CLOUD COMPUTING IN SUPPORT OF SUPPLY CHAIN INFORMATION SYSTEM INFRASTRUCTURE: UNDERSTANDING WHEN TO GO TO THE CLOUD

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Research suggests that there are other, more granular factors within the domain of innovation diffusion theory that influence the adoption of technological innovations. In this study, the circumstances that affect a firm's intention to adopt cloud computing technologies in support of its supply chain operations are investigated by considering tenets of classical diffusion theory as framed within the context of the information processing view. We posit that various aspects of an organization and its respective environment represent both information processing requirements and capacity, which influence the firm's desire to adopt certain information technology innovations. We conducted an empirical study using a survey method and regression analysis to examine our theoretical model. The results suggest that business process complexity, entrepreneurial culture and the degree to which existing information systems embody compatibility and application functionality significantly affect a firm's propensity to adopt cloud computing technologies. The findings support our theoretical development and suggest complementarities between innovation diffusion theory and the information processing view. We encourage other scholars to refine our model in future supply chain innovation diffusion research. The findings of this study might also be used by industry professionals to aid in making more informed adoption decisions in regard to cloud computing technologies in support of the supply chain.

Keywords: *cloud computing; cross-functional interfaces; electronic commerce; technology management; regression analysis; survey methods; diffusion of innovation; information processing view*

INTRODUCTION

The diffusion of low-cost information technology (IT) continues to marshal the world's population into the information era. As firms look for ways to enhance competitive advantage via leveraging their supply chains (Barney, 2012; Hunt & Davis, 2012; Priem & Swink, 2012), various IT solutions have been shown to improve management effectiveness and, subsequently, supply chain process performance (Fawcett, Wallin, Allred, Fawcett, & Magnan, 2011; Lai, Li, Wang, & Zhao, 2008; Paulraj & Chen, 2007; Sanders, 2005; Weber & Kantamneni, 2002). However, as with any resource that is imitable, substitutable and no longer rare, simply adopting an off-the-shelf technology might enhance performance but will likely not induce a long-term competitive advantage (Barney, 1991; Kros, Richey, Chen, & Nadler, 2011; Paulraj & Chen, 2007; Wade & Hulland, 2004). Indeed, IT should complement an organization's existing resources and business processes if it is to greatly enhance an organization's standing within the competitive landscape (Hazen & Byrd, 2012; Nevo & Wade, 2010; Ray, Mahanna, & Barney, 2005). Thus, it is important that firms choose to adopt only those technologies that align with their supply chain management strategy and enable them to generate

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exclusive capabilities that can be used to enhance business performance. The unique circumstances surrounding the information needs of each firm suggest that not every technology is suitable for every firm. Distinctive aspects of the firm's business processes, organizational culture and existing information systems should thus significantly influence a firm's decision to adopt a new IT (Archer, Wang, & Kang, 2008; Huang, Gattiker, & Schroeder, 2010). In this study, we investigate how such factors affect an organization's propensity to adopt cloud computing technologies for managing the supply chain.

Cloud computing is a virtualized IT resource and can take the form of software as a service (SaaS), infrastructure as a service (IaaS) and/or platform as a service (PaaS). Cloud technologies are dynamically reconfigurable, meaning that they can often be tailored to meet the specific needs of the adopting organization (Vaquero, Rodero-Merino, Caceres, & Lindner, 2008). Therefore, cloud computing may offer several advantages over traditional information systems, including the ability to be deployed rapidly while remaining scalable to meet future, and often unanticipated, computing needs (Aymerich, Fenu, & Surcis, 2008). These advantages offered by cloud computing help organizations to maintain alignment between ever-evolving supply chain initiatives and IT, thus enhancing firm agility (Vickery, Droge, Setia, & Sambamurthy, 2010). Agility refers to an organization's ability to sense, adapt, respond and perform well in the face of rapidly changing environments (Sambamurthy, Bharadwaj, & Grover, 2003; Tallon & Pinsonneault, 2011) and may be one of the greatest benefits that firms might realize via using cloud technologies for supply chain applications (Greer, 2009).

In recent years, a host of providers has begun to offer cloud-based resources that may be useful for managing the supply chain and enhancing agility (Thomas, 2008). For instance, well-established technology service providers such as Amazon, Google and IBM offer cloud products that allow organizations to quickly scale systems to meet their needs for capacity, collaboration and coordination without sacrificing control or paying for additional, unneeded capacity (Lohr, 2007). In addition, the rapidly expanding demand for cloud products has created an emerging industry that has attracted several new market entrants. For example, Salesforce.com now offers a wide variety of cloud-based customer relationship management applications. Once a service contract is initiated, their service is almost immediately available to users, who do not need to install and integrate the actual software onto current systems This may not only save a great deal of time and resources, but users from across an organization may also access their data from any Web browser.

Although practical industry developments related to cloud computing in support of supply chain operations continue to proliferate at a rapid pace, there is a dearth of academic research that explains its application from a theoretical perspective. A review of the published research reveals that much of the extant literature regarding cloud computing tends to focus on either exploring the architectures and applications of the cloud environment or proposing various opportunities and obstacles for firms considering cloud computing (Armbrust et al., 2009; Buyya, Yeo, & Venugopal, 2008; Fox, 2009; Yeo, Venugopal, Chu, & Buyya, 2009). Absent from the literature is a thorough understanding of the circumstances that drive firms to adopt cloud computing to meet their information needs, especially in the supply chain domain. Furthermore, research is limited regarding the critical aspects of cloud computing adoption from within a sound theoretical basis. In this study, we help to fill these gaps by examining factors that might affect a firm's intention to adopt cloud computing from a theoretically grounded perspective.

Previous research within the domain of classical diffusion theory indicates that characteristics perceived to be specific to a particular technological innovation, such as cloud computing, might provide a basis for explaining a firm's decision as to whether or not to adopt the innovation (Rogers, 2003). However, recent research suggests that there may be other, more granular factors within the domain of innovation diffusion theory that influence the adoption of innovations like cloud computing by organizations. For instance, Melville and Ramirez (2008) suggest that research should examine technological innovations through the lens of the information processing view and argue that various aspects of an organization and its respective environment create different information needs that may influence the adoption of IT innovations. In addition, there is a specified need for greater theory development in the supply chain management literature (Carter, 2011; Fawcett & Waller, 2011). Such need is purported to be satisfied, in part, by combining theories orthogonally to provide greater insight into a phenomenon (Choi & Wacker, 2011). In this study, we seek to enhance such theoretical development by examining organizational adoption of cloud computing through the combined lenses of classical diffusion theory and the information processing view. In doing so, this research provides academicians and practitioners alike with an enhanced understanding as to under what circumstances a firm might be more inclined to adopt cloud computing technologies for supply chain applications. Therefore, the general research question examined in this study is: In what circumstances are organizations more apt to adopt cloud computing?

The remainder of this paper is structured as follows. In the next section, we discuss the literature that describes classical innovation diffusion theory and the information processing view. Next, we combine tenets of these theories to create our theoretical model that then becomes the basis of our investigation and hypothesis development. We follow with a discussion of the methodology employed in this research, including instrument development, data collection and analysis. We then present a summary of our findings and discuss implications thereof. Finally, we close with a brief discussion of limitations and concluding remarks.

THEORETICAL BACKGROUND

Innovation Diffusion Theory

A review of the literature indicates that innovation diffusion theory is among the most commonly used research paradigms from which scholars examine IT adoption (Brynjolfsson & Hitt, 2000; Henderson & Venkatraman, 1992; Melville & Ramirez, 2008; Rogers, 2003). It is from this foundation that our research begins to examine organizations' intentions to adopt cloud computing as an IT resource. An *innovation* may be defined as an idea, practice or object that is perceived as new by an individual or group (Rogers, 2003). Although the definition is relativity simple, the generalized paradigm of innovation diffusion is expansive and includes theories that pertain to both the adopter of an innovation and the aspects of the actual innovation itself. In this research, we are interested in the latter criterion, the characteristics of the innovation, as they are perceived by a potential adopter of cloud computing. In summary, these characteristics include: (1) relative advantage, (2) compatibility, (3) complexity (4) trialability and (5) observability (Rogers, 2003).

Although several innovation characteristics have been shown to affect adoption, the literature suggests that not every characteristic applies to every setting or circumstance (Hazen, Wu, Sankar, & Jones-Farmer, 2012b; Rogers, 2003). Thus, considering the features of cloud computing, we focus our attention on *relative advantage* and *compatibility*. As described earlier, cloud computing may provide a clear advantage relative to traditional IT solutions; it can deliver desired computing functions quickly without requiring firms to invest in additional infrastructure. In addition, the service (software, infrastructure or platform) that the end-user receives remains unchanged, as does the organization's existing information systems. This suggests that cloud services will be inherently compatible with existing systems. Although additional innovation features might be considered in future research, relative advantage and compatibility are the most pertinent to our research setting and are therefore examined herein.

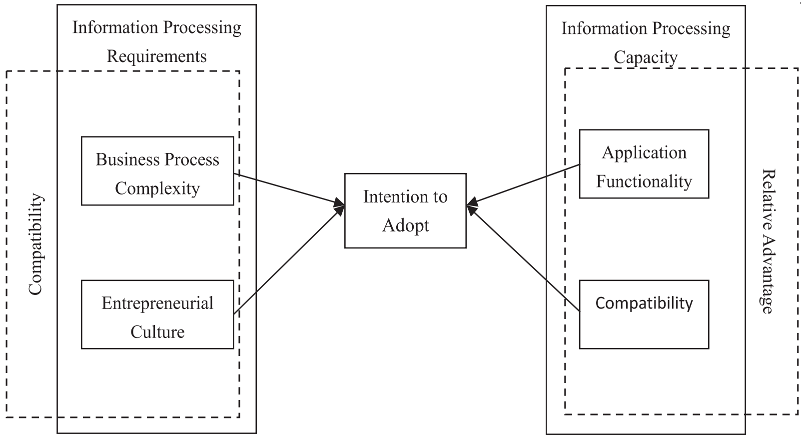
Relative advantage is the degree to which an innovation is perceived to be better than a previously accepted idea. One can measure relative advantage along many facets, such as economic, social, convenience or satisfaction (Rogers, 2003). Previous research indicates that, in general, innovations perceived to have a greater degree of relative advantage stand a greater likelihood of adoption (Carter & Belanger, 2004). *Compatibility* is the extent to which a potential adopter perceives an innovation to be consistent with existing norms, experiences and needs. Diffusion research indicates that innovations that conflict with an existing system's norms or needs face a decreased likelihood of adoption (Ettlie, Bridges, & O'Keefe, 1984). Both relative advantage and compatibility are constructs encompassed by innovation diffusion theory and are commonly considered in IT adoption research (Cooper & Zmud, 1990). In these studies, these constructs represent the diffusion of innovation component of our theoretical model.

Information Processing View

According to the *information processing view* (IPV), organizational decision-making is a process governed by uncertainty (Melville & Ramirez, 2008). The IPV suggests that an organization is an imperfect decision-making system due to incomplete knowledge; therefore, organizations seek to systematically evolve to support decision-making in the face of increased uncertainty (March & Simon, 1958; Van de Ven & Ferry, 1980). In the context of the IPV, uncertainty is associated with inadequate knowledge related to decision-making (Karimi, Somers, & Gupta, 2004). Inadequate knowledge is thought to be the result of inadequacies in supporting the organization's *information processing requirements*, *information processing capacity* or some combination of both.

Information processing requirements denote an organization's need for new or additional information to support decision-making in the face of uncertainty (Galbraith, 1977). Information processing capacity, on the other hand, addresses an organization's ability to actually utilize new or additional information in the decision-making process (Tushman & Nadler, 1978). When requirements and/or capacity are constrained and no longer adequately mitigate uncertainty in regard to decision-making, the organization will seek out ways in which to adjust the boundaries of their requirements and capacity to enhance decision support (Daft & Lengel, 1986). IT has been suggested as a mechanism that can increase organizations' information processing abilities (Galbraith, 1974; Wang, 2003). In this respect, we propose that cloud computing may provide an organization with the ability to cultivate and exploit additional informa-

FIGURE 1
The Information Processing View Framed Within a Classical Diffusion Perspective



tion by providing a quick and efficient means of expanding IT infrastructure.

The elements of the IPV, information processing requirements and information processing capacity, are functions of *organizational tasks,* the processes in which organizational resources are engaged and the *organizational environment*, the comprehensive domain in which the organization engages in completing tasks that support the achievement of organizational objectives (Cooper & Zmud, 1990; Tornatzky & Fleischer, 1990). Typically, organizations seek to establish routines that facilitate task completion. However, uncertainty generated from the task environment forces organizations to continuously discard or revise established routines in favor of new routines, which are built upon more complete information. The net result of task uncertainty is reduced decision-making efficacy (Cooper & Zmud, 1990). In this context, we suggest that many organizations may find value in the adoption of cloud computing as a means to satisfy information processing requirements and enhance information processing capacity. However, not all circumstances may encourage adoption of cloud computing.

Aligning Innovation Diffusion Theory and the Information Processing View

Research suggests that one-way organizations can enhance their information processing capability through the adoption of IT innovation (Karimi et al., 2004; Melville & Ramirez, 2008; Mendelson & Pillai, 1998; Wang, 2003). Thus, the information processing view has been seen as a useful foundation from which scholars have augmented and expanded the boundaries of IT adoption research. As discussed by both Fichman (2004) and Lyytinen and Rose (2003), there is a need for scholars to develop a more holistic perspective in understanding IT innovation. We propose that the information processing view is a granular extension of the classical innovation diffusion research tradition. Specifically, we assert that information processing requirements and information processing capacity represent refined constructs of elements of the classical innovation diffusion model. We therefore characterize information processing requirements and information processing capacity within their corresponding constructs (compatibility and relative advantage) from classical diffusion theory. We consider business process complexity and entrepreneurial culture as constructs representative of information processing requirements; application functionality and compatibility are considered as constructs representative of information processing capacity. This theoretical model is presented in Figure 1 and discussed in detail in the next section.

CONCEPTUAL FRAMEWORK

Information Processing Requirements

According to the IPV, organizations seek information as a means of reducing the threat of uncertainty and enhancing decision-making capabilities (March & Simon, 1958; Van de Ven & Ferry, 1980). Research suggests that uncertainty is derived from both an organization's tasks and its environment (Cooper & Zmud, 1990; Tornatzky & Fleischer, 1990). Thus, we posit that business process complexity and a firm's cultural environment will affect its propensity to adopt cloud technologies in support of its supply chain management efforts.

Business Process Complexity. Process complexity refers to the degree to which a process is difficult to understand or carry out (Muketha, Ghani, Selamat, & Atan, 2010); it denotes complications derived from the combination of units or activities. Thus, we define business process complexity as the degree to which an organization's business processes are difficult to analyze, understand or explain (Cardoso, 2005). Business process complexity reflects the dynamism of operating procedures within an organization; the more difficult an organization's business processes are to describe and understand, the greater the degree of business process complexity (Krees, 2010). Various dimensions are used throughout the literature to characterize business process complexity and are often chosen in consideration of the study's context (Eimaraghy & Urbanic, 2004; van Hoek, 1998; Li, Yang, Sun, Ji, & Feng, 2010; Melville & Ramirez, 2008; Novak & Eppinger, 2001). However, the literature suggests two common dimensions that transcend most contexts: knowledge intensiveness and technology integration.

Knowledge intensiveness refers to knowledge that is embedded within production processes (Eimaraghy & Urbanic, 2004; van Hoek, 1998; Li et al., 2010; Novak & Eppinger, 2001). Knowledge intensiveness creates large volumes of information that requires processing by the organization. For example, processes that support products with an intricate bill of materials require more manufacturing steps and generate more data throughout production than a process that supports products with a simple bill of material. Technology integration denotes the degree to which technology is used within manufacturing or service processes (van Hoek, 1998; Li et al., 2010; Melville & Ramirez, 2008). Greater degrees of technology usage suggest greater levels of operational complexity, which affect information processing requirements (van Hoek, 1998). For example, compared with manual assembly, automated assembly lines often simplify the production process, yet produce (and require) a greater degree of data.

In addition to the common dimensions of business process complexity described previously, we also consider dimensions that are specific to our study's context. Research suggests that the number of product types (Beamon, 1998; Perona et al., 2001), number of suppliers (Beamon, 1998; Perona et al., 2001) and number of customers (Beamon, 1998; Melville & Ramirez, 2008; Perona et al., 2001) also reflect business process complexity within the supply chain environment. A more diverse product portfolio requires more attention be given to inventory and stock management activities and can also increase the difficulty associated with managing orders and deliveries (Beamon, 1998; Perona et al., 2001). Similarly, a greater number of trading partners reflect a more complex business process, in part because as the number of trading partners increases, organizations must devote more attention to managing their stock and logistics functions (Milgate, 2001).

Greater levels of business process complexity induce greater and more dynamic information processing requirements (Galbraith, 1977; van Hoek, 1998; Melville & Ramirez, 2008). Cloud computing is a virtualized resource that is dynamically reconfigurable to support various degrees of information processing needs (IBM, 2009; Vaquero et al., 2008). Compared with traditional IT solutions, cloud technologies can be acquired and deployed rapidly, without the need for an organization to greatly expand or modify their existing infrastructure (Aymerich et al., 2008), thus offering an organization the opportunity to adapt as needed. Cloud solutions are also scalable to meet changing computing needs; therefore, cloud technologies should be especially useful for supporting complex business processes. Because of these advantages, organizations with more complex business processes may recognize the opportunities to leverage cloud computing technologies and, thus, may be more apt to adopt cloud computing to meet their dynamic computing needs.

> **H1**: There is a positive relationship between the degree of business process complexity and intention to adopt cloud computing.

Entrepreneurial Culture. Related to how an organization manages complexity is its organizational culture, which encompasses the environment within which all tasks are completed (Leidner & Kayworth, 2006). Organizational culture reflects many facets of an organization, such as basic assumptions, beliefs, values, models of behavior and technology, which describe the dynamics of a particular organization (Hofstede, Neuijen, Ohayv, & Sanders, 1990). Prior research has shown that organizational culture encompasses a wide range of values that guide firms' behaviors (Leidner & Kayworth, 2006; Whitfield & Landeros, 2006), such as passivity and aggression (Cooke & Lafferty, 1989), consistency and adaptability (Denison & Mishra, 1995) and task-orientation (Cooke & Lafferty, 2003). These values have been shown to mark the characteristics of the organization and its performance — for example, an entrepreneurial organization, which embodies an aggressive culture, desires flexibility and innovation and thus operates under more uncertainty. Conversely, less entrepreneurial organizations, which express a more passive culture, often desire stabilization and cost efficiency and, compared with their more entrepreneurial counterparts, operate under less uncertainty (Bradley, Pridmore, & Byrd, 2006).

Research has examined the impact of organizational culture on various issues regarding IT, such as information system development (Dubé, 1998), IT adoption and diffusion (Klepper & Hoffman, 2000), IT use and outcomes (Alavi, Kayworth, & Leidner, 2006) and information system quality (Bradley et al., 2006). In this study, we consider a facet of organizational culture: entrepreneurship. We define an entrepreneurial culture as one that is marked by its dynamic commitment to innovation (Bradley et al., 2006; Eisenhardt & Schoonhoven, 1996; Quinn & Spreitzer, 1991). Entrepreneurial organizations are noted as being "agents through which a creative new product, process or service is brought into the marketplace" (Russell, 1989, p. 7). They create a dynamic organizational environment and emphasize flexibility to adapt to the environment and grow quickly (Denison & Spreitzer, 1991). They also value competitiveness and the opportunity to outperform industry rivals (Bradley et al., 2006). Such tenacity generates information processing requirements to detect market opportunity and move faster than competitors. Therefore, this type of organization tends to adopt IT innovation to facilitate such needs (Sabherwal & Chan, 2001). Formal organizations, on the other hand, create a relatively less dynamic and more structural organizational environment. These businesses seek to mitigate uncertainty, as the company values stabilization over change. Therefore, formal organizations have fewer information processing requirements and tend to adopt innovation later (Bradley et al., 2006). Thus, it follows that the degree to which a firm is entrepreneurial will significantly affect its propensity to adopt emerging cloud technologies.

H2: There is a positive relationship between the degree to which a firm is entrepreneurial and intention to adopt cloud computing.

Information Processing Capacity

We define information processing capacity as the ability to satisfy information processing needs using existing information systems. To satisfy such needs, information systems should embody a degree of infrastructure flexibility (Davenport & Linder, 1994; Gebauer & Schober, 2006). Generally, flexibility is characterized by the degree to which the system can withstand change without a significant increase in cost. Duncan (1995) describes IT infrastructure flexibility through the qualities of connectivity, compatibility and modularity. Byrd and Turner (2000) suggest eight general dimensions of flexibility: (1) IT connectivity, (2) application functionality, (3) IT compatibility, (4) data transparency, (5) technology management, (6) business knowledge, (7) management knowledge and (8) technical skills.

Because we are concerned with a single technology in this research effort (cloud computing), we are able to provide a much more focused characterization of flexibility. Cloud computing is characterized by its on-demand and scalable computing power, rapid deployment capability, reduced support infrastructure needs and low cost (Aymerich et al., 2008; Vaquero et al., 2008). Based on these characteristics, we suggest that compatibility and application functionality reflect pertinent relative advantages of cloud computing, which may influence an organization's propensity to adopt the technology. Thus, we consider compatibility and application functionality as representative of information processing capacity. In summary, it follows that if the current information system infrastructure already embodies greater levels of compatibility and application functionality, then an organization may be less likely to adopt cloud computing. In the remainder of this section, we further refine this argument.

Compatibility. Compatibility is defined as the degree to which any type of information can be shared across technology components (Byrd & Turner, 2000). A high degree of system compatibility suggests that a system's infrastructure is designed with sharable and reusable modules (Bush, 2010). This compatibility allows for data or programs to be used by other systems, regardless of manufacturer, make or type and suggests a degree of integration between infrastructure components. Systems with a high degree of compatibility allow current computing resources to be used for new functions (Posey & Bari, 2009); data or processes can be shared and used in new ways when systems are integrated with others (Duncan, 1995). For instance, the use of standardized gateways to access data and applications can enhance the reusability of resources by simplifying systems developers' access to them (Byrd & Turner, 2000). Such an information system provides more infrastructure flexibility because it enables extended use of the information system by providing the ability to adapt to new information processing requirements and capacity needs quickly and cost-effectively (Duncan, 1995). In short, an information system that is highly compatible may also be thought of as having a large capacity for information processing (Wiederhold, 1992). This enhanced degree of existing capacity might reduce the motivation for organizations to seek out and adopt cloud computing.

H3: There is an inverse relationship between the degree of existing systems' compatibility and intention to adopt cloud computing.

Application Functionality. We define application functionality as the degree to which an information system's modules or other components can be added, modified or removed without negatively affecting the collective information system (Byrd & Turner, 2000). Research suggests that when an organization employs an information system that embodies a high degree of application functionality, it can enhance the organization's ability to support change (Gebauer & Schober, 2006; Weber, Reichert, & Rinderle-Ma, 2008). Indeed, application functionality allows a system to be adapted to incremental changes without changing the underlying application software. An information system that embodies a greater degree of application functionality is characterized by a greater number of application features, a greater degree of feature coverage and a greater degree of knowledge embedded within each function when compared with a system with a lesser degree of application functionality (Byrd & Turner, 2000; Gibson, 1994). Application functionality implies the integration of several application features to meet potential functional requirements; therefore, users may only need to reconfigure the application to meet future capacity requirements (Gebauer & Schober, 2006). Unfortunately, application functionality comes at a cost because the application not only contains features for current usage, but also prepares extra features for potential future needs (Byrd & Turner, 2000).

The difference between application functionality and compatibility is that compatibility provides an organization the opportunity to share any type of information across technology components (Byrd & Turner, 2000). Conversely, application functionality provides flexibility to modify application functions to a certain degree without changing the software or the hardware (Gibson, 1994). However, whether via application functionality or compatibility, both imply a greater degree of existing information processing capacity. As such, when organizations already possess a system with a high degree of application functionality, they may not feel as inclined to adopt cloud computing.

H4: There is an inverse relationship between the degree of existing systems' application functionality and intention to adopt cloud computing.

RESEARCH METHODOLOGY

Instrument

In this study, we used a survey method. The instrument used in this research was a combination of several previously used measures. The six items used to measure business process complexity were adapted from van Hoek (1998) and Perona et al. (2001). The two items used to assess entrepreneurial culture were adopted from Bradley et al. (2006), who based their measure on Quinn and Spreitzer's (1991) competing values culture model.

For variables regarding information processing capacity, we adopted a three-item measure of compatibility from Byrd and Turner (2000). After searching the literature, no suitable measure for application functionality was found; therefore, we developed four items to capture this construct based on definitions and dimensions identified in the literature (i.e., Byrd & Turner, 2000; Gibson, 1994). After these items were generated, they were subjected to an assessment of content validity, which is discussed below in our pilot testing procedures. To measure our dependent variable, intention to adopt cloud computing, we used a three-item measure employed by Venkatesh and Bala (2008), who measured user intention in the context of the technology acceptance model. Their measure is adapted from Davis (1989) and Davis, Bagozzi, & Warshaw, 1992) and has been validated across several contexts (Chau, 1996; Legris, Ingham, & Collerette, 2003).

In total, we began with 18 items to measure the constructs under investigation in this study. However, when testing for measurement reliability and validity (as will be discussed in the data analysis section), we dropped one of the business process complexity items. The item failed to load properly on its intended construct. After investigating further, we concluded that the item itself, which addressed product modularity, was likely not representative of the construct which it was intended to measure. After purification, five items measure business process complexity, two items measure entrepreneurial culture, three items measure compatibility, four items measure application functionality and three items measure intention to adopt cloud computing, as shown in Table 1. In addition, we use firm size and IT department size as control variables, as these factors have been noted in several innovation studies to affect intention to adopt IT (Karimi, Somers &, Bhattacherjee, 2007; Teo, Wei, & Benbasat, 2003).

Data Collection

We combined all measurement items, control items and pertinent demographic questions into a Web-based survey instrument. Then, a two-phase pilot test was conducted. In the first phase, five academicians who have published in the area of supply chain information systems and five practitioners (IT and production managers) examined our instrument. They were asked to pay close attention to our newly created measure of application functionality. This process provides a critical means for reducing ambiguity and bias in the meaning of the measures (Churchill, 1987; Green, Tull, & Albaum, 1988) and helps to establish content validity (Hinkin, 1998). Minor changes to the wording of the items were made after this phase. In the second phase, a link to the questionnaire was sent to several MBA students at a large southeastern university. The purpose of this phase was to test the functionality of our Web-based

TABLE 1

Scale Items

Items	Mean	SD	Cronbach's Alpha
Business process complexity			
My company requires complex technologies to support its business processes.	3.88	0.39	0.75
My company's business processes are knowledge-intensive.			
Compared to its competitors, my company has many different suppliers.			
Compared to its competitors, my company has many different customers.			
My company has many different products in its product portfolio.			
Entrepreneurial culture			
My company is a very dynamic and entrepreneurial place.	4.39	0.59	0.91
The glue that holds my company together is commitment to innovation and development.			
Compatibility			
Software applications can be easily accessed and used across multiple platforms.	4.28	0.52	0.94
User interfaces provide transparent access to all platforms and applications.			
Information is shared seamlessly across our organization, regardless of the location.			
Application functionality			
In my company, cross-functional software applications support the business processes adequately.	4.00	0.50	0.85
The function of our software applications meets the business requirements of our organization very well.			
My company's software applications can be quickly modified to meet incremental changes in the business environment.			
In my company, the software applications are very reliable even after changes.			
Intention to adopt			
Assuming that I had the ability to adopt some form of Cloud Computing technology for my company, I intend to do so.	4.33	0.38	0.79
Given that my company had access to some form of Cloud Computing technology, I predict that my company would use it.			
My company plans to adopt some form of Cloud Computing in the next 6 months.			

N = 289; 5-point scale.

questionnaire and collect preliminary data to assess convergent and divergent validity of the measures; therefore, MBA students provided an appropriate sample frame for this phase of pilot testing (Stevens, 2011; Thomas, 2011). Of note, these student responses were only used for pilot testing; the cases were omitted for hypothesis testing. The pilot testing resulted in minor modifications to the wording of some items and the directions.

To determine the appropriate sample size required to test our hypothesized model using multiple regression, a power analysis was conducted (Cohen, 1988). To obtain sufficient power (0.90) to detect an effect size of $d = 0.3$ at the $\alpha = 0.05$ level of significance, a sample size of 117 organizations is required (Soper, 2012). To obtain this sample, the following data gathering steps were followed.

The target population for this study consists of U.S. firms operating within the manufacturing and retail industries. Three large professional organizations that operate within the domain of manufacturing, retail and logistics provided us with our sample frame (these organizations asked that we did not publish their names). The sample frame for the study was derived from individual members of these organizations who had expressed intent to attend one of the respective industry associations' annual conferences. From this pool of potential participants, we selected only individuals that held a position of manager or executive. Using this contact information, 1,232 individuals (each representing a unique organization) were contacted to solicit participation. To qualify for participation and because we rely on single informants, our invitation stressed that the participant must have decision-making authority in regard to aspects of the firm's supply chain information systems (Liu, Ke, Wei, Gu, & Chen, 2010). Because of this criterion, the majority of our respondents self-identified as IT managers or executives. We reasonably assume that having authority over supply chain information systems implies that the individual possesses enough knowledge to not only answer our questions regarding IT, but to also answer basic questions regarding the firm's business processes (i.e., number of suppliers, number of customers, technologies used, etc.).

Three hundred forty individuals completed the questionnaire. After a thorough review of the surveys submitted, 51 surveys were unusable for this study and were removed from the sample. Of the 289 surveys retained, 187 responses were from firms in the manufacturing sector, and 102 responses came from retail organizations. Respondent demographics are reported in Table 2.

TABLE 2

Participant Demographics

	Count	Percent	Cumulative Percent
Industry			
Manufacturing	187	64.7	64.7
Retail	102	35.3	100.0
Firm size			
1–250	242	83.7	83.7
251–1,000	31	10.8	94.5
1,001–5,000	14	4.8	99.3
5,001–10,000	2	0.7	100.0
IT department size			
1–5	63	21.8	21.8
6–10	168	58.1	79.9
11–20	58	20.1	100.0
Respondent job			
IT Manager	235	81.3	81.3
Operations Manager	46	15.9	97.2
IT Executive	8	2.8	100.0

N = 289.

Nonresponse and Common Method Bias

Nonresponse bias can present a host of problems in survey research within the supply chain domain (Wagner & Kemmerling, 2010). To assess whether such bias may be present in our data, we used wave analysis, as suggested by Rogelberg and Stanton (2007). Data from early responders were compared with data recovered from late responders. Comparison of the study variables via two-way t-tests indicated no significant differences in responses.

Ideally, common method bias is controlled for within the design of the study and the survey instrument (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Therefore, we employed several controls in this study, to include protecting respondent–researcher anonymity, providing clear directions, proximally separating the dependent variables from the independent variables and assuring respondents that it is acceptable not to respond to any item that they do not feel comfortable with (Podsakoff et al., 2003). We also pilot tested the instrument in an attempt to enhance the clarity and readability of items, reduce item complexity and ambiguity and reduce the presence of technical jargon and unfamiliar wording, all of which help to reduce the threat of common method bias (Hinkin, 1995, 1998, 2005; Peterson, 2000; Spector, 1987, 1992).

Although such design considerations should help to allay significant bias, we also tested for bias statistically. As referred to by Podsakoff and Organ (1986), Harman's one factor test (Brewer, Campbell, & Crano, 1970; Greene & Organ, 1973; Harman, 1960) was used to determine whether common method bias is a threat to the validity of this study's results. The unrotated factor solution indicates that no factor accounts for 50 percent or more of the variance, which indicates that common method bias may not be a significant threat to the validity of this study.

DATA ANALYSIS AND RESULTS

Before analyzing the data, we assessed reliability and validity of our measures. In addition, we examined the degree to which our data met appropriate statistical assumptions. In the case of multiple linear regression, these assumptions include normality, independence, homogeneity and linearity (Hair Jr., Black, Babin, & Anderson, 2010; Kutner, Nachtsheim, Neter, & Li, 2005). After extensive analysis, we conclude that our data met the requisite assumptions and were deemed appropriate to use in our analysis. Cronbach's alphas, means and standard deviations are reported alongside the items in Table 1. The Cronbach's alphas are all well above 0.70, indicating adequate reliability of the measures (Hair et al., 2010).

Convergent validity was examined via confirmatory factor analysis (CFA) in AMOS 19. As shown in Table 3, the analysis results indicate that all items load well (0.59 or greater at $p < 0.01$) on their intended construct. The results also show that all factor coefficients are greater than twice their standard errors, which is an additional indicator of convergent validity (Anderson & Gerbing, 1988). To assess discriminant validity, we conducted a procedure recommended by Anderson and Gerbing (1988) and more recently employed by Hong and Hartley (2011). We conducted chi-square differences tests for each combination of pairs of latent constructs (intention to adopt, business process complexity, entrepreneurial culture, compatibility and application functionality). For each test, we first ran a CFA and allowed the two constructs to correlate freely. Then, we ran a second CFA where the correlation between the two constructs was constrained to equal one. As shown in Table 4, the chi-square values are significantly lower for each of the unconstrained models than for its commensurate constrained model, which provides evidence of discriminant validity (Anderson & Gerbing, 1988; Hong & Hartley, 2011). Additionally, the construct-level correlation matrix is shown in Table 5.

TABLE 3

Confirmatory Factor Analysis Results

	Item	Std. Factor Loading	Std. Error
Business process complexity	BPC1	0.80	0.09
	BPC2	0.91	0.08
	BPC3	0.72	0.09
	BPC4	0.68	0.09
	BPC5	0.79	0.07
Entrepreneurial culture	EC1	0.81	0.09
	EC2	0.82	0.09
Compatibility	CMP1	0.75	0.08
	CMP2	0.69	0.07
	CMP3	0.65	0.06
Application functionality	AF1	0.70	0.09
	AF2	0.59	0.08
	AF3	0.61	0.09
	AF4	0.63	0.09
Intention to adopt	INT1	0.62	0.07
	INT2	0.59	0.09
	INT3	0.71	0.09

All loadings are significant at $p < 0.01$.

To examine our hypotheses, multiple regression analysis was performed using SPSS 19. Results are provided in Table 6. The dependent variable was intention to adopt cloud computing; the independent variables were business process complexity, entrepreneurial culture, application functionality and compatibility. We also included firm size and IT department size as control variables in the analysis.

The overall regression model is significant ($F = 101.894$, $p < 0.001$). All four relationships proposed in our hypothesized model are also significant. However, only two of the relationships are as hypothesized: entrepreneurial culture ($\beta = 1.836$, $p < 0.01$) and compatibility ($\beta = -2.207$, $p < 0.001$). Although significant, the nature of the relationships regarding business process complexity ($\beta = -1.113$, $p < 0.01$) and application functionality ($\beta = 0.746$, $p < 0.01$) is not in the hypothesized direction. These findings, both in support of and against our hypotheses, have important implications for theory and practice, which are discussed in the next section.

IMPLICATIONS FOR RESEARCH AND PRACTICE

The results suggest that business process complexity and compatibility are negatively related to intention to adopt cloud computing, while entrepreneurial culture and application functionality are positively related to intention to adopt. Although not all the findings are consistent with our original hypotheses, the results are reasonable in consideration of the specific characteristics of cloud computing and the literature regarding outsourcing.

We hypothesized that organizations with more complex business processes might find that cloud computing offers a relative advantage over traditional IT solutions and is more compatible with their information processing requirements, which would in turn enhance their propensity to adopt cloud technologies. However, it appears that this may not be the case and that there are potentially other factors that might dissuade adoption. One explanation might be found in the outsourcing literature. A common outsourcing strategy is to identify and control the core of the value

TABLE 4

Discriminant Validity: Chi-Square Difference Between Constrained and Unconstrained Models

	BPC	EC	CMO	AF	INT
Business process complexity (BPC)	—				
Entrepreneurial culture (EC)	125.8	—			
Compatibility (CMP)	118.9	106.5	—		
Application functionality (AF)	172.5	124.4	180.0	—	
Intent to adopt (INT)	146.8	109.9	139.7	126.5	—

All figures are chi-square differences; all differences are significant at $p < 0.001$.

TABLE 5

Correlation Matrix

	Size	IT Size	INT	BPC	EC	CMP	AF
Firm size	1						
IT size	0.118*	1					
Intent to adopt (INT)	0.031	0.278**	1				
Business process complexity (BPC)	−0.021	0.238**	−0.205**	1			
Entrepreneurial culture (EC)	−0.019	0.124*	0.161*	0.418**	1		
Compatibility (CMP)	−0.022	0.114	−0.297**	0.067	0.145**	1	
Application functionality (AF)	−0.055	0.082**	0.131*	0.101	0.499**	0.649**	1

$N = 289$; *$p < 0.05$; **$p < 0.01$.

TABLE 6

Hypothesis Testing Results

	Hypotheses	UnStd. Coefficient	Supported
H1	Business process complexity → Intention	−1.113**	No
H2	Entrepreneurial culture → Intention	1.836**	Yes
H3	Compatibility → Intention	−2.207***	Yes
H4	Application functionality → Intention	0.746**	No

$N = 289$; **$p < 0.01$; ***$p < 0.001$.

chain in-house, while outsourcing all other activities (Lee, Miranda, & Kim, 2004; Sanders, Locke, Moore, & Autry, 2007; Sislian & Satir, 2000). In complex production processes, there are strong technical interdependencies between the tasks that a firm completes in-house and what it requires from their upstream suppliers, such as materials, components and software (Miozzo & Grimshaw, 2005; Skilton & Robinson, 2009). Thus, these relationships and processes are knowledge-intensive and crucial to the survival of the firm. As a result, firms often tend to keep proprietary knowledge and information tied to their core competencies in-house. This might therefore deter the use of cloud technologies for supporting complex business processes, even if such processes entail greater information processing requirements.

The characteristics of cloud computing mentioned earlier indicate that firms may need to outsource an entire information system, to include hardware, to the third party cloud provider. There are several potential risks in doing so. First, firms forfeit control of the system and the data (Armbrust et al., 2010; Smith, 2009). Without such control, firms may have little knowledge about the physical location of the data.

Also, confidential data might be accessed by the third party without notice. Second, firms run the risk of data lock-in with the vendor. Transfer of the data may be difficult if the cloud computing service vender goes out of business or the firm otherwise wants to switch providers, because there is no common standard among the vendors' systems (Armbrust et al., 2009; Leavitt, 2009; Sultan, 2010). Considering these risks of moving into the cloud as well as the strategy of keeping core businesses in-house, it is reasonable that firms might avoid outsourcing systems to a cloud provider if their business processes are very complex. Therefore, it appears that the relative advantage offered by cloud computing may be outweighed by the perceived risks. We encourage future research to investigate factors such as security considerations or other perceived risks of adoption for the purpose of understanding why firms with more complex business processes may be discouraged from going to the cloud.

The positive effect of entrepreneurial culture supports our hypothesis that more entrepreneurial organizations are more likely to adopt cloud computing. This finding helps to extend the literature regarding the role of organizational culture on IT and supply chain innovation adoption (Hazen, Overstreet, & Cegielski, 2012a). Firms with an entrepreneurial culture embody a dynamic commitment to innovation (Eisenhardt & Schoonhoven, 1996; Quinn & Spreitzer, 1991). Such organizations emphasize spontaneity, flexibility and individuality and prefer to move ahead of competitors and set trends (Bradley et al., 2006; Cameron & Freeman, 1991; Jung, 2003), which generally makes them more willing to adopt emerging IT innovation. In this study, the role of entrepreneurial culture is considered under the realm of information processing requirements. Less entrepreneurial firms tend to be more rigid and stabilized and they tend to follow market trends rather than establishing them; thus, their need for information processing is more predictable and stable. Entrepreneurial firms are more aggressive and would prefer to set the market trends; thus, they will have a greater and more dynamic information processing requirements. Our findings suggest that such firms are more apt to adopt cloud computing.

Finally, the results generally suggest that firms with greater existing information processing capacity may be less likely to adopt cloud computing. This suggests that if an organization's current information processing capacity can adequately satisfy its needs, then it is likely less eager to look to new technologies, such as cloud computing. When this is the case, perhaps normal change considerations (i.e., switching costs) outweigh any other perceived benefits of adopting cloud technologies. Conversely, firms with less compatible systems may find that cloud computing offers them a relative advantage in terms of meeting current and anticipated information processing capacity needs. Of note, the negative relationship found between existing system compatibility and intention to adopt cloud computing is in contrast to the positive relationship found between application functionality and intention to adopt cloud computing. Perhaps, potential adopters view higher levels of their existing systems' application functionality as enabling the transition to or addition of cloud technologies, which suggests a greater degree of perceived compatibility. We recommend that future research examine additional capacity considerations in regard to cloud computing adoption for supply chain applications, perhaps through the lens of absorptive capacity theory (Cohen & Levinthal, 1990).

LIMITATIONS AND CONCLUSION

Several studies have addressed IT innovation adoption in the supply chain context (e.g., Grawe, 2009; Patterson, Grimm, & Corsi, 2003, 2004). However, few use the theoretical lens provided by the information processing view. Many scholars, such as Fichman (2004) and Lyytinen and Rose (2003), argue that there exists a need for scholars to develop a more holistic perspective in understanding IT innovation beyond the traditional lens provided by innovation diffusion theory. In this study, we sought to answer this call by proposing a model using the information processing view to extend the classical innovation diffusion research tradition. We empirically test how the interplay between these theories may provide a more enhanced theoretical perspective in which to view organizations' intention to adopt cloud computing. The study serves as a preliminary effort to investigate how information processing requirements and capacity affect firms' intention to adopt IT innovation in the supply chain.

Additionally, the findings of this study provide practitioners with a greater understanding of the circumstances that may drive organizations to adopt or not adopt, cloud computing. In summary, when a firm's business processes are complex or when the firm's existing information systems already encompass a great deal of compatibility, then adoption of cloud computing may be seen as less favorable. Conversely, entrepreneurial firms or firms that have information systems that embody higher levels of application functionality may be more apt to adopt cloud computing. These findings provide managers with enhanced insight into the reasons for and against the use of cloud technologies to help them make a more informed adoption decision.

Although our findings may be useful, the research presented herein is not without limitation. First, we only choose two factors in which to embody information processing requirements; other factors may also contribute to such requirements, such as the turbulence of the environment and government regulations. Investigating the role of these and other factors may be a fruitful area for future research. Second, because we felt that they were the most salient capacity considerations applicable to cloud computing, only application functionality and compatibility were chosen to be representative of the information processing capacity of a firm's existing information systems. Additional factors may also need to be considered when assessing information processing capacity, such as the connectivity and modularity of systems. Again, future research may wish to consider such capacity considerations. Third, the sample frame consists only of firms within the retail and manufacturing industries; a wider sample frame including other industries may provide more generalizable results. For instance, future research may consider supply chain service industries to determine whether our findings generalize to the service sector. Finally, cloud computing was the IT artifact examined in this study. Because of its unique characteristics compared with more traditional supply chain IT, such as radio frequency identification or electronic data interchange, our results may not generalize to other IT artifacts. We encourage scholars to test our model and extensions thereof using other supply chain IT innovations so as to provide greater understanding regarding the applicability of combining these theories for examining supply chain IT innovation adoption.

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