of cited articles of each field (P), and the mean citation age ($MeCA$), mean values for each year are shown.

Table 1. The outlook of the six research areas.

	A	*CD*	*N*	*P*	*MeCA*
BIh	92355	629512	169.75	0.79	9.66
BIl	69315	918630	169.38	0.83	8.53
GEh	60466	923737	165.63	0.89	10.74
GEl	8592	150170	125.13	0.92	11.63
COh	21192	254681	166.25	0.76	10.15
COl	14802	93605	127.13	0.90	11.12

Results and discussion

Transition in the number of different fields to which cited articles belong (N), that in the Pratt's measure (P), and that in the mean citation age ($MeCA$) are shown in Figures 1, 2, and 3, respectively. In addition, a scatter diagram between N and P is shown in Figure 4.
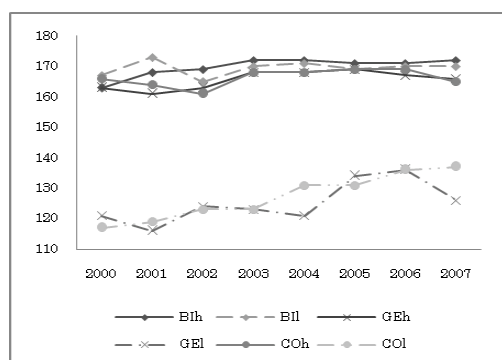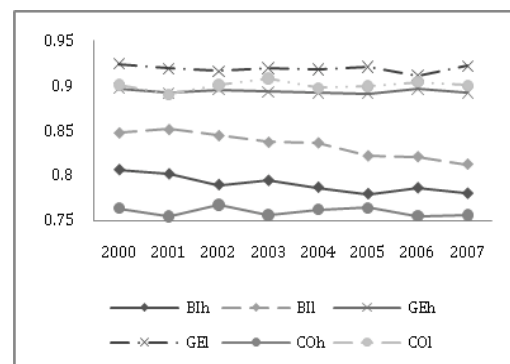

Figure 1. Transition in *N*.
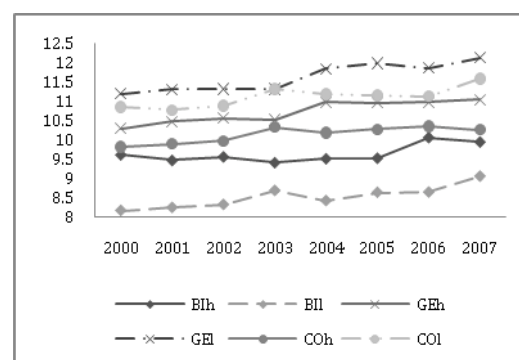

Figure 2. Transition in *P*.

Figure 3. Transition in *MeCA*.

Regarding the comparison between more and less interdisciplinary areas for each of the three subjects (i.e., biology, geosciences, and computer science), the area with higher interdisciplinarity has higher N and lower P. That is to say, it can be confirmed that an interdisciplinary research tends to cite articles from a relatively large number of fields with relatively similar frequencies. However, with respect to the two areas of biology (i.e., BIh and BIl), their values of N are almost equal; the difference between them was confirmed in P more definitely (see Figure 4). On the other hand, no consistent result is obtained in comparison of $MeCA$. With respect to geosciences and computer science, the area with high interdisciplinarity has smaller $MeCA$, that is, an interdisciplinary research tends to refer newer articles. But with respect to biology, the opposite result holds. Concerning secular changes of the indices, for all the six research areas, $MeCA$

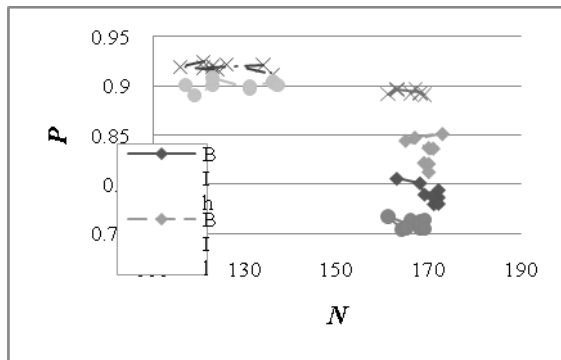increases, that is, the tendency to refer new articles becomes weaker.

Figure 4. Changes in *N* and *P*.

Conclusions

The number of cited fields, the Pratt's measure for the number of cited articles of each field, and mean citation age (i.e., the variety, concentration, and recency of cited articles) are considered to be strongly related not only to the interdisciplinarity of researches but also to their subjects. However, in comparison within areas in the same subject, it was confirmed that, in the area whose interdisciplinarity is regarded to be high, the number of cited fields is larger while the Pratt's measure is lower. Further, even in the areas where the numbers of cited fields are nearly equal, there appeared a difference in the Pratt's measure. In identification of interdisciplinary areas, indices measuring the concentration such as the Pratt's measure are suggested to be useful.

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