MAPPING THE FIELD OF VIRTUAL WORK: A CO-CITATION ANALYSIS

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ABSTRACT

Interest in the area of virtual work continues to increase with articles being written from different disciplinary perspectives – e.g. information systems (IS), management, psychology and transportation. In this paper, we map research on virtual work to (a) understand the intellectual base from which this field has emerged, (b) explore how this field has evolved over time, and (c) identify clusters of research themes that have emerged over time and the relationships between them. Specifically, we use co-citation analysis of research published in all social science disciplines to map the field at three points in time – 1995, 2000 and 2006. Our results show that the field has grown from nine research clusters in 1995 to sixteen in 2006. A comparison across these maps suggests that research in the cluster of “virtual teams” has gained significance even as research within some earlier clusters such as “urban planning and transportation” has lost ground. Our longitudinal analysis identifies relevant concepts, theories and methodologies that have emerged in the field of virtual work. This analysis can help interested researchers identify how they may want to contribute to the field of virtual work – by adding to popular clusters, enriching emerging smaller clusters or by acting as bridges across clusters.
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With advances in information technology, ‘virtual work’ in the form of global virtual teams, telecommuting and distributed work is now being embraced by most organizations (The Telework Advisory Group, 2007). Reasons for its growing popularity range from productivity gains that can be realized from such a work mode to an ability to harness talent that lies distributed across time and space (Gajendran & Harrison, 2007). Consequently, it is not surprising to note that academicians from disciplines as diverse as information systems (IS), management, psychology and transportation have become interested in researching this new work form.

How can we tap into the insights that these diverse literatures have to offer? Unfortunately, this is not a straightforward task. Given its multi-faceted nature, there are several meanings associated with the term ‘virtual work’. For instance, terms such as computer-mediated work, telecommuting, and distributed work, all have a bearing on our understanding of this new work mode. Given this proliferation of terms, it is difficult to identify the connections across the different contributions and to take full advantage of the accumulated knowledge.

To address these issues, we use IS tools to conduct a bibliometric study to map the field of virtual work. This approach allows us to uncover underlying connections between the contributions on virtual work from different disciplines. Scientific research is a social activity with researchers building upon the efforts and insights of many (Karuga, Lowry & Richardson, 2007; Oh, Choi & Kim, 2006). The mapping process that we apply in this paper to study the field of virtual work is premised on such an understanding. Specifically, we use co-citation analysis to (a) understand the intellectual base from which this field has emerged, (b) explore how this field
has evolved over time, and (c) identify clusters of research themes that have emerged over time and the relationships between them.

The approach that we have used and the outcome of our analysis is of value to those directly engaged in the area of virtual work. By understanding the genesis of the field and where it has reached as of today, such a map helps us find fruitful avenues for future research. At the same time, the method that we use here can be applied to study other important areas in IS, complementing other methods that have been used to track a field.

BACKGROUND

Virtual Work Reviews

With advances in information technologies, individuals are no longer constrained by time and space. It is therefore not surprising to note that virtual work has grown along with advances in technologies such as broadband communication (that allows for easy transmission of data) and groupware (that enables decision making and problem solving from distributed locations). Correspondingly, researchers from different disciplines have become interested in examining this new work mode and the body of literature in this area has grown significantly. This may be an opportune time for both academicians and practitioners to take stock of the developments in this growing field to determine future courses of action.

To conduct such a review, several methodologies such as meta-analysis, descriptive review and bibliometric approaches can be used. Insights from science and technology studies suggest that the methods that we use critically shape our understanding of a field and our subsequent research (Latour & Woolgar, 1979). Each method is “a way of seeing and a way of not seeing” (Poggie, 1965: 284) and, for this reason, we briefly review meta-analysis and
descriptive reviews as approaches that can be used to review a field before proceeding to offer greater details about co-citation analysis.

**Meta Analysis.** Meta-analysis is an approach designed to statistically summarize the relationships found significant between variables across multiple studies so as to arrive at an overall estimate of the coefficients involved (Gajendran & Harrison, 2007). To conduct a meta-analysis, researchers access both published and unpublished large sample studies (i.e. no case studies or theoretical articles are included). Typically a meta-analysis requires that the researchers choose the articles to be included based upon the specific relationships that they would like to explore.

Different studies may have used different participant samples, methodologies and measures, and a meta-analysis aggregates all these findings into one overall finding (Cooper, 2003). This is both its strength and its weakness. By bringing together various findings into one study, it provides researchers with a “bird’s eye view” of some of the more robust relationships between a set of predictors and outcomes that have been found in the literature. For instance, Gajendran and Harrison’s (2007) recent meta-analysis of 46 studies on virtual work identified perceived autonomy of individuals as an important variable that mediates the relationship between virtual work and beneficial outcomes such as job satisfaction, performance and turnover. At the same time, however, such a macro perspective is often gained at the expense of the micro processes constituting the phenomenon including the specific context of each study.

**Descriptive Literature Review.** In contrast to meta-analysis, with a descriptive literature review, researchers can more readily include case studies, field studies and theoretical articles. With such an approach, researchers access and read relevant articles to summarize findings, often guided by an overall framework. For instance, in a review of virtual work, Baruch (2001)
summarized the definition, antecedents (such as information technology, employee/employer willingness) and the outcomes (such as benefits and shortcomings) of virtual work. In a similar vein, Fjermestad and Hiltz (2000) reviewed 79 papers on Group Support Systems and categorized the methodology and results into four factors – contextual, intervening, adaptation and outcomes. Through this review, the authors offer the GSS researchers and managers an up-to-date descriptive evaluation of GSS research in organizations.

As may be apparent, conducting a descriptive literature review requires considerable attention on the part of those conducting the review. And herein lies this method’s strength and weakness. On the one hand, such reviews offer in-depth analyses of articles (the seminal ones, in particular) and provide a more nuanced understanding of the contextual issues involved as to how and why new work modalities such as virtual work may succeed. On the other hand, though, conducting a comprehensive and exhaustive review can be demanding. Such a review is constrained by the time and energy of the researchers involved who have to choose the articles that they can review, often based on their specific research interests. Consequently, there is a real possibility that several bodies of work can easily be excluded.

**Bibliometric analysis.** A bibliometric approach uses IS tools to conduct a comprehensive search of relevant articles that appear in multiple databases. Such an analysis is different from a typical research review in that researchers’ priors do not limit the review. This is because software tools can help categorize research into clusters by extracting information from bibliographic records (Schneider, 2006).

Citation analysis is a major bibliometric approach that can be used to identify underlying patterns of relationships between articles based on the references that these cite (Osareh, 1996). Advances in information technologies for indexing and searching scholarly work have made this
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method all the more possible. Indeed, with the availability of the database from the Institute for Science Information (ISI), citation analysis has developed as an important method for the study of developments in scientific communities (Garfield & Welljams, 1992; Gmür, 2003).

This approach is premised on citations being key indicators of past and present scientific activities (Braam, Moed & van Raan, 1991; Garfield, Malin & Small, 1983; Small & Griffith, 1974) and the method allows for the inclusion of research articles from different disciplines. For example, Karuga, Lowry and Richardson (2007) have used citation analysis to define the maturity of the IS discipline by examining the impact of 879 articles on IS and non-IS research (such as, management, engineering and organizational behavior). Manually reviewing this vast literature is a daunting task and is possible only because of the availability of software tools.

Co-citation analysis is a specific type of citation analysis used to identify clusters of references “co-cited”\(^1\) by subsequent articles (Small, 1973). This approach is particularly well suited to gaining an understanding of a research trajectory by studying relationships that exist across prior work because it is based on the inputs of those who are the most knowledgeable in a research field, i.e. those contributing articles to the field. Specifically, by co-citing references in their bibliography, contributing authors establish connections between two or more references that have been published in the past. The assumption is that two co-cited references are related, either because they are part of the same research cluster or because their foci are similar (Garfield et al., 1983; Peters, Braam & van Raan, 1995).

The presence of a sufficiently large number of citing articles in a field makes it possible to identify systematic co-citation patterns while ignoring random connections. These systematic patterns can be visualized in a co-citation network diagram (what we call as a ‘map’ in this

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\(^1\) In other words, when two or more references (such as Nilles, 1988 and Mokhtarian, 1991) co-occur in the reference lists of articles, a link is established between these co-cited references.
paper) where the more frequently co-cited references can be placed in close proximity in Euclidian space (Small & Griffith, 1974). Clustering by co-citation is a self-generating, dynamic classification system because relationships between the different contributions (indicated by the contributors) are continually being updated by ongoing scholarly work.

A co-citation analysis of virtual work offers several advantages. It makes it possible for us to understand the structure of the intellectual base underpinning virtual work; one that is constituted through the contributions of scholars from different disciplines. Specifically, it enables the identification of connections across a large number of articles based on their references. Researchers can use co-citation analysis as a complement to other review methods. For example, researchers can choose to conduct a more in-depth review of cited references that the co-citation analysis demonstrates as being central in the network. They can also use co-citation analysis to see how seminal citations included in a traditional descriptive literature review connect with others.

**METHODODOLOGY**

**Data source**

We used the Social Sciences Citation Index (SSCI) of the ISI Web of Science to identify our sample of articles for this analysis. The SSCI is a multidisciplinary index covering multiple journals across social science discipline. It indexes individually selected, relevant articles from over 3,300 of the world's leading scientific and technical journals. Each week, on average 2,900 new records and 60,000 new cited references are added.

To reduce the possibility of drawing too narrow a search boundary (Chen, 2006), we contacted 7 researchers in the IS and management disciplines and identified the terms that they would most readily associate with virtual work. Our queries resulted in the following words:
‘telework’, ‘telecommute’, ‘virtual work/team’, ‘distance work/team’, ‘distributed work/team’, ‘computer mediated work/team’. To ensure that our search was comprehensive, we truncated search terms and used wildcards to include words that were different from the word-stem. We considered all articles from the SSCI containing at least one of the search terms in their titles, abstracts or keywords.

SSCI contains some data that have been entered manually or have been scanned from hardcopies of articles. Consequently, there is a small possibility that errors may have crept in. Also, differences in the use of initials or mistakes in the spellings of authors can result in different names appearing for the same author. To rationalize such inconsistencies, we checked all the references in the sample for potential spelling errors. In some obvious cases (e.g., same journal, year, volume, page but different spelling of author name), the record was corrected to its most frequently used form. In the less obvious cases, we used Google scholar to verify whether references with similar names represented different publications.

Some articles included multiple citations to a reference (e.g., references to different pages of the same publication). These references were investigated to verify whether the record indeed cited two different references published in the same issue of a journal. If the records were merely referring to different pages of the same article, duplicate references were removed to avoid a distorted citation count and co-citation pattern.

Analyses

Our search yielded 490 articles on virtual work in the ISI Web of Science that had been published between the period 1976 and 2006 and we included the complete set of 490 articles. These 490 articles cited 12,759 references. The inclusion of such a large number of references in the analyses would have resulted in a very fine-grained map. For this reason, it is desirable to

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2 Google scholar was used for convenience. It has information about books in addition to articles that SSCI contains.
exclude references with low citation counts from a co-citation analysis (Mane & Börner, 2004). Such exclusion does not significantly impact the structure of the resulting map.

We used the freely available Sitkis (Schildt, 2005) software package to construct a co-citation network. From the 12,759 references cited by the articles on “virtual work” in our sample, we initially selected those that had been cited by at least 15 articles in our sample (Chen, 2006). We then incrementally lowered this citation-threshold until the map was at a level of granularity that was sufficient for us to visualize the evolution of major clusters in the field. Eventually, we arrived at a list of 140 references that had been cited by at least 10 articles i.e., 2% of the 490 articles in our sample. These 140 references served as the basis for drawing the connections across the 490 articles.

In the next step, to identify research clusters from the overall co-citation network we clustered the frequently co-cited references (Small & Griffith, 1974). Clustering is a process of rearranging references through the use of an iterative algorithm such that related references appear close to one another. Traditional clustering approaches such as hierarchical clustering, agglomerative clustering, and iterative partitioning (McCain, 1990) appear to be suboptimal for bibliometric research because these algorithms assign every cited reference to a cluster even if they are not relevant to any specific cluster (Schildt & Mattsson, 2006).

To overcome this problem we utilized the dense sub-network grouping algorithm suggested by Schildt and Mattsson (2006). This algorithm forms a cluster of co-cited references; the formation of a cluster is initiated by first selecting two references from the sample that are most similar to one another. This similarity is determined by the Jaccard index (Small &

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3 A similar approach has been used by Leydesdorff (2004) who progressively lowered thresholds to find “articulation points” between different network components that can be considered as sub-disciplines.

4 The Jaccard index is defined as the size of the intersection divided by the size of the union of two sample sets:

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|}$$
Greenlee, 1980). The Jaccard index is the ratio between (a) the intersection of two sets, and (b) their union. The Jaccard value between two references can be calculated by dividing the number of articles that co-cite these references by all the articles citing any of the two references. The figure can range from 0 (representing a situation where these two references were not co-cited even once by these articles) to 1 (representing a situation where these references were co-cited by all these articles).

A cluster of references emerges as the algorithm, after seeding the process, iteratively adds additional references from the remaining pool that have the highest average similarity score with the references already in the cluster. This process continues until the average similarity of the remaining references is below a pre-selected cutoff Jaccard value when a new cluster is formed. A low cutoff Jaccard value results in few but relatively large sized clusters with some overlaps between references. Conversely, a high cutoff value generates more distinct but smaller sized clusters and some references may not belong to any cluster at all. Selecting an appropriate cutoff value requires the judgment of researchers in evaluating the trade-off between assigning maximum possible references to a cluster while generating several distinct clusters (Schildt, Zahra & Sillanpää, 2006).

Using an iterative process, we experimented with different cutoff values for generating the clusters. We used Jaccard index values of 0.05, 0.10, 0.15, 0.20, 0.25 and 0.30 for this exploration. Each time, after changing the index values, we evaluated the effect on the number and size of clusters that emerged. After testing different alternatives, we selected a cutoff value of 0.10. This parameter setting resulted in a sufficient number of distinct clusters for visualizing the evolution of research clusters on virtual work.

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5 The relationships between the different clusters are structurally similar across the different parameter settings. The results are therefore robust for different settings of this parameter.
RESULTS

We present two kinds of maps based on the approach that we described. First, to provide the reader with a macro-level understanding of the field, we present overview maps of the field depicting the various research clusters and their connections at three different points in time. Second, to provide the reader with micro-level details, we zoom into the major clusters comprising the most recent map of the field (as of 2006) and show the most influential scholarly works and how these are related. Both types of maps are important as it is difficult to understand the complete picture without understanding its nuances and vice versa. The possibility of going back and forth between macro-level understanding and micro-level detail helps generate a holistic understanding of the field.

**Longitudinal Co-citation Networks**

To trace the evolution of research on virtual work, we generated three snapshots of the field – as they appeared in 1995, 2000 and 2006 (Figures 1 a, b and c).

A visual comparison of the networks across panels a, b and c suggests that the field has emerged from a disparate set of nine clusters as of 1995 (Fig 1a) to one exhibiting small world characteristics among sixteen clusters as of 2006 (Fig 1c). By small world, we mean that the connections between two or more densely connected networks is established by relatively short paths (Watts & Strogatz, 1998). In 2006, for instance, there appear to be two such networks (in dotted lines, representing two major research domains) connected by a cluster related to references on “work-family/review” and a cluster related to “practitioner focus”.

A further examination of these maps shows that there were two major domains of research as of 1995 (Figure 1a) – a larger, denser one focusing on “urban planning and
transportation” and “early theory” (research domain A) and a smaller one focusing on “virtual teams” and “computer mediated communication” (research domain B). Research in domain A offered descriptions of the virtual work phenomenon, initial empirical evidence for its emergence and early theoretical models to explain the changes in work modes that were occurring. This research served as a platform to spawn subsequent empirical explorations and conceptual developments (as the map of the field in 2000 shows). Research in domain B was very small and distinct. There were no crossovers between research topics in the two domains.

The map of the field as of 2000 shows that research domain B, drawing upon a theory base that advanced understanding of virtual team processes, grew by encompassing research on virtual organizations and global virtual teams (Figure 1b). Two clusters, in particular, bridged research domain A with research domain B. One had a “practitioner focus” and another examined “organizational structures” such as network organizations. Although connecting the two research domains, the “work-family” cluster was in the periphery.

The 2006 map (Figure 1c) shows re-emergence of the partition between the two research domains that had almost come together in 2000. Domain B has evolved to become larger and denser in comparison to domain A. The “work-family” cluster has moved from its status of a connector across the two research domains and has established stronger ties with research domain A. Within research domain B, the “virtual teams” cluster has grown denser and has become more prominent. The “practitioner focus” cluster remains as a major bridge across the two research domains. The “literature review” cluster is another bridge connecting the two research domains through its link with the research in practitioner-oriented cluster.

Network Composition
We can examine the structure of knowledge generation within and across research clusters by probing deeper into the network composition. For simplicity, we focus only on the 2006 map and then allude to the networks in the other two maps as required. Rather than provide a cluster-by-cluster description of all the 16 clusters comprising the 2006 map (Figure 1c), we focus our description on the larger clusters that account for 73% of all citations. The clusters marked “early theory” and “urban planning and transportation” are the two largest clusters within research domain A. “Virtual teams” and “computer mediated communication” are the two largest clusters within research domain B. To understand the composition of these 4 clusters please see Figures 2 a-d.

---- Figures 2 a-d here ----

In these graphs, the size of the circles is proportional to the number of citations each reference has received. The thickness of the lines represents the extent to which these references were co-cited by the 490 articles as measured by the Jaccard index that we explained earlier. In our description we provide a general sense of the cluster’s characteristics, common theories and research methodologies used by the group of researchers.

The “urban planning and transportation” cluster (Figure 2a) represents research examining the impact of virtual work on job-housing balance and travel patterns in urban and suburban areas. Research in this cluster predicts the spread of telecommuting by examining (a) individuals’ decision to telecommute based on their perception of constraints and their motivations (Mokhtarian, 1998; Mokhtarian & Salomon, 1994), (b) occupations conducive to telecommuting (Handy & Mokhtarian, 1995), and (c) the impact of telecommuting on travel distances and travel times (Pendyala, Goulia & Kitamura, 1991).

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6 The entire network resulting from this analysis is available on request from the authors.
Most of the research in this cluster originated in the state of California, known for its heavy traffic patterns, rising cost of urban living and disruption of transportation due to possible earthquakes (e.g., Mokhtarian, 1991a). The region is also known for most of the innovations in communications technology. The research examines the impact of virtual work on decreasing automobile congestion, traffic diversions, energy consumption and air pollution. Some of the research is directed towards developing public policy changes for mass transit and urban planning (e.g., Mahmassani, Yen, Herman & Sullivan, 1993). Interestingly, research in this cluster offers definitions and nuanced understandings of virtual work that can be found even today. For example, Nilles (1991) defined telework and telecommuting as:

“Telework is the substitution of telecommunication technology for work related travel. Telecommuting, a subset of teleworking, is the partial or total substitution of telecommunication and or computer technology for daily commute to work”.

Further, research from this cluster distinguished between home based work and telecenter based work (Mokhtarian, 1991b; Stanek & Mokhtarian, 1998). Telecommuting, according to this research, is not an all-or-nothing approach. Consequently, telecommuting should be viewed along a continuum, thus broadening the potential base of telecommuters (Mokhtarian, 1991b). A notable difference between this cluster and the other clusters was the consistent use of the terms ‘telework’ and ‘telecommute’ rather than ‘virtual work’.

Distinct from a public policy perspective, the “early theory” cluster (Figure 2b) adopts an employee-centric approach to focus primarily on home-based work. It draws upon theories from sociology, psychology and organizational behavior such as Hackman and Oldham’s (1976) task characteristic model and Maslow’s need hierarchy to explain the effects of reduced socialization and increased identity conflicts (Salomon & Salomon, 1984; Shamir & Salomon, 1985). The outcomes explored include work family balance, organizational identification, employee
productivity, stress and job satisfaction. The determinants examined include an individual’s ability to manage social isolation, self-determination, the availability of information technology and family structure (Kraut, 1989; Venkatesh & Vitalari, 1992).

This “early theory” cluster represents some of the initial empirical research utilizing the theoretical bases described earlier. The prevalent research methodology in this cluster consists of interviews, case studies and small sample surveys (DeSanctis, 1984; Olson & Primps, 1984) because of the difficulties in identifying large samples of home workers (Kraut, 1989). The viability of virtual work is an undercurrent that runs through a number of articles in this cluster (e.g., Kraut, 1989; Shamir & Salomon, 1985). Overall, this cluster can be credited for identifying many constructs central to virtual work that have been examined in greater depth by researchers belonging to the other clusters.

The “computer-mediated communication” (CMC) (Figure 2c) cluster builds upon Social Presence theory, Social Information Processing theory and Media Richness theory (e.g., Daft & Lengel, 1986) to offer a socio-technical lens in understanding the impact of communication technology (Sproull & Kiesler, 1986). A critical evaluation of the theories and research on CMC by Walther (1992) provides insights into the core ideas of this cluster. A common understanding was that CMC, because it lacks non-verbal cues, would result in an exchange of messages that would be impersonal and task-oriented. Walther (1992), however, suggested that this might be true for only certain situations. In many cases, CMC may facilitate those involved in developing deeper relationships, especially if communications are allowed to unfold within an expanded time frame. Specifically, given enough time, computer supported groups will exchange enough information to form social and emotional bonds (Chidambaran, 1996). Likewise, electronic mail can prove to be an effective communication medium if an organization encourages and supports
its use (Markus, 1994). Most empirical studies in this cluster compare computer-mediated groups with face-to-face groups in laboratory settings and evaluate participants on the use of technology in accomplishing specific tasks.

The “virtual teams” cluster (Figure 2d) focuses on geographically distributed teams and, in many cases, globally dispersed teams that transcend time, space and culture (e.g., Jarvenpaa & Leidner, 1999; Lipnack & Stamps, 1997). The cluster identifies the benefits as well as the challenges related to trust, cohesion and technology that virtual teams may confront (Townsend, DeMarie & Hendrickson, 1998). Adaptive Structuration (DeSanctis & Poole, 1994) is a dominant theory within this cluster. This theory describes the interplay between advanced technologies, social structures and human interactions that forms the basis for an understanding of processes associated with virtual teams (DeSanctis & Poole, 1994; Maznevski & Chudoba, 2000).

Within the “virtual teams” cluster, there is a sub-cluster focused on global virtual teams (Cramton, 2001; Jarvenpaa, Knoll & Leidner, 1998; Jarvenpaa & Leidner, 1999; Maznevski & Chudoba, 2000) that is becoming important given the rise of multinational firms. Global virtual teams consist of people who are distributed across international boundaries and who deal with issues that are global in nature (Maznevski & Chudoba, 2000). In addition to the challenges that virtual teams confront, global teams have to deal with challenges related to working across international time zones, cultures and geography. Research in this cluster frequently uses grounded theorizing from in-depth case studies (Glaser & Strauss, 1967) because researchers have limited access to global virtual teams while requiring rich data to understand this relatively new work form. Some of the issues examined include: (a) the temporal pattern of interaction incidents (face to face versus on-line) as it relates to decision-making processes and relationship
building (Maznevski & Chudoba, 2000), (b) the development of trust (Jarvenpaa et al., 1998; Jarvenpaa & Leidner, 1999) and, (c) the failures in developing mutual knowledge and consequently collaboration (Cramton, 2001).

Other research in this cluster focuses on answering questions central to virtual teams. These include questions such as – do face-to-face teams have higher performance, information exchange and relational links than virtual teams (e.g., DeSanctis & Poole, 1994; Jarvenpaa et al., 1998; Walther, 1995)? The cluster, as a whole, makes significant contributions to our understanding of the critical issues that drive virtual team processes. Much of this work represents the theoretical and empirical foundations for current virtual team research.

In addition to these four major clusters, 12 additional smaller clusters define the virtual work domain. For the sake of brevity we do not describe these clusters in detail here and, instead, provide a brief description of all the 16 clusters in Table 1 along with examples of references cited by researchers.

--- Table 1 here ---

These clusters show some overlaps in research topics, concepts and problem-sets. However, a closer look at each individual cluster reveals that the different research clusters build upon different literature bases. For instance, they examine relatively distinct aspects of virtual teams, such as, technological facilitators, organizational outcomes or cross-cultural issues (Figure 1c).

**DISCUSSION**

Through our analysis, we have tracked the progress made in the field of virtual work over time and have offered our readers with maps of the field on three different occasions. Tracking the development of a dynamic field can be useful to see how early ideas shape emerging discourses around the field and to draw implications for future research. Such an analysis has
become all the more feasible because of developments in information systems. For example, the ISI Web of Science makes it possible to explore scholarly work produced over decades and to identify relevant articles with little effort. Clearly defined data structures and cross linkages between references that they cite make it possible for us to identify underlying connections between articles that could otherwise have remained obscured if we had been dealing with paper copies. From this perspective, the approach we have taken can be easily used to map and track other fields of interest to IS researchers.

Our analysis helps us understand developments in virtual work at several levels. At one level, the map shows a network of research topics and ideas in the field. Specifically, the map identifies key research themes as well as the themes that are most influential in connecting clusters. At another level, the maps provide a processual account of the emergence of new topics in scientific fields. For example, in the case of virtual work, the map of the field as of 2006 (Figure 1c) shows that the “virtual teams” cluster is not only highly cited but that it is also densely connected with other clusters, a situation that results in the development of a platform to which researchers may like to preferentially attach themselves (Newman, 2001). In comparison the “urban planning” cluster seems to be growing slower than the “virtual teams” cluster and it is not as densely connected with other clusters (Figures 1c). Barring exogenous changes that may once again bring urban planning to the fore, this cluster appears to be losing in relative importance. The broader principle of preferential attachment (Bianconi & Barabasi, 2001; Newman, 2001) is that the growth of a cluster will be determined by a combination of two factors – the presence of a critical mass as well as the existence of critical connections with other clusters.
We also note that the clusters that connect others in the map as of 2006 are not the ones from which the field emerged as captured by the map in 1995. The co-citation analysis demonstrates that few will attribute the origins of the field of virtual work to early contributions from literatures such as urban planning and information technologies. These maps show that the emergence of the field has been far from a linear process. The early map of the field (Figure 1a) makes these origins transparent and shows that early theoretical developments and definitional attempts are related to transportation rather than to the now dominant topic of distributed/virtual teams. An understanding of the historical development of the field offers insight into the current continuing use of concepts and terminology such as ‘tele-commuting’, the etymology of which would have remained obscured if we were to focus only on more recent research. It also tells us why certain concepts may have been forgotten.

**IMPLICATIONS FOR RESEARCH ON VIRTUAL WORK**

One of the most important contributions of an analysis of this kind is the comprehensiveness with which a search is conducted. In this regard, the method we have used allows us to analyze a broad range of literature bases: e.g. transportation, management, IS and organization behavior. Consequently, we can identify multiple themes that are related to different facets of virtual work. Examples of these themes that cut across different facets of this work phenomenon include, (a) conflict, isolation, communication ambiguities and trust - drawing attention towards the dynamics of behavior and attitudes, (b) family, team members and co-workers - drawing attention towards interpersonal relationships and, (c) performance and identity - drawing attention towards outcomes. The very fact that these themes span different bodies of literature signals to researchers the broader impact of this work mode. In this way, our analysis
generates options for researchers rather than prescriptions for specific relationships that they ought to explore.

Our longitudinal analysis suggests that some of the constructs that early theorists had identified have set the seeds for future research. For instance, in the early years, researchers were curious to learn how distance would impact the organizational identity of individuals who no longer came in contact with their peers or organizational symbols on a regular basis (Shamir & Salomon, 1985). In later years, this question was fleshed out both through empirical research as well as theoretical modeling (Fiol & O'Connor, 2005; Thatcher & Zhu, 2006; Wiesenfeld, Raghuram & Garud, 1999). Interest in identities continues as users adapt communication technologies to contemporary work patterns. Examples include, research on self-presentation and on-line identities in virtual communities (Golden, 2006; Shumate & Pike, 2006). The underlying assumption of this research cluster is that some individuals shape their on-line identities to create desirable relationships with their virtual communities (such as customers or virtual team members). Likewise, examples can be found in the research examining the impact of media richness on collaboration in virtual teams (Banker, Bardhan & Asdemir, 2006; Majchrzak, Malhotra & John, 2005). A historical review of this kind highlights the resilience of issues such as organizational identity and conflict/collaboration. Thus, researchers interested in examining these issues in the virtual work context can utilize historical developments across clusters to deepen their research and expand the theoretical lenses available to them. Further, a historical perspective allows them to better identify the significance of their own contributions in a far more nuanced fashion.

Another area that research on virtual work may benefit from is in defining virtual work. These maps show that researchers have grappled not only with the question of what is ‘virtual’ –
is it geographic distance, technology used for work, frequency of face-to-face contact, (Fiol & O’Connor, 2005) – but also with how such ‘virtualness’ may be labeled. Accordingly, terms such as telework, telecommute, distance work, all referring to some of the same underlying dynamics of dispersion also reflect the fact that they have distinct origins. For instance, geographically distributed teams are referred to as ‘virtual teams’ (Cluster 3, Figure 2c) rather than as ‘tele-teams’ or ‘telework teams’ that would be consistent with terminologies used in Clusters 1 or 2 (Figure 2a and 2b). Given that language and labels constitute how we theorize (Whorf, 1956), it is useful for researchers and reviewers alike to be aware of the roots of this new work mode, a facet that can be easily forgotten.

By examining the clusters in Figure 1, we not only discover unique interests that researchers may like to pursue, but also the possibilities for bridging research clusters in the future. For instance, there may be an opportunity to bridge the more recent research on virtual teams with ideas developed in earlier work on urban planning and transportation. The transportation research has focused on the ways in which objectives such as reducing commute times and increasing cost efficiency may be achieved. Virtual teams and CMC have focused on objectives related to balancing technological and relational facets of communication. Research targeted at accomplishing objectives that are relevant to both clusters (i.e. achieving efficiency of work, while enhancing effectiveness through relational and technological facets of communications) is one such possibility. In this regard, both the “practitioner focus” and the “literature review” clusters may have some interesting perspectives to offer as they act as bridges. The “practitioner focus” cluster provides research on (a) the benefits that businesses can derive from virtual work, (b) the conditions under which such work will be appropriate (Cascio, 2000), (c) the role of managerial trust (Handy, 1995), and (d) design and task delegation to
virtual teams (Bell & Kozlowski, 2002). The “literature review” cluster, on the other hand, draws upon “initial empirical research” as well as “European research” to identify relevant issues. This cluster proposes a link with existing organizational theories to better understand the impact of telework (Bailey & Kurland, 2002; Kurland & Egan, 1999).

However, it is possible that authors who are “trans-disciplinary” (Stokols, Harvey, Gress, Fuqua & Phillips, 2005) may find that their contributions are not readily embraced by others who squarely belong to any one discipline. It is here that an appreciation of the network structure and the specific issues constituting each cluster become useful. Specifically, the map of the field in 2006 suggests how researchers might position their research to address productive tensions and complementarities between clusters. In this sense, the map of virtual work from our analysis serves as a boundary object for researchers from the different clusters so that they might connect their research with ideas from other research clusters. A boundary object is a ‘flexible epistemic artifact that inhabits several intersecting social worlds and satisfies the information requirement of each of them’ (Star & Griesemer, 1989). The map of the field in 2006 and our understanding of the various clusters offer a perspective as to where the gaps exist in literature. It also suggests which clusters can be more productively integrated to yield new insights in the field of virtual work. Additionally, these maps can be invaluable to journal editors and reviewers in identifying referees and possible literature that can help authors.

**IMPLICATIONS FOR RESEARCH METHODOLOGY**

Co-citation analysis as a method leverages the availability of IS tools and data bases to explore the emerging structures of a scientific field. It helps to capture conceptual and methodological changes that have taken place over time by adopting a historical approach (Cooper, 2003). Compared to alternative approaches such as descriptive literature reviews or
meta-analysis, this method has its own advantages but, at the same time, certain limitations as well. The primary limitation stems from the very vantage point of such an approach – it offers an overview perspective of the literature. By itself, it cannot offer readers an in-depth understanding of the field that traditional reviews can generate. Thus, co-citation analysis is not an alternative to a careful reading of the articles of potential interest. Instead, the goal of co-citation analysis is to generate an understanding of the underlying structure of a field and its dynamics (Braam et al., 1991) that can then motivate a more nuanced reading of articles considered to be important. Such facility becomes all the more useful in a field such as virtual work that is increasing rapidly over time.

Indeed, co-citation analysis lets us interact with the results. As we mentioned earlier, the map is a boundary object that makes it possible for different researchers to draw relevant inferences for themselves. The degrees of freedom that this mapping process affords, renders this technique all the more powerful. Specifically, it is in a researcher’s control to generate a representation of the field at the level of granularity that is most informative. At the macro level, for instance, it is possible to plot the data longitudinally or represent the state of a scientific domain as it has evolved up to a specific point in time. At the micro-level, it is possible to zoom into any cluster to explore the dynamics and to identify individual actors and groups that form invisible colleges (Crane, 1969) as well as the specific topics they are pursuing. The availability of common IS data sources such as the Web of Sciences or CiteSeer makes it possible to zoom out of a map and to look at the connections a particular field of interest has with other disciplines. This possibility may be particularly useful for IS researchers as one of the strengths of this discipline is its ability to cross boundaries and to connect and contribute to research from
other disciplines such as psychology, management and operations research (e.g., Briggs, Nunamaker & Sprague, 2006; Karuga et al., 2007).

CONCLUSION

The advent of information technologies has resulted in a world that is rapidly changing and one that is being driven by the convergence of boundaries. These dynamics are manifest in the emergence of organizational forms and work modes such as virtual work that we have explored in this paper. Given the fluidity of boundaries and dynamics of change, researchers need a way to tap into emerging insights offered by existing literature as well as to also tap into what may have been forgotten over time. Mapping of a field using co-citation analysis is one such way. Not only is it an easy-to-use tool for tracking developments in a field, but it also provides researchers with a way to understand its underlying structure so that they can more mindfully locate themselves and their contributions.

When we applied this mapping process, we found that the field of virtual work is robust and dynamic, as new strands of research on this phenomenon are being realized in different ways and with different terminologies. We found that topics such as virtual teams are gaining in strength at the expense of some of the earlier framings around the need to transcend physical distance. But, insights from the sociology of science (Mane & Börner, 2004) suggest that researchers often re-visit earlier insights as a field matures to develop more robust and holistic understandings. We believe that this may be true of virtual work as researchers become once again become interested in concepts related to physical distance given current concerns about the environment. And, the mapping process that we have explored will certainly be useful.
REFERENCES


Leydesdorff, L. 2004. Top-down decomposition of the Journal Citation Report of the Social Science Citation Index: Graph- and factor-analytical approaches. Scientometrics, 60(2): 159-180.


FIGURE 1

a. Co-citation network across research clusters until 1995

b. Co-citation network across research clusters until 2000

c. Co-citation network across research clusters until 2006

Legend:

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</table>
Mapping the field of virtual work 32

FIGURE 2

a. Co-citation network of the research cluster on urban planning and transportation

b. Co-citation network of the research cluster on early theory

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c. Co-citation network of the research cluster on computer mediated communication

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d. Co-citation network of the research cluster on virtual teams

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TABLE 1: 16 most cited clusters of virtual work research*

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* This is a partial list representing references with high number of citations.
**Names of only first authors are provided due to space constraints.
Appendix A

Complete list of references included in each cluster
(arranged in order of number of citations received within the cluster)

Cluster 1: Urban Planning and transportation


**Cluster 2: Early theory**


**Cluster 3: Computer mediated communications**


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Cluster 4: Virtual teams


**Cluster 5: European research/ definitional**


**Cluster 6: Work-family**


**Cluster 7: Literature review**


**Cluster 8: IT and theoretical modeling on teams**


**Cluster 9: Theory base for remote work**


**Cluster 10: Practitioner focus**


**Cluster 11: Distributed teams and information technology**


**Cluster 12: Definitional**


**Cluster 13: Initial empirical evidence**


**Cluster 14: Virtual organization**


**Cluster 15: Cross cultural teams**


**Cluster 16: Organizational structures**
