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Are Citations to Academic Journal Articles a Measure of Quality or Something Else? An Exploratory Analysis with Emphasis on Design Science and IS Technical Research

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ABSTRACT

One pervasive belief about scholarly citations that underlies several studies appearing in the IS literature is that the number of citations to a paper reflects the quality of the study. For example, a paper that receives 200 citations is perceived as having higher quality than another study that receives 50 citations. While most experts acknowledge that there are other factors that drive citations, such as the number of years a paper was available to be cited – or possibly "gaming" of citations by authors who cite themselves frequently (author self-citations) or over-zealous editors who incent prospective authors to cite their journals (journal self-citations), there is an underlying assumption that, barring such unscrupulous behavior, citations are a measure of research quality. This paper critically examines this assumption using a validated typology identifying 13 distinct subject areas that characterize IS research. Results show that papers on some topics (e.g., IT adoption and use; new measurement development and validation) consistently receive more citations than average – while some topics consistently receive below-average citation rates (e.g., IS development; IT project/risk management). Unless one assumes that all papers on a given topic are consistently of higher quality than all papers on other topics, our data suggest that a key driver of citations are the subject area of the study and, in turn, the size of the research community that conducts research on the topic.

Keywords (Required)

Adoption, citations, design science, scientometrics, research philosophy, research quality, technical research.

INTRODUCTION

Scientometrics is the area of research within information science that examines of research processes and outcomes. In recent years, leading IS journals have exhibited an increased openness to research conducted in the scientometric tradition – as illustrated by Straub's (2006) editorial comments in Journal of the Association for Information Systems where, referring to scientometric research, he advocates "the value of this kind of work – work that deals with fundamental questions of how scientific disciplines evolve." Moreover in describing two studies that reached opposite conclusions about the level of impact of IS research on other disciplines, Straub notes that "these articles raise the level of discourse to the highest level. They pose interesting research questions that have to do with the nature of the scientific enterprise" (2006, p. 241).

Not surprisingly, there have been many scientometric studies in recent years in leading IS journals that identified the most-cited papers in the IS literature (Lowry et al. 2007), the most-cited IS scholars (Karuga et al. 2007), as well as the "macro" pattern of citations between academic IS journals and those in other fields (Polites & Watson 2009). In addition, there have been scores of studies over the past few decades identified the leading IS journals and academic departments, starting with an early study by Vogel and Wetherbe (1984) and continuing with scores of replications up until today (Lowry et al. 2004).

One widely accepted belief about scholarly citations – and one underlying the studies mentioned above concerning citation counts or "macro" citation patterns – is that the number of citations to a scholarly paper reflects the quality of the research. For example, a published study that receives 200 citations is regarded as having higher quality than another study receiving 100 citations, which is, in turn, regarded as having higher quality than a third one receiving 50 citations. While most researchers acknowledge that there may be other factors that drive citation counts – such as the number of years that a study has been available to be cited, and possibly even the "gaming" of citations by authors who often cite themselves (author self-citations), or over-zealous editors who encourage superfluous citations to their journals (journal self-citations) (Gray 2009) – there remains an underlying assumption that, barring the effect of such unscrupulous behaviors, citations reflect the quality of

the study being cited. Following in the tradition of recent work that questions deeply-held assumptions (e.g., (Truex et al. 2009), I critically examine the belief that citations reflect research quality, using citation data for three IS journals.

My interest in this question emerged from a prior study in which my coauthor and I sought to understand whether the number of coauthors listed on a paper affects the number of citations that it accrues over time (Gallivan & Ahuja, forthcoming). In general, we found support for our hypothesis that papers with more authors receive more citations over time; however, we found an opposite pattern for one IS journal (*Information Systems Research*), where the relationship between the number of authors and citations was negative. To clarify, there was a statistically significant inverse, linear relationship between number of authors and the rate of citations to papers in *ISR*. Not only was this relationship directly opposite to our initial hypothesis, but also it was contrary to the underlying (positive, linear or curvilinear) effect that we found in three other IS journals (*MIS Quarterly, European Journal of IS*, and *Journal of MIS*). After attempting to control for several other covariates that are believed to affect the number of citations – such as the page length of a published paper (Acedo et al. 2005) and the number of persons acknowledged in the paper (Brown 2005), I speculated that that the subject matter of a study may be the neglected covariate that also affects the number of citations to a published paper. Based on an informal analysis of papers in *ISR* with different subject areas, I concluded that the subject area of a paper was indeed a factor that helped to explain the paradox that papers with more authors in *ISR* receive fewer citations.

Because my goal in this prior effort was simply to tease out the counter-intuitive relationship between number of authors and citations in one journal (*ISR*), I coded the subject matter of published papers using a relatively coarse typology: whether a paper's subject area was behavioral, technical or IS economics research – similar to a typology that Oh, Choi and Kim (2006) used to analyze networks among IS coauthors. I concluded that, not only did the number of authors of technical research papers (i.e., those using formal modeling, simulation, and mathematical proofs) often feature *more* authors than behavioral studies published in *ISR*, but such technical research papers generally accrued fewer citations over time than behavioral studies *ISR*. While this revealed that the subject area was a covariate that explains why the number of authors was inversely related to citations to papers published in *ISR*, I was not content with such an emergent explanation based on results from a single journal. In this paper, I seek to broaden the investigation of this question.

Thus, the initial purpose of this study was to broaden the investigation in order to answer the question: Are the number of citations to published IS studies a function of the study's subject area?

RESEARCH METHODS

I followed a two-phase process for gathering and analyzing data for this study. First, in order to informally test my emergent notion that IS economics research and technical papers (now often labeled "design science" research) is cited less often than other types of IS research, I requested a copy of the PhD course syllabus from a well-respected design science researcher who teaches a PhD seminar on "design science research" in the CIS department at my university. I coded the set of journal papers from this syllabus based on author names, journal title, date published, and the number of citations to each paper, as reported by ISI/Thomson in its "Web of Science" database. (Web of Science is an online database that tracks all citations captured by "Social Science Citation Index" and "Science Citation Index." The latter products are established tools for tracking citations to papers published in a small but prestigious subset of English-language scholarly journals in scores of academic disciplines. Among studies that conduct scientometric analyses of citations, most have relied on ISI/Thomson's "Web of Science" data. In recent years, however, more scholars have begun to use alternative citation databases – Google Scholar (Truex et al. 2009), Scopus (Jacsó 2009; Meho & Yang 2007), or Inspec (for computer science, engineering, and physical sciences research).

For each paper, I identified its citation rate (i.e., total citations, as reported in Web of Science, divided by the elapsed time since it was published). I compared this result to the number of citations that would normally be expected for a paper published in that journal during a given year – again based on data regarding the typical citation rate for papers published in that journal in a given year (the journal's impact factor). While this phase of data collection targeted a small number of "design science" papers (i.e., articles published in academic journals for which "Web of Science" tracks the citations to those specific journals for the specific publication year), these results revealed the number and proportion of papers for which the citation rate met or exceeded the "impact factor" for the journal in which it was published – or conversely, the proportion of papers for which the citation rate failed to achieve the typical citation rate for the journal. As I describe in the Results section, since half of the design science papers with available data in Web of Science exceeded the mean citation rate for the journals in which they are published, this appeared to disprove my initial assumption that technical research papers will receive fewer citations than is "normal" for the journals in where they appeared.

On the basis of this disconfirmation, I undertook a more extensive data collection effort to test my assumption that subject area and citations are related. In the second phase of my analysis, I examined papers published from 1999 to 2005 in three, North American IS journals (*ISR*, *MIS Quarterly*, and *Journal of MIS*).[1] I identified the total number of citations to these papers as of the first quarter of 2011 and I calculated the "citation rate" to each paper by dividing the total number of citations reported in "Web of Science" by the amount of time elapsed since the paper was published. (Wherever possible, I computed elapsed time to the nearest quarter, based on bibliographic details of the month or quarter of the journal's publication).

I obtained a set of subject area codes from one author who had previously classified the topic areas of papers published in *ISR*, *MIS Quarterly*, and *Journal of MIS* (Sidorova et al. 2008). In their study, Sidorova et al. used latent semantic analysis (LSA) to content analyze the papers published in these three leading North American IS journals from 1985 to 2006, which allowed them to identify 13 subject area codes that accounted for 75% of the papers published in these journals. The results of the LSA followed by exploratory factor analysis identified a single subject code as matching the paper's content in 75% of all cases; however, approximately 25% of the papers matched two or three distinct subject area codes, while a similar fraction of papers did not match *any* of their 13 subject codes. I obtained this dataset (consisting of an array of 13 factor loadings that represented the level of fit between each paper and the subject codes, for papers published in 1985 to 2006). I then merged this data with bibliographic details and citation data that I had collected for papers published paper in the same journals from 1999 to 2005. Figure 1 shows the list of subject areas revealed by the LSA that Sidorova et al. (2008) conducted.

I analyzed the merged dataset separately for each journal separately (e.g., first *MIS Quarterly* alone, followed by each of the other journals). Treating citation rate as the dependent variable, I analyzed the subject codes as independent variables (using stepwise regression) and I produced conventional regression metrics – the amount of variance explained (R^2 adj) by the set of subject codes that were statistically significant predictors, as well as the sign and magnitude of path coefficients. After performing these analyses separately for each journal, I performed a consolidated analysis of the merged data (including dummy variables for each journal, to allow for a different citation rate for each journal as well as each topic). I analyzed which subjects were associated with higher citation rates – or conversely, lower citation rates – across all journals together.

#1: IS development
#2: IS management
#3: Value of IT
#4: IT adoption and use
#5: IT and markets
#6: IT for group support
#7: Measurement instruments
#8: IS discipline development
#9: Decision support systems
#10: Human resource issues in IS
#11: Virtual collaboration
#12: IT project and risk management
#13: IT use by individuals

Figure 1. Subject Areas Identified by Sidorova et al. (2008)

In conducting these analyses, I chose to omit subject codes corresponding to topics that matched less than 3% of papers published during this time period. The subject codes that I deleted were "Decision support systems," "IS Management," and "Human Resource Issues in IS." It is likely that these and other topic areas identified by Sidorova et al. (2008) were the focus of more frequent research during the early years of their data collection period (i.e., 1985-1990) compared to the later years they analyzed (2002-2006). The latter is similar to the time period for which I had available citation data. The subject codes that I omitted were popular in the 1980s and early 1990s, but were no longer the focus of much IS research a decade later.

[1] I also collected citation data for two European journals – *European Journal of IS* and *Information Systems Journal* – however, as I explain below, Sidorova et al. (2008) did not collect and analyze the subject areas or derive the subject factor loadings for these journals.

After omitting these subject codes, I analyzed the remaining ten subject codes as predictors. I noted the sign of all regression coefficients to identify topics that were more highly cited than average – or conversely, less-cited – for a given journal.

RESULTS

For phase one, there are 22 "design science" papers that appeared in IS journals for which Web of Science tracks citation data for these journals (see Appendix A). Nearly all of these papers appeared in established (older) journals such as *Communications of the ACM, Decision Support Systems, Journal of MIS, MIS Quarterly,* and *ISR*.[2] Several readings items that appeared on my colleague's syllabus for her PhD design science course were books, papers appearing in edited books, or papers from conference proceedings. ISI/Thomson does not track citation data for such items in Web of Science. Some papers appeared in newer IS or computer science journals for which ISI/Thomson did not track citations (at the time the paper was published).

First Author Surname	Journal Name	Year	# Citations as of Feb. 2011	Month/ Issue	Elapsed Time	Citation Rate	Journal Impact Factor	Journal Impact Factor
							Year of publication	One year after later
Albert, T.C.	MIS Quarterly	2004	26	June	6.58	3.9	2.88	4.98
Freeman, P.	Communic. of ACM	2004	4	August	6.42	0.6	1.87	1.80
Gregor, S.	Journal of AIS	2007	42	May	3.67	11.5	1.84	2.25
Hevner, A.R.	MIS Quarterly	2004	444	March	6.83	64.9	2.88	4.98
Kuechler, B	European J. of IS	2008	4	October	2.25	1.78	1.20	1.20
March, S.T.,	Decision Supp. Sys.	1995	180	December	15.08	11.9	0.26	0.28
Markus, M.L	MIS Quarterly	2002	104	September	8.33	12.5	2.87	2.81
Peffers, K.,	Journal of MIS	2008	15	Winter	3.00	5.0	3.76	2.10
Pries-Heje, J.	MIS Quarterly	2008	8	December	2.08	3.8	5.18	4.49
Bapna, R.	MIS Quarterly	2004	48	March	6.83	7.0	2.88	4.98
Bapna, R.	Info. Systems Res.	2008	28	September	2.33	12.0	2.26	1.79
Whinston, A.	MIS Quarterly	2004	11	June	6.58	1.7	2.88	4.98
Fan, M.	European J. of IS	2000	43	March	10.83	4.0	0.40	0.68
Lee, B.	MIS Quarterly	1997	23	March	13.83	1.7	1.62	1.55
Fan, M.	Info. Systems Res.	2003	32	March	7.83	4.1	1.92	3.51
Konana, P.	Info. Systems Res.	2000	13	June	10.58	1.2	0.92	0.64
March, S.	Info. Systems Res.	2002	40	December	8.08	5.0	1.33	1.92
Fan. W.G.	Journal of MIS	2005	17	Spring	5.83	2.9	1.41	1.82
Fan, W.G.	Journal of MIS	2007	1	Winter	4.00	0.3	1.87	3.76
Tang, Q.	Journal of MIS	2006	0	Winter	5.00	0.0	1.818	1.867
Ba, S.	Journal of MIS	2005	2	Spring	5.83	0.3	1.406	1.818
Hu, X.	Info. Systems Res.	2004	23	September	6.33	3.6	3.512	2.054

Table 1. Total Citations and Calculated Citation Rate Compared to Journal's Impact Factor

[2] For example, *ISR* (which was established in 1990) was not tracked by ISI/Thomson until the beginning of 1994 – four years later.

This was the case for papers published in newer journals – such as *Journal of the AIS*. ISI/Thomson only admits journals to be tracked following a three-year evaluation process, and a positive outcome from the evaluation. This evaluation process usually begins only *after* the journal is well established; there are times when ISI/Thomson decides to exclude the journal.[3]

Table 1 shows the citation rate for citations to each paper on the PhD course syllabus for which citation data were available, as well as the annual "journal impact factor" that ISI/Thomson computes for the journal during the year of publication or for the subsequent year after the year of publication. I include the latter metric because impact factors can fluctuate greatly from one year to the next. Based on the results in Table 1, we can observe that in half of the cases, the citation rate for a given paper *exceeded* ISI/Thomson's published journal impact factor.[4] It is noteworthy that two papers achieved *ten times more* than the average citation rate for the journal in which they were published:

- Hevner, A.R., March, S.T., Park, J., Ram, S., "Design Science in IS Research," *MIS Quarterly*, 2004.
- March, S. and Smith, G. "Design and Natural Science Research on IT," *Decision Support Systems*, 1995.

For the paper by Hevner et al. (2004), the computed citation rate is 34.4 citations per year, compared to the reported impact factor for *MIS Quarterly* in 2004 – which was 2.90. For the second paper by March and Smith (1995), the citation rate was 6.4 citations per year, compared to the 1995 impact factor score for *Decision Support Systems* – which was 0.24.

In addition to these two papers, nine other papers in Table 1 (out of a total of 20 papers) exceeded the impact factor for the journal in the year in which it was published. Although based on a small sample of just 22 papers, these results disprove the initial assumption that motivated this study (i.e., that technical IS papers are cited less often than other papers published in the same journals in a given year). Of course, the papers appearing in Table 1 may be exemplars of design science research – since they appear in the PhD syllabus of a leading PhD program – rather than a random set of *typical* design sciences papers.

To reiterate the steps for our phase two analysis, we merged the data for the subject area codes from Sidorova et al. (2008), but excluded subject area codes corresponding to less than 3% of the papers in our dataset. We first mention the three subject areas for which there were a very few papers to analyze – and we show the specific keywords or word "stems" identified by Sidorova et al. (2008) as the result of their LSA (from Table B1 of the online appendices for their paper in *MIS Quarterly*). We show these details of the prior study's results to give readers a sense of keywords corresponding to the subject areas that we omitted from our analysis.

#2: IS Management (keywords: execut*, strateg*, success, issu*, implement*, top, system, corpor*, busi*, organ*, function, competit*, resourc*, comput*, interview*, IC, factor, oper*, integr*, respons*, critic*, senior, MIS, meet*, organiz*, center*, EIS, identi*)

#9: Decision Support Systems (keywords: DSS, decision, maker, support, problem, design, compon*, system, cognit*, ES, expert, strategi*, effort, solv*, featur*, aid*, strateg*, network*, creativ*, experi*, literatur*, restrict*, assump*, activ*, subject*, behavior*, guidanc*, involv*, theori*, improv*,)

#10: Human Resource Issues in IS (keywords: job, satisfac*, career, work, profession, analyst, employe*, skill, personnel, orient*, role, variabl*, user, survei*, comput*, found*, turnov*, IC, requir*, characterist*, MIS, plan, differ*, risk, qualiti*, percep*, indic*, motiv*, task, programm*)

[3] ISI/Thomson did not begin citation tracking for ISR until 1994; likewise *Journal of the Association for Information Systems* – which was founded in 1999, but did not publish a steady flow of papers until 2003 – was admitted by ISI/Thomson for citation tracking in 2008. Some other journals, such as *Communications of the Association for Information Systems, Information Technology & People*, *and Information and Organization* are either not tracked by ISI/Thomson, or were only recently approved for citation tracking in future years.

[4] The journal impact factor is the average rate of citations to papers published in the journal during the two years subsequent to the calendar year in which the paper was published. Thus, for a paper published in January 2001, ISI/Thomson counts the number of citations through year-end 2003 – a total of 35 months after publication. In contrast, for a paper published in December 2001, ISI/Thomson counts the total number of citations through December 2003 – a total of 25 months after publication. To calculate a journal's impact factor, ISI/ Thomson counts all subsequent citations to papers published in a given journal in a given year – but the interval for which they record citations is a minimum of 25 months and a maximum of 35 months, depending on how early or late in a given year the cited paper was published.

We analyze the remaining 10 subject area codes in our analysis. Our results reveal that papers corresponding to one topic (IT adoption and use) receive *far* more citations than the average citation rate for the given journal, as do three other topics with higher-than-average citations: measurement instrument development; IS discipline development; and virtual collaboration).

Subject Area Title	**Mean** (citations rate and std.dev.)	**Statistically significant (Y/N)**	**Regression Coefficient** (unstandardized)
#1: IS development	**1.96 (2.36)**	**Yes – negative**	-1.645 (p<.01)
#3: Value of IT	3.76 (3.91)	No	n/a
#4: IT adoption and use	**9.04 (11.51)**	**Yes – positive**	5.167 (p<.001)
#5: IT and markets	4.03 (7.20)	No	n/a
#6: IT for group support	2.88 (3.70)	No	n/a
#7: Measurement instruments	**9.14 (15.32)**	**Yes – positive**	4.493 (p<.001)
#8: IS discipline development	**5.91 (7.33)**	**Yes – positive**	1.959 (p<.001)
#11: Virtual collaboration	4.97 (7.21)	**Yes – positive**	1.091 (p<.05)
#12: IT project/risk management	3.23 (2.36)	**Yes – negative**	-1.520 (p<.05)
#13: IT use by individuals	4.97 (5.09)	No	n/a
Mean for *MIS Quarterly* papers only	6.54 (3.16)		
Mean for *ISR* papers only	3.81 (4.13)		
Mean for *Journal of MIS* papers	2.13 (3.16)		
Mean for all papers in all 3 journals	3.99 (5.79)		

Table 2. Descriptive Statistics and Regression Coefficients for Subject Areas

We show data from Sidorova et al corresponding to papers with higher than average citation rates. Partial bibliographic detail appears in Appendices B, C, and D for IT Adoption and Use; Measurement Instruments; and IS Discipline Development.

#4: IT Adoption and Use (keywords: adop*, perceived, usage, influence, behavior, accept, factor, intention, trust, ease, outsource*, th eory*, social, individual, attitude, belief, innov*, test, context, adopt, EDI, relationship, construct, empir*, theoret*, find*, percep*, determine, variable, success).

#7: Measurement Instruments (i.e., new construct development / validation) (keywords: instrum*, valid*, measur*, construct, reliabl*, satisfac*, scale*, item*, qualiti*, dimen*, accept*, web, servic*, ease, perceiv*, empir*, assess*, servqual, test*, metric, user, evid*, euc, analysi, use*, commerc*, trust, site, factor*, survei*).

#8: IS Discipline Development (keywords: MIS, chang*, knowledg*, issu*, field, theori*, social, methodologi*, framework, perspect*, innov*, organiz*, practic*, understand*, journal*, transform*, outsourc*, action, scienc*, GSS, theoret*, interpret*, approach*, analysi*, role*, literatur*, articl*, organ*, discuss*, eme*)

#11: Virtual Collaboration (keywords: team, trust, virtual, collabor*, project, commun*, knowledge, coordin*, integr*, web, custom, enabl*, mechan*, capabl, work, MIS, learn*, leader*, electronic, commerce, organiz*, business, role, relationship, invest*, structur*, compet*, perspective, challeng*, build).

Finally, two subjects were associated with a lower than average citation rate: "IS Development" (which consists of technical papers, proofs, and formal models) and "IT project and risk management." Most papers belonging to "IS development" were published in *ISR* or *Journal of MIS*, with few in *MIS Quarterly*. Papers that match to "IT project/risk management" appear mostly in *MIS Quarterly* and *Journal of MIS*. Appendix E shows the titles and bibliographic detail for papers corresponding to "IS Development." We can observe that papers corresponding to "IS Development" are technical papers – including many of the papers identified as leading "design science" papers in phase one of my analysis.

#1: IS Development (keywords: database, method*, design, requir*, system, approach*, languag*, techniqu*, problem, network*, applic*, queri*, structur*, knowledg*, represent*, prototyp*, expert, integr*, tool*, object*, form*, data, propos*, describ*, environ*, base*, analysi*, gener*, methodologi*)

#12: IT Project and Risk Management (keywords: project, risk, software, team, control, cost, electron:*, outsourc*, option, estim*, invest*, approach, failure, coordin*, networks, methodology*, EDI, escal*, real, method, success, quality*, practice, contin*, problem, custom*, schedul*, capabl, goal, factor).

Papers corresponding to the remaining four areas did *not* differ significantly from the average citation rate for the journal in which they were published (e.g., value of IT, IT and markets, IT for group support, and IT use by individuals). The fact these subject areas were not statistically significant in our analysis may be due to the fact that the average citation rate for papers corresponding to these topics had similar mean citation rates to the overall mean for all papers (which was 4.0 citations per year). The four subject areas that were not significant all exhibited mean values quite close to this (i.e., between 2.88 and 4.97 citations per year). Another explanation may be the large amount of variance associated with citation rates for some topics – such as "IT and Markets." Some papers in this category are cited very frequently, while others papers on the same topic are not well cited. Due to such "noise" in the citation data, there was no significant effect for some subject areas.

DISCUSSION

The results of phase one show that design science papers that prominently appear on a PhD course syllabus are generally well-cited; in fact, half of the papers had citation rates that are higher than the impact factor of the journal in which they were published (and two papers are cited about ten times more frequently than is typical for the journals in which they appeared: *MIS Quarterly* and *Decision Support Systems*).

The results from phase two revealed that studies corresponding to one behavioral IS research topic accrue substantially higher citation rates than all other subject areas (IT adoption and use). Moreover, three other subject areas are also associated with papers accruing higher-than-average citations (i.e., Measurement Instrument Development; IS Discipline Development; and Virtual Collaboration). Finally, two subject areas receive *lower* than average citation rate – the topics labeled "IS Development" and "IT Project and Risk Management" by Sidorova et al. (2008). The first of these topics ("IS Development") seems to correspond to technical IS research – what is now labeled "design science" research.

Phase two results thus demonstrate a relationship between the subject area of a paper and the frequency of citations to it – at least for four behavioral IS research topics (IT adoption and use; Measurement instrument development; IT project and risk managements; virtual collaboration), as well as one technical topic (IS development) and one generic topic (IS Discipline Development).[5] In short, four out of ten subject areas we analyzed were statistically significant, in terms of being the triggers to corresponding papers receiving either higher-than-average or lower-than-average numbers of citations subsequently.

These results raise the following concern: if we adhere to the conventional belief that citations are a function of a paper's research quality, then this implies that some research topics consistently generate papers that are of higher than average quality (i.e., IT adoption and use; measurement instrument development; IS discipline development; virtual collaboration), while other topics consistently generate papers of less than average quality (IS development; IT project and risk management). Studies corresponding to other topics are of just average quality. Such an implication seems unreasonable!

First, such an implication – that papers corresponding to certain research topics are consistently of higher quality than papers on other topics – would seem insulting to scholars who conduct research in certain areas (e.g,. IS development), or in any of the four subject areas that were not statistically significant. Conversely, would also suggest unrealistically positive appraisals for all researchers who conduct research in the four areas that were cited higher than average (IT adoption and use; measurement instruments development; IS discipline development; virtual collaboration). Second, if it were true that some subjects yield research that is consistently of lower quality, this would suggest that journal reviewers and editors were not performing their jobs adequately (i.e., because they have consistently accepted low-quality research on certain topics).

What seems more reasonable than assuming that certain topics consistently yield papers that are inherently of higher quality than others is a very different conclusion: research papers corresponding to different subjects have distinct citation patterns, in part because the *size of the research sub-communities* who conduct research on these topics varies greatly. For example, in

[5] "IS Discipline Development" consisted of interpretive field studies, essays about research epistemology, and conceptual review papers.

IS, there were historically more behavioral researchers studying IT adoption and use than there were researchers studying "IT project and risk management." I argue that the frequency of citations to published studies are, in turn, a function of the size of the research sub-community that conducts research on a given topic – since authors who conduct research on a given topics are most likely to read the earlier papers on the same topic and have a need to cite those papers in their own work. (The only exception to this will be for studies of "Instrument measurement development," where a new, validated instrument will later be cited by a range of different researchers using the instrument, regardless of the subject area in which they are working).

This implies that a given subject area that has a substantially higher than average citation rate (i.e., IT adoption and use) is one with more than 10% of all active IS researchers; in contrast, another subject area with a smaller than average citation rate (e.g., IS development; IT project management) is one in which less than 10% of all IS researchers are working. We specify this 10% value as the reference point because our regression analysis in phase two featured ten distinct subject areas, after excluding the three topics for which we had very few papers in our dataset (less than 3% of papers in our dataset).

IMPLICATIONS AND CONCLUSION

There are several implications of our results: first, there should be some concordance between the relative number of papers published in each subject area and the relative ranking of the average citation rates. For example, if studies of IT adoption and use represent the highest-cited papers for the time period 1999-2005, then papers that correspond to this topics should account for the largest share of published papers. Conversely, if papers corresponding to a given topic have the lowest citation rate of the ten subject areas, then there should be the fewest papers in this category.

Since this implication is readily testable, I conducted a *post hoc* analysis of the ordinal ranks of the subject areas. I conducted a correlation analysis for rank-ordered data (the Wilcoxon signed rank test) to see if the fraction of papers corresponding to a given topics was correlated with the average citation rate for papers that belong to that subject.[6] The results show that the ordinal ranks are generally consistent – with the exception of "Instrument measurement" papers (which account for just 5% of the papers, but are the second most-highly cited topic) and "IS development" (which account for 10% of papers – the fifth largest category, but this topic has the lowest rate of citations of all topics). When these two topics are excluded from the correlation analysis of ranks, the remaining topics are well-correlated (in terms of the ordinal rankings of average citation rate for papers of a given topic vs. the fraction of papers represented by each subject category).

Another possible explanation for why papers in some subject areas receive fewer citations is that they tend to be shorter (in terms of number of pages or words), or because they contain shorter literature reviewer sections and hence, fewer references within them.[7] We explain this alternative possibility below; however, we also make explicit our assumption that papers published within a given subject area tend to primarily cite other papers in the same subject area. Thus, studies about individual IT adoption and usage will mostly cite other, previous studies of the same; studies about the business value of IT will primarily cite other such studies, etc. With this assumption in mind, we can explore how the fact of shorter length of a paper (or shorter literature review – one consisting of fewer references within a paper) would ultimately lead to such papers receiving fewer subsequent citations.

For example, if design science research papers tend to have very short literature review sections, then there may be no need for an extensive list of references within such papers. If this is true, then one corollary is that design science papers should contain fewer references to prior work within them. This explanation was suggested by a recent Ph.D. graduate who wrote a design science dissertation, while also gaining experience conducting behavioral research. He noted that "design science is about creating something new – not reviewing the prior designs that other people created. Hence there is no reason for design science research to contain a long literature review or dozens of citations. Your goal is to create something new and useful!"

We can also test this alternative explanation, by analyzing data with regard to average length (in pages, controlling for the specific journal) or data showing the number of references contained within papers that correspond to different subject areas. We have not included these results here; but we will do so before the AMCIS 2011 conference.

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[6] This average can be operationalized as either a mean or a median. It is possible that slightly different rank orders exist, depending on whether citation rates for various subjects are represented as means or median values.

[7] Here is it is critical to distinguish the notion of references listed *within* a paper vs. subsequent citations to the paper.

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Not only do the two phases of our analysis provide contradictory results, but there are limitations of each phase of our study. Phase one utilized a PhD course syllabus of exemplar "design science" studies, which may bias the results of the analysis toward papers that are well-known and well-regard – hence, well-cited. Of course, we were able to analyze the frequency of citations for just 22 of the studies listed on the PhD syllabus, since many others readings consisted of books, chapters in edited book or conference proceedings, or papers in journals not tracked by ISI/Thomson's Web of Science.

While phase two analyzed a much larger number of papers published in three leading North American IS journals, there are limitations here as well. First, about 25% of the published papers did not load on any of the 13 factors reported by Sidorova et al. (2008) – a limitation that also applied to their earlier study. The subject area classification and dataset that we borrowed from these authors was based on a Latent Semantic Analysis of abstracts of papers published in the same three IS journals, but over a period of up to 20 years (from 1985 or the first year that each journal was published up to 2006). This means that some subject areas that may have been popular a decade or two ago – such as "Decision Support Systems," "IT Management" or "Human Resources Issues in IS" are not as popular in the IS literature of the past decade.[8] Also, new topics that have emerged over the past decade – ecommerce, mobile computing, social networks – will not appear as separate topics in their analysis. These are limitations of using a typology of topics that was derived from an earlier time period.

In future research, I plan to perform my own classification of published papers, according to the typology identified by Oh et al (2006). I plan to code each paper as belonging to the general categories of IS economics, technical IS research (i.e., design science, formal modeling), or behavioral research. In order to classify a published paper into one of these categories, I will search the abstract and the full-text of each paper for keywords that identify the study as technical research (e.g., terms such as formal model, proof, theorem, lemma, corollary, etc.) or as IS economics research (Cobb-Douglas equation, Lagrangian analysis, game theoretic model, etc.) in order to classify these papers accurately. Such a coding exercise will have the advantage of analyzing the full-text of the paper, rather than the abstract alone. It will also not be constrained by subject codes that may have been derived from an earlier time period of research. We can then compare the citation rate of papers that match the category of technical IS research, IS economics, and behavioral IS research to assess whether there are significant differences among them – for each journal individually, or for all journals together.

Although I have shown that citations are a function of a paper's subject area, this does not necessary mean that they cannot also be a measure of a paper's research quality; it does mean, however, that they are not *just* a measure of research quality! In the regression analysis, just 14% of the variance in the papers' citations rates was explained by the six subject codes that were significant in our analysis, which means that there is room for other factors to account for some unexplained variance. One of these factors may indeed be research quality; however, along with a coauthor, I previously showed that the *number* of authors listed on a published paper is also an antecedent (Gallivan and Ahuja, forthcoming), which reflects overall author visibility.

My goal in this study has been to question the unexamined assumption that citations are primarily a function of a paper's quality; in doing so, I showed that a paper's subject area is a factor that shapes the number (or rate) of citations. Of course, quality may be an antecedent of equal, or even greater, importance. At this time, this remains assumed – rather than proven.

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18. Truex, D.P., Cuellar, M. and Takeda, H. "Assessing Scholarly Influence: Using the Hirsch Indices to Reframe the Discourse," *Journal of the Association for Information Systems*, 10, 2009.
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Appendix A:

List of Design Science papers for Which Citation Data Were Available in "Web of Science"

Papers published in *Information Systems Research*:

Bapna, R., Goes, P. and Gupta, A. "Replicating Online Yankee Auctions to Analyze Auctioneers' and Bidders' Strategies," 14, 2003.

Fan, M., Stallaert, J. and Whinston, A. "Decentralized Mechanism Design for Supply Chain Organizations Using an Auction Market," 14, 2003.

Hu, X.R.; Lin, Z., Whinston, A., and Zhang, P. "Hope or Hype: On the Viability of Escrow Services as Trusted Third Parties in Online Auction Environments," 2004.

Konana, P. Gupta, A., and Whinston, A.B., "Integrating User Preferences and Real-Time Workload in Information Services," 11, 2000.

March, S., Hevner, A. and Ram. S. "Agenda for IT Research in Heterogeneous and Distributed Environments," 11, 2000

Papers published in *Journal of Management Information Systems*:

Ba, S., Stallaert, J, Whinston, A. and Zhang, P. "Choice of Transaction Channels: The Effects of Product Characteristics on Market Evolution," 21, 2005.

Barua, A., Ravindran, S. and Whinston, A., "Efficient Selection of Suppliers Over the Internet,"13, 1997.

Fan, W., Gordon, M. and Pathak, P., "Genetic Programming-based Discovery of Ranking Functions for Effective Web Search,"21, 2005.

Fan, W.G., Kumar, S., and Whinston, A.B. "Selling or Advertising: Strategies for Providing Digital Media Online," 24, 2007.

Peffers, K., Tuunanen, T., Rothenberger, M. and Chatterjee, S., "A Design Science Research Methodology for IS Research," 24, Winter 2007/2008.

Tang, Q. and Cheng, H., "Optimal Strategies for a Monopoly Intermediary in Supply Chain of Complementary Web Services," 23, 2005/2006.

Papers published in *MIS Quarterly*:

Albert, T. C., Goes, P. B., & Gupta, A. "GIST: A Model for Design and Management of Content and Interactivity of Customer-Centric Web Sites, *28*, 2004.

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Whinston, A. and Geng, X. "Operationalizing the Essential Role of the IT Artifact in IS Research: Gray Area, Pitfalls and the Importance of Strategic Ambiguity, 28, 2004.

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Fan, M., Stallaert, J. and Whinston, A. "The Adoption and Design Methodologies of Component-Based Enterprise Systems," *European Journal of Information Systems*, 9(1), 2000.

Freeman, P., and Hart, D., "A Science of Design for Software-Intensive Systems," *Communications of the ACM*, 47, 2004.

Gregor, S. and D. Jones, "The Anatomy of a Design Theory," *Journal of Association for Information Systems*, 8, 2007.

Kuechler, B., and Vaishnavi, V., "On Theory Development in Design Science Research: Anatomy of A Research Project," *European Journal of Information Systems,* 17, 2008.

March, S.T., and Smith, G.F., "Design and Natural Science Research on Information Technology," *Decision Support Systems*, 15, 1995.

Appendix B:

Papers published 1999-2005 Corresponding to "IT Adoption and Use" category

Papers published in *Information Systems Research*:

Kaufman et al , "Opening the "Black Box" of Network Externalities in Network Adoption," 11, 2000.

Venkatesh , "Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion Into the Technology Acceptance Model," 11, 2000

Agarwal et al., "The Evolving Relationship between General and Specific Computer Self-Efficacy," 11, 2000.

Belanger et al, "Technology Requirements and Work Group Communications for Telecommuters," 12, 2001

Chidambaram and Tung, "Is Out of Sight, Out of Mind? An Empirical Study of Social Loafing in Technology-Supported Groups," 16, 2005

Chwelos et al., "Research report: Empirical test of an EDI Adoption Model," 12, 2001.

Jarvenpaa and Shaw, "Toward Contextualized Theories of Trust: The Role of Trust in Global Virtual Teams," 15, 2004

Koufaris, "Applying the TAM and Flow Theory to Online Consumer Behavior," 13, 2002.

Lee et al. "IT Outsourcing Strategies: Universalistic, Contingency and Configurational Explanations of Success," 15, 2004.

McKnight et al ., "Developing and Validating Trust Measures for E-Commerce: An Integrative Typology," 13, 2002.

Pavlou and Gefen, "Building Effective Online Marketplaces with Institution-Based Trust," 15, 2004.

Plouffe et al, "Research Report: Richness versus Parsimony in Modeling Technology Adoption Decisions," 12, 2001.

Sussman and Siegal, "Informational Influence in Organizations: An Integrated Approach to Knowledge Adoption," 14. 2003.

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Zhu and Kraemer, "Post-Adoption Variations in Usage and Value of E-Business by Organizations," 16, 2005.

Papers published in *Journal of Management Information Systems*:

Au and Kauffman, "Should We Wait? Network Externalities, Compatibility, and Electronic Billing Adoption," 18, 2001.

Bhattacherjee, "Individual Trust in Online Firms: Scale Development and Initial Test," 19, 2002.

Gallivan., Spitler and Koufaris, "Does Information Technology Training Really Matter? A Social Information Processing Analysis of Coworkers' Influence on IT Usage in the Workplace," 22, 2005.

Gefen, "What Makes an ERP Implementation Relationship Worthwhile: Linking Trust Mechanisms and ERP Usefulness," 23, 2004.

Hall and Liedtka, "Financial Performance, CEO Compensation, and Large-Scale IT Outsourcing Decisions," 22, 2005.

Hardgrave et al.,"Investigating Determinants of Software Developers' Intentions to Follow Methodologies," 21, 2003.

Hu et al., "Examining the TAM Model Using Physician Acceptance of Telemedicine Technology," 17, 2000.

Malhotra and Galletta, "A Multidimensional Commitment Model of Volitional Systems Adoption and Usage Behavior," 22, 2005.

Peace et al., "Software Piracy in the Workplace: A Model and Empirical Test," 20, 2003.

Pennington et al., "The Role of System Trust in Business-to-Consumer Transactions," 20, 2004.

Son et al., "Effects of Relational Factors and Channel Climate on EDI Usage in Customer-Supplier Relationships," 22, 2005.

Thatcher et al., "Turnover of IT Workers: Examining Empirically the Influence of Attitudes, Job Characteristics and External Markets," 20, 2003.

Papers published in *MIS Quarterly*:

Agarwal and Karahanna, "Time Flies When You're Having Fun: Cognitive Absorption and Beliefs about IT Usage," 34, 2001.

Ang and Slaughter, "Work Outcomes and Job Design for Contract Vs Permanent IS Professionals on Software Development Teams," 34, 2001.

Bhattacherjee, "Understanding Information Systems Continuance: An Expectation-Confirmation Model," 34, 2001

Bhattacherjee and Premkumar 2004, "Understanding Changes in Belief and Attitude toward IT Usage," 37, 2004.

Bock et al., "Behavioral Intention Formation in Knowledge Sharing," 38, 2005

Brown and Venkatesh, "Model of Adoption of Technology In Households: A Baseline Model Test and Extension," 38, 2005.

Gefen et al., "Trust and TAM In Online Shopping: An Integrated Model," 36, 2003.

Heijden 2004, "User Acceptance of Hedonic Information Systems," 37, 2004.

Kankanhalli et al., "Contributing Knowledge to Electronic Knowledge Repositories," 38, 2005.

Ko et al., "Antecedents of Knowledge Transfer from Consultants to Clients in Enterprise System Implementation," 38, 2005.

Lapointe and Rivard, "A Multilevel Model of Resistance to Information Technology Implementation," 38, 2005.

Levina and Ross, "From the Vendor's Perspective: Exploring the Value Proposition in IT Outsourcing," 36, 2003.

Lewis et al., "Sources of Influence on Beliefs about IT Use: An Empirical Study of Knowledge Workers," 36, 2003.

Sharma and Yetton, "The Contingent Effects of Management Support and Task Interdependence," 36, 2003.

Teo et al., "Predicting Intention to Adopt Interorganizational Linkages: An Institutional Perspective," 36, 2003.

Thatcher and Perrewe, "An Empirical Examination of Individual Traits as Antecendents to Computer Anxiety," 35, 2002.

Venkatesh and Brown "A Longitudinal Investigation of Personal Computers in Homes," 34, 2001.

Venkatesh and Morris, "Why Don't Men Ever Stop to Ask for Directions? Gender, Social Influence, and their Role in Technology Acceptance and Usage Behavior,"33, 2000.

Appendix C:

Papers Published 1999-2005 Corresponding to "Instrument Development" Category

Papers published in *Information Systems Research*:

Agarwal and Venkatesh, "Assessing Firm's Web Presence: A Heuristic Evaluation Procedure for Measurement of Usability, 13, 2002.

Allport and Kerler, "Research Note Regarding the Development of the Consensus on Appropriation Scale, 14, 2003.

Devaraj, Fan, and Kohli, "Antecedents of B2C Channel Satisfaction: Validating E-Commerce Metrics, 13, 2002.

Krishnan, Peters, Padman, and Kaplan, "Data Reliability Assessment in Accounting Information Systems, 16, 2005.

McKinney, Yoon and Zahedi, "Measurement of Web-Customer Satisfaction: An Expectation and Disconfirmation Approach, 13, 2002.

McKnight, Choudhury and Kacmar, "Developing and Validating Trust Measures for E-Commerce, 13, 2002.

Palmer, "Web Site Usability, Design, and Performance Metrics," 13, 2002.

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Stewart and Segars. "An Empirical Examination of the Concern for Information Privacy Instrument, 13, 2002,.

Straub, Hoffman; Weber and Steinfield, "Toward New Metrics for Net-Enhanced Organizations, 13, 2002.

Torkzadeh and Dhillon, "Measuring Factors That Influence the Success of Internet Commerce, 13, 2002.

Zhu and Kraemer, "E-Commerce Metrics for Net-Enhanced Organizations: Assessing the Value of E-Commerce," 13, 2002.

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Bhattacherjee, "Individual Trust in Online Firms: Scale Development and Initial Test, 19, 2002.

Byrd and Turner, "Measuring the Flexibility of IT Infrastructure: Exploratory Analysis of a Construct, 17, 2000.

Chang,and King, "Measuring the Performance of Information Systems: A Functional Scorecard, 22, 2005.

Chan, "IT Value: The Great Divide between Qualitative and Quantitative and Individual and Organizational Measures, 16, 2000.

Doll, Xiaodong, et al., "The Meaning and Measurement of User Satisfaction: Measurement Invariance Analysis," 21, 2004.

Nelson, Todd, and Wixom, "Antecedents of Information and System Quality," 21, 2005.

Ravichandran and Rai, "Total Quality Management in IS Development: Key Constructs and Relationships, 16, 1999.

Straub, Rai and Klein, "Measuring Firm Performance at the Network Level: A Nomology of the Business Impact of Digital Supply Networks, 21, 2004.

Templeton, Lewis and Snyder, "Development of a Measure for the Organizational Learning Construct, 19, 2002.

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Bhattacherjee, "Understanding IS Continuance: An Expectation-Confirmation Model," 25, 2001.

Boudreau, Gefen and Straub, "Validation in IS Research: A State-of-the-Art Assessment," 25, 2001.

Jiang, Klein an. Carr, "Measuring Information System Service Quality: ServQual from the Other Side," 26, 2002.

Kettinger and Lee, "Zones of Tolerance: Alternative Scales for Measuring IS Service Quality," 29, 2005.

Venkatesh, Morris; Davis and Davis, "User Acceptance of IT: Toward a Unified View," 27, 2003.

Appendix D:

Papers published 1999-2005 Corresponding to "IS Discipline Development" Category

Papers published in *Information Systems Research*:

Barrett, and Walsham, "Electronic Trading and Work Transformation in the London Insurance Market,"10, 1999.

Robey and Boudreau, "Accounting for the Contradictory Organizational Consequences of Information Technology," 1999.

Papers published in *Journal of Management Information Systems*:

Chan, "IT Value: Great Divide between Qualitative and Quantitative and Individual and Organizational Measures," 16, 2000.

Gold, Malhotra and Segars, "Knowledge Management: An Organizational Capabilities Perspective," 18, 2001.

Iivari, Hirschheim and Klein, "A Dynamic Framework for Classifying IS Development Methodologies," 17, 2000.

Templeton, Lewis, and Snyder, "Development of a Measure for the Organizational Learning Construct," 19, 2002.

Vessey, Ramesh and Glass "Research in IS: An Empirical Study of Diversity in the Discipline and its Journals," 19, 2002.

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Alavi and Leidner, "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," 25, 2001.

Benbasa and Zmud, "Empirical Research in Information Systems: The Practice of Relevance," 23, 1999.

Benbasat and Zmud, "The Identity Crisis within the IS Discipline: Defining and Communicating the Discipline's Core Properties," 27, 2003.

Chiasson and Davidson, "Taking Industry Seriously in Information Systems Research," 29, 2005.

Dubé and Paré. "Rigor in IS Positivist Case Research: Current Practices, Trends, and Recommendations," 27, 2003.

Garud and Kumaraswam,"Vicious and Virtuous Circles in the Management of Knowledge: The Case of Infosys," 29, 2005.

Hevner, March; Park and Ram, "Design Science in Information Systems Research," 28, 2004.

Jasperson, 'Jon; T.A. Carte; et al., "Review: Power and IT Research: A Metatriangulation Review," 26, 2002.

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Reich and Kaarst-Brown. "Seeding the Line": Understanding the Transition from It to Non-It Careers," 23, 1999.

Schultze and Leidner, "Studying Knowledge Management in Information Systems Research," 26, 2002.

Swanson and Ramiller, "Innovating Mindfully with Information Technology," 28, 2004.

Trauth and Jessup, "Understanding Computer-Mediated Discussions: Positivist and Interpretive Analyses of Group Support System Use," 24, 2000.

Van de Ven, "Running in Packs to Develop Knowledge-Intensive Technologies," 29, 2005.

Wade and Hulland, "The Resource-Based View and IS Research: Review, Extension, and Suggestions," 28, 2004.

Walsham and Sahay, "GIS for District-Level Administration in India: Problems and Opportunities," 23, 1999.

Walsham, "Cross-Cultural Software Production and Use: A Structurational Analysis," 26, 2002.

Wastell, "Learning Dysfunctions in IS Development: Overcoming Social Defenses with Transitional Objects," 23, 1999.

Appendix E:

List of Papers Published 1999-2005 Corresponding to "IS Development" Category

Papers published in *Information Systems Research*:

Blanning and Basu. "A Formal Approach to Workflow Analysis," 11, 2000.

Bordetsky and Mark, "Memory-Based Feedback Controls to Support Groupware Coordination," 11, 2000.

Harker and Tan, "Designing Workflow Coordination: Centralized vs Market-Based Mechanisms," 10, 1999.

Kim, Hahn, and Hahn,"How Do We Understand a System with (So) Many Diagrams? Cognitive Integration Processes in Diagrammatic Reasoning," 11, 2000.

Krishnan, Peters, Padman.and Kaplan, "On Data Reliability Assessment in Accounting IS," 16, 2005.

Menon, Sarker, and Mukherjee, "Maximizing Accuracy of Shared Databases When Concealing Sensitive Patterns," 16, 2005.

Porra, "Colonial Systems," 10, 1999.

Sarathy, and Muralidhar, "The Security of Confidential Numerical Data in Databases," 13, 2002.

Sarkar, and Ramaswamy, "Knowledge Base Decomposition to Facilitate Verification," 11, 2000.

Sarker, and Dey, "Modifications of Uncertain Data: A Bayesian Framework for Belief Revision," 11, 2000.

Whinston, Konana, and Gupta, "Integrating User Preferences and Real-Time Workload in Information Services," 11, 2000.

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Back, et al. "Contents Matching Defined by Prototypes: Methodology Verification with Books of the Bible," 18, 2001.

Balachandran, et al. "MOTC: An Interactive Aid for Multidimensional Hypothesis Generation," 16, 1999.

Benaroch, "Managing IT Investment Risk: A Real Options Perspective," 19, 2002.

Bieber, et al. "Toward Virtual Community Knowledge Evolution," 18, 2001.

Boehm, et al. "Integrating Collaborative Processes and QA Techniques: Experiences from Requirements Negotiation," 20, 2003.

Brezillion, et al. "Operational Knowledge Representation for Practical Decision-Making," 18, 2001.

Browne and Pitts, "Stopping Behavior of Systems Analysts during Information Requirements Elicitation," 21, 2004.

Browne and Rogich. "An Empirical Investigation of User Requirements Elicitation: Comparing the Effectiveness of Prompting Techniques," 17, 2000.

Capiello, Francalanci, and Pernici, "Time- Related Factors of Data Quality in Multichannel IS," 20, 2003.

Chen, Goes, and Marsden, "Query-Driven Approach to Design and Management of Flexible Database Systems," 19, 2002.

Chen, Chung, and Nunamaker, "A Visual Framework for Knowledge Discovery on the Web," 21, 2005.

Choobineh and Loh, "CABSYDD: Case-based System for Database Design," 21, 2004.

Dorohonceanu, Krebs, and Marsic, "Supporting Collaboration in Heterogeneous Environment," 20, 2003.

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Fazlollahi, and Vahidov. "A Method for Generation of Alternatives by Decision Support Systems," 18, 2001.

Heiminger and Kelley, "Assessing the Digital Rosetta Stone Model for Long-Term Access to Digital Documents," 21, 2005.

Jain, Nazareth, Purao, "Approach to Distribution of Object-Oriented Applications in Loosely Coupled Networks," 18, 2001.

Kakola and Koota, "Redesigning Computer-Supported Work Processes with Dual IS," 16, 1999.

Kiers, et al. "Multiparty Negotiation Support: The Role of Visualizations Influence on the Development of Shared Mental Models," 19, 2002.

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