

EXPLORING THE INVISIBLE KNOWLEDGE NETWORK BETWEEN IT INVESTMENTS AND PERFORMANCE

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Abstract: This study is to map the intellectual structure between IT investments and performance that embedded in leading publications, and to explore the key research themes in this field between 1980 and 2007. Using the invisible network of knowledge (INK) approach, this study analyzes and maps 166 articles and associated 8,930 references from the SCI and SSCI of the ISI databank. The results reveal the evolution of research trend regarding IT investments and pay off, and provide researchers a valuable way to identify the linkages among different authors and their contributions in this area.

INTRODUCTION

The information technology (IT) has played an important role in business organization since 1990 and change the way of business operation and management. Many companies allocate their resources on IT investments, presumably expecting a bountiful payoff. However, empirical studies of the impacts of IT investments on performance of firm level, industry level or country level are inconsistent. To identify where the business value be affected by IT investments is not an easy task.

For past decades, the research regarding this topic in the field of information system (IS) has been very active, and thus produced a large number of journal papers and other documents. People are easily confused with the subjects and contributions of the studies regarding IT investments and performance. The key point is what the theories in this booming field that are essential in the intellectual structure (McCain, 1990) of this topic. To have a better understanding of the relationship between IT investments and pay off, people need a systematic and objective approach.

The invisible network of knowledge (INK) approach provides such a tool. The invisible network of knowledge (INK) refers to the communication process embodied in written and published works of a given field. By using epistemological scientometrics, this approach is able to sketch-out the invisible knowledge network of the relationship between IT investments and performance in terms of its intellectual architects (who), their respective contributions (what), and the time and place in which they published them (when and where), except “why” and “how” (Etemad & McLee, 2003).

The objective of this study is to conduct an overall examination of the intellectual structure of the IT investments and pay off. The goals are to (1) explore the relationship between IT investments and performance; (2) identify authors who play a crucial role in this area; (3) map the intellectual structure in a two dimensional space to reveal spatial distances between intellectual themes.

THE INVISIBLE NETWORK OF KNOWLEDGE (INK) MODEL

Knowledge is the output of learning or knowing process, a novice should become familiar with the intended knowledge generation of a given field in order to understand the nature, its potential uses, and the evolutionary process in this field over times (Latour, 1987). Scholars who working in the same research area are linked together in research networks through informal ties (Price, 1963). In those research networks, researchers can identify specific colleagues working on the same or related topic, learn what these colleagues know and communicate with them either through the literature or interpersonally. Network commonly refers to a system which is optimally designed to perform a designated task effectively. The two important components of network are key nodes and linkages whereby key nodes point out the system resources for knowledge generation with their well connections by way of linkages (Chandy & Williams, 1994; McCain, 1990).

Knowledge is complex and invisible. It is difficult for those who attempt to obtain knowledge since people have their own views concerning knowledge, which often results in misunderstanding about what is the knowledge and where the knowledge is residing. As a result, there's a strong need for an effective approach for helping people visualize knowledge, and further maintain and representation of knowledge. The invisible network of knowledge approach provides such a tool.

An INK model of any given field embodies both the knowledge contents of its nodes and the inter-linkages of those nodes within its domain and to other fields. It can be viewed as the organized and the de-facto mirror of a field (Etemad & McLee, 2003). Beyond the advantages of traditional concept of knowledge network, INK model focuses more on the effect of invisible knowledge on a discipline (or a field) to make the invisible more visible by computer-aided epistemology. INK model can help mapping the knowledge network of a discipline, and reveal its locus of theory development and evolutionary trends and is an

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	Barney J	1991	Firm Resources and Sustained Competitive Advantage.
	Harris S	1991	Organizational Performance and Information Technology Investment Intensity in the Insurance Industry.
	Delone W	1992	Information Systems Success: The Quest for the Dependent Variable.
	Weill P	1992	The Relationship Between Investment in Information Technology and Firm Performance: A Study of the Valve-Manufacturing Sector,
	Brynjofsson E	1993	The Productivity Paradox of Information Technology
	Dos Santos B	1993	The Impact of Information Technology Investment Announcements on the Market Value of the Firm,
	Mahmood M	1993	Measuring the Organizational Impact of Information Technology Investment: An Exploratory Study
	Hiitt L	1994	The Three Faces of It Value: Theory and Evidence.
	Loveman G	1994	Information Technology and the Corporation of the 1990s: Research Studies.
	Barua A	1995	Information Technologies and Business Value: An Analytic and Empirical Investigation.
	Brynjofsson E	1995	Information Technology as a Factor of Production: The Role of Differences among Firms,
	Lichtenberg F.	1995	The Output Contributions of Computer Equipment and Personnel: A Firm-Level Analysis.
	Mukhopadhyay T	1995	Business Value of Information Technology: A Study of Electronic Data Interchange
	Brynjofsson E.	1996	Paradox Lost? Firm Level Evidence on the Return to Information Systems Spending,
	Hiitt L	1996	Productivity, Business Profitability, and Consumer Surplus: Three Different Measures of Information Technology Value
	Dewan S	1997	The Substitution of Information Technology for Other Factors of Production: A Firm Level Analysis.
	Rai A	1997	Technology Investment and Business Performance.
	Bharadwaj A.	1999	Information Technology Effects on Firm Performance As Measured by Tobin'S Q.
	Bharadwaj A	2000	A Resource-Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation
	Brynjofsson E	2000	Beyond Computing: Information Technology, Organizational Transformation and Business Performance
	Tallon P	2000	Executives Perspectives on the Business Value of Information Technology.

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Phase III: Developing the Invisible Knowledge Network between IT Investments and Performance

In this phase, data mapping was conducted and an intellectual structure of the relationship between IT investments and performance was revealed to describe the knowledge distribution process in this area, and to capture a snapshot at a distinct point in time of what is actually a changing and evolving structure of knowledge (Small, 1993).

Based on the completed top 32 highly cited authors list from phase 2, we have to create a co-cited data matrix by counting the frequency of a certain pair of authors that have been cited by the same article in those 8930 references. Then we converted those counts into a (32x32) Pearson correlations matrix to remove difference in scale and to understand how similar the co-cited authors are. This Pearson correlations matrix is also the input for further factor analysis to gain insights regarding the relationships among authors.

FACTOR ANALYSIS:

Authors who work in specific areas tend to build on each other's ideas, and are likely to be co-cited by other scholars in the field (McCain, 1990). By conducting factor analysis, such authors in specialized field tend to load on the same factor. The factor loading indicates the degree to which an author belongs to a factor. A factor thus considers as a subfield whose theoretical underpinnings may be deduced by examining the writings of the authors who load highly on it. Authors who have a prevalent influence on the field will appear in more than one subfield (Nerur, Rasheed, & Natarajan, 2008). Factor analysis, when applied on the co-citation data, is a powerful tool to identify the specialties that constitute an academic discipline.

Only factors with eigenvalue above 1 were extracted. An author with factor loading greater than ± 0.7 is likely to have

		Barua (-0.579)
		Dos Santos (0.568)
		Delone (0.564)
		Brynjolfsson (0.533)

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Factors extracted with loading > ± 0.5

There are three factors have been extracted in this study:

Factor 1: IT and business value in firm level

Factor 1, dominated by authors like Bharadwaj, Rai, Hitt, and Dewan, shows that most of researches focus on where and how IT value is realized in firm level(Bharadwaj, Bharadwaj, & Konsynski, 1999; Rai, Patnayakuni, & Patnayakuni, 1996; Hitt & Brynjolfsson, 1996; Dewan & Min, 1997) The benefits of IS/IT spending have not been found in aggregate output in the late 1980s (Loveman, 1994; Roach, 1991), and there was a so-called “productivity paradox”(Brynjolfsson, 1993).

Scholars were trying to explain this phenomenon by conducting a more rigorous scientific analysis and using more representative data set. Researchers concluded that the sample size, data source, industry character, mismeasurement of outputs and inputs, time lags due to learning and adjustment to any new technology, mismanagement of information technology, and redistribution of profits could be the explanations for the paradox (Brynjolfsson, 1993; Kohli & Devaraj, 2003). Brynjolfsson and Hitt (1996) used 367 large firms data on several components of IS spending for 1987-1991 to realize the potential benefits of IS in firm level. Results show that IT spending has made a concrete and significant contribution to firm output. Other studies, which used larger datasets and more refined research methods, also revealed positive and significant impacts of IT investments on productivity (Brynjolfsson & Hitt,1995; Barua, Kriebel, & Mukhopadhyay, 1995; Dos Santos & Sussman, 2000; Lichtenberg, 1995)..

Factor 2: IT spending and Productivity growth in industry and country level

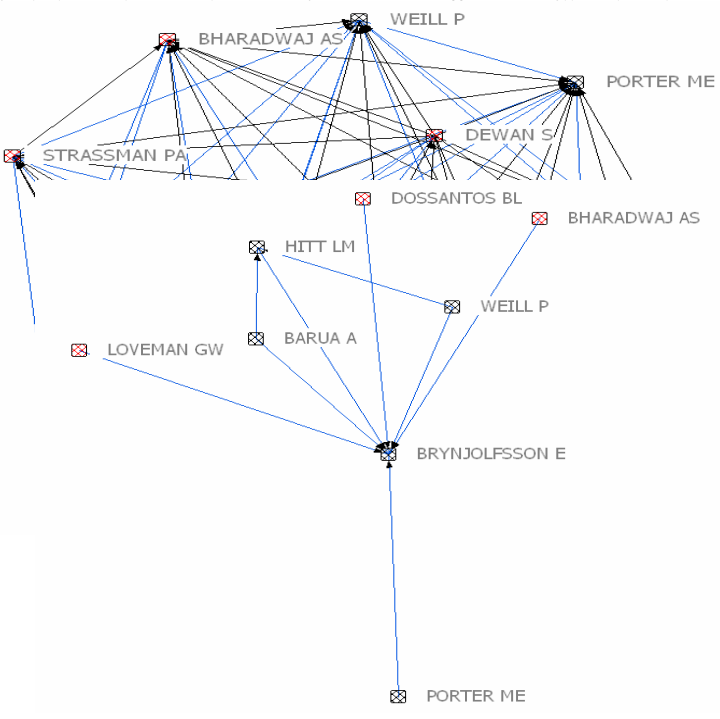
This factor is dominated by authors like Gordon, Berndt, Jorgenson, Gurbaxani, and Bresnahan, shows that through the accumulation of IT spending, labor productivity growth accelerated in many industries and in many countries in year 1995-1999 (Gordon, 2000; Jorgenson, 2001; Gurbaxani & Mendelson, 1990). Jorgenson and Stiroh (1995) examine what the incremental contribution of IT investments has been to US economic growth between 1958 and 1989. They find it’s very important to distinguish the services provided by computer capital in a given year with the value of the computer assets, the annual user costs of computers were larger due to the loss in capital value.

In 1989, the asset value of computer capital was only 4% of the country’s total capital asset value. But as a proportion of the value of the country’s total capital services, computer services accounted for about 22% of the total value. The decreasing prices of computer in the 1980s, have resulted in a large increase in its demand, encouraging organizations to substitute IT for labor and other production factors. Most studies found that productivity increases in the manufacturing industries as well as in service sectors. IT investments also have had a major impact on labor productivity and GDP growth at the country level (Dewan & Kraemer, 2000).

Factor 3: Strategic IT deployment and organizational effectiveness

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Figure 2 Author co-citation mapping with frequency > 20

Both figure 1 and 2 show the two dimensional mappings of nodes (representing authors) generated by the UCINET 6.0 for Windows. The correlation coefficients of high cited authors' matrix are used as proximity measures to determine the placement of each point in space (McCain, 1984). The mapping analysis results provide some interesting insights about the invisible network of the intellectual community in IT investments and performance.

Scholars who study the relationship between IT investments and performance clearly clustered together in the past decades (figure 1). A high level of closure means low variation and a high level of information flow within a cluster (Nerur, Rasheed, & Natarajan, 2008). Figure 2 shows the most important linkages for those authors who have been co-cited above 20 times in this research area. It is clearly to see that Brynjolfsson, Hitt, Weill, and Barua are the top four influential scholars in the study of IT investments and performance in past decades. Brynjolfsson, with 39 co-citation pairs, is the most influential scholar among them. He has published and co-worked with Hitt many papers since 1990s. Brynjolfsson has played a brokerage role between strategic management and other disciplines.

When assessing the benefits of IT, microeconomic theory and business strategy can provide useful foundations. (Hitt & Brynjolfsson, 1996) The competitive strategy (Porter, 1980) has been cited widely since it published. Porter (1985) argued that every company should understand that IT can change industry structure, support cost and differentiation strategies and create sustainable competitive advantages.

CONCLUSIONS AND LIMITATIONS

The study of IT investments and pay off is one of the most important contemporary research topics in IT/IS field. Using articles dealing with the relationship between IT investments and performance between 1980 and 2007 collected in ISI databank, this study demonstrates the application of the invisible knowledge network model in identifying the most influential scholars and publications that have defined the development and growth of the relationship of IT investments and performance, and further in mapping an intellectual structure in this related area.

The development of the invisible network of knowledge model production is an important step forward in systematizing the use of citation data for the study of IT investments and performance research. This proposed model can help us obtain a better understanding of the concepts, ideas, frameworks, and theories related to studies of IT investments and payoff by tracing the research path and mapping the changing structure through the cited references.

This paper is accomplished by conducting a co-citation analysis of the leading authors in this research area. However, this approach has its own limitations. The issue of all citations being treated alike when in fact they are not has been a major source of criticism. (Cronin, 1984) It is unavoidable some degree of subjectivity in deciding the number of authors to be included in an analysis. There could be noise accompany with the data for the way co-citation data are retrieved. Only first author's name is built in the reference databank, however rest of the authors could have equal contributes to the paper. To avoid this possible bias, a co-article approach could be conduct for future study.

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