The Moderating Effects of Network Centrality between IT Initiatives and Firm Performance: An Empirical Study

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***Abstract*— The IS research community has accumulated a critical mass of studies on IT business value, but the questions of how and why IT creates business values remain understudied. In this study, we focus on the role of network centrality and conjecture that network centrality moderates the effects of IT initiatives on firm performance. We collected data of 26 public companies cross 19 industries over a period of 1994-2008 (15 years) and conducted a multiple-level analysis. The results of data analysis show that IT initiatives are significantly, positively related to firm performance only in the high network centrality situation.**

Keywords-IT business value; network Centrality; IT initiatives; firm performance

I. INTRODUCTION

One of the fundamental tasks of the Information Systems (IS) discipline is to measure and promote the business value of Information Technology (IT) [1]. The IS research community has accumulated a critical mass of studies [e.g., 2, 3-5] and proposed a set of productive perspectives to explain how and where IT provides business values, including "IT synergy" [6] , "IT-dependent strategic initiatives" [7], "resource complementarity" [8], "digital option" [9], "competency-based view" [10], and "IT capabilities" [11]. In general, however, the questions of how and why IT creates business values remain understudied [12]. Therefore, it will be interesting to investigate under what influences IT matters more in creating business values.

One of the plausible influences is network centrality, which indicates the position a firm occupies in a network and measured by the number of strategic alliances that a firm has in a network [13]. The link between IT and network centrality seems straightforward, as firms with more strategic alliances need stronger alliancing capability [14] and such capability can be significantly enhanced by a wide adoption of IT [9]. So far, however, studies on the relationship between IT and network centrality is still on the early stage and scholars are calling for more contributions to this topic [15].

In this study, we target on this topic by focusing on the role of network centrality and conjecture that network centrality moderates the effects of IT initiatives on firm performance. We argue that a high network centrality of a firm indicates its operation in an environment where the power of IT can be totally released and the cost of IT initiatives can be justified for improving firm performance. With this conjecture, we collected data from 26 public companies cross 19 industries and the results of data analysis support our argument.

We claim several contributions. First, since there are only very limited studies focusing on firm performance and network centrality, our study helps extend this research stream with potential prolific contributions to IT business value study and draws attention for further research on this topic. Second, we adopt IT initiatives to represent IT, instead of using traditional IT spending. This adoption has been suggested by existing studies [11] but requires more time-consuming, complicated data collection, which may discourage researchers to adopt it. Thus, the results of our study can encourage researchers to rethink of adopting this method. Finally, to our knowledge, our study is among the first ones that provide significant empirical results on this topic.

II. RESEARCH BACKGROUND AND HYPOTHASIS

A. IT Business Value

Traditionally, IT business value research focuses on the economic value such as reducing costs or differentiating products or services that are derived from IT [16]. Numerous case studies demonstrate the value of IT on differentiating service operations [17], improving customer service and increasing switching costs [18], differentiating service support [19], and reducing inventory costs [20]. The general conclusion is that IT can add value to firms in a wide variety of circumstances [16].

As IT applications (computer-based systems) become more and more pervasive, the focus of IT business value research has shifted from whether IT creates value to whether IT creates competitive advantage, a term used to specifically indicate 'win' or 'lose' in business competition. While all companies in the same industry may benefit from IT adoption, only some of them can perform better than others since they compete in the same market for the same population of customers. Because

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most IT applications are readily available to all firms, researchers have argued that IT-based advantage eventually vanishes and IT cannot produce sustainable advantage as a result of imitation of competitors [21]. Moreover, some practitioners even argued that "IT doesn't Matter" by claiming that IT is just like other replicable, standardized infrastructural technologies such as railroads and telegraphs, which create benefits to all firms and cannot provide competitive advantage for just some of them [22].

IS researchers refute this criticism by pointing out that they confuse undifferentiated IT assets like infrastructure, and the ability to manage these assets (so called IT capabilities) [11, 23]. While IT assets cannot create sustainable competitive advantage, IT capabilities are likely to be a source of sustained competitive advantage because they need long time to develop through an accumulating process of trial and error learning [16]. Recent research has identified a batch of IT capabilities that are related to competitive advantage, such as "IT project barrier" [7], "IS integration" [24], "IT-enabled business intelligence competence" [25], "relationship infrastructure", "IT business experience", and "intensity of organizational learning" [23].

While abundant perspectives on IT capabilities exist, few studies provide solid empirical evidence to support the direct relationship between IT and firm performance (the indicator of competitive advantage), mostly due to the challenge of operationalizing IT capabilities, which cannot be measured by using IT spending reported in a firm's annual financial statements [11]. In this study we adopted IT initiatives successfully implemented by firms to represent IT and believe these successes have to be based on firm IT capabilities, which provide competitive advantage. Such adoption has also been supported by recent studies [15, 26].

B. Network Centrality

The concept of network centrality was introduced by Bavelas in 1948 for solving human communication problems [27]. An actor's (participant) position is called centralized "to the extent that all relations in the network involve him" [28, p. 92]. This term is used to describe the inequality in actors' relations in a network [29]. Basically, network centrality indicates the extent to which an actor is directly connected to other actors in a network. An actor with high degree of centrality has the visibility or the potential for communication activities in a network and enjoy plenty of opportunities to get access to resources of their network partners.

In the scenario of organizations, network is presented as connections of strategic alliances that a firm enters for some specific purposes. Strategic alliances are defined as "voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services" [13, p. 293]. A strategic alliance involves at least two firms, which remain legally independent, share benefits and managerial control over the assigned tasks of the alliance, and make continuing contributions in strategic areas [30]. Strategic alliances are presented in many different forms, which are considered "hybrids" that combine varying degree of hierarchical relations (one firm acquires or mergers another firm) and market relations (arm's-length transactions coordinated only through the price mechanism) [30]. There exist a variety of forms of strategic alliance, such as joint ventures, equity investments, R&D consortia, franchising, and licensing (see [30] for a comprehensive view of basic forms of strategic alliance).

Recent research explores the effects of centrality in strategic alliance network on a variety of topics, such as innovation, knowledge acquisition, venture performance, firm survival, and system use. For example, Owen-Smith & Powell [31] found centrality in a geographically dispersed network will positively affect innovation. Stam & Elfring [32] detected negative effects of network centrality on new venture performance. Tsai [33] revealed positive effects of network centrality and absorptive capability on business unit innovation. Hansen [34] found that the combination of knowledge relatedness and network centrality explained knowledge acquisition, but any of them could not provide explanation individually.

C. IT and Network Centrality

The relationship between IT and network centrality (as a network structure) can be investigated from different perspectives. An early case study recorded the failure of an Inter-Organizational Systems (IOS) implementation in a dense network [35]. Based on that case, Kumar and his colleagues argued that there should be a third rationality (i.e., that of relationships and trust) of information systems to explain the IT phenomena in networks. In that study IT negatively interacted with network structures because the purpose of using IT was to facilitate collaboration but collaboration is already a basic characteristic in a dense network [36]. A recent study took a perspective of IT-enabled capability to investigate the effects between IT and network structures on firm competitive actions [15]. Based on the awareness motivation-capability theory, Chi and her colleagues argue that IT-enabled sensing and responding capability moderates the relationship between network structures and competitive actions. They concluded that IT-enabled capability can substitute the effects of network structure or complement these of network density.

In this study, we take a perspective of network centrality moderating the relationship between IT and firm performance. The basic argument is that IT does have power, but such power is very expensive and can be justified only in situations where firms need such power for competition. In other words, there are situations where competition is not determined by the use of IT (such as oil extraction industry) so that the cost of adopting IT cannot be justified. In an alliance network, firms need the capability to maintain alliances and deploy resources obtained from alliance partners effectively (so-call alliancing capability). We argue that alliancing capability is significantly enhanced by, or dependent of, the adoption of IT applications. This argument can be understood from two aspects. First, for effective coordination and cooperation among alliance partners, IT is indispensable [37]. Second, to effectively mobilize and deploy network resources with their own resources, firms are suggested to digitalize their processes, which requires wide adoption of IT applications [9]. Thus, alliance networks do present situations where the cost of

adopting IT can be justified. Since IT initiatives are projects related to IT implementation, they can be used to indicate the level of IT adoption. Thus, it is reasonable to argue that the effects of IT initiatives (representing the power of IT) on firm performance are more significant within alliance networks. Since network centrality represents the number of alliances that firms enter, we argue,

Hypothesis: network centrality moderates the effects of IT initiatives on firm performance.

III. METHODOLOGY

A. Firm Performance

In this study we adopted three major financial indicators of firm performance: return on assets (ROA), operating expenses to sales (OEXPS), and Tobin's q (the ratio between the market values and the physical asset values of a firm), all of them are widely adopted in IT business value studies [e.g., 4, 5, 11, and 38]. Especially, ROA refers to the capability of a firm to create profit, OEXPS to reduce cost, and Tobin's q to increase market value (stock price).

B. Control Variables

This study compares firm performance among different companies across different industries. To make these companies comparable, firm size and industry type need to be taken into account. Firm size is indicated by the number of employees in a firm and widely used as an important control variable in firm performance studies [5, 11, 39]. Industry types can be distinguished by average industry R&D spending, which indicates the level of industry dynamism [26]. To obtain adequate samples, we adopted a longitudinal study (1994-2008), which requires to control the effects of time factor since firm performance may be influenced by some events occurred in specific years. Thus, we include firm size, industry type, and year as control variables in this study.

C. Sample Selection

This study focuses on IT business value especially within alliance networks. There are several important considerations for the sample selection. First, companies are actively involved in network alliances. Second, to avoid unbalanced media attention that companies might get, companies are leaders in their industry (i.e., included in Fortune 500 or S&P 500) and public companies in the U.S. Third, companies are in industries that report some level of R&D spending in their annual statements[1]. Fourth, because this is a cross-industry study, there should be a balanced representation of companies from different industries. Based on these criteria, we obtained a sample of 26 companies across 19 industries as presented in Appendix.

[1] This requirement is important because the level of R&D spending usually indicates the dynamism of external environments [26].

D. Data Collection

Scholars have pointed out that two major popular computer journals, Computerworld (CW) and InformationWeek (IW) cover 80%-90% of the news about various IT practices in the U.S. [11] and have been used as the major data sources in a number of other studies [38, 40, 41]. Following this practice, we adopted LexisNexis database, which includes these two major computer journals as well as eWeek, as the data source for information about IT initiatives deployed by the sample companies during the 15-year span.

The number of strategic alliances that a firm maintained in a specific year was calculated by using data from the SDC Platinum dataset, which is regarded as one of the most comprehensive sources of data on alliances [42, 43] and widely used for strategic alliance network studies [e.g., 44, 45, 46]. Data of firm performance, the number of employees in a firm, and the average industry R&D spending were obtained from COMPUSTAT.

E. Sensitivity Test

Because this study includes 26 companies cross 19 industries, some industries are represented by more than one company. To address the uneven distribution issue, we chose only one company every time from these industries and tested how sensitively these changes will influence the conclusions. The results show that there is no significant influence on the conclusions by including different companies from these industries.

F. Data Analysis

Longitudinal data with multiple companies are usually clustered, or nested because observations within companies (level 1) are typically more similar than observations between companies (level 2). Various methods are used to address the issue of nested data, such as disaggregation/aggregation, ANCOVA/Fixed effects approach, and multilevel modeling. In this study we adopted multilevel modeling (MLM) for data analysis. Compared with other methods, MLM treats clusters as if they are sampled from a larger population of clusters and enhances the generalizability of results. In other words, cluster–level effects are not estimated separately for each cluster and regression weights are assumed to have a particular distribution across clusters. Moreover, MLM is particularly well-suited to the analysis of longitudinal data (i.e., repeated measures on the same individuals over time) because it allows varying intercepts and varying slopes and models multilevel growth (e.g., changes over years are allowed different within clusters and between clusters). To justify the use of multilevel analysis, we first calculated the intra-class correlation (ICC), which is the proportion of observed variance that is between units (the between- and within-cluster variances sum to the observed variance) and similar to R^2 in regression. All ICCs for the three firm performance indicators are over .40, which indicates MLM is worthwhile [47].

With MLM, we created the statistical model:

First level:

$$y_{ij} = \beta_{0j} + \beta_{1j}\,\mathrm{Year}_{ij} + \beta_{2j}\,\mathrm{FirmSize}_{ij} + \beta_{3j}\,\mathrm{IT\ Initiatives}_{ij} + e_{ij}$$

Second level:

$$\beta_{0j} = \gamma_{00} + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10} \qquad e_{ij} \sim N(0, \sigma^2_e)$$

$$\beta_{2j} = \gamma_{20} \qquad \mu_{0j} \sim N(0, \tau_{00})$$

$$\beta_{3j} = \gamma_{30}$$

Subscript i represents firms (i = 1 to 26) and j represents years (j =1 to 15), respectively. β is the coefficient (slope) of the independent variables and β0 is the intercept at the level-one. μ is the coefficient (slope) and γ is the intercept at the level-two. σ is the variance at the level-one and τ is the covariance at the level-two.

To test the moderated effects of network centrality on firm performance, we created high and low network centrality groups. High centrality group includes 299 observations with strategic alliances range from 6 to 62, and low centrality group includes 292 observations with strategic alliances range from 0 to 24.

IV. Results

Tab. I provides the descriptive statistics and correlation matrix of all variables included in the analysis. As expected, all three indictors of firm performance (i.e., ROA, OEXPS and Tobin's q) are highly, significantly correlated with each other, which indicates that those indicators reflect the profitability of a firm from different aspects. Industry Type is significantly correlated with ROA and OEXPS, not IT initiatives and Tobin's q, which indicates that differences on performance are significant cross different industries (but no significant differences on IT initiatives and Tobin's q). Year is significantly related to Industry Type, IT initiatives, ROA, OEXPS, and Tobin's q, which indicates that average industry R&D spending, IT initiatives, and three performance indicators varies significantly in these years. Firm Size are significantly correlated to Industry Type, IT initiatives, and Tobin's q, which indicates that firm size is different cross industries, related to IT initiatives and Tobin's q. Thus, the correlation relationships justify the inclusion of those control variables.

TABLE I. Descriptive Statistics and Correlation Matrix

	N	Mean	Std Dev	1	2	3	4	5	6
1	299			1					
2	299	41	40	.08	1				
3	299	122	98	.35[c]	.38[c]	1			
4	297	.89	.80	-.21[c]	.20[c]	.05	1		
5	299	.06	.09	-.12[a]	.07	.30[c]	.14[b]	1	
6	299	.81	.13	-.10[a]	-.09	-.37[c]	-.13[b]	-.53[c]	1
7	286	2.78	5.65	-.15[b]	-.17[c]	.01	.19[c]	.17[c]	-.21[c]

a. Significant at 10%; b. significant at 5%; c. significant at 1%; 1-year, 2-firm size, 3-industry type, 4-IT initiatives, 5-ROA, 6 OEXPS, 7-Tobin's Q

The results of data analysis for the low network centrality group (LOW group) and the high network centrality group (HIGH group) are compared in Tab. II. As we can see, the estimates of the coefficients for the HIGH group are all bigger both in size of coefficients and significance level than those of the LOW group. Specifically, compared with the values from the HIGH group, the estimates of the coefficients for ROA, OEXPS, and TOBIN'S Q in the LOW group are all statistically insignificant. Thus, our hypothesis that network centrality moderates the effects of IT initiatives on firm performance (ROA, OEXPS, and Tobin's q) is supported.

TABLE II. Comparison between Groups

	High Centrality Group		Low Centrality Group	
	coefficients	*p value*	*coefficients*	*p value*
ROA	0.00931[a]	0.09697	0.00519	0.38410
OEXPS	-0.01361[b]	0.02019	-0.01070	0.12922
TOBIN'S Q	0.84411[b]	0.04390	0.26460	0.49465

a. Significant at 10%; b. significant at 5%

V. Discussion

The results of data analysis support our hypothesis for all three firm performance indicators (ROA, OEXPS, and Tobin's q), with different levels of significance and sizes of coefficient for the high network centrality group. However, the statistical relationship between ROA and IT initiatives is only marginally significant. At the same time, the coefficient is rather small (0.009). Even though small coefficients are very common in firm performance studies, comparing with the other two firm performance indictors (OEXPS and Tobin's q), we can see that ROA is not the best indicator of the effects of IT initiatives on firm performance. This finding confirms the suggestion from existing literature that operating income/cost (OEXPS) is a more appropriate measure of the direct value of IT because net income (ROA) also includes non-operating income, such as stock investments [48].

Moreover, the coefficient of Tobin's q is the biggest among the three performance indicators. The fact is also observed within the LOW group, even though their p-values are not significant. There are good reasons for this finding. First, the effects of IT initiatives on firm performance usually take years to present [49]. Since Tobin's q represents future firm performance, the strong relationship between IT initiatives and Tobin's q indicates that IT initiatives do have influence on firm future performance. Second, Tobin's q is based on perceptions of investors, which will be influenced by media reports [50]. Since IT initiatives are reported on media, it make sense to find that IT initiatives are significantly related to Tobin's Q.

VI. Limitations, Implications, and Future Research

The major limitation in this study is the sample size. Unlike other disciplines, such as psychology, where scholars can easily found thousands of similar subjects, organizational studies are always challenged by finding enough similar sample companies. This study included 26 companies cross 19 industries in a 15-year time span (1994-2008). Even though the sample size is comparable with other similar studies, such as 12 companies overs 16 years (1988-2003) in [15] and 20 companies over 7 years (2000-2006) in [51], we believe that a bigger sample size can potentially reveal more information. We remind readers to keep this limitation in mind when interpret the findings of this study.

Since our study is among the first ones to provide empirical evidence on the moderating effects of network centrality on the relationship between IT initiatives and firm performance, it has

important implications. First, traditional IT business value studies usually adopt IT spending to present IT but fail to find the direct relationship between IT and firm performance. Our study suggests that IT initiatives, rather than IT spending, is a better representative of IT for IT business value research. Second, our study can attract more attention of scholars to investigate important moderating as well as mediating factors between IT and firm performance. Finally, studies on the relationship between IT and network structure is still in the early stage. Our study is calling for more efforts on this topic.

For future studies, we encourage scholars to extend our study and include more network structure measures, such as structural hole [52] and simmelian tie [53]. We believe that the relationship between IT and network is complicated and need to be studied from multiple perspectives. We also believe that as IT has become more and more pervasive, research on the relationship between IT and network structures will provide more guides on important topics, such as how to use IT effectively and how to obtain competitive advantage by using IT in today's network environments.

VII. Conclusion

The debate over whether IT can create competitive advantage has been going on for over a decade. On the one side, IT does become affordable for most companies. On the other side, the patterns and levels of competition have continuously changed. To understand the role of IT in the complicated process of competition, researchers need to develop multiple perspectives of IT. While IT does become affordable for most companies, we do not believe that most companies use IT effectively. Moreover, other factors, such as network structures, can moderate the relationship between IT and competitive advantage. Our study provides empirical evidence to support the direct connection between IT and competitive advantage in highly strategic alliance networks. We expect further studies will find more direct connections in other environments.

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APPENDIX

Johnson Controls Inc
DuPont
Bristol-Myers Squibb Co, Merck & Co Inc, Eli Lilly & Co, Pfizer Inc
Sigma-Aldrich Corp
Dell Inc
EMC Corp
Pitney Bowes Inc
Harris Corp, QUALCOMM Inc
Advanced Micro Devices Inc
Lockheed Martin Corp
Raytheon Co
Hasbro Inc
Comcast Corp
Tech Data Corp
Ingram Micro Inc
American Express Co
Yahoo! Inc
Autodesk Inc, Electronic Arts Inc
McAfee Inc
Unisys Corp
Acxiom Corp