A Dynamic Network Measure of Knowledge Evolution: A Case Study of MIS Quarterly

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Abstract

Citation measures are the central metrics to assessing the impact of an article, the viability of research streams, the career success of scholars, as well as the quality and status of journals and academic units. While measuring the magnitude of the future usage, they cannot capture the substantial effects that an article may have on the subsequent use of its predecessors - whether it amplifies or disrupts the existing literature. We embrace that it is imperative to not only assess its impact but also assess how an article reinforces the existing research streams or breaks into a new stream to understand its true effect. Accordingly, we introduce a new, dynamic measure, and conduct a case study using all articles published between 1979-2016 at MIS Quarterly to illustrate the validity of the new measure, and conclude with some future research topics and implications.

1. Introduction

The structure of knowledge evolution distinguishes between two routes to knowledge creation. The first is called normal science [1], which is firmly built on one or more past scientific achievements. Under the region of normal science that implicitly defines the legitimate problems and methods of a research field, scholars committed to the same rules and standards for scientific practice; the knowledge gained is cumulative. The second is called scientific revolution or paradigm change, which is taken to be the non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one. For example, Copernican astronomy replaces Ptolemaic, Einstein's Theory of Relativity replaces Newtonian's mechanisms, which in turn replaced Aristotelian dynamics. In short, new research may amplify or disrupt the existing knowledge.

Despite the substantive and theoretical importance of differentiating between these two routes of knowledge creation, no quantitative measures exist to capture the distinction [2]. Systematic explanations for why, when, and how new knowledge has different effects on their context remain elusive. Assessment of knowledge dynamics traditionally relied on detailed case studies [1]. Quantitative studies are almost exclusively based on forward-citation counts of a work, such as impact factor, five-year impact factor, and h-index, and lead to insightful meaning and implications. However, the literature's focus on citation counts and citation-based measures of impact has a limitation. Although such measures can reflect the magnitude of a work's later use, they often fail to capture other dimensions of knowledge change in terms of differentiating revolutionary scientific breakthroughs from practice-oriented work [2]. Focusing on impact of a new work without considering how it relates to extant knowledge creates bias and incomplete understanding of knowledge evolution.

The quest for citation impact without distinction between two routes of scholarship may at least partially contribute to several limitations of the current management literature. First, it is widely acknowledged that there are few original theories in the management field, which is argued to largely result from manager scholars' overreliance on borrowing from other disciplines, such as economics, psychology and sociology, rather than pursuing an indigenous approach [3]. Second, leading scholars such as Weick and Mintzberg have criticized that top management journals favor deductive rather than inductive research, ideas derived from well-known rather nascent theories, literature-driven research rather than phenomena-driven research, and methodology rigor rather than novelty[4]. Third, while scholars without the western training are expected to have a unique position to initialize new theories due to their different experience and national culture, under the pressure to publish in highly cited journals, they fall within the confines of well-known Western theories, rather than pursuing indigenous issues for theoretical innovation [4]. For example, while they are becoming important players, East Asian scholars are unlikely to take ground-breaking theorizing positions because they believe that top management journals are unlikely to be impressed by new theories they develop [4]. As a result, their success comes largely from a close adherence to the Western research paradigm and their research is becoming indistinguishable from those by Western scholars in terms of guiding theoretical framework and

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methodologies. Even though national culture can be a visible research topic to generate new theories, a culture-general approach is dominant [5].

In this study, we build on Funk and Owen-Smith's dynamic measure of technological change [2] and extend it to a dynamic network measure of knowledge evolution, which captures the effects that a new article has on the use of its predecessors in the future development. Such a dynamic network measure is important to complement the citation impact because, unlike citation measures that only capture the magnitude of the later usage of an article, our new measure captures the effect of an article on its predecessor in future development. A new article as a new node can reshape the network of articles by shifting scholars' attention to or away from the knowledge they built on [2]. In other words, the new measure captures the direction of its effect related to extant knowledge: whether an article reinforces the status quo of the existing literature, or disrupts the existing literature with a new stream.

In the following, we first review the existing measure of scholarship and their limitations, then introduce the new, dynamic measure, conduct a case study using all articles published in 1979~2016 at MIS Quarterly (MISQ) to illustrate the validity of the dynamic measure of scholarship, and conclude with some future research and its research implications.

2. Related work

2.1. Existing measures of impact

Many quantitative measures view articles as a variable in their impact, i.e. the extent to which they are later used [2]. Although the real impact of an article is hard to assess, citations of articles are increasingly used as a criterion to assess the impact and the viability of research streams, the career success of scholars, and the quality and status of journals and academic units [6]. Leung laments that citation impact has become "the sine quo non of scholarship assessment" [4] (p.510). Accordingly, schools and departments have adopted internal policy that encourages scholars to target high-impact journals, some universities even only reward "hits" at A-journals. Many journal editors aim to raise journals' impact factor as their primary objective. Some scholars have described impact factor as "The Number That's Devouring Science" [7]. Impact measures are attractive because they reflect the intuitive idea that new articles offering big improvements over existing literature should be more widely cited than those with small refinements.

However, impact measures suffer several limitations. First, since impact measures of an article focus on the amount of its later usage, they miss a key substantial distinction between articles whose value is from reinforcing the trajectories which they originate from and those whose value results from disrupting the current stream [2]. Hence, the impact measures are valid to assess the extent to which an article is used, but they cannot provide insights into how the article is used, particularly how its usage shapes the directions of future development in the context of existing scholarship. The latter is the central issue of the evolutionary theory of change [1, 8, 9]. Second, both normal science or practice-oriented research and novel research can have large number of citation, so the impact factor cannot distinguish their differences, which can have important policy implications. Third, the citation count of an article or journal is influenced not only by its later usage, but also type of research such as literature review vs. novelty research and the popularity of a field. For example, it is well-know that Management Science publishing high-quality novel research has low impact factor and Journal of Management publishing review pieces by largely summarizing the exist knowledge has a high impact factor.

With the advance of information technology, scholars can access a much boarder range of information than before, but due to the limitation of scholars' attention and time, they have to be selective about what journals will be their focus. Therefore, it is rational to choose the higher impact journals as citation impact signals their powerful status. At the same time, article citation is primarily influenced by reputation of journals [6], high impact journals become self-fulfilling, perhaps leading to winner-take-all and convergence in management journals all scholars aim at [4].

In short, the existing impact measures cannot capture the substantial effects that new articles may have on the subsequent use of their predecessors or the evolution of a broader stream. We embrace that, to understand an article's effect, it is necessary to not only assess its impact, but assess how an article fits into existing research streams or apart away from them by influencing the future work in using its predecessors. By extending the Funk and Owen-Smith's dynamic measure of technological change, we develop a new measure below to overcome the limitation of citation measures.

2.2. A dynamic measure

According to Funk and Owen-Smith [2], a dynamic measure for evaluating scholarly impact should have the following features:

- *Structural* (in a network sense): How it affects the use of other articles rather than its own use. How is an article used in the existing literature, or how does an article reshape the literature?
- *Dynamic*: the extent to which an article changes the use of other literature over time. This captures the idea that new articles emerge in the context that are comprised of other research [8].
- *Emergent*: capture the effect ex post in the context of its use rather than ex ante in the context of its discovery.
- *Continuous*: capture degrees of amplification and disruptiveness rather than using category classification.
- *Valenced*: to distinguish between disrupting and amplifying scholarship.

We follow these guidelines when designing out dynamic measure of knowledge evolution.

3. Measure Development

In this paper, we develop a graph-based measure, disruptiveness index. Unlike citation count that measures an article's impact by the magnitude of its own use, our measure quantifies the extent to which an article consolidates or destabilizes the subsequent use of the prior arts on which it builds.

3.1. Basic measure

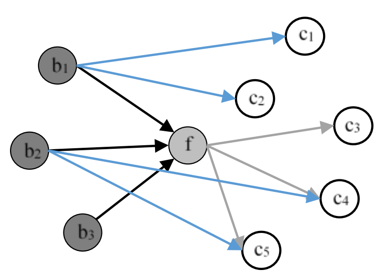


Figure 1. A tripartite citation graph

Our measure is defined based on the citation relationships among research articles in a tripartite directed graph $G = (V_1, V_2, V_3, E)$, see Figure 1. In this graph, we have three types of vertices and an edge set.

- V_1: focal article(s) *f*'s;
- V_2: prior art $\{b\}$, which are cited by *f* in its bibliography; and
- V_3: forward citations $\{c\}$, which are new articles that published after *f* and cite *f* or its prior arts.
- *E*: citation links $\{e\}$, in which each edge *x* ® *y* represents an article *x* is cited by an article *y*.

For a new article *c* in V_3, if it considers work in V_1 and V_2 relevant and important, there are three ways of attaching a to the network:

1) *c* cites *b*;
2) *c* cites *f*;
3) *c* cites both *b* and *f*.

In [2] Funk and Owen-Smith defined an index that measures a patent's disruptiveness on *all* of its prior arts as a whole. In this study, we modify their definition and introduce a new measure D_{it} to quantify the disruptive impact of focal article *f* on a *particular* prior art b_i in $\{b_1, ..., b_m\}$.

For a focal article *f*, its prior art is represented as a set $\mathbf{b} = \{b_1, \dots, b_m\}$, where *m* is the number of articles cited by *f*. Set $\mathbf{c} = \{c_1, \dots, c_n\}$ represents forward citations to article *f* and/or its prior art **b** at time *t*. We use *i* to subscript *f*'s prior arts in **b** and *j* to subscript *f*'s subsequent articles in **c**. The disruptiveness of article *f* on a prior art b_i is defined as:

$$D_{\text{it}} = \frac{1}{n_t} \sum \left(-2 f_{\text{jt}} b_{\text{ijt}} + f_{\text{jt}}\right)$$

where n_t is the number of forward citations to *f* and/or b_i in **c** at time *t*,

$$f_{\text{jt}} = \begin{cases} 1 & \text{if } c_j \text{ cites the focal article } f \\ 0 & \text{otherwise,} \end{cases}$$

and

$$b_{\text{ijt}} = \begin{cases} 1 & \text{if } c_j \text{ cites the focal article's prior art } b_i \\ 0 & \text{otherwise.} \end{cases}$$

This measure D_{it} indicates the disruptiveness of the focal patent *f* on its prior art b_i.

Based on this definition, the three different ways for a new article c_j to join the citation network will have different implications on the focal article *f*.

1) c_j cites b_i but not *f*: $f_{jt} = 0$, $b_{ijt} = 1$, hence $D_{it} = -2*0*1 + 0 = 0$. The new article considers the prior art b_i more important than *f*. Article *f* has zero effect on b_i.
2) c_j cites *f* but not b_i: $f_{jt} = 1$, $b_{ijt} = 0$, hence $D_{it} = -2*1*0 + 1 = 1$. The new article considers the focal article *f* more important and discards the prior art b_i. This indicates that *f* may be based

on b_i but have introduced a shift from b_i in its knowledge creation process.

3) c_j cites both b_i and f: $f_{jt} = 1$, $b_{ijt} = 1$, hence $D_{it} = -2*1*1 + 1 = -1$. The new article considers both b_i and f important. Therefore, f did not disrupt but amplify the importance of b_i in the literature.

Specifically, for the citation network in Figure 1, we can calculate the disruptiveness of f on its three prior arts b_1, b_2 and b_3 as follows:

1) f on b_1: $D_{1t} = (0 + 0 + 1 + 1 + 1) / 5 = 0.60$;
2) f on b_2: $D_{2t} = (1 - 1 - 1) / 3 = -0.33$;
3) f on b_3: $D_{3t} = (1 + 1 + 1) / 3 = 1$.

In this example, the article f is shown to be most disruptive on b_3, as indicated by the greatest score $D_{3t} = 1$. None of the new articles that cite f also cites b_3 in that they consider f more important than b_3. For articles b_1 and b_2, even though they both have three citations, they receive totally different disruptiveness from f, 0.6 and -0.33, respectively. Among the five new articles that cite b_1 and f, two of them cite b_1 only but not f, while the other three cite f only but not b_1. The positive score $D_{1t} = 0.6$ indicates that there seems to be a knowledge shift from b_1 to f. On the contrary, among the three new articles that cites b_2 or f, two of them cite both b_2 and f, while only one of them cites f but not b_2. The negative score $D_{2t} = -0.33$ indicates that f is built upon b_2 but does not seem to destabilize the position of b_2 in the literature.

3.2. Aggregate measures

So far, we have defined a measure, D_{it}, which quantifies the effect of a specific focal article f on one of its prior art b_i. Now, let us take a global look at a citation graph, in which each node is an article and each link is a citation from an article i to an article j (j cites i). Using the measure defined above, we can calculate the disruptiveness score on each citation link (i ® j), which indicates the disruptiveness of article j on its prior art i.

In such a directed graph representing a citation network, we can further define a number of aggregate measures that can infer the importance of each article in the literature of this field.

- *In-degree*

In-degree is defined as the number of in-links pointing to a node. Specifically, in a citation network, the in-degree represents the number of references cited in the bibliography. This number does not change over time. In Figure 1, since f has three prior arts b_1~b_3, its in-degree is always 3.

- *Out-degree*

Out-degree is defined as the number of out-links coming out of a node. Specifically, in a citation network, the out-degree represents the number of times this article has been cited. Unlike the in-degree, the out-degree does change over time as an article may receive more citations as time goes by. In Figure 1, since f has three forward citations c_3~c_5 so far, its out-degree is 3 at this time.

- *Weighted average in-degree*

Each citation link is associated with weight, i.e., the disruptiveness score D_{it}. Thus, for a focal article f, we can calculate the weighted average of all D_{it}'s on its prior arts to measure its overall disruptiveness at time t. In Figure 1, the weighted average in-degree of f is (0.6 – 0.33 + 1) / 3 = 0.42. A great weighted average in-degree means that new articles consider the article more important and tend to cite this article other than its prior arts. Thus, the article tends to be disruptive and lead to knowledge shift in this field.

- *Weighted average out-degree*

For an article that is cited by other articles in the citation network, the weight on each citation link indicates the disruptiveness of the citing article on the focal article. Thus, for a focal article f, we can determine the weighted average of all disruptiveness scores of the citing articles at time t. In Figure 1, the weighted average out-degree of f is the weighted average of the disruptiveness scores it received from c_3~c_5. A great weighted average out-degree means that new articles consider the article's citing articles more important and tend to cite them rather than the focal article. In other words, this article or topic is becoming obsolete and replaced by others in the field.

4. A case study on MIS Quarterly

MISQ is widely regarded as one of the most prestigious journals in the information systems discipline since it was first established in 1977. During the past four decades, MISQ has shaped and witnessed the evolution of information system research as a scientific discipline. In this study, we apply our proposed measures on articles published in MISQ over the 40 years of period, in order to identify impactful articles that have played critical roles in shaping the information systems field and illustrate the different meanings and implications of the disruptiveness index from citation counts.

4.1. Data collection

We collected citation data of MISQ articles from the Web of Science. Although MISQ was established in 1977, the Web of Science's database does not seem to contain the first two volumes of MISQ, Vol. 1 in 1977 and Vol. 2 in 1978. Hence, our data set only contains 1,287 articles published in Vol. 3(1) in 1979 ~ Vol. 40(1) in 2016. For each MISQ article, we collect its metadata, including Web of Science access number (unique identifier), year, volume, issue, authors, title, number of cited references, number of times cited, and list of citing articles. Thus, starting from the 1,287 MISQ articles, we follow their total of 76,769 citations and build a citation network of 27,780 articles. Such a network represents the chronicle development history of MISQ over the past 40 years.

4.2. Citation graphs

We divide the 40 years from 1979 to 2016 into four 10-year stages (1977 and 1978 were not included due to lack of data on the Web of Science). The number of MISQ articles included in our four citation networks is listed in Table 1. Articles without any citation relationships (i.e., neither citing any prior MISQ articles nor cited by any articles) were not included in the citation networks.

Table 1. Number of MISQ articles in the four citation networks

Years	# of articles
1979~1986	110
1987~1996	381
1997~2006	653
2007~2016	1126

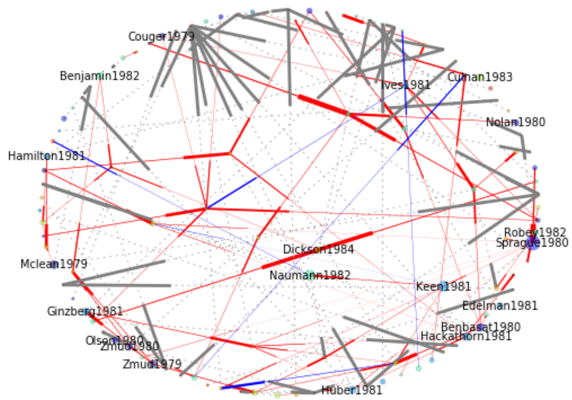
For each stage/decade, we calculate the disruptiveness indices of all articles that have been published so far. We are also able to visualize the citation network at each stage in Figure 2 (a)~(d). In these graphs, each node is an MISQ article and each directed edge is a citation link, on which the thick end connects the citing article. The size of a node represents the number of citations the article has received so far. The color of the node represents the age of the article. Newer articles are in warmer colors while older articles are in cooler colors. The color of an edge indicates the sign of the disruptiveness score, i.e., red (solid) being positive, blue (solid) being negative and gray (dotted) being zero. The width of an edge indicates the magnitude of the disruptiveness. For the sake of visibility, we only include the top 200 nodes with the highest citations in each of these four graphs and label the top 20 most cited articles by the first author and year.

4.3. Finding the most disruptive articles

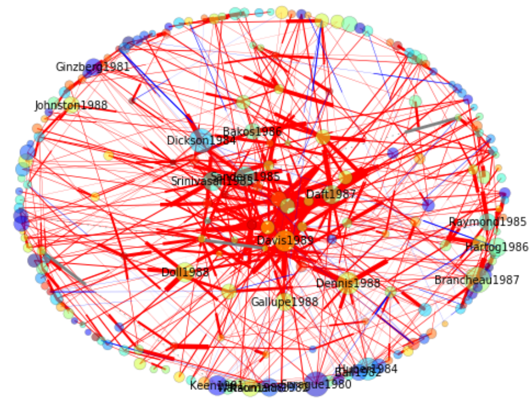
In this study, we are interested in finding the most significant MISQ articles that have helped to shape and define the MIS field. Therefore, we calculate the weighted average in-degree of each MISQ article to represent its disruptiveness.

For each of the four decades of MISQ, we rank all articles by the weighted average disruptiveness index and identify the top five articles, as shown in Tables 2 (a)~(d). The column "Citations by year" is the number of citations the article has received so far in the Web of Science core collection under Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI), and Arts & Humanities Citation Index (A&HCI). The last column is the weighted average disruptiveness index of the article in that year.

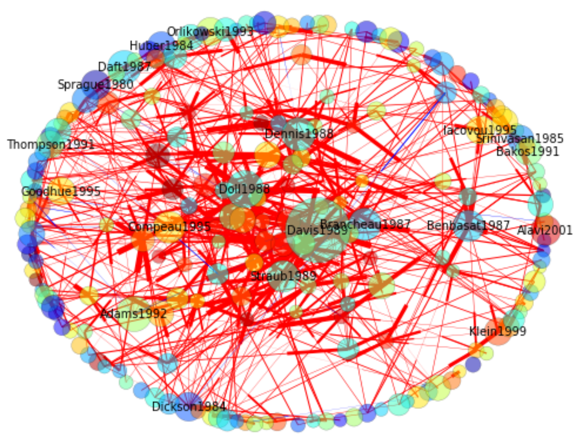
As shown in Tables 2(a)~(d), several most cited MISQ articles are also included in the list as the most disruptive ones. For instance, Davis's 1989 article "Perceived usefulness, perceived ease of use, and user acceptance of information technology" is the most cited one in the history of MISQ (4294 in 2016) [10]. It also has the highest disruptiveness score (0.9779) in 2016. Nevertheless, articles with high disruptiveness score may not necessarily all be the ones with the most citations. A good example is Watson et al.'s 2010 article "Information systems and environmentally sustainable development: energy informatics and new directions for the IS community." By far, this article has received 67 citations, which is far less than some of the most cited articles in MISQ, partially because it was published only six years ago. However, its disruptiveness score (0.9645) is the second highest among all MISQ articles in 2016. This article is considered one of the seminal works in the new stream of IS research on environmental sustainability, which has gained a lot of attentions in recent years.



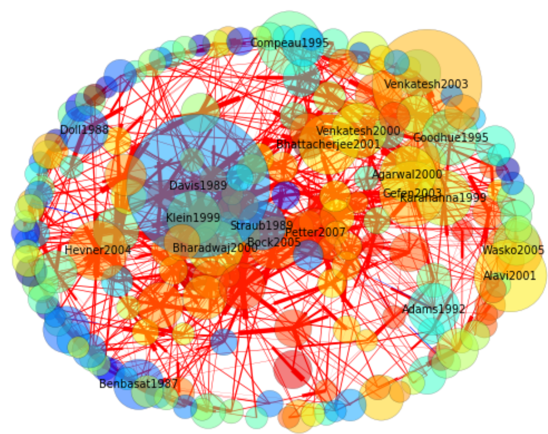
(a) 1977~1986



(b) 1987~1996



(c) 1997~2006



(d) 2007-2016

Figure 2. Citation networks of MIS Quarterly articles in four decades

Table 2. Top five disruptive MISQ articles in the four decades

(a) 1977~1986

Authors	Year	Vol.	Iss.	Title	Citations by 1986	Weighted Avg. Disruptiveness$_{1986}$
Sprague	1980	4	4	A framework for the development of decision support systems	42	0.8636
Dickson et al.	1984	8	3	Key information-systems issues for the 1980s	7	0.6250
Rockart et al.	1982	6	5	Future role of the information systems executive	4	0.5905
Ginzberg	1981	5	2	Key recurrent issues in the MIS implementation process	12	0.5000
Baroudi	1985	9	4	The impact of role variables on IS personnel work attitudes and intentions	1	0.5000

(b) 1987~1996

Authors	Year	Vol.	Iss.	Title	Citations by 1996	Weighted Avg. Disruptiveness$_{1996}$
Sprague	1980	4	4	A framework for the development of decision support systems	131	0.9338
Pyburn	1983	7	2	Linking the MIS plan with corporate strategy: an exploratory study	42	0.9333
Ives & Jarvenpaa	1991	15	1	Applications of global information technology - key issues for management	21	0.8750
Daft et al.	1987	11	3	Message equivocality, media selection, and manager performance - implications for information-systems	75	0.7136
Davis	1989	13	3	Perceived usefulness, perceived ease of use, and user acceptance of information technology	97	0.7054

(c) 1997~2006

Authors	Year	Vol.	Iss.	Title	Citations by 2006	Weighted Avg. Disruptiveness$_{2006}$
Pyburn	1983	7	2	Linking the MIS plan with corporate strategy: an exploratory study	60	0.9524
Davis	1989	13	3	Perceived usefulness, perceived ease of use, and user acceptance of information technology	790	0.9112
Sprague	1980	4	4	A framework for the development of decision support systems	159	0.9107
Ives & Jarvenpaa	1991	15	1	Applications of global information technology - key issues for management	55	0.8983
Benbasat et al.	1987	11	3	The case research strategy in studies of information-systems	185	0.8270

(d) 2007~2016

Authors	Year	Vol.	Iss.	Title	Citations by 2016	Weighted Avg. Disruptiveness$_{2016}$
Davis	1989	13	3	Perceived usefulness, perceived ease of use, and user acceptance of information technology	4294	0.9779
Watson et al.	2010	34	1	Information systems and environmentally sustainable development: energy informatics and new directions for the IS community	67	0.9645
Pyburn	1983	7	2	Linking the MIS plan with corporate strategy: an exploratory study	74	0.9487
Cotteleer & Bendoly	2006	30	3	Order lead-time improvement following enterprise information technology implementation: an empirical study	40	0.9302
Sprague	1980	4	4	A framework for the development of decision support systems	202	0.9289

For each of the four stages, we perform a correlation analysis between the number of citations and disruptiveness index, as shown in Table 3. It shows that there is a positive correlation between the two measures. Highly cited articles are more likely to be impactful to a field, but the correlation strength is only moderate. In other words, disruptiveness is telling us something about these articles that cannot be fully explained by citation count.

These findings suggest that our proposed measure of disruptiveness, provides a new dimension of evaluating the impact of an article in the literature.

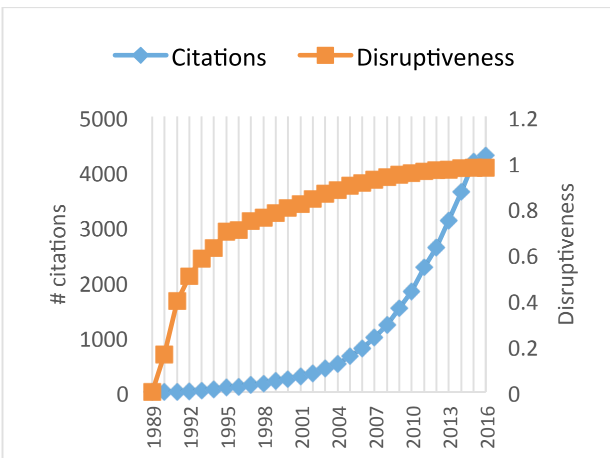
Table 3. Correlation analysis between citations and disruptiveness

Years	Pearson's Correlation
1979~1986	0.4361
1987~1996	0.4484
1997~2006	0.4372
2007~2016	0.3683

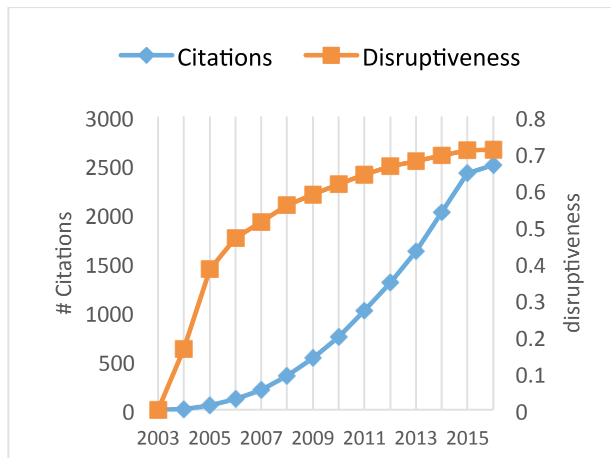
4.4. Change of disruptiveness over time

The disruptiveness index we introduce in this article is not a static measure but a dynamic measure that can change as time passes and new articles join the citation network by citing the prior arts. Therefore, it would be interesting to analyze how an article's disruptiveness score changes over time, which can provide insights into the development trajectory of a topic or even a field.

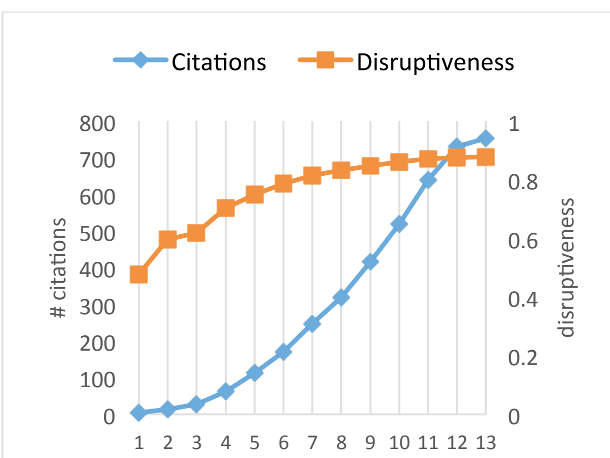
In this study, we select the top five most cited MISQ articles and plot their citation counts and disruptiveness scores in a line chart. Since Alavi's and Leidner's 2001 article[11] did not cite any MISQ articles according to Web of Science, its disruptiveness score in MISQ remains zero. Thus, we do not include its analysis below. In Figure 3(a)~(d), we can see that:



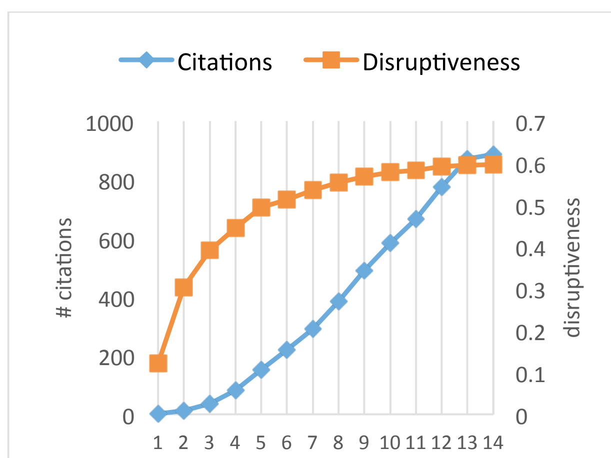
(a) Davis, 1989



(b) Venkatash et al. 2003



(c) Hevner et al., 2004



(d) Gefen et al., 2003

Figure 3. Citations and disruptiveness of the five most cited MISQ articles

- From the day an article is published, it will receive more and more citations as time passes, as illustrated by the monotonic increase of the citation curves. These four articles have received hundreds and even thousands of citations. The large citation count indicates their significance impact in the field of IS.
- All of the four disruptiveness curves also show a monotonic increasing trend over time.
- For these four articles, the citation lines all start off at a small slope, i.e., low increasing rate. After a few years, the curve ticks up and accelerates in the process of accumulating more citations.
- Unlike the "slow-start" citation lines, the disruptiveness lines demonstrate a completely different shape. For these highly impactful articles, we tend to see a rapid increase in its disruptiveness score within the first couple of years. Then, as time passes, the changes in disruptiveness score tend to slow down gradually until it converges. Such a "quick-start" shape makes our proposed disruptiveness index an early detector of impactful work in a field. Without waiting for years before an article receives sufficiently large number of citations, we can look at its disruptiveness score after a much shorter time to forecast its future impact to the field. This also explains why, in Section 4.3, we could identify the fairly recent publication, e.g., [Watson et al., 2001], with a relatively small number of citations, as one of the most disruptive work.
- Another interesting thing we found is with the disruptiveness line in Figure 3(c). Unlike the other three charts, in which the disruptiveness starts with a small value near zero, this article's disruptiveness score was nearly 0.5 already in the year of publication. Since then, it keeps increasing until it reaches 0.9 by far. This was the famous Hevner et al.'s 2004 article "Design science in information systems research."[12] This article categorizes the IS discipline into two paradigms: behavioral science and design science. It provides a conceptual framework and guidelines for conducting design-science research. When it was published in 2004, it became an instant "hit" and stimulated a number of design-science research, including a MISQ special issue on design science research in 2008. The high disruptiveness score this article received in the first year (2004) provides an early and strong predictor of the upcoming knowledge shift towards more design-science research in MISQ.

5. Conclusions and future directions

While citation impact, the current central metric to assessing scholarship, can measure the magnitude of the future usage of an article, it cannot capture the substantial effects that an article may have on the subsequent use of its predecessors - whether it amplifies or disrupts the existing literature. The quest for citation impact without distinction between two routes of scholarship is argued to partially contribute to limitations of the current management literature such as lack of original theories. We then embrace that it is imperative to not only assess the impact of an article but also assess how it reinforces the existing research streams or breaks into a new stream to understand its true effect. Accordingly, we introduce the dynamic disruptiveness index of scholarship, and conduct a case study using all articles published in 1979~2016 at MISQ to illustrate the validity of the dynamic measure of scholarship. The empirical results suggest the difference between citation counts and the disruptiveness index with some interesting findings.

This study suffers several limitations and points out future research directions. First, our analysis only focuses on a small set of articles from one journal (MISQ) and one database (Web of Science). Further research is needed to expand the scope of the dataset by including other journals/databases and compute the disruptiveness of an article in terms of its all predecessors. Second, since our current approach only analyzes the citation links without looking at the content, we cannot differentiate articles by their approaches (e.g., quantitative or qualitative) or the reasons for citation (e.g., theoretical foundation or criticism). We also plan to use text analytics approaches to enrich our citation analysis on scientific articles. Third, the objective of this paper is to introduce the disruptiveness index to complement the citation measures, hence we only describe the differences and meanings of the two types of measurement without conducting a systematic and rigorous test. We will further assess its validity by examining if and how a variety of factors such as characteristics of articles, authors, and journals influence the disruptiveness index and impact factor differently.

Finally, and most importantly, it is imperative to examine whether and how the two measures correspond to the routes toward normal science or paradigm shift, respectively, in different disciplines. For example, it is critical to ask whether, by adopting a new disruptiveness index to assess scholarship, scholars will tend to take an indigenous approach, focusing more on phenomena-driven and inductive research, and will be more willing to break existing paradigms. If the disruptiveness index will be established as a measure to assess the performance or impact of author, journal, or institution, the research community should focus on more revolutionary research rather than normal science. This is because researchers will care about more the real impact of their research in terms of new knowledge creation rather than big number of citations or knowledge usage. While high number of citations could come from different reasons including real new knowledge, the disruptive index can capture new knowledge creation. By changing measurement criteria, communities can construct niches to favor such a direction so that different types of journals may emerge. Hence, the community caring about new knowledge creation may not target the existing high impact journals that appreciate the number of citations more than knowledge creation.

In this study, we only take the first step to embrace the disruptiveness index. Upon its further validation, such an index can have board theoretical, managerial, and policy implications. We hope such a new measure will be adopted to assess scholarship, for example, in Google Scholar and Web of Science. We hope using this index may facilitate new trends of scholarship toward divergence rather than convergence and toward indigenous rather than formative approach.

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