Communications of the Association for Information Systems

CAIS

An Exploratory Study of Information Systems Researcher Impact

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Abstract:

Citation counts of refereed articles are a potentially valuable measure of the impact of a researcher's work, in the information systems discipline as in many others. Citation counts can be generated from a number of data collections, including Thomson's ISI database and Google Scholar.

This paper reports on an exploratory study of the apparent impact of IS researchers, as disclosed by citation counts of their works in those two collections. Citation analysis using currently available databases is found to be fraught with many serious problems, particularly if the ISI collection is used.

Unless these problems are appreciated and addressed, IS researchers will be under-valued by those with authority over research funding and employment, to the serious detriment of the IS discipline.

Keywords: researcher impact, citations, ISI, Google Scholar, journals, publishing venues, discipline leaders, early-career researchers

This paper was received on July 22, 2007 and was with the author for 8 days for one revision.

Volume 22, Article 1, pp. 1-32, January 2008

EXECUTIVE SUMMARY

The Thomson/ISI database is being increasingly used as a basis for citation analysis, and for generating measures of the academic impact of individual IS researchers.

The Thomson/ISI collection encompasses only about 40 percent of the publication set that is relevant to the IS discipline. In addition, it contains significant errors even within that limited collection, and the company continues to resist submissions to upgrade its holdings.

Use of the Thomson/ISI database may be appropriate for some disciplines, but it currently generates erroneous and seriously misleading results for IS researchers. At present, there are only limited prospects of the quality of the data being improved.

Google Scholar has access to a much more substantial proportion of the relevant publication set. Its holdings and services are not sufficiently transparent, but the product appears to have reached a level of maturity, and it appears to be a more appropriate basis for citation analysis.

Citation analysis can produce many impact measures, which have various advantages and disadvantages. A pair of measures that may represent a fair compromise is the so-called “h-index,” supplemented by the “h-count.” A researcher scores an h-index of 15 if they have 15 articles that have at least 15 citations. The h-count is the total citation count for all 15 articles.

The Association for Information Systems (AIS) needs to take steps to avoid ISI-based citation analysis causing serious harm to the discipline’s access to research funding and senior academic positions.

I. INTRODUCTION

Information systems (IS) is a maturing discipline, with a considerable specialist literature, and relationships with reference disciplines that are now fairly stable and well understood. In a mature discipline, various forms of “score-keeping” are undertaken. One reason for this is as a means to distinguish among applicants for promotion, and contenders for senior appointments. A further application of score-keeping is as a factor in the allocation of resources to support research. In some countries, this second application is increasingly significant.

One approach to score-keeping is to count the number of works that a researcher publishes, and treat it as a measure of research quantum. The count of works may be moderated by the time span over which they were published, the categories of publication venues (such as books, conference papers and journal articles), and the quality of the publication venues. This represents a measure of research quality rather than quantity. Yet another approach is to count the number of citations of the publications, in order to generate an indicator of the researcher's impact.

This paper performs an analysis of citations of IS researchers, in order to examine the extent to which currently available collections provide satisfactory measures of researcher impact. It is motivated by the concern that, whether or not such analyses are performed by members of the IS discipline, others will do it for us. For example, in the U.S.A, deans of graduate schools of business are understood to use citation analyses, and in the U.K., New Zealand and Australia, government departments use bureaucratic processes partly based on citation analysis as evaluation tools. If the collections are inadequate, or the techniques are inappropriate, these uses will be detrimental to the interests of individual IS researchers, and to the IS discipline as a whole.

The paper commences by discussing citation analysis and its hazards. The research objectives and research method are described. The raw scores generated from two major sources are presented, and issues arising from the analysis are identified and examined.

II. CITATION ANALYSIS

This section briefly reviews the concept of citation analysis, recent developments in the area, and its use to date in IS.

The Concept

"Citations are references to another textual element [relevant to] the citing article. . . . In citation analysis, citations are counted from the citing texts. The unit of analysis for citation analysis is the scientific paper" [Leydesdorff 1998]. Leydesdorff and others apply citation analysis to the study of cross-references within a literature, in order to document the intellectual structure of a discipline. This paper is concerned with its use for the somewhat different purpose of evaluating the quality and/or impact of works and their authors by means of the references made to them in refereed works.

Authors have cited prior works for centuries. Gradually, the extent to which a work was cited in subsequent literature emerged as an indicator of the work's influence, which in turn implied significance of the author. Whether the influence of work or author was of the nature of notability or notoriety was, and remains, generally ignored by citation analysis. Every citation counts equally, always provided that it is in a work recognised by whoever is doing the counting.

Citation analysis can be put to many purposes, including: "1) paying homage to pioneers; 2) giving credit for related work; 3) substantiating one's knowledge claims; 4) providing background reading; 5) articulating a research methodology; 6) criticizing research; and 7) correcting one's earlier work" [Garfield 1977, as reported in Hansen et al. 2006].

The use of citation counts to formally measure the quality and/or impact of works, and of their authors, is a fairly recent phenomenon. Indeed, the maintenance of citation indices appears to date only to about 1960, with the establishment of the Science Citation Index (SCI), associated with Garfield [1964]. SCI was later joined by the Social Sciences Citation Index (SSCI) and the Arts & Humanities Citation Index (A&HCI). The combination of the three services was referred to as the Institute for Scientific Information (ISI). ISI was subsequently acquired by Thomson Scientific. ISI became widely available only in 1988, on CD-ROM, and from 1997 on the Web [Meho 2007].

Recent Developments

During the late 20th century, a broader movement has developed around citation analysis, under the title *bibliometrics* or *scientometrics*. The undertaking needs to be seen within the broader context of the electronic library. This was conceived by Vannevar Bush [1945], and articulated by Ted Nelson in the 1960s as *hypertext*. As outlined in Nelson's never-completed Project Xanadu, the electronic library would include the feature of *transclusion*, that is to say that quotations would be included by precise citing of the source, rather than by replicating some part of the content of the source. The strength and weakness of the World Wide Web was its very limited form of hyperlink. As a result, the Web falls far short of the Bush/Nelson vision of a tightly linked, reliable and minimally redundant electronic library.

During the last 15 years, SCI has been the market-dominant citation database but has been subject to increasing competition. The advent of the open, public Internet, particularly since the Web exploded in 1993, has stimulated many developments. Individual journal publishing companies such as Elsevier, Blackwell, Kluwer, Springer, and Taylor & Francis have developed automated cross-linkage services, at least within their own journal sets.

Meanwhile, the open access movement is endeavouring to deliver something much closer to a cohesive electronic library, including full and transparent cross-referencing within the literature. A leading project in the area was the Open Citation (OpCit) project in 1999-2002. An outgrowth from the OpCit project, the Citebase prototype, was referred to as "Google for the refereed literature." It took little time for Google itself to discover the possibility of a lucrative new channel: it launched Google Scholar in late 2004.

It is to be expected that citation analysis will give rise to a degree of contention, because any measure embodies biases in favour of some categories of researcher and against others. Dissatisfaction with it as a means of evaluating the quality and impact of works and of researchers has a long history [Hauffe 1994; MacRoberts and MacRoberts 1997; Adam 2002].

A simple citation count, for example, favours longstanding researchers over early-career researchers, because it takes time firstly to achieve publications, second, for other researchers to discover and apply them, and third, for their publications to appear. Using citations per paper, on the other hand, favours researchers with few publications but one or two "big hits" over prolific researchers whose total count is distributed over a larger denominator. Moreover, it may only be possible to achieve a meaningful measure by taking into account the quality of the publishing venues in which the citations appear, and in which the paper itself was published.

Various proposals have been put forward for particular measures that can be used for particular purposes. Hirsch's proposal for an h-index [Hirsch 2005] has unleashed a flurry of activity. The measure is argued to balance quantity against impact. Hirsch is a physicist. Physics has a relatively very large population of academics. It also has the best-developed publication-and-citation mechanisms of any discipline, and unlike many other disciplines, it has not ceded control over its output to for-profit publishers. It appears that the values of h-index achieved, and the measure's effectiveness, are both highly dependent on the number of academics and publications in the discipline, and of course on the reliability of the citation-data.

A range of refinements to the h-index has been proposed, and are summarised by Harzing [2007]. These endeavour to balance the measure for such factors as time in the discipline, the distribution of the citation counts, the length of time since each work was published, and the number of co-authors.

Because the research reported on in this paper concludes that the h-index may provide an effective basis for converting raw citation data into meaningful information, a brief description and example is provided in Appendix 1.

Citation Analysis in IS

Within the IS discipline, there is a long history of attention being paid to citations. The primary references appear to be Culnan [1978, 1986], Culnan and Swanson [1986], Culnan [1987], Cheon et al. [1992], Cooper et al. [1993], Eom et al. [1993], Holsapple et al. [1993], Eom [1996], Walstrom and Leonard [2000], Vessey et al. [2002], Schlogl [2003], Katerattanakul and Han [2003], Galliers and Meadows [2003], Hansen et al. [2006] and Whitley and Galliers [2007]. That is a fairly short list of articles.

A brief assessment of the impact of these papers represents a valuable, preliminary case study in citation analysis. Two alternative searches were performed on the ISI database. The *General Search* (which is described later) showed that the most cited among them [Holsapple et al. 1993] had only accumulated a count of 24 in April 2006. This had risen to 30 in June 2007, unchanged in November 2007. But by then it had been overtaken by Culnan [1987], with 55.

If instead the ISI Cited Ref facility was used, and a deep and well-informed analysis conducted, then the most cited paper was established by combining several counts for a total of 61 for Culnan [1987] — up to 66 on revisit in June 2007, and 71 in November 2007.

On Google Scholar, the largest citation count in April 2006 appeared as 63, for each of Culnan [1986] and Culnan [1987]. When the test was repeated on 30 June 2007, the Culnan counts were 81 and 78, with Holsapple et al. [1993] up to 64. By November, the Culnan counts had grown to 93 and 97, but the Holsapple count had mysteriously dropped to 54. As will be shown, these are significant counts, but not outstanding ones.

The primary purposes of the research reported in the papers listed above have been to develop an understanding of the intellectual structure of the IS discipline, of patterns of development within the discipline, and of the dependence of IS on reference disciplines. In some cases, the impact of particular journals has been in focus (in particular Cooper et al. 1993, Holsapple et al. 1993 and Katerattanakul and Han 2003]. In one instance [Walstrom and Leonard 2000], highly-cited articles were the primary concern. Another, Hansen et al. [2006] reported on a deep analysis of the ways in which citing articles used (and abused) the cited paper. Galliers & Meadows [2003] used it to assess globalism and parochialism in IS research papers, and Whitley and Galliers [2007] analysed citations as a means of determining the characteristics of the European IS research community.

The aim of the research reported on in this paper is to understand the effectiveness of citation analysis, using available data collections, in evaluating the impact of individual IS researchers. The literature search conducted as part of the present project did not identify any articles which had utilised citation analysis for this primary purpose.
A number of deficiencies in the use of citation analysis for this purpose are apparent from the outset. In the course of presenting the research, more will emerge, and a consolidated list is provided at the end of the paper. Despite these deficiencies, score-keeping is increasingly being applied to the allocation of research resources. The work reported on here accordingly has significance as scholarship, but also has a political dimension.

III. THE RESEARCH PURPOSES AND METHOD

Because little prior research has been conducted in this specific area, the essential purpose was to provide insights into the effectiveness of citation analysis applied to individual IS researchers. For this reason, the process and the desiderata underlying it, have been described in considerable detail.

Because of the vagaries of databases that are organised primarily on names, considerable depth of knowledge of individuals active in IS research is needed in order to achieve a reasonable degree of accuracy. The project accordingly focused on researchers known to the author.

In-depth analysis was first conducted in relation to an extensive list of academics active from the late 1970s to 2005 in the author's country of long-term residence. This was appropriate not only as a means of achieving reasonable data quality, but also because the scale was manageable. The method and results of this part of the research are reported in Clarke [2008]. Using the expertise gained in that pilot study, similar analyses were then performed for some leading researchers in North America and Europe.

One important insight that was sought related to publishing venues. It is vital that the databases that are available to support citation analysis contain the publishing venues that are most relevant to an evaluation of IS researcher impact, and do not contain many nonrelevant venues. Rather than simply tabulating citation counts, the research accordingly commenced by establishing a list of relevant journals and conference proceedings.

The set of venues was developed by reference to the now well-established literature on IS journals and their rankings, for which a bibliography is provided at Saunders [2005]. Consideration was given to the lists and rankings there, including the specific rankings used by several universities, and available on that site. Details of individual journals were checked in the most comprehensive of the several collections [Lamp 2005]. In parallel with this research, the international body of IS researchers, the Association for Information Systems (AIS) has addressed concerns within the USA about inappropriate valuations of IS publications by the Deans of Graduate Schools of Business. In addition, ranking lists for IS journals relevant to IS in Australia were developed by Fisher et al. [2007] and subsequently the Australian Council of Professors and Heads of Information Systems (ACPHIS). The ACPHIS list contains 182 IS journals, allocating nine as A+ (limited by Australian government Rules to 5 percent of the total), 29 A, 32 B and 112 C-grade journals. There is broad correspondence among these several lists, but there are also many specific differences.

The set selected is listed in the first two columns of Exhibit 1. (The remainder of the columnar format will be explained shortly). The inclusions represent a fairly conventional view of the key refereed journals on the management side of the IS discipline. The list significantly underrepresents those journals that are in reference disciplines generally, especially in computer science and at the intersection between IS and computer science. The reason for this approach is that otherwise a very large number of venues would need to be considered, and many included, in which the large majority of IS researchers neither read nor publish.

Less conventionally, the list separates out a few “AA-rated” journals and divides the remainder into general, specialist and regional journals. The purpose of this was to enable evaluation of the coverage of the data collections in relation to the top stratum of IS-relevant journals, as well as IS journals generally. There is, needless to say, ample scope for debate on all aspects of the selection and classification, but it was designed to aid the analysis, and did so.

It can be argued that papers accepted for the major refereed conferences should be included within the scope of IS citation analysis. This applies in particular to the international and regional events that are accessible and indexed in the Association for Information Systems' AIS eLibrary. For pragmatic reasons, however, the analysis focussed primarily on journal papers.

As the next step, a survey was conducted of available data collections. It was clear that Thomson / ISI needed to be included, because it is well known and would be very likely to be used by evaluators. Others considered included:

- Elsevier's Scopus;
- The Computer Science Bibliography, at Universität Trier;
- CiteSeer Scientific Literature Digital Library, at Penn State University;
- The Collection of Computer Science Bibliographies, at Universität Karlsruhe;
- Google Scholar.

Elsevier's Scopus has only been operational since late 2004. The next three are computer science indexes adjacent to IS, and at the time the research was conducted the last of them was still experimental. The decision was taken to utilise Thomson/ISI, and to extract comparable data from Google Scholar. A more comprehensive project would be likely to add Scopus into the mix.

The third and fourth columns of Exhibit 1 show whether the journal is included in the Thomson/ISI SCI or SSCI Citation Indices. The final column shows the inferences drawn by the author regarding the extent of the Thomson/ISI coverage of the journal. Many problem areas were encountered, are reported on below, and are highlighted in the final column of Exhibit 1 in bold-face type. Only 15 of the 30 IS journals are represented, many only partially. The coverage is further considered later in greater depth.

Exhibit 1: Refereed Venues Selected

Journal Name	Journal Abbrev.	SSCI	SCI	Issues Included
AA Journals (3)				
Information Systems Research	ISR	Y		**Only from 1994, Vol. 4 ?**
Journal of Mngt Info. Syst.	JMIS	Y		**Only from 1999, Vol. 16**
Management Info Syst. Qtly	MISQ	Y		**Only from 1984, Vol. 8**
AA Journals in the Major Reference Disciplines (4)				
Commun ACM (Research Articles only)	CACM		Y	From 1958, Vol. 1
Management Science	MS	Y		From 1955, Vol. 1
Academy of Management Journal	AoMJ	Y		From 1958, Vol. 1
Organization Science	OS	Y		From 1990, Vol. 1?
A Journals – General (9)				
Communications of the AIS	CAIS			**None**
Database	Data Base	Y		**Only from 1982 Vol. 14?**
Information Systems Frontiers	ISF		Y	**Only from 2001, Vol. 3**
Information Systems Journal	ISJ	Y		**Only from 1995, Vol. 5**
Information & Management	I&M	Y		**Only from 1983, Vol. 6**
Journal of the AIS	JAIS			**None**
Journal of Information Systems	JIS			**None**
Journal of Information Technology	JIT	Y		**Only 18 articles**
Wirtschaftsinformatik	WI		Y	**Only from 1990, Vol. 32**
A Journals – Specialist (15)				
Decision Support Systems	DSS		Y	From 1985, Vol. 1
Electronic Markets	EM			**None**
Int'l Journal of Electronic Commerce	IJEC	Y		From 1996, Vol. 1
Information & Organization	I&O			**None**
Information Systems Management	ISM	Y		**Only from 1994, Vol. 11**
Information Technology & People	IT&P			**None**
Journal of End User Computing	JEUC			**None**
J. of Global Information Management	JGIM			**None**
J. of Infor. Systems Education	JISE			**None**
J. of Infor. Systems Management	JISM			**None**
J. of Management Systems	JMS			**None**
J. of Org'l and End User Computing	JOEUC			**None**
J. of Org'l Computing & E-Commerce	JOCEC			**None**
J. of Strategic Information Systems	JSIS		Y	From 1992, Vol. 1 ?
The Information Society	TIS	Y		**Only from 1997, Vol. 13**
A Journals – Regional (3)				
Australian J. of Information Systems	AJIS			None
European J. of Information Systems	EJIS		Y	**Only from 1995, Vol. 4**
Scandinavian J. of Infor. Systems	SJIS			None

In assembling a list of individuals as a basis for research of this nature, there are challenges to be overcome. When determining the set of IS academics in a particular country, immigration, emigration and expatriates create definitional challenges. People enter and depart from the discipline. Topic areas do as well. For example, the various specialisations within software engineering since about 1980 can be defined to be within the IS discipline, outside it, or both, depending on the phase of history being discussed.

There are overlaps with the Computer Science discipline, with various management disciplines, and with the IS profession. One indicator of the IS discipline's diversity is that, of the 15/30 IS journals that are within-ISI, six are in SCI (science) and nine are in SSCI (social science).

For the preliminary Australian study, a comprehensive list of individuals active in IS research from 1978 to 2000 was established, as described in Clarke [2008].

For the international researchers, on the other hand, the selection process was purposive. It favoured uncommon surnames, and individuals whose work was reasonably familiar to the author of this paper. The purpose of adopting this approach was to reduce the likelihood of data pollution through the conflation of articles by multiple academics. The selection of a sample of 25 people relied on this author's longstanding involvement in the field internationally, and his knowledge of the literature and the individuals concerned. The use of a sample of this nature clearly precludes any claims of external validity. In an exploratory study of this nature, that was perceived by the author to be an appropriate approach to adopt, and compromise to accept.

Data was extracted from the SCI and SSCI citation indices over several days, for the preliminary Australian study in late January 2006 and for the main study in April 2006. Access was gained through the ANU Library Reverse Proxy, by means of Thomson's "Web of Science" offering. Both sets of searches were restricted to 1978-2006, across all Citation Indices (SCI, SSCI and A&HCI). Multiple name spellings and initials were checked, and where doubt arose were also cross-checked with the AIS eLibrary and the (A)ISWorld Faculty Directory.

Subsequently, Google Scholar was searched for each researcher. Supplementary research was then undertaken within the Thomson/ISI database. These elements were performed in respectively early and late April 2006. It was apparent from retesting that the contents of the ISI database and hence the citation counts were accumulating at a modest rate. The Google Scholar data, on the other hand, grew rapidly, and, unlike ISI, ongoing changes were apparent in both the scope of the Google collection and the Google service.

Some re-sampling was undertaken in June 2007, in order to provide information about the stability of the data collections, and the rate of change of citation counts. Further experiments were performed, in order to enhance understanding of the quality of the counts. The next section reports on the results of the Thomson/ISI study.

IV. THOMSON/ISI

Thomson/ISI is accessible as three elements of the Web of Science product. In January 2006, the site stated that SCI indexed 6,496 journals (although some are proceedings), and that SSCI indexed 1,857 journals. On 2 July 2007, the corresponding figures appeared to be 6,700 and 1,986. The company's policies in relation to inclusion (and hence exclusion) of venues are explained at http://scientific.thomson.com/mjl/selection/. An essay on the topic is at Thomson [2005].

The processes of extraction and analysis required some experimentation. A discussion is provided in Appendix 2. The following subsection presents the results of the pilot citation analysis using the ISI General Search feature. Further subsections evaluate the quality of the data and report on further analysis using the ISI Cited Ref Search.

Citation Counts for a Few Leading International IS Academics

Exhibit 2 shows the resulting data for some well-known leaders in the discipline in North America and Europe. 25 individuals were selected. A threshold of 100 total citations was applied (for reasons relating to the Australian study, and explained in Clarke 2008]. This resulted in a list of 16 people whose data are reported following.

The relatively low counts of the leading European academics are interesting. Rather than undertaking a necessarily superficial analysis here, the question is left for other venues. But see Galliers and Meadows [2003] and EJIS [2007].

Quality Assessment

An important focus of this exploratory study concerned the effectiveness of the available databases in reflecting the extent to which the individuals concerned were actually cited. This subsection reports on several tests that were applied, which identified a substantial set of deficiencies.
The ISI collection's coverage does not extend to all journals that are perceived by each discipline to comprise the relevant publication-set. Not only are the decisions made solely by the company, but the criteria and process are not transparent. This inevitably results in misleading citation counts.

In the case of the IS discipline, the effect appears to be that only six of the 30 core IS journals are included in their entirety, with a further nine included in part. As a result, it appears that only about 40 percent of the papers that have been published in the IS journals in Exhibit 1 are included within an ISI citation analysis.

Exhibit 2: ISI Data for a Few Leading International IS Academics

CAVEATS:

1. The data was gathered in January 2006.
2. For reasons that are discussed later in this paper, there are strong arguments for not utilising the data in this table, and for not utilising the ISI General Search, as a basis for assessing the impact of individual researchers or individual articles
3. The selection of individuals is emphatically not an attempt to identify the "intellectual leaders" in the IS discipline (which would require a much more careful and rather different research design). People were chosen who the author considered (a) were likely to have relatively high counts, but crucially also (b) had distinctive names, and (c) were known to the author, in order to reduce the risks of conflating their publications with those of other people, and of overlooking relevant publications.
4. The count for Eph McLean is particularly seriously understated, and that for Sal March probably also. The reasons are important, and are addressed later in this paper.

	Citation Count	No.of Articles	Largest Per-Article Count
North American			
Lynne Markus (as ML)	1,335	39	296
Izak Benbasat (as I)	1,281	71	155
Dan Robey (as D)	1,247	45	202
Sirkka Jarvenpaa (as SL)	960	40	107
Detmar Straub (as D and DW)	873	49	160
Rudy Hirschheim (as R)	600	44	107
Gordon Davis (as GB)	428	48	125
Peter Keen (as PGW)	427	21	188
** Sal March (as ST)	190	29	37
** Eph(raim) McLean (as E and ER)	119	30	31
Europeans			
Kalle Lyytinen (as K), but in the USA since 2001	458	55	107
Leslie Willcocks (as L)	231	42	28
Trevor Wood-Harper (as T, AT and TA)	200	26	50
Bob Galliers (as RD, R and B), but in the USA since 2002	185	37	25
Guy Fitzgerald (as G)	121	50	38
Enid Mumford (as E)	103	21	42

A test was conducted to gain further insight into the comprehensiveness of coverage. An exhaustive search was undertaken for all refereed publications of a single author. The results were as follows:

- of the selected author's 25 papers in the core 30 IS journals, ISI had only 13 – although a 14th appeared to be missing in error (52%);
- of the author's 36 papers in IS-relevant journals, the coverage was still only 13 (36%).

- of the author’s 63 papers in refereed venues, 15 were in ISI (24%).

These venue-exclusion issues are discussed in greater detail in Appendix 3A.

The inverse problem exists as well, in that some categories of material are inappropriately included, resulting in the inflation of the item-counts and citation counts of some authors. In the comprehensiveness test referred to immediately above, ISI was found to contain seven non-refereed items for the selected author, in comparison with only 13 of 36 journal articles and a further two of 27 refereed conference papers. Further discussion is provided in Appendix 3B.

Multiple problems were encountered in relation to the way in which ISI handles authors’ names. The initial(s) used by and for authors can seriously affect their discoverability. Publications in languages other than English are excluded. ISI does not support diacritics. Apostrophes within names are handled inconsistently. And compound surnames separated by hyphens and spaces lead to uncertain outcomes. This is discussed in Appendix 3C.

The low counts for several well-known scholars were surprising. Experiments were conducted. The most revealing related to Delone and McLean's “Information Systems Success: The Quest for the Dependent Variable.” This is discussed further following, and in Appendix 3D.

A re-check of a sample of searches was performed in June 2007. It appeared that the ISI collection was fairly stable during the intervening 14 months, with the only additional items detected being papers published after early 2006. There was a moderate growth in the counts during this time, e.g. 25 percent for Peter Weill and 39 percent for the author of this paper (although from a base only one-quarter of Peter Weill's count).

An Alternative Method

The ISI service enables at least two other approaches to citation analysis to be adopted. They are discussed in Appendix 2. One of them, the Cited Ref Search, was applied. It provides citation counts for papers that are not included in the General Search. These are citations *within* papers in the ISI collection to papers that are *not* in the ISI collection. This search was used to extract data for a sub-sample of researchers in each category. In order to investigate the impact on researchers whose total citation counts fall behind the leading pack, several researchers were included in the subsample whose counts in the previous round fell below the 100 threshold.

Exhibit 3 provides the results of this part of the study. The first three columns of the table show the number of citations for each author of articles that are in the ISI database, together with the count of those articles, and the largest citation count found. (This data should correspond with that for the same researcher in Exhibit 2, but in practice there are many small variations, mainly arising from the three-month gap between the studies that gave rise to the two tables). The next three columns show the same data for articles that are not in the ISI database. The final two columns show the sum of the two Citation Count columns, and the apparent Expansion Factor (computed by dividing the Total Citations by the Citation Count for articles in the ISI database).

The data in Exhibit 3 enables the following inferences to be drawn:

- Researchers with very high citation counts for articles published in ISI venues also tend to have substantial numbers of citation counts within ISI for articles that they have published in non-ISI venues (e.g. Sirkka Jarvenpaa's count was 60 percent higher);
- Researchers much of whose material is relevant to the IS profession and management may have very large citation counts within ISI for articles that they have published in non-ISI venues (e.g. Peter Keen's count was higher by a factor of 5, and so were those for Ron Stamper and the author of this paper, i.e. all three have four times as many ISI citations for articles published outside ISI venues as for articles within ISI's collection-scope);
- Researchers who came into IS from an established social science or management discipline may have only limited additional ISI citations of papers in non-ISI venues, because most of their publications are already counted by the General Search (e.g. Philip Yetton).

Dependence on the General Search alone provides only a restricted measure of the impact or reputation of an academic. Moreover, it may give a seriously misleading impression of the impact of researchers who publish in non-ISI venues such as journals targeted at the IS profession and management, and books. To the extent that citation analysis of ISI data is used for evaluation purposes, a method needs to be carefully designed that reflects the objectives of the analysis.

Butler and Visser [2006] argue, however, that an antidote is available. On the basis of a substantial empirical analysis within the political science discipline, they conclude that the ISI collection can be mined for references to many types of publications, including books, book chapters, journals not indexed by ISI, and some conference publications. Replication of the study in the IS context would be needed before firm conclusions could be drawn.

Exhibit 3: ISI General Search cf. Cited Ref Search, April 2006

	------- In ISI Database -------			---- Not in ISI Database ----				
Researcher	Citation -Count	Article -Count	Highest Cite-Count	Citation -Count	Article -Count	Highest Cite-Count	Total Cit'ns	Expn Factor
Sirkka Jarvenpaa	973	34	110	575	118	88	1548	1.6
Peter Keen	425	14	190	1625	325	463	2050	**4.8**
Eph McLean	132	14	41	84	29	42	216	1.6
Corrected	132	14	41	532	20	448	664	**5.0**
	---	---	---	---	---	---	---	---
David Avison (D)	66	9	46	99	37	16	165	2.5
Ron Stamper (R, RK)	59	13	16	255	149	19	314	**5.3**
Frank Land (F)	74	16	19	161	88	25	235	3.2
	---	---	---	---	---	---	---	---
Iris Vessey	622	32	114	186	52	76	808	1.3
	---	---	---	---	---	---	---	---
Philip Yetton	278	20	59	65	51	6	343	1.2
Peter Seddon (P, PB)	81	4	69	67	30	22	148	1.8
Graeme Shanks (G)	66	10	15	51	32	7	117	1.8
Paula Swatman (PMC)	43	4	31	102	39	23	145	3.4
Roger Clarke (R, RA)	41	11	17	176	131	8	217	**5.3**
Guy Gable (GG)	35	4	29	73	24	39	108	3.1

Another alternative, an upstart competitor to ISI, is considered in the following section.

V. GOOGLE SCHOLAR

Although Google Scholar was introduced in 2004, it is still an experimental service. From a bibliometric perspective, it is crude, because it is based on brute-force free-text analysis, without recourse to metadata, and without any systematic approach to testing venues for quality before including them. Google's data and processes are new, in a state of flux, unaudited, and even less transparent than ISI's. Considerable caution must therefore be applied in using Google Scholar as a means of assessing researcher impact. On the other hand, it has the advantages of substantial depth, ready accessibility, and popularity. It is inevitable that it will be used as a basis for citation analysis, and therefore important that it be compared against the more formal ISI database.

The approach adopted necessarily differed from that taken with ISI. A trial was undertaken in an attempt to achieve an exhaustive count of all papers, but the nature of the data and the limited granularity of Google's search tools make it a very challenging exercise. Two techniques were developed. One involves the extraction of only the "top 10" of each author's citation counts. The other applies the h-index. In that case, the effort involved for each researcher is proportional to the impact of their research. A discussion of the research approach is in Appendix 4.

The following subsections examine leading researchers, then the middle ground of researchers and early-career researchers. This is followed by an assessment of quality, and of citation-count patterns.

Google and Leaders

Google was assessed as a potential vehicle for score-keeping by extracting and summarising Google citations for the same sets of academics as were reported on in Exhibit 2. The sequence in which the researchers are listed is the same as in the earlier Exhibit. This part of the analysis was conducted in June 2007.

The data shown in Exhibit 4 comprises Hirsch's h-index, the h-count (i.e. the citation count for the researcher's publications that were included in the h-index), and the largest per-item count found in that set.

Citation analysis based on Google Scholar data provides deeper and potentially much richer information. The Google h-count for most of the sample was 2.5 to six times that of the ISI total citation count, with outliers at 7.5 to 10 times. (The ISI count for Eph McLean is an anomaly, and is discussed below). Similarly, the largest single-item count based on Google Scholar data was in almost all cases two to six times that for ISI. Within the sample, the apparent sequencing of researchers was somewhat different, but among the top 10 of the 16 only at the margin. As reported in Clarke [2008], the relationship was similar for the leading seven Australian and four Australian-expatriate researchers.

On the basis of experimentation described in Appendix 5, it would appear that fully automated citation analysis would be very challenging, but that automated support tools are feasible, even for people whose names clash with others in the database.

Exhibit 4: Google Data for A Few Leading International IS Academics

CAVEATS:
1. This data is based on an experimental service, and a collection of undeclared extent, which appeared to be changing during the course of the study, most of which was undertaken in June 2007.
2. The scores for researchers marked with asterisks may be seriously understated due to the non-inclusion of the proceedings of conferences at the technical end of the IS discipline.

	h-Index	Citation Count of h Items	Largest Per-Item Count
North American			
Lynne Markus	36	4,664	591
Izak Benbasat	36	4,589	790
Dan Robey	33	3,245	539
Sirkka Jarvenpaa	34	4,406	635
Detmar Straub	23	2,708	405
Rudy Hirschheim	33	3,159	326
Gordon Davis	21	2,327	484
Peter Keen	21	2,012	350
** Sal March	11	472	187
Eph(raim) McLean	18	1,950	1,166
Europeans			
Kalle Lyytinen, USA since 2001	31	2,511	285
Leslie Willcocks	34	2,286	208
Trevor Wood-Harper	15	779	199
Bob Galliers, USA since 2002	24	1,411	161
Guy Fitzgerald	16	1,034	518
Enid Mumford	21	1,286	178

Google and the Middle Ground

For leading IS academics, ISI provided results that were incomplete and misleading, but not entirely untenable, at least in the sense that the relativities among members of the sample are roughly maintained across the ISI and Google measures. ISI was of very limited value, however, for researchers outside the narrow band of well-established leaders with multiple publications in AA journals.

The Google Scholar data is deeper and finer-grained than that extracted from ISI. A test was therefore undertaken to determine whether meaningful impact measures could be generated from Google citation counts for the next level of researchers. This was done using a purposive sub-sample of Australians and is reported on in Clarke [2008]. The conclusions were that the data provides an effective means of identifying middle-ground researchers, but may still be too shallow to support comparisons among middle ground researchers.

Google and Early-Career Researchers

It would be seriously problematical if citation counts were used as the primary basis for resource allocation, because citation analysis is inherently biased towards established researchers, and represents a severe barrier to entry for the next generation. There has to be some “rite of passage” whereby new leading researchers can emerge.

On the one hand, it would appear to be futile to depend on the historical record of citations to play a part in that rite of passage, because of the long lead-times involved, and the challenges of performing research without already having funding to support it. Nonetheless, it appeared to be necessary to perform some experimentation, to see whether some metric might be able to be devised. For example, if the data were sufficiently finely grained, it might be feasible to use econometric techniques to detect citation-count growth patterns. Alternatively, counts of article downloads might be used [Harnad and Brody 2004].

A modest sample of early-career researchers was prepared, who had come to the author's notice through multiple refereed publications and award-winning conference papers. All suffered the same problem within the Google Scholar collection that even middle-ground researchers suffered within ISI: the data was simply too shallow to enable any meaningful analysis to be performed.

A separate study provides complementary data. Hansen et al. [2006, Figure 1] shows the timeline of citations of Markus [1983] — a paper that in November 2007 had an ISI citation count of 335 (up from 296 in January 2006] and a Google Scholar citation count of 616. The distribution was roughly symmetrical over its first decade, peaking after five years, with total citations about five times the count in its peak year (although the measures are confounded by a “mid-life kicker” published in its sixth year). A total of nine citations in the first 2-1/2 years indicates no early signs of the article becoming a classic, and hence the author's subsequent eminence could not have been predicted at that time by an analysis of citation counts for this article.

Further research is needed, but citation-analysis appears to be an unpromising way of discovering “rising stars.”

Cross-Comparison Quality Testing

A number of experiments were undertaken in order to gain an insight into the accuracy and reliability of ISI results, by means of comparison with Google Scholar results. The experiments are described in Appendix 6.
The conclusions are as follows:

- ISI fails to contain a number of papers that, under its own terms, it should contain;
- ISI omits many papers that are highly-cited in the IS literature. The relationship between Google Scholar h-counts and ISI total citation counts exhibits wide variations among researchers. In the sample of Australian researchers used, it varied from 1.15 to almost 9. Among international researchers, two apparent anomalies were investigated, showing that the multipliers for Ron Stamper and David Avison were both about 18;
- An apparent data-capture error in the ISI database results in one of the most highly cited of all IS papers (Delone and McLean's “Information Systems Success: The Quest for the Dependent Variable”) not being visible under Eph Mclean’s name.

Together with evidence elsewhere in this paper, the inference is that it would be seriously inappropriate to use ISI’s data collection as a basis for citation analysis to support the evaluation of the impact of IS researchers.

Citation-Count Patterns

How many citations does a paper need in order to be considered to have had a moderate, high or outstanding impact? Several assessments were undertaken, and are reported on in Appendix 7, with implications discussed in the following section.

Another aspect of interest is the delay factor before citations begin to accumulate. Some insight was gained from an informal sampling of recent MISQ articles, supplemented by searches for the last few years' titles of this author's own refereed works. A rule of thumb appears to be that there is a delay of six months before any citations are detected by Google, and of 18 months before any significant citation count is apparent. The delay is rather longer on ISI General Search. This is to be expected, because of the inclusion of edited and lightly refereed venues in Google, which have a shorter review-and-publication cycle than ISI-included journals, most of which are heavily refereed. Further understanding of citation accumulation patterns will depend on the development and repeated application of disciplined extractions from the citation services.

VI. Implications

Reputation and impact are highly multi-dimensional constructs. Mechanistic reduction of a complex, multi-dimensional reality to a single score is morally dubious, intellectually unsatisfying, and economically and practically counter-productive. On the other hand, the frequency with which a researcher's publications are cited by other authors is a factor that an assessment of reputation would ignore at its peril.

This paper has presented an evaluation of the effectiveness of citation analysis of IS researchers' impact on their peers by means of two major data collections. This section draws implications in the following areas:

- the quality (or rather lack of quality) of the ISI data collection;
- the potential impact of that lack of quality on the IS discipline;
- ways of minimising the negative impacts arising from the lack of quality of data collections;
- actions that the Association for Information Systems should consider.

Deficiencies in Citation Collections

The research presented in this paper has demonstrated that there are enormous problems to be confronted in applying currently available databases to citation analysis as a measure of IS researcher impact. Two aspects are highlighted as follows, and expanded upon in Appendix 8.

The most significant concern relates to the coverage of the data collection that is used as the basis for citation analysis. ISI contains at best only 40 percent of the core body of IS publications, and arguably a lower proportion that that. The ISI collection also has significant quality problems. Google Scholar's content appears to be much more extensive, but its collection rules and business processes are even less transparent than ISI's.

A second major concern is the difficulties involved in generating an accurate count. Some of the difficulties are unavoidable (e.g. duplications of names). Others arise because of data quality problems, data-encoding problems (e.g. for diacritics and hyphens), and name-variants.

The Impact of ISI's Deficiencies on I.S.

Some of the deficiencies of the ISI data collection appear likely to fall fairly evenly on all disciplines (e.g. the apparent incompleteness of journals that are claimed to be indexed, and the failure to differentiate refereed from unrefereed content in at least some journals).

Other impacts are likely to vary significantly between disciplines. Those that are well-established, focus on relatively stable phenomena, have recognition, have friends in high places, and have large numbers of active members, appear likely to have their journals well represented in the ISI collection.

IS deals with rapidly mutating phenomena. The count of IS researchers is comparatively small — c. 2,000-4,000 actively publishing researchers worldwide. Few IS researchers have achieved levels of influence, either intellectual or political, beyond the IS discipline. IS journals have struggled to gain acceptance in the ISI lists.

Based on those criteria, IS is an outsider looking in. IS researchers have only a small proportion of their journals in the collection, representations on behalf of well-reputed IS journals have been declined by Thomson on multiple occasions, and there is little prospect of that changing. It appears only reasonable to conclude that citation analysis based on ISI data will indicate to people in authority, and will continue for the foreseeable future to indicate to them, that both individual IS researchers and the discipline as a whole are poorly performed.

Moreover, the deficiencies result in differential effects on individual researchers. ISI's data-holdings are highly conservative, and the barriers to entry work against the interests of people working in new subdisciplines and research domains.

Citation analysis, in particular using the ISI data collection, is becoming institutionalised as a means of evaluating research impact. It is a norm in US graduate schools of business, where a large proportion of North American IS researchers are employed. ISI is a readily available tool for the government bureaucracies in the U.K., New Zealand, and Australia that evaluate researcher impact — and had been formally adopted by the relevant Australian government department for the 2008 "Research Quality Framework" round of evaluations (although the change of Government on 24 November 2007 may have resulted in a stay of execution).

These uses of citation analysis directly influence the distribution of research funding, and in some contexts the allocation of resources within universities and senior appointments. In short, the IS discipline stands to lose a great deal from the deficiencies of the ISI data collection.

Coping Mechanisms

It is inevitable that citation analysis will be used in ways that are harmful to the interests of IS researchers. So it would be prudent for the IS discipline to develop and publish norms that will mitigate the harm. External evaluators can be legitimately challenged, if necessary through legal process, if they blindly apply general rules to a discipline that has established and well-grounded evaluation processes.

Exhibit 5 suggests heuristics emerging from the analysis reported on in this paper.

Exhibit 5: Heuristics Arising from the Study

- Apply citation analysis only to researchers whose career is sufficiently advanced (e.g. 7-10 years after completion of their doctorate), and not to early-career researchers.
- Do not apply citation analysis results in a manner harmful to the interests of an individual researcher without first providing them with the opportunity to review the data, identify omissions and anomalies, and submit supplementary information.
- Do not use ISI data, unless and until the coverage has improved from its current c. 40 percent of the core IS publications set to in excess of 80 percent.
- Strongly resist the use of any single measure, because of the substantial and unpredictable biases any such measure entails. A possible small set of measures that provide greater balance is discussed in Appendix 9.
- If a short list of measures is necessary, use the Google Scholar h-index and h-count, as described in Appendix 1.

Actions the A.I.S. Can Take

The discipline as a whole, through its professional body the Association for Information Systems (AIS), could undertake steps that would be instrumental in the emergence of an effective framework for score-keeping.

Exhibit 6 identifies actions that the AIS can take, which arise from the analysis conducted in this paper. They are discussed at greater length in Appendix 10.

Exhibit 6: Action Items for AIS

- Representations to Thomson regarding the inclusion in the collection of the missing c. 60% of the ISI discipline's publication set. The representations need to relate to a publication set that reflects the needs of the discipline internationally, and not only the interests of U.S. researchers.
- A project to devise a search and scoring method for IS researchers, based on a list of each person's published items, and resulting in an ordered list of citation counts, an analysis of them, and links to the citing items.
- A project to establish indicators of the citation-count thresholds at which refereed papers could be regarded as being "a classic" (suggested on the basis of this study as being currently a Google Scholar citation count of 500), a high-impact article (75) and a significant-impact article (40).
- A project to establish indicators of the thresholds at which individual researchers could be regarded as being in the leadership group or in what was pragmatically referred to in this paper as the middle ground. The suggested measures for leadership arising from this study are a Google Scholar h-index of 25 and an h-count of 1,500, and for the middle ground of 15 and 500.

VII. Conclusions

There may be a world in which the electronic library envisioned by Bush and Nelson has come into existence, and in which all citations can be reliably counted, traced, and evaluated.

Back in the real world, however, the electronic library is deficient in a great many ways. It is fragmented and very poorly cross-linked. And the interests of copyright owners (including discipline associations but particularly the for-profit corporations that publish and exercise control over the majority of journals) are currently building in additional and substantial barriers rather than working towards integration. It remains to be seen whether the barriers will be broken down, perhaps by the communitarian open access movement, or by the new generation of corporations spearheaded by Google.

Simplistic application of raw citation counts to evaluate the performance of individual researchers and of research groupings would disadvantage some disciplines, many research groupings, and many individual researchers.

The IS discipline is highly exposed to the risk of simplistic application of citation analysis. For the many reasons identified in this paper, citation counts will suggest that most IS researchers fall short of the criteria demanded for research funding and senior academic posts. As a result, the IS discipline in at least some countries is confronted by the spectre of reduced access to research funding, because of the application of citation analysis to an inadequate data collection.

Citation analysis is currently a very blunt weapon, which should be applied only with great care, but which appears very likely to harm the interests of the less politically powerful disciplines such as IS. Concerted action is needed by the IS discipline, through its professional body.

Acknowledgements

The work reported on in this paper was conducted within the context of a major collaborative project on the IS discipline, led by Guy Gable and Bob Smyth at QUT. The report on IS in Australia was published in a special Issue of the *Australian Journal of Information Systems* 14, 1 [AJIS 2006]. The report on IS in Pacific Asia was published as a special Issue in *CAIS* (2007].

Dave Naumann provided assistance in relation to data from the AISWorld Faculty Directory. The paper has benefited from feedback from colleagues within and beyond the team. All researchers mentioned in the paper were invited to comment on the draft and many of their suggestions have been incorporated. Comments by Peter Seddon of the University of Melbourne and Linda Butler of the ANU were particularly valuable. The work of the CAIS Editor and reviewers resulted in substantial restructuring and enhancement of the paper, for which I am very grateful.

Responsibility for all aspects of the work rests, of course, entirely with the author.

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APPENDICES

APPENDIX 1: The H-Index

This appendix provides a brief overview of the h-index that was proposed in Hirsch (2005). It has attracted considerable attention in the bibliometric literature, and has potential as a means of evaluating the impact of IS researchers on other researchers. The formal definition provided by Hirsch is:

A scientist has index h if h of his/her N_p papers have at least h citations each, and the other (N_p – h) papers have no more than h citations each.

Less formally, a person with an h-index of 21 has published 21 papers that have at least 21 citations each.

Computation of the h-index involves the following steps:

1. Acquire a list of a person’s publications, including the citation count for each;
2. Sort the publications in descending order of citations;
3. Count down them until the publication-count matches or exceeds the citation count.

The following is an example of data extracted from Google Scholar for a particular IS researcher. The citation counts were:

`518, 219, 199, 56, 56, 51, 43, 22, 21, 19, 17, 17, 16,` **`15, 13,`** `12, 12, 11, ...`

Counting down this sequence resulted in the following:

`1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13,` **`14, 15,`** `16, 17, 18, ...`

Inspection of the two series shows that the 14th count is 15, and the 15th is 13. The 14th qualifies, but the 15th does not. Hence the author’s h-index is 14.

A potentially useful complementary measure is the total citation count of the papers in the h-index. In this case, it is 1,269.

Harzing [2007] provides a software tool called Publish or Perish, which computes the h-index and various other indices based on citation searches conducted using Google Scholar.

APPENDIX 2: The Research Method for the Thomson/ISI Analysis

The data collected for each of the authors was the apparent count of articles, and the apparent total count of citations.

The ISI site provides several search techniques. The search technique used in the first instance was the **General Search**. It was selected partly because it is the most obvious, and hence the most likely to be used by someone evaluating the apparent contribution of a particular academic or group of academics. It is also the most constrictive definition available, and hence could be argued to be the most appropriate to use when evaluating applicants for the most senior or well-endowed research appointments.

The ISI General Search provides a list of articles by all authors sharing the name in question, provided that they were published in venues that are in the ISI database. For each such article, a citation count is provided, which is defined as the number of other articles in the ISI database that cite it. (It should be noted that although the term “citation” is consistently used by all concerned, the analysis appears to actually utilise the entries in the reference list provided with the article, rather than the citations that appear within the text of the article).

The search terms used in this study comprised author-surname combined with author-initial(s), where necessary wild-carded. Where doubt arose, AIS resources and/or the researcher's home page and publications list were consulted. No researchers were detected in the sample who had published under different surnames, but multiple instances were detected in which initials varied. The date range was restricted to 1978 onwards. Each list that was generated by a search was inspected, in order to remove articles that appeared to the author to be by people other than the person being targeted.

Experiments conducted with Hirsch's h-index showed it to be impracticable, because of the many problems with the ISI data, particularly the misleadingly low counts that arise for all IS academics, and especially for those who are not leading researchers.

The extraction and analysis process was first applied to Australian IS researchers. For researchers with common names, the search-terms were qualified with "Australia", and the results are reported in Clarke [2008]. As regards the international researchers, the results for the 16 / 25 who were above the threshold of a total citation count of 100 are reported in the main body of this paper.

In addition to ISI's General Search, two other categories of search are available. **Advanced Search** provides a form of Boolean operation on some (probably inferred) meta-data. This had to be resorted to on several occasions, e.g. while investigating the Bjørn-Andersen and McLean anomalies. If a common evaluation method were able to be defined, it may be feasible to use Advanced Search to apply it. The facility's features seem not to be entirely consistent with the conventions of computer science and librarianship, however, so considerable care would be needed to construct a reliable scheme.

The other category of search is called **Cited Ref Search**. A General Search counts citations only of papers that are themselves within the collection. The Cited Ref Search, on the other hand, counts all citations within papers in the collection. This delivers a higher total-citations score for those authors who have published papers in venues which are outside ISI's collection scope, but that are cited in papers that are within ISI's collection scope.

In order to test the likely impact of applying this alternative approach to IS researchers, Cited Ref Search was used to extract data for a subsample of researchers in each category. In order to investigate the impact on researchers whose citation counts fall behind the leading pack, several researchers were included in the subsample whose counts in the previous round fell below the selected total-citation threshold of 100.

The design of the search facility creates challenges because it makes only a small number of parameters available. For example, it does not enable restriction to <Address includes "Australia">. In addition, very little information is provided for each hit, the sequence provided is alphabetical by short journal title, and common names generate in excess of 1,000 hits. Further problems are that there is enormous variation in citation styles, and in the accuracy of the data in reference lists. This results in the appearance of there being far more articles than there actually are: many articles were found to have two or three entries, with instances found during the analysis of five and even seven variants.

APPENDIX 3: Deficiencies in the ISI Data Collection

This appendix provides information arising from the study which demonstrated significant problems with the ISI database, both generally and from the specific perspective of the IS discipline.

APPENDIX 3A: Venue Exclusions

The ISI database does not contain all of the venues that would be regarded by any particular discipline as comprising its publication set. The primary causes are the exclusion of:

- some journals;
- almost all conference proceedings;
- all articles from some journals prior to an ISI-selected start-date;
- all articles from some journals after some ISI-selected finish-date;
- some articles that appear to be within the ISI criteria but are nonetheless missing; and
- all books.

Thomson has set substantial barriers to entry for journals into the collection. The criteria and process remain somewhat obscure.

An examination was conducted of the ISI database's coverage of the selected publishing venues listed in Exhibit 1. Nothing was found on the ISI site that declared which Issues of journals were in the database, and it was necessary to conduct experiments in order to infer the extent of the coverage. The examination disclosed a wide range of omissions, as follows:

- The short list of AA journals in reference disciplines appeared to be included in their entirety;

- The AA journals within the IS discipline itself were covered only from quite late in their histories:
  - MISQ was the first and for a long time the only AA journal, yet articles prior to Volume 8 are omitted;
  - ISR's first three volumes are omitted;
  - only the most recent 6 of the 16 volumes of JMIS are included.
- The coverage of generalist A journals was severely inadequate:
  - the first five volumes of I&M are missing;
  - so are the first three refereed volumes of Database (1979-1981);
  - ISJ and ISF were adopted only some years into their lives;
  - JIT is very sparsely represented;
  - JIS, JAIS and CAIS are entirely omitted.
- The specialist A journals are very poorly covered. This includes both IS subdisciplines and journals oriented towards particular research domains. The latter publish research using diverse methods and written from a wide range of disciplinary perspectives, but are important venues for publishing the results of IS research. There is especially poor coverage of:
  - specialisations that have emerged during the last decade;
  - journals that focus on research domains and that accordingly accept papers written from varying disciplinary perspectives; and
  - the interfaces between IS and law, and IS and public policy.
- Of the regional A journals, only EJIS is represented, but omitting the first three volumes.

In summary, only 15 of the 30 IS journals listed in Exhibit 1 are represented in ISI. Of those 15, only six are present in their entirety. Eight are only represented from a particular date onwards, and one is only represented patchily. As a result, it appears that only about 40 percent of the papers that have been published in this core set of 30 IS journals are included within an ISI citation analysis.
Anecdotally, and from this author's personal experience, a number of well-respected IS journals have been unable to achieve inclusion in ISI, in some cases despite strong cases and repeated requests.

Further, many branches of computer science, particularly those in rapid development and hence with a very short half-life for publications, have largely abandoned journals in favour of conference papers. This means that many leading computer scientists have very low scores on ISI, and so do members of the IS discipline who operate at the boundary with computer science — within the sample studied, notably Ross Jeffery and Sal March.

A further test was undertaken in order to provide a comprehensive assessment of the inclusion and exclusion of the refereed works of a single author.

A highly convenient sample of one was selected: the author of this paper. In the author's view, this is legitimate, for a number of reasons. This was exploratory research, confronted by many challenges, not least the problems of false inclusions and exclusions, especially in the case of researchers with common names. This author has a very common surname, and has a substantial publications record. Those publications are scattered across a wide range of topics and venues, and some of the papers have had some impact. Most crucially, however, the author is well-positioned to ensure accuracy in this particular analysis because his publications list is well documented, and he knows them all.

The outcome of the analysis was as follows:

- Of this author's 36 refereed journal articles to the end of 2005:
  - Only 13 (34 percent) were in the SCI and SSCI combined;
  - One (3 percent) was in a journal that is claimed by Thomson to be indexed, but the paper could not be located (JIT);
  - 22 (62 percent) were in journals not indexed by Thomson. These comprised:
    - Nine (25 percent) in four A-list IS journals (as per Exhibit 1) (JSIS, TIS, IT&P and CAIS).

These include two papers that Google Scholar suggests are the author's third and fourth most highly cited;

  - Two (6 percent) in Computer Science and Engineering journals;
  - Eleven (31 percent) at the interfaces between IS and other disciplines — four in law (which is especially badly supported), two in commerce and economics, and five in public policy, ethics, and the humanities;

- Of the author's 27 refereed conference papers to the end of 2005, 2 (7.5 percent) were in the SCI and SSCI combined, although with few citations;
- A further seven papers were in the index (albeit with a total of only three citations), which were unrefereed. These included notes from panel sessions, a guest editorial, a bibliography, and an edited but unrefereed opinion in MISQ.

The results of this comprehensiveness test has implications for all IS academics. On the broadest view, an appropriate measure of impact would take into account the citation counts for all 63 refereed papers (possibly weighted according to venue); but only 15 are included (24 percent). A more restrictive scope would encompass journal articles only, in which case the coverage was still only 13/36 (36 percent). At the very least, the core IS journals should be included, in which case ISI's coverage still only scores 13/25 (52 percent).

APPENDIX 3B: Over-Inclusiveness

A range of items are included within the ISI collection that are inconsistent with its purpose. The following categories were apparent:

- Non-refereed items in listed journals (particularly editorials, but also book reviews). These doubled the article count for some academics, although it inflated their citation count to a much smaller extent;
- Many (and possibly all) items in some non-academic outlets that are edited but are not refereed academic venues in the manner in which the mainstream journals are (in particular, Sloan Mngt. Rev., Harv. Bus. Rev.);
- All articles in a journal that now publishes many non-academic papers (specifically CACM); and
- Some items in a few (mostly old) purely trade outlets (e.g. Datamation and I-S Analyzer, but also Computerworld).

As noted in Appendix 3A, an exhaustive examination of the ISI entries for the author of this paper located only 13 of 14 expected and 36 relevant journal-articles, but also two of 27 refereed conference papers, and seven non-refereed items.

APPENDIX 3C: Vagaries in Author Data

The initial(s) used by and for authors can seriously affect their discoverability. Several authors in the samples have published using two sets of initials — most awkwardly Ross Jeffery as D.R. as well as R.; and three researchers were detected who have publications under three sets of initials. Considerable effort was necessary in multiple cases among the c. 130 analyses performed, and the accuracy of the measures adopted is difficult to gauge.

Niels Bjørn-Andersen suffers three separate indignities. Firstly, ISI largely excludes publications in languages other than English, including Danish. Secondly, ISI does not support diacritics, so "ø" is both stored and rendered as "o". The third problem discovered was that, although a few papers with a very small number of citations were found under "Bjorn-Andersen", for the three of his papers that appear to have attracted the most citations, his name has been recorded as "BjornAndersen" (i.e. without a hyphen or other separator). Those papers can be detected using several search strategies but not using the author's actual surname.

Given the problem discovered with hyphens, a further test was performed on Trevor Wood-Harper. This disclosed that the same problem occurred — and was further complicated by the existence of three different sets of initials. (Retesting was not performed until June 2007, and the citation count shown for this researcher in Exhibit 2 was deflated slightly in an attempt to achieve closer correlation with the figures that would have likely been visible in April 2006).

APPENDIX 3D: Vagaries in Article Data

Several experiments were conducted, the most instructive relating to an article that, in this author's view at that time, could have been expected to be among the most highly cited in the discipline (Delone and McLean's "Information Systems Success: The Quest for the Dependent Variable"). The paper did not appear in Eph McLean's list. It was published in ISR 3, 1 (March 1992), but ISR is indexed only from 5, 1 (March 1994).

Using the "Cited Ref Search" provided by ISI also fails to detect it under McLean E.R., but detects a single citation if the search is performed on "INFORM SYST RES" and "1992". It can also be located using <Author = Delone W.H.>, with seven variants of the citation, all misleadingly shortened to "INFORMATION SYSTEMS.". These disclose the (relatively very large) count of 448 citations (As this article went to press, it was drawn to attention by A.-W. Harzing that cited items that are *not* included in ISI are listed for the first author only. This may be the primary (but not sole) explanation for the Mclean anomaly).

APPENDIX 4: The Research Method for the GOOGLE Analysis

The aim of the research was twofold. It was important to assess the usefulness of citation analysis using Google Scholar data as a means of measuring the impact of IS researchers. In addition, insight was sought into the quality of both the Google and the ISI data.

The analysis presents considerable challenges. Searches generate long lists of hits, each of which is either an item indexed by Google, or is inferred from a citation in an item indexed by Google. The term *item* is used in this case because, unlike ISI, Google indexes not only articles but also some books, some reports, and some conference proceedings. As is the case with ISI, it appears that the "citations" counted are actually the entries in the reference list to each item, rather than the citations within the article's text.

Each item has a citation count shown, inferred from the index, and the hits appear to be sorted in approximate sequence of apparent citation count, most first. Very limited documentation was found; and the service, although producing interesting and even valuable results, appeared during the period from April 2006 to June 2007 to be anything but stable.

Various approaches had to be experimented with, in order to generate useful data. From a researcher's perspective, Google's search facilities are among the weakest offered by search engines, and it has a very primitive implementation of metadata. It is reasonable to infer that the indefinite article "a" and the pronoun "I" are stop-words in the indexing logic, and hence searches for names including the initials "A" and "I" required careful construction. The common words "is" and "it" are also stop words, and hence it is difficult to use the relevant expressions "IS" (for "information systems") and "IT" (for "information technology") in order to restrict the hits to something more manageable. Search terms of the form <"I Vessey" OR "Vessey I"> appeared to generate the most useful results.

Experiments with searching based on article titles gave rise to other challenges, in particular the desirability of a richer starting point for the analysis: a comprehensive list of article titles for each researcher.

A preliminary trial was performed on data relating to this author's own publications. After constructing what appeared to be an efficient mechanism, it was still necessary to scan 2,000 entries in order to extract 124 items totalling 1,441 citations. Application of the h-index had the effect of limiting the search to only the first 18 of the 124 items. The 106 papers omitted had at most 17 citations each and an average of only seven, so the total citation count was reduced by a little over half, from 1,441 to 684. On the other hand, the author in question is relatively prolific, in both the good and bad senses of the term, and hence most authors would lose far less than half of their citation count; and the "long tail" is in any case far less significant than the high-impact papers at the top of the list.

The method adopted was to conduct searches using the names of sub-sets of the same samples of researchers whose ISI-derived data appears in Clarke [2008] for Australian researchers and Exhibit 2 for the sample of international researchers. A small sample was used, however, because of the resource intensity involved, and the experimental nature of the procedure.

For the Australian component of the study, a purposive subsample was selected, in order to avoid conflation among multiple authors and the omission of entries. Only the first 10 articles for each author were gathered (generally, but not reliably, those with the highest citation count). The technique was also applied to a small sample of international researchers.

The intensity of the "multiple authors with the same name" problem is highly varied. For many of the researchers for whom data is presented, there was no evident conflation with others, e.g. their top-10 appeared on the first page of

10 entries displayed by Google Scholar. For a few, it was necessary to skip some papers, and move to the second or even third page. To reach Eph McLean's 10th-ranked paper, it was necessary to check 60 titles, and to reach Ron Weber's 10th, 190 titles were inspected. The check of this author's own entries was more problematical, and is further discussed in Appendix 5.

Experimentation showed that, because substantially more data is available, use of the h-index is feasible. Moreover it is advantageous, because:

- it has the effect of curtailing the search;
- it requires a relatively shallow search for authors who have had only limited impact as measured by citation counts;
- it necessitates more effort for those authors whose impact warrants it.

Accordingly, for the international researchers, a revised procedure was adopted. Articles and associated citation counts were extracted from Google Scholar sufficient to enable computation of the h-index and h-count, as described in Appendix 1.

APPENDIX 5: THE FEASIBILITY OF AUTOMATING GOOGLE CITATION ANALYSIS

An experiment was conducted in order to establish whether the recognition of matches and spurious matches could be achieved with confidence, and in an automatable (or semi-automatable) manner. The experiment was conducted on the author’s own, fairly common name.

The search on Google Scholar resulted in 12,700 hits in April 2006 (but 34,800 when the experiment was repeated in June 2007 and 35,700 in November 2007). To reach the 10th-most-cited paper, it was necessary to inspect the first 558 entries.

The challenges involved in this kind of analysis are underlined by the fact that those first 558 entries included a moderate number of papers by other R. Clarkes on topics and in literatures that are at least adjacent to topics published on and venues published in by the targeted R. Clarke. These could have easily been mistakenly assigned to the R. Clarke in question by a researcher who lacked a detailed knowledge of the targeted person’s publications list. Similarly, false negatives would have easily arisen. There are many researchers with common names, and hence accurate citation analysis based on name alone is difficult to achieve.

A further experiment was conducted in June 2007 to check the effectiveness of more restrictive search terms. The term <information OR privacy author:Clarke author:R> was used in an endeavour to filter out most extraneous papers without losing too many genuine ones. The 10^{th}-most-cited paper was then found at number 33 of 7,380, rather than 558 of 34,800. The total citations for those 10 papers was 481 (cf. 417 when the search was first performed 14 months earlier). The lowest counts of the 10 were 16, 19 and 22; but later counts were larger (30 at no. 59, 37 at no. 74, and 25 at no. 112); so the sequencing is not reliably by citation count, and there is no apparent way to influence the sequence of presentation of the results of a search.

A retest in November 2007 found that the numbers had grown somewhat. The 10^{th}-most-cited paper was at 26 of 8,240, the citations for the top 10 at 525, lowest-counts 19, 20 and 21. A search of the remainder of the top 200 (of which 42 were for the author in question) located later items with significantly higher citations than 5 of the apparently top 10, plus 4 duplicates of surviving top-10 entries. The re-calculated citation total for “the real top 10” was 623, suggesting an under-statement through missequencing of close to 20 percent. The patterns appeared to be stable, however.

The comprehensiveness of the coverage was tested by continuing the scan across the first 1,000 entries. (Google Scholar does not appear to enable display of any more than the first 1,000 hits). This identified a total of 117 items with 1,365 citations (about a dozen of which represented double-counting of publications, although apparently not of citations).

The extent to which the search-term missed papers was tested using its complement, i.e. < -information -privacy author:Clarke author:R>. A scan of the first 1,000 entries of 19,900 detected only 7 papers that had been missed by the earlier search (numbers 161, 531, 534, 690, 792, 795 and 861) with a total of 76 citations (respectively 27, 10, 10, 8, 7, 7 and 7).

The stability of the results of applying this technique was checked by means of a repeat of the procedure in November 2007. The 19,900 entries had grown to 21,100, and the first of the seven papers found through the complement search had moved to number 164. Because the patterns remained very similar, it is reasonable to surmise that the scope of the data collection and the processes had both stabilised by mid-2007, and that the changes evident since then have arisen primarily from the natural accretion over time of papers within existing venues.

A person-specific specification or protocol appears feasible, but it would be very challenging to fully automate it in order to support periodic recalculation.

APPENDIX 6: CROSS-COMPARISON QUALITY TESTING

A series of experiments was conducted, in order to gain insights into the quality of the ISI database, based on cross-comparisons with Google Scholar results.

A6.1 Multiple, Person-Specific Tests

In order to assess the implications for researchers more generally, a subset of seven of the Australian researchers was selected, including three of the seven leaders and four of those whose ISI counts fell below the threshold. Their top-10 Google citation counts were extracted in April 2006, and comparison made with the ISI results. In each case, careful comparison was necessary, to ensure accurate matching of the articles uncovered by Google against those disclosed by ISI. The data is shown in Clarke [2008], at Exhibits A1 to A7.

Google finds many more items than ISI, and finds many more citations of those items than ISI does. In the sample, the ISI count includes only 39/70 items, and even for those 39 the total ISI citation count is only 45 percent of the total Google citation count.

To some extent, this is a natural result of the very different approaches that the two services adopt: indiscriminate inclusiveness on the one hand, and narrow exclusivity on the other. However, a deeper assessment produced the following evidence:

- There are multiple instances of papers that should be in ISI but that are not. For example, four of Iris Vessey's articles with a total of 267 Google citations appear to be erroneous omissions from the ISI database (see Exhibit A1);
- Many papers in “A-list” journals that are missing from ISI have high citation counts in Google. For example, among the 70 papers are seven in JIS, TIS , IT&P and EJIS, all of which are excluded from ISI's coverage but have a total of 475 citations or an average of 68 each (see Exhibits A2, A5, A6 and A7);
- The net effect of those two deficiencies is that, of the seven authors’ 10 highest Google-count papers, 59 percent are not counted by ISI (41/70). Even if books, lower-ranked conferences and government reports are removed from the lists, 45 percent are omitted (24/53);
- If the analysis is narrowed to each author’s top four works based on Google-citations, 15/28 are missing from ISI, and the missing items account for 54 percent of the combined Google citation count of 2,204;
- The difference between ISI and Google counts varies very substantially between individuals:
    - The ISI counts represent as high as 70 percent of the Google counts (Iris Vessey and Philip Yetton) and as low as 38 percent (Ron Weber), 35 percent (Peter Seddon), 28 percent (Paula Swatman) and 17 percent (Roger Clarke). The range was therefore 17-70 percent and the mean of the sample 50 percent.

      Meho and Yang [2007] reported that, for a sample of 25 highly-published researchers in information science/librarianship the corresponding figures were 25-100 percent and 40 percent;
    - A comparison between the Google citation count for each author's top 10 papers against the total ISI count for all of the author's papers is even more stark: Iris Vessey's partial Google count is only 15 percent higher than her total ISI count, but Ron Weber's and Philip Yetton's are double, Peter Seddon's four times, Paula Swatman's seven times, and Roger Clarke's and Guy Gable's between eight and nine times.

The analysis throws serious doubt on the adequacy of ISI as a basis on which to assess IS academics' research impact.

A6.2 Anomaly Investigations

The citation counts were further examined for several researchers whose ISI counts had been lower than this author had anticipated.

Ron Stamper (as R. and R.K.) generated only 32 citations from 13 articles on ISI. On Google Scholar the count in April 2006 was 511 citations of 36 articles (the largest single count being 60), plus 64 citations of 1 book, for a total of 575 citations. The scan found those 37 relevant entries among the first 100 hits of a total of 7,970 hits in all, and doubtless somewhat under-counts. A repeat of the experiment in June 2007, using the search term <author:Stamper author:R*>, found 33 relevant entries among the first 100 hits of a total of only 830 entries, but for a total of 677 citations, or 18% more than 14 months earlier.

An expansion rate of a factor of 18 from ISI to Google is extreme, and suggests that this particular researcher's specialisations are very poorly represented in ISI's collection. In Google Scholar, his h-index was 14 and his h-count around 400; yet in ISI he fell well below the threshold of 100 total citations.

David Avison generated under 100 citations on ISI, including 56 for a CACM paper in 1999. On Google Scholar, that paper alone generates 219 citations, an *Australian Computer Journal* article (which is excluded from ISI) 199, three IT&P papers around 50 each, another CACM paper 43, and a book 518.

A researcher whose Google Scholar scores are an h-index of 14 and an h-count of 1,282, fell well below the 100-citation cut-off used for Exhibit 2.

A6.3 An Article-Specific Test

A further experiment was conducted in order to test the impact of ISI's collection closedness in comparison with Google's open-endedness. Delone and McLean's "Information Systems Success: The Quest for the Dependent Variable" was sought by keying the search term <E McLean W DeLone> into Google Scholar, and critically considering the results. The test was performed twice, in early April 2006 and late April 2006. The results differed in ways that suggested that, during this period, Google was actively working on the manner in which its software counts citations and presents hits. The later, apparently better organised counts are used here.

The analysis was complicated by the following:

- There has been a considerable subsequent literature that applies, extends and re-visits the topic addressed by the article, and sets of words that appear in the original article are used in the titles of many of the later papers. This highlights a limitation of the "brute force" text-analysis approach of Google in comparison with a more refined metadata-analysis approach;
- Some links were broken; and
- Many of the hits require particular conditions to be fulfilled by the searcher in order to gain access to sufficient information to test the validity of the putative citation – in particular subscriptions to commercial services.

The raw results comprised 824 citations for the main entry (and a total of 832 hits). Based on a limited pseudo-random sample from the first 40, many appeared to be indeed attributable to the paper. This is a citation count of a very high order. An indication of this is that the largest ISI citation count for an IS paper that was located during this research was 296, for a paper in CACM by Lynne Markus. In Google, that paper scored 472. So the Delone and McLean paper scored 75 percent more Google-citations than the Google-citation score of the highest-ranked IS paper that had otherwise been located in the ISI database during the course of the research.

The experiment was repeated in June 2007, with significantly different results. One change was that the output was far better organised than 14 months earlier, with most duplications removed and apparently consolidated into a single entry. The second was that the citation count was 1,166 in the principal entry (plus 22 more in a mere four other entries). This represented an increase of 44 percent on the citation count 14 months earlier.

As indicated in Appendix 3D, this paper is not in the ISI collection (in the sense that it was published in a volume of ISR that precedes the date on which ISR was adopted into the ISI database). It can be detected in the ISI collection by indirect means, however, because it is cited by many papers that are in the ISI database. But it could not be detected using "McLean" as a search term. Hence it appears that, as a result of what is quite possibly data capture error, ISI denies one of the authors the benefit of being seen to have co-authored one of the most highly-cited papers in the entire discipline. An assessment of the counts achieved for highly-cited papers when using the Google Scholar collection instead is provided in Appendix 7.

It is not straightforward to confidently construct searches of the ISI collection to determine citation counts for specific papers.

APPENDIX 7: Google Scholar Citation-Count Thresholds

A series of experiments was conducted, in order to provide an empirically-based indication of what levels of Google Scholar citation count were associated with high-impact papers and with "classic" papers.

The first experiment involved inspection of the third column of Exhibit 4, which showed the largest per-item count for the 16 international researchers in the sample. The top 10 of these were, largest first:

1166, 790, 635, 591, 539, 518, 484, 405. 350, 326

A second approach adopted was to conduct searches on a dozen terms of considerable popularity in recent years. The terms were not selected in any systematic manner. Consideration was given to using a pseudo-random selection of terms from Barki et al. 1993; but the set would have required substantial updating.

The following displays the counts of the top 10 results for each term, highlighting the total, the largest and the 10th most highly-cited article. This provides an indication of the depth of the heavily cited literature using that term:

- "technology acceptance model" – **1957** (**370**, 349, 174, 190, 196, 117, 89, 173, 194, **105**)
- "soft systems methodology" – **1474** (**1038** – but a book, 79, 123, 49, 32, 32, 34, 34, 31, **22**)
- "outsourcing" – **1329** (**238** – but a book, 104, 164, 105, 154, 121, 128, 123, **91**, 101)
- "information systems success" – **1208** (**722**, 89, 46, 35, 58, 43, 47, 41, **31**, 96)
- "structural equation modelling" – **959** (162, **279**, 124, 53, 92, 82, **17**, 62, 47, 41)
- "B2B" – **950** (**350**, 166, 57, 72, 71, 56, 60, 54, 43, **21**)
- "key issues in information systems management" – **929** (**205**, 101, 155, 216, 22, 165, 16, 31, 14, **4**)
- "strategic alignment" – **711** (**342**, 107, 52, 44, 38, 34, 28, 26, 25, **15**)
- "information systems failure" – **546** (139, **209**, 46, 25, 18, 12, 52, 11, **8**, 26)
- "citation analysis" AND "information systems" – **380** (**63**, 38, **63**, 54, 47, 11, 53, 30, 13, **8**)
- "reintermediation" – **224** (**76**, 40, 22, 24, 15, 14, 13, 8, 7, **5**)
- "B2C" – **186** (**60**, 22, 16, 11, 7, 7, 6, 6, **5**, 46)

On the basis of this unsystematic experiment, the 10 largest per-item counts among 12 popular terms were, largest first:

1038, 722, 370, 350, 342, 279, 238, 209, 205, 76

Re-tests in July 2007 showed substantial growth in Google citation counts during the intervening 14 months of 67 percent for "strategic alignment" to 1,186, 61 percent for "key issues in information systems management" to 1,499, 53 percent for "citation analysis" AND "information systems" to 581, 50 percent for "technology acceptance model" to 3,127, and 46 percent for "B2B" to 1,395. "B2C," on the other hand, had grown only 12 percent to 208. These changes might result from considerable expansion in the Google Scholar catchment, an explosion in IS publications and/or the existence of bandwagon effects in IS research.

A third approach was to extract the count for Markus [1983], which was the object of study of Hansen et al. [2006]. This showed a Google citation count in June 2007 of 602. Hansen et al. also drew attention to DeSanctis and Poole [1994], which showed 718 Google citations.

A fourth approach involved the extraction of Google Scholar citation counts for the highly cited papers published between 1988 and 1994 that were identified in Walstrom and Leonard [2000, Table 7]. This gave rise to the following top 10:

1468, 743, 712, 483, 434, 405, 296, 142, 111, 49

This identified a new contender for most highly cited paper in IS – Davis et al. [1989]. Of the three authors of that paper, two do not publish in the IS literature, but the lead author, Fred (F. D.) Davis does. Examination of his Google Scholar citation counts disclosed an article with a yet-higher citation count – Davis [1989] – which scored 2,516 citations.

A tentative explanation for the scale of the citation counts for these two papers is that many of the citations may be from researchers in disciplines that are cognate with IS (rather than from within IS), and which comprise larger numbers of researchers than does IS itself.

Davis' citation count of h-items (column 2 of Exhibit 4) was 7,161, considerably higher than the highest otherwise encountered during this study. Davis' h-index was 22, however, which is rather lower than for many of the other leading researchers in the sample.

Following discovery of the highly cited Fred Davis papers, the term "user acceptance" was added to the list of 12 popular terms trialled above. In July 2007, this disclosed the two Davis articles, but the counts for the third to 10th most cited articles were not at the same high levels:

- "user acceptance" – **5,245** (**2,516**, 1,468, 406, 484, 89, 69, 40, 74, 50, **49**)

Based on the above experiments, in June 2007, the combined top 10 appeared as follows:
2516, 1468, 1166, 1038, 790, 743, 722, 718, 712, 635

This is of course not authoritative, because the method did not assure a comprehensive search of all journals, authors or keywords. The scope of the searching was, however, sufficiently rich that it appears reasonable to draw some cautious inferences.

Very few papers appeared to be scoring above a total citation count above 600. Moreover, even in topic areas that are mainstream within the discipline, it appears that a relatively small proportion of items has to date achieved 100 citations. (In the above sample of 13 topic areas in early 2006, there were about 40, with only a few more apparent by mid-2007).

Moreover, many topics either fail to attract any more interest, or subsequent researchers do not develop a "cumulative tradition" in that they fail to cite predecessor papers. Hence citation counts above perhaps 75 could be argued to indicate a high-impact article, and above perhaps 40 a significant-impact paper.

Appropriate thresholds on ISI General Search would appear to be somewhat less than half of those on Google, perhaps 50 and 20.

These thresholds are of course indicative, and could be contentious. They are specific to IS, and other levels would be likely to be appropriate in other disciplines, and perhaps in (M)IS in the USA. The applicability of such thresholds is time-limited, with a half-life perhaps as short as six months, because of the growth inherent in citation counts at this early stage in the maturation of both the discipline and the databases on which the analysis depends.

APPENDIX 8: Deficiencies in Citation Collections

This Appendix provides a consolidated list of the problems that are evident in the use of existing data collections as a basis for citation analysis generally, with particular reference to their use as a means of assessing the impact of individual IS researchers.

The Collections

Based on the evidence gathered during this study, the following deficiencies are apparent in the ISI and Google Scholar data collections.

- **Exclusion of refereed publishing venues relevant to the discipline's publication-set**. Relevant venues include especially refereed journals, but also at least the most significant refereed conference proceedings and scholarly books. ISI's deficiencies are quite extreme, with only about 40 percent of relevant IS journals included, and almost no conference proceedings or books. Google Scholar's coverage is not clear, but is substantial
- **Exclusion of relevant items from publishing venues that are nominally within the collection**. This arises in a variety of circumstances, including where articles are indexed only after a certain date, or (less commonly) only before a certain date, and as a result of data capture omissions, and data capture errors. ISI's deficiencies are considerable. Google Scholar's quality is difficult to gauge, but its problems in this area appear to be less serious
- **Inclusion of publishing venues that are not part of the discipline's publication-set**, such as non-refereed, professional and trade publications. ISI has a moderate degree of over-inclusiveness. Google Scholar appears to be highly inclusive

- **Inclusion of items that appear within an appropriately-included publishing venue, but that are not themselves refereed**. This applies in particular to editorials, notes, book reviews, and letters. ISI has a moderate degree of over-inclusiveness. Google Scholar appears to be highly inclusive
- **Delay in the inclusion of new publishing venues**. ISI sets very high hurdles, and hence is damaging to emergent new research domains, sub-disciplines and even whole disciplines. Google Scholar appears to be highly tolerant of and adaptive to such change
- **Nontransparency** in relation to inclusions and exclusions of publishing venues and items within them, and the criteria underlying decisions made. Both ISI and Google fall far short of reasonable transparency standards

The Data

- **Data capture errors**, such as misspellings of journal titles, authors' names and keywords
- **Citation errors in the articles from which the data is acquired**, including misspellings of journal titles, authors' names and keywords, and incorrect and missing volume numbers, issue numbers, page-numbers, and dates
- **Name-variants**, variously in spelling, in transliteration of diacritics and non-Roman alphabets, and in the completeness of the set of initials (including initials inferred from commonly-used given names), and arising from changes of name, e.g. on marriage, and where pseudonyms are used

The Services

- **Limited and nonstandard search capabilities**, hindered by software functionality and user-interface constraints and arbitrary design decisions about searchable fields
- **Limited capabilities to address the problem of non-uniqueness of author name**. This gives rise to the risks of:
  - conflation of the publications of multiple individuals
  - the overlooking of publications of an individual, lost in the flood of publications by one or more other people with closely similar names, particularly where they publish in closely related disciplines and domains and even the same publishing venues
- **Barriers to automated searching**, such as the lack of a published application programming interface (API) and limitations on the number and/or speed of accesses

Research Community Factors

- **Great variability in the size of the researcher population**
- **Great variability in the size of the researcher population that subsequently publishes in each topic-area**. (IS is driven by rapidly changing technology, and hence topic areas are volatile, and many papers are left behind as fashion sweeps onwards)
- **Underestimation of researcher impact**, arising from such sources as:
  - failure of subsequent researchers who are influenced by the researcher's work to actually cite it. (Anecdotally, there appears to be a tendency among IS researchers to over-cite papers that have appeared in high-status venues, and to under-cite more relevant papers that have appeared in lower-status venues)
  - inherent bias in favour of works in the English language, and against works in other languages. (This is very much the case in IS, with Wirtschaftsinformatik the only recognised journal whose primary language is other than English. CAIS commenced accepting French-language articles in 2003 – with five published by late 2007 – and, in June 2007, the AIS Council announced that it intended to launch a Spanish-language journal)
  - the time-delay that is inherent in the emergence of a citation count for even the most successful articles
  - time delay in the emergence of a citation count until after the researcher’s active career. Many important ideas are “ahead of their time”, and their impact comes after the originator's career is over, and in some cases even after their death. Hence some researchers, particularly those

focussed on “pure research”, risk being starved of research funding throughout their careers

- **Exaggeration of researcher impact**, arising from such sources as:
  - bandwagon effects. These arise as researchers flock to a new “idea in good standing” or fashion, or sculpt their focus or methods to those currently preferred by funding agencies' assessors and journal-article editors and reviewers
  - self-citation. This is in principle legitimate, but is a potential source of inflated measures
  - “courtesy citation” of works of limited relevance, such as those authored by the author's supervisor or colleagues
  - the inclusion of minor contributors in the author list. (The norm in IS is for very short lists of authors, most commonly either one or two, with only those included who made a very substantial contribution to the paper; whereas some disciplines list many authors per paper)
  - the publication of many, short articles. This is feasible for researchers who work within a well-established pattern of “normal science”. (In IS, this is anything but the norm. Some maturation may be feasible, however. For example, Clarke 2006 proposed the codification of “AIS research technique practice guides”, to enable quicker writing and reviewing of articles that report on research that uses mainstream techniques)

APPENDIX 9: Measures Arising from Citation Analysis

This appendix suggests a number of measures that could be generated from Google Scholar data (or ISI data if and when it covers a sufficiently large percentage of the core IS publication set).

It is strongly preferable that several measures be used rather than one, in order to reflect different patterns of research and publication, and provide deeper insight into the researcher's impact within the literature.

Measures that could be considered include:

- the total item count
- the total citation count
- the mean citation count per item
- the citation count(s) of the highest-scoring item(s)
- the full reference(s) for the highest-scoring item(s), in particular the venue and date of publication
- the h-index on Google Scholar data – but not on ISI data unless and until its coverage of major venues for the IS discipline is extended well beyond its current level of about 40 percent of the relevant publication-set
- the h-count, i.e. the total citation count for the items in the h-index
- re-computed scores based on the above, applying a published weighting scheme that reflects the quality of publishing venues of the person's articles and/or of the articles citing them

If circumstances force the application of a very short list of measures, then it is suggested that the following be used:

- the h-index on Google Scholar data; complemented by
- the h-count, defined as the total citation count for the items in the person's h-index

APPENDIX 10: Elements of an A.I.S. Strategy

This Appendix provides further detail about possible actions that could be taken by AIS in order to address the serious problems in the area of citation analysis that have been identified in this paper.

A Search and Scoring Method

An AIS project could devise a search and scoring method for each individual IS researcher that is comprehensive, and that addresses the risks of both false-inclusions and false-exclusions.

The method could be supported by a tool that accepts as input a list of an individual’s published items, and generates from the Google Scholar collection (or ISI, if and when it covers a sufficient proportion of the IS publication set) an ordered list of citation counts, an analysis of them, and links to the citing items.

Further, the tool could support the computation of weighted scores. This would require the establishment of an AIS-approved quality-classification scheme of publishing venues, and a process for progressively reviewing and adapting it.

A prerequisite for this would be the development of a comprehensive database of publication titles and reference lists. Indeed, in June 2007, the AIS Council announced that "A new, integrated AIS e-library will be launched, using ProQuest. The new e-library will enable, amongst other things, searching across all AIS journals and conferences."

More radically, the AIS could embark on an initiative to recover control over the product of its members through open access mechanisms, or if necessary through the outright recapture of journals from uncooperative for-profit journal publishers. The politics of open content and open access are examined in Clarke and Kingsley [2007].

Indicators of the Impact of Individual Publications

An AIS project could establish indicators of the citation count thresholds at which refereed papers could be regarded as having had significant (or greater) impact. The project would also need to establish a process for progressively reviewing and adapting the thresholds.

On the basis of the analyses conducted in this research, the following indicative values could be considered as thresholds for citation counts for IS papers in 2007:

	Google	ISI
Classic	500	150
High-Impact	75	40
Significant-Impact	40	25

Indicators of the Impact of Individual Researchers

An AIS project could establish indicators of the threshholds at which individual researchers could be regarded as having had significant (or greater) impact. The project would also need to establish a process for progressively reviewing and adapting the thresholds.

As was discussed earlier in this paper, the selection of a measure is very challenging, because the choice will have differential effects on different categories of researcher. A realistic compromise would see the selection of at least two measures, preferably of a composite nature.

The two measures that the analysis leads to are:

- the Google Scholar h-index (and/or the ISI h-index, if and when the ISI collection encompasses a sufficiently large proportion of the IS publication set);
- the Google Scholar h-count, defined as the total citation count for all items in the person's h-index (and/or the ISI h-index, subject to the above proviso).

Hirsch is reported in Mayo (2007) to have suggested that an ISI h-index of 20 indicates a “successful” physicist, and 40 an “outstanding” physicist.

On the basis of the analyses conducted in this research, the following indicative values could be considered as thresholds for Google Scholar scores for IS researchers in 2007:

	h-index	h-count
Outstanding/Leadership Group	25	1,500
Successful/ “Middle-Ground”	15	500

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Communications of the Association for Information Systems

ISSN: 1529-3181