Dig Deeper or Diversify? The Rewards and Penalties of Knowledge Exploration and Exploitation Capabilities in the Context of IS Scholar Publication Productivity

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Abstract

We develop a model of knowledge creation in rapidly changing academic disciplines and posit that it is important for scholars in such environments to explore a variety of knowledge domains as opposed to focusing on narrow domains to ensure publication productivity. We hypothesize that in the IS domain, an example of a rapidly changing knowledge environment, explorative knowledge capability will positively impact knowledge creation. On the other hand, exploitative knowledge capability will penalize the researcher by negatively impacting knowledge creation. Using bibliometric information of IS scholars who published in top 10 IS journals from 2000- 2011, we perform a co-citation analysis and identify the key IS knowledge domains. Using indices borrowed from ecology and economics, we operationalize explorative and exploitative knowledge capabilities based on a researcher's breadth and depth of previous publications in those knowledge domains. Results from a regression analysis of 91 IS scholars provide strong evidence for our hypotheses.

Keywords: Knowledge creation, Publication productivity, Knowledge exploration, Knowledge exploitation, Co-citation analysis, IS discipline

Introduction

Knowledge creation has fascinated scholars from different disciplines for many years (Nerkar 2003). There are fundamental differences in knowledge creation between academia and industry (Sauermann and Stephan 2013; Shrivastava and Mitroff 1984). Universities and research institutes constitute social academic communities that play a vital role in creating and transmitting scientific knowledge, which is the fundamental source and driver for societal progress and development. Thus, enhancing the scientific knowledge creation process in academia will have a significant impact on the society (Tsui et al. 2009). In academia, the major work associated with developing and publishing a research paper is conducted by an individual – a professor or a research scholar, who needs to read, think, and write (Latour and Woolgar 2013). In academia, every scholar strives to improve academic publication performance by developing

domain expertise and new domain exploration. As posited by the organizational learning literature, both, familiar domain exploitation and new domain exploration serve as the two important processes of learning and knowledge creation (Gupta et al. 2006). It is generally believed in the organizational learning and knowledge-based literature in the management and IS disciplines that both exploration and exploitation strategies improve knowledge creation by refining existing knowledge or by creating knowledge in new domains (e.g., Benner and Tushman 2003; Gupta et al. 2006; Im et al. 2008; March 1991). However, in rapidly changing knowledge domains, the pressure to keep up with new technology knowledge pushes each researcher to respond quickly and absorb new knowledge and use it for new knowledge creation before that particular knowledge becomes obsolete. Given that academic research generally involves individuals or small teams rather than large groups of researchers, the burden of new knowledge assimilation on the part of individuals and small teams is consequently also high from the perspective of successful knowledge creation and subsequent academic paper publication. Further, as new domains of knowledge develop and older domains gradually become obsolete, publication prospects in the older knowledge domains diminish due to intense competition among researchers for limited journal page space, at least in the premier journals of an academic discipline. Therefore, it is possible that knowledge exploitation and exploration capabilities at the individual level in the academia in rapidly changing knowledge domains will show different effects on knowledge creation and subsequent publication. However, to our knowledge, there is no study that examines individual scholar publication productivity in a rapidly changing academic discipline from the perspective of knowledge exploration and exploitation. This question is not only immensely important for individual scholars in academia whose salary, promotions, tenure, and scholarly prestige depend upon research productivity and publication record (e.g., Gomez-Mejia and Balkin 1992; Starbuck 2005) as well as academic institutions who draw prestige from their institutional rankings partly based on research productivity (Trieschmann et al. 2000), but also from the perspective of knowledge creation in rapidly changing knowledge environments in general.

This study addresses the above gap in our understanding about individual-level knowledge creation in rapidly changing knowledge environments in academia. We posit that the information systems (IS) discipline constitutes one of the most rapidly changing knowledge environments in the business school in the academia, and ask: What are the effects of knowledge exploration and exploitation capabilities of individual IS scholars on their publication productivity in premier IS journals? We use a theoretical framework that is based on knowledge creation theory and knowledge exploration/exploitation literature to examine how knowledge exploitation and exploration capabilities of an individual IS scholar predict his/her knowledge creation performance in terms of quality-adjusted publication productivity. Further, we use objective publication and bibliometric data in the IS field to assess IS scholars' knowledge exploration and exploitation capabilities as well their research productivity. Using co-citation analysis, we first identify the key knowledge domains in which IS scholars published research papers since the year 2000 in 10 premier IS journals (discussed later). We chose 2000 as the starting point for our analysis as the IS discipline started rapidly changing very fast around this time due to the emergence of Internet and e-commerce around this time. We then operationalize exploitation capability of an author as his/her maximum of Herfindahl-Hirschman index (HHI) in various knowledge domains in which an author published papers. We calculated the author's exploration capability as the reverse of Simpson Index to measure the author's true diversity of publications in various knowledge domains. A key premise of the present study is that previous co-citations of an article imply a knowledge domain with which the authors are familiar (Chen et al. 2010). These previous knowledge exploitation and exploration capabilities of authors measured using their previous publication performance in terms of publishing extensively in one domain (authors who have exploited a particular domain) or publishing extensively in multiple diverse domains (authors who have explored several domains), respectively, should be logically associated with their current knowledge creation performance in terms of article publications. However, we argue that deep, as opposed to diverse, knowledge stocks of a researcher represents a learning trap preventing scholars from finding novel topics to study and publish in rapidly-changing knowledge domains. In contrast, we argue that exploration capability will enable a scholar to quickly respond to rapidly changing domains. The proposed hypotheses are tested using a sample of 91 authors who published articles in 2011 in 10 premier IS journals, and with data about this sample on co-citations pertaining to the period 2005-2008 and other variables in 2011.

By investigating the above penalty issue, this study attempts to contribute to the literature in two ways. First, to our knowledge, this is the first study that addresses the exploitation and exploration capabilities'

effect on knowledge creation in rapidly changing knowledge environment. We do so by linking knowledge creation theory to co-citations analysis because co-citations can generate scientific factors as knowledge domains from objective observation of bibliometric information of a scholar. We show that in a rapidly changing academic discipline such as the IS disciple, a researcher is penalized for working predominantly and deeply in one or few knowledge clusters as opposed to several diverse knowledge clusters. We show this by extending the exploitation and exploration literatures with arguments about learning traps in scientific publications and rigidity from previous knowledge stock (Anderson Jr and Lewis 2014; Colquitt and George 2011) during knowledge creation process in rapidly-changing knowledge environment. Second, to our knowledge, this is also the first study, not only in the IS field but in the entire realm of co-citation and publication productivity studies in general, that operationalizes knowledge creation capabilities based on well-established indices from ecology and economics literature such as HHI and Simpson Index for knowledge exploitation and exploration capabilities, respectively. From a practical standpoint, we believe this study also has important implications for researchers' career strategies and research domain choice.

The paper is constructed as follows: we first develop arguments for knowledge creation capability in fast changing knowledge domains. Following that, we discuss the importance of knowledge exploration and exploitation capabilities in knowledge creation process. In the next section, based on different perspectives of knowledge creation and learning theories, we develop hypotheses to test the basic relationships between exploration and exploitation capabilities and knowledge creation. After that, the hypotheses are tested using co-citation analysis method with bibliometric information of authors who published in top IS journals. Finally, we present conclusions, contributions, limitations and future research directions.

Theoretical Foundations

Knowledge Creation

New knowledge is defined as a discovery about phenomena not known previously (McFadyen and Cannella 2004). New knowledge is created by individuals through the knowledge creation process as and when new problems emerge (Armstrong and Hardgrave 2007). The knowledge creation theory (Nonaka 1994) and the organizational learning theory (Crossan et al. 1999) state that new knowledge is first created and then processed by individuals in an organization. In order to guide them in new knowledge creation, individuals leverage existing knowledge structures and seek additional knowledge sources. The newly created knowledge is then integrated with the existing knowledge structure of the individuals (Nerkar 2003). However, it is important to note that academics and practitioners differ in their fundamental knowledge creation process assumptions and beliefs such as types of valid information sources, definition of sense-making information, past experience to evaluate knowledge validity, etc. (Sauermann and Stephan 2013; Shrivastava and Mitroff 1984).

The key characteristic that differentiates academic and practitioner knowledge creation is the sharing of workload. In academia, an individual researcher shares the majority of the workload, perhaps along with a small team of collaborators, as opposed to an industry researcher who creates new knowledge by sharing the workload within a larger knowledge network. In organizations, knowledge creation begins with an individual, then expands within and between groups (Alavi and Leidner 2001). The focus of knowledge creation in industry is to improve knowledge sharing among knowledge network members, and eventually to gain firm competitive advantage (Arikan 2009; Carrillo and Gaimon 2000; McFadyen and Cannella 2004; Nonaka 1994; Nonaka and Takeuchi 1995). On the other hand, scientific contributions such as publications are achieved by a systematic process of reading, writing, and experimentation, planned and executed largely by individuals, in addition to discussion with others from their knowledge networks (Latour and Woolgar 2013). Hambrick sums up the process of publishing a paper in top-tier journals by referring to the annual Academy of Management meetings and saying: "each August, we (academics) come to talk with each other; during the rest of year, we read each others' papers in our journals and write our own papers so that we may, in turn, have an audience the following August: an incestuous closed loop" (Hambrick 1994, p. 13). Recent research extending the academic knowledge creation model demonstrates that scientific knowledge creation outcomes are affected by researcher's relationships with others within knowledge networks (McFadyen and Cannella 2004; Phelps et al. 2012; Rotolo and Messeni

Petruzzelli 2013). However, this recent research does not address how individual knowledge capabilities of knowledge exploitation and knowledge exploration affect individual knowledge creation, even though the majority of the time and energy in academic knowledge creation is focused on an individual's capabilities to generate knowledge that manifest in the form of publications.

Across research disciplines, including the management field, it has been established that the number of researchers' publications are associated with other assessments of scientific impact, such as appointment, promotion, awards, departmental prestige, research grants, academic rank and peer judgments (Aleamoni and Yimer 1973; Gomez-Mejia and Balkin 1992; Panaretos and Malesios 2009; Van Looy et al. 2004). In the late 90's and early 2000's, research in the Information Systems (IS) field burgeoned largely due to the explosive growth and popularity of the Internet. Publications on Internet-applications became a broad new research area since 2000, according to Taylor's bibliometric analysis of IS publications (Taylor et al. 2010). Since then, IS research topics have evolved rapidly largely due to rapid technological advancements. For example, the latest topics in IS top journals include health IT research (Romanow et al. 2012), big data (Baesens et al. 2014), cloud computing (Bharadwaj et al. 2013), business analytics (Chen et al. 2012), social media (Matook et al. 2015), virtual community (Kim et al. 2012), open source (Von Krogh et al. 2012), platform ecosystems (Tiwana 2015), among many others. None of them were mainstream IS top-journal foci 10 or 15 years ago. This rapid change in the research domains and topics is one of the key characteristics and hallmarks of academic IS knowledge creation in the IS discipline, because of which this discipline is quite well-suited to be used as an example of a rapidly changing knowledge environment.

Knowledge Creation in Rapidly-Changing Knowledge Domains

It has been argued that a rapidly changing knowledge environment produces a learning disruption and turns a core capability of a subject into core rigidities (Anderson Jr and Lewis 2014; Leonard□Barton 1992). For organizations, core rigidities originate from local search along a firm's existing technological itinerary without much awareness of the technological dynamics of the external environment. Disruptive events such as a product or a process change, affect learning by reducing the fit of knowledge with the environment (Leonard-Barton 1992). Due to this lack of fit, firms' existing knowledge becomes less valuable or even obsolete (Polidoro 2012). Previous studies indicate that knowledge stock can depreciate, reducing the potential for learning and productivity (Argote et al. 1990; Darr et al. 1995). Amburgey et al. (1990) find that firm age, which can be understood as stock of accumulated knowledge over time, interacted with change of newspaper publication strategy to affect the newspaper's productivity. The older the firm, the higher the risk of failure to keep productivity high after a change happens. In other words, the power of previous knowledge stock depends on the amount of accumulated knowledge as a holdback and interruption for a knowledge recipient to learn new knowledge.

Technological innovations in rapidly changing knowledge environments have the potential to disrupt individual knowledge (Carrillo and Gaimon 2000). The demands to cope up with changing environment is higher in the IS field compared to other fields due to the rate at which technological innovations happen in the IS field. New technologies bring about new phenomena, which requires IS scholars to create new knowledge that explains the new phenomena. If an IS scholar fails to keep abreast with new technologies and how they can enable new organizational forms, strategies, processes, and practices, how they can be adopted and used within individual, group, and organizational settings, and the individual, group, and organizational-level impacts of those technologies, both positive and detrimental, her existing knowledge loses value in the knowledge creation and publication process. The principle of obsolescence is neatly captured in what is known as the "Paul Principle": Over time, people become uneducated and, therefore, incompetent to perform at the level that they once performed at adequately (Cascio 2001).

In search of rankings, accreditations and prestige, management schools stress IS scholars to publish in top tier journals. However, only a few journals are considered as top-tier journals in the IS field, and consequently there is a limited number of journal pages that a large number of IS scholars are competing for. This is evident from the extremely high rejection rate that the IS academic field is witnessing recently. For instance, the average acceptance rate of MISQ was 13.6% during 1995-2001 based on final disposition decision (Weber 2002), while the rate dropped to 5% in 2011. The increasing demand for publication spots has not been addressed by increasing the number of top tiers journals, issues, or slots per issue. Furthermore, due to the increase in number of scholars in the IS discipline, the competition for

publication slots further increases (Hyslop-Margison 2012; McGill and Settle 2012; Salisbury et al. 2014). For instance, the Academy of Management Journal (AMJ), an academic journal with one of the highest impact factors in the business field, requires a research paper to have the attributes of "significance, novelty, curiosity, scope and actionability" to merit a publication (Colquitt and George 2011). A review of recent publication topics in the IS top journals indicates that the topics cover a multitude of research domains indicating novelty and diversity in what is being published in top-tier journals.

Novel papers are often a result of knowledge creation by connecting two or more literatures or disciplines. Also considering the frequent knowledge updates in the IS domain, it is necessary to pursue the "right" phenomena to increase the chances of journal acceptance. Finding the "right" novel topics requires the scholar to be both familiar with certain disciplines and/or fields and also be open to new disciplines or field trends. With a thorough understanding of a discipline, an IS scholar can build an overall history and development of a certain field, such as what has been studied in this field, what other principles have been combined with current field, etc. Tracking the new trends in other fields help encourage an IS scholar with "novel" research perspectives and theoretical lenses. Therefore, we consider two types of capabilities considered as predictors in knowledge creation under frequently updated knowledge domains.

Knowledge Creation Capability from Knowledge Exploration/Exploitation

The knowledge-creation capability refers to the capacity to combine and exchange knowledge (tacit, explicit, individual and collective, internal and external) in order to develop new knowledge (Arikan 2009; Smith et al. 2005). A researcher can exhibit two types of knowledge creation capabilities. First is knowledge exploitation capability, the capability of a researcher to create new knowledge by modification of existing knowledge. Second is the knowledge exploration capability, the capability of the researcher to create new knowledge by expanding to new knowledge domains (Gupta et al. 2006). In our paper, we explore whether a researcher's explorative knowledge creation capability and exploitative knowledge creation capability influence future knowledge creation outcomes, under rapidly changing knowledge domains.

Exploration and exploitation, the two fundamental knowledge creation processes has been studied extensively, especially in the strategy literature. In his foundational model, March (1991) noted that knowledge exploration and exploitation behaviors take place at both individual and organizational levels. Exploration refers to learning gained through processes of concerted variation, planned experimentation, and play (Baum et al. 2000; March 1991). Exploitation is learning gained via local search, experiential refinement, and selection and reuse of existing routines (Baum et al. 2000; March 1991). At individual-level learning, exploration and exploitation will generally be mutually exclusive, and the scarcer the resources needed to pursue both exploration and exploitation, the greater the likelihood that the two will be mutually exclusive (Gupta et al. 2006). Knowledge exploration in academia is rooted in observations of new field trends, collaborations with scholars from other domains that is new to the scholar, conference presentation and getting feedback from a large audience, etc. (Ynalvez and Shrum 2011). In academia, knowledge exploitation is likely to happen from local search such as literature reviews, where individual authors take up much of the workload. Such knowledge creation is more likely to produce publications in the domains that the scholar is most familiar with and has previous successful publications in. It is also a process of building domain reputation of an established scholar (Hyland 2003; Judge et al. 2007). Recent research work extending March's original model (Durcikova et al. 2011) demonstrates that learning outcomes are affected by individuals' capability to balance between knowledge exploitation and exploration. However, research in the knowledge creation area has assumed similar knowledge creation outcomes in all scenarios. None of the studies address the role of researcher's explorative knowledge creation capability and exploitative knowledge creation capability in future knowledge creation outcomes in fast-changing knowledge domains.

The phenomenon of knowledge creation in rapidly changing knowledge domains can be studied using the theoretical lens of knowledge exploration and exploitation. In academia, much of the knowledge used in the scientific discovery process is complex and is embedded in particular field(s) and associated methodologies (McFadyen and Cannella 2004). In problem solving process, knowledge from other domains or perspectives is more likely to create more radical or break-through ideas as new knowledge (March 1991). Such knowledge creation takes time and effort, as expertise is needed to try different possible explanations or combine solutions from multiple domains. Individuals who only have expertise

in a limited number of focused-domains are limited in their knowledge components. Eventually they are also limited in the number of possible recombinations, which are crucial in producing break-through ideas. The newly explored knowledge elements these individuals create, may not differ from the existing ones in terms of problem identification, formulation, and solution (Wu and Shanley 2009). On the other hand, diverse knowledge created through the process of exploration covers a wide range of fields with regards to perspectives, topics, or domains (Mishra et al. 2007; Wu and Shanley 2009). Overall, exploration capabilities in academic knowledge creation process bring in potentially more novel and break-through ideas and publications.

Experts with deep knowledge in one specific domain or topic can quickly perform knowledge exploitation. Deep knowledge can help a researcher better synthesize knowledge and can help the recipient construct a more refined understanding of the existing knowledge in the same domain (Kale et al. 2007). It is easy for such experts to find solutions from their most familiar domain when facing a new problem. Academic productivity for a researcher with deep knowledge results from refining knowledge in the researcher's familiar domains and generating articles that are closely related to previous publications. Ahuja and Lampert (2001) found that organizations must overcome three pathologies of learning to create novel breakthroughs: the tendency to favor the familiar over the unfamiliar, the mature over the nascent, and solutions similar to existing approaches over completely new ones. These three pathologies of "the familiarity trap," "the maturity trap," and "the nearness trap" are also worthy considerations during individual knowledge creation process. In academia, these three traps have the potential to prevent a scholar from finding a novel research topic (Colquitt and George 2011). We discuss the effects of exploration and exploitation in more detail while discussing our research model and hypotheses below.

Research Model

In academia, publications represent documented new knowledge and indicate the extent to which they advance a field of the research (McFadyen and Cannella 2004; Stephan and Levin 1991). The process of brainstorming is described as the opposite to academic knowledge creation processes. The ways in which knowledge is created in academia is explained by the Triple Helix Spiral (Tsui et al. 2009). Knowledge creation in academia involves three spirals, according to the Triple Helix Spiral model: hermeneutics (gathering scientific information and knowledge from literature, web and other sources, reflecting on these materials and interpreting them), debate (discussing with a research group), and experiment (testing ideas and hypotheses by experimental research). These three spirals describe the most essential elements of academic research: gathering and interpreting information and knowledge, debating and experimenting. In academic knowledge creation, information gathering and interpretation takes into account both the huge amount of concepts and their inter-relationships embedded in the respective domains and associated methodology.

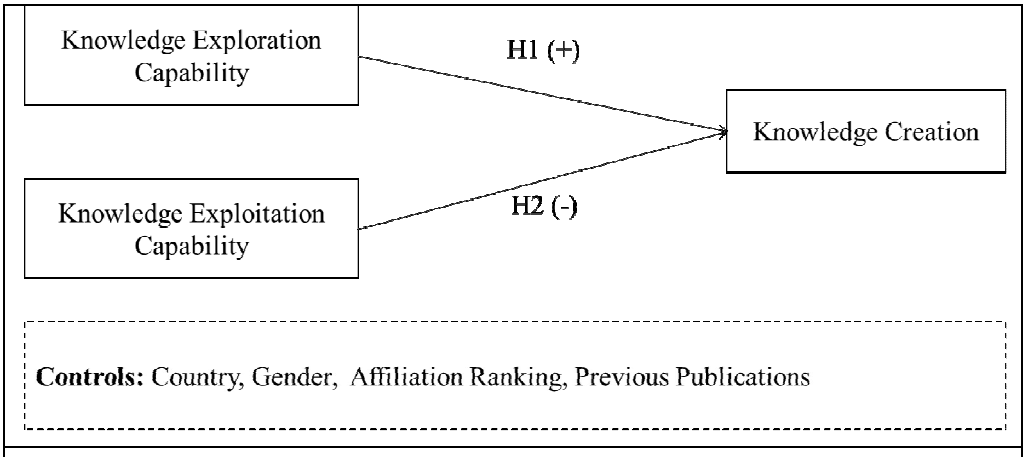

Figure 1. Research Model: Knowledge Creation in Fast-changing Environment

To study the knowledge exploitation and exploration capabilities in fast-changing knowledge domains, we examine the publication productivity of IS scholars. The IS academia is a research environment in which technology and knowledge have been changed and enhanced frequently. We propose a research model to test the different effects of knowledge exploration and exploitation capability in academic knowledge creation. In order to conceptualize these two capabilities, we use a knowledge cluster based approach. In academic publications, it is also common that scholars are likely to publish with the others with common language or previous co-authorship (Inkpen and Tsang 2005; McFadyen and Cannella 2004). Therefore, we conceptualize knowledge exploration capability as the capability of a scholar to publish in multiple domains or knowledge clusters. We conceptualize knowledge exploitation capability as the capability of a scholar to publish in a focused domain or knowledge cluster rather than multiple domains. Our research model is shown in Figure 1.

Knowledge Exploration Capability and Knowledge Creation

Fast-changing knowledge domains offer scope for researchers with knowledge exploration capability to be successful in academia. Researchers with an exploration focus have the ability to communicate and exchange knowledge with researchers from different knowledge clusters (Alavi and Leidner 2001; Anderson Jr and Lewis 2014; Wang and Haggerty 2009). The knowledge exploration capability helps a researcher assimilate and innovate on emerging technology. The research in knowledge creation has shown the benefits of explorative capability, such as the ability to accumulate expertise across a variety of disciplines (Benner and Tushman 2003; Gupta et al. 2006; Meyer and Curley 1991; Prabhu et al. 2005). Previous research has also shown that knowledge sharing ability to be a key moderator in the effect of innovation climate on innovation solutions (Durcikova et al. 2011). Research has also shown that innovation enhancing benefits of exploration(Alavi and Leidner 2001). "Novel topics can often result from knowledge recombination, with something 'new' being created by building a bridge between two literatures or disciplines" (Colquitt and George 2011) page 433. Empirical evidence has shown that frequent scientific collaboration with others from different domains does improve academic productivity (McFadyen et al. 2009; Ynalvez and Shrum 2011). Thus, researchers with knowledge exploration ability are prone to choose these emerging technologies for their research mainly due to their capability to work on multiple knowledge domains and awareness of these new technologies.

Moreover, the scope for novelty will always be higher for an emergent technology when compared to a technology that has been researched extensively (Durcikova et al. 2011; Katila et al. 2002; March 1991). Given the push by journals for novel topics, the novelty scope of these technologies makes them an obvious choice to research on, a task, which is easy for an academic with knowledge exploration capability. Research done in these topics tends to get more traction from journals, as journals too can attract a broader academic and practitioner community. Therefore, we propose the following hypothesis:

H1. Explorative knowledge production capability is positively associated with individual knowledge creation in rapidly changing knowledge domains.

Knowledge Exploitation Capability and Knowledge Creation

On the other hand, we posit that explorative knowledge management capability will penalize an academic researcher. In rapidly changing knowledge domains, a researcher with high exploitation capability will find it difficult to accept the concepts in the new domain due to the rigidity of his/her existing deep knowledge structure. By the time the exploitative researcher gets abreast with a new paradigm, a newer one replaces the "current new" paradigm. These rigidities and delayed responses will in turn prevent the academic from creating high quality publications. In this regard, Ahuja et al.'s (2001) three types of knowledge traps for scholars choosing a research topic apply to an exploitative researcher. The traps are "the familiarity trap," "the maturity trap," and "the nearness trap" (Ahuja and Lampert 2001). Working on a familiar topic may result in a study that would just be a marginal extension of an existing research. Analyzing a mature topic raises concerns about redundant contribution. Finally, choosing closely related topic could result in overlapping ideas that are not radical enough to warrant publication in top journals (Colquitt and George 2011). For academic publications, top journals show the directions of the academic development of the science. IS field has a long tradition "of being open to new ideas, as required in extremely rapidly changing fields" (King and Lyytinen 2004, p. 547). With a limited number of publication opportunities per year, the competition for publication slots between topics is more fierce in

the IS domain, especially when new technology developments bring in more research questions and novel topics. Based on top journals bibliometric analysis, the IS domain has evolved into a more diverse set of research areas after 2000 (Taylor et al. 2010). Also, an analysis of topics in top journals before (Athey and Plotnicki 2000) and after 2000, shows that new topics such as e-commerce and social media have emerged since 2000 (Huang and Hsu 2005), In rapidly changing domains, without a sufficient understanding and full utilization of new knowledge, incremental improvement and refinement of existing ideas rather than the development of true breakthroughs is more likely (Katz and Du Preez 2008). Between-topics competition brings more pressure for a scholar to publish an article with a marginal extension of an existing research, although the deep and thorough understanding does bring contribution to the existing research. Simulation studies have shown that although cumulative knowledge can enhance knowledge creation, the very processes can eventually restrict knowledge creation over a period of time, especially when individuals' knowledge becomes too specialized in a certain domain (Anderson Jr and Lewis 2014).

Due to the general proclivity and recent preference of top journals to promote publication of novel, impactful, and highly significant research papers (Colquitt and George 2011), the available space and slots for publication of incremental research in established knowledge domains has gradually shrunk over time. Further, given the fierce competition among IS scholars for top journal page space, the prospects of publication in top journals have shrunk further for "exploitative" authors who remain focused in one or few domains without exploring new research developments and are looking to publish incremental research in established domains. Although it is still possible to publish incremental research in established research domains using an exploitative strategy, the journal publication trends are hardly in their favor, specifically in rapidly changing knowledge disciplines like the IS discipline. Significant changes in the most proficient authors in top journals over time provides some evidence that exploitation strategy may not work very well in rapidly changing fields (Huang and Hsu 2005). Therefore, in academic knowledge creation, exploitation capabilities could become an obstacle instead of aiding in new knowledge creation. Therefore, we propose the following hypothesis:

H2. Exploitative knowledge production capability is negatively associated with individual knowledge creation in rapidly changing knowledge domains.

Control Variables

In this study, we controlled for other important factors that can affect an individual author's knowledge creation behavior. As (Judge et al. 2007) argued, scholar productivity could be impacted by past productivity, affiliation prestige, country, and gender of the focal author. The intellectual credit given to and the reputation and the social position of an author is high when he/she publishes in top journals. Further, the high social position of authors can also be indicated by their university prestige. Multiple empirical studies have shown that scholars from elite universities are more productive in top-tier journals (Long et al. 1998), and gain more recognition and reputation than those from non-elite universities (Crane 1965; Helmreich et al. 1980; Rigney 2013). Therefore, we include affiliation prestige of the focal author as a control variable. Further, prior research has shown that male and female scientists differ in scholarly activities due to gender gap and biases (Sotudeh and Khoshian 2014). Therefore, we include gender of the focal author as a control variable in our model. Besides the three variables mentioned above, we also consider country of the author as a control variable in the present study because academic activities in different countries maybe different (Pezzoni et al. 2012) as competition for limited resources depends on the different types of promotion and reward systems that may be prevalent in universities across different countries. Also, the citation impact for management research has been found to be different between the east and west (Leung 2007).

Research Methodology

Data Sample

We considered articles published only after 2000 for our initial sample, since post-2000 is the time when research on information systems and technology began to bloom due to the popularity of the internet. We chose 10 leading journals for performing the co-citation analysis (described in detail in later sections), which is used to identify knowledge domains in which the author has published. These 10 focal journals

are *Decision Support Systems, European Journal of Information Systems, Information & Management, Information Systems Journal, Information Systems Research, Journal of the AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems, and MIS Quarterly*. Eight of these 10 journals are in the AIS Senior Scholars' Basket of Journals (http://aisnet.org/?SeniorScholarBasket). We add *Decision Support Systems* and *Information & Management* to this list as both journals have consistently been ranked as premier journals in various rankings of IS journals based on survey data as well as journal impact factors. The 10-journals information science dataset contains 14288 bibliographic records, from 4621 articles and 11527 unique authors. All these articles cite 120104 unique references and citing 170132 authors.

Knowledge Factor Generation through Co-Citation

Co-citation analysis is a form of bibliometric technique applied on the citation-related information of the published literature within a certain domain (McCain 1990; White and McCain 1998). As one of the most commonly used methods in quantitative studies of science, both author and document co-citation analysis serve as a fundamental grouping mechanism to identify specialties in terms of aggregations of co-cited individual items (Chen et al. 2010). Co-cited documents serves as representations and symbols of scientific ideas, methodology, and experiment, which has been found within a high degree of uniformity in specific concepts (Small 1978). Recent studies also found that factors of noun phrases can be extracted from citation contexts of cited documents (Schneider 2006). A cited reference in document co-citation analysis is relatively easier to identify the knowledge specialty than a cited author in author co-citation analysis (Chen et al. 2010). Therefore, we adopt document co-citation analysis to identify knowledge specialties in the IS field and then construct the knowledge exploration and knowledge exploitation ability based on of each author's previous publication information in these specialties.

Due to the extremely large size of the original sample, majority of values in the co-citation matrix will be zero. When the majority of the matrix is zero value, the bibliometric information from the co-citation matrix will have very less knowledge clustering value (White 2003). Thus, we follow the citation count limit method (Raghuram et al. 2010; Small and Griffith 1974) to reduce the zero appearances. Based on this method we then define the focal articles as those 313 articles which were published in 10 premier IS journals after 2000 and cited at least 5 times by top-10 journals during 2005-2008. The choice of the citation window of 2005 -2008 is in line with prior studies (Li et al. 2013). Previous studies have suggested that a bibliometric study of articles should have a citation window of at least 3 years (Van Raan 2006). In line with this recommendation, we adopted a 4-year citation window of 2005-2008 for an article. We gathered all publication related data for co-cited article dyads for the 313 focal articles, including dyad-wise co-citations during 2005-2008. Since publication in top-tier journals takes time from idea generation to data gathering, analysis, writing the manuscript, and several rounds of review, we use a 2-year window for a scholar to produce new knowledge and ultimately receive article acceptance as a representation of knowledge creation. Therefore, we use the year 2011 for measuring publication productivity. We collected information for control variables such as each author's publication, affiliation, gender, publication information, and country of his/her institution, of the focal articles' selected author (91 focal authors) who published at least one paper in 2011, in top-10 IS journals. The time periods of independent and dependent variables do not overlap. Such fixed-window approach to citation count allows us to avoid the immediate research impact derived by high-quality article and ensure that the productivity capabilities are built over time. Our dataset gives us the opportunity to examine the influence of IS scholar's academic knowledge creation capability on knowledge creation outcomes with the co-citation analysis. More details of our variables and analyses are discussed below.

In co-citation analysis, factor analysis is based on a matrix of the co-citation count between the dyadic pair. To build the co-citation matrix, every co-cited article pair (abbreviated as an article pair or an article dyad) were created by co-citation count about each article along with the other 312 articles. Hence, the co-citation matrix is represented in a 313*313 matrix as it represents the times cited together between each possible dyadic combination of the 313 focal articles. Since the co-citation matrix is a symmetric matrix of the 313 focal articles as column and row subjects, the diagonal represents self co-citation as the number of times the focal article is co-cited with itself, not a useful information for factor analysis. Following the most commonly applied method for addressing this problem (White and McCain 1998), all the diagonal numbers are replaced by mean co-citation count. Principal components with oblimin rotation was employed to extract the key factors and their correlations (Nerur et al. 2008; Zhao and Strotmann 2014).

Only factors with a minimum eigenvalue of 1 were extracted. Within each factor, there are at least 2 articles with absolute value of factor loadings larger than 0.4, which is the typical co-citation cut-off value (McCain 1990; White and McCain 1998). Results yielded a forty-factor solution for the 2005–2008 period, which included 219 articles and 396 authors. Among all the 396 authors, only 91 published in 2011. Therefore, the final focal author of current study is composed of 91 authors that published in 2011, in a top-10 IS journal and also belonged to at least one knowledge factor according to their co-citations bibliometric information during 2005-2008. The major steps in co-citation analysis and computation of research variables are summarized in Figure 2.

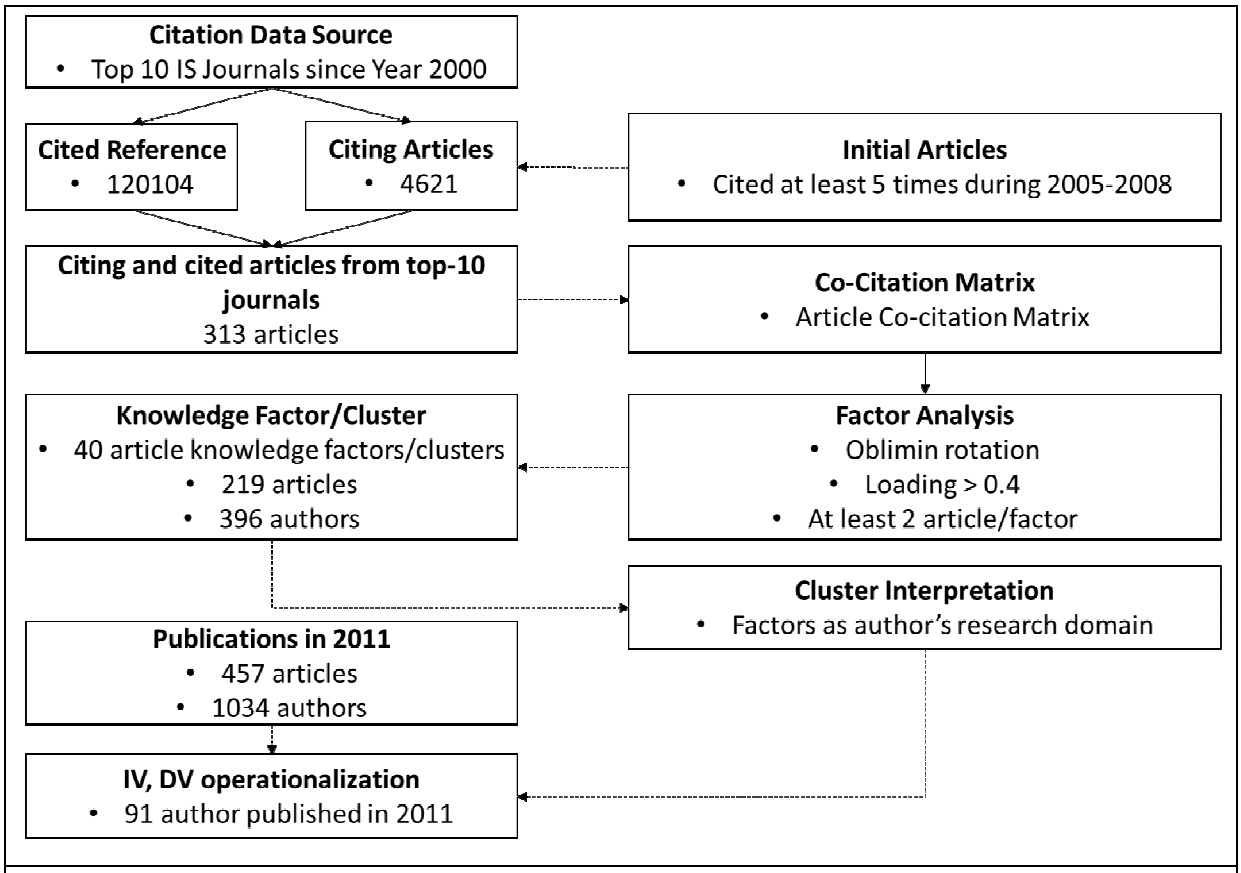

Figure 2. Major Steps in Co-citation Analysis and Computation of Research Variables

Measurement and Operationalization of Variables

Our dependent variable, *knowledge creation* in 2011 by an author *i* is operationalized as the weighted number of articles by author *i* in all the articles published in the 10 focal journals during the year 2011, weighted by each journal's 5-year impact factor in 2011. Our measure of knowledge creation is analogous to the use of patenting activity to measure firm knowledge creation in the strategy literature (Almeida and Phene 2004).

As to the two independent variables, *exploration capability* of author *i* is operationalized as 1/Simpson index as described below:

$$Exploration\ Capability\ of\ Author\ i\ (1/Simpon\ Index) = \frac{1}{\sum_{j=1}^{40}\left(p_{ij}\right)^2}$$

$$p_{ij} = \frac{m_{ij}}{\sum_{j=1}^{40} m_{ij}}$$

m_{ij} is author i's articles published in factor j, i = 1, 2 , 3… 91 authors, and j = 1, 2 , 3… 40 factors.

p_{ij} is the proportion of author i's articles published in knowledge factor j over all his/her total publications across the total 40 knowledge factors, i = 1, 2 , 3… 91 authors and j = 1, 2 , 3… 40 knowledge factors.

Exploitation capability of author *i* is the maximum of author i's publication HHI as described below.

$$\textit{Exploitation capability of Author } i \text{ (Max HHIj)} = \max_{j=1,2\ldots40} (s_{ij})^2$$

$$s_{ij} = \frac{m_{ij}}{N_j}$$

N_j is the total number of articles published in factor j, j = 1, 2 , 3 … 40 factors.

m_{ij} is author i's articles published in factor j, i = 1, 2 , 3… 91 authors, and j = 1, 2 , 3… 40 factors.

s_{ij} is author i's articles share in knowledge factor j compared to all the articles published in knowledge factor j by the 91 authors, i = 1, 2 , 3… 91 authors, and j = 1, 2 , 3… 40 knowledge factors.

For example, author X has in-total 5 articles included in the sample of co-citation analysis: 2 articles in factor A and 3 articles in factor B. Factor A has 6 articles in total and Factor B has 10 articles in total. The exploitation capability of author X is max $[(2/6)^2, (3/10)^2]$ = 0.111. The exploration capability of author X is then $1/[(2/5)^2 + (3/5)^2]$ = 1.923.

With regards to the control variables, focal author's previous article publication is operationalized as the total number of articles published by an author during 2005-2008 in the 10 focal journals (for capturing overall publication productivity of the author). Affiliation prestige of the focal author is operationalized as the dummy variable whether the focal author's affiliation belongs to a world top-100 university, based on the 2012 Financial Times ranking (non-top-100 ranking = 0, top-100 ranking = 1). Focal author gender is a dummy variable to indicate whether the focal author is male or not (Female = 0, Male = 1). Besides the three variables mentioned above, we also consider country of the author as a control variable in the present study (non-US = 0, US = 1).

Results

OLS regression was performed by regressing knowledge creation on the independent variables, exploration and exploitation capabilities, and control variables country, gender, previous article publication, and university ranking. The results are shown in Table 1. Model 1 includes only the four control variables: age, gender, country, and previous article publications. Model 2 adds the two independent variables exploration and exploitation capabilities. The results from Model 1 through Model 2 offer strong support for Hypothesis 1 and Hypothesis 2. The majority of the controls are not significant predictors except the gender of the author. In both Model 1 and Model 2, gender shows negative effect on current knowledge creation. Although males are the dominant gender with respect to distribution, female scholars publish more top-tier journal publications in the IS domain. Surprisingly, university pressure, country culture, and previous publications show no statistically significant effects on current knowledge creation.

Model 2 is significant and offers strong support for both Hypothesis 1 and 2. The coefficient of exploration capability is positive and statistically significant (b = 0.322, p<0.001), as suggested in hypothesis 1. The

coefficient of exploitation capability is negative and statistically significant (b = -0.184, p<0.1), indicating that working on the most familiar domain will reduce the knowledge creation of IS scholars,as suggested by hypothesis 2. Comparing the magnitude of these two effects, the improving effects of exploring new domains bring more benefit than the reducing effects of stickiness to the same domain (0.322 > 0.184).

Table 1. Regression Results: the Effect of Exploitation and Exploration Capabilities on Knowledge Creation

	Variables	**Model 1**	**Model 2**
Controls	Country	-0.069 (-0.627)^	-0.031 (-0.294)
	Gender	-0.223** (-2.121)	-0.190* (-1.872)
	Previous Article Publication	0.017 (0.157)	0.029 (0.286)
	University Ranking	-0.079(-0.730)	-0.047 (-0.444)
Independent Variables	Exploration Capability		0.322*** (2.947)
	Exploitation Capability		-0.184* (1.667)
R^2		0.058	0.149
F value of R square		1.313	2.46
ΔR^2		0.058	0.092
F value of ΔR^2		1.313	4.538

*** p < 0.01, ** p < 0.05, * p < 0.10

^ Number within parenthesis represents the t-value of the coefficient.

Discussion

The objective of this research was to study the impact of exploration and exploitation capabilities on knowledge creation in rapidly changing knowledge domains. From the theoretical lens of exploration and exploitation, we studied the phenomena of knowledge creation in the IS discipline, which we posited to be a rapidly changing knowledge environment. We argue that exploitation reduces knowledge creation in rapidly changing knowledge domains, an argument not found in the extant exploitation and exploration literature (Benner and Tushman 2003; March 1991; Wu and Shanley 2009). We do so by linking learning theory to citations analysis, because citation analysis can generate knowledge domains based on co-citation networks in macro-level research domains. Then each author's publication statistic is essentially a reflection of knowledge creation strategy in a knowledge network at the micro level of individual capabilities. Then we carefully operationalized the constructs of exploration and exploitation on scholar's knowledge creation behaviors. Our study results provide support for our hypothesis that knowledge exploitation capability has a significant negative effect on knowledge creation performance. There are several explanations for this. First, we posit that our findings are mainly due to previous knowledge stocks acting as rigidities and knowledge traps(Ahuja and Lampert 2001; Anderson Jr and Lewis 2014). Second, given our study's setting of rapidly changing knowledge domain, the frequent knowledge updates in such a domain bring more risks and variances to the knowledge stocks of individual scholars. In other words, the turbulence of the knowledge domain changes the strategic benefits of exploitation and exploration capabilities. On the other hand, we show that the capability to explore new knowledge domains is significantly positively associated with knowledge creation performance. These results are consistent with the broader exploration argument of research topics in individual learning and academic knowledge creation literatures (Anderson Jr and Lewis 2014; Colquitt and George 2011). Although there are major differences in knowledge creation work between academia and industry, exploitation and exploration as knowledge creation strategies do not change. Exploration is to discover or invent new solutions in a new field besides the familiar ones, while exploitation is to reconstruct existing knowledge stocks to develop new solutions. The penalty conclusion we obtained for exploitation fits the industry as well. In order for a company to survive and thrive in fast-changing environments, continuous new product development with innovative functions rather than improvement of existing products is crucial. While the conclusions from the current study are mainly applicable to the academic, they can still provide general suggestions for the industrial practitioners as well.

The statistically not significant results of control variables are also worthy of discussion and study in future research. Our results show that in the IS discipline, the tendency to publish in top-tier IS journals is not related to country background, elite university affiliation and the publication pressures that such an affiliation brings, or previous publication record, as some prior research has suggested (Judge et al. 2007). In the male-dominated academia, the higher productivity of female IS scholars compared to male scholars is also quite a surprising finding in our results worthy of future investigation.

Contributions

Our study makes two key contributions to the literature on academic productivity in particular, and the knowledge management literature in general. First, we provide empirical evidence about a new theory of knowledge creation in rapidly changing knowledge environments in the context of IS discipline. By combining the literatures on knowledge exploration and exploitation, with the literature on learning, knowledge traps and knowledge creation in rapidly changing environments, we are able to propose and show that rather than conferring a competitive advantage to an individual scholar for knowledge creation, knowledge exploitation capability actually exacts a penalty on the future publication productivity of an IS scholar. We argued that for individuals, especially for academic researchers in rapidly changing knowledge disciplines, the negative effect of exploitation capability comes from the learning traps and the associated stickiness to previous knowledge stock (Ahuja and Lampert 2001; Anderson Jr and Lewis 2014). This viewpoint gives new perspective to exploration and exploitation in knowledge creation process, especially in rapidly changing knowledge environments. As mentioned earlier, prior literature generally proposes that both exploration and exploitation strategies improve knowledge creation by refining existing knowledge or by creating knowledge in new domains (e.g., Benner and Tushman 2003; Gupta et al. 2006; Im et al. 2008; March 1991). This finding about knowledge exploitation exacting a penalty on future knowledge creation and publication of top-tier journal articles is a novel finding not only in the literature on academic productivity but in the larger literature on knowledge creation at the individual level. The major contribution of current study is to provide empirical evidence that exploitation, as one approach of knowledge creation, may harm knowledge productivity in the fast-changing environment.

By making this first contribution, we also make a subsidiary second contribution. We borrow the HHI and Simpson Index, well-established indices in ecology and economics literature, to develop our constructs of knowledge exploration and exploitation capabilities. Our study applies a well-established bibliometric methodology with a systematic co-citation analysis to generate clustering factors as knowledge domains for further computation of research variables. With bibliometric information and objective observation of scholar publications, we develop the constructs of knowledge exploration and exploitation capabilities. Both indices are well established in ecology and economy domains, and the rigorous operationalization of our research constructs lends further credibility to our results and contributions.

There are some practical implications of our findings as well. The first relates to managing the development of over-specialized knowledge as a knowledge exploitation capability. Although fostering specialization helps a scholar to develop in the short run, overspecialization has some serious risks in turbulent knowledge domains. Because increases in specialized knowledge acquisition inhibit new knowledge growth in changing environments, it might be disadvantageous for individuals as it will be difficult to follow the development of the whole community. For example, rather than encouraging individual knowledge workers to work on the same domain over and over, the society should introduce some domain variety early in the learning cycle (Colquitt and George 2011; McFadyen and Cannella 2004). Another alternative to help overspecialized personnel is to encourage cross training so that they can acquire knowledge relevant to the new trends and technological innovations. However, given the strong, negative effects of rigidity and trap, it may take a significant amount of time for the effects of cross-training to make up for the stickiness to the previous knowledge stock (Anderson Jr and Lewis 2014).

Limitation and Future Direction

Our paper has several limitations. First, our sample uses only 91 IS scholars' citation and publication information in 10 premier IS journals during the 2005-2008 for calculation of knowledge exploration and

exploitation capabilities. In the future, more bibliometric information about journal articles can be included. A larger sample size can provide us with more robust empirical support for our exploitation penalty effects. For example, the dependent variable, which now covers on 2011, can cover longer range of time, rather than one year. Second, our sample uses only the IS scholar's citation information in top-10 journals after 2000. Future research can compare the exploration and exploitation estimates obtained pre- and post-2000 to get a better sense of how the relationships are different in rapidly changing knowledge domains. It is possible that the IS domains has a long tradition of rapidly changing knowledge clusters even before the popularity of Internet beginning in early 2000's. In the future, more bibliometric information about journal articles can be included in current study to include the citation information of the articles published before 2000. Third, we only study the IS domain as the rapidly changing knowledge environment. In the future, other domains can be included to compare domain differences. Or we can also introduce less rapidly changing environments as control groups to compare the results of the current study. In this way, we can also verify the conclusion on penalty effect of knowledge exploitation capability. Fourth, we did not include the notion of ambidexterity, i.e. the interaction of exploration and exploration capabilities, in the present study. Although prior studies have shown ambidexterity to impact knowledge creation(Gupta et al. 2006), the theoretical rationale for ambidexterity's impact in rapidly changing knowledge domains needs to be well thought out considering that contrary to conventional wisdom, knowledge exploitation has a negative effect on future knowledge creation. Such a study analyzing the impact of ambidexterity will be a good avenue for future research. In addition, since we obtain contrasting effects of exploration and exploitation capabilities, strong theory support is needed to build the logic and argument for the ambidexterity effect. Fifth, while we included an extensive set of premier IS journals in this study, we did not include the articles published in the IS section of Management Science in our sample due to the limited number of articles published in that section. We do not expect the inclusion of those articles to change the results of this study in any significant manner. However, from the perspective of rigor and for the sake of completeness, future research should incorporate the IS section of Management Science in any co-citation analysis. Sixth, we only considered top journal publications in the IS field as part of the sample. One reason is that top journal publications have high impact on the rest of the field. They provide guidance and direction for the field development in the IS domain by highlighting new and emerging trends. Although there is debate about certain journals being incremental by accepting "another TAM paper," the current study is not affected by such claims since it captures knowledge creation based on publications that include 10 top journals in the IS field, rather than one or two journals. Seventh, we did not remove outliers from our study as there is ample evidence of highly skewed distributions of scholarly outputs of individuals working in various academic fields, and not just in the IS field (Chung and Cox 1990). In fact, this finding has come to be known as the generalized Lotka's law, which stipulates that the productivity of individuals in an academic discipline follows an inverse power function with exponent *c*. A study focusing on exploration versus exploitation strategy of highly productive scholars would be interesting by itself but given the small number of highly productive scholars in our sample, this is not feasible for the present study. Future studies should definitely explore this avenue. Further, in future research, more variables can be included in the current research model to enhance the results and contribution of this study. For example, gender of the co-authors can also be considered as one control variable. Authors who are able to co-author a lot with others (and thus publish on more diverse topics) will publish more than authors who rather stick to one topic and have thus only limited access to potential other co-authors. Other variables that capture different levels of promotion requirement, seniority of the scholar and stages of academic career, and resource allocation to different institutions might be fruitful in our pursuit of explaining knowledge creation. Different types of promotion are faced by IS scholars at different career stages, such as tenure requirement, etc., and the seniority level of each scholar may be different in different schools. Future studies should consider some of these specific variables to study the relative impacts they have as knowledge creation inducing factors.

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