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Use of citation per publication as an indicator to evaluate contingent valuation research

ZHI LI,[a] YUH-SHAN HO[b]

[a] *The Key Laboratory for Environmental and Urban Sciences, Shenzhen Graduate School, Peking University, Shenzhen (P. R. China)*
[b] *Department of Environmental Sciences, College of Environmental Sciences, Peking University, Beijing (P. R. China)*

This is the first article using bibliometrics to study the field of contingent valuation research. The purpose of this study was to evaluate the contingent valuation research performance based on all the related articles in SCI and SSCI databases from 1991 to 2005. An indicator named citation per publication (CPP) was presented in this study to assess the impact of article output per year, different countries, institutes, and authors from the worldwide. Publication per institute (PPI) in a country was used to be an indicator to compare institute's research performance by country. Citation analysis was made to select the most frequently cited articles since publication to 2005 of each year. A citation model was applied to describe the relationship between the cumulative number of citations and article life. The results indicate that with the increase article output per year, the CPP decreased slightly since 1997. The USA produced 55% of all pertinent articles. Institutes from the UK had a higher PPI. The most prolific institutes and authors, and the most frequently cited articles per year were all listed. In addition, a citation model was successfully applied to evaluate performance of each year, and the most frequently cited articles of each year were also compared by the model.

Introduction

Contingent valuation, as the principal means for measuring passive use values [BJORNSTAD & KAHN, 1996], or the only method of estimating non-use values of

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Address for correspondence:
YUH-SHAN HO
Department of Environmental Sciences, College of Environmental Sciences
Peking University, Beijing, 100871, People's Republic of China
E-mail: dr_ysho@hotmail.com

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environmental benefits [WANG, 1997], has become one of the most widely used non-market valuation methods, especially for environmental cost-benefit analysis and environmental impact assessment [VENKATACHALAM, 2004í]. Survey questions, like 'how much money you are willing to pay for', are used in this method to elicit information that allows monetary values for non-market resources to be estimated by analyzing respondents' answers [SMITH, 2004]. Most economists consider Ciriacy-Wantrup was the first who suggested the use of survey to value non-market resources, when he talked about the benefits of preventing soil erosion in the article *Capital Returns from Soil-Conservation Practices* [CIRIACY-WANTRUP, 1947]. While until the Ph.D. dissertation, *The Value of outdoor Recreation: An Economic Study of the Maine Woods*, was presented by DAVIS [1963], this method began to be used empirically to value non-market goods in academic research. Until now contingent valuation has been developed for about half a century. As one of the mainstream environmental economics topics [MA & STERN, 2006], it is helpful to evaluate its research performance for indicating the contribution and impact of different countries, institutes and authors from the worldwide.

The purpose of this study was to evaluate the contingent valuation research performances based on 1432 articles published in Science Citation Index Expanded – and Social Sciences Citation Index – indexed periodicals between 1991 and 2005. In addition to traditional indicator, an indicator named citation per publication (CPP) was presented in this study to assess the impact of a publication of years, countries, institutes, and authors.

Materials and methods

The 2005 edition of the *Journal Citation Reports* (JCR), published by the Institute for Scientific Information (ISI), lists 6088 journals in the Science Citation Index (SCI) and 1747 journals in the Social Sciences Citation Index (SSCI). Data used in this research were obtained from the two databases: SCI and SSCI, both subscribed from the online version of the ISI *Web of Science*, Philadelphia, PA, USA. Only 1432 documents of article type from 1991 to 2005 were downloaded which had the following terms in titles, abstracts or keywords: contingent valuation, contingent valuations, and contingency valuation. Downloaded information included author name, contact address, title, publication year, keywords, subject categories, and journal name. The records were downloaded into spreadsheet software (Microsoft Office Excel), and additional coding was manually performed for institute and country of origin of the collaborators. Collaboration type was determined by the address of each author. As for institute, 'independent' was assigned if all authors were from the same institute, and 'inter-institutional collaboration' if authors were from different institutes. In the same way for country, 'independent' was assigned if all authors were from the same country, and

'International collaboration' if authors were from different countries. In addition, articles originating from England, Scotland, Northern Ireland, and Wales were grouped under the UK heading.

The impact of a publication is assessed in terms of the number of citations that it has received. However, the number of times cited for an article is highly correlated with the length of time since its publication. A variable was created to adjust for that. Similar to the journal impact factor (IF) defined by the JCR, the variable TC2 (times cited during the second and third full year after publication) was used to assess the visibility of articles. According to GARFIELD [1972], 'the typical cited article is most heavily cited during the 2 years after its year of publication', and there were many cases to support that [CHIU & HO, 2005; HSIEH & AL., 2004; MARX & CARDONA, 2003]. In addition, CHUANG & AL. [IN PRESS] found that, in stroke-related research in Taiwan, the relationship between the average number of times cited per paper and the number of years since its publication shows that the frequency of being cited was the highest in the 2nd full year since its publication, and began to decrease thereafter. Though the peak position depended on the research discipline and might be shifted to 3 or more years [HANSEN & HENRIKSEN, 1997], TC2 was chosen for the consistent with ISI. For example, a TC2 for an article published in the year 2000 would be the number of citations this article received during the two full years 2001 and 2002. TC2 reflects a kind of diachronic impact, similar with the diachronic publication impact presented by INGWERSEN & AL. [2000].

With TC2, an indicator named citation per publication (CPP) can be further calculated. Let P be total number of publications and C the sum of TC2 for total publications. The average first 2 full year citations per publication (CPP) for the whole studied period are defined as the ratio of C to P. INGWERSEN & AL. [2000, 2001] used similar indicators to evaluate research centers and journals, named *Center Impact Factor* (CIF) and IMP, respectively. Their CIF was applied to evaluate the performance of research center based on a specific program. While the CPP was based on a specific research topic or field. As matter of a fact, for every publication has a TC2, CPP can be obtained by year, country, institute, and author, respectively. Thus, with the CPP for different aspects of the publications, each aspect can be assessed according to the impact indicated by CPP, and then the performance of different years, countries, institutes, and authors could be compared respectively from the worldwide. In addition, since papers published in 2004 and 2005 do not have TC2, in some cases; the documents only published in the period from 1991 to 2003 were used.

Results and discussion

Documents of article type were firstly analyzed according to article output, country, institute, and author. Then citation analysis was made and citation history for total

articles was presented. Finally, a citation model was applied to evaluate research performances.

Article output

Figure 1 shows the article output from 1991 to 2005. A linear correlation with a coefficient of determination of 0.951 was found between the yearly number of articles and the year. An increase of nine articles was found each year. In the year 1991, 28 articles were published, while in 2005 the number of articles was 149, over 5 times of that in 1991. However, with the increase of quantity, the value of CPP for the period 1991 to 1997 goes up and down and then slightly decreased. The mean value of CPP for the earlier years was 2.4, while it decreased to 1.9 after 1997.

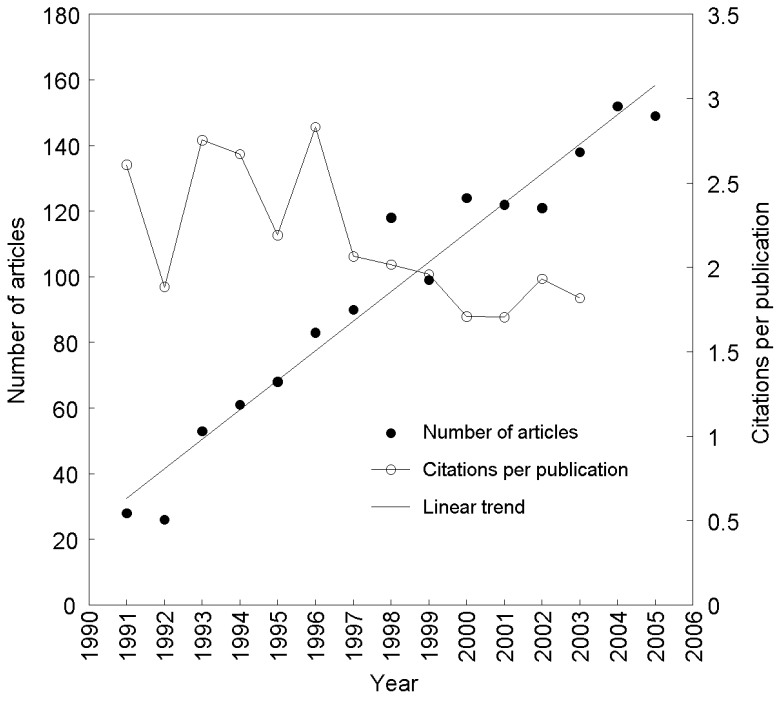

Figure 1. Article output and CPP by year on contingent valuation

Publication and citation analysis of country

There were 8 (0.56%) articles without author address information. The 1124 articles with author address information, published from 1991 to 2003, covered 61

countries/territories, of which 187 (17%) articles were international collaborations covering 52 countries/territories and 937 (83%) were independent publications covering 40 countries/territories. Twenty-one (34%) countries had no independent and 9 (15%) countries had no collaborative publications. Table 1 lists countries/territories, which published on average at least one article a year. The USA and the UK contributed 55% and 20% of total articles respectively, and the USA produced more than a half whether independently or collaboratively. The geographic distribution of independent articles could reflect the effect of economic factor in some degree. Ninety percent of independent articles were produced by the 9 most independently productive countries, including North America (58%, 2 countries), Europe (26%, 5 countries), Oceania (5%, 1 country), and Asia (1%, 1 country). In Asia, South Korea is the top one of independent research country. Canada had the highest CPP for total articles (2.9), while Sweden and Germany had the highest CPP for independent (2.7) and international (3.9) collaboration publications respectively. Moreover, for 31 countries had both independent and international collaboration publications, mean value of CPP_C (2.0) was higher than CPP_S (1.3), which means collaborative publications had higher impact in the research field.

Table 1. Publication activity of countries from 1991 to 2003 and their citation impact in the 2 years after publication year

Country/Territory	TP (%)	CPP_T (Rank)	SP (%)	CPP_S (Rank)	CP (%)	CPP_C (Rank)
USA	615 (55)	2.3 (3)	506 (54)	2.2 (3)	109 (58)	2.5 (7)
UK	222 (20)	2.1 (6)	153 (16)	2.0 (4)	69 (37)	2.3 (9)
Sweden	70 (6.2)	2.7 (2)	47 (5.0)	2.7 (1)	23 (12)	2.8 (5)
Canada	68 (6.0)	2.9 (1)	34 (3.6)	2.3 (2)	34 (18)	3.4 (3)
Australia	67 (6.0)	1.9 (8)	44 (4.7)	1.6 (5)	23 (12)	2.5 (7)
Norway	31 (2.8)	2.2 (5)	18 (1.9)	1.2 (6)	13 (7.0)	3.5 (2)
Spain	18 (1.6)	0.50 (13)	13 (1.4)	0.46 (13)	5 (2.7)	0.60 (12)
France	16 (1.4)	1.4 (10)	11 (1.2)	0.73 (11)	5 (2.7)	2.8 (5)
Italy	16 (1.4)	1.6 (9)	5 (0.53)	1.0 (8)	11 (5.9)	1.9 (10)
Netherlands	16 (1.4)	2.1 (6)	6 (0.64)	0.83 (9)	10 (5.3)	2.9 (4)
South Korea	16 (1.4)	0.69 (12)	13 (1.4)	0.77 (10)	3 (1.6)	0.33 (13)
Germany	13 (1.2)	2.3 (3)	6 (0.64)	0.50 (12)	7 (3.7)	3.9 (1)
New Zealand	13 (1.2)	1.2 (11)	6 (0.64)	1.2 (6)	7 (3.7)	1.3 (11)

TP: Total country publications
CPP_T: Citation per publication of total country publication
SP: Single country publications
CPP_S: Citation per publication of single country publication
CP: International collaboration publications
CPP_C: Citation per publication of international collaborative publication

Publication and citation analysis of institute

Among the 1124 articles with author address information, published from 1991 to 2003, 601 (53%) were inter-institute collaborations, and 523 (47%) were independent publications. The percentage of collaboration between institutes was much higher than that between countries (17%). In total, there were 721 institutes, 468 (65%) of which had no independent articles, and 109 (15%) had no collaborative articles. Table 2 lists institutes with total articles more than 2% of all. Colorado State University in USA was the most productive for both total articles and independent articles. However, Stockholm School of Economics in Sweden had the highest CPP_T, CPP_S, and CPP_C. For 144 institutes with both independent and inter-institute collaboration articles, average number of collaborative articles per institute (5.8) was higher than that of independent (2.8), and mean value of CPP_C (2.5) was higher than CPP_S (2.1), which means collaboration produced more articles and collaborative articles had higher impact in the research field.

Table 2. The 10 most productive institutes from 1991 to 2003 and their citation impact in the 2 years after publication year

Institute	TP (%)	CPP_T (R)	SP (%)	CPP_S (R)	CP (%)	CPP_C (R)
Colorado State University, USA	51 (4.5)	1.5 (10)	19 (3.6)	1.8 (6)	32 (5.3)	1.3 (10)
University of East Anglia, UK	46 (4.1)	2.6 (3)	10 (1.9)	2.7 (2)	36 (6.0)	2.6 (4)
US Forest Service, USA	40 (3.6)	2.2 (7)	5 (0.96)	1.2 (8)	35 (5.8)	2.3 (8)
University of Newcastle Upon Tyne, UK	33 (2.9)	2.3 (5)	12 (2.3)	2 (5)	21 (3.5)	2.5 (6)
University of Maryland, USA	31 (2.8)	2.7 (2)	10 (1.9)	2.3 (4)	21 (3.5)	2.9 (2)
Stockholm School of Economics, Sweden	28 (2.5)	4.1 (1)	9 (1.7)	3 (1)	19 (3.2)	4.6 (1)
East Carolina University, USA	28 (2.5)	1.6 (9)	8 (1.5)	1.1 (9)	20 (3.3)	1.8 (9)
Duke University, USA	26 (2.3)	2 (8)	8 (1.5)	1.3 (7)	18 (3.0)	2.4 (7)
University of Aberdeen, UK	24 (2.1)	2.5 (4)	10 (1.9)	2.4 (3)	14 (2.3)	2.6 (4)
Cornell University, USA	23 (2.0)	2.3 (5)	5 (0.96)	0.8 (10)	18 (3.0)	2.7 (3)

TP: Total institute publications
CPP_T: Citation per publication of total institute publication
SP: Single institute publications
CPP_S: Citation per publication of single institute publication
CP: Inter-institute collaboration publications
CPP_C: Citation per publication of inter-institute collaborative publication

In order to compare institute's research performance by country, publication per institute (PPI) in a country was used to be an indicator. A country's PPI is equal to the ratio of the publications of the country and the number of related institutes of the country. In contingent valuation research field, the USA produced the most articles (615, 55%), but it also had the most institutes (271, 38%). Thus, the PPI of USA was 2.3 (the ratio of 615 to 271). However, the institutes from the UK had a higher PPI of 2.4. It should be noted that, for one article, the sensitivity of the value of PPI mainly

depends on the number of institutes. If the number of institutes is not large enough, the uncertainty resulted from the number of articles (if there is) would affect PPI considerably. In order to reduce the possible error, countries with at least 20 related institutes were selected, which means that the effect of one article to the PPI is at least less than 5%. Table 3 shows the PPI of countries with at least 20 related institutes.

Table 3. The PPI of countries with at least 20 related institutes

Country	Number of articles	Number of institutes	PPI
UK	222	93	2.4
Sweden	70	30	2.3
USA	615	271	2.3
Canada	68	38	1.8
Australia	67	39	1.7

PPI: publication per institute by country

Publication and citation analysis of author

According to the author name information downloaded from the ISI Web of Science database, the 1131 articles published from 1991 to 2003 were written by 1703 authors, and 20 (1.2%) authors contributed at least ten articles. Table 4 shows the top 20 most-productive authors, with the number of their total articles, first author articles and corresponding author articles, and the CPP for the three kinds of articles. Among the top 20 authors, 13 were from the USA, 6 from the UK, and 1 from Sweden. Johannesson, M from Stockholm School of Economics in Sweden, and Loomis, J from Colorado State University in USA, were the most productive authors with 27 articles respectively. Johannesson, M also had the highest CPP for both total articles (4.6) and articles as corresponding author (5.0), and the second highest CPP for articles as first author (4.6). Loomis, JB from Colorado State University in USA, had the most first author and corresponding author articles. It should be noted that there were two authors from Colorado State University in USA, who are named after "Loomis, J" and "Loomis, JB" respectively. Through further investigation, it was found that "Loomis, J" and "Loomis, JB" are not the same name but the same person. Loomis published 26 articles with the name of 'Loomis, JB', and 27 with 'Loomis, J'. According to the downloaded information from the ISI *Web of Science* database, the two names would be recognized as two different authors. Thus the real most productive author was Loomis, JB with 53 articles in total, almost two times of the number of articles the author Johannesson, M had published. The phenomena of the same authors using different names in their publications also occurred to other authors in Table 4 and will affect the ranking.

Table 4. The 20 most productive authors between 1991 and 2003

Author	Institute	TP (%)	CPP_T (Rank)	FA (%)	CPP_F (Rank)	RA (%)	CPP_R (Rank)
Johannesson, M	Stockholm School of Economics, Sweden	27 (2.4)	4.6 (1)	11 (0.97)	4.6 (2)	10 (0.92)	5.0 (1)
Loomis, J	Colorado State University, USA	27 (2.4)	1.9 (16)	13 (1.15)	1.8 (12)	14 (1.3)	1.7 (13)
Loomis, JB	Colorado State University, USA	26 (2.3)	1.7 (18)	17 (1.50)	1.5 (15)	19 (1.8)	1.6 (14)
Whitehead, JC	Appalachian State University, USA	26 (2.3)	1.4 (20)	15 (1.33)	1.3 (18)	13 (1.2)	1.2 (19)
Bateman, IJ	University of East Anglia, UK	21 (1.9)	2.3 (11)	7 (0.62)	2.7 (8)	6 (0.55)	2.8 (8)
Hanley, N	University of Stirling, UK	17 (1.5)	2.8 (8)	9 (0.80)	3.2 (7)	9 (0.83)	3.2 (7)
Langford, IH	University of East Anglia, UK	15 (1.3)	2.5 (9)	5 (0.44)	1.4 (16)	6 (0.55)	2.0 (12)
Berrens, RP	University of New Mexico, USA	15 (1.3)	1.5 (19)	10 (0.88)	1.1 (19)	11 (1.0)	1.5 (17)
Brown, TC	US Forest Service, USA	14 (1.2)	3.3 (6)	5 (0.44)	4.8 (1)	5 (0.46)	4.8 (2)
Willis, KG	University of Newcastle Upon Tyne, UK	14 (1.2)	2.2 (13)	5 (0.44)	1.4 (16)	5 (0.46)	1.4 (18)
Boyle, KJ	University of Maine, USA	13 (1.1)	3.4 (4)	7 (0.62)	4.1 (4)	6 (0.55)	4.2 (3)
Garrod, GD	University of Newcastle Upon Tyne, UK	13 (1.1)	2.4 (10)	6 (0.53)	2.2 (11)	6 (0.55)	2.2 (11)
Blomquist, GC	University of Kentucky, USA	13 (1.1)	2.0 (14)	3 (0.27)	0.33 (20)	4 (0.37)	0.75 (20)
Smith, VK	North Carolina State University, USA	12 (1.1)	3.3 (7)	6 (0.53)	4.2 (3)	6 (0.55)	4.2 (3)
Whittington, D	University of North Carolina, USA	12 (1.1)	1.8 (17)	7 (0.62)	2.3 (10)	7 (0.65)	2.3 (10)
Poe, GL	Cornell University, USA	12 (1.1)	2.3 (12)	6 (0.53)	1.7 (13)	8 (0.74)	1.5 (15)
Ryan, M	University of Aberdeen, UK	12 (1.1)	3.7 (2)	11 (0.97)	3.5 (5)	11 (1.0)	3.5 (5)
Carson, RT	University of California, San Diego, USA	11 (1.0)	3.4 (5)	10 (0.88)	3.5 (6)	10 (0.92)	3.5 (6)
Swallow, SK	University of Rhode Island, USA	11 (1.0)	1.9 (15)	4 (0.35)	1.5 (14)	4 (0.37)	1.5 (15)
Alberini, A	University of Maryland, USA	10 (0.88)	3.4 (3)	9 (0.80)	2.6 (9)	9 (0.83)	2.6 (9)

The institute is according to the address provided by the author's latest article until 2005.
TP: One author's total publications
CPP_T: Citation per publication of one author's total publications
FA: One author's publications as the first author
CPP_F: Citation per publication of one author's publications as the first author
RP: One author's publications as the corresponding author
CPP_R: Citation per publication of one author's publications as the corresponding author

For example, Bateman, IJ from University of East Anglia in UK, published 4 articles with the name "Bateman, I", and Brown, TC from US Forest Service, USA published 3 articles with the name "Brown, T", with which Brown, TC would be ranked higher. There might be another two possible problems as follows: 1) different authors have the same name, 2) authors may have different affiliations over their career. To solve these kinds of problems, an "international identity number" is proposed. Such a system would allow for easy tracking of authors based on an assigned number when they publish a paper in an ISI listed journal for the first time.

Citation analysis of article

There were 11652 citations in the total of 1432 articles for an average of 8.1 citations per article during the 15 years. Among contingent valuation research articles, the most frequently cited was 'Contingent valuation: Is some number better than no number?' This paper published by Diamond, PA & Hausman, JA (1994), in the *Journal*

of Economic Perspectives was cited 268 times since it was published to 2005. It furiously criticized the methodology of contingent valuation on credibility, and wrote that 'contingent valuation is a deeply flawed methodology for measuring nonuse values' [DIAMOND & HAUSMAN, 1994]. However, this method is still developing rapidly until now (Figure 1) and this criticism has not impeded researchers from using CV or CV-like methods [SMITH, 2004]. In addition, the most frequently cited articles since publication to 2005 of each year in the time span of 1991 to 2005 were selected as shown in detail in Table 5. There were 3 articles selected for 2004 for all of them had the same highest citations. Except for the year 1998, all the first authors were also the corresponding authors. Of all the corresponding institutes, 9 were from the USA, 4 from by the UK, 2 from Canada which were the same institute, and 1 from South Africa and Netherlands respectively. Figure 2 shows the yearly cumulative trend of citations of the most frequently cited articles since publication to 2005 of each year in the time span of 1991 to 1998. It provided a way to compare the performance of the yearly most cited articles by article life with a citation model. The article in 1994 had the most citations (268) and citation-increase speed (24 times per year). Though the article in 1998 did not have the second most total citations, it had the second highest citation-increase speed (14 times per year).

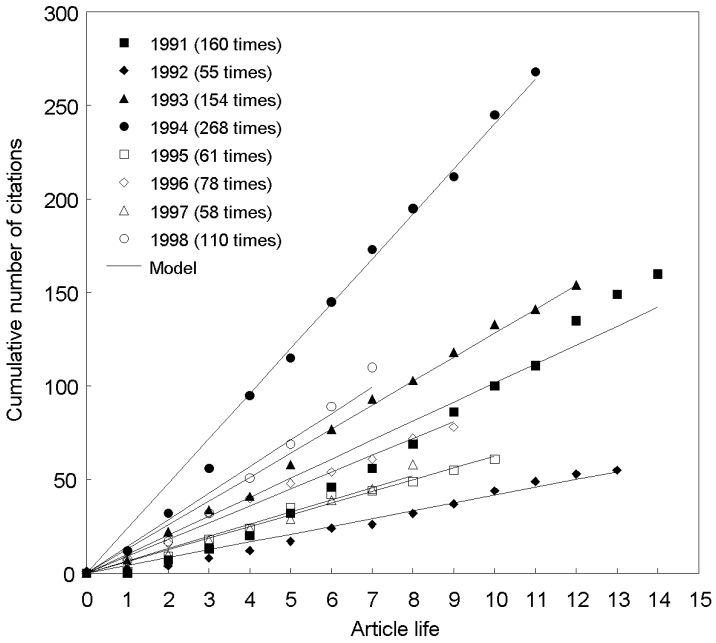

Figure 2. Yearly cumulative numbers of citations of the most frequently cited articles since publication till 2005 of each year in the time span of 1991 to 2000

Table 5. Most cited articles for each year from 1991 to 2005

Year	Title	Author	RI	C
1991	Statistical efficiency of double-bounded dichotomous choice contingent valuation	Hanemann, M*; Loomis, J; Kanninen, B	University of California, Berkeley, USA	160
1992	Combining contingent valuation and travel cost data for the valuation of nonmarket goods	Cameron, TA*	University of California, Los Angeles, USA	55
1993	Value orientations, gender, and environmental concern	Stern, PC*; Dietz, T; Kalof, L	National Research Council, USA	154
1994	Contingent valuation: Is some number better than no number?	Diamond, PA*; Hausman, JA	Massachusetts Inst. of Technology, USA	268
1995	Preferences, information and biodiversity preservation	Spash, CL*; Hanley, N	University of Stirling, UK	65
1996	When do the "dollars" make sense? Toward a conceptual framework for contingent valuation studies in health care	Obrien, B*; Gafni, A	St. Joseph's Hospital, Canada	78
1997	Using donation mechanisms to value nonuse benefits from public goods	Champ, PA*; Bishop, RC; Brown, TC; McCollum, DW	US Forest Service, USA	58
1998	Health care contingent valuation studies: A review and classification of the literature	Diener, A; O'Brien, B*; Gafni, A	St. Joseph's Hospital, Canada	110
1999	Using conjoint analysis to take account of patient preferences and go beyond health outcomes: An application to in vitro fertilisation	Ryan, M*	University of Aberdeen, UK	66
2000	Willingness to pay for a quality-adjusted life year: In search of a standard	Hirth, RA*; Chernew, ME; Miller, E; Fendrick, AM; Weissert, WG	University of Michigan, USA	81
2001	Do explicit warnings eliminate the hypothetical bias in elicitation procedures? Evidence from field auctions for sportscards	List, JA*	University of Maryland, USA	29
2002	Predictably incoherent judgments	Sunstein, CR*; Kahneman, D; Schkade, D; Ritov, I	University of Chicago, USA	25
2003	Economic value of terrestrial and marine biodiversity in the cape floristic region: Implications for defining effective and socially optimal conservation strategies	Turpie, JK*; Heydenrych, BJ; Lamberth, SJ	University of Cape Town, South Africa	15
2004	Music, pandas, and muggers: On the affective psychology of value	Hsee, CK*; Rottenstreich, Y	University of Chicago, USA	7
2004	Valuing health care using willingness to pay: A comparison of the payment card and dichotomous choice methods	Ryan, M*; Scott, DA; Donaldson, C	University of Aberdeen, UK	7
2004	On visible choice sets and scope sensitivity	Bateman, IJ*; Cole, M; Cooper, P; Georgiou, S; Hadley, D; Poe, GL	University of East Anglia, UK	7
2005	Economic valuation of informal care: The contingent valuation method applied to informal caregiving	van den Berg, B*; Brouwer, W; van Exel, J; Koopmanschap, M	Erasmus Medical Center Rotterdam, Netherlands	4

*: corresponding author
RI: Corresponding institute

Citation history

Citations of an article varied with time. The variation with article life of citation per publication for all the 1432 articles was displayed in Figure 3. During the first 3 years after the publication year the citation per publication had the rapidest increase, and reached its first peak in the 6th year, which was different from other research disciplines where the top could be shift to the 2nd year [CHIU & HO, 2005], the 3rd year [ADAMS, 2005], or the 4th year [AYRES & VARS, 2000]. The peak for the whole article life was the last point at the 14 year after the publication year, where there was an obvious uprise after keeping a declining trend since it had reached the first peak. Analyzing in detail the articles published in 1991 which determined the last point in Figure 3, among the 28 articles of 1991, 5 articles had been cited 5 or more times in 2005, and 4 articles had been cited more than 90 times until 2005. Further more, another line excluding the articles of 1991 was drawn (Figure 3), in which the first peak and the peak for the whole article life was the same point in the 6th year.

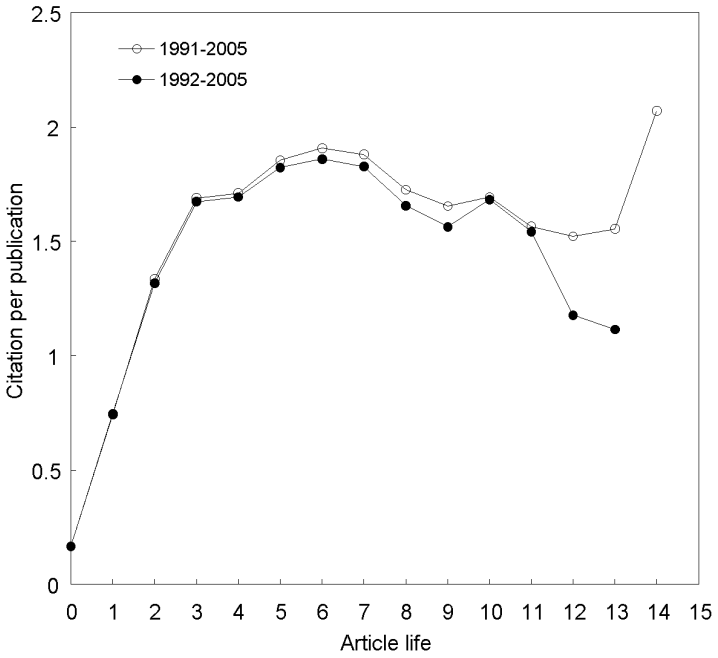

Figure 3. Variation of citation per publication with article life

Citation model

A model was reported to evaluate research performance [CHIU & HO, 2005]. The model could describe the relationship between the cumulative number of citations, C_c, and the article life, Y, and could be expressed as:

$$C_c = KY + S ,$$

where K is the citation rate (number of times cited/year), and S is the visibility potential when a paper is published (number of times cited in the published year). CHIU & HO (2005) pointed that there was a linear relationship with a high coefficient of determination for homeopathy research papers published in 1991 to 1997. A good linear relationship with a coefficient of determination (0.992) was obtained for contingent valuation research articles published from 1991 to 1998. The model can be written as:

$$C_c = 923Y - 296 .$$

The citation rate K was 923 times cited/year which meant annual total citations for articles published from 1991 to 1998. The number of citations in the published year was –296. CHIU & HO [2005] presented that S measures how quickly the "average article" in the field is cited. Then S below zero might mean articles published in the field of contingent valuation are generally not cited in the publication year and also higher citation rate would appear in later years. In fact, of the total 527 articles from 1991 to 1998, 89% were not cited in the published year, 8.3% were cited one time. These two items covers 97% of all articles. Since that, the model could be simplified as:

$$C_c = KY ,$$

which means a hypothesis that there is no citation in the publication year. This simplified model is more consistent with the case for contingent valuation research described above than the original model. With the revised model, a better linear relationship with a coefficient of determination (0.995) was obtained. The model can be rewritten as:

$$C_c = 864Y .$$

For articles published per year there were also significantly linear relationships between the cumulative number of citations and the article life (Figure 4 by the simplified model). All of the fitting curves for each year from 1991 to 1998 have coefficients of determination higher than 0.995. Articles published in 1998 had the highest citation rate. However, it should be noted that K is determined by two factors: number of articles per year and citations per article. Based on the data from 1991 to 1998, the correlation coefficient of K and number of articles per year was as high as 0.907, passed 1% significance level test. That means K increased with the increase of

the number of articles. Figure 4 basically obeyed this trend except the year 1994. Further investigation indicated that until 2005 citation per article of 1994 was 25, higher than that of the other 7 year's except the year 1991. Thus the exception of 1994 might reflect the effect of citation contribution in some degree.

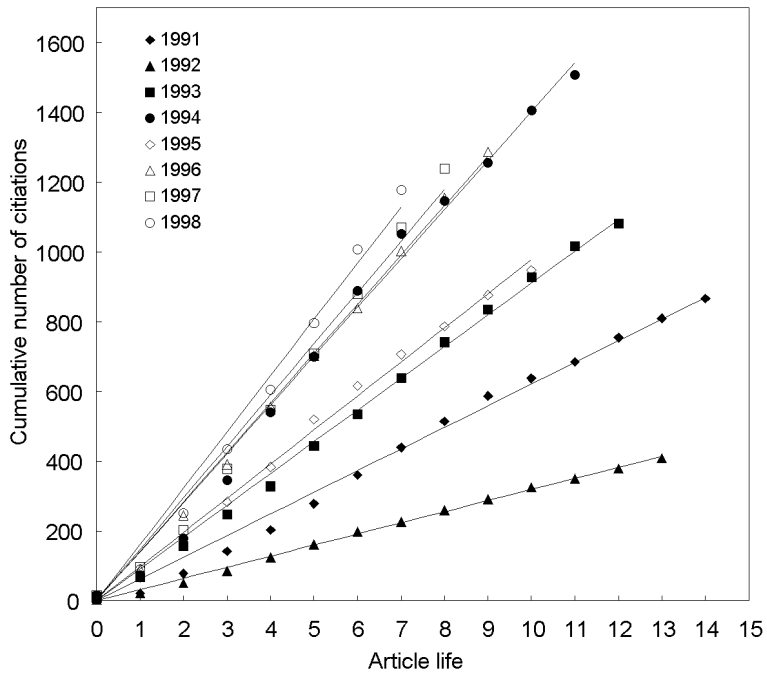

Figure 4. Relationship between the cumulative number of citations and the article life with simulated models

Conclusions

The indicator of CPP provided an effective way to assess impact of a publication. Number of articles for each year linearly increased from 1991 to 2005, but the CPP per year slightly decreased since 1997. The USA and the UK were the most productive countries, while Canada, Sweden, and Germany had higher CPP values. On average, both international and inter-institutional collaborative publications had higher impact. According to the indicator PPI, the institutes from the UK were more productive than those from the USA. The citation per publication on contingent valuation peaked at the sixth year after the publication year. Finally, a linear citation model successfully provided a way to compare the performance of the yearly most cited articles and each

year. The most cited article in 1994 had the highest citation rate, while articles published in 1998 had the highest citation rate. Moreover, initial phase of no citations was identified, and *K* value (citation rate) per year was highly correlated with annual number of articles.

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