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2008

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ABSTRACT

While a significant number of organizations have attempted to build relationships with their upstream and downstream business partners through inter-organizational systems, not many have been able to successful leverage their investments in such systems. In this paper, we present a framework to analyze complementarities to understand their role in the value added by information technology (IT) in extended enterprises. Our framework integrates inter- and intra-organizational perspectives from the information systems (IS) standpoint and extends the notion of complementarity between and within processes and technologies at the firm level to the level of extended enterprises. Specifically, we discuss three complementarities, those between processes, between technologies, and between processes and technologies within and across the firms participating in the extended enterprise. We illustrate the utility of the framework by citing the experiences of Cisco, Dell and Ford as examples. The primary contribution of this research lies in the utility of the framework to evaluate the determinants of the performance of IT in an extended enterprise. Practitioners can use this framework to rethink and re-deploy the complementarities that exist inside their organizations and extend them to their suppliers, customers and strategic partners.

Keywords

Information system value, extended enterprise, complementarity.

INTRODUCTION

The advent of Internet and other technologies such as electronic commerce, electronic data interchange (EDI), or Intranets and Extranets have allowed organizations to extend their organizational boundaries to form extended enterprises. An extended enterprise (EE) includes organizations that collaborate to act purposefully. Organizational participants include customers, suppliers and partners and other alliance partners. Other terms that have been used in the literature to describe the 'extended enterprise' concept include value chains, or value networks. While information and communication technologies have provided the necessary push for organizations to form relationships with their upstream or downstream business partners, there remains a lack of clarity on how such technologies add value to various entities participating in an extended relationship (Riggins et al., 1994). Some organizations have been able to leverage their investments in information technologies (IT) by building extended relationships with business partners better than others. For instance, Dell and Cisco can be considered as exemplars of extended enterprises in terms of the leverage that they have been able to derive from their IT investments in successfully managing relationships with their business partners. On the other hand, the experiment of building an electronic exchange, COVISINT, by auto manufacturers such as General Motors and Ford Motors to forge relationships with their suppliers has not met with much success (Baldi and Borgman, 2001). So, the difficult issue before organizations that have already invested in technologies to extend their organizational boundaries and those that are trying with the idea of investing in such technologies is understanding how information technology (IT) impact the internal and external performance of an EE.

In this paper, we develop a framework premised on the notion of complementarity that addresses both technology and process variables in the context of an EE to analyze the impact of IT on EEs. Our framework integrates inter- and intra-organizational perspectives from the IS standpoint and extends the notion of complementarity between process and technology artifacts at the firm level to EEs. We illustrate the utility of the framework by citing the experiences of Cisco, Dell and Ford as examples.

The outline of the paper is as follows. The next section provides background and motivation for this study. Subsequent section presents a complementarity based framework for the EE followed by a discussion on performance determinants of the EE. We conclude the paper by discussing implications for research and practice.

BACKGROUND AND MOTIVATION

The study of IT value in general, and in the context of technologies that have the potential to extend organizational boundaries such as Internet, necessitates analysis across levels of organizational abstractions such as firm level or inter-firm level or even the individual level. Such a study, that spans multiple levels of abstraction, requires a cross-disciplinary perspective.

To that end, we identify three perspectives or views that are helpful to understand the potential, impacts and consequences of IT for organizations. The first view is firm-centric and takes into account strategic issues at the firm level. This strategic viewpoint addresses the issue of strategic value of IT and is premised on Porter's work on the five forces model (Porter and Millar, 1985). Strategic value, from an organization's standpoint, can be considered to be the value associated with long-term implications for the survival and growth of an enterprise as also its relations with customers, competitors and collaborators. However, in many situations, the development of an organizational strategy depends on the power relationships within an alliance that the organization is a part of. This alliance is almost always the EE. As a result, it is important to examine the nature of an organization's linkages to other players in the EE to understand IT value in an EE.

The second view, the network view, distinguishes itself from the firm view by moving away from the purely atomistic view of the firm. It addresses firms as embedded in the networks of social, professional, and exchange relationships with other individual and organizational actors (Gulati, 1998, Gulati et al., 2000). From this standpoint, collaboration, strategic alliances, extended value chains, and EEs – linkages that bind entities - accord business value. Therefore, IT that can help organizations in either building such alliances or sustaining such relationships over time effectively can lead to business value. The network viewpoint also addresses the issue of social value. The notion of social value is derived from the concept of social capital (Putnam, 1993). The term social capital refers to a "virtuous circle" of trust, including group membership and informal social ties. From this standpoint, social value can be associated with membership in a community or communities. The implication of this viewpoint from IT standpoint lies primarily in terms of facilitating the process of forming and maintaining alliances and distributing the negotiating power that alliance partners have in an EE.

The third view, the economic view, which emanates from the transaction cost economy tradition, has been adopted to analyze the migration from hierarchical structures to market-like structures as a result of diminishing coordination costs. The economic viewpoint addresses the issue of economic value. Economic value can be defined to be the value associated with reduced costs of doing business and/or increased revenues due to improved reach. However, assessing economic returns for IT is challenging. The challenge is heightened in the case of Internet technology and associated e-commerce initiatives that form the basis of EEs in the majority of such endeavors.

In summary, from the IT value standpoint, the firm view helps address the question of how IT adds value to an organization. While the strategic view, exemplified by Porter's five forces model, is adequate in many situations, it fails to take into account the network of relationships that an organization is embedded into and how this affects organizational performance. The network view shifts the focus to the EE and allows us to analyze how IT adds value to the EE. However, the network view is an emerging view that has not been used adequately in studying impact of IT on EE. The economic view spans across the firm- and network views but has been employed primarily at the firm level to study impact of IT on a firm's economic performance, yielding some valuable insights. Our research adopts the notion of complementarity to develop an integrated framework to analyze how IT adds value in an EE. When resources are complementary, their potential to create value is particularly enhanced (Milgrom et al., 1991). Since, in EEs each partner excels in particular sub-processes and/or has a critical knowledge about the process or access to resources, we use complementarity insights from the firm level and extend them to the network of organizations.

PROPOSED FRAMEWORK

The proposed framework is premised on the idea of complementarity not only among technologies and processes across the *extended* value chain that IT enables but also the intra -process and intra-technology complementarities. We extend the notion of complementarity in influencing IT value at firm level to EEs where levels of complementarities are much more complex and difficult to isolate. The current stream of research largely ignores the complementarities that exist across intra or inter-organizational processes or those that exist across a set of technologies being implemented by the firm and its business partners. Such complementarities are important in context of EE where a set of organizations with different business processes and different IT infrastructures attempt to leverage their investments in IT. From this standpoint, in the framework presented in Figure 1, we identify three types of complementarities in the EE that have the potential to influence performance of IT in an EE.

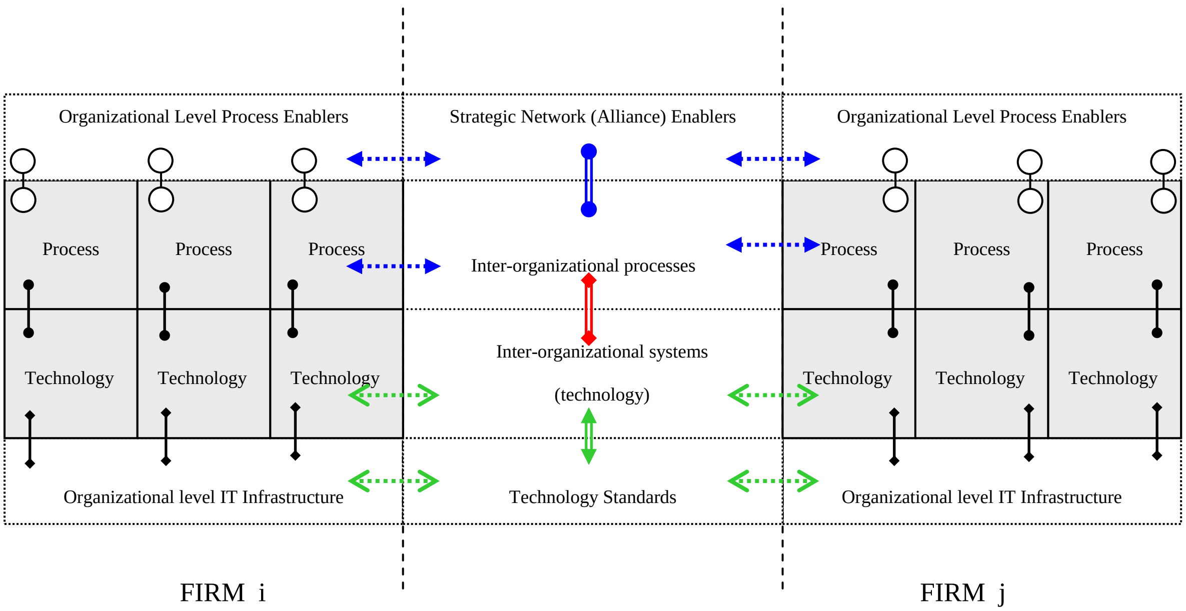
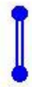
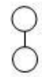


Figure 1. Proposed Framework

These include complementarities across processes (process-process or P-P complementarity), complementarities across information technologies (technology-technology or T-T complementarity), and complementarities across processes and information technologies (process-technology or P-T complementarity). In an EE, these three complementarities can exist at three levels, namely, at the individual organization level, across the participating organizations (inter-organizational level), or at the boundaries of the participating organizations. The notations and symbols used in Figure 1 are explained in Table 1. The only complementarity that is not shown is that between processes and technology at the organizational boundary. We now examine each of these complementarities both within a firm and across firms.

Table 1. Explanation for Figure 1

Complementarity	At the inter-organizational level	At the intra-organizational level	At the boundaries
Process complementarities (P-P)			
Technology complementarities (T-T)			
Process- technology complementarities (P-T)			Not shown

Process-Process (P-P) Complementarity

Process-process complementarities indicate the leverage individual processes provide to other organizational processes to exploit the investments in technological resources. For instance, some organizational cultures enable process improvements while others inhibit such improvements. Organizational culture, often determines the ways IT is used and managed (De Lisi, 1993). In context of IT value, information orientation (Marchand et al., 2000) is a manifestation of the complementarity of organizational (enterprise-wide) processes and processes related to IT management and IT use. Marchand et al. (2000) show how processes associated with technology practices, information management and information behavior and values co-create IT value for an organization. The lack of process complementarity manifests itself in what Keen (1997) calls the process paradox. This is the case where individual processes improve (some times dramatically) but such improvements do not translate into business value. At the inter-organizational level, process complementarities can be understood as the complementarity between processes that are external to the organization and those processes that exist inside an organization. For instance, the ingredients (processes) that allowed Dell to form strategic linkages with Sony and UPS, are the same one that can be utilized by others (which they probably employ). However, no organization has been able to replicate the efficiency of Dell's supply chain. Processes can include high level routines like social capital development or new products or service development that lead to network effects and alliance formation. The relationship between supply chain management and electronic commerce is an example of inter and intra-organizational process-process complementarity. Electronic commerce is an extra-organizational process and derives from the transaction perspective while supply chain management is both an internal and external process and derives from the flow perspective (typically end-to-end flows of goods and services in the entire supply chain).

Inter-organizational complementarities exist between processes of the two alliance partners that form an EE. These complementarities can exist at multiple levels. For instance, there is a reflexive relationship between the alliance forming capacity for an organization (levels of trust, processes in place, technologies in place) and relationship quality or alliance quality. This type of complementarity is shown in Figure 1 as the complementarity between strategic network processes and organizational level processes. The implication of such complementarities, in the context of extended organizations, is that processes, in separate organizations that are linked by information technology (e.g. supply chain processes), need to resonate with each other (or match each other), in order to provide IT-enabled value.

Technology –Technology (T-T) Complementarity

Complementarities exist within and across technologies too. Some technologies work well with others and allow other technologies to build upon them. This complementarity can best be conceptualized in terms of IT infrastructure and the application portfolio. For instance, a robust network and telecommunication infrastructure is necessary in order for a multi-location or global enterprise system (like an ERP or EWIS). Investments in enterprise systems are either preceded or followed up by investments in strengthening IT infrastructure. As an example, Enterprise Application Integration (EAI) technologies benefit from the existence of a central database (a data warehouse perhaps), and a communications infrastructure that provides web like connectivity for users. Although it is possible to provide an EAI solution without these supporting technologies, the resulting solution is likely to be sub-optimal and relatively weak in terms of flexibility and scalability. Another example of a complementary investment in technology is in the context of server sizing. More often than not, servers that host ERP applications are undersized and this shows up only after systems go live. According to Porter (2001) the "technological possibilities available today derive not just from the Internet architecture but also from complementary technological advances such as scanning, object-oriented programming, relational databases, and wireless communications (p. 15)."

In context of technologies that facilitate EEs, Hale (2002) analyzes the complementarities in EDI and e-commerce technologies. According to Halé (2002) rather than competing against each other, EDI and Internet-based commerce will grow together because they have complementary attributes that suit different requirements. Halé provides an interesting example of this complementarity in the vehicle registration offered on-line by the State of California. This system combines a Government-to-Citizen (G2C) portal with on-line links to insurance companies (B2B). Users can register their vehicle on-line while the system checks their insurance status through an electronic Proof of Insurance and complete the registration. This application, which has been used by 400,000 users, is capable of 6,000 simultaneous transactions and a rate of 10 transactions per second at peak time.

Other technology complementarities are emerging and organizations are working toward explicitly aiming to leverage such complementarities. ERP applications and Knowledge Management (KM) applications represent one such complementary pair of technologies. Based on a detailed case study that was designed to explore whether KM and ERP technologies were contradictory or complementary, Newell et al. (2003) report that both the ERP and KM initiatives encouraged the enactment of metaroutines. It is interesting to note that ERP and KM are both considered processes as much as "technologies" and hence when we expect technology-technology complementarities to play out, we need to implicitly assume that the underlying processes are there for those complementarities to be enacted out. From the vantage point of EEs, IT value is enhanced when technologies (that exist inside organizations that form an EE) are compatible with each other or help leverage one another.

Process -Technology (P-T) Complementarity

Process-technology complementarities at the inter-organizational level refer to the complementarities between technologies and processes that have to do with inter-organizational systems (IOSs). Technological aspects include extranets, security frameworks, and technology standards. Process issues have to do with supply chain management, creation and maintenance of strategic networks and IT governance frameworks or even inter-organizational routines (Pentland, 2004).

An example of such complementarity can be seen played out in the success and horror stories associated with ERP implementation. Those organizations that have strong and mature processes (work processes and IT implementation processes) find it relatively easier to implement ERP and are more likely to see meaningful returns on their investments. Organizations that have weak processes and tend to use ERP implementations to formalize or rationalize their internal work processes find ERP implementation to be a painfully process. Such implementations are often disruptive and even when they "succeed" they do not result in the expected returns on investments. Many dotcoms succumbed to the lack of process-technology complementarity when they failed to develop the back-end and delivery systems once they had the website up and an increasing number of customers started placing orders. The early e-commerce pioneers concentrated on the end of the action that they reckoned to understand: website design and snazzy marketing (Anonymous, 2000). Many outsourced the whole tiresome business of order checking and distribution. In its early days, even Amazon relied wholly on Ingram's book-wholesaling operation. Consumer-electronics sites left the business to Micro, another big wholesaler and distributor. Everybody used United Parcel Services (UPS), Federal Express or the post for delivery. Yet two things soon became clear. One was that shipping costs were (and remain) one of the biggest deterrents for consumers considering online purchases of physical products. The second was that traditional warehouse and distribution centers were not well suited to the business of e-commerce fulfillment: if it is to work properly, it needs newly designed systems. Both these things have combined to undermine some of the economic advantages of online shopping. The process-technology complementarity is by far the most interesting from at IT value perspective. This is because the adoption of IT for an EE is not just a decision made by individual and isolated firms. It is embedded in an on-going social and technological context created by a group of organizations. The diffusion and infusion of technology requires considerable changes and modifications to organizational processes and practices. As always, technology adoption can never be just a question of installing some new hardware, or adopting a new software package. A wide range of organizational and managerial changes are required in all participating organizations of the EE to absorb and leverage the technology.

Having discussed the three types of complementarities in our framework, we argue that that the extent to which such complementarities can be achieved depends on two factors, namely, degree of integration in EE and depth of integration with the business partners. In the next section, we discuss these two aspects.

DEGREE OF INTEGRATION IN EE

Process and technology complementarities (IOP_{ij}, IOT_{ij}) at the inter-organizational level are influenced by certain parameters determined by the strategic alliance enablers. One such parameter is the degree of integration across the EE that can be described in terms of the nature and the extent of interaction possible between partners. For example, the interaction between two partners can be either unidirectional or bi-directional. That is, a supplier may be able to track order information in his downstream partners' system, but the partner may not be able to check, say, inventory levels of the supplier.

We illustrate the importance of this point using Cisco's $2.2 billion inventory write-off in the third fiscal quarter of 2001, which was later attributed to supply chain inefficiencies. A major part of the problem was the process of collecting data (that were noisy) to feed into sophisticated forecasting models. In addition, the inflation of demand across supply chain tiers led to a build-up of inventory. There is evidence to suggest that forecasting results within Cisco and those within its suppliers were diverging. However, the nature of relationship (I order, you make) implied a one-way information flow. One of the suppliers believes that "it would have been presumptuous to confront a company like Cisco and tell it was wrong. When had Cisco ever been wrong?" But it is clear that that over-reliance on the forecasting technology led people to undervalue human judgment and intuition, and inhibited frank conversations among partners (Berinato, 2001). Their process maturity was much less than their technology maturity. This lack of complementarity ran counter to the insight offered by their CFO who, while explaining Cisco's real-time accounting system, considers the key to lie more in the process than the technology (Carter, 2001). This also highlights the difference between control and coordination. Accounting inside Cisco implied control over information and processes. Coordinating with alliance partners (in the context of outsourced manufacturing) implies less use of control and more dependence on contractual clauses and negotiating processes. This is an example of inter-organizational process complementarity.

DEPTH OF INTEGRATION IN EE

Another aspect of the EE is the number of tiers across which partners attempt to integrate. It may be desirable in a particular EE to have integration across all tiers, whereas in others integration with immediate partners may suffice. Here again, the ability to be able to integrate across multiple tiers is a function of individual firm capabilities in terms of process and technology capabilities. As an example, Ford's foray into establishing technology-based linkages with its suppliers was affected by the suppliers' ability (financial and organizational) to implement intranet technologies. This is an instance where lack of internal complementarities in tier two and tier three suppliers limited the integration of the EE. In this scenario, inter-organizational complementarities remained weak at the technology as well as process levels (Austin, 1997).

Factors that may help organizations determine the number of tiers across which to integrate could be based on the value added along each of the tiers. For example integration is more desirable at downstream stages of the EE when substantial value would have been added and thus it becomes critical for partners to exchange information to manage inventory levels and product flows. The implication of this can be seen in the emerging structures of EE, typified by hubs/exchange structures at upstream stages and tightly coupled links at the downstream stages. For example, a supplier could be part of a market exchange (buy side) though which it acquires materials that it supplies to individual firms on the sell side through individually and strongly coupled links with each firm. Exchanges make sense when commodities (or raw materials) are involved. Recent work by Cavusoglu et al. (2005) provides encouraging evidence of such value in terms of cost savings and potential loss in the context of security value by way of the finding that optimal configuration of intrusion detection system (IDS) depends not on the firm's internal cost parameters but on the external hacker parameters.

A FRAMEWORK FOR MEASURING IT VALUE IN EE

The success of an organization is increasingly being equated with the success of the EE it participates in. The complementarity framework discussed earlier provides a mechanism to relate the performance of information technology in an EE to three types of complementarities, namely, P-P, T-T, and P-T that are either present in the individual firms participating in extended relationship or those that emerge from their relationships. When assessing value of IT in an EE using the complementarity framework discussed earlier, one needs to realize that there exists a hierarchy of complementarities across processes, across technologies, and across the tier of the supply chain or the value chain to which an a particular entity in the EE belongs. For example, for two firms i and j participating in an extended relationship, not all business processes in firm i or j are likely to be complementary to each other nor will all the business processes in firm i be complementary to all the business processes in firm j. The same applies for the complementarities observed in the technologies implemented in the two organizations. Therefore, to identify the processes and technologies across which complementarities exist in an EE, a hierarchy of such complementarities needs to be developed. Also, it is difficult to establish the same level of complementarity in business processes or technologies across all tiers of business partners in an EE. It is very likely that business processes and technologies between immediate business partners will exhibit highest level of complementarity than that between a firm and its business partner who is farther down the value chain. Therefore, to formalize IT value mathematically in an EE involving two firms i and j , one can conceptualize it as:

IT Value (in EE) = function (…, …, IOP_{ij}, IOT_{ij}, Degree of integration, Depth of integration …) … (1)

where IOP_{ij} and IOT_{ij} refer to quality of inter-organizational processes and technologies between firms i and j.

Equations (2) and (3) formalize the process-technology complementarity relationship at the inter-organizational level where IOP_{ij} has been posited as a function of IOT_{ij}.

IOP_{ij} = function(P_{ik}, P_{jk}, IOT_{ij}, Strategic Alliance Enablers) … (2)

IOT_{ij} = function (T_{ik},T_{jk}, IOP_{ij}, Technology Standards) … (3)

P_{ik} and T_{ik} represent k^{th} process and technology respectively in firm i while P_{jk} and T_{jk} represents k^{th} process and technology in firm j.

Replicating the same logic for the processes and technologies in the individual firms i and j, we can represent the process and technological complementarities as:

P_{ik} = function(P_{im}, T_{ik}, Strategic business choices)

T_{ik} = function(P_{ik}, T_{im}, Technological choices)

P_{jk} = function(P_{jm}, T_{jk}, Strategic business choices)

T_{jk} = function(P_{jk}, T_{jm}, Technological choices)

The above sets of functions represent a way of formalizing IT value in an EE using process-process, technology-technology, and process-technology complementarities between two organizations in an extended relationship. However, if there are more than two participating organizations, another factor, depth of integration, will affect IT value. So, for more than two organizations, IT value function will be:

IT Value (in EE) = function (…., …., IOP_{ij}, IOT_{ij}, Degree of integration, Depth of integration,….,) … (4)

In this case, degree of integration could vary across different tiers of business partners in the value chain. A model formulated in this manner lends itself to theoretical and empirical analysis. For example, theoretical analysis could investigate the nature of these functions in terms of supermodular characteristics (Barua et al. 1995). Such an analysis would help determine the optimal levels of investments in technology and processes, for various organizations and their interfaces in the EE. Empirical analysis could be conducted to verify the nature of complementarities at the EE level and relate them to complementarities the firm level (Bresnehan and Brynjolfsson, 2001).

CONCLUSION

We have suggested an IT value framework based on the notion of complementarity in context of an EE. This framework can be used to model the effectiveness of IT in an EE in terms of the complementarities that exist between process and technology dimensions across and within individual firms. Case-based evidence and examples provided to support the arguments presented in the paper seem to suggest that existing organization with strong processes stand to benefit the most from emerging technologies. This is consistent with earlier phenomena observed in the context of ERP and IT-enabled reengineering initiatives in the early 1990s. EEs that have existing investments in well defined processes for partnering and governance structures are able to leverage the potential of emerging Internet technologies to experience dynamic stability (Boynton, 1993) in a hyper-dynamic environment.

Implications for practitioners can be derived from the framework. A firm can determine, based on this framework, the degree of fit between processes and technologies internal to the firm and those outside it. This allows a firm to better understand how IT impacts the performance of the EE it participates in. From a research standpoint, this framework opens up new avenues to investigate. Questions that deserve attention include the following: Do performance characteristics of the EE display properties of super-modularity in terms of the inter-organizational process and technology dimensions? What are the optimal levels of the process and technology variables in different EEs? Empirical evidence will help establish specific relationships between the variables identified in the complementarity framework.

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