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RESEARCH ESSAY

# Fragmentation or cohesion? Visualizing the process and consequences of information system diversity, 1993–2012

Yong Liu[1], Hongxiu Li[2], Jorge Goncalves[3], Vassilis Kostakos[3] and Bei Xiao[4]

*[1]Department of Information and Service Economy, Aalto University School of Business, Helsinki, Finland; [2]Turku University School of Economics, Turku, Finland; [3]Department of Computer Science and Engineering, University of Oulu, Oulu, Finland; [4]Department of Information Technologies, Åbo Akademi University, Turku, Finland*

**Correspondence: Yong Liu, Department of Information and Service Economy, Aalto University School of Business, Runeberginkatu 22–24, Helsinki 00076, Finland.**
**Tel: +358 50 4637989**

**Abstract**
In information systems (IS) literature, there is ongoing debate as to whether the field has become fragmented and lost its identity in response to the rapid changes of the field. The paper contributes to this discussion by providing quantitative measurement of the fragmentation or cohesiveness level of the field. A co-word analysis approach aiding in visualization of the intellectual map of IS is applied through application of clustering analysis, network maps, strategic diagram techniques, and graph theory for a collection of 47,467 keywords from 9551 articles, published in 10 major IS journals and the proceedings of two leading IS conferences over a span of 20 years, 1993 through 2012. The study identified the popular, core, and bridging topics of IS research for the periods 1993–2002 and 2003–2012. Its results show that research topics and subfields underwent substantial change between those two periods and the field became more concrete and cohesive, increasing in density. Findings from this study suggest that the evolution of the research topics and themes in the IS field should be seen as part of the natural metabolism of the field, rather than a process of fragmentation or disintegration.
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## Introduction

There is protracted debate on the coherence and identity of information systems (IS) research (e.g., Keen, 1980; Banville & Landry, 1989; Agarwal & Lucas, 2005; Larsen & Levine, 2005; Taylor *et al*, 2010). The argument includes early statements such as that management information systems (MIS) 'is a mirage' (Dearden, 1972), that 'MIS is a fragmented adhocracy' (Banville & Landry, 1989, p. 56), and that 'IT [information technology] doesn't matter' (Carr, 2003), along with the claim of a more recent empirical study, by Larsen & Levine (2005), that 'a cumulative research tradition [of MIS] remains elusive' (p. 357). Given the aforementioned challenges, key IS researchers have elaborated on both the nature of IS and the direction the field should take in its development. In this process, various opinions have been raised, occasioning related debate.

The contention has predominantly been related to whether and how the field can survive and prosper by fostering either a coherent research focus or instead diversity, alongside whether change should be viewed as a crisis or, rather, an opportunity for growth (Galliers, 2003; Taylor *et al*, 2010; Rowe & Truex, 2011). From several researchers' perspective, the diversity evident in

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IS research has resulted in an ambiguous and ill-defined core identity (Benbasat & Weber, 1996; Benbasat & Zmud, 2003; Weber, 2003; Hirschheim & Klein, 2006). In the opinion of these authors, 'this failure to develop a stable, integrated, and coherent core research agenda has resulted in increasing fragmentation of the field and threatens the continuity and survival of the discipline' (Taylor *et al*, 2010, p. 649). However, some researchers question the latter view and note that diverse and adaptive IS research is vital for fostering continued growth and contributions to knowledge across a broad range of topics in an extensive body of IS knowledge (for a summary, see Taylor *et al*, 2010). They advocate an approach acknowledging that 'within IS there is already a sufficient set of "core" and "real" knowledge elements (i.e. topics, concepts, and phenomena) that can be considered unique and as such IS has become mature enough to become a reference discipline for others' (Bernroider *et al*, 2013, p. 75). A number of researchers argue against the attempt to define a core and a boundary of IS research (for a summary, see Bernroider *et al*, 2013), since 'any definition can be exclusive and potentially detrimental to the diversity of the contributing groups that form the IS community and to the fluidity of the discipline' (p. 74). The notion of the IS discipline should be viewed as a fluid and contingent one, with well-defined boundaries being neither helpful nor desirable (Bryant, 2008; Bernroider *et al*, 2013).

In response to the debate referred to above, a recent paper by Taylor *et al* (2010) reported that IS research achieved temporal stability in the years between 1986 and 2005 because of the existence of both focus and diversity in IS research. They stated that the increase seen in the number of researchers and co-citing of works reflects robust health of the field. From an analysis of European Conference on Information Systems (ECIS) proceedings in 2003–2012 and reflection on Galliers & Whitley's (2007) literature review focusing on ECIS papers published in 1993–2002, Stein *et al* (2014) have argued that European IS research achieved temporal continuity. Nevertheless, there is a need for further examination of whether fragmentation has, in fact, affected the field. From a network perspective, as the structure of the knowledge network of a fragmented field becomes dispersed or segmented, few subfields of the research therein remain temporally stable or are even enhanced. Furthermore, there is lack of knowledge of the extent to which the individual subfields of IS research have matured, along with where the various subfields and research topics are conceptually located in the full knowledge map of IS (e.g., their level of centrality and how they are connected with each other, through which topics). Finally, there is a scarcity of macro-level knowledge of how the knowledge structure of IS research differs from that of other scientific disciplines. For instance, does the IS field have a knowledge structure similar to that of well-established scientific disciplines such as consumer-behavior research or psychology?

Proceeding from the work of Albert & Whetten (1985), Rowe & Truex (2011) stated that 'to claim legitimacy as a separate field of endeavor, a discipline must establish (1) the central character it is studying; (2) its distinctiveness; and (3) its temporal continuity' (p. 48). The goal with the present paper is to offer comprehensive treatment of these three points based on an evaluation of recent developments in the IS field, by employing a co-word analysis approach. Specifically, our study was designed to address the following elements and research questions:

(1) *Detailed measurement of the subfields of IS studies:*
Have substantial changes in IS research subfields taken place between 2003 and 2012 in comparison to the previous decade, the period between 1993 and 2002, in line with the research fields identified by Taylor *et al* (2010)? At the detail level, how have various subfields emerged, merged, been absorbed, or even faded? How have the diversified tastes of the main IS journals contributed to the diversity of knowledge in the field?
(2) *A macro-level perspective of the IS field as a whole:*
Have the rapid changes in the IS field resulted in healthy evolution of the field or fragmentation of its knowledge? Has the field become more cohesive, and, if so, how did this occur?
(3) *Comparison of knowledge structure between the IS field and other scientific disciplines:*
How does the knowledge network structure of the IS field differ from those of other well-established scientific disciplines, such as psychology, consumer behavior research, and biology? How can we refer to the unique nature of IS research in light of this comparison?

To address the above research questions, our study employed a co-word analysis approach to visualize the intellectual map of the IS discipline. A sample of 9551 articles (47,467 keywords associated) that appeared in 10 major IS journals and two leading IS conferences between 1993 and 2012 was collected. The sample was separated into sub-samples from two periods – 1993–2002 and 2003–2012 – for visualization of the changes in the research topics and subfields from a longitudinal perspective. Various analysis techniques were borrowed from recent advances in bibliometric studies for visualization of the intellectual map of the IS field – hierarchical cluster analysis, strategic diagrams, network analysis, etc.

The body of the paper is structured thus: In the next section, we provide a summary of prior bibliometric studies focusing on IS and discuss their results. Then, we present our research methods, after which we describe the data-collection method and provide sample statistics. Once this foundation is laid, we can report the results and main findings. We discuss the results and identify the emerging, cumulative, and fading subfields in IS research. Finally, we present our conclusions.

## Research background

Several bibliometric studies have been conducted in the past 30 years to present the intellectual map of IS – partly in response to the field's rapid evolution. These studies

document the intellectual development of IS in 1972–1982 (Culnan, 1986), 1980–1985 (Culnan, 1987), and 1986–2005 (Taylor *et al*, 2010), and all are based on the use of (author) co-citation analysis. Recently, this approach has been applied to investigation of the evolution of subfields or specific theories within IS research, such as the intellectual development of the technology acceptance model (TAM) (Hsiao & Yang, 2011), research themes, and trends in knowledge management (Lee & Chen, 2012).

Comparison of the results from prior studies shows rapid changes in the subfields of IS research. Specifically, the intellectual structure of IS between 1972 and 1982 was found to include seven subfields as revealed by publications in English: systems science, foundations/management theory, computing impacts/computers in government, MIS/DSS implementation, human factors, individual differences, and computer conferencing (Culnan, 1986). The intellectual structure of IS between 1980 and 1985 indicates five major subfields: foundations, MIS management, MIS curriculum, individual approaches, and organizational approaches to MIS design and use (Culnan, 1987). Referring to an analysis of co-citation counts and bibliographies from 100 foundational authors in 1986–2005, Taylor *et al* (2010, p. 662) noted that the field of IS has demonstrated 'temporal stability and a polycentric focus on the IS development and use thematic miscellany, IS strategy, and group work and decision support subfields'. In light of the three aforementioned studies, it is apparent that substantial changes occurred in the field in the periods examined.

In addition to the work by Taylor *et al* (2010), several similar bibliometric studies of IS have been conducted that explore the field's evolution but take alternative perspectives. Córdoba *et al* (2012) conducted citation and co-citation analysis for two major IS academic journals (*EJIS* and *MISQ*) for 1995–2008 and concluded that IS research was currently consolidated around the theme of 'IS acceptance'. Bernroider *et al* (2013) applied a combined citation/co-citation analysis to the eight Association of Information Systems (AIS) basket journals and 22 subjective classification frameworks in 1995–2011, reporting that IS is a fluid discipline dynamically embracing a broad range of adjacent reference disciplines while maintaining interaction with them.

Larsen & Levine (2005) conducted basic co-word analysis of keywords collected from four IS journals between 1990 and 2000 by comparing frequencies of keyword occurrence and co-occurrence. They noted that the field's hubs of coherence changed over time and they deemed a cumulative research tradition elusive.

In addition to works applying bibliometric methods, there have been several studies that borrow theories on disciplines' development to interpret the development of the IS field – in particular, Bauman's concept of liquid modernity (Bauman, 1992) and the ideas in Foucault's *Archeology of Knowledge* (Foucault, 1972). According to Foucault (1972), what scholars of a discipline need is common subject matter for the discipline, not agreement on the research themes, methodology, and theories. The process of 'disciplining' involves development of both the knowledge elements and the practices, norms, and ethics narratives that distinguish one field of study from others by characterizing the discourse practice itself (Foucault, 1972, 1984). Related to Foucault's concept of discursive formation is Bauman's demonstration 'that disciplines cannot be defined in terms of what might appear to be the "obvious" aspects such as "permanence of a thematic" or a "well-defined alphabet of notions"' (Bryant, 2008, p. 697). The use of these two theories has led to propositions and findings that, as a flawed discursive formation, IS is a variety-rich, fluid, and contingent discipline that is continuously realigned by interacting with other ('reference') disciplines (Hassan & Will, 2006; Bryant, 2008; Bernroider *et al*, 2013).

## Research methods

### Co-word analysis

For the study, we adopted a co-word analysis approach as the basic research method responding to the requirements of the study, considering its particular features and recent advances. Co-word analysis is an important bibliometric approach based on co-occurrence analysis and has been widely applied to illustrate how concepts, ideas, and problems within a given scientific field interact and to explore the concept network within the relevant field (Callon *et al*, 1983, 1991).

In co-word analysis, it is assumed that 'a paper's keywords constitute an adequate description of its content or, the links the paper established between problems' (Ding *et al*, 2001, p. 818). A co-word approach summarizes articles in terms of forceful words and traces the development of a field of knowledge by examining occurrences and co-occurrences of the words at an aggregate level (Callon *et al*, 1986). Co-word analysis represents a rhetorical or sociological view of the field investigated (cf. Leydesdorff & Hellsten, 2006), in which keywords serve as a proxy for the 'objective' terms to represent the knowledge structure of the field. Based on study of the co-occurrence of powerful words in pairs, co-word analysis aids in extracting the themes of science even without prior definition of the themes (Callon *et al*, 1986; He, 1999). Co-word analysis thereby assists bibliometric researchers in following actors (e.g., researchers) objectively (Callon *et al*, 1986) and considering the dynamics of interaction or subject-area changes as results of actor strategies (Callon *et al*, 1991).

Superficially, a keyword with a certain frequency is assumed to reflect a specific research topic (cf. Liu *et al*, 2011): 'Two keywords co-occurring within the same paper are an indication of a link between the topics to which they refer' (Cambrosio *et al*, 1993, p. 123). As Zong *et al* (2013) and Liu *et al* (2014) have pointed out, the presence of frequent co-occurrences of two words or the same words within scientific papers reveals that there is a locus of strategic alliance within the articles and that they may correspond to a research theme. As Ding *et al* (2001) stated, '[c]o-word analysis reveals patterns and trends in a specific

discipline by measuring the association strengths of terms representative of relevant publications produced in [the relevant] area' (p. 819). A well-established bibliometric approach, co-word analysis is a useful tool for researchers for identifying existing paradigms, potential new directions, and the most prominent themes while also locating their work within the field (Culnan, 1987; Liu *et al*, 2011; Muñoz-Leiva *et al*, 2011; Wang *et al*, 2011; Zhao & Zhang, 2011). It is worth noting that before keywords entered popular use in scientific papers, co-word analysis was based on study of the words extracted from the body, abstract, or title of papers.

Co-word analysis reduces the large space required for descriptors (or keywords) by turning them into a set of network graphs (multiple related smaller spaces), which 'are easier to comprehend but are also indicative of the actual partitions of the interrelated concepts in the literature under consideration' (Coulter *et al*, 1998, p. 1208) while able to retain crucial information (Ding *et al*, 2001). Specifically, in co-word network graphs, the keywords are represented as the nodes in a network map, while the co-occurrence of two distinct keywords in a paper is manifested as a connection between the two specific nodes representing those keywords. The strength of the connection between the two keywords represents the co-occurrence frequency of those two keywords across the various papers. By computing all the nodes and their connections in a network, we can visualize the position and also the connections of an individual keyword or a group of keywords in a network structure. Accordingly, this approach helps one visualize the intellectual structure of a specific discipline as a network structure of the conceptual space, allowing a time-series record of the changes that occurred in the conceptual space (Ding *et al*, 2001). Employing analysis of a sample of 2012 articles, a study by Ding *et al* (2001) demonstrates 'the feasibility of co-word analysis as a viable approach for extracting patterns from, and identifying trends, in large corpora where the texts collected are from the same domain or sub-domain and are divided into roughly equivalent quantities for different time periods' (p. 836).

Co-word analysis has been widely used in prior literature for mapping the conceptual networks of various disciplines, such as consumer-behavior research (Muñoz-Leiva *et al*, 2011), business intelligence (Vaughan *et al*, 2012), software engineering (Coulter *et al*, 1998), patent analysis (Chang *et al*, 2010), biology (Cambrosio *et al*, 1993; An & Wu, 2011), education (Ritzhaupt *et al*, 2010), and library and information science (Ding *et al*, 2001; Liu *et al*, 2011; Hu *et al*, 2013; Zong *et al*, 2013).

However, it is important to note that, as do the co-citation and co-authorship approaches, works based on co-word analysis have their advantages and disadvantages (for a review, see Lu & Wolfram, 2012). For instance, the meaning of certain words used in the text may change from context to context, and subjectivity in the assignment of the keywords may bias the interpretation of the scientific structure (cf. Lu & Wolfram, 2012).

We employed co-word analysis as the research method in our study because of several unique features this approach possesses (see Garfield, 1989; Callon *et al*, 1991; He, 1999; Clarke, 2008). First, as is noted above, a co-word approach facilitates representation of the conceptual space of a field. Furthermore, as an approach with both qualitative and quantitative aspects, 'the co-word approach […] not only *allows successful translation to be traced* and distinguished from those that quickly disappear; it also makes it possible to uncover the many direct and indirect links that exist between translations whether or not these lead rapidly to social problems and interests' (Callon *et al*, 1986, p. 108). Whereas co-citation analysis describes 'the structure of a research field through pairs of documents that are jointly cited […] *co-word analysis deals directly with sets of terms shared by documents* […] and *maps the pertinent literature directly from the interactions of key terms* instead of from the interaction of citations' (Monarch, 2000, p. 8). He (1999) stated that co-word analysis is based on publications' scientific content and that this approach can serve the purpose of studying the knowledge structure of a field directly. Moreover, co-word analysis is preferred when one is examining interaction between the academic world and technology, because the indicators (keywords) used in co-word analysis can reflect the subjects themselves (Callon *et al*, 1991; He, 1999). Co-word analysis is consistent with our study's aim of examining the research topics covered by core IS publications, such as those addressed in heavily read IS journals, while co-citation analysis, in contrast, relies on people openly citing papers. In our research, we employed various analysis techniques, including hierarchical cluster analysis, graph theory, and co-word analysis artifacts. These techniques have been successfully implemented previously in study of the evolution of knowledge in areas such as human-computer interaction (HCI) (cf. Liu *et al*, 2014).

## Methods

Recent advance in social network analysis (SNA) have been widely employed in modern bibliometric research to study the intellectual structure of co-word network maps (e.g., Liu *et al*, 2011; Muñoz-Leiva *et al*, 2011; Hu *et al*, 2013; Zong *et al*, 2013). In a similar manner, our study borrowed several approaches from SNA to examine the characteristics of the intellectual structure of IS research, including analysis of structural holes, core-periphery analysis, degree centrality, degree density, and strategic diagrams.

***Analysis of structural holes*** The structural hole theory originally focused on the information benefits – in particular, the social capital – of an actor that are derived from the positional advantages gained in connecting otherwise disconnected actors (Burt, 1992). Structural holes reflect the capacity of any actor to build bridges or liaisons between non-related units (Burt, 1992). Building bridges in a network is seen as a valuable function, since it affords communication and facilitates flow between otherwise

unconnected or isolated actors (Burt, 1992). The structural hole theory has a fundamental difference from the weak tie theory: while the former is oriented toward the existence or non-existence of ties, the latter focuses on the strength of the ties (Poell *et al*, 2015).

The concept of structural holes has been applied in examination of various types of networks, such as tourism-destination networks (Shih, 2006), a network of software development (Mayer-Schönberger, 2009), a co-citation network (Chen *et al*, 2009), and a national communication network (Eagle *et al*, 2010). Therefore, we argue that those keywords with a large number of structural holes should function as the bridge or broker in the knowledge network. In other words, the greater the number of structural holes for a keyword, the greater the role the research topic represented by the keyword serves in connecting otherwise isolated research topics or research themes. If these keywords with a great number of structural holes were removed from the research network, the whole network would break into a number of research subfields that are separated and unconnected with each other (Liu *et al*, 2014). Thus the entire research network loses its scientific cohesion and identity. Burt's (1992) metric of the effective size of an ego network was adopted in our study for calculation of the value of structural holes. Specifically, with a whole-network model, the value of structural holes is calculated as the quantity of alters minus the average degree of alters within the ego network, not counting ties to the ego (Burt, 1992).

***Core-periphery analysis*** Ascertaining a network's core-periphery structure renders it possible to determine which nodes belong to a densely connected core and which contribute to a loosely connected periphery (Borgatti & Everett, 1999; Rombach *et al*, 2014). Specifically, core nodes must be well-connected both to other core nodes and to peripheral nodes, while periphery nodes are loosely connected to a core node and to each other (Borgatti & Everett, 1999; Rombach *et al*, 2014), as shown in Figure 1. In other words, the core nodes represent the research topics that are well-connected to many other research topics at the periphery but also to other core research topics. Therefore, the chain or the sub-network of core keywords represents a land of core knowledge that tends to be more robust and solid, because the topics in this sub-network are highly relevant to and support each other. Accordingly, those research topics with a high core value should delimit the core of the IS knowledge structure for the period in question (cf. Ocholla *et al*, 2010). This approach has been widely applied in many network contexts, including friendship networks, transportation networks, co-authorship networks, roll-call vote networks (Rombach *et al*, 2014), crewmember-by-movie networks (Cattani & Ferriani, 2008), international trade networks (Clark, 2010), co-word networks (Hu *et al*, 2013), and inter- and intra-organizational networks (cf. Valente, 2012). In our study, the degree of coreness of each keyword is estimated by fitting a continuous model of core-periphery structure through the use of UCINET (Borgatti & Everett, 1999; Cattani & Ferriani, 2008; Clark, 2010).

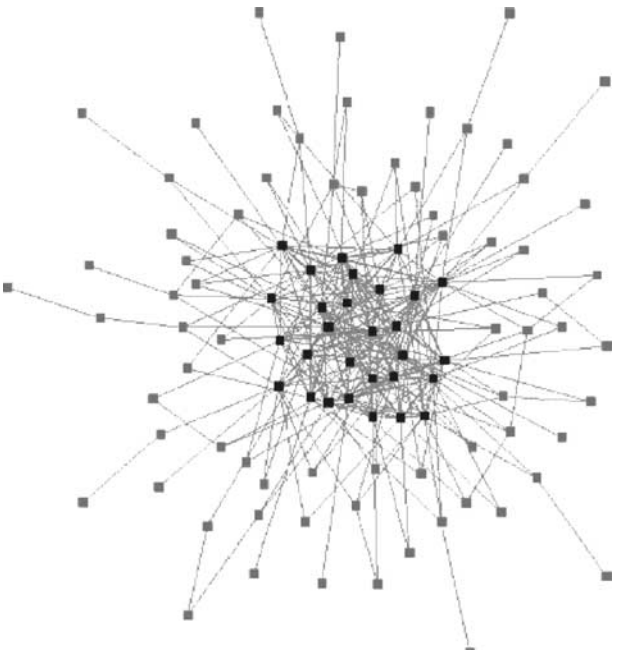

**Figure 1** Visualization of core-periphery structure – an example. *Note*: The dark nodes form the core, while the lighter-colored nodes reside at the periphery.
(*Sources*: Cattani & Ferriani 2008; Krebs & Holley 2002).

***Centrality*** Centrality, or the external cohesion index, measures the intensity of connections of a given cluster or sub-network with other clusters or sub-networks (Callon *et al*, 1991; Everett & Borgatti, 1999; Nielsen & Thomsen, 2011). The stronger these connections are, the more the given cluster designates a set of research topics or problems considered crucial by the community (Callon *et al*, 1991). Centrality 'measures the strength of external ties to other themes' and can be understand as 'a measure of the importance of a theme in the development of the entire research field analyzed' (Muñoz-Leiva *et al*, 2011, p. 1080). A subject area having a greater number and strength of connections with other subject areas will be more central in the whole research network (Bauin *et al*, 1991). The algorithm developed by Everett & Borgatti (1999) was applied in our study in measurement of sub-network centrality, implemented via the software UCINET.

***Density*** Density, or the internal cohesion index, 'measures the strength of internal ties among all keywords describing the research theme' (Muñoz-Leiva *et al*, 2011, p. 1080). One can understand this value as 'a measure of the theme's development' (Callon *et al*, 1991; He, 1999; Muñoz-Leiva *et al*, 2011). Density offers a good indicator of a theme's capacity to preserve itself and to evolve over the course of time in the field under consideration (Callon *et al*, 1991;

He, 1999). The higher the density value, the more coherent the cluster and the more likely it is that said cluster will have inseparable or connected expressions (Callon *et al*, 1991; Viedma-del-Jesús *et al*, 2011). Density can be computed by means of the density algorithm of UCINET. Specifically, the total number of ties is divided by the total quantity of possible ties to calculate the density value.

***Strategic diagrams*** A strategic diagram is a conceptualized two-dimensional space built by plotting themes in accordance with their centrality and density values (Viedma-del-Jesús *et al*, 2011). The *x*-axis reflects the degree centrality, representing the extent of interaction between a specific research theme and the other research themes in the relevant research network, whereas the *y*-axis refers to the degree of density of a research theme in the research network, showing the degree of internal cohesion of a specific research theme in that research network (Hu *et al*, 2013; Liu *et al*, 2014).

Strategic diagrams have been widely used in prior co-word analysis studies (Coulter *et al*, 1998; Liu *et al*, 2011; Muñoz-Leiva *et al*, 2011). Generally, the research themes in quadrant I (in the upper right) are both internally coherent and central to the research network under investigation (Muñoz-Leiva *et al*, 2011). These research themes manifest high density and strong centrality both, and they can be considered the motor themes in a specific discipline (Muñoz-Leiva *et al*, 2011; Liu *et al*, 2014). In quadrant II (the upper left), coherent themes always appear. These themes show high or medium density and low centrality, indicating that they are internally well-structured and also specialized themes with unimportant external ties throughout the research network (Muñoz-Leiva *et al*, 2011; Liu *et al*, 2014). In quadrant III (the lower left-hand area), the themes display low density and low centrality – these themes are weakly developed and of only marginal interest within the research network as a whole; they can be regarded as either emerging or fading themes (Muñoz-Leiva *et al*, 2011; Liu *et al*, 2014). The themes in quadrant IV (in the lower right) can be regarded as weakly structured ones, because of their high/medium centrality and low density. These subjects, individually, are strongly linked to specific external research interests but only weakly linked with each other, which points to said themes as having low conceptual development but potential to become quite important research themes for the research network as a whole (Muñoz-Leiva *et al*, 2011; Liu *et al*, 2014). The characteristics of a strategic diagram are summarized in Figure 2 (Callon *et al*, 1991; Muñoz-Leiva *et al*, 2011).

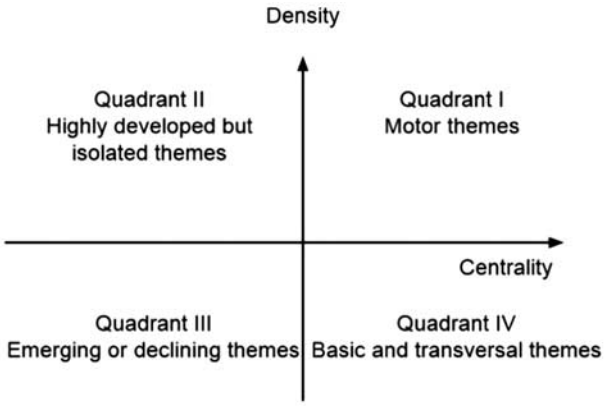


**Figure 2** The quadrants and main axes of a strategic diagram.

## Data

The data were collected from 10 major IS journals and two important IS conferences. Eight of the journals are from the 'Senior Scholars' Basket of Journals', journals recommended by the Senior Scholars Consortium of the AIS. Our study included two more journals: *Information and Management* and *Communications of the Association for Information Systems*, both of which are important journals in the field (cf. Larsen & Levine, 2005). The result was the collection of 10 vital IS journals shown in Table 1. Two highly selective IS conferences, the International Conference on Information Systems (ICIS) and the European Conference of Information Systems, are also included. Many new research ideas have been presented at these two conferences and then converted into journal publications – usually after a lengthy review process. With the inclusion of 10 heavily read and well-regarded IS journals and two highly selective IS conferences, the study could capture the essence of prior IS research.

From the aforementioned sources, 9551 related articles and their associated keywords were collected as the full corpus for co-word analysis. To achieve more precise results, we standardized these keywords by merging synonyms (for example, 'research method' and 'research methodology' are replaced by 'research method/methodology', and 'customer satisfaction', 'consumer satisfaction', and 'user satisfaction' are replaced with 'user/consumer/customer satisfaction') and filtered out the general items that are too broad to be of practical interest, such as 'management information systems', 'information technology', 'information systems', and 'research' (see Liu *et al*, 2011; Wang *et al*, 2011; Zong *et al*, 2013). The merging was conducted by two authors jointly looking for synonyms among the keywords with a frequency of five or more occurrences. The merging of synonyms mainly involved abbreviations and acronyms/initialisms, singular and plural forms of nouns, and nouns and gerunds.

It is important to note that the keyword frequencies follow a power-law distribution with an exponent of –8.760E–05 ($P<0.001$; $R^2=46.8\%$), indicating that in the 20 years examined the research structure of the IS field has been a scale-free network. In a network following a power-law distribution, there is a small number of 'well-connected' but significant nodes connected to a very large quantity of other nodes, with these highly connected nodes dominating the connectivity (Barabasi & Albert, 1999). In, for instance, the power-law distribution in semantic networks, most nodes have 'relatively few

**Table 1 Journal and conference information**

| *Journal or conference* | *Published since …* | *Keyword first found from …* | *Articles* | *Keywords* |
|---|---|---|---|---|
| *European Journal of Information Systems* (EJIS) | 1991 | 2003 | 383 | 1840 |
| *Information Systems Journal* (ISJ) | 1991 | 1993 | 353 | 1636 |
| *Information Systems Research* (ISR) | 1990 | 1993 | 555 | 3128 |
| *Journal of the Association for Information Systems* (JAIS) | 2000 | 2000 | 260 | 1522 |
| *Journal of Information Technology* (JIT) | 1986 | 2004 | 225 | 1103 |
| *Journal of Management Information Systems* (JMIS) | 1984 | 1993 | 734 | 3987 |
| *Journal of Strategic Information Systems* (JSIS) | 1991 | 1993 | 341 | 1553 |
| *MIS Quarterly* (MISQ) | 1977 | 1993 | 562 | 3333 |
| *Communications of the Association for Information Systems* (CAIS) | 1999 | 1999 | 902 | 4671 |
| *Information and Management* (I&M) | 1977 | 1993 | 1068 | 5666 |
| European Conference on Information Systems (ECIS) | 2000 | 2000 | 2177 | 9444 |
| International Conference on Information Systems (ICIS) | 1994 | 1997 | 1991 | 9584 |
| Total | | | 9551 | 47467 |

connections joined together through a small number of hubs with many connections' (Steyvers & Tenenbaum, 2005, p. 41).

In this regard, the power-law distribution of the keyword network implies that a few 'very connected' keywords – that is, hubs of connectivity (connections between keywords) – shape the way the network (the intellectual structure of IS studies as represented by the keywords) operates (cf. Barabasi & Albert, 1999; Steyvers & Tenenbaum, 2005). In other words, only a few keywords are needed to capture the main foci of the research and the major influences on the field. Therefore, it is acceptable for the study to be focused on a relatively small number of keywords (those with the highest frequencies).

## Results

In order to examine the paradigm changes in IS over the 20 years in question (1993–2012), we split the sample into two sub-samples of 10 years: 1993–2002 and 2003–2012. As Table 1 shows, several of the journals were first published in the late 1990s. Therefore, the sub-sample size for papers published in the period 1993–2002 ($N = 2011$) is below that for those published in 2003–2012 ($N = 7540$). This is largely attributable to the fact that most IS journals and, especially, conferences have shown an increase in the number of published articles in recent years.

Note that the frequency of a keyword largely reflects the importance of that keyword. The power-law distribution of the keywords indicates that an investigation into the most frequent keywords should be enough for us to obtain information about the most important research topics and themes, as is mentioned above (cf. Liu *et al*, 2011; Zong *et al*, 2013). Ninety-six keywords with a frequency of 11 or above were selected as the research sample for 1993–2002. We considered these 96 keywords (total frequency: 2199), covering 1343 (66.78%) of the full set of 2011 papers published during the decade in question, to represent the main content of the IS research. For the period 2003–2012, 98 keywords with a frequency of 39 or above were selected (total frequency: 7597), covering 4796 (63.61%) of the 7540 papers published in the second period. If the degree of diversity can be preliminarily measured via determination of what percentage of the research topics emerged in the latter 10 years *vs* the first 10, then 48 of the 98 keywords (48.98%) from 2003–2012 are new, implying a high degree of change in the major focus of the research over the past 20 years.

Figure 3 presents word clouds for the most commonly occurring keywords for each of the two distinct 10-year periods. In the word clouds, the font size of each word is proportional to its frequency of appearance in the respective period. For instance, 'adoption/acceptance' was the most heavily used keyword in 2003–2012.

To show how IS journals, such as *EJIS*, contribute to the field by introducing new research topics and cooperating with other publication venues with regard to emerging topics, we performed a correspondence analysis between the IS journals and the 48 top keywords for 2003–2012 that did not appear in the list from 1993–2002. Through correspondence analysis, those keywords and IS journals that are closely related are positioned near each other in a visualization. As Figure 4 shows, different IS journals have facilitated the emergence of different topics to different degrees. Take *EJIS* for example. That journal has offered an outstanding contribution to knowledge on the topics of enterprise systems and e-government. It is worth noting that several keywords are placed at the edges of the figure and far from most of the journals. This may imply that IS journals have diverse preferences as to topics for publication, which may contribute to the diversity of the field.

It is interesting to note that *MISQ, JMIS, JAIS*, and *ISR* are regarded as U.S.-centered, or as having a wider North American focus, while *EJIS, JIT, ISJ*, and *JSIS* are broadly seen as outlets for Europe- and Australia-based authors (Mingers, 2003; Dwivedi & Kuljis, 2008; Akhlaghpour *et al*, 2013; Bernroider *et al*, 2013). We can observe that *MISQ, JMIS, JAIS*, and *ISR* are close to each other, as shown in


**Figure 3** The word cloud for each decade.
(a): 1993–2002; (b): 2003–2012.

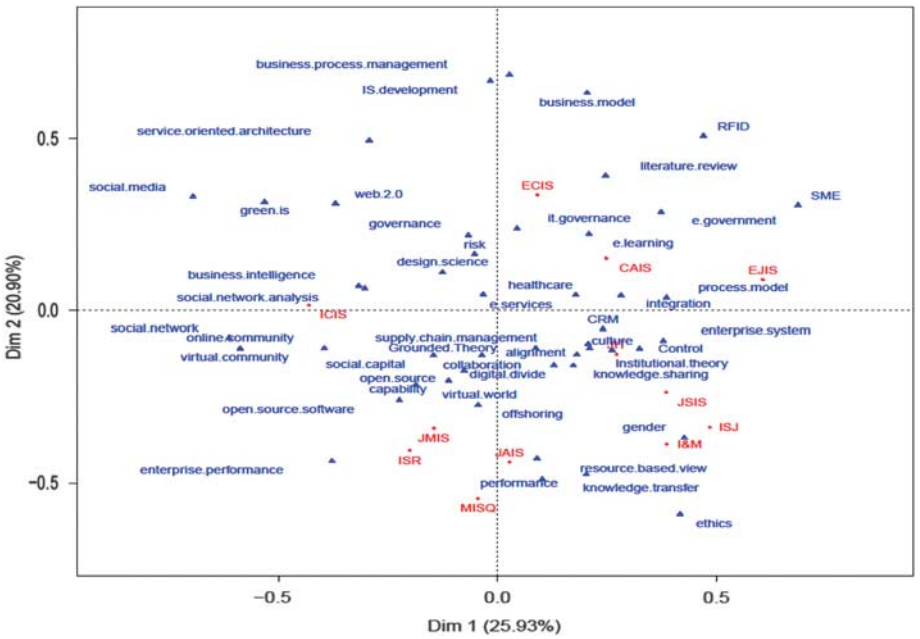


**Figure 4** Correspondence analysis for IS journals and emerging topics.
*Note*: Names of journals appear closer to the topics on which they tend to publish comparatively often.

Figure 4, and hence can be regarded as a cluster. Meanwhile, the triangle formed by the more European-oriented *EJIS, JIT, ISJ*, and *JSIS* is positioned on the right in the figure, implying a different cluster. No North American journal considered lies within the triangle delimited by the European ones. To some extent, this indicates that there

**Table 2 Popular, core, and bridging topics in IS research, 1993–2002**

| *No.* | *Popular topics* | *Frequency* | *Core topics* | *Core value* | *Bridging topics* | *Structural holes* |
|---|---|---|---|---|---|---|
| 1 | E-commerce | 93 | E-commerce | 0.311 | E-commerce | 34.16 |
| 2 | Group support system | 69 | Group support system | 0.202 | Group support system | 24.26 |
| 3 | Adoption/acceptance | 68 | Adoption/acceptance | 0.344 | Adoption/ acceptance | 37.80 |
| 4 | DSS | 66 | DSS | 0.175 | DSS | 29.57 |
| 5 | Implementation | 58 | Implementation | 0.271 | Implementation | 40.85 |
| 6 | Research methods/ methodology | 57 | Research methods/ methodology | 0.188 | Research methods/ methodology | 28.34 |
| 7 | Case study | 56 | Case study | 0.245 | Case study | 37.44 |
| 8 | **Inter-organizational systems** | **46** | **Inter-organizational systems** | **0.159** | Organizational learning | 19.70 |
| 9 | Business process reengineering | 45 | Business process reengineering | 0.152 | Business process reengineering | 22.90 |
| 10 | Diffusion | 44 | Diffusion | 0.198 | Diffusion | 28.05 |
| 11 | Knowledge management | 41 | User/consumer/customer satisfaction | 0.152 | User/consumer/customer satisfaction | 18.37 |
| 12 | **Electronic data interchange** | **40** | **Electronic data interchange** | **0.145** | End user computing | 17.66 |
| 13 | Expert system | 39 | **Usage** | **0.192** | **Usage** | **20.02** |
| 14 | **Group decision support** | **37** | **Group decision support** | **0.126** | Strategic IS | 17.80 |
| 15 | **Strategic planning** | **37** | Electronic meetings | 0.129 | **Strategic planning** | **19.63** |
| 16 | Strategy | 36 | Success | 0.145 | Success | 18.63 |
| 17 | Outsourcing | 35 | **System development** | **0.126** | **System development** | **19.47** |
| 18 | Internet | 35 | Internet | 0.129 | Internet | 18.09 |

*Note*: Boldface is used for those keywords appearing in at least two featured groups.

may be differences in research-topic preferences between North American outlets and European ones, implying potentially differing understanding of the field's future development. In other words, North American and European IS researchers tend to have different research preferences and focus in the field. Both contribute to the emergence of new research topics and to the diversity of the field, but at the same time the two groups compete for the resources and attention of IS scholars and to direct the future of IS research. Furthermore, as is shown in Figure 4, ECIS and ICIS, the two leading IS conferences, apparently differ from each other in the research interests they represent, even though they coincide to some extent with respect to a number of research topics. The European journals and ECIS are located close to each other, which may be due to the availability of similar visitors or audiences. In a similar finding, ICIS was found to be situated near North American journals.

## Popular, core, and bridging topics in IS research

After insertion of all keywords into a database, co-occurrence frequency and co-occurrence correlation matrices were produced for further examination. In this analysis, we identified the core research topics in the network structure of the two spans of time (the decade 1993–2002 and 2003–2012) with a core-periphery matrix produced by means of UCINET. Thereby, 18 keywords (concentration: 0.828) were identified as the core research topics of the whole network in the period 1993–2002, whereas there were 11 keywords (concentration: 0.817) in 2003–2012, as shown in Tables 2 and 3. Those keywords with a high core value [0, 1] describe a set of topics that underpin each other to constitute the core in the first decade, 1993–2002. Also, the top 18 keywords in terms of structural holes are reported in Table 2. Keywords ranking high for structural holes agglutinate the field. In other words, these represent the important research topics tying together IS research during the period in question, agglutinating otherwise separated topics into a cohesive intellectual map of the whole field. In accordance with the frequency of the various keywords in the publications, popular research topics are listed in Tables 2 and 3.

As Table 2 shows, the core research topics and bridging research topics show great consistency within the period 1993–2002. In this regard, the overlapping core and bridging research topics include e-commerce, group support system, adoption/acceptance, decision support systems (DSS), implementation, research methods/methodology, case study, business process reengineering, diffusion, user/consumer/customer satisfaction, usage, success, system development, and Internet. Inter-organizational systems, electronic data interchange, electronic meetings, and group decision support were found to be associated with a relatively small number of structural holes, indicating that, though these topics are situated within the core structure of the field, they did not substantially aid in aggregating otherwise separated topics during the first period. Furthermore, while organizational learning, strategic IS, and end-user computing were not popular or core research topics in

**Table 3 Popular, core, and bridging topics in IS research, 2003–2012**

| *No.* | *Popular topics* | *Frequency* | *Core topics* | *Core value* | *Bridging topics* | *Structural holes* |
|---|---|---|---|---|---|---|
| **1** | Adoption/ acceptance | 368 | Adoption/acceptance | 0.395 | Adoption/acceptance | 69.26 |
| **2** | E-commerce | 271 | E-commerce | 0.258 | E-commerce | 49.40 |
| **3** | Knowledge management | 233 | Knowledge management | 0.208 | Knowledge management | 61.00 |
| **4** | Case study | 222 | Case study | 0.295 | Case study | 66.34 |
| **5** | Outsourcing | 188 | Outsourcing | 0.191 | Outsourcing | 47.97 |
| **6** | Trust | 164 | Trust | 0.218 | Trust | 53.19 |
| **7** | ERP | 136 | ERP | 0.183 | ERP | 46.87 |
| 8 | **Implementation** | **137** | **Implementation** | **0.165** | Collaboration | 46.46 |
| 9 | Social network | **130** | Strategy | 0.147 | Social network | **42.85** |
| 10 | Research methods/ methodology | 129 | Diffusion | 0.166 | Strategy | 48.54 |
| 11 | Healthcare | **121** | Business value | 0.157 | Healthcare | **46.42** |

*Note*: Boldface indicates those keywords appearing in at least two featured groups.

the field, these three research topics have played important roles in agglutinating research into various research topics to help establish a cohesive internal research field for the IS discipline. In addition, we found, e-commerce, group support system, adoption/acceptance, DSS, implementation, research methods/methodology, case study, business process reengineering, diffusion, and Internet were popular, core, and bridging topics. Therefore, these were the most important research topics in 1993–2002. Research into knowledge management, outsourcing, expert system, and strategy is popular, but these are neither core nor bridging topics. This hints somewhat that, even though much research effort has been devoted to these topics, in the period considered they had not yet moved to the core of the field to aggregate it. The three groups all demonstrate great consistency, showing that IS developed in a healthy manner.

Eleven keywords (concentration: 0.817) were found to be the core research topics in the period 2003–2012, as shown in Table 3. Nine of these keywords are listed among both popular and bridging topics, which suggests that the bridging of IS research received good support for maintaining cohesion in IS studies. These nine keywords are 'adoption/ acceptance', 'e-commerce', 'knowledge management', 'case study', 'outsourcing', 'trust', 'ERP', 'social network', and 'healthcare'. In addition, we found, adoption/acceptance, e-commerce, knowledge management, case study, outsourcing, trust, and ERP were popular, core, and bridging topics. The fact that the keywords in the three groups of topics are highly consistent implies that IS developed in a healthy direction in the second period too.

The topics of diffusion, implementation, and business value have a good coreness value, indicating that studies on these topics are, in relative terms, in the core region of the field. However, these three topics have relatively low structural holes values (36.92; 37.66; and 40.28, respectively). Hence, they are not strong bridging research topics. Research on social networks has a high frequency (130) over the 10 years in question and possesses a relatively high structural holes value (42.85) but does not represent a core topic. This implies that the knowledge obtained on social networks has a weak connection to the core topics.

It is worth noting here that knowledge management and outsourcing were popular but not core or bridging topics in the period 1993–2002 and that they became popular, core, and bridging topics in the second period, 2003–2012, implying that IS researchers have pushed these two topics into the core region of IS research and aggregated the field with them. While research related to the keywords 'trust', 'ERP', 'social network', and 'healthcare' did not appear on the list of the top popular, core, or bridging topics for the first period, these are listed for the second period as popular and bridging topics. This indicates that studies on these topics have been performed in large numbers (i.e., with high frequencies) in connection with many other research topics (that is, the bridging values are high). In particular, trust and ERP have high core values, indicating that the relevant research has been integrated well with work on other core topics in the IS field.

In comparison of the two tables, many new research topics ($N = 48$) appear between 2003 and 2012, replacing research topics from the period 1993–2002. Clearly, the focus of the research changed substantially between the two decades. The research topics of adoption/acceptance, e-commerce, and case study are traditional ones that appear for both decades among the popular, core, and bridging topics, implying the existence of traditions as to research topics. Several keywords appear in the list for the latter 10 years only – for example, 'social network' and 'healthcare'.

### Detecting the major research themes

The co-occurrence correlation matrix indicates both the similarity and dissimilarity for each keyword pair, and it serves as a solid basis for studying the degree of correlation among research topics. We applied hierarchical clustering using Ward's method as the cluster method and squared Euclidean distance as the distance measurement (Ward, 1963), in the manner shown in the appendix, in Figures A1 and A2 (Liu *et al*, 2011; Zong *et al*, 2013).

**Table 4 Research themes in 1993–2002**

| *Cluster (size)* | *Keywords* |
|---|---|
| A1 (24) | **Research methods/methodology, end user computing, project management**, system development, evaluation, survey research, user involvement, measurement, design, software development, structural equation modeling, data warehouse, action research, case, communication, empirical study, satisfaction, critical success factor, software project management, systems analysis, partial least squares, qualitative research, risk management, software quality |
| A2 (3) | **Adoption/acceptance, usage, TAM** |
| A3 (6) | **DSS, expert system, decision making**, neural networks, data mining, machine learning |
| A4 (7) | **Group support system, group decision support, electronic meetings**, groupware, electronic brainstorming, brainstorming, group decision making |
| A5 (10) | **Implementation, case study, diffusion**, e-mail, organizational learning, ERP, productivity, computer-mediated communication, cross-cultural study, field study |
| A6 (10) | **Strategic planning, strategy, strategic IS**, IT investment, competitive advantage, infrastructure, IS planning, business value, business strategy, impact |
| A7 (5) | **E-commerce, Internet, e-business**, privacy, security |
| A8 (2) | **Conceptual model, ontology** |
| A9 (5) | **Business process reengineering, organizational change, business process redesign**, change management, reengineering |
| A10 (2) | **Inter-organizational systems, electronic data interchange** |
| A11 (2) | **Executive IS, executive support systems** |
| A12 (3) | **User/consumer/customer satisfaction, success, effectiveness** |
| A13 (2) | **Knowledge management, knowledge** |
| A14 (3) | **Trust, virtual organization, virtual team** |
| A15 (9) | **Electronic market, outsourcing, multimedia,** IS personnel, education, transaction cost, information economics, simulation, small business |
| A16 (3) | **HCI, motivation, training** |

The 96 keywords from the 1993–2002 sub-sample were divided into 16 clusters, which were labeled as Clusters A1 – A16. Each cluster represents a research subfield or research theme in IS studies (Liu *et al*, 2011; Zong *et al*, 2013). Specifically, Cluster A6 is related to IS strategy, and Cluster A4 is related to group work, while Cluster A3 is related to decision support; this is largely consistent with the clusters identified by Taylor *et al* (2010). In the same way, the 98 keywords from the sub-sample for 2003–2012 were divided into 13 clusters, labeled as Clusters B1 – B13. Given the frequency, the top three keywords (in boldface in the Tables 4 and 5) in each cluster were used to represent those clusters because keywords with lower frequencies received relatively little attention from researchers (Liu *et al*, 2011; Zong *et al*, 2013), as reflected in Tables 4 and 5.

To enable demonstrating the importance and status of each research focus, we calculated total frequency, co-word frequency, and average frequency and co-word frequency values for each cluster, as shown in Tables 6 and 7. The total frequency and average frequency indicate the way in which, on average, the overall research attentions of IS scholars has been directed to specific research themes and to the individual research topics. Clusters A2 (adoption/acceptance; usage; TAM), A5 (implementation, case study, diffusion), A7 (e-commerce; Internet; e-business), and A10 (inter-organizational systems; electronic data interchange), from 1993–2002, and B2 (adoption/acceptance; TAM; diffusion), B6 (case study; implementation; ERP), and B11 (outsourcing; offshoring), from 2003–2012, have the highest average frequency and average co-word frequency, indicating that the research topics in those clusters were most popular.

### Maturity and cohesion of the subfields of research

For further ascertaining the cohesion and maturity of the research themes in the IS field in the two periods, we assessed the values of degree centrality and density for each cluster, working from the co-occurrence frequency matrix. Based on the values for both cluster centrality and density, a strategic diagram was drawn for intuitively grasped depiction of the current status of the research topics. Because groups differ from each other in their number of keywords, the influence due to the difference in group size was reduced via normalization of the cluster-density value for the size of the non-group-member set. The group *K*-step reach represents the number or proportion of non-group members that can be reached from a group member in *K* steps or fewer. One-step reach is used here, given the densely connected network.

As shown in Figure 5, two strategic diagrams for IS research were generated, for the period 1993–2002 and the period 2003–2012. The origins are 0.394 and 4.15 for 1993–2002 and are 0.748 and 8.622 for 2003–2012; these are the average value of degree centrality and density,

**Table 5 Research themes in 2003–2012**

| *Cluster (size)* | *Keywords* |
|---|---|
| B1 (6) | **Research methods/methodology, design science, action research**, business process management, qualitative research, process model |
| B2 (4) | **Adoption/acceptance, TAM, diffusion,** usage |
| B3 (36) | **E-commerce, healthcare, e-government,** Internet, empirical study, inter-organizational systems, e-services, institutional theory, open source software, software development, evaluation, design, electronic market, decision making, survey research, RFID, performance, education, success, user/consumer/customer satisfaction, digital divide, IT governance, SME, critical success factor, grounded theory, literature review, supply chain management, green IS, business model, ethics, IS development, alignment, Open Source, service-oriented architecture, CRM, integration |
| B4 (3) | **DSS, business intelligence, data mining** |
| B5 (9) | **Business value, strategy, e-business**, IT investment, capability, resource-based view, enterprise performance, productivity, competitive advantage |
| B6 (5) | **Case study, implementation, ERP,** enterprise system, organizational change |
| B7 (6) | **Knowledge management, knowledge sharing, social capital,** knowledge transfer, social network analysis, organizational learning |
| B8 (2) | **Ontology, conceptual model** |
| B9 (12) | **Trust, project management, security**, privacy, infrastructure, culture, risk, risk management, satisfaction, gender, governance, control |
| B10 (7) | **Social network, collaboration, virtual team**, virtual world, computer-mediated communication, HCI, e-learning |
| B11 (2) | **Outsourcing, offshoring** |
| B12 (4) | **Online community, social media, Web 2.0**, virtual community |
| B13 (2) | **Structural equation modeling, partial least squares** |

**Table 6 The frequency and co-word attributes of each cluster, 1993–2002**

| *Cluster* | *Total frequency* | *Total co-word frequency* | *Average frequency* | *Average co-word frequency* | *Centrality* | *Density* |
|---|---|---|---|---|---|---|
| A1 | 444 | 437 | 18.50 | 18.21 | 0.792 | 0.330 |
| A2 | 127 | 198 | 42.33 | 66.00 | 0.527 | 8.333 |
| A3 | 166 | 131 | 27.67 | 21.83 | 0.489 | 1.600 |
| A4 | 178 | 210 | 25.43 | 30.00 | 0.315 | 3.667 |
| A5 | 300 | 354 | 30.00 | 35.40 | 0.849 | 1.089 |
| A6 | 237 | 214 | 23.70 | 21.40 | 0.477 | 1.067 |
| A7 | 163 | 169 | 32.60 | 33.80 | 0.505 | 3.000 |
| A8 | 26 | 18 | 13.00 | 9.00 | 0.064 | 5.000 |
| A9 | 105 | 132 | 21.00 | 26.40 | 0.429 | 1.900 |
| A10 | 57 | 92 | 28.50 | 46.00 | 0.287 | 17.000 |
| A11 | 29 | 39 | 14.50 | 19.50 | 0.160 | 7.000 |
| A12 | 75 | 109 | 25.00 | 36.33 | 0.344 | 4.667 |
| A13 | 54 | 39 | 27.00 | 19.50 | 0.191 | 7.000 |
| A14 | 42 | 52 | 14.00 | 17.33 | 0.237 | 2.667 |
| A15 | 162 | 112 | 18.00 | 12.44 | 0.437 | 0.417 |
| A16 | 34 | 38 | 11.33 | 12.67 | 0.215 | 1.667 |
| Average | 137.43 | 146.50 | 23.28 | 26.61 | 0.394 | 4.150 |

**Table 7 The frequency and co-word attributes of each cluster, 2003–2012**

| *Cluster* | *Total frequency* | *Total co-word frequency* | *Average frequency* | *Average co-word frequency* | *Centrality* | *Density* |
|---|---|---|---|---|---|---|
| B1 | 453 | 371 | 75.50 | 61.83 | 0.783 | 4.133 |
| B2 | 684 | 732 | 171.00 | 183.00 | 0.872 | 16.333 |
| B3 | 2362 | 2148 | 65.61 | 59.67 | 1.000 | 0.610 |
| B4 | 200 | 177 | 66.67 | 59.00 | 0.568 | 6.000 |
| B5 | 643 | 807 | 71.44 | 89.67 | 0.854 | 4.667 |
| B6 | 617 | 757 | 123.40 | 151.40 | 0.935 | 10.500 |
| B7 | 515 | 499 | 85.83 | 83.17 | 0.891 | 4.733 |
| B8 | 129 | 86 | 64.50 | 43.00 | 0.323 | 13.000 |
| B9 | 838 | 878 | 69.83 | 73.17 | 1.000 | 1.924 |
| B10 | 510 | 504 | 72.86 | 72.00 | 0.791 | 3.524 |
| B11 | 243 | 247 | 121.50 | 123.50 | 0.594 | 26.000 |
| B12 | 250 | 237 | 62.50 | 59.25 | 0.564 | 5.667 |
| B13 | 153 | 155 | 76.50 | 77.50 | 0.552 | 15.000 |
| Average | 584.38 | 584.46 | 86.70 | 87.39 | 0.748 | 8.622 |

respectively. The full set of research themes was divided into four quadrants. For 1993–2002, we can see that:

(1) Cluster A2 (adoption/acceptance; usage; TAM) is in quadrant I. It has good values for both degree density and centrality. This indicates that Cluster A2 is quite developed and widely connected to other clusters. Therefore, the research topics in Cluster A2 are the core field of IS in 1993–2002.

(2) Clusters A8 (conceptual model; ontology), A10 (Inter-organizational systems; electronic data interchange), A11 (executive IS; executive support systems), A12 (user/consumer/customer satisfaction; success; effectiveness), and A13 (knowledge management; knowledge) lie in quadrant II. These clusters have high density but low centrality, indicating that the research topics in these clusters are marginal but mature. In other words, the topics in these clusters are isolated but well-developed internally. Also, the low total frequencies of these research topics indicate that said topics received relatively limited attention, even though they are largely mature.

(3) Clusters A4 (group support system; group decision support; electronic meetings), A14 (trust; virtual organization; virtual team), and A16 (HCI; motivation; training) lie in quadrant III. Together, their low values for both density and centrality suggest that the research topics in these clusters represent either

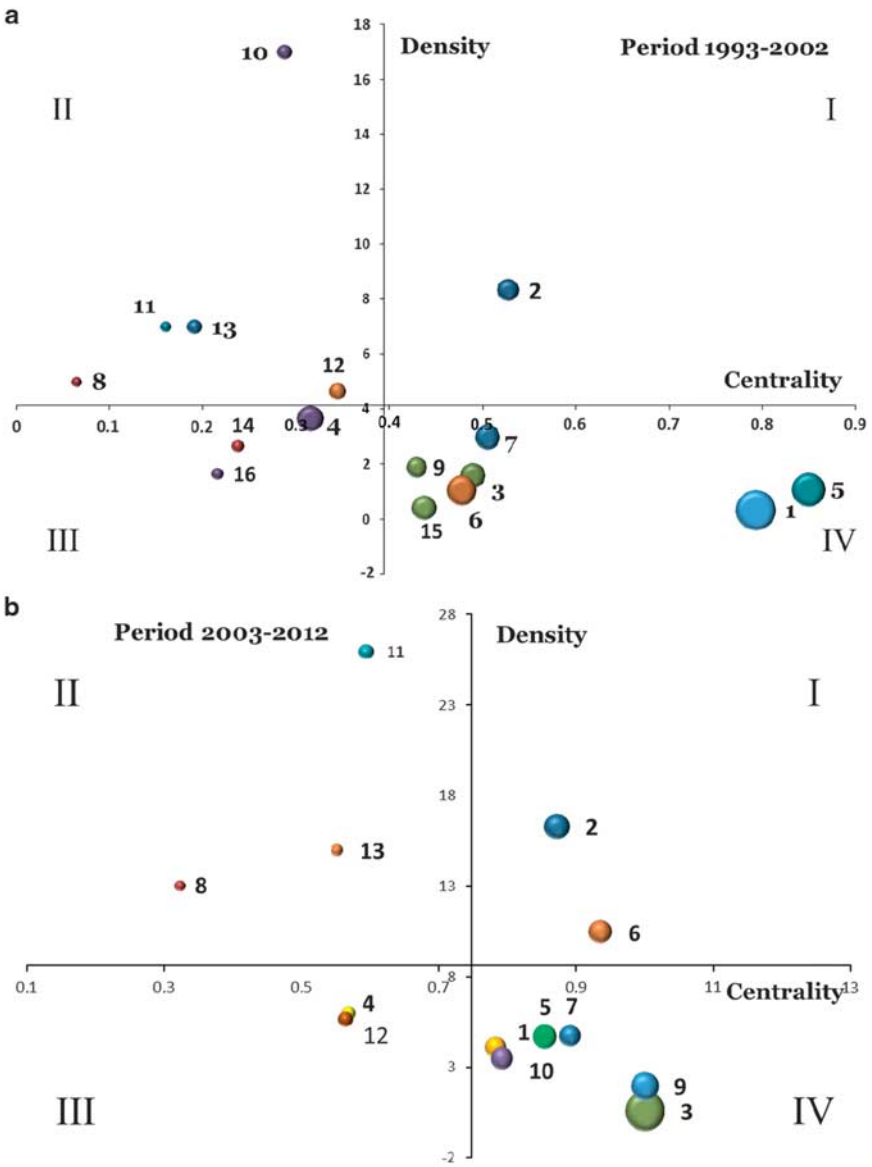


**Figure 5** Strategic diagrams for IS research.
(a): 1993–2002; (b): 2003–2012.
*Note*: Node size represents the frequency of the keywords included.

emerging or fading sub-disciplines. Accordingly, the research topics in these clusters are subject to change.

(4) Clusters A1 (research methods/methodology; end-user computing; project management), A3 (DSS; expert system; decision making), A5 (implementation; case study; diffusion), A6 (strategic planning; strategy; strategic IS), A7 (e-commerce; Internet; e-business), A9 (business process reengineering; organizational change; business process redesign), and A15 (electronic market; outsourcing; multimedia) are found in quadrant IV. These have high centrality but low density, suggesting that the research topics in these clusters are central to the field but undeveloped. These clusters have a high total frequency, indicating that IS scholars conducted fundamental research in order to establish more cohesive research subfields.

Regarding 2003–2012, we find that:

(1) Cluster B2 (adoption/acceptance; TAM; diffusion) and Cluster B6 (case study; implementation; ERP) are in quadrant I. Accordingly, the research topics in clusters B2 and B6 represent the motor research themes of IS in the period 2003–2012. These research topics not only developed such that they achieved an above-average

level of internal maturity but also gained relatively good connection with the research topics in other clusters.

(2) Cluster B8 (ontology; conceptual model), Cluster B11 (outsourcing; offshoring), and Cluster B13 (structural equation modeling; partial least squares) are in quadrant II. These clusters have high density but low centrality, indicating that research on the themes they cover is relatively mature but isolated. In other words, they can be said to be well focused and highly developed but lacking in influence on other research themes. Therefore, for survival or future development of work on these research topics, communicating the results of the associated research with reference to other research themes would be useful.

(3) Clusters B4 (DSS; business intelligence; data mining) and B12 (online community; social media; Web 2.0) are in quadrant III. The clusters in this quadrant have low centrality and density, implying that their research topics are emerging or fading.

(4) Clusters B1 (research methods/methodology; design science; action research), B3 (e-commerce; healthcare; e-government), B5 (business value; strategy; e-business), B7 (knowledge management; knowledge sharing; social capital), B9 (trust; project management; security), and B10 (social network; collaboration, virtual team) lie in quadrant IV. These clusters represent basic and transversal research themes. A relatively large number of research themes and a high total frequency of keywords are seen in this quadrant, implying that IS research developed on broad foundations in the second period.

By comparing the centrality of the clusters between the two periods, we obtain an intuitive understanding of what is located at the center of IS research and the identity of the field. As is shown in Figure 5, clusters A1, A5, B3, and B9 have the highest centrality values and are therefore at the center of IS research. It is noteworthy that these four clusters all have large group sizes and also cover a broad range of new IT artifacts and IT research methods, theories, and perspectives, which goes some way toward implying that IS research is grounded in studying various IT artifacts and their impacts by employing or developing new research methods as well as new research perspectives. In addition, only nine of the keywords in clusters A1 and A5 appear in clusters B3 (36 keywords) and B9 (12 keywords), indicating a more than 80% difference. Therefore, the center of IS research has changed rapidly, as has the emergence of new IT artifacts and research perspectives. This is consistent with the view of Agarwal & Lucas (2005), who argued that information technology has always been a story of change and that IS research at a macro level should be transformational in nature.

Furthermore, we found that research on adoption/acceptance has been situated at the center of IS research in the past 20 years, considering both the high centrality values and the highest average co-word frequencies for clusters A2 (adoption/acceptance; usage; TAM) and B2 (adoption/acceptance; TAM; diffusion). Similar results have been reported by Córdoba *et al* (2012), who noted that IS research is consolidated around the theme they referred to as 'IS acceptance'.

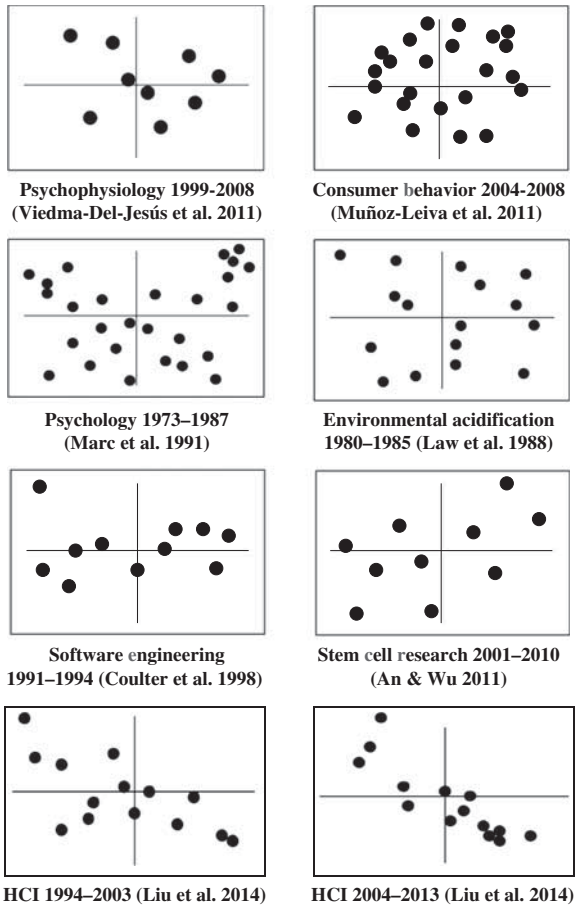


**Figure 6** Indicative strategic diagrams from other scientific disciplines.

## Distinctive IS research: a comparison with other scientific fields

Several prior bibliometric studies have generated strategic diagrams for specific fields of interest, offering us an opportunity for direct comparison of the development of IS studies with that of other scientific fields. Figure 6 shows simplified strategic diagrams of six fields as presented in the literature: psychology, psychophysiology, consumer-behavior research, studies of environmental acidification, software engineering, and stem-cell research. Strategic diagrams for studies of HCI are included in Figure 6 too. Inclusion of HCI, as a close neighbor of IS that is focused on studying new ICTs, should enable more intuitive comparison between more ICT-focused fields (IS and HCI) and less related or non-ICT-related fields.

Two major differences are found in comparing IS and HCI with those six other fields. First, IS and HCI research have

produced more subfields in quadrant IV. Other fields, however, ranging from social-science-oriented ones (psychology, psychophysiology, and studies of consumer behavior) to the natural-science-oriented (environmental acidification, software engineering, and stem-cell research), maintain a rather limited proportion of subfields in quadrant IV. Second, of the six fields highlighted in Figure 6, motor themes (the cluster in quadrant I) are found to have rather high centrality. In relative terms, the motor themes of IS research, in both periods, have low centrality values. Similarly, HCI has a motor theme with a low centrality value in 2004–2013 also.

We should bear in mind the above reminder that information technology has always been about change (Agarwal & Lucas, 2005). There is almost no other field grounded in studying such rapidly changing objects of ICTs as HCI and IS do (cf. Liu *et al*, 2014). Therefore, we argue that, caused by fast changes in technology, the rapid diversification in terms of research topics may account for the uniqueness of IS research, and this diversity of new research topics may inhibit the relevant research from achieving a high level of density. In contrast, other fields (stem-cell research, research into consumer behavior, etc.) may have a relatively stable set of subjects, which facilitates the accumulation of knowledge and affords reaching a high level of density. From our analysis, we argue that the overall high-centrality, low-density structure of the IS field will remain, on account of continued diversity in this research field. In other words, we believe that IS research will remain centered on studying new and emerging IT artifacts and relevant topics. Therefore, it would be a difficult or lengthy process for IS field to become as internally focused as other scientific fields.

## Discussion: evolution, change, and integration

### Emerging research paradigms

By comparing the two IS strategic diagrams in Figure 5, we can clearly see an interesting evolution of the field over the two periods considered. For instance, Cluster B12 (online community; social media; Web 2.0) represents a completely new research theme emerging between 2003 and 2012 (quadrant III). There was also growing research interest in statistical methods related to IS in 2003–2012, resulting in a new research theme based on structural equation modeling and partial least squares (Cluster B13). The high density of Cluster B13 indicates that the research topics in this cluster have gained a high level of internal cohesion, even if they are relatively isolated from other subfields and have a limited impact on the field as a whole.

Furthermore, research on outsourcing and offshoring, Cluster B11, started to become independent from the electronic-market-related research subfield (Cluster A15) and quickly attracted a considerable amount of research attention. Research on outsourcing was a popular topic in 2003–2012, becoming highly developed during that period. In a similar manner, study of research methods/methodology, associated with the topics of design science and action research, started to form an independent area (Cluster B1) in the second decade from within the first decade's Cluster A1.

### Cumulative tradition: coherent research paradigms

The diagrams show that Cluster A2 (adoption/acceptance; usage; TAM) and its descendant, Cluster B2 (adoption/acceptance; TAM; diffusion), form the motor theme for both periods. Therefore, research on the related topics (adoption/acceptance in general) is a constant focus of IS communities, implying the forming or existence of an important research tradition in IS in the past 20 years.

Cluster A13 (knowledge management; knowledge) evolved from a highly developed but marginal research theme to become a basic and transversal research theme during 2003–2012 by incorporating more new research topics into its subfield, such as SNA, social capital, and virtual teams (Cluster B7). That inclusion moved the research theme towards the center of the whole field. However, this subfield is not yet mature and research on these topics lacks density.

Ontology and conceptual models was a highly developed research theme in both periods (as examination of Cluster A8 and Cluster B8 shows), though the frequency of the associated keywords is constantly low. The frequency value for ontology increased from 13 during 1993–2002 to 78 during the second period, 2003–2012, while that for conceptual model rose from 13 during 1993–2002 to 51 during 2003–2012. By comparing the frequency of these two keywords, we can see a shift in research resources with respect to the theme.

Clusters A12 (user/consumer/customer satisfaction; success; effectiveness) and A10 (Inter-organizational systems; electronic data interchange) in the period 1993–2002 were largely merged into Cluster B3 in the second period studied. Cluster B3 encompasses study of several new IS services and applications, such as RFID, CRM, green IS, and supply-chain management, which appear to have become basic and transversal research themes. 'Healthcare' is the most frequently appearing keyword in this cluster, indicating that it represents one of the most popular services to be investigated. As a highly developed but isolated research theme, Cluster A6 (strategic planning; strategy; strategic IS) has absorbed several new research topics, among them e-business, the resource-based view, and firm performance, and evolved into a central and mature (low-density) research theme (Cluster B5) in the second research period.

### Fading research paradigms

The research topics in Cluster A14 (trust; virtual organization; virtual team), which show up as potentially emerging or fading clusters in quadrant III in 1993–2002, have been split and absorbed by clusters B9 (trust; project management; security) and B10 (social network; collaboration; virtual team). Research topics in clusters A3 (DSS; expert

system; decision making) and A4 (group support system; group DSS; electronic meeting systems) appear to have faded away somewhat in the IS field in the period 2003–2012. The Cluster A3 research theme has undergone internal change involving research attention shifting from research topics such as neural networks and machine learning toward the topics of business intelligence and data mining (Cluster B4). The relatively low total and average frequencies for Cluster B4's overall research theme suggest that less research attention has been devoted to it, indicating that this research theme is fading. All of the topics originally in Cluster A4 disappeared from the sample in 2003–2012, which may show partial evolution into Cluster B10 (social network; collaboration; virtual team). Similar keyword evolution may be observed in a shift from A3 (expert system) to B4 (business intelligence) and from A5 (computer-mediated communication; organizational learning) to B6 (enterprise system; organizational change).

The research theme represented by Cluster A11 (executive IS; executive support systems) disappeared from the list of the main research topics during 2003–2012, even though it was a highly developed and mature subfield of IS research in 1993–2002. The research theme formed by Cluster A16 (HCI; motivation; training) appears to be equally on the decline. Also, the research topics of motivation and training, present in 1993–2002, were absent from the list of top research topics in 2003–2012. HCI became a subsidiary research topic in Cluster B10 (social network; collaboration; virtual team), implying that HCI became more an approach to doing research than a relatively independent subfield. It is worth noting that waning of a research paradigm in the field of IS does not imply the paradigm itself fading out from science as a whole. For instance, research on HCI has developed into a rich and concrete discipline in its own right. This suggests that interaction and competition between IS and other scientific disciplines should be regarded as a normal metabolic process within IS.

### Changes in motor research paradigm

In comparison to other research themes, the centrality and density values for motor themes should be higher than average. The motor research theme was found to have expanded from one cluster (Cluster A2: adoption/acceptance; usage; TAM) to two clusters – Cluster B2 (adoption/acceptance; TAM; diffusion) and Cluster B6 (case study; implementation; ERP). Cluster B6 can be seen as a natural evolution of Cluster A5 (implementation; case study; diffusion), since the former is more focused and cohesive. It is significant also that Cluster A5 (implementation; case study; diffusion; e-mail; organizational learning; ERP) is linked to enterprise systems. Therefore, it is suggested that research on enterprise systems has been an important driving force in advancing the field in the more recent 10-year period.

Evidence of the healthy evolution of the field in response to emergence of new research topics can also be seen. For instance, new research topics such as social capital, SNA, and knowledge transfer have become subsidiary topics within Cluster B7 (knowledge management; knowledge sharing; social capital), with the topic of knowledge management at its leading edge. The new topics of social media and virtual community have become integrated well into the existing research theme represented by Cluster B12. These new research topics were found to be integrated well into the field, indicating healthy development of IS research, no matter the field's rapid diversification of research topics.

### Cohesion of the field

The measurement of centrality and density offers an approach for directly detecting whether a field has become more coherent or instead fragmented. As we noted in the previous section of the paper, the average centrality and density value for all the clusters showed a substantial increase between 2003 and 2012 (0.748 and 8.622, respectively) relative to 1993–2002 (0.394 and 4.15, respectively), which indicates that the whole field has advanced to greater research cohesion and depth of research. In our study, the difference in size between the keyword corpora from the two distinct time periods may raise concerns related to biased research. To reduce the possibility of bias, we converted the co-occurrence frequency matrix such that it became a co-occurrence binary matrix serving as the basis for calculating the overall network density. In this study, we used a value of 0 (not connected) or 1 (connected) to represent each pair of keywords in the co-occurrence binary matrix. Consequently, the overall density of the IS intellectual map was found to have increased from 0.153 in 1993–2002 to 0.352 for 2003–2012. Therefore, we were able to conclude that IS has become a more concrete and internally cohesive research field today on account of the constant effort of IS scholars over the past 20 years. Several research topics have disappeared, but new ones have emerged and been absorbed into the field, as is shown by the relationship between Cluster A1 and Cluster B3, which indicates that the field manifests a natural metabolic process.

### How cohesion occurs

For further investigation of how the process of cohesion occurred, we can evaluate the network centralization value of the two networks. There are two main ways in which a network can become more cohesive: either new connections are built broadly among various nodes, rather than focusing on a few central nodes, or new connections are built mainly via connection of a few central nodes to other peripheral nodes. The network centralization value is a measurement reflecting the degree to which a network is dominated by one or a few very central nodes. Through the use of UCINET and the co-occurrence frequency matrix, the network centralization value was found to have increased from 5.03% for 1993–2002 to 8.16% for 2003–2012. For instance, adoption/acceptance was found

to link 78 distinct keywords in 2003–2012 in comparison to 43 keywords in 1993–2002. Thus, there is a clear tendency for new research topics to be increasingly connected to the topics of adoption/acceptance, case study, knowledge management, trust, and e-commerce. In other words, when a new technology (represented as a research topic) enters the field, it is highly likely for that technology to be studied from the perspective of adoption/acceptance, knowledge management, trust, and e-commerce, and also through the use of case study methods. If we consider the keyword 'case study', we find that it appeared in a similar proportion of publications between 1993–2002 ($N = 56$, 2.78%) and 2003–2012 ($N = 222$, 2.94%) but was connected with a much broader spectrum of topics in the second period, as is shown in Table 8.

## Investigating knowledge-building: an analysis focused on TAM

When we considered the issue of an overarching theory for IS (Larsen & Levine, 2005), one theory (TAM) was found in the list of top keywords for 1993–2002 while two theories (TAM and institutional theory) appear in the list of top keywords for 2003–2012. Institutional theory may best be considered a theoretical lens (Björkman *et al*, 2007), instead of a specific theory in its own right. Hence, because TAM has been developed especially for IS research, it appears to be the most suitable candidate for characterization as the dominant, overarching theory of IS in the past 20 years – if we must choose one.

**Table 8 Centralization of the intellectual map of IS research**

| *1993–2002* | | *2003–2012* | |
|---|---|---|---|
| *Most connected keywords* | *Number of keywords connected* | *Most connected keywords* | *Number of keywords connected* |
| Implementation | 46 | Adoption/ acceptance | 78 |
| Adoption/ acceptance | 43 | Case study | 75 |
| Case study | 42 | Knowledge management | 68 |
| E-commerce | 38 | Trust | 61 |
| Diffusion | 33 | E-commerce | 57 |

Given the popularity and importance of TAM in the field, two ego-network maps of TAM have been developed, for the first and the second period, to visualize the knowledge-building accompanying this topic. It is assumed that if TAM research is associated with different keywords in different periods, possibilities for new knowledge-building exist. As is shown in Figures 7 and 8, TAM exhibits a positive correlation with 15 distinct keywords in 1993–2002, and the number grows to 24 for 2003–2012. Six keywords are duplicated between the periods: 'adoption/acceptance', 'structural equation modeling', 'satisfaction', 'diffusion', 'e-commerce', and 'usage'. In addition, the keywords 'user/consumer/customer satisfaction' and 'culture' in the second period overlap somewhat with 'satisfaction' and 'cross culture study' from the first decade. After exclusion of these duplicated or partly overlapping keywords, TAM research in the more recent decade has actually been extended to 16 new topics, including e-learning, process model, virtual world, collaboration, education, ERP, gender, trust, e-government, success, security, Internet, privacy, digital divide, organizational change, and Web 2.0. This suggests that, to some extent, TAM-related research has indeed contributed to knowledge-building in the field in the more recent decade.

## Visualizing the intellectual maps: 1993–2002 vs 2003–2012

A relation network was generated for visualization of the structure and relationships of keywords and of clusters. This was created on the basis of correlation coefficients

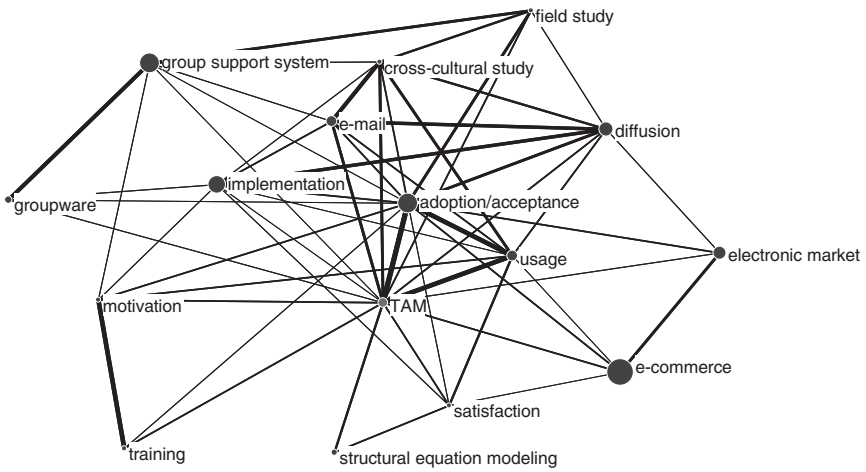


**Figure 7** The ego network structure for the keyword 'TAM' in 1993–2002.
*Note*: The lines represent links between keywords with a correlation above 0.

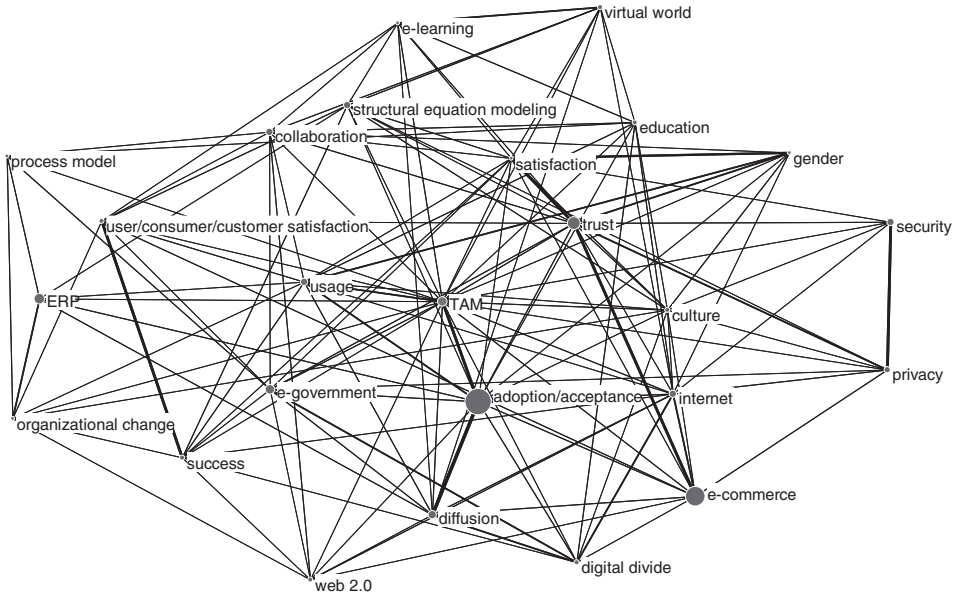


**Figure 8** The ego network structure for the keyword 'TAM' in 2003–2012.
*Note*: The lines represent links between keywords with a correlation above 0.

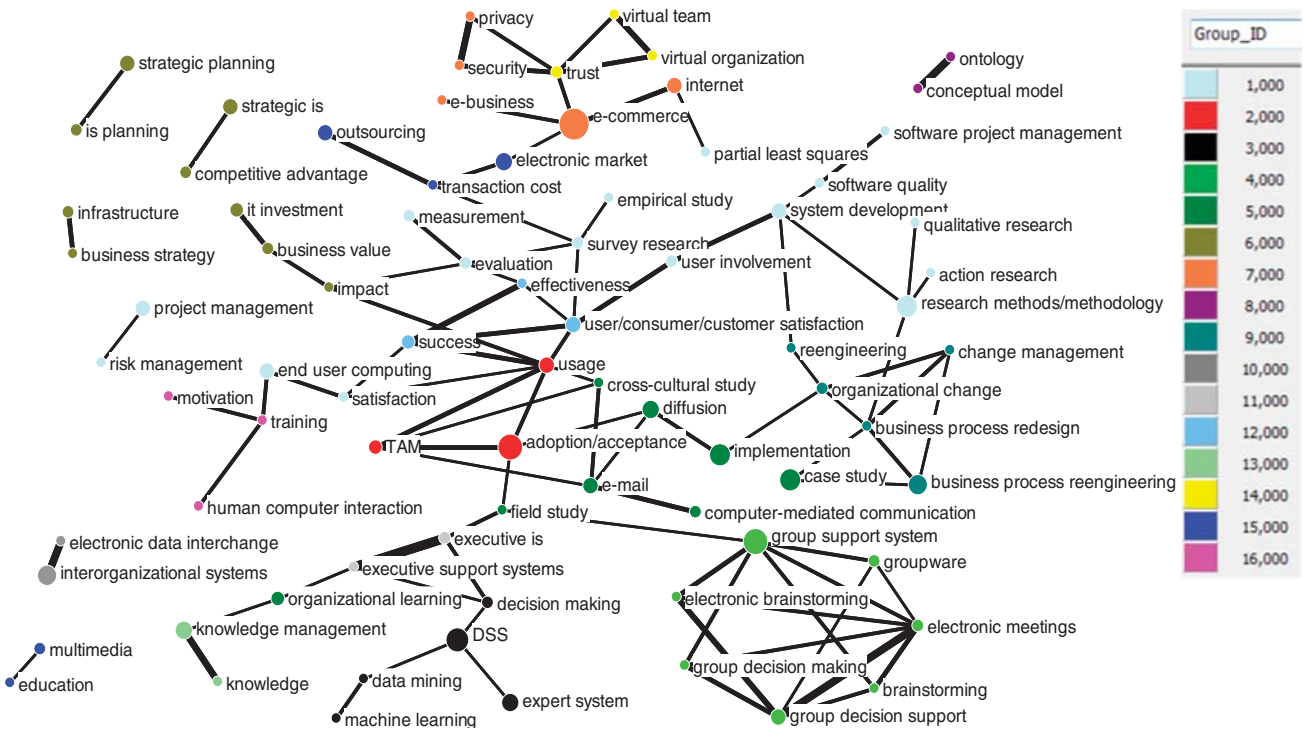


**Figure 9** The network structure for the keywords in 1993–2002.
Note: Each line represents a link between two keywords with a correlation coefficient ≧ 0.09, the color of the nodes represents the group ID, the thickness of the line represents the strength of the correlation between the keywords, and the size of the node represents the frequency of the keywords. Please see the online interactive version of the figure at http://goo.gl/Icfjrx.

through the use of NetDraw. Evidence of increased centrality and density is provided by the network map for 1993–2002, which was shown to have 1396 ties while the map for 2003–2012 had 3276. This indicates that the extensive diversity in research topics, as addressed in the foregoing discussion, is not necessarily leading to

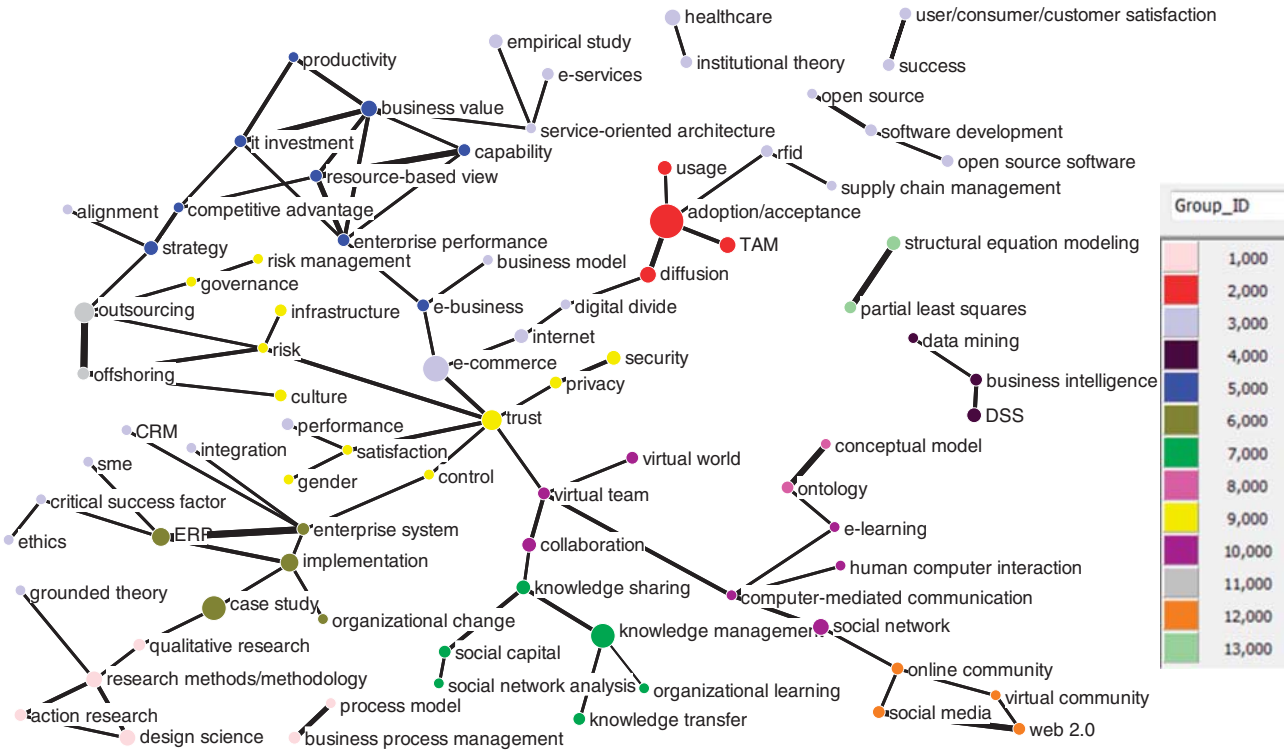


**Figure 10** The network structure for the keywords in 2003–2012.
Note: Each line represents a link between two keywords with a correlation coefficient ≧ 0.06, the color of the nodes represents the group ID, the thickness of the line represents the strength of correlation between the keywords, and the size of the node represents the frequency of the keywords. Please see the online interactive version of the figure at http://goo.gl/4nSa3L.

fragmentation of the field. Instead, diversity and cohesion may go hand in hand.

Furthermore, these maps can assist IS scholars who operate in various areas to understand the intellectual map of IS as a whole, since they show how individual research themes are connected with each other through a specific research topic and how a given research theme or topic can be extended to other research topics or themes. For instance, in Figure 10, 'healthcare' is found to be correlated strongly with institutional theory, implying that this theory is highly likely to be the basis for investigation of health-care IS. Meanwhile, DSS has a much smaller node size in Figure 10 than in Figure 9, indicating that research attention generally shifted away from that topic in the second 10-year period. Trust is found at the center of the map, which connects all three general research themes – clusters B3 (e-commerce; healthcare; e-government), B9 (trust; project management; security), and B10 (social network; collaboration; virtual team) – in Figure 10. This suggests that trust performs an important bridging function in the map.

No evidence of the hypothesized fragmentation of the field has been detected. We visualized the network map of all keywords for 2003–2012 and sought to detect fragmentation by setting different thresholds for co-occurrence frequency and correlation. All the nodes remain connected as one integrated map when the thresholds are set to over 0.03 for co-occurrence correlation. In order to facilitate better visualization for Figures 9 and 10, two interactive network maps have been developed, which are accessible via the Internet at http://goo.gl/ICfjrx and http://goo.gl/4nSa3L, respectively. They were developed on the basis of a Google Fusion table.

## Limitations

The study was based on a co-word analysis approach. A limitation of this approach is that authors' subjectivity in assignment of the keywords may bias the results (cf. Law & Whittaker, 1992; Lu & Wolfram, 2012). Some authors may misuse keywords, such that the keyword used does not fully reflect the content of their publication. In addition, the general 'habit' of assigning keywords in the field has certain effects on the presentation of results. For instance, most empirical IS studies did not include 'empirical study' as a keyword, while the same might not be said for 'case study'. Also, there is a limitation related to our decision to merge particular controversial keywords, as in 'acceptance/adoption' and 'user/consumer/customer satisfaction'. While some IS scholars use certain keywords interchangeably, with one example being 'adoption' and 'acceptance' (cf. Dwivedi *et al*, 2008; Williams *et al*, 2009), others may argue that doing so is

incorrect (Hernandez *et al*, 2009; Holden & Karsh, 2010). In addition, the meaning of keywords may change from context to context in articles, and it may evolve over time (cf. Leydesdorff, 1997), even though it is difficult to measure the degree to which the keywords in their new form are similar to the original ones. Furthermore, on account of limits to resources, such as time constraints, the study was based only on the keywords collected from 10 well-regarded journals and two highly selective conferences. Therefore, our results are contingent on the preferences of the publishers, which might result in generalization problems when one interprets the development of the whole field. The results could be improved via inclusion of more IS journals and conferences in the database. We also acknowledge that our selection of the 12 IS research venues in question differs from the selections used in earlier IS bibliometric studies and does not perfectly represent the overall field of IS research. Furthermore, more papers were published in the second period. This may introduce some bias to the results, even though we attempted to control for this by using techniques such as average centrality and binary network analysis. Finally, future studies might be able to produce interesting results by building an intellectual map covering, for example, the last three years in order to detect more recently emerging subfields.

## Conclusions

In our study, we strove to take advantage of recent advances in bibliometric studies to enrich understanding of the process and consequence of the evolution of IS research over the past 20 years. We adopted several bibliometric techniques, including hierarchical cluster analysis, strategic diagrams, network analysis, and graph theory, to visualize the evolution of the field by investigating, in total, 47,467 keywords, from 9551 articles in major IS publications.

In findings consistent with the work of Taylor *et al* (2010), we discovered the existence of research foci on IS strategy, group work, and decision support during the period 1993–2002. However, the results for 2003–2012 suggest that temporal stability, as suggested by the work of Taylor *et al* (2010), is not a feature of IS studies. In particular, the research foci of IS strategy and group work have mostly disappeared from the list of the top IS research topics, while research in relation to DSS has started to wane in the field. Research topics in Cluster A4 (group support system; group decision support; electronic meetings) may have undergone rapid evolution to become the foundation for Cluster B10 (social network; collaboration; virtual team). Considering the fact that the research foci have been in constant change since 1972 (Culnan, 1986; Culnan, 1987; Taylor *et al*, 2010), we find constant rapid change to be probable for the future and, accordingly, expect the intellectual structure of IS research present in the years between 2003 and 2012 – as identified in this study – to change dramatically in the future.

With regard to the cumulative tradition of IS research, research related to clusters B2 (adoption/acceptance; TAM; diffusion), B4 (DSS; business intelligence; data mining), B6 (case study; implementation; ERP), B7 (knowledge management; knowledge sharing; social capital), and B8 (ontology; conceptual model) appears to have become an IS tradition over the past 20 years or so, for the most common research topics in these clusters appear for both periods. The existence of these tradition research themes implies that there is temporal continuity of IS research, rendering the field distinct from other scientific disciplines. However, it is worth noting that IS research traditions are constantly evolving as new topics get increasingly included in the subfields, replacing old ones.

The process of the evolution of IS research seems to be facilitated by distinctive foci maintained by the main IS journals. By examining the association between new IS research topics and major IS journals, the correspondence analysis indicates that IS journals have diverse preferences as to topics for publication and therefore contribute to the diversity of IS research as a whole.

Concrete evidence was found in support of the view that the IS field has become more cohesive instead of fragmented. Examination of the two periods showed that the values for cluster centrality, density, overall network density, and network map ties increased in the latter decade. Therefore, we conclude that extensive diversity in the field does not necessarily lead to its fragmentation. In fact, the whole field became more cohesive as IS studies rapidly diversified. From the network centralization value results, we argue that increased cohesion of the field is achieved by increasing connection of new research topics to a set of core IS topics, such as adoption/acceptance, knowledge management, trust, and e-commerce. The corresponding keywords are indicators of the centralized character of IS research.

Considering that new research topics have become integrated well into the various subfields of IS research, we argue that the general change in research topics and themes should be regarded as part of the natural metabolism of the IS field rather than a process of fragmentation or disintegration. We conclude, accordingly, that the rapid changes in the IS field has resulted in healthy evolution of IS research. In particular, we observe that many research topics (HCI, e-government, outsourcing, social networks, etc.) have been brought to the IS field from other disciplines. This lends good support to the argument that IS is 'a fluid discipline dynamically embracing a diverse range of adjacent reference disciplines' (Bernroider *et al*, 2013, p. 74). In other words, IS research is not restricted to a fixed range of topics but keeps evolving in interaction with other disciplines in terms of problems, concepts, and theories (cf. Bernroider *et al*, 2013). Abbott (2001) noted that all disciplines answer the same questions but each in its own, unique ways, by using different data sources, methods, or habits of thinking. We argue that IS research fits this picture well, since the 'borrowed' new topics are connected well to other IS topics to form a more cohesive knowledge structure.

Compared to other well-established scientific disciplines, such as psychology, IS research has a knowledge map that features a high-centrality and low-density overall structure. As technology constantly changes, sometimes quite radically, the resulting rapid diversification in research topics may inhibit the field from achieving a high level of density as a whole. Given that IS research will remain focused on studying new and emerging IT artifacts and relevant topics, we argue that a structure displaying high centrality and low density will feature in the IS research for a long time to come.

Overall, our study serves as an 'archive' chronicling the course of the growth of the IS discipline over the past 20 years by offering IS scholars an intuitive tool for exploring the field's evolution. It is important to note that 'researchers in all academic disciplines benefit from an understanding of the intellectual development of their field', which is essential for conducting studies that systematically build on past studies (Culnan, 1986, p. 156). By visualizing the intellectual map of IS research, our study provides useful information for researchers entering the field and helps them to identify the main approaches and areas of interest. For experienced IS scholars, the study offers an overview of the various research interests in IS studies and reveals possible directions for future research.

## About the authors

**Yong Liu** is an assistant professor of the Department of Information and Service Economy at Aalto University School of Business, Finland. His research interests cover the areas of big data social science, electronic commerce, mobile commerce, and online social networks. He has more than 55 publications at top international conferences and journals, such as *ACM Transactions on Computer-Human Interaction* (TOCHI), *Decision Support Systems, Information Systems Journal, Information & Management, Government Information Quarterly*, and *PLOS ONE*.

**Hongxiu Li** is a post-doctoral researcher at Turku School of Economics, University of Turku, Finland. Her expertise and research interests cover the areas of IS adoption and post-adoption behavior, e-services, social media, eWOM, and big data. She has more than 40 research publications in outlets such as *Computer & Education, Computers in Human Behavior, Decision Support Systems, Information Systems Journal, Information & Management, PLOS ONE*, and the most popular international conferences in IS field, such ICIS, ECIS, PACIS, and AMCIS.

**Jorge Goncalves** is a postdoctoral researcher and a member of the Community Imaging research group at the University of Oulu, Finland. Dr. Goncalves has more than 45 publications at top international conferences and journals in the field of Human-Computer Interaction, such as *ACM Transactions in Computer-Human Interaction* (TOCHI), *ACM CHI, Interacting with Computers, Computer Networks, ACM CSCW, International Journal of Human-Computer Interaction, ACM UIST*, etc. His work has also appeared in leading media outlets in the field like the *New Scientist* magazine and *Gizmodo*. Dr. Goncalves received a Ph.D. with distinction in Computer Science from the University of Oulu, Finland. He is a member of ACM. He can be contacted at jorge.goncalves@ee.oulu.fi.

**Vassilis Kostakos** is a professor of Computer Engineering and the director of the Community Imaging research group at the University of Oulu, Finland. His research interests include ubiquitous computing, human-computer interaction, and social systems. Kostakos received a Ph.D. in Computer Science from the University of Bath, U.K. He has more than 140 refereed publications, many in leading journals and conferences such as CHI, UbiComp, *ACM Transaction on Computer Human Interaction, IEEE Computer, Interacting with Computers*, and *Personal and Ubiquitous Computing*. He is a member of ACM. He can be contacted at vassilis@ee.oulu.fi.

**Bei Xiao** is a master student of the Department of Information Technologies at Åbo Akademi University, Finland. His recent work has appeared in ACM CHI conference.

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## Appendix

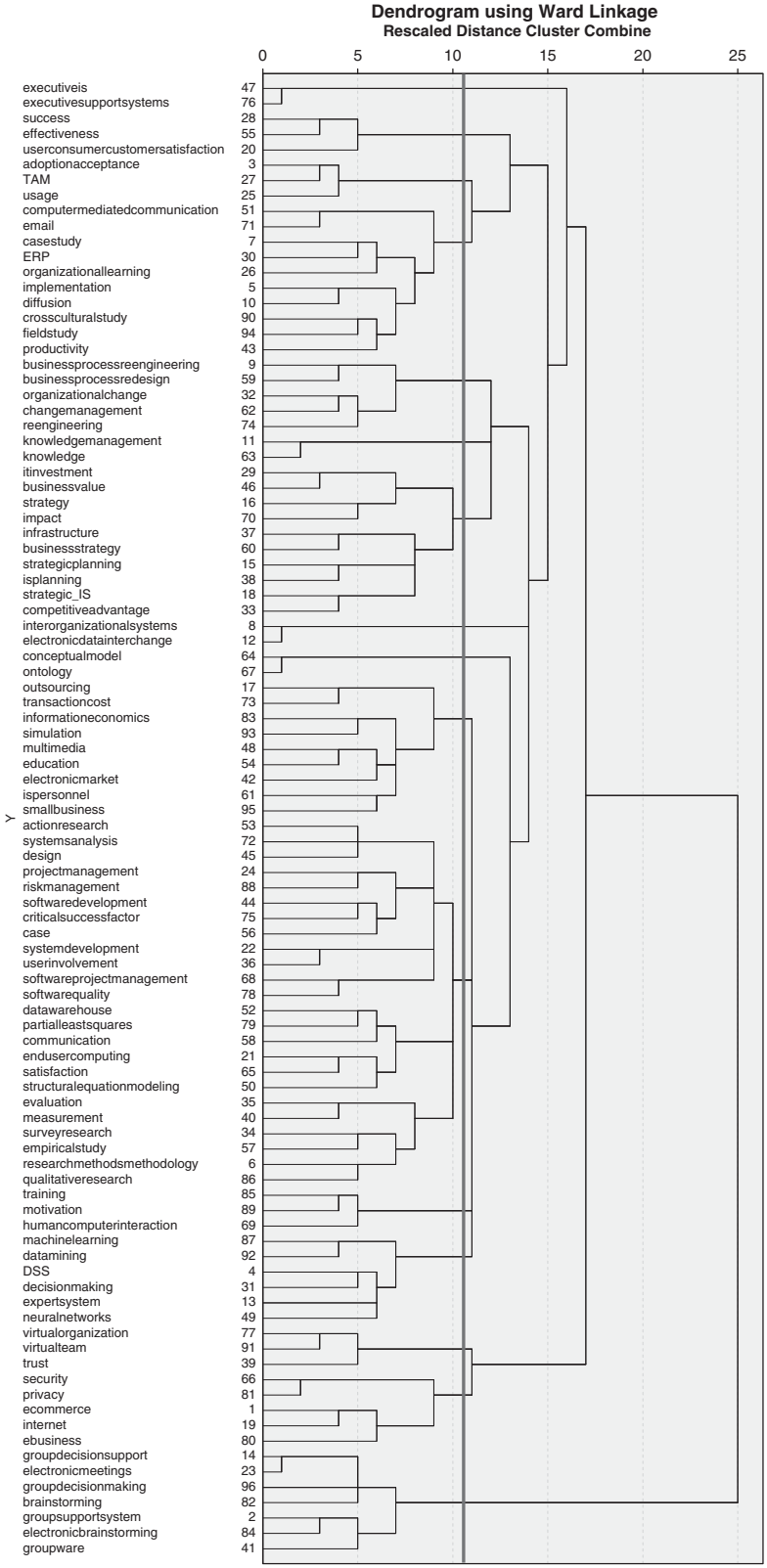


**Figure A1** Clustering analysis for the keywords, 1993–2012.

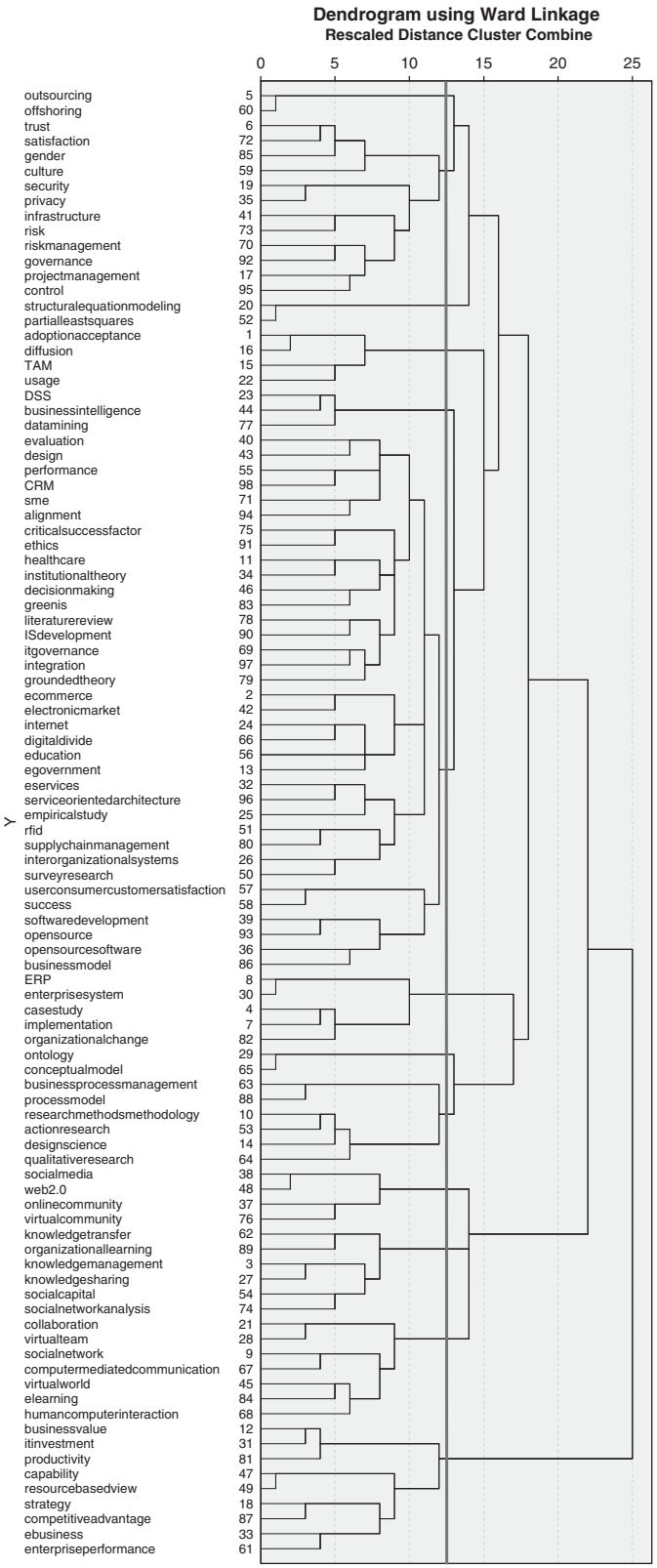


**Figure A2** Clustering analysis for the keywords, 2003–2013.