A technology-centric framework for investigating business operations

Liang-Chieh (Victor) Cheng and Michael L. Gibson
Department of Information and Logistics Technology, University of Houston, Houston, Texas, USA
Edward E. Carrillo
WorleyParsons – Resource and Energy, Bellaire, Texas, USA, and
Grayson Fitch
Constellation NewEnergy, Inc., Houston, Texas, USA

Received 4 November 2010
Revised 15 January 2011
Accepted 28 January 2011

Abstract

Purpose – This paper seeks to explore the necessity to incorporate technology as a key component in studying business operations of industrial entities.

Design/methodology/approach – Reviews of key management theories that shaped organization-centric and process-centric views in industrial management research are conducted. The paper then identifies the limitations of these two schools of thinking and develops a technology-centric framework that integrates technology, organization, and process in general. A series of case studies that apply the framework at multiple levels of observations are presented. The research concludes with theoretical and managerial implications.

Findings – This paper presents a "trinity" framework that includes three core constructs that can simultaneously develop into variants. Technology as a holistic concept must be taken into consideration when researchers or practitioners take a dynamic view to study business entities. A multi-dimensional, technology-centric framework acknowledges technology as the transformational resource and helps the practitioners and researchers to examine technology as potential facilitators for organizational operations.

Originality/value – A review of the cases found that technology, organizational structures, and business processes impact one another. Firms' actions are indicative that in today's technology-intensive environment, organizational structures and business processes need to be developed or modified in coordination with technological development. In doing so, organizations will gain the potential to harvest benefits from technology-organization-process integration.

Keywords Management theory, Information technology

Paper type Research paper

Introduction

This research explores the necessity to incorporate technology as a key component in studying business operations of industrial entities (Hughes and Love, 2004; Zammuto *et al.*, 2007). Technology has transformed organizational structures and outlooks (Agarwal *et al.*, 2002). Information technology (IT) systems, e.g. enterprise

The authors would like to express their acknowledgement to Gerardo Gonzales, Kwang Hee Jeon, and Divya Tummala and all sponsor companies for their contributions and insights into this research endeavor.

Industrial Management & Data Systems
Vol. 111 No. 4, 2011
pp. 509-530

0263-5577
DOI 10.1108/02635571111133524

resource planning (ERP), bar codes, and radio frequency identification (RFID) entail organizational adjustments before they become operational (Lee and Özer, 2007). Specifically, implementing ERP requires an organizational hierarchy that reflects administrative privileges (Pan and Jang, 2008). Bar codes and RFID systems usually reconfigure coordination mechanisms in supply chains (Park *et al.*, 2010).

Technology often transforms the landscape of an industry (Leem *et al.*, 2008; Lin and Tseng, 2006; Yang *et al.*, 2007). As an instance, computer-aided design, computer-aided manufacturing, flexible manufacturing system (FMS), etc. help modularize an integrative supply chain and create a phenomenon called "modular production network" (Sturgeon, 2002). Inter-organizational IT, e.g. electronic data interchange (EDI), accelerate a firms pace in implementing outsourcing strategies (Fang and Wu, 2006). As well, technology influences the dynamics of downstream industries and distribution strategies (Sanchez and Mahoney, 1996).

Furthermore, technology widely impacts processes in the supply chain: it changes not only organizational structures but the re-design of business processes (Rantala and Hilmola, 2005; Zhao, 2004). A salient instance is the continuous expansion of e-commerce. e-Bay and Amazon, for example, re-defined purchasing behaviors via e-commerce. EDI, e-mail, and online transmission also change organizational routines in collaboration between trading partners. At the broadest level, technological advances shape public policies according to the changes influenced by new technology (Elliot, 2006; Lyons *et al.*, 2004).

While technology plays a key role in an organization, extant literature in operations management still hold an organization-centric or process-centric point of view when studying business entities (Arvanitis and Loukis, 2009). In the present research, organizations are defined as the administrative structures that govern an entity with division of labor and a hierarchy of administrative authorities (Blau, 1968; Ouchi, 1980). Processes are defined as sequential flows of tasks that systematically complete organizational missions (Chandy and Lamport, 1985; Van De Ven, 1992). Technology is a tangible or intangible system used to execute business functions (Barley, 1990; Das and Teng, 1998; Zigurs and Buckland, 1998). Despite the significant impacts of technology, the three-way technology-organization-process interaction has been largely neglected in the literature (Helper and Sako, 2010; Zammuto *et al.*, 2007).

Observing the gap in the literature, we are motivated to conduct the present research that develops a technology-centric view for managing industrial entities. We ask the following questions:

RQ1. How can technology as a whole be justified by management theories as a key dimension incorporated in a theoretical framework in analyzing operations?

RQ2. How can a technology-centric framework be constructed to investigate the dynamics among technology, organizations, and processes in industrial management?

To address the issues above, our research interests are to construct a new theoretical framework for analyzing business operations and to assess businesses' readiness for implementing this framework. A novel, multifaceted methodology is established to address these issues. In the first theory-building phase, we endeavor to construct a technology-organization-process "trinity" framework and derivative variants. Our theory repositions technology in general as a distinct yet inseparable element in a business organization. Namely, technology in general co-evolves with organizational arrangements and business processes and will impact firm performance. In the empirical phase, we perform case studies over various types of technological systems across industries. The trinity framework and variants are applied to real world contexts. The case studies assess the implementation abilities of organizations to apply the new framework.

This research contributes to the industrial management in the following aspects:

- The technology-organization-process trinity framework infuses insights into studied constructs' individual and mutual impacts on business organizations.
- The approach of applying the trinity framework illustrates implementation of our theory to reality.
- The empirical work assesses the abilities of multiple organizations to use our new theory in general business strategies.

The rest of the paper is organized as follows: we first conduct reviews of key management theories that shaped organization-centric and process-centric views in industrial management research. We next identify the limitations of these two schools of thinking and develop a technology-centric framework that integrates technology, organization, and process in general. We proceed to present a series of case studies that apply the framework at multiple levels of observations. The research concludes with theoretical and managerial implications.

Literature review on theories shaping organization-centric and process-centric views

This section reviews the theories that serve as paradigms to govern organizational operations:

- value chain;
- resource-based view (RBV);
- transaction cost economics; and
- evolutionary economics (EE).

These paradigms shape the prevalent organization-centric and process-centric views.

The value chain framework (Porter, 1998) incorporates process and technology for management and evaluation of value creating systems (Woiceshyn and Falkenberg, 2008). Further, technology is positioned as a key supporting role in a value chain. Technology facilitates primary management processes, such as R&D, inbound and outbound logistics, production, marketing, etc. to create value for the operational system (Porter, 1998). Porter's model perhaps is the first to simultaneously include technology and managerial processes in a framework. Value chain theory is consistent with emerging supply chain management (SCM) concepts and similarly takes a process-centric view. Research on value chain and SCM have merged to take the leading role in developing research in strategic management (Cheng and Grimm, 2006).

The RBV suggests that firms need to develop strategic resources that sustain competitive advantages (Barney, 1991; Olavarrieta and Ellinger, 1997). RBV theorists state that to be qualified as a strategic resource, a firm's asset need to display specific characteristics (Mata *et al.*, 1995). First, it needs to be scarce and difficult to imitate.

Second, the resource needs to be immobile. Technology exhibits the prior features and is considered as a key resource for competitive advantage and shall be distinguished as a standalone construct (Liang *et al.*, 2010; Stieglitz and Heine, 2007).

RBV researchers clearly point out that technological systems *per se* do not constitute strategic resources. Without proper management as a foundation, any advantages from technology will be temporary and not sustainable (Mahoney and Pandian, 1992; Mata *et al.*, 1995). The generation of sustainable competitive advantage is contextual. Specifically, it is the interconnectedness of technology and business systems that becomes advantages within organizations (Olavarrieta and Ellinger, 1997). They are difficult to imitate by outsiders because of the complex causation between technology and management that leads to superior performances (Lai *et al.*, 2006).

In addition, a new technology entails substantial endeavor by management in developing new procedures and possibly re-engineering for operational processes (Valorinta, 2009). The installation and implementation of technology into an organization typically experiences a lengthy, socially complex path (Barney, 1991). The complex path to seamlessly incorporate technology into an organization makes it difficult for competitors to duplicate similar technology-process integration. This complexity becomes a source for sustainable advantages (Peteraf, 1993).

Transactional cost economics (TCE) is considered a framework for organizing governance structures (Williamson, 1991). TCE analyzes and makes transaction costs operational when the firm boundaries change (Müller and Seuring, 2007). TCE's primary reasoning relative to technological commitment states that management needs to align governance structures with inter-organizational technologies, so the transaction costs in the supply chain can be minimized. TCE acknowledges that relation-specific investment, e.g. technological systems, can determine organizational make-or-buy decisions, which will in turn affect transaction efficiencies (Langlois and Robertson, 1995). Accordingly, TCE is valuable in probing how the technological features lead to forming inter-organizational governance structures. A body of research has found that relation-specific investment will lead to a higher level of integration between business partners (Shelanski and Klein, 1995). This integration is the source of superior performance (Malone *et al.*, 1987).

Finally, EE is perhaps the first theory that inspects organizational issues from a dynamic view (Jacobides and Winter, 2005). EE, with a root in Schumpeter's destructive innovation, suggests that a business evolves according to historical paths and knowledge they accumulate. EE research indicates that management and technology co-evolve along the following dimensions: technology adoption, knowledge management, and operations (Consoli, 2008). Namely, management's collective knowledge develops as an organization grows due to technological investment (Agarwal *et al.*, 2002). Certainly, the management-technology interaction can lead to sustainable advantage of firms (Littler and Wilson, 1990).

The aforementioned theories serve as the mainstream theoretical thinking in the literature (Cheng and Grimm, 2006; Liang *et al.*, 2010; Müller and Seuring, 2007). The majority of this literature can be further categorized into two groups:

(1) organization centric; and

(2) process centric.

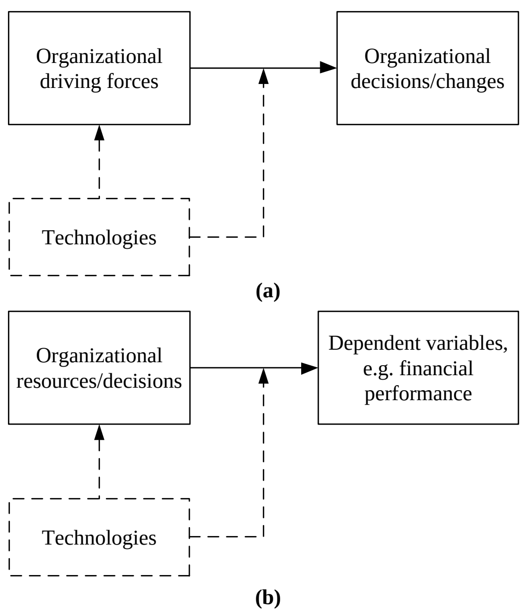
TCE, RBV, and EE theories are the prominent theories for the organization-centric view. Value chain and SCM theories represent the process-centric view. While the two groups shaped existing paradigms, the logic in either group exhibits weaknesses in studying variables relative to technology. Little research highlights and investigates the simultaneous impacts among technology, organization, and process (Hempell and Zwick, 2008). In the next section, we discuss the need to jointly study these three factors for the technology-driven management.

Development of a technology-centric analytical framework

In this section, we critique limitations in organization-centric and process-centric views in assessing business operations. We in turn develop a "trinity" framework and a set of derivative models to address the weaknesses in the prevalent managerial views.

Limitations on organization-centric view relative to managing technology

The organization-centric view considers the organization as the dominant factor in determining operations and performances (Da Silveira, 2002). Scholars agree that technology and organization mutually reinforce each other to generate performance (Consoli, 2008; Fang and Wu, 2006). However, technology is often viewed as a separable and non-integrative variable (Da Silveira, 2002; Zigurs and Buckland, 1998). Administrative arrangements can replace technology, and technology, once implemented, becomes a dormant entity inside an organization (Zigurs and Buckland, 1998). Figure 1 shows an organization-centric view that illustrates administrative arrangements and operations as substitutions for technology. In our view, the organization-centric view cannot precisely capture the dynamics between technology and organizations. Hence, it lacks insights into continuous changes brought forth by technology (Stabell and Fjeldstad, 1998).



Notes: (a) Organizational decision as the dependent variable; (b) organization as the determinant of performance

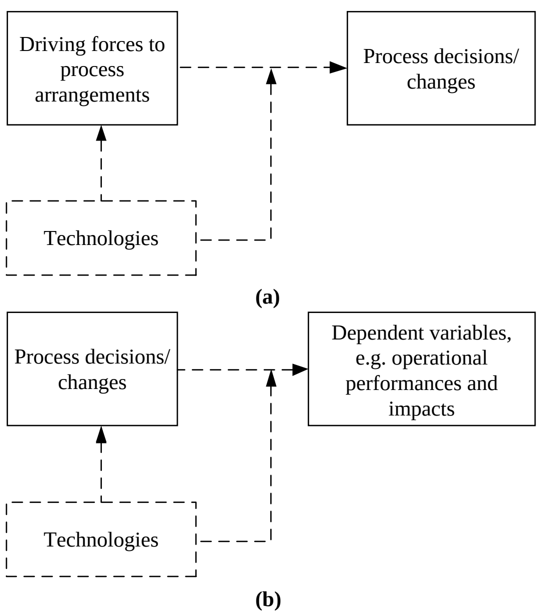
Figure 1. Organization-centric framework

Limitations on organization-centric view relative to managing technology

The process-centric frameworks in management literature consider technology a moderating factor (Fritz and Hausen, 2009; Van De Ven, 1992), as shown in Figure 2. This process-centric view positions technology as a transitional factor relative to operations (Jayaraman and Luo, 2007). It opines that business strategies are executed in a sequential manner and asserts that business processes evolve with minimal association with the underlying technology (Jayaraman and Luo, 2007). The linear thinking in this view ignores the simultaneity among other dimensions and, hence, lacks insight into the role that technology plays in developing and transforming business processes, or vice versa (Narasimhan *et al.*, 2010).

Necessity for including technology in theoretical framework

Technology, organization, and process impact each other and those encounters do not necessarily take place in a sequential manner (Hempell and Zwick, 2008; Hughes and Love, 2004). These factors should be simultaneously studied (Pan and Jang, 2008; Pentland and Feldman, 2007; Zammuto *et al.*, 2007). Recently, researchers developed theoretical frameworks for micro- or macro-societal systems that capture the simultaneity of driving forces in industrial management. Fine (2000) proposed a "Double Helix" model to capture the dual forces of integration and modularization that constantly change industrial structures. Leydesdorff *et al.* (2006) established a "Triple Helix" model to examine the interrelationship between universities, industries, and firms that contribute to the knowledge-based economy.



Notes: (a) Process decision as the dependent variable; (b) process as the determinant of performance

Figure 2.
Process-centric framework

A stream of research (González-Benito, 2007; Lai *et al.*, 2006; Yang *et al.*, 2007) stressed that IT can generate long-lasting impacts on organizational performance than administrative activities. In the same vein, we argue that technology should be viewed as a distinct and necessary construct in the theory's structure (Pentland and Feldman, 2007). The interrelationship between technology and other variables needs to be examined. Figure 3 shows the framework that encompasses the technology-organization-process "trinity."

A trinity view generates a view that includes simultaneity and dynamics. The technology component hereby investigates firms infrastructure within which operations are constrained (Yang *et al.*, 2007). Figure 4 shows the dynamics of the trinity model, where technology, organization, and processes are three co-existing and co-inhering constructs with constant interactions. These dimensions are systemically integrated into an entity. This set of multi-dimensional frameworks synthesizes the research-based view and EE paradigms and recent contributions by Fine (2000) and Leydesdorff *et al.* (2006).

The generic framework in Figure 4 can be developed into two variants. One variant replaces the process with knowledge. The distinction between process and knowledge is necessary in that process embodies the knowledge acquired externally or developed internally and possesses tangible forms (Helper and Sako, 2010). In contrast, knowledge may be a work in process, emerging from experience within operations and/or business programs (Fang and Wu, 2006). According to the RBV literature, knowledge is a critical resource to a firm for competitiveness (Leydesdorff *et al.*, 2006; Woiceshyn and Falkenberg, 2008). With that said, knowledge may only exist in an intangible manner, and pertinent routines are not formally established. This know-how and experience may be functional but they are not formalized as formal processes within or between organizations (Schweizer, 2005; Teece *et al.*, 1997). As such, this variant, as shown in Figure 5, is an intermediate framework in transit to Figure 4.

Another variant is a more comprehensive framework that includes knowledge and three constructs (Figure 6). The co-existence of process and knowledge suggests that formal, tangible routines and informal, intangible know-how simultaneously exist and

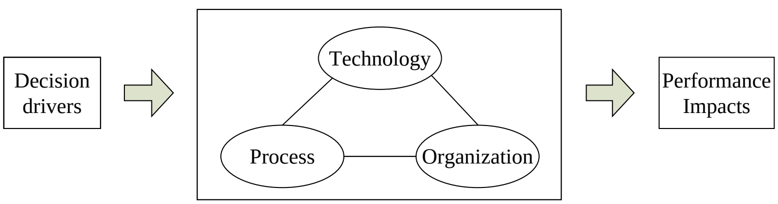


Figure 3.
Technology-centric framework for analyzing business entities

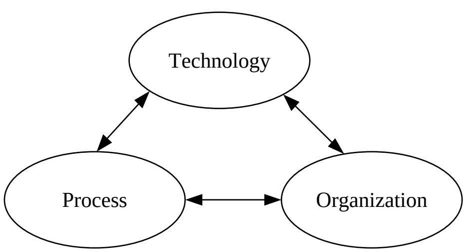


Figure 4.
A simultaneous technology-organization-processes view

function in an industrial entity (Woiceshyn and Falkenberg, 2008). It is necessary to distinguish between tangible processes and intangible knowledge (Pehrsson, 2006).

Exploratory case studies were conducted to apply the framework shown in Figures 4-6. Contextual aspects of the framework were applied within the respective case studies to align the conceptual model with the unique scenario of each individual organization.

Case studies that apply the technology-centric framework

During the time span between September 2007 and June 2009, a research team investigated five firms across multiple industries. The dual purposes of case studies are:

(1) application of the trinity framework to real world business organization; and

(2) assessment of the abilities of the organizations to implement the framework.

The unit of analysis for each case study ranges from a business process, an operational system, a company, to a relationship between supply chain partners.

The technologies were identified jointly by managers of the sponsor organizations and the researchers in light of the following criteria:

- significance of each technology in the published research; and
- salience of technologies relative to each sponsor's operations.

The technologies assessed in case studies are categorized into four primary types listed below. Each type of technology displays unique functions distinctively different from one another:

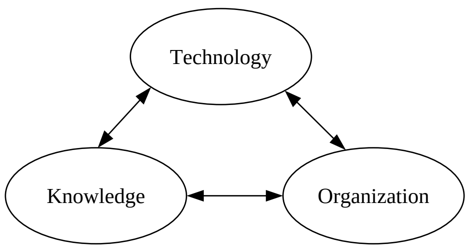


Figure 5. Technology-centric framework with a "knowledge/routine" component

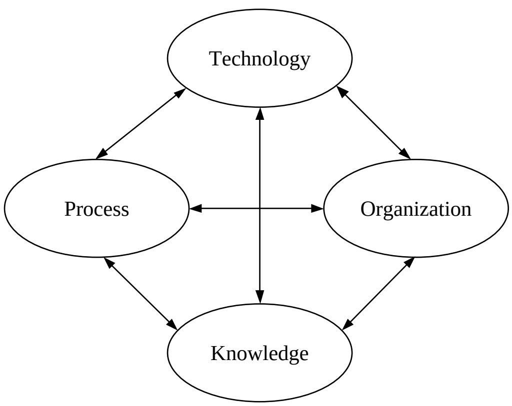


Figure 6. Framework including knowledge/routines as a primary component

- *Information technology*. Technological systems that collect, store, and process data from business organization and process to generate meaningful information for decision making and problem solving (Liang *et al.*, 2010; Zammuto *et al.*, 2007).
- *Manufacturing technology*. Technological systems that perform manufacturing processes to convert raw materials or work in process to finished goods (St John and Harrison, 1999; Sturgeon, 2002).
- *Supply chain/logistics technology*. Technological systems relative to procurement, warehousing, material handling, transportation, and physical distribution (Jayaraman and Luo, 2007; Olavarrieta and Ellinger, 1997).
- *Other computer-based systems*. Supporting systems that are computerized and account for specific business operations (e.g. security system) (Littler and Wilson, 1990).

We provide an overview of technological systems examined in each study in Table I. Three cases studied two or more types of technologies because of the research scope of technology-organization-process interaction. Table I also presents studied technologies and extant published works associated with each type of technologies.

Primary data were collected at the sponsor organizations. The research team used the following methods to collect primary data when conducting case studies at sponsor organizations:

	Technology category			
Case study	Information technology	Manufacturing technology	Supply chain/logistics technology	Other computer-based system
1	EDI			
2	RFID, ERP and MRP		Warehousing and materials handling system	
3	EDI			Data security technology
4	ERP			
5	Enterprise communication system	Chemicals production system	Railroad transportation system for chemicals	Safety alarm system
	Studied technology		*Empirical work on respective technology*	
	EDI		Fang and Wu (2006) and Zmud and Massetti (1996)	
	RFID		Park *et al.* (2010) and Smart *et al.* (2010)	
	Enterprise data/ communication system		Mata *et al.* (1995) and Pan and Jang (2008)	
	Manufacturing technology		Langlois and Robertson (1995) and Sturgeon (2002)	
	Logistics technology		Olavarrieta and Ellinger (1997)	
	Security technology		Lalwani *et al.* (2006)	

Table I. Technologies assessed in five case studies and pertinent references

- interview;
- survey;
- observation; and
- archival data acquisition.

The selected method depended on the type of data sought. Interviews and surveys gathered information from employees in studied companies (Driscoll and Brizee, 2010). The interviews were performed through face-to-face, telephone calls, or conference meetings. Surveys typically contained Likert scales, a prevalent questionnaire technique (Chin *et al.*, 2008).

Data obtained through observations and interviews were analyzed by applying content analysis. We performed qualitative analysis methods on the recorded data and extracted meaningful information. Archived data were analyzed by performing the same technique.

Case study 1. Inter-firm IT and buyer-supplier relationship management

The studied company is an export packing and crating company in the US Southwest region and offers a full line of export logistics services. In Figure 7, the case study includes three components: inter-firm communication technology, logistics service provider-client relationship, and supply chain processes. The studied technology is an EDI system. The process component of the framework is well established in the studied company.

This study examined the B2B EDI depth and level of integration between supply chain partners. EDI depth refers to the extent of integration established by trading partners, from low level of file-to-file connection to high level of system-to-system integration (Zmud and Massetti, 1996). The buyer-supplier relationship of the company was the "file-to-file" level of EDI depth. In spite of the relatively low level, EDI has helped the company change supply chain governance from sporadic, arms-lengths transactions to more coordinated, integrative relationships. Data were more accurate, and the company was able to improve supply chain processes (e.g. forecast and scheduling). In total, 75 percent of management in the company suggested that EDI reduced data errors. Other gains are: transaction efficiencies, faster cash flow, and improved customer service.

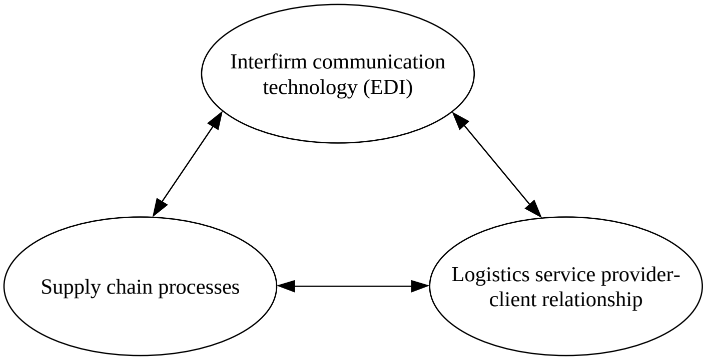


Figure 7.
Framework of the case study for inter-firm IT and buyer-supplier relationship management

Thus, EDI enhances the value creating processes of the organization (Jeffers, 2010). Using the lens of the value chain, EDI is viewed as the common technology to facilitate communication in the supply chain processes (Sturgeon, 2002). So, EDI depth is a function of the inherent characteristics of relationships. Bensaou and Anderson (1999) state that albeit an improved transactional coordination, a buyer-supplier relationship may not be integrated. According to the TCE, perhaps the studied firm intended to constrain specific commitments toward clients (Müller and Seuring, 2007). Thus, management of the studied firm as well as their supply chain partners need to develop supplementary technology (e.g. security systems) to ensure a trusting and integrative relationship.

Case study 2. Inventory management technology and organizational and process change

The studied company is a fastener manufacturing company located in Texas with global operations. This case study includes the following components in Figure 8: inventory management technology, organizational arrangement, and inventory control process.

The company developed a plan to implement an inventory control system that included an auto-ID system, software solutions, and logistics technologies. The auto-ID technology of interest is the RFID system. It is critical to determine the compatibility of RFID to the company's hierarchical structure because the existing material requirements planning (MRP) system is embedded in the established management hierarchy. MRP and ERP determine key inputs for inventory control, e.g. demand forecast, order quantities, cycle and safety stock levels, and materials handling. The prior IT systems eventual affect operations of the studied firm's logistics technologies that include automatic guided forklift trucks and high-capacity order-picking facilities.

An organization cannot implement an advanced, new system without a plan to modify the existing operational routines and organizational arrangements (Park *et al.*, 2010; Smart *et al.*, 2010). We discovered that employees of the studied company lacked an understanding regarding the capabilities and benefits of RFID technology. They also lacked the necessary training that makes supporting software operational. Accordingly, new training schedules were developed and conducted regularly to inform and prepare employees for changes in the operational technology.

Through the lens of the RBV theory, technology is imperative for the company to differentiate itself in terms of supply chain performance and to stay competitive in the marketplace (Lai *et al.*, 2006). Technology entails changes in organizational structure

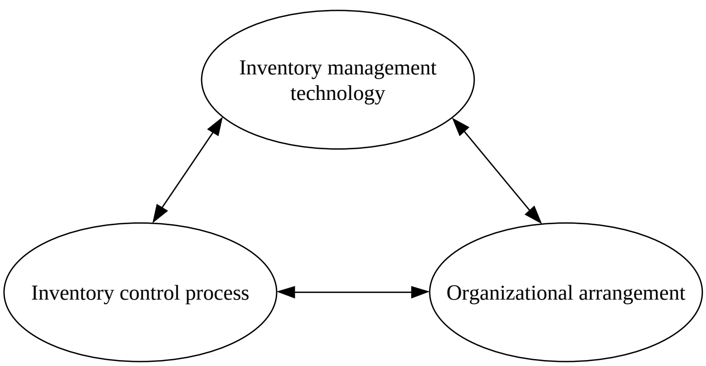


Figure 8.
Framework of the case study for inventory management technology and organizational and process change

and business processes. Hence, managers of the company accepted advice to reengineer its organizational structure beyond adding training programs. They also revised logistics processes to co-evolve with the technology selected for managing its global supply chain (Arvanitis and Loukis, 2009).

Case study 3. E-procurement system and supporting IT

The studied company is one of the world's leading construction companies with the executive office located in Seoul, Korea. We examined the EDI technology and security systems implemented to enhance the procurement processes. Figure 9 shows the components: communication technology for procurement, procurement role in the organization, procurement processes, and new procurement knowledge and routines. An additional component, knowledge, is created in that the company developed know-how and routines on an *ad hoc* basis after installing an EDI system to conduct procurement. This *ad hoc* know-how may eventually be formalized as standard processes (Fang and Wu, 2006).

For this case, EDI is the necessary technology to perform procurement, another supporting component in the value chain theory (Narasimhan *et al.*, 2010). In the studied company, technology emerged as one of the most important components of the framework because EDI helped integrate procurement processes and achieve efficiencies. According to field interviews, shortage or distortion of procurement data caused supply chain problems – excessive inventory, poor customer services, misled investments, ineffective transportation, missed production schedules, etc. The company built EDI connections and a supporting information system with key suppliers to treat the foregoing symptoms and create value.

The firm intended to use relation-specific technology to facilitate supply chain integration. IT-enabled integration is safeguarded by security technology to protect data from "unauthorized disclosure, transfer, modification, or destruction"

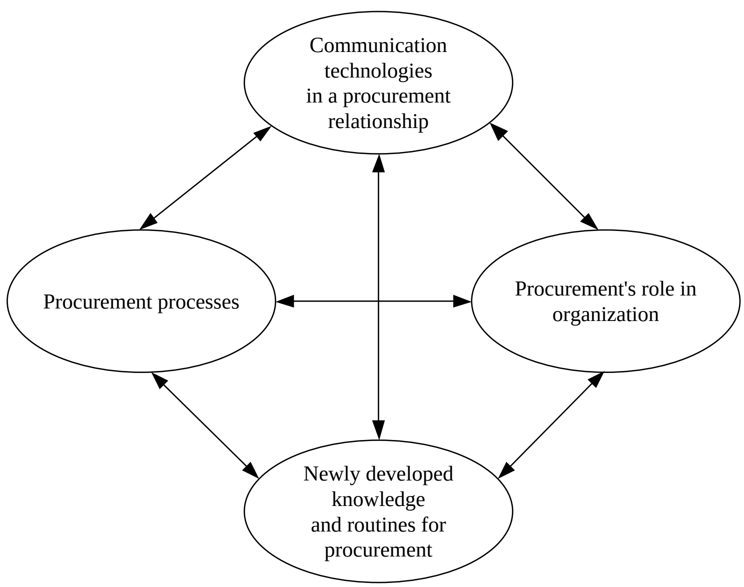


Figure 9.
Framework of the case study of e-procurement system and supporting IT

(Institute for Telecommunication Sciences, 1996). Low-level security affects efficiencies and relationships in the supply chain (Bulgurcu *et al.*, 2010). The sponsor organization hence considered security management in conjunction with EDI a top priority for developing procurement strategies.

The communication technology hence reshaped the procurement process. Data security reinforces the value creation through the procurement function (Aboelmaged, 2010). Management of the company and trading partners reported that they jointly gained efficiencies through the safeguarded procurement processes enabled by EDI. They were able to mitigate the potential transaction hazards associated with this technological integration, e.g. relationship-specific investments and high switching costs which may undermine coordination between trading partners (Müller and Seuring, 2007).

Case study 4. ERP and SCM strategy

The studied company is a Texas food service company that develops its supply base in Central America. It is operating a custom ERP for international operations. The study investigated ERP's impacts on the internal and external structures of the firm's supply chain and pertinent investment processes. Figure 10 shows the components in this case study: an ERP system as an integrative technology, supply chain network structure, and supply chain investment process.

The RBV provides a valuable insight to the ERP's role in gaining positive impacts within the supply chain of the studied firm (Mata *et al.*, 1995). Installing an ERP requires its management to re-think existing operational processes and structures within the organization. For its international import and export and distribution processes, the company needs well-planned and structured supply chain operations in place relative to implementing an ERP system. Otherwise, the consequences are inefficiencies that cause wastes in investments.

At the time of study, the company had not developed structured capabilities for SCM in association with designs of the ERP technology. Issues with product quality started to emerge, along with detrimental impacts to relationships with their customers. The company also incurred financial instability of their operations. The company began to align organizational structures and processes with ERP requirements. In doing so, it gradually transformed the ERP to a performance enabler rather than a platform for operational routines.

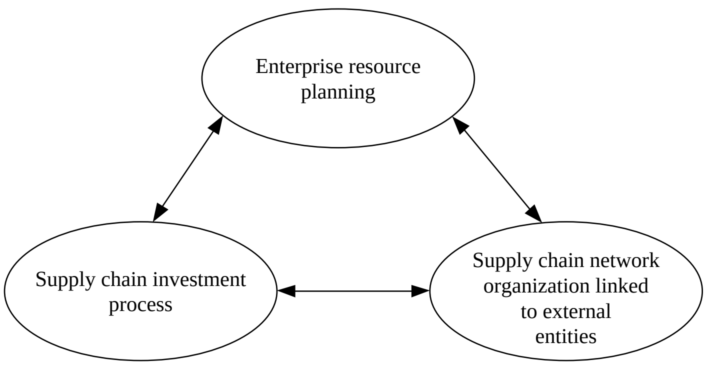


Figure 10.
Framework of the case study of ERP and SCM strategy

ERP was changing the company coordination mechanisms and the modification helped minimize discrepancy within organizational operations (Paulraj and Chen, 2007b). Because of this ERP-supply chain integration, new investments were constrained by the requirements of ERP and new processes. Management learned to thoroughly review respective implementation strategy and constantly upgraded organizations and processes at business unit and network levels (Small, 2006; Yang *et al.*, 2007). Therefore, as the managers developed the process for network-wide investments, the return on investments evaluation may reflect the benefits for the entire supply chain, e.g. overall inventory reduction and cost savings.

Case study 5. Operational technology and risk management for chemical transportation
The studied company is a leading producer of chemical products and fuel products in North America. Figure 11 shows aspects used to analyze the firm's technology, organization, and processes to develop a risk management system for railroad transportation of chemicals. The components are: technologies for risk management and operations, risk management guidelines, organization arrangement and execution of risk management, and risk management processes.

The risk management guideline is a standalone component, because one objective for the case was to develop a guideline for risk management. To establish a comprehensive risk management guideline, the company management constantly reviewed technology with a broad view that encompasses chemical production, safety alarm system, IT, and logistics systems of rail network in the supply chain. Contrastingly, processes related to risk management were not systematically established but merely documented sporadically in archival databases.

This case illustrated the co-development and co-evolution of technology, rail system operations, and risk management. First, the role that technology plays in the shipping

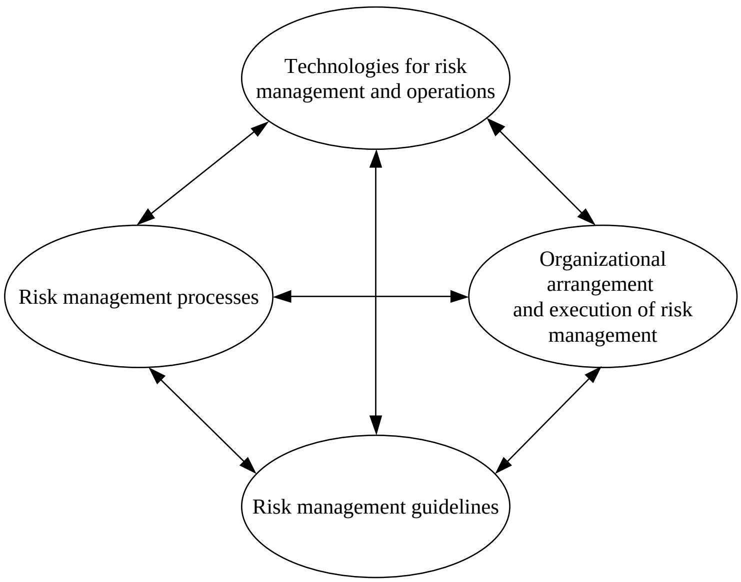


Figure 11.
Framework of the case study for operational technology and risk management for chemical transportation

industry is increasingly important in that communication systems, e.g. RFID and global positioning system (GPS), enhance chemical transportation and customer service (Whitaker *et al.*, 2007). Information system applications also facilitate the risk assessment process of the rail network through faster communication and coordination (Gaonkar and Viswanadham, 2007). Ultimately, better operations and services resulting from improved risk management help a company allocate financial resources to mitigate network risks (Lalwani *et al.*, 2006).

Around the end of the case study, the company was well-positioned relative to many of the risk guidelines. It now has a disruption response plan that accounts for risk prevention, environmental compliance, and operational vulnerabilities. A gap analysis reveals the following opportunities relative to technology support: management shall capitalize on technologies such as RFID and GPS in its rail network to improve competitiveness. It should also consider emerging analytical systems (e.g. simulation) that model key supply chain processes, such as inventory control and distribution systems.

Research implications

The new trinity model displays a convergence of research streams on technology-organization and technology-process integration, respectively. As shown in Figures 3 and 4, our framework together with empirical research establishes the simultaneous, mutual impacts among technology, on organization, and process. An important insight can be derived in the fact that modern business organizations consist of complex organizational structures and operational processes embedded in sophisticated technologies. In a complex system, interactive effects among technology, organization, and process do not take place in a sequential manner. This trinity framework therefore alters the linear thinking in paradigms of extant schools of thinking.

In addition, our research offers insight into the role that technology plays in developing and transforming business organizations and processes, or vice versa. Our theoretical and empirical research clearly illustrates that technology in general cannot be considered as a transitional or dormant component in businesses. Rather, technology is a driving force that stimulates changes within organizations. With this insight, researchers will more precisely capture the dynamics among our studied constructs and study changes brought forth by technology.

The technology-organization-process simultaneously poses challenges yet generates opportunities for business organizations and researchers. The framework serves as an instrument for developing refutable hypotheses on industrial management to gain new insights into the role of technology in general and performance outcomes. A challenge hereby is to generate measures relative to the complex technology-organization-process interactions. The trinity framework warrants further debate to construct and validate composite measurement that reflect the simultaneity and mutuality of studied constructs in new business realities.

Managerial implications

A critical lesson from our research is that technology in general will cause internal and external changes to organizations and processes. Citing IT as an example, Paulraj and Chen (2007a) stated that, “More than ever before, information technology is permeating the supply chain at every point, transforming the way exchange-related activities are performed and the nature of the linkages between them.” Apparently, management must foresee the need to integrate technology, organization, and process so firms can excel in competition. This poses a new challenge for the managers in the modern, technology-driven competitive environment.

Evolution in technology, either revolutionary or incremental, can alter a firm's processes and business routines. Only technology-savvy managers can capitalize on their knowledge of technologies to determine the orientation of an industry, industrial structure, and competition. A goal now exists for organizational management to identify the optimal integration of technology, organization, and process.

Researchers point out that organizational inertia prevents businesses to adapt to changes in technology (Langlois and Robertson, 1995). From time to time, management failed to align organization and/or process with technology which shapes new competition. A well-known illustration is the weaken competitiveness of IBM against other brand name PC companies (Fine, 2000). Therefore, management will need to proactively and continually modify their business models in light of the evolution of technology and evaluate the gap between internal and external technological developments.

An emerging supply chain model, the "modular production network," illustrates a prevailing instance of the lead companies' advantages relative to technology-organization-process integration. In electronics and computer industries, global suppliers and manufactures capitalize on advances in R&D innovations, manufacturing technologies, and information technologies to form modular networks (Sturgeon, 2002). These networks are capable of swift introduction of innovative products while maintaining scale economies. Modular networks are found to outperform vertically integrated business structures which are less adaptable to new technologies.

Applying our trinity framework, management needs to implement technology-organization interaction in optimizing operations. When technology changes, management must recognize that the organization is no longer a constant but a variable. This variable is influenced by technology that entails specific structuring or restructuring hierarchies to implement the technology. This rule also applies to an inter-firm, supply chain setting. It is hence imperative to develop logic for organization re-engineering to implement and execute the intended technology. For instance, joint production systems that consist of complex manufacturing technological systems motivate suppliers and automobile manufacturers to establish integrative alliance partnerships (Aláez-Aller and Longás-García, 2010). In this context, management needs to evaluate the impacts of technology on not only return on investment but also re-configuration of the entire supply chain organization.

The organization-technology integration is a relatively static beginning. The trinity framework also guides managers regarding the mutual influences among technology and processes. Managers need to ensure that an operational process is compatible with embedded technology and can maximize technological functions. Lately, a set of managerial strategies for SCM has been implemented for technology-intensive industries. As an example, the FMS embodies complex computer-based technologies. FMS can be coupled with specific supply chain processes, e.g. postponement and modularity, to maximize its agility and efficiencies (Van Hoek, 2001). Likewise, our case studies indicate that technology-process integration will be a driving force for efficiencies and operational performance.

As such, in the technology-driven competitive environment, a key task for management is to possess knowledge on necessary process designs. When management tailors processes to enhance technological systems, the mutual evolution of technology and process will likely occur. While the complex causality of the co-evolution causes a primary challenge for management to monitor and control, these managers will be rewarded with superior competitive advantages through technology-process integration.

Conclusion

In the current ever changing world, technology has become a crucial driving force for organizational or process change and, ultimately, financial performance. This phenomenon is particularly significant for large-scale applications such as ERP, EDI, bar code, etc. Thus, a technology-centric framework for investigating business operations in industrial entities needs to be developed. We presented a "trinity" framework that includes three core constructs that can simultaneously develop into variants. Technology as a holistic concept must be taken into consideration when researchers or practitioners take a dynamic view to study business entities. A multi-dimensional, technology-centric framework acknowledges technology as the transformational resource and helps the practitioners and researchers to examine technology as potential facilitators for organizational operations.

Our theoretical framework enriches the current lenses to study business operations by establishing technology in general as a distinctive component of an operational system. It should be noted that this technology-centric view is not meant to replace or overturn organization-centric or process-centric frameworks, but to supply a supplementary thinking mechanism to diagnose business problems. We applied the framework to case studies. The case studies illustrated not only applications of the technology-centric framework but the analytical power to real organizations. A review of the cases found that technology, organizational structures, and business processes impact one another. Firms' actions are indicative that in today's technology-intensive environment, organizational structures and business processes need to be developed or modified in coordination with technological development. In doing so, organizations will gain the potential to harvest benefits from technology-organization-process integration.

Limitations and future research

The first limitation is the scope of the present study. The trinity framework captures key dimensions in analyzing a business entity, being an enterprise or a project. While the model is tested in multiple cases, other dimensions, such as human resources, marketing, finance, etc. are not directly examined by the research. The untested dimensions can be impacted or even revolutionized by technological advances. Therefore, the trinity framework can serve as a baseline to augment the research subject.

In addition, our case studies focus on the assessment of the ability of the organizations to implement our technology-centric framework rather than a comprehensive examination for existing technologies. With that said, IT constitutes the majority of studied technological systems, as shown in Table I. As a consequence, our results are likely to apply more for studied technologies than for others beyond our research. Certainly, technology in general is not limited to the four studied categories. Studies on technologies in other fields, e.g. engineering, medicine, biology, etc. and their implementation to the trinity framework are hence in order.

One extension can be the joint impacts by the three constructs on performance metrics. This research did not propose causality between the trinity model and performance metrics. Part of the reason is that individual constructs, i.e. technology, organizations, and processes interact with one another, so the drivers for operational performances cannot be easily identified. Researchers may consider to first study all relationships between the major constructs of the model and then decide whether individual constructs and/or the interaction of the constructs contribute to operational and/or financial performance.

References

Aboelmaged, M.G. (2010), "Predicting e-procurement adoption in a developing country: an empirical integration of technology acceptance model and theory of planned behaviour", *Industrial Management & Data Systems*, Vol. 110 No. 3, pp. 392-414.

Agarwal, R., Sarkar, M.B. and Echambadi, R. (2002), "The conditioning effect of time on firm survival: an industry life cycle approach", *Academy of Management Journal*, Vol. 45 No. 5, pp. 971-94.

Aláez-Aller, R. and Longás-García, J.C. (2010), "Dynamic supplier management in the automotive industry", *International Journal of Operations & Production Management*, Vol. 30 No. 3, pp. 312-35.

Arvanitis, S. and Loukis, E.N. (2009), "Information and communication technologies, human capital, workplace organization and labour productivity: a comparative study based on firm-level data for Greece and Switzerland", *Information Economics & Policy*, Vol. 21 No. 1, pp. 43-61.

Barley, S.R. (1990), "The alignment of technology and structure through roles and networks", *Administrative Science Quarterly*, Vol. 35 No. 1, pp. 61-103.

Barney, J. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17 No. 1, pp. 99-120.

Bensaou, M. and Anderson, E. (1999), "Buyer-supplier relations in industrial markets: when do buyers risk making idiosyncratic investments?", *Organization Science*, Vol. 10 No. 4, pp. 460-81.

Blau, P.M. (1968), "The hierarchy of authority in organizations", *The American Journal of Sociology*, Vol. 73 No. 4, pp. 453-67.

Bulgurcu, B., Cavusoglu, H. and Benbasat, I. (2010), "Information security policy compliance: an empirical study of rationality-based beliefs and information security awareness", *MIS Quarterly*, Vol. 34 No. 3, pp. A523-7.

Chandy, K.M. and Lamport, L. (1985), "Distributed snapshots: determining global states of distributed systems", *ACM Transactions on Computer Systems*, Vol. 3 No. 1, pp. 63-75.

Cheng, L.C. and Grimm, C.M. (2006), "The application of empirical strategic management research to supply chain management", *Journal of Business Logistics*, Vol. 27 No. 1, pp. 1-56.

Chin, W.W., Johnson, N. and Schwarz, A. (2008), "A fast form approach to measuring technology acceptance and other constructs", *MIS Quarterly*, Vol. 32 No. 4, pp. 687-703.

Consoli, D. (2008), "Co-evolution of capabilities and preferences in the adoption of new technologies", *Technology Analysis & Strategic Management*, Vol. 20 No. 4, pp. 409-25.

Das, T.K. and Teng, B.-S. (1998), "Resource and risk management in the strategic alliance making process", *Journal of Management*, Vol. 24 No. 1, pp. 21-42.

Da Silveira, G.J.C (2002), "Improvement trajectories in operations and technology management: concept, process and content issues", *Technology Analysis & Strategic Management*, Vol. 14 No. 2, pp. 227-40.

Driscoll, D.L. and Brizee, A. (2010), "Interviewing", available at: http://owl.english.purdue.edu/owl/resource/559/04/ (accessed 2 January 2011).

Elliot, S. (2006), "Technology-enabled innovation, industry transformation and the emergence of ambient organizations", *Industry & Innovation*, Vol. 13 No. 2, pp. 209-25.

Fang, L.-Y. and Wu, S.-H. (2006), "Accelerating innovation through knowledge co-evolution: a case study in the Taiwan semiconductor industry", *International Journal of Technology Management*, Vol. 33 Nos 2/3, pp. 183-95.

Fine, C.H. (2000), "Clockspeed-based strategies for supply chain design", *Production and Operations Management*, Vol. 9 No. 3, pp. 213-21.

Fritz, M. and Hausen, T. (2009), "Electronic supply network coordination in agrifood networks: barriers, potentials, and path dependencies", *International Journal of Production Economics*, Vol. 121 No. 2, pp. 441-53.

Gaonkar, R.S. and Viswanadham, N. (2007), "Analytical framework for the management of risk in supply chains", *IEEE Transactions on Automation Science & Engineering*, Vol. 4 No. 2, pp. 265-73.

González-Benito, J. (2007), "Information technology investment and operational performance in purchasing", *Industrial Management & Data Systems*, Vol. 107 No. 2, pp. 201-28.

Helper, S. and Sako, M. (2010), "Management innovation in supply chain: appreciating chandler in the twenty-first century", *Industrial & Corporate Change*, Vol. 19 No. 2, pp. 399-429.

Hempell, T. and Zwick, T. (2008), "New technology, work organisation, and innovation", *Economics of Innovation & New Technology*, Vol. 17 No. 4, pp. 331-54.

Hughes, V. and Love, P.E.D. (2004), "Toward cyber-centric management of policing: back to the future with information and communication technology", *Industrial Management & Data Systems*, Vol. 104 No. 7, pp. 604-12.

Institute for Telecommunication Sciences (1996), "Information security", available at: www.its.bldrdoc.gov/fs-1037/dir-019/_2726.htm (accessed 5 May 2010).

Jacobides, M.G. and Winter, S.G. (2005), "The co-evolution of capabilities and transaction costs: explaining the institutional structure of production", *Strategic Management Journal*, Vol. 26 No. 5, pp. 395-413.

Jayaraman, V. and Luo, Y. (2007), "Creating competitive advantages through new value creation: a reverse logistics perspective", *Academy of Management Perspectives*, Vol. 21 No. 2, pp. 56-73.

Jeffers, P.I. (2010), "Embracing sustainability: information technology and the strategic leveraging of operations in third-party logistics", *International Journal of Operations & Production Management*, Vol. 30 No. 3, pp. 260-87.

Lai, F., Zhao, X. and Wang, Q. (2006), "The impact of information technology on the competitive advantage of logistics firms in China", *Industrial Management & Data Systems*, Vol. 106 No. 9, pp. 1249-71.

Lalwani, C.S., Disney, S.M. and Naim, M.M. (2006), "On assessing the sensitivity to uncertainty in distribution network design", *International Journal of Physical Distribution & Logistics Management*, Vol. 36 No. 1, pp. 5-21.

Langlois, R.N. and Robertson, P.L. (1995), *Firms, Markets, and Economic Change: A Dynamic Theory of Business Institutions*, Routledg, New York, NY.

Lee, H.L. and Özer, Ö. (2007), "Unlocking the value of RFID", *Production & Operations Management*, Vol. 16 No. 1, pp. 40-64.

Leem, C.S., Kim, B.W., Yu, E.J. and Paek, M.H. (2008), "Information technology maturity stages and enterprise benchmarking: an empirical study", *Industrial Management & Data Systems*, Vol. 108 No. 9, pp. 1200-18.

Leydesdorff, L., Dolfsma, W. and Van der Panne, G. (2006), "Measuring the knowledge base of an economy in terms of triple-helix relations among 'technology, organization, and territory'", *Research Policy*, Vol. 35 No. 2, pp. 181-99.

Liang, T.-P., You, J.-J. and Liu, C.-C. (2010), "A resource-based perspective on information technology and firm performance: a meta analysis", *Industrial Management & Data Systems*, Vol. 110 No. 8, pp. 1138-58.

Lin, C. and Tseng, H. (2006), "Identifying the pivotal role of participation strategies and information technology application for supply chain excellence", *Industrial Management & Data Systems*, Vol. 106 No. 5, pp. 739-56.

Littler, D. and Wilson, D. (1990), "The evolution and strategic management of new technology-based sectors: the case of computerized business systems", *Technology Analysis & Strategic Management*, Vol. 2 No. 2, pp. 159-79.

Lyons, A., Coleman, J., Kehoe, D. and Coronado, A. (2004), "Performance observation and analysis of an information re-engineered supply chain: a case study of an automotive firm", *Industrial Management & Data Systems*, Vol. 104 Nos 8/9, pp. 658-66.

Mahoney, J.T. and Pandian, J.R. (1992), "The resource-based view within the conversation of strategic management", *Strategic Management Journal*, Vol. 13 No. 5, pp. 363-80.

Malone, T.W., Yates, J. and Benjamin, R.I. (1987), "Electronic markets and electronic hierarchies", *Communications of the ACM*, Vol. 30 No. 6, pp. 484-97.

Mata, F.J., Fuerst, W.L. and Barney, J.B. (1995), "Information technology and sustained competitive advantage: a resource-based analysis", *MIS Quarterly*, Vol. 19 No. 4, pp. 487-505.

Müller, M. and Seuring, S. (2007), "Reducing information technology-based transaction costs in supply chains", *Industrial Management & Data Systems*, Vol. 107 No. 4, pp. 484-500.

Narasimhan, R., Swink, M. and Viswanathan, S. (2010), "On decisions for integration implementation: an examination of complementarities between product-process technology integration and supply chain integration", *Decision Sciences*, Vol. 41 No. 2, pp. 355-72.

Olavarrieta, S. and Ellinger, A.E. (1997), "Resource-based theory and strategic logistics research", *International Journal of Physical Distribution & Logistics Management*, Vol. 27 Nos 9/10, pp. 559-87.

Ouchi, W.G. (1980), "Markets, bureaucracies, and clans", *Administrative Science Quarterly*, Vol. 25 No. 1, pp. 129-41.

Pan, M.-J. and Jang, W.-Y. (2008), "Determinants of the adoption of enterprise resource planning within the technology-organization-environment framework: Taiwan's communications industry", *Journal of Computer Information Systems*, Vol. 48 No. 3, pp. 94-102.

Park, K.S., Koh, C.E. and Nam, K. (2010), "Perceptions of RFID technology: a cross-national study", *Industrial Management & Data Systems*, Vol. 110 No. 5, pp. 682-700.

Paulraj, A. and Chen, I.J. (2007a), "Environmental uncertainty and strategic supply management: a resource dependence perspective and performance implications", *Journal of Supply Chain Management*, Vol. 43 No. 3, pp. 29-42.

Paulraj, A. and Chen, I.J. (2007b), "Strategic buyer-supplier relationships, information technology and external logistics integration", *Journal of Supply Chain Management*, Vol. 43 No. 2, pp. 2-14.

Pehrsson, A. (2006), "Business relatedness and performance: a study of managerial perceptions", *Strategic Management Journal*, Vol. 27 No. 3, pp. 265-82.

Pentland, B.T. and Feldman, M.S. (2007), "Narrative networks: patterns of technology and organization", *Organization Science*, Vol. 18 No. 5, pp. 781-95.

Peteraf, M.A. (1993), "The cornerstones of competitive advantage: a resource-based view", *Strategic Management Journal*, Vol. 14 No. 3, pp. 179-91.

Porter, M.E. (1998), *Competitive Advantage: Creating and Sustaining Superior Performance*, The Free Press, New York, NY.

Rantala, L. and Hilmola, O.-P. (2005), "From manual to automated purchasing: case: middle-sized telecom electronics manufacturing unit", *Industrial Management & Data Systems*, Vol. 105 No. 8, pp. 1053-69.

Sanchez, R. and Mahoney, J.T. (1996), "Modularity, flexibility, and knowledge management in product and organization design", *Strategic Management Journal*, Vol. 17, pp. 63-76 (Special Issue).

Schweizer, L. (2005), "Organizational integration of acquired biotechnology companies into pharmaceutical companies: the need for a hybrid approach", *Academy of Management Journal*, Vol. 48 No. 6, pp. 1051-74.

Shelanski, H.A. and Klein, P.G. (1995), "Empirical research in transaction cost economics: a review and assessment", *Journal of Law, Economics, & Organization*, Vol. 11 No. 2, pp. 335-61.

Small, M.H. (2006), "Justifying investment in advanced manufacturing technology: a portfolio analysis", *Industrial Management & Data Systems*, Vol. 106 No. 4, pp. 485-508.

Smart, A.U., Bunduchi, B. and Gerst, M. (2010), "The costs of adoption of RFID technologies in supply networks", *International Journal of Operations & Production Management*, Vol. 30 No. 4, pp. 423-47.

Stabell, C.B. and Fjeldstad, Ø.D. (1998), "Configuring value for competitive advantage: on chains, shops, and networks", *Strategic Management Journal*, Vol. 19 No. 5, pp. 413-37.

Stieglitz, N. and Heine, K. (2007), "Innovations and the role of complementarities in a strategic theory of the firm", *Strategic Management Journal*, Vol. 28 No. 1, pp. 1-15.

St John, C.H. and Harrison, J.S. (1999), "Manufacturing-based relatedness, synergy, and coordination", *Strategic Management Journal*, Vol. 20 No. 2, pp. 129-35.

Sturgeon, T.J. (2002), "Modular production networks: a new American model of industrial organization", *Industrial and Corporate Change*, Vol. 11 No. 3, pp. 451-96.

Teece, D.J., Pisano, G. and Shuen, A. (1997), "Dynamic capabilities and strategic management", *Strategic Management Journal*, Vol. 18 No. 7, pp. 509-33.

Valorinta, M. (2009), "Information technology and mindfulness in organizations", *Industrial & Corporate Change*, Vol. 18 No. 5, pp. 963-97.

Van De Ven, A.H. (1992), "Suggestions for studying strategy process: a research note", *Strategic Management Journal*, Vol. 13 No. 1, pp. 169-88.

Van Hoek, R.I. (2001), "The rediscovery of postponement a literature review and directions for research", *Journal of Operations Management*, Vol. 19 No. 2, pp. 161-84.

Whitaker, J., Mithas, S. and Krishnan, M.S. (2007), "A field study of RFID deployment and return expectations", *Production & Operations Management*, Vol. 16 No. 5, pp. 599-612.

Williamson, O.E. (1991), "Comparative economic organization: the analysis of discrete structural alternatives", *Administrative Science Quarterly*, Vol. 36 No. 2, pp. 269-96.

Woiceshyn, J. and Falkenberg, L. (2008), "Value creation in knowledge-based firms: aligning problems and resources", *Academy of Management Perspectives*, Vol. 22 No. 2, pp. 85-99.

Yang, K.H., Lee, S.M. and Lee, S.-G. (2007), "Adoption of information and communication technology: impact of technology types, organization resources and management style", *Industrial Management & Data Systems*, Vol. 107 No. 9, pp. 1257-75.

Zammuto, R.F., Griffith, T.L., Majchrzak, A., Dougherty, D.J. and Faraj, S. (2007), "Information technology and the changing fabric of organization", *Organization Science*, Vol. 18 No. 5, pp. 749-62.

Zhao, F. (2004), "Management of information technology and business process re-engineering: a case study", *Industrial Management & Data Systems*, Vol. 104 No. 8, pp. 674-80.

Zigurs, I. and Buckland, B.K. (1998), "A theory of task/technology fit and group support systems effectiveness", *MIS Quarterly*, Vol. 22 No. 3, pp. 313-34.

Zmud, R.W. and Massetti, B. (1996), "Measuring the extent of EDI usage in complex organizations: strategies and illustrative examples", *MIS Quarterly*, Vol. 20 No. 3, pp. 331-45.

About the authors

Liang-Chieh (Victor) Cheng is an Assistant Professor in the College of Technology at the University of Houston. His current focus of research is strategic SCM and inter-organizational IT. Dr Liang-Chieh (Victor) Cheng's research has resulted in publications in *Journal of Business Logistics*, *International Journal of Agile Systems and Management*, and *International Journal of Manufacturing Technology and Management*. Liang-Chieh (Victor) Cheng is the corresponding author and can be contacted at: lcheng6@uh.edu

Michael L. Gibson is Professor and Chair of the Information and Logistics Technology Department at the College of Technology, University of Houston. With over 35 years as an information systems professional and educator, Dr Michael L. Gibson has completed much research while performing the duties of an academic and professional researcher, educator, and trainer. Dr Michael L. Gibson has over 150 publications in refereed journals, business publications, books, and proceedings of academic and professional conferences.

Edward E. Carrillo is a Senior Supervising Engineer at WorleyParsons – Resources and Energy and an Adjunct Professor at the College of Technology at the University of Houston. Mr Edward E. Carrillo specializes in the development, applications, and integration of petrochemical process analyzers. He holds MS degree in Technology Project Management with the concentration in Logistics and SCM at the University of Houston.

Grayson Fitch is the Manager of Data Management at Constellation NewEnergy, Inc. He has worked on projects related to database development and system migrations. He earned his MS in Project Management specializing in SCM at the University of Houston. He also holds a Bachelor of Business Administration in Information and Operations Management specializing in MIS and SCM at Texas A&M University.