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A probe into dynamic measures for h-core and h-tail

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ABSTRACT

Using the concepts of h-core and h-tail, shape descriptors and shape centroids, *k*-index and *k*′-index, dynamic measures are probed, with practical data in the fields of Physics and sociology. It is revealed that there are obvious differences between natural sciences (Physics, particles & fields) and social sciences (sociology) when *c*-descriptor, h-core centroid and *k*-index are applied as dynamic measures, while few differences exist when using *t*-descriptor, h-tail centroid and *k*′-index, following a time span from 1 to 10 years.

1. Introduction

Since the *h*-index was introduced in 2005 (Hirsch, 2005), it has been applied as an academic measure (Alonso, Cabrerizo, Herrera-Viedma, & Herrera, 2009; Egghe, 2010) and has led to a simple and meaningful unification of publications and citations (Ye, 2009, 2011).

The *h*-index is regarded as a robust indicator of measuring both the impact and output of publications, which link with quality and quantity respectively. Mostly, the mistaken data on citations are easily caused in the long-tail part of low-citation publications when we count citations in a database; therefore the *h*-index has high accuracy in academic assessment (Vanclay, 2007). On the other hand, the *h*-index can be applied to forecast the future academic performance of scholars (Hirsch, 2007). However, the *h*-index is presented in an integral in which similar *h*-indices in scholars or institutions readily exist, making it ineffective indifferentiating academic performances (Nair & Turlach, 2012). Huang and Chi (2010) also compared three different indices for the institution level research evaluation. Hence, some h-type indices have been introduced to improve the *h*-index, and several related indicators have been observed (Egghe, 2006; Glanzel, 2006; Jin, Liang, Rousseau, & Egghe, 2007; Kuan, Huang & Chen, 2011a, 2011b, 2012a, 2012b; Ye, 2010).

Meanwhile, the *h*-index ignores its research target's number of papers and citation distribution, which may result in *h*-inconsistency in some cases (Waltman & van Eck, 2012). Some scholars consider that the number of papers and citation distribution in h-core and h-tail should be looked to for a more correct academic assessment (Rousseau, 2006; Ye & Rousseau, 2010). Kuan et al. (2011a) suggested the two indicators, *c*-descriptor and *t*-descriptor, for analyzing patent performance of assignees according to their rank-citation curves based on practical data. Since *c*-descriptor and *t*-descriptor are not able to

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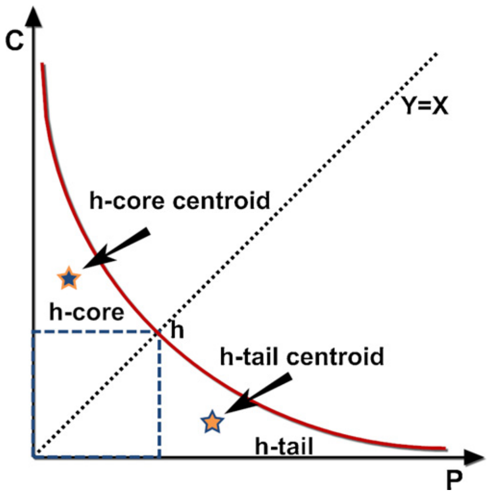

Fig. 1. h-core and h-tail in *P*–*C* plane.

instantly show the relative patent performance of all assignees, Kuan et al. (2011b) further introduced h-core centroid and h-tail centroid, which are located at the geometric centers of the h-core and h-tail areas following the rank-citation curves. Comparing with g-core (Egghe, 2006), pi-core (Vinkler, 2010), with 0.1, 0.01, and 1% of total papers, etc. (Radicchi, Fortunato, & Castellano, 2008), with the I3-index (Leydesdorff & Bornmann, 2011), or with CDS-index (Vinkler, 2011), h-core is simpler and easier so that we choose it as elite concept, even though the others also possess potential.

When Liang (2006) introduced the *h*-index sequence and *h*-index matrix to overcome the faults of the *h*-index in specific time spans, Rousseau and Ye (2008) also proposed dynamic the h-type index for measuring the dynamic non-linear properties. While Egghe (2009a, 2009b) set up the mathematical model for the *h*-index sequence, Nair and Turlach (2012) developed the stochastic *h*-index. Also, we mention dynamic h-measures with references (Egghe, 2007; Vinkler, 2010; Ye, 2012). All the studies show that scholars have paid attention to dynamic process of the *h*-index.

In the beginning, Hirsch found that there were differences among different fields with ten cases each in Physics, particles & fields and biology when he proposed the *h*-index (Hirsch, 2005). In recent years, many scholars have revealed the informetric differences in various fields (Batista, Campiteli, Kinouchi, & Martinez, 2006; Iglesias & Pecharroman, 2007; Lillquist & Green, 2010). Batista et al. (2006) set the fields of Physics, Chemistry, Biology/Biomedicine and Mathematics as targets for the analysis of the differences in co-author status among various fields and subjects, and applied h_I-index to correct the expansion that co-authors caused in the *h*-index. Iglesias and Pecharroman (2007) compared different fields with a simple method for scaling the *h*-index so that we could compare *h*-indices across fields. Lillquist and Green (2010) focused on several target institutions and collected scholars' paper data in the fields of Biology, Chemistry, Mathematics, Physics and Engineering. They further divided the Engineering field into Civil, Mechanical, Electrical and Chemical Engineering as major disciplines, and analyzed researchers' *h*-index performance in Biology, Chemistry, Mathematics, Physics, Engineering and the sub-fields of Engineering, to observe if diversity of the *h*-index was shown.

Based on above studies, we try to probe into the dynamic measures for h-core and h-tail, with indicators such as *c*-descriptor, *t*-descriptor, h-core centroid (c_x, c_y) and h-tail centroid (t_x, t_y), as well as k and k' (Ye & Rousseau, 2010). On the basis of the data used, the time span was changed from one or two years to 10 years, the dynamic changes of publications, citations, and rank-citation curves in different fields during the 2001–2010 period have been studied, particularly in the fields of Physics (as one of the typical natural sciences) and Sociology (as one of the typical social sciences).

2. Methodology

2.1. Method

It is well known that publications (P) and citations (C) can be arranged into a diagram when ranked according to total citations of each publication from high to low, in which the *h*-index is always located on the P–C curve (as R–C, rank-citation). In the P–C plane, the h-core and h-tail are distributed as shown in Fig. 1.

We are interested in the h-core and h-tail portions, and the difference between natural science and social science, for which the *e*-index (Zhang, 2009) and *k*-index (Ye & Rousseau, 2010) could be defined as:

$$C_H = h^2 + e^2 \quad (1)$$

$$k = \frac{C/P}{C_T/C_H} \quad (2)$$

Table 1
Total data.

Field	Jn	P	C	h	C_H	C_T
Physics	27	91,252	1,146,184	219	84,775	1,061,409
Sociology	132	57,718	209,443	103	17,953	191,490

where C_H and C_T denotes citations in h-core and in h-tail, respectively. Since C/P is seen as average impact, it is also problematic (Rousseau & Leydesdorff, 2011) and as the $C–P$ is logically consistent (Rousseau & Ye, 2011), we can modify k as k' for measuring core-tail ratio with same decreasing tendency as follows:

$$k' = \frac{C-P}{C_T - C_H} \tag{3}$$

Using the shape descriptors (both c-descriptor and t-descriptor) that we proposed (Kuan et al., 2011a), we have:

$$c\text{-descriptor} = \frac{\sum_{i=1}^{h} C(P_i)^2}{\sum_{i=1}^{h} C(P_i)} \tag{4}$$

$$t\text{-descriptor} = \frac{\sum_{i=h+1}^{Nc} iC(P_i)^2}{\sum_{i=h+1}^{Nc} C(P_i)} \tag{5}$$

where Nc stands for the number of cited publications (with at least one citation). Meanwhile, shape centroids, including h-core centroid (c_x, c_y) and h-tail centroid (t_x, t_y), can be obtained according to our studies (Kuan et al., 2011b):

$$c_x = \frac{\sum_{i=1}^{h} (i-0.5)C(P_i)}{\sum_{i=1}^{h} C(P_i)} \tag{6}$$

$$c_y = \frac{1}{2}\frac{\sum_{i=1}^{h} C(P_i)^2}{\sum_{i=1}^{h} C(P_i)} = \frac{1}{2}\text{c-descriptor} \tag{7}$$

$$t_x = \frac{\sum_{i=h+1}^{Nc} (i-0.5)C(P_i)}{\sum_{i=h+1}^{Nc} C(P_i)} = \text{t-descriptor} - 0.5 \tag{8}$$

$$t_y = \frac{1}{2}\frac{\sum_{i=h+1}^{Nc} C(P_i)^2}{\sum_{i=h+1}^{Nc} C(P_i)} \tag{9}$$

Since the c_y and t_y are in the same mathematical form, we can only apply c_x and t_x as independent measures of h-core centroid and h-tail centroid respectively.

2.2. Data

For numerical comparison, we searched sample data from the *Journal Citation Reports (JCR)* 2010 in the fields of Physics, particles & fields and Sociology in journals.

In Physics, particles & fields, data are collected from the JCR category "Physics, particles & fields," with a total of 27 journals, while Sociology is collected from the category "Sociology" with a total of 132 journals. All changes in journal names are taken into account, and these changed journals have also been searched.

Then, we used the journal titles to search data from the *Science Citation Index* (SCI) and *Social Science Citation Index* (SSCI), including all document types from 2001 to 2010.

For total data see Table 1, in which Jn represents the number of journals.

During 2001–2010, there were 27 journals in the field of Physics, particles & fields, with a total of 91,252 papers, a total of 1,146,184 citations and h 219. And there were 132 journals in the field of Sociology, with a total of 57,718 papers, a total of 209,443 citations and h 103.

To compare the changes in every year, we collected accumulative data respectively originated from 2001, as shown in Tables 2 and 3. The continuous one-year, two-year, three-year (to ten-year) accumulative publication and citation data from 2001 are collected. The citation window of each publication is from the date published to the date data collected in 2012.

In Tables 2 and 3, c-max denotes the maximum citations of the most cited paper.

3. Results

According to the data in Table 1, during 2001–2010, there were 91,252 papers published in 27 journals in the field of Physics, particles & fields, while there were 50,734 papers published in 132 journals in the field of Sociology. Overall, the

Table 2
Data on time stages in physics.

Physics	Jn	P	C	h	C_H	C_T	c-max
2001–2001	19	7754	146,312	132	30,220	116,092	575
2001–2002	20	15,182	296,897	163	49,109	247,788	2673
2001–2003	21	23,189	442,056	185	63,140	378,916	2673
2001–2004	22	32,554	589,053	201	71,378	517,675	2673
2001–2005	23	41,733	718,695	209	74,475	644,220	2673
2001–2006	23	50,506	838,835	214	80,428	758,407	3545
2001–2007	26	60,389	942,261	216	81,807	860,454	3545
2001–2008	27	70,314	1,036,031	218	82,941	953,090	3545
2001–2009	27	80,808	1,106,150	219	83,674	1,022,476	3545
2001–2010	27	91,252	1,146,184	219	84,775	1,061,409	3545

Table 3
Data on time stages in sociology.

Sociology	Jn	P	C	h	C_H	C_T	c-max
2001–2001	87	5043	35,150	70	9799	25,351	921
2001–2002	87	9965	66,254	82	13,314	52,940	921
2001–2003	92	15,040	95,922	93	15,053	80,869	921
2001–2004	92	20,150	123,965	99	16,851	107,114	921
2001–2005	94	25,399	149,378	101	17,800	131,578	921
2001–2006	97	30,918	169,568	102	18,030	151,538	921
2001–2007	110	37,018	186,374	103	17,953	168,421	921
2001–2008	129	43,895	198,995	103	17,953	181,042	921
2001–2009	129	50,734	206,361	103	17,953	188,408	921
2001–2010	132	57,718	209,443	103	17,953	191,490	921

number of citations in Physics, particles & fields is 5.5 times as many as that in Sociology, and its number of papers is 1.6 times greater than that in Sociology. However, the number of journals is only one fifth that in Sociology. If each kind of journals focuses on a specific research theme which is capable of catching attention, Sociology may be regarded as a more diverse research field than Physics, particles & fields.

According to data in Tables 2 and 3, the paper numbers in both Physics, particles & fields and Sociology stably increased for the most part when the number of years in the time span was gradually increased. However, the increment of citations was moderate when the time span is longer than five years. The number of the h-index rose with the increasing of the time span; the greatest h-index increment was shown when the time span is increased from one year to two years. The h-index also stabilized when the time span was longer than seven years in the field of Sociology and nine years in the field of Physics, particles & fields, which fits the dynamic h-index model by Egghe (2007). The result shows that the growth range in h-index decreases as the time span increases.

Paper citations take time to accumulate, however, and the impact of a paper decreases after a certain time span. Therefore, a proper time span is required for citations accumulation when calculating h-index. In other words, the time span should be set above nine years for h-index performance in Physics, particles & fields, and be set to seven years in Sociology. The values of C_H in the two fields are similar to the performance of the h-index. The growth of C_H in Physics, particles & fields is mostly static when the time span is above nine years, and the movement of C_H value in Sociology is completely stopped when the time span is above seven years. The values of C_T in the two fields increase when the time span increases, however, the growth of C_T gradually goes slowly. On the basis of the above data, we have computed the shape centroids, shape descriptors and the core-tail radio k- & k'-indices, and the results are merged into Tables 4–6.

From Tables 4 and 5, we synthesize the information of the h-index, c-descriptor and h-core centroid (c_x, c_y), and differences between Physics, particles & fields and Sociology are shown. In Physics, particles & fields, the h-index becomes stable when the time span is longer than 9 years, but the c-descriptor and h-core centroid (c_x, c_y) continue to exhibit a slight change. The citations of h-core papers in Physics, particles & fields are increasing, and its h-index may continue to grow in future. In Sociology, the h-index is firm when the time span is longer than 7 years, the c-descriptor and h-core centroid (c_x, c_y) are also stable without changes. This is a sign of the differences measured by shape descriptor and centroid between natural sciences and social sciences.

Table 4
Results with core-tail measures on total data.

Field	Shape centroids				Shape descriptors		k and k'	
	c_x	c_y	t_x	t_y	c-descriptor	t-descriptor	k	k'
Physics	79.35	349.45	14,963.60	23.12	698.89	14,964.10	1.0032	1.0802
Sociology	37.85	129.08	4873.73	12.29	258.16	4874.23	0.3402	0.8743

Table 5
Results with core-tail measures in physics on time stages.

Physics	Shape centroids				Shape descriptors		k and k′	
	c_x	c_y	t_x	t_y	c-descriptor	t-descriptor	k	k′
2001–2001	51.08	134.91	1535.43	22.59	269.82	1535.93	4.9119	1.6135
2001–2002	59.20	240.20	2921.75	25.31	480.39	2922.25	3.8758	1.4179
2001–2003	66.94	287.60	4315.29	26.52	575.2	4315.79	3.1766	1.3265
2001–2004	74.11	286.99	5905.98	26.76	573.98	5906.48	2.4949	1.2469
2001–2005	78.07	283.87	7470.65	26.53	567.74	7471.15	1.9909	1.1882
2001–2006	76.97	351.96	9039.15	25.89	703.92	9039.65	1.7613	1.1628
2001–2007	78.12	349.43	10,665.88	25.10	698.86	10,666.38	1.4835	1.1326
2001–2008	79.21	347.73	12,258.53	24.44	695.46	12,259.03	1.2822	1.1098
2001–2009	79.82	346.80	13,787.20	23.71	693.59	13,787.70	1.1202	1.0922
2001–2010	79.35	349.45	14,963.60	23.12	698.89	14,964.10	1.0032	1.0802

Table 6
Results with core-tail measures in sociology on time stages.

Sociology	Shape centroids				Shape descriptors		k and k′	
	c_x	c_y	t_x	t_y	c-descriptor	t-descriptor	k	k′
2001–2001	23.42	127.45	554.05	13.36	254.9	554.55	2.6942	1.9359
2001–2002	28.52	130.515	1037.20	14.7	261.03	1037.7	1.6721	1.4205
2001–2003	33.98	125.735	1529.22	15.07	251.47	1529.72	1.1872	1.2289
2001–2004	36	129.025	2031.28	15.09	258.05	2031.78	0.9678	1.1501
2001–2005	36.93	129.04	2560.26	14.73	258.08	2560.76	0.7956	1.0897
2001–2006	37.43	128.655	3115.09	14.08	257.31	3115.59	0.6525	1.0385
2001–2007	37.85	129.08	3679.75	13.43	258.16	3680.25	0.5367	0.9926
2001–2008	37.85	129.08	4244.13	12.83	258.16	4244.63	0.4496	0.951
2001–2009	37.85	129.08	4658.91	12.46	258.16	4659.41	0.3876	0.913
2001–2010	37.85	129.08	4873.73	12.29	258.16	4874.23	0.3402	0.8743

The above results show a decreasing tendency in k-index and k′-index, which are same as revealed cases (Ye & Rousseau, 2010), as shown in Fig. 2.

In both Physics, particles & fields and Sociology, decreasing tendency of k-index and k′-index follows an almost identical pattern, in which the ratios of k-index in Physics, particles & fields and Sociology increase when the time span increases, from 1.8 to 2.9. The tendency changes in the k' index in both fields are similar, as well as their values.

This study analyzed the k-index and k′-index in Physics, particles & fields and Sociology. The ratios of k-index and k′-index in Physics, particles & fields decrease when the time span is extended. The ratios of the k-index are 4.92 and 1.00 when the time span is set at one year and ten years, while the ratios of the k′-index are 1.61 and 1.08 over the same time span lengths. The ratio evolutions of the k-index and k′-index in Sociology are similar. Within a three year time span, the ratio of the k-index is greater than that of the k′-index; during a longer time span, the ratio of the k′-index is greater than that of the k-index. In order to probe into the evolutionary reasons for different k-indices and k′-indices, we have attempted to draw evolutionary figures of various reference values, including C/P and C_T/C_H, $C–P$ and $C_T–C_H$, as shown in Fig. 3 and Fig. 4. The C/P in Physics, particles & fields is three times larger than that in Sociology, while the C_T/C_H increases from three to ten times when the time span increases from one to ten years, so the k-index has become changeable. Meanwhile, only slight changes occur in $C–P$ and $C_T–C_H$ during every time span similar to the numbers in the k′-index.

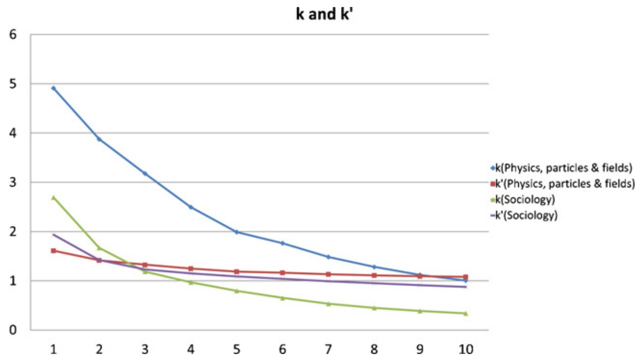

Fig. 2. The changes of k- and k′-indices on time stages in Physics, particles & fields and Sociology.

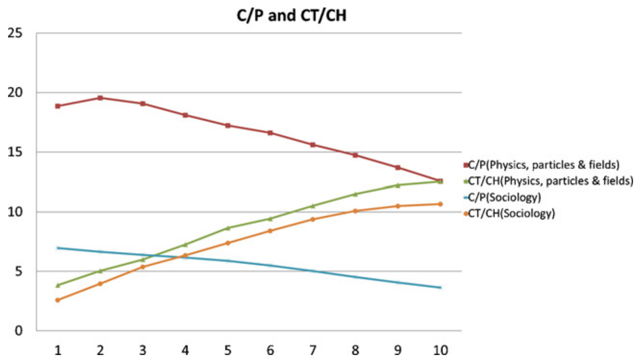

Fig. 3. The changes of C/P and C_T/C_H on time stages in Physics, particles & fields and Sociology.

4. Analysis and discussion

Suppose the P–C curve is a continuous function $C(x)$, where x denotes the publications ranked by citations. The analytical definitions of the shape descriptors and shape centroids are as follows

$$c\text{-descriptor} = \frac{\int_1^h C^2(x)dx}{\int_1^h C(x)dx} \tag{10}$$

$$t\text{-descriptor} = \frac{\int_{h+1}^{Nc} xC^2(x)dx}{\int_{h+1}^{Nc} C(x)dx} \tag{11}$$

$$c_x = \frac{\int_1^h (x-0.5)C(x)dx}{\int_1^h C(x)dx} \tag{12}$$

$$c_y = \frac{1}{2}\frac{\int_1^h C^2(x)dx}{\int_1^h C(x)dx} \tag{13}$$

$$t_x = \frac{\int_{h+1}^{Nc} (x-0.5)C(x)dx}{\int_{h+1}^{Nc} C(x)dx} \tag{14}$$

$$t_y = \frac{1}{2}\frac{\int_{h+1}^{Nc} C^2(x)dx}{\int_{h+1}^{Nc} C(x)dx} \tag{15}$$

The changes of P–C curve and shape centroids are shown in Fig. 5. Although above definitions exclude time as a factor, the changes of shape centroids are reflected in the evolution. Following the time stages, the h-index will increase, and h-core and h-tail will grow larger so that shape centroids will move along in the up-right direction.

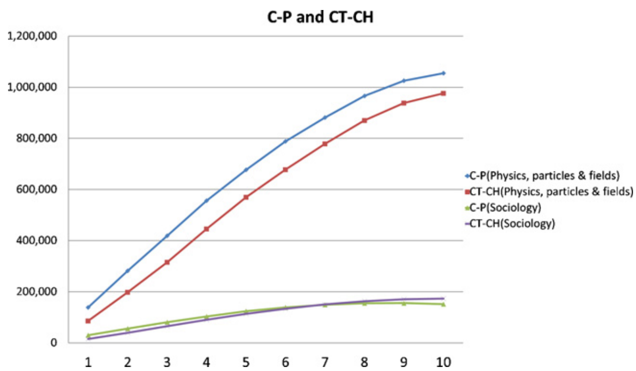

Fig. 4. The changes of P–C and C_T–C_H on time stages in Physics, particles & fields and Sociology.

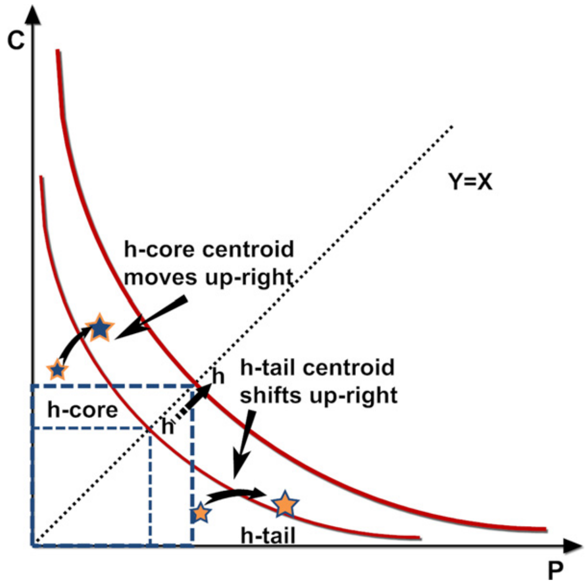

Fig. 5. The changes of *P–C* curve and shape centroids.

However, the changes of *P–C* curve and shape may become complex as another coordinate in the h-core centroid (c_x, c_y) or h-tail centroid (t_x, t_y) may also fluctuate. The h-core and h-tail are divided into two parts for analysis and discussion of dynamic evolution.

4.1. The evolution of h-core

For characterizing h-core, we apply its c-max, *c*-descriptor and h-core centroid (c_x, c_y) as dynamic measures. In Physics, particles & fields, there are three significant stage changes in c-max, from 575 at time span of one year, through 2673 during time spans between two and five years, to 3545 when the time span is six to ten years. There are two stage changes in *c*-descriptor and h-core centroid (c_x, c_y), with a rapid increase and stop afterward, as shown in Figs. 6 and 7. It is worth mentioning that the h-core centroid (c_x, c_y) moves rightward when *c*-descriptor stops. In Sociology, c-max remains at 921 and *c*-descriptor is without large changes, while the h-core centroid (c_x, c_y) also moves rightward.

4.2. The evolution of h-tail

Although the fields of Physics, particles & fields and Sociology are different from each other, their evolutionary h-tails show the same pattern. Using the *t*-descriptor and h-tail centroid (t_x, t_y) as dynamic measures, their *t*-descriptors show a stable increase when their h-tail centroid (t_x, t_y) moves to the up-right direction during time spans from one to four years and moves to the down-right direction during time spans from five to ten years, as shown in Figs. 8 and 9.

The above evolutionary measures of h-core and h-tail reveal interesting characteristics in both natural sciences (Physics, particles & fields) and social sciences (sociology).

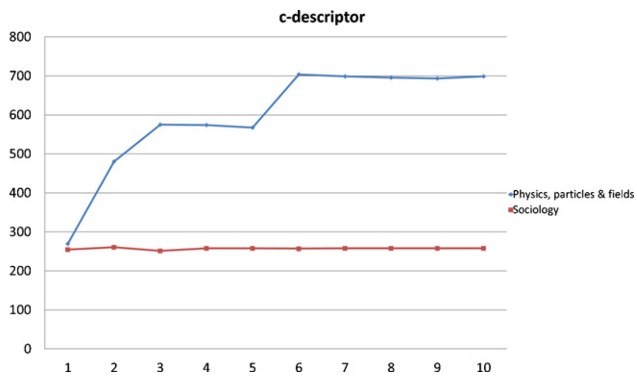

Fig. 6. The changes of *c*-descriptor on time stages.

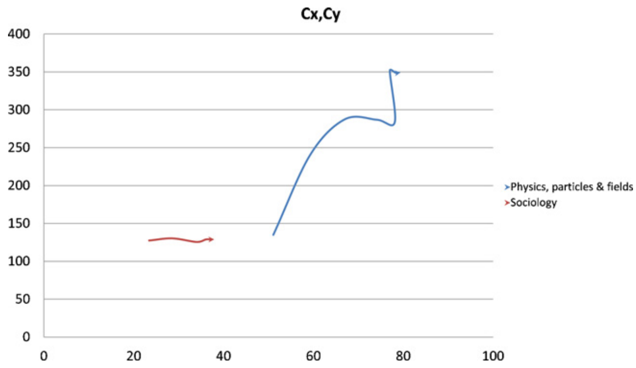

Fig. 7. The changes of h-core centroid (c_x, c_y) on time stages.

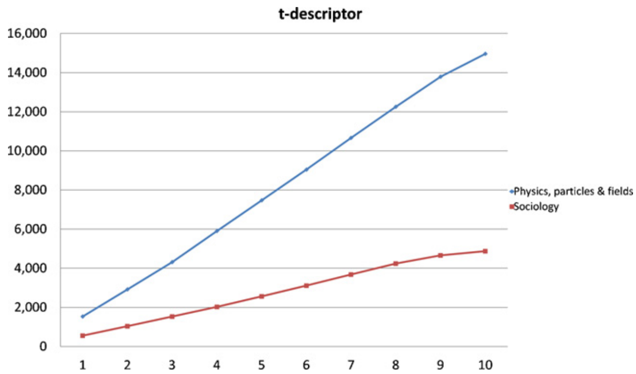

Fig. 8. The changes of t-descriptor on time stages.

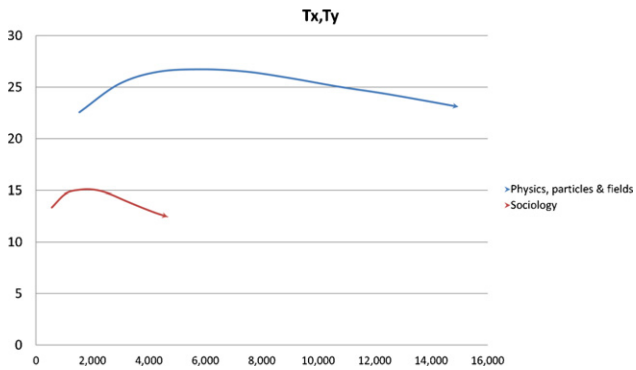

Fig. 9. The changes of h-tail centroid (t_x, t_y) on time stages.

5. Conclusion

In the cases of Physics, particles & fields and Sociology, we collected data from the period 2001 to 2010 and applied the related indicators to analyze h-core and h-tail, such as c-descriptor, t-descriptor, h-core centroid (c_x, c_y), h-tail centroid (t_x, t_y), k-index and k'-index as dynamic measures in specific time span. The researches revealed that there are significant differences between natural sciences (Physics, particles & fields) and social sciences (Sociology) when c-descriptor, h-core centroid (c_x, c_y) and k-index are applied as dynamic measures. Several differences occur between natural sciences (Physics, particles & fields) and social sciences (Sociology) when t-descriptor, h-tail centroid (t_x, t_y) and k'-index are used as dynamic measures among time spans from one to ten years. Also, we stressed that the findings are only valid for large data sets, not for the rarely meanings in individual cases (e.g. comparing individual journals).

Besides, this study uses Physics, particles & fields as the representative of research sample. In fact, JCR covers more than 400 physics journals. Physics, particles & fields is the only one of the eight physics subfields. However, the size of data is too large to be included in our research so that we could only select the Physics, particles & fields in the field of Physics as a sample, it is the limitation of this study.

This method cannot eliminate all the objections against the h-method, which neglects the use of plus citations to the h-core papers. We suggest that the *c*-descriptor, *t*-descriptor, h-core centroid (c_x, c_y), h-tail centroid (t_x, t_y), *k*-index and k'-index indicators could be regarded as useful dynamic measures for studying and analyzing the development of academic fields, as well as for comparison across fields.

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