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thao phuong trinh
rmit university - school of BIT and Logistics, phuongthao.trinh@rmit.edu.au

Alemayehu Molla
School of Business IT and Logistics, RMIT University

Konrad Peszynski
School of Business IT and Logistics, RMIT University

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Thao Trinh-Phuong

School of Business IT and Logistics, RMIT University

phuongthao.trinh@rmit.edu.au

Alemayehu Molla

School of Business IT and Logistics, RMIT University

Konrad Peszynski

School of Business IT and Logistics, RMIT University

Abstract:

The impact of enterprise systems (ES) on organizational agility (OA) is an under-researched area. Given that most organizations are heavily investing on ES infrastructure and the increasing demand for agility, the lack of research on ES and OA is a critical oversight. This article reviews previous literature on information systems in general and ES in particular and organizational agility. The article offers a comprehensive and deepened perspective toward the existing discourses on ES-enabled organizational agility. Using insights from the dynamic capability theory, we propose a conceptual framework that highlights how organizations can exploit ESs to improve their agility in two significant ways—by creating and constantly developing an ES-enabled sensing and responding capability. We also argue that the quality of the ES competence provides the necessary technical and business platform for deploying and exploiting ES in building and rebuilding sensing and responding capabilities. The proposed framework sheds light on three important missing factors in the realm of IT-enabled organizational agility, namely ES competency, the alignment between ES-enabled sensing and responding capability, and environmental dynamism. Our theorizing makes an original contribution to ES and IS research by extending previous works of IT-enabled organizational agility by introducing the three constructs previously mentioned.

Keywords: enterprise systems, information systems, organizational agility, sensing and responding capability

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I. INTRODUCTION

The highly competitive and turbulent business environment is forcing organizations not only to flexibly adapt to changes when they occur, but also to proactively predict the changes before they impact business operations. Organizational agility (OA) refers to an organization's ability to compete and thrive in an unstable business environment by quickly detecting and seizing opportunities and tackling threats [Sambamurthy, Bharadwaj, and Grover, 2003]. Therefore, organizational agility is regarded as a key business factor and an enabler of competitiveness [Ganguly, Nilchiani, and Farr, 2009; Mathiassen and Pries-Heje, 2006]. A McKinsey and Company survey found that nine out of ten executives ranked OA as both critical to business success and growing in importance over time [Sull, 2009]. A 2009 survey by the Economist Intelligence Unit indicated that 88 percent of 249 executives around the world claimed that agility is either extremely important or somewhat important. OA is also an important topic that has been researched from economics [Ganguly et al., 2009], strategic management [Soule, 2002; Weill, Subramani, and Broadbent, 2002], and information systems perspectives [Izza, Imache, Vincent, and Iounis, 2008; Sambamurthy et al., 2003].

A number of previous researchers have investigated the factors, processes, strategies, and structures that contribute to OA. For example, Zhang and Sharifi [2000] identify agility drivers, providers, strategies, and capabilities. Hermansen and Caron [2003] report on factors that impact a pro-agility organizational culture. Breu, Hemingway, Strathern, and Bridger [2002] investigate workforce agility elements. Of all these areas, the role of information systems (IS) and information technology (IT) in OA is of particular interest to this article. This is because contemporary organizations depend on their IS, cannot survive or grow without IS support, and are investing to build their IT infrastructures to improve performance [Mathiassen and Pries-Heje, 2006; Peppard and Ward, 2004].

The contribution of IS to businesses' agility in the literature is contentious because of two views of the IS infrastructure: (a) a technical-oriented view that considers IS as complex technical artifacts and (b) a digital platform view that considers IS as a leveragable infrastructure [Sambamurthy et al., 2003; Fichman, 2004]. The first view promotes the idea that information systems represent business processes that are "hardwired" through rigidly predefined process flows [Desouza, 2006; Izza et al., 2008]. While this characteristic of IS stabilizes and increases the efficiency and effectiveness of business processes, it nonetheless discourages business process modifications in the instance of change. The second view emphasizes that the adoption and use of IS in organizations is inseparable from business strategies and management capabilities. IS in this context is viewed as a digital platform that is incorporated with non-IT capabilities to control the information flow inside an organization [Sambamurthy et al., 2003]. These two views have led to contradicting conclusions regarding the role of IS in advancing OA. While the IS as a technical artifact view argues that IS, unless inherently agile, inhibit organizational agility [Desouza, 2006], the digitally platform view supports the view that IS are socio-technical systems and can be leveraged to support organizational agility [Sambamurthy et al., 2003].

Although there are a number of studies on the relationship between IS and OA, we identify four gaps. First, with the exception of Mathiassen and Pries-Heje [2006] and Sherehiy, Karwowski, and Layer [2007], which have provided a review of the agility literature in general, there is no systematic review focusing on organizational agility in the IS realm.

Second, although the concept of IT-enabled organizational agility is recognized in a few previous studies, what this concept actually means and its constituting parts lack definitional clarity. Researchers have used the concept to imply IT deployment agility [Tan, Pan, Chou, and Huang, 2010], IT capability [Overby, Bharadwaj, and Sambamurthy, 2006], and IS-enabled digital options [Sambamurthy et al., 2003]. The IS literature is also less clear in its treatment of the concept of organizational agility vis-à-vis the two fundamental attributes of agility, that is, sensing and responding. For example, Overby et al. [2006] view sensing and responding as two components of agility. They argue that by breaking the complex concept of agility into its constituent parts of sensing and responding, agility can be observed and measured separately. This means the concepts of sensing and responding are not different from agility. On the other hand, Seo and Paz [2008] treat sensing and responding as two sequential processes to achieve agility. The output of sensing would become the input of responding. Thus, sensing and responding, although strongly related to and able to influence agility, are different from agility. Sambamurthy et al. [2003] view IS as a platform that can be leveraged to digitize processes and knowledge to create digital options. Under the moderating effect of entrepreneurial alertness, which consists of strategic foresight and systemic insight, digital options, in turn, enable organizational agility.

The above three views imply that the structural or ontological standing of how information systems contribute to organizational agility and the claims or statements that can be made about the relationship between the two needs clear construct definition and further theorization. To address this concern, in this article, we define *organizational agility* as one of the organizational performance indicators and differentiate it from the IS-enabled sensing and responding capabilities and from the IS competencies that are necessary to build sensing and responding capabilities. Such a structure facilitates developing testable statements of relationships about IS and organizational agility and will allow for knowledge to be accumulated in a systematic manner.

Third, prior IS studies on organizational agility use IS-related constructs such as IS competence [Sambamurthy et al., 2003], IT usage and IT acceptance [Zain, Rose, Abdullah, and Masrom, 2005], and the quality of the IT infrastructure [Tallon, 2008] that are too broad and abstract. As such, the IS artifact that the studies refer to is generically defined. For example, enterprise systems (ES) such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Supply Chain Management (SCM) are the most widely used types of information systems and have received a lot of research attention that specifically identifies the challenges, implementation issues, and benefits of such systems [Moon, 2007; Lim, Pan, and Tan, 2005]. Nevertheless, except for anecdotal treatment (see, for example, Sambamurthy et al., 2003), how enterprise systems either facilitate or inhibit agility remains under-researched. In view of the volume of ES specific studies, a lack of research on ES and organizational agility is a significant oversight that needs to be addressed. Orlikowski and Iacona [2001] stress the importance of specifically defining the IS artifact under investigation to advance the relevance and value of IS research. They caution researchers not to take the IT artifact for granted and advise them to "explicitly theorize about specific technologies with … distinctive computational capabilities … used for certain activities" [Orlikowski and Iacona, 2001, p. 131]. Although some interpret "enterprise systems" as the same as "information systems" and others [Devadoss and Pan, 2007] identify a number of distinguishing characteristics of enterprise systems, Alter [2008, p. 458] conjectures that "various types of information systems differ so greatly in form and function that IS in general have few concepts or generalizations in common." He suggests that, in order to understand the true role of information systems, researchers need to specifically and clearly define the IS that they allude to. Given the tradition of ES-specific research, and following Orlikowski and Iacona's [2001] and Alter's [2008] suggestions, in this article we focus on enterprise systems only. Our intention, however, is not to draw distinctions between IS and enterprise systems, but to deeply engage with the unique attributes of enterprise systems that are not necessarily shared by legacy information systems [Devadoss and Pan, 2007] in theorizing how organizations can exploit enterprise systems to enable their sensing and responding capabilities and advance agility.

ES refer to integrated information systems that use both technology and the management capabilities of that technology to manage information flow in an organization [Davenport, 1998]. Although ES are sometimes viewed as constraining and inflexible, "like cement, highly flexible in the beginning, but rigid later" [Davenport, 2000, p. 16], ES such as ERP, CRM, and SCM harness the power of contemporary IT and are pervasively used in most large organizations [Devadoss and Pan, 2007; MacKinnon, Grant, and Cray, 2008]. For example, the five-year compound annual growth rate for Enterprise Business Intelligence (BI), CRM, ERP, and SCM Solution Services is expected to be 4.7 percent through 2013 [Gartner, 2009], while the overall ERP application revenue alone was predicted to reach approximately $45.5 billion by 2011 [Hamerman, Martens, and Moore, 2011]. ES inherit some of the IS characteristics but have unique features such as scope, business logic, complexity, standardization, integration, being process oriented, and continued vendor dependence [Goodhue, Chen, Boudreau, Davis, and Cochran, 2009; Devadoss and Pan, 2007; Lengnick-Hall, Lengnick-Hall, and Abdinnour-Helm, 2004], which results in a distinct contribution toward organizations' performance.

Fourth, the sensing and responding processes are interrelated and should be aligned. If organizations are unable to sense effectively, opportunities and threats remain unobserved and disregarded. This will limit organizations' ability to take appropriate actions to respond to the opportunities and threats. Alignment between sensing and responding capabilities enable organizations to effectively capture business opportunities by optimizing organizational resources [Overby et al., 2006]. Moreover, the pressure of change on organizations varies and organizations have different level of agility needs [Oosterhout, Waarts, and Hillegersberg, 2006; Zhang and Sharifi, 2000]. Organizations that operate in a dynamic environment require agility more strongly and urgently than organizations that operate in a less turbulent business environment [Moitra and Ganesh, 2005]. The level of environmental dynamism is dependent on both the sophistication of internal conditions and the turbulence of the external business environment [Oosterhout et al., 2006]. However, existing discourses on IS and organizational agility have overlooked the concepts of the alignment between ES-enabled sensing and responding capabilities and environmental dynamism from the nomological net of factors that explain organizational agility.

The above four areas drive this research, which is particularly concerned with ES and their relationship to OA. The first aim of this article is to review the existing literature on IS and OA in general and ES and OA in particular. The second aim of the article is to propose a conceptual framework and set of propositions with clear ontological

structures constituted of ES competence, ES-enabled sensing and responding capabilities, alignment between ES-enabled sensing and responding capabilities, organizational agility, and environmental dynamism. The main question that the article addresses is: How do organizations exploit ES to become and stay agile? The research bridges the gaps in the IS literature described above regarding the relationship between ES and OA. It also extends the current body of knowledge on ES strategic contribution to organizations. The research also contributes to the IS research, as it provides a clear structural and ontological foundation for IS and organizational agility research.

The rest of the article is organized into four sections—research methods, literature review, conceptual framework and proposition development, and conclusion.

II. RESEARCH METHOD

The study is based on a structured literature review. A literature review method is suitable for creating a firm foundation for advancing knowledge and theory development [Webster and Watson, 2002]. To identify relevant articles, we conducted a thirteen-year (1998–2010) review of papers published in the top twelve IS journals. These journals are *Decision Support Systems*, *European Journal of Information Systems*, *Information Systems Journal*, *Information Systems Research*, *Journal of Information Technology*, *Journal of Management Information Systems*, *Journal of the Association for Information Systems*, *MIS Quarterly*, *Harvard Business Review*, *Communications of the ACM*, *Communications of the Association for Information Systems,* and *Information and Management*. The reason to choose the highest ranking journals for the pool of data collection is that those journals represent the most advanced and widely-recognized knowledge of the subject among IS researchers [Webster and Watson, 2002].

Papers were identified through online database searches of each of the journals. To be included in the review, a paper had to meet the following criteria:

1. Because "Agility," "flexibility," and "adaptability" concepts are used interchangeably in the literature [Sherehiy et al., 2007], papers are included if they contain any of the following concepts in their full text: "organization agility," "organization flexibility," and "organizational adaptability." Further, papers that contain "enterprise agility" and "business agility" in their keywords were included. This process resulted in an initial pool of fifty-two papers.
2. It is noticeable from the literature that information system and information technology concepts are often used interchangeably. Thus the initial pool of papers was screened for the presence of "information system" or "information technology," either in their abstract or body. This process has excluded eight papers, resulting in forty-four papers.
3. The forty-four papers were further screened in order to determine the extent of engagement of a paper with the concepts of "organizational agility," "organizational flexibility," and "organizational adaptability." Articles that make a passing reference to, and that do not deeply engage with, these concepts were excluded from further analysis. We have established a "rule of thumb" criteria: if either of the three concepts appear in an article less than twice, we treat that article as lacking a deep engagement and excluded it from the review. This process excluded ten articles, resulting in thirty-four relevant papers.
4. Additional articles were identified following the suggestion from Webster and Watson [2002] that, with each selected article, we go backwards to determine the precedence articles that this paper cites, and go forward by using the Web of Science and Google Scholar to identify the papers citing this article for comprehensive coverage of the topic. This process identified fifteen extra journal, conference, and book chapter articles which were not published in the high-ranking journals but do discuss the impact of information systems on organizational agility.

The complete list of journals along with the number of papers found based on steps 1–4 is provided in Appendix 1. Although the structured approach described above ensures the comprehensiveness of the coverage, it nonetheless does not guarantee completeness. As a result, we have also referred to a number of articles from non-IS journals, which are related to the organizational agility theme in order to get a deeper understanding of the concepts. These articles were chosen based on their relevance to the topic, that is, theoretical sampling.

The findings show that, although there is some research on IS and OA [Overby et al., 2006; Sambamurthy et al., 2003; Swafford, Ghosh, and Murthy, 2008], there are only eight academically published papers on ES and OA [Davis, 2005; Gattiker, Chen, and Goodhue, 2005; Goodhue et al., 2009; Ignatiadis and Nandhakumar, 2007; MacKinnon et al., 2008; Newell, Wagner, and David, 2007; Seethamraju, 2009; Seethamraju and Seethamraju, 2009]. In the following section, we discuss the concept of OA and the common perspectives on the link between IS (ES) and OA in the IS literature.

III. THE CONCEPT OF ORGANIZATIONAL AGILITY IN IS RESEARCH

As organizational agility is a research topic in various disciplines, there are many interpretations of what constitutes an agile organization and how it can be achieved [Li, Chung, Goldsby, and Holsapple, 2008]. The concept of organizational agility is derived from performance characteristics of an agile organization and is rooted in two related concepts—"organizational adaptability" and "organizational flexibility" [Sherehiy et al., 2007]. Organizational adaptability focuses on how an organization's form, structure, and degree of formalization influence its ability to quickly adapt to its business environment [Sherehiy et al., 2007]. Organizational flexibility represents an organization's capacity to adjust its internal structures and processes in a predetermined response to changes in the environment [Dove, 2001; Yusuf, Sarhadi, and Gunasekara, 1999]. Adaptability underlies the fit of organizational operations to their environment while flexibility emphasizes the readiness of organizational resources and the ease of resource mobilization. The "agility" concept encompasses both flexibility and adaptability [Christopher and Towill, 2001]. An agile organization is not only "flexible" to cater to predictable changes, but also is able to respond and adapt to unpredictable changes quickly and efficiently [Oosterhout et al., 2006].

An agile organization requires not only effective knowledge management and learning capability through data collection and analysis, but also efficient decision making and quick deployment of solutions in responding to changes. Thus, agility involves all aspects of an organization's architecture, such as technology, business processes, people, information, and strategy. Likewise, various studies have looked into organizational agility either from an organizational perspective or from a particular area of an organization such as workforce agility [Breu et al., 2002; Crocitto and Youssef, 2003], strategic agility [Doz, 2008; Weill et al., 2002], technology and business process agility [Raschke and David, 2005; Seethamraju and Seethamraju, 2009; Tallon, 2008], and operational agility [Lee, Peng, Kuilboer, and Kuilboerl, 2009]. On the other hand, in identifying the various IT/IS antecedents of organizational agility, researchers typically draw from either one or more of the resource-based view (RBV), dynamic capability theory (DCT), knowledge-based view (KBV), and process-based view (PBV). (See Table 1 for a summary.)Some studies [Fink and Neumann, 2007; Tallon, 2008; Bhatt et al., 2010] seek the antecedents of organizational agility from a resource-based view (RBV). The resource-based view postulates that organizational resources that are rare, valuable, inimitable, and non-substitutable (VRIN) are able to create organizational competitive advantages [Barney 1991]. The two leveraging mechanisms of resource picking (identifying or creating resources) and capability-building (building unique capabilities from the resources) transform organizational resources into capabilities that support organizational competitive advantage [Barney, 1991]. Arguably, agility is a type of organizational competitive advantage and involves all areas of organizational architecture. Thus the RBV allows organizations to identify the resources that enable agility from a holistic view of the overall organization. The two mechanisms of resource picking and capabilities explain how organizational agility can be obtained. Within the IS field, researchers argue that IS is one type of organizational resource that can be leveraged to enable organizational agility. They postulate that IS resources operate in synergy with other complementary organizational capabilities to enable organizational agility. Various types of IT- and IS-related resources that enable organizational agility are identified in the literature. These include the technical, behavioral, and business capabilities of IT personnel [Fink and Neumann, 2007], flexible IT infrastructure [Bhatt et al., 2010], IT system characteristics and IT applications [Gattiker et al., 2005; Goodhue et al., 2009], managerial IT capabilities (IT-business partnerships, strategic planning, and ex-post IT project) [Tallon, 2008], agile IT strategy and agile project management [Lee et al., 2006].

Extended from the resource-based view, other researchers [Sambamurthy et al., 2003; Lee et al., 2004] took a dynamic capability-based view to explain how organizational agility can be achieved through IS. Instead of merely identifying the VRIN attributes, as in RBV, these studies argue that maintaining sustainable organizational agility requires a continuous process of resources identifying and leveraging. Thus, the dynamic capability view, which emphasizes the reconfigurability and renewability of resources in maintaining sustainable competitive advantage, can explain organizational agility more precisely. IT/IS resources can be leveraged to provide dynamic capabilities. To illustrate, digitization of business processes and knowledge provide digital options that enable organizations to adapt to changing requirements more quickly by changing information-based value propositions, forging value-chain collaborations with partners, and rapidly exploiting market niches [Sambamurthy et al., 2003]. The dynamic capability view implies that organization agility can be achieved through strategic foresight, systemic insight and organizational learning to generate IT-enabled capabilities that complement other organizational capabilities.

The third group of studies explains organizational agility from a knowledge-based view [Ashrafi et al., 2005, 2006]. Agility is possible only if an organization is capable of recognizing and assimilating changes rapidly. To do so, organizations need to maintain alertness to market changes, assess internal and external knowledge and exploit knowledge, and assimilate knowledge internally to relevant decision makers. Therefore, the process that obtains

Table 1: Dominant Theoretical Perspectives in the IS and OA Literature							
Citation	RBV	DCT	KBV	PBV	Other	Type of study	IS-enabled OA antecedents
Ashrafi, Xu, Sathasivam, Kuilboer, and Koehler, 2005; Ashrafi, Xu, Kuilboer, and Koehler, 2006		X	X			Conceptual	IT capabilities of managing knowledge: knowledge acquisition, knowledge distribution, knowledge identification, knowledge upgrade
Bhatt, Emdad, Roberts, and Grover, 2010	X		X			Empirical	Infrastructure flexibility, information dissemination, information generation
Fink and Neumann, 2007	X					Empirical	Flexible IT infrastructure (IT personnel capabilities)
Lee, Lim, and Wei, 2004		X				Empirical	IT dynamic capability building through process improvement or innovation, IT dynamic capability creation through innovative adoption of new IT capabilities
Lee, Banerjee, Lim, Kumar, Hillegersberg, and Wei, 2006	X					Conceptual	Agile IT strategy, agile project management, agile IT Infrastructure
Overby et al., 2006		X		X		Conceptual	IS-enabled sensing capability, IS-enabled responding capability
Sambamurthy et al., 2003		X				Conceptual	IT competence (Investment scales, IT capabilities), digital options (process reach, process richness, knowledge reach, knowledge richness)
Seo and Paz, 2008				X		Conceptual	Anecdotal example of IT/IS systems and technologies that support business functions in the process of pursuing organizational agility
Tallon, 2008	X					Empirical	Managerial IT capabilities (IT-business partnership, strategic plans for IT use, post-implementation reviews), technical IT capabilities (hardware compatibility, software modularity, network connectivity, IT skills adaptability)
Wu, Gang, and Zengyuan, 2006	X					Conceptual	Internal integration, business process redesign, strategic revolution
Zain et al., 2005					TAM	Empirical	Actual system or technology usage, perceived usefulness and perceived ease of use of IT

agility is actually the process of managing knowledge within an organization. Since IS help to manage information throughout an organization, IS play a crucial role in facilitating the gathering of market intelligence and providing collaborative work processes that augment agility. The mechanisms of how organizational agility can be achieved from IS consist of the IT/IS capabilities of knowledge acquisition, knowledge distribution, knowledge identification, and knowledge upgrade (maintenance).

Finally, a number of studies develop models surrounding the definition of organizational agility as the ability of an organization to sense environmental changes and respond effectively to the changes from the process-based view. Three key processes are identified in pursuing agility. These are the process of sensing changes in the internal and external environment, the process of responding to changes effectively in a timely and cost efficient manner, and the process of learning from the experience to improve the competencies of an organization [Seo and Paz, 2008]. Sensing refers to an organization's ability to detect, capture, and interpret organizational opportunities [Oosterhout et al., 2006; Seo and Paz, 2008]. Proactively sensing through systematically scanning environment (i.e., looking for early indications of new ideas or trends, forecasting market movements) enables organizations to adjust to changes quickly [Tan and Sia, 2006]. Responding represents an organizational ability to mobilize and transform resources to react to the opportunities that it senses [Gattiker et al., 2005; Oosterhout et al., 2006]. Learning refers to the ability of organizations to acquire new knowledge based on the organization's experience [Wang and Ahmed, 2003]. In the IS field, IT/IS has been found to strongly facilitate the sensing and responding processes through the creation of a digital option, thus enabling organizational agility [Haeckel and Nolan, 1996; Overby et al., 2006; Sambamurthy et al., 2003]. For example, the adoption of RFID technology provides current information of the product management

(e.g., quickly detection of error in products), hence the technology directly and positively impacts organizational agility [Zelbst, Green, Sower, and Abshire, 2011].

While the four theories have been extensively used, a single theory does not provide a complete framework that explains how organizational agility can be achieved. For instance, a knowledge-based view focuses only on an organization's ability to manage knowledge, whereas organizational agility refers to an organization's ability to manage change. The responding component of organizational agility needs to use the newly acquired and assimilated knowledge, it places emphasis on consequent actions and their effects rather than the input knowledge. The RBV and DC focuses on drivers and the factors influencing the implementation of agility. However, the leveraging process (resource picking and capability building) in RBV and DC is overly abstract to explain why certain capabilities make a substantial impact on the agility level of organizations. Likewise, the process-based view alone does not illustrate the drivers and factors influencing the implementation of agility.

IV. PERSPECTIVES ON ORGANIZATIONAL AGILITY AND INFORMATION SYSTEMS

Agility is not a static resource and "does not come in a can" [Dove, 2001]. It must be developed by organizations when they combine different organizational resources. As information systems bring in benefits to organizational performance, including organizational flexibility [Shang and Seddon, 2002], the role of IS in OA has attracted some research attention. The literature on the link between IS and OA promotes three perspectives—the facilitating, inhibiting, and neutral perspectives. These three perspectives relate to the two distinctive views of IS infrastructure, that is, IS as a complex technical artifact versus IS as a leveragable digital platform. The inhibiting perspective comes mostly from the restricted scope of IS as an application artifact, while the neutral and facilitating perspectives are found in the research that integrate IS digital platforms along with complementary organizational capabilities. Table 2 provides a summary of these perspectives.

IS Facilitates Organizational Agility

The facilitating perspective argues that OA is directly or indirectly associated with IS. Results from a survey [Zain et al., 2005] involving 329 managers and executives in manufacturing firms in Malaysia showed that actual system or technology usage had a strong direct effect on organizational agility. Meanwhile, perceived usefulness and perceived ease of use of IT influenced organizational agility indirectly through actual systems or technology use and attitudes toward using the technology [Zain et al., 2005]. Desouza [2006] opines that agile organizations and agile information systems are the same thing, due to the dependency of contemporary organizations on their information system from operational to strategic management level. He argues that agile information systems enable agile organizations and vice versa. In that perspective, an agile information system must be able to align information system architectures with the changing information needs of an organization in responding to changes. IS has the capability to quickly compile and analyze data and information, streamline and automate business processes without any effort, as well as build inter-organizational relationships [Lee et al., 2007; Seo and Paz, 2008]. Wade and Hulland [2004] find that IS enables firms to track shifts in customer choices much more rapidly, hence enables organizations to quickly react to changes in customer preferences. IS support for organizational learning, exploration, and exploitation is a critical enabler of OA [Lyytinen and Rose 2006].

Further, the availability of IS that provides consistent and accurate information and the uptake of new working models have positive association with creating agility [Breu et al., 2002]. Sambamurthy et al. [2003] argue that the transformation from the traditional economics of physical components to digital economics demonstrates the enabling effect of IT/IS on organizational agility. IS competencies and the entrepreneurial alertness provide digital options that are generated through the digitization of knowledge and the business process, which in turn facilitates agility. Researchers in new product development [Pavlou and Sawy, 2010] identify the IS-leveraging capabilities that are reflected through three IS systems (1) as project and resource management systems and (2) organizational memory systems and cooperative work systems that facilitate the organization's ability to spontaneously reconfigure existing resources to build new operational capabilities to address urgent unpredictable and novel environment situations.

Scholars advocating the facilitating perspective of IS on organizational agility share a common argument that the alignment between IS and business process is the most essential element that moderates the positive contribution of IS to organizational agility. The IS development effort to align the IS with process changes in a dynamic basis allows every decision for a change to be implemented in the system immediately, thus, facilitating agility [Olsen and Sætre, 2007]. Organizational agility also requires IT infrastructure flexibility. IT infrastructure flexibility generates information building, and this directly impacts a firm's ability to respond to environmental change [Bhatt et al., 2010]. Similarly to the other key areas of an organization, flexible IT infrastructure enables organizations to respond quickly to strategic moves by competitors [Byrd and Turner, 2001]. Fink and Neumann [2007] signify a positive effect of IT-dependent system agility on IT-dependent information agility, and of both on IT-dependent strategic agility. IS

infrastructure flexibility maintains a certain level of standardization and works as a business platform that is capable of introducing changes throughout the organization en masse [Gallagher and Worrell, 2008]. An integrated IT infrastructure enables an organization to share information, coordinate activities, and align processes with its partners while IT reconfiguration enables an organization to accommodate new applications and reduces the effort a firm needs to change or recombine resources to support evolving requirements to manage its inter-organizational relationship portfolio [Rai and Tang, 2010].

Table 2: IS Perspectives on Organization Agility

Citation	Method	Main argument/finding	Perspectives on OA		
			Facilitate	Inhibit	Neutral
Breu et al., 2002	Survey	Availability of IS that provide consistent and accurate information and the uptake of new working models contribute to agility.	X		
Desouza, 2006	Conceptual framework	Agile organizations and agile IS are the same thing.	X		
Elfatatry, 2007	Conceptual framework	Delivering software as a service potentially increases business agility.	X		
Fink and Neumann, 2007	Survey	IT personnel business, behavior, and technical capability support IT infrastructure capability, which in turn enables IT dependent OA.	X		
Francalanci and Morabito, 2008	Survey	IS integration enables a higher degree of process orientation and overall organizational flexibility.	X		
Holmqvist and Pessi, 2006	Single case study	Agility is nurtured by action through implementation and strategic awareness and by keeping projects small enough that it is possible to both comprehend and lead development.	X		
Lyytinen and Rose, 2006	Conceptual framework	IS functions support organizational learning and exploration and exploitation, which enable OA.	X		
Melville, Gurbaxani, and Kraemer, 2007	Panel data	Flexibility of IT enables response to rapid changes in the competitive environment.	X		
Moitra and Ganesh, 2005	Exploratory research (interview)	Web services connect disparate applications, which enable flexible business process and ultimately organizational adaptation.	X		
Newell et al., 2007	Single case study	IS cannot promote agility because they are built to help enforce control and efficiency. Agility is spurred by chaos rather than control.		X	
Oosterhout et al., 2006	Conceptual framework	The nature of the agility gap influences the role of IS as either a facilitator or inhibitor of OA.			X
Overby et al., 2006	Conceptual framework	IS mismanagement, rather than IS per se, is the main influence on OA.	X	X	X
Sambamur-thy et al., 2003	Conceptual framework	IS competencies and the entrepreneurial alertness enable digital options, which together enables agility.	X		
Seo and Paz, 2008	Conceptual framework	IS captures large amounts of data, from multiple sources, in multiple formats, and make the data accessible to enable sensing capability of organizations.	X		
Tallon, 2008	Survey	Information legacy systems can be inflexible or unresponsive to change.		X	
Weill et al., 2002	Conceptual framework	The right balance of investment in high-capability IS infrastructures enables strategic agility. Nonetheless, imbalance investment leads to waste of resources.	X	X	X
Zain et al., 2005	Survey	IS acceptance directly and indirectly enables organizational agility.	X		

IS Inhibits Organizational Agility

The inhibiting perspective maintains that complex IT architecture may hinder organizations from being agile [Newell et al., 2007; Tallon, 2008]. For example, Newell et al. [2007] argue that IS cannot promote agility because they are built to help enforce control and efficiency. Agility, on the other hand, is spurred by chaos rather than control and efficiency. As discussed earlier in this article, organizational agility means having more options than have been preset. However, information systems can be optimized only in situations when the process is well defined. The balance between control and flexibility is not always set at the optimal level; hence, IS may inhibit agility in certain circumstances. Tallon [2008] points out that once an IS is implemented, it will soon become a legacy system, while technology keeps developing. Legacy systems reduce flexibility and innovation, and restrict rather than release the improvisational skills of users as they confront new and unpredictable situations. Seo and Paz [2008] indicate that information systems that are built at a certain point are relevant to solve specific problems that were important at that given time. The dynamic business environment can cause the information system to be out of date with the needs of future business conditions. Especially, large organizations are entangled in large, complex IS with hard coded embedded business processes and complex linkage between applications, which are developed in segregation by different IS vendors [Oosterhout et al., 2006]. Changing requirements on such information systems takes a long time and much effort to implement and shrink the IT budget to be spent on innovation, which is the main provider to organizational agility. Although tight IT integration (e.g., collaboration with business partners) streamlines and speeds up the automation of business processes, it discourages any modification that may become essential in the instance of changing business requirements (e.g., increase technological switching cost) [Rai and Tang, 2010].

A flexible IT infrastructure allows an organization to respond to environmental change [Fink and Neumann, 2007]. On the contrary, an inflexible IT infrastructure inhibits the firm's ability to respond to market opportunities, due to delays or rushed implementations and limited information sharing [Bhatt et al., 2010; Weill et al., 2002]. Legacy systems are often rigid, which also limits an organization's ability to respond to external opportunities. Furthermore, attempts to upgrade such systems often lead to performance issues without an increase in flexibility [Bhatt et al., 2010].

The Neutral View of IS and Organizational Agility

The neutral view maintains that IS can either enable or inhibit OA, depending on the existence of agility gaps that are generated by IS and the nature of IS management in place [Oosterhout et al., 2006]. OA gaps refer to the difference between the level of agility required and achieved. Overby et al. [2006] point out that, like other organizational resources, IS mismanagement, rather than IS per se, is the main reason that negatively influences OA. Without appropriate IS governance, IS will inhibit instead of enable an organization's agility. Furthermore, Mondragon, Lyons, and Kehoe [2004] signify that poor support of information systems to operations does not necessarily determine the level of agility achieved and is not an impediment for developing agility. Companies, especially those in the manufacturing sector, rely on non-IT attributes to improve the agility of their operations. Therefore, IS should be considered secondary or as second-order enablers of agility involving the enhancement of agile business processes. First-order enablers are used during the first phase of the development of agile business processes [Mondragon et al., 2004]. Moitra and Ganesh [2005] also postulate that flexible business processes are a key determinant of organizational adaptation or organizational agility.

The review of research on the impact of IS on OA in Table 2 indicates an inconclusive outcome on the role of IS on OA and the scarcity of empirical evidence on both sides of the arguments. Nevertheless, this existing knowledge provides a general domain for the research on the impact of enterprise system on OA.

V. ENTERPRISE SYSTEMS AND ORGANIZATIONAL AGILITY

Although research that explicitly investigates the relationship between ES and OA is rare (Table 3), the literature, similar to the general IS and OA literature, tends to be equivocal on the relationship between ES and OA.

Enterprise Systems Facilitate Organizational Agility

A number of researchers suggest a positive relationship between the use of ES and OA. An increase in OA is one of the benefits brought about by ES implementations [Davenport, 1998]. First, due to the advancement in ES applications and technologies, enterprise systems can speed up activities, provide intelligent and autonomous decision-making processes, and enable collaborations and distributed operations [Huang and Nof, 1999]. All three activities lead to agility [Holsapplea and Sena, 2005; Huang and Nof, 1999]. Second, ES contain mechanisms such as built-in flexibility, process integration, data integration, and availability of "add-on" software applications to support agility [Gattiker et al., 2005]. Seethamraju and Seethamraju [2009] identify three types of ES integration—vertical, horizontal, and technical integration.

Vertical integration refers to integration between different hierarchical levels. *Horizontal integration* refers to integration between departments or functions within an organization. *Technical integration* refers to integration between different systems to be compatible to one another. Among the three types of integration, vertical integration, which enhances the visibility, accessibility, control, and decision support capability, enables top management to comprehend better the critical need for changes and supports agility. Huang and Nof [1999] also argue that if the definition of agility is concerned with an enterprise system which consists of multiple, flexible, and cooperative subsystems, the whole system may still provide high agility. A study of fifteen large organizations that have implemented and used enterprise systems [Goodhue et al., 2009] identifies the finding that, when facing changes in their business environment, 39 percent of these organizations, which account for the largest proportion, would seek a response from the prebuilt business process implemented within enterprise systems. Besides, the availability of system add-ons which are developed to serve special functionalities create a wide range of different capabilities that firms can attach to their backbones to meet their unique needs and to respond to agility challenges [Goodhue et al., 2009]. Moreover, through the availability of built-in and add-on functionalities, enterprise systems provide more options for responses to meet agility challenges that do not require changing the backbone of a tightly integrated program code [Goodhue et al., 2009]. Hence, built-in and add-on solutions can be viewed as one source of agility that ES provide to organizations.

Flexible enterprises require ERP systems that enable mass customization of business practices so that organizations can develop and maintain operational and strategic distinctiveness [Lengnick-Hall et al., 2004]. Previous enterprise systems were developed based on tight coupling between business process components and business processes. Tight coupling of applications is more economical and faster to execute and relevant to operate in predictable environments [Moitra and Ganesh, 2005]. However, as the business processes are tightly coupled, it creates difficulty to adapt quickly. This is because any change made to one process would have an effect on many other processes. As the need for agility increases, there is a corresponding need for enterprise systems to become reconfigurable and, hence, the need for loosely coupled architecture. Likewise, the ES ecosystem has been undergoing a paradigm shift [Bardhan, Demirkan, Kannan, Kauffman, and Sougstad, 2010; Lorincz, 2007]. ES vendors are innovating their software products by providing new versions of ES. For example, SAP's ERP systems have been developed from R3, through ECC6 to business suite 7.0. This is an incremental and continuous development without radical modification of the core enterprise system. Moreover, vendors have developed the Web services (WS), service-oriented architecture (SOA), and business process management suites (BPMS). The introduction of WS, SOA, and BPMs have increased the flexibility of ES infrastructures and changed ES capabilities [Moitra and Ganesh, 2005; White, Daniel, and Mohdzain, 2005]. The interface among the information system network is increasingly becoming plug-and-play. This allows better collaboration within an organization internally, as well as between an organization and its partners externally [Konsynski and Tiwana, 2004]. Loose coupling, which is the fundamental characteristics of WS, SOA, and BPMS, is becoming embedded into the development of ES. Such development is making ES agility-enabling applications [Chen, Zhang, and Zhou, 2007].

Enterprise Systems Inhibit Organizational Agility

The general benefits of enterprise systems are (a) integrating data and applications, (b) implementing generic business model based on "best practices," (c) providing standardized solutions of business problems, and (d) building on modularized structure [David, McCarthy, and Sommer, 2003; Devadoss and Pan, 2007; Lorincz, 2007]. Despite these benefits, enterprise systems are viewed as organizational control systems, which enable organizational efficiency rather than promoting organizational agility. Some authors claim that ES have a negative impact on agility because of tight integration to make any process change [Newell et al., 2007] and lack of functional fit with business requirement [Ni, Kawale, and Ran, 2002]. Tight integration between different parts of the business may increase the complexity of the system as well as the whole organization [Goodhue et al., 2009]. The more complex an organization is, the more difficult to restructure when that organization needs to change. Customization in ES, which results from the lack of fit between organizationally owned business processes with standard processes provided by ES vendors, brings additional complexity, which may reduce OA [Davis, 2005]. Besides, although there is some evidence that enterprise systems allow firms to develop their business processes to closely match the current business environment, some of the evidence of positive impacts has come from organizations whose business environment is relatively stable. Efficiency and cost reduction that are the fundamental benefit of ES adoption may reduce organizational agility [Galliers, 2007; Newell et al., 2007].

The Neutral View of Enterprise Systems and Organizational Agility

Finally, a few researchers have introduced a neutral conclusion on the roles of ES on organizational agility. The introduction of an enterprise system creates power differentials, which serves to increase control in the organization [Ignatiadis and Nandhakumar, 2007]. This results in increased rigidity and a possible decrease in organizational flexibility and resilience. On the other hand, enterprise systems can also cause drift, resulting from the unexpected consequences of these power differentials, as well as from the role of perceptions of people in solving a problem

within the enterprise system. This reduction in control may serve in some circumstances as an enabler of organizational resilience [Ignatiadis and Nandhakumar, 2007].

Table 3 provides a summary of the literature on ES and OA. Most of the studies listed in Table 3 were exploratory using single case study. Overall, the literature thus far has not provided a rigorous framework that shows the mechanisms by which organizations can become and stay agile by exploiting the power of ES. In the next section, we present such a conceptual framework.

Table 3: Summary of Literature on Enterprise Systems and OA

Citation	Method	Main argument/finding	Perspective on OA		
			Facilitate	Inhibit	Neutral
Davis, 2005	Conceptual framework	Conceptual link between ERP customization and strategic agility			X
Gattiker et al., 2005	Case study	The characteristics of ERP, that is, built-in flexibility, process and data integration, and consultant knowledge, supports agility.	X		
Goodhue et al., 2009	Case study	The built-in solutions and 3rd party add-ons of ES provide more options for responses to meet agility.	X		
Ignatiadis and Nandhakumar, 2007	Single case study	Introduction of ES impacts on power differentials and drift within an organization, resulting in either a decrease or increase of organizational resilience respectively.			X
MacKinnon et al., 2008	Survey	ES can either support or constrain aspects of strategy management and the flexibility of strategic, operational, human capital, and information.			X
Newell, 2007	Single case study	ES is used for introducing efficiency and control rather than agility.		X	
Seethamraju and Seethamraju, 2009	Single case study	ES integration, best practice, business process orientation, and standardization promote business process agility.	X		

VI. CONCEPTUAL FRAMEWORK

The central argument of our conceptual framework (Figure 1) is in line with the "facilitating view of IS/ES and OA." However, we argue that the impact of ES on OA is not direct. Rather, organizations need to transform ES resources to develop an agility-enabling ES capability. To understand the structure of these resources and capabilities, we draw from the dynamic capability theory (DCT). The DCT is an extension of the resource-based view (RBV) [Teece et al., 1997].

The DCT regards firms' ability to constantly adapt, renew, and reconfigure their capabilities and competences as a major source of performance [Teece et al., 1997]. Dynamic capabilities are "the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die" [Eisenhardt and Martin, 2000, p. 1105]. While the RBV emphasizes the appropriate selection of resources, the DCT emphasizes the evolvement of resources [Teece, Pisano, and Shuen, 1997], which is signified by two processes: resource-picking and capability-building in the organization-learning loop. Dynamic capabilities are commonly associated with a dynamic environment where an organization needs to keep changing its resources to suit the organization's strategy at a particular circumstance [O'Connor, 2008]. Hence, from the DCT perspective, organizational resources need to be adaptive, renewable, and reconfigurable to provide sustainable competitive advantage [Teece et al., 1997]. Under different conditions of the business environment, different types of dynamic capabilities are needed. Therefore, dynamic capabilities have to be adaptive to various business contexts that organizations fall into. Besides, in order to sustain competitive advantage, dynamic capabilities should be renewable and reconfigurable. The DCT provides a relevant theoretical lens to conceptualize the link between ES and OA.

ES represent valuable and arguably rare resources. They provide an essential business platform; can be key sources of organizational capabilities; and can potentially, albeit indirectly, contribute to OA [Sambamurthy et al., 2003]. However, ES resources are not static or ultimately superior in enabling OA. Instead, ES resources need to be carefully selected, configured, and combined with other non-ES organizational resources to generate two critical dynamic capabilities—sensing and responding.

Sensing capability refers to an organizational ability to quickly detect, interpret, and capture organizational opportunities [Oosterhout et al., 2006; Seo and Paz, 2008]. Responding capability represents an organizational ability to quickly mobilize and transform resources to react to the opportunities that the organization senses [Gattiker et al., 2005; Oosterhout et al., 2006]. Sensing and responding capabilities are interrelated. If organizations are unable to sense effectively, opportunities will be missed, responses will be ineffective, and resources will be wasted. Therefore, there should be alignment between sensing and responding capabilities to effectively capture business opportunities [Overby et al., 2006]. Sensing and responding capabilities, therefore, can be considered as types of dynamic capabilities that can be further enhanced through ES [Sambamurthy et al., 2003]. The extent to which an organization leverages its valuable ES competencies to enable its sensing and responding capabilities can significantly influence its level of agility. ES competencies and ES-enabled sensing and responding capabilities can together help organizations to quickly and effectively adapt to changes, renew and reconfigure their capabilities, and become and stay agile. Figure 1 captures the structure of the conceptual framework.

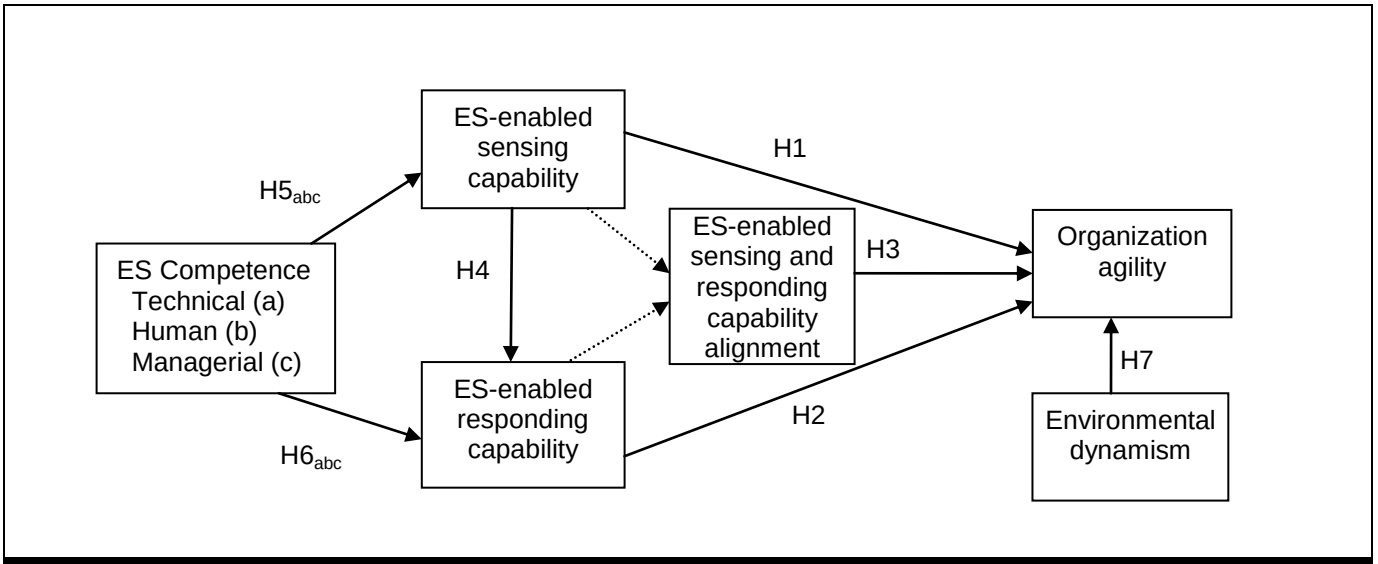

Figure 1. A Conceptual Framework Linking Enterprise Systems to Organizational Agility

Organizational Agility

Organizational agility is viewed in this article as both a quality of organizational performance and a high level dynamic capability that an organization excels in. The frequency of concepts appearing in various definitions of OA indicate that the nomological net of achieving OA comprises of sensing capability, responding capability, speed, and impact of the environment dynamism dimensions. The two concepts—sensing and responding—demonstrate the fundamental process that every organization performs when confronted with changes. Hence, fundamentally, enterprise agility has two core enabling elements: (1) sensing capability which refers to awareness of changes accurately and timely, and (2) responding capability which refers to an ability to change business processes and to customize operational responses in real time [Dove, 2005]. Thus we define OA as follows:

> *OA refers to the performance of an organization to excel in utilizing its resources in order to quickly sense changes from its business environment and respond to those changes appropriately.*

ES-enabled Sensing Capability

To conceptually ground the notion of ES-Enabled Sensing Capability (ESESC), we draw from the strategic management literature. In the strategic management literature, sensing capability is closely related to the market orientation and absorption capability [Cohen and Levinthal, 1990; Kohli et al., 1993; Overby et al., 2006]. *Market orientation* refers to a firm's ability to generate and use market intelligence about current and future customer needs [Kohli et al., 1993]. Absorptive capacity refers to the ability to acquire, assimilate, transform, and apply knowledge [Cohen and Levinthal, 1990]. Thus, sensing capability covers both market orientation and absorptive capability [Overby et al., 2006]. Sensing capability not only indicates the ability of an organization to sense current changes, but also to develop market foresight to anticipate changes in the future. Organizations that are able to anticipate changes in their business environment can quickly devise their responding actions ahead of their competitors.

There are various ways of building sensing capability. Neill, McKee, and Rose [2007] argue that organizations that perform a better capability to communicate relevant information among members of the decision-making team, interpret their environment in a multidimensional way, and analyze the information simultaneously by incorporating

multiple perspectives will have higher sensing capability and eventually become more agile. Furthermore, anticipatory capability, which refers to the ability to predict the way that the market is moving can be an essential dimension of sensing capabilities [Day, 1994]. Overall, the development of sensing capability requires organizations to scan the business environment and capture business insights beyond the usual sources. Such capability can be developed by organizational technologies, processes, values, and norms that together generate knowledge about the future condition [Sambamurthy et al., 2003].

Based on the above logic, we postulate that ES, as valuable resources, can be deployed as one source of capability building mechanisms to either directly or indirectly enable sensing capability. We name this construct as *ES-enabled sensing capability* and define it as follows:

> *ES-enabled sensing capability refers to the ability of an organization to quickly and efficiently use its ES to digitize the process of sensing and develop a strategic market foresight about its business environment.*

The sensing process includes capturing, interpreting, and analyzing change signals from business environment. ES functionalities can digitize the sensing process. Table 4 juxtaposes the concept matrix of the ES-enabled sensing capability, which is followed by a discussion of the construct.

Table 4: Concept Matrix: ES-enabled Sensing Capability

Domain	Citation	Method	ES-enabled sensing capability		
			Capturing	Interpreting	Analyzing
ES	Seethamraju, 2009	Case study	X		X
	Coltman, 2007	Survey	X	X	X
	Dong and Zhu, 2008	Survey	X	X	X
IS	Goodhue et al., 2009	Case study	X	X	X
	Huang and Nof, 1999	Case study	X		X
	Dove, 2005	Conceptual	X		
	Setia et al., 2008	Case study		X	X
	Overby et al., 2006	Conceptual	X	X	X
	Sambamurthy et al., 2005	Conceptual	X	X	X
	Izza et al., 2008	Conceptual	X	X	X
	Gallagher and Worrell, 2008	Conceptual	X	X	
	Lee et al., 2009	Survey	X	X	X

ES, when implemented correctly, offer organizations many advantages, such as standardizing procedures across global divisions, consolidating detailed transaction data from different functions, and methods to access data throughout the entire range of organizational activities [David et al., 2003]. Therefore, ES enable organizational sensing capabilities by extending richness and range of information available to the organization, hence, creating organizational agility [Sambamurthy et al., 2003]. Enterprise systems offer global connectivity of activities, data, and process. This connectivity makes it easier to integrate information internally across departments and externally with business partners [Gattiker et al., 2005]. Internal and external integration allow organizations to sense opportunities and problems in various areas such as changes in customer demand or partnering relationships [White et al., 2005]. ES store data centrally and allow the use of powerful data analysis tools, such as business intelligence, to quickly see hidden trends in data and to disseminate the information across an organization.

Although Newell et al. [2007] postulate that ES alone increases organizational efficiency while reducing organizational agility, their research also suggests that, in cases where ES is complemented with the concurrent implementation of flexibility-focused initiatives (e.g., knowledge management system), ES would improve both organizational efficiency and innovation capability simultaneously. This allows organizations to make better decisions [Dong and Zhu, 2008]. Sensing processes incur costs. Therefore, only significant changes that can create considerable impacts with a moderate level of severity should be treated. Organizations that can quickly classify changes will have a more efficient sensing mechanism. When organizations use ES with built-in KPIs and benchmarks, they will be able to quickly filter for potential changes that have significant magnitude. This allows them to sense changes in real time while lowering operating costs and increasing agility [Oosterhout et al., 2006]. Coltman [2007], for example, suggests that the customer analytic functionality of CRM can enable organizations to develop proactive rather than reactive market sensing.

ES provide digital options by digitizing knowledge and business processes [Sambamurthy et al., 2003]. Digitized knowledge with sufficient reach and richness can significantly impact a firm's sensing capability and, through that, its agility. Digitized knowledge reach is defined as comprehensiveness and accessibility of codified knowledge in a firm's knowledge base and the interconnected networks and systems for enhancing interactions among individuals

for knowledge transfer and sharing [Sambamurthy et al., 2003]. *Digitized knowledge richness* is defined as systems of interactions among organizational members to support sense-making, perspective sharing, and development of tacit knowledge [Sambamurthy et al., 2003]. While digitized knowledge represents ES-enabled strategy execution ability, the strategy generation for business environment sensing is facilitated by market (business environmental) foresight and organizational learning ability. The above leads to:

> *Hypothesis 1: Organizations that use enterprise systems (such as ERP, CRM, SCM) in building and renewing their sensing capabilities are more likely to become highly agile*.

ES-enabled Responding Capability

Response capability is an essential and distinguishing feature of an agile organization [Christopher, Lowson, and Peck, 2004; Dove, 2001]. Responsiveness, along with knowledge management and value proposition, is the cornerstones of agility [Dove, 2005]. While sensing capability generates knowledge of the business environment, responding capability transforms that knowledge into action effectively [Gattiker et al., 2005; Haeckel, 1999]. Responding capability is thus reflected by the change-enabling capabilities that are embedded in organizational processes [Li et al., 2008]. Christopher et al. [2004] suggest that short time-to-market, the ability to scale up (or down) quickly, and the rapid incorporation of consumer preferences into the design process are typical characteristics of responsiveness. Response acts are the result of a range of operating and strategy capabilities that organizations develop. Overby et al. [2006] suggest four fundamental responding capabilities: (1) production development capabilities to facilitate a firm's ability to embark on new ventures; (2) systems development capabilities to quickly and efficiently implement change to existing systems such as reusable service, SOA; (3) supply-chain and production capabilities to adjust existing ventures by shifting production to match a pending change in demand such as high supply chain visibility; and (4) flexible resource utilization to shift resources to areas of need to embark on new ventures or adjust existing ventures. Based on the above understanding of responding capability, we postulate that ES as valuable resources can be deployed as a source of responding capability building mechanisms. We name this construct as *ES-enabled responding capability* and define it as follows, with Table 5 summarizing the concept matrix:

> *ES-enabled responding capability refers to an organization's capability to deploy its ES resources and embed them in its production development, systems development, supply chain and production, and flexible resource utilization strategies and processes to quickly and efficiently respond to changes*.

Table 5: Concept Matrix: ES-enabled Responding Capability

Domain	Citation	Method	ES-enabled responding capability			
			Product development	System development	Supply chain and production	Flexible resource utilization
ES	Goodhue et al., 2009	Case study	X	X	X	
	Seethamraju, 2009	Case study	X	X	X	X
IS	Dove, 2005	Conceptual	X	X	X	X
	Tan et al., 2009	Case study	X	X	X	X
	Overby et al., 2006	Conceptual	X	X	X	X
	Sambamurthy et al., 2005	Conceptual	X	X	X	X
	Izza et al., 2008	Conceptual	X	X	X	X
	Gallagher and Worrell, 2008	Conceptual	X	X		X
	Lee et al., 2009	Survey	X	X	X	
	Seo and Paz, 2008	Conceptual	X	X	X	X

Organizations can exploit their various ES to excel in their responding capabilities. Ravinchandran and Lertwongsatien [2005] suggest that organizations can employ ES to access markets, reengineer business processes, and develop new products or services. ES provide background information that can be used to design competitive response initiatives [Mondragon et al., 2004]. ES also provide shared values between different business units (sales, manufacturing, human resource, etc.) inside organizations and across their business partners. Shared values enable collaboration in designing or implementing changes [Seethamraju and Seethamraju, 2009]. Standardization and integration, which are the fundamental outcome of ES, create simplicity and facilitate faster decision making and action and, thus, enable response capability [Gattiker et al., 2005].

Organizations that have used ES can leverage the digital business ecosystem to advance agility [Tan et al., 2009]. Information is shared across the ecosystem regardless of geographical or time constraints, which can reduce response time. Information and business process integration within the organization's ecosystem enable an

organization to have better visibility regarding the operation of its business partner, as well as strengthen the relationship within the whole supply chain, thus enabling organization responsiveness. Furthermore, the availability of ES built-in flexibility provided by ES vendors, such as Web services, and SOA determines OA [Gattiker et al., 2005]. Further, organizations can increase their digital process reach and richness through ES. Digitized process richness refers to the quality of information collected about transactions in the process, transparency of that information to other processes and systems that are linked to it, and the ability to use that information to reengineer the process [Sambamurthy et al., 2003]. *Digitized process reach* refers to the extent to which a firm deploys common, integrated, and connected IT-enabled processes. The capability of ES to provide digitized process reach and richness enables organizational response capability as it facilitates organizations to quickly and easily (re)configure and mobilize organizational resources/capabilities. Sambamurthy et al. [2003] provide the example of eBay's online auction which relies on its enterprise system to integrate its sales processes with a variety of partner processes, including payment and shipping processes. The extent to which organizations exploit ES to underpin their strategies can result in significant variations in ES-enabled responding capability and in OA. This leads to the following proposition:

> *Hypothesis 2: Organizations that use enterprise systems (such as ERP, CRM, SCM) in building and renewing their responding capabilities are more likely to become highly agile.*

ES-enabled Sensing and Responding Capability Alignment

Organizational agility places a strong emphasis on rapidity because, in order to operate in a dynamic environment, speed is an essential quality [Sherehiy et al., 2007]. Time has two critical dimensions in OA. First, it refers to the speed in detecting and responding to threats or opportunities. This includes the time to sense the events, the time to interpret what is happening and to assess the consequences to the organization, the time to explore options and decide on which actions to take, and the time to implement appropriate responses [Tan and Sia, 2006]. Second, it refers to the time that organizations retain competitive advantage before those advantages are imitated by competitors [Mathiassen and Pries-Heje, 2006]. However, there is no specific indication of how quickly the action should take place. The speed should be understood within the timeframe of available opportunities and competitors' actions [Piccoli and Ives, 2005]. Agile organizations need to be quick, both in detecting opportunities and in taking and implementing actions. Changes happen unexpectedly and continuously in the business environment; hence, organization agility indicates a continuous process of aligning to changing business requirements.

Changes identified through the sensing process requires an appropriate response. The alignment between sensing capability and responding capability ensures that no changes are ignored or organizational resources are wasted, thus obtaining the optimal effect on organizational agility and, ultimately, organizational performance [Haeckel, 1999; Overby et al., 2006; Teece, 2007]. The "strategic fit" between sensing and responding capabilities has been discussed in the literature under various constructs. Dove [2005] suggests value propositioning skills, along with knowledge management and responding capabilities, as the three cornerstones of the agility. *Value propositioning* refers to effective prioritization and choice making among competing response alternatives. Thus, value propositioning skills align the requirement for responding to the opportunities that an organization can sense and the actual responding capabilities of the organization. Sambamurthy et al. [2003] postulate that entrepreneurial alertness, which consists of strategic foresight and systemic insight, is considered to be essential for converting digital options into agility. Entrepreneurial alertness refers to the mechanism that aligns the need for promoting agility (sensing capability) and digital options (responding capability). Both value propositioning skills and entrepreneurial alertness refers to the alignment of sensing and responding capabilities.

The alignment between sensing and responding capabilities can be taken from three perspectives: moderating, matching, and mediating [Bhatt et al., 2010]. Based on the moderating perspective, the impact of responding capabilities on organizational agility varies according to different levels of sensing capabilities. By sensing more opportunities or threats (higher sensing capabilities), organizations will have a higher chance of taking more action in responding to these changes. However, the moderating view is valid only if organizations are proactively learning over a period of time. From the mediating perspective, organizational agility is dependent on the ability of the organization to respond to only the changes that it is able to capture. Lewis, Hornyak, Patnayakuni, and Rai [2008], through cross-case analysis of IT strategies at two companies, Zara and Li & Fung, that are famous for being highly agile in volatile businesses such as the apparel industry, suggest that organizations need to design a decision rights architecture with the ability to respond and act on available information to achieve a high level of agility. From the matching view, development of sensing capabilities and responding capabilities is separate [Overby et al., 2006]. The match between sensing capabilities and responding capabilities would lead to various states of alignment of sensing and responding capabilities (i.e., high sensing/high responding, high sensing/low responding, low sensing/high responding and low sensing/low responding). The stronger the alignment between sensing and responding capabilities, the better the performance of organizational agility. However, if the alignment is low, a high

level of sensing capability would be wasted if the organization cannot respond, while high levels of responding will not improve organizational agility due to not being able to detect opportunities. Thus:

Hypothesis 3: Better alignment of enterprise systems-enabled sensing capability and enterprise system-enabled responding capability is more likely to lead to higher organizational agility.

Furthermore, the relationship among sensing capability, responding capability, and organizational agility can be viewed from a process-based view perspective. From a process-based view, organizational agility is "a set of processes that allows an organization to sense changes in the business environment, respond efficiently and effectively in a timely and cost-effective manner and learn from the experience to improve the competencies of the organization" [Seo and Paz, 2008, p. 136]. None of these steps can be omitted from the process. Teece [2007] also finds that organizations that more frequently engage in market sensing and more frequently seizing opportunities and reconfiguring the resource base will be more capable of dealing with market turbulence and be better prepared to align the resource base with the environment than organizations with less practice. Although the variation in sensing and responding capability can create different types of agility levels, high sensing capabilities can generally lead to high responding capabilities, allowing firms to rapidly retool existing products, change production volumes, and customize service offerings. Thus:

Hypothesis 4: Higher enterprise systems-enabled sensing capability is more likely to lead to higher enterprise system-enabled responding capability.

ES Competence

The creation of ES-enabled sensing and responding capabilities depends on the quality of the ES infrastructure an organization has put in place. Enterprise systems are not simple IT solutions but include the dexterous combination of human- and business-related competencies [Coltman, 2007]. ES competence refers to the quality of the ES infrastructure. For the purpose of this research, we focus on the ES competences developed after the adoption and during the continuance of ES use [Lim et al., 2005]. As enterprise systems are regarded as the most prominent development of information systems, we draw from the IS competences literature to define ES competences. A review of the literature has resulted in the identification of two fundamental dimensions of IS competences: technical infrastructure competence and human and managerial competences [Bhatt et al., 2010; Piccoli and Ives, 2005; Tallon, 2008; Wade and Hulland, 2004]. These dimensions are summarized in Table 6.

Table 6: Dimensions of IS Competencies

IS competence	Sub-category	Description	Citations
Technical competence	Hardware compatibilities	Systems interoperability and integration, seamless access via common user interface	Byrd and Turner, 2000, 2001; Piccoli and Ives, 2005; Stratman and Roth, 2002; Tallon, 2008; Wade and Hulland, 2004; Weill et al., 2002
	Software modularity	Rapid software development, reusable code, software portability across systems, ability	
	Network connectivity	Ability to expand or contract network reach, remote access to shared data pools, adaptable links to internal and external parties	
Human and managerial competences	Technical knowledge and skills	The technical ability of IT personnel based on their specific expertise in technical areas	Bharadwaj, 2000; Bhatt and Grover, 2005; Byrd and Turner, 2000; Fink and Neumann, 2007; Piccoli and Ives, 2005; Ravichandran, 2007; Stratman and Roth, 2002; Tallon, 2008; Weill et al., 2002
	Behavioral knowledge and skills	The interpersonal and management ability of IT personnel to interact with and manage others	
	Business knowledge and skills	The ability of IT personnel to understand the overall business environment and the specific organizational context	

The general IS competences coupled with the unique characteristics of ES such as integrating data and business processes, standardization of providing solutions to business problems, building on modularized structure, and allowing customizations for the specific business process define the domain of ES competences [Devadoss and Pan, 2007; Lorincz, 2007]. Therefore, extending from the literature of IS competences and based on other research on ES capabilities [Devadoss and Pan, 2007; Maurer, 2009; Stratman and Roth, 2002; Dong and Zhu, 2008], we identify three dimensions of ES competences—ES technical infrastructure competence, ES human competence, and ES managerial competence (see Table 7 for the concept matrix).

ES technical infrastructure competence is defined as the ability of ES technical infrastructure to deliver and support fast design, development and implementation of ES, and the ability to distribute any type of information across organizations. Two essential qualities of the ES technical infrastructure are integration and adaptability [Sprott, 2000; Stratman and Roth, 2002]. Integration refers to the establishment of a collaborative platform, which allows a free-flow of information internally within the organization and externally with information systems of business partners [Seethamraju, 2009; Swafford et al., 2008]. The adaptability of ES indicates the extent to which the ES can be easily (re)configurable or restructured in accordance to new conditions. The IS flexibility is assessed based on two strategies: (1) the flexibility-to-use, which refers to the features that IS supports without major modification to the IS, and (2) flexibility-to-change, which refers to the process requirements supported by IS through adjustments and modifications on the IS [Gebauer and Schober, 2006]. Therefore, the adaptability of ES requires both a high level of reach and richness of ES functionalities that support the business operation and the reconfigurability of the ES. The technological ES competence enables system interoperability with other enterprise systems, which may be developed by other ES vendors, or special-purpose add-on systems provided by third-party vendors [Goodhue et al., 2009].

High ES technical infrastructure competence enables a free flow of information within an organization and between the organization with its business partners in the supply chain, thus supporting a quick capture and analysis of information to identify changes more efficiently. Moreover, ES technical infrastructure competence indicates a highly flexible ES infrastructure that allows add-ons and reconfiguration of the ES system when needed; hence, it enables responsive capability. Thus:

Hypothesis 5a: Organizations that have developed a high level of ES technical competence are more likely to exploit that competence in order to build their ES-enabled sensing capability.

Hypothesis 6a: Organizations that have developed a high level of ES technical competence are more likely to exploit that competence in order to build their ES-enabled responding capability.

The ES human competence refers to the technical and managerial knowledge and skill of using enterprise systems in performing business process [Dong and Zhu, 2008; Stratman and Roth, 2002]. This includes technical, business, and behavioral skills [Fink and Neumann, 2007]. *Technical skills* refers to IT staff's and end-users' ability to configure, maintain, and effectively use ES respectively [Stratman and Roth, 2002]. *Business skills* refers to the management skills and business process knowledge possessed by individuals working on ES [Lim et al., 2005; Maurer, 2009; Stratman and Roth, 2002]. *Behavioral skills* refer to the interpersonal skills of the people involved in ES, such as the ability to work cooperatively in cross-functional teams with personnel from other departments [Fink and Neumann, 2007, 2009]. Organizations should not only develop these skills generally but also focus deeply on the ES-specific absorptive capacity [Daghfous, 2007]. For example, "CRM-specific absorptive capacity allow the firm to acquire, assimilate, analyze and leverage customer-specific knowledge to produce an array of tailored innovative products and services that meet the ever-changing customer needs" [Daghfous, 2007, p. 61].

ES human competence enables sensing capabilities of organizations in terms of higher knowledge transfer across different business areas in an organization, thus allowing the information to be quickly captured and analyzed. Besides, rich knowledge on ES capabilities allows a quick recall of business processes that can be supported by ES, thus enabling a higher responding capability. Therefore:

Hypothesis 5b: Organizations that have developed a high level of ES human competence are more likely to exploit that competence in order to build their ES-enabled sensing capability.

Hypothesis 6b: Organizations that have developed a high level of ES human competence are more likely to exploit that competence in order to build their ES-enabled responding capability.

The *ES managerial competence* refers to management's project management, change readiness, and strategic planning acumens [Stratman and Roth, 2002]. Since ES are mostly provided by vendors such as SAP and Oracle, the procurement skills—the ability to learn, develop, and work with external suppliers for appropriate ES deployment—is crucial in managing ES [Maurer, 2009]. Changing business environment requires changes in business processes and technology that supports the business processes. Hence, organizations need to frequently evaluate the performance of ES, allocate resources for upgrade and maintenance, and align ES development with the overall IS and organizational strategies. With high ES managerial competence, organizations can maintain the system to be up-to-date to support any modification in organizational business processes, thus enabling sensing and responding capabilities. Thus,

Hypothesis 5c: Organizations that have developed a high level of ES managerial competence are more likely to exploit that competence in order to build their ES-enabled sensing capability.

Hypothesis 6c: Organizations that have developed a high level of ES managerial competence are more likely to exploit that competence in order to build their ES-enabled responding capability.

ES competences allow organizations to integrate a wider range of systems internally and externally and to capture data from various sources. Furthermore, the ability to distribute any type of data across an organization enables data to be interpreted from various perspectives. Capturing data from various sources and interpreting them with various perspectives enables organizations to detect and capture changes quickly and respond to them efficiently [Dove, 2005; Maurer, 2009].

Table 7: Concept Matrix of ES Competence

Citation	Method	ES competence		
		Technical	Human	Managerial
Daghfous, 2007	Conceptual	X	X	
Dong and Zhu, 2008	Survey	X		
Devadoss and Pan, 2007	Case study	X		
Fink and Neumann, 2007	Survey		X	X
Fink and Neumann, 2009	Survey		X	X
Goodhue et al., 2009	Case study	X		X
Grant and Chen, 2005	Survey	X	X	
Lim et al., 2005	Case study		X	X
Maurer, 2009	Conceptual	X	X	X
Sprott, 2000	Conceptual	X		
Stratman and Roth, 2002	Survey		X	X

Environmental Dynamism

The proposed framework has one boundary condition, that is, the impact of environmental dynamism factors such as competitiveness and complexity of the environment [Sambamurthy et al., 2003]. The dynamism factors can influence the level of agility required in an organization (i.e., organization operating in stable industry with predictable changes will require different levels of agility to those who operate in a fast changing environment) [Tallon, 2008]. The impact of market-sensing activities on organizational performance vary with the degree of market turbulence [Eisenhardt and Martin, 2000], while environmental dynamism also significantly requires faster strategic decision-making speed, thus higher responsive capabilities [Baum and Wally, 2003]. Organizations operating in turbulent environments face higher uncertainty, thus need to process information more rapidly than organizations that operate in more stable business surroundings. Enterprise systems centrally manage information flows within an organization and across the organization and its business partners. Therefore, we propose that the extent of environmental dynamism serves as a control variable on how ES can be used to achieve agility:

Hypothesis 7: Organizations that operate in fast-changing environments where product shelf life is short are more likely to develop high ES competence and high ES-enabled sensing and responding capability than those that operate in a relatively stable environment.

VII. SUMMARY AND IMPLICATIONS

Organizations that are faced with challenges from a highly turbulent business environment have looked into agility as a new capability and success indicator to respond to those changes and achieve a high level of performance. Likewise, how IT/IS influences agility is a topic of interest in IS research. Yet the IS literature has not been very clear in regard to the conceptualization of organizational agility: IT-enabled organizational agility and the "IT artifact." Further, the literature is inconclusive about the relationship between IS/IT and organizational agility. Some view the role of information systems on organizational agility as that of facilitator; others consider it to be an inhibitor. In addition, most, if not all, of the studies that investigated IS-related agility antecedents work on the assumption of a direct relationship between IS-related factors and organizational agility. Changes from the business environment come from various sources, causing organizations to have various distinctive ways of responding to changes. Hence, organizational agility is viewed to have polymorphous aspects (Lee et al., 2007). In that context, simply viewing the direct relationship between IS and OA constrains the understanding of how IS supports the polymorphous aspects of organizational agility.

Since the early days of computerization, there have been significant improvements in organizational IS ecosystems as organizations move from in-house developed systems to off-the-shelf enterprise-wide architectures and systems.

Enterprise systems, which capture the most advanced development of IT, are becoming common fixtures in most organizations. Although ES are classified as one type of information system implemented in organizations, thus inheriting the common IS characteristics, they have unique features that differentiate them from legacy information systems [Devadoss and Pan, 2007]. ES can improve organizational performance. However, literature on ES is still dominated by ES implementation issues rather than post-implementation issues [Moon, 2007]. As such, how ES affect OA has been less researched. This article aimed to review the existing literature on IS and OA in general and ES and OA in particular and to provide a framework to theorize the mechanisms by which organizations can exploit their ES to advance agility.

In achieving the first aim, the article offers a comprehensive and deepened perspective toward the existing discourses on IS/IT and ES-enabled organizational agility. We followed a systematic and rigorous approach to identify, select, and analyze the literature. The review represents an original contribution to IS research and can serve as a building block for future research on IS and organizational agility.

In pursuing the second aim, the article extends the IS and ES literature in three areas. First, the research contributes to the current body of knowledge on the post-implementation benefits of ES, which is still less researched [Moon, 2007]. Following the suggestions of Orlikowski and Iacona [2001] and Alter [2008], the article explicitly theorizes about enterprise systems-related competencies that can be exploited to develop distinctive ES-enabled sensing and responding capabilities to advance organizational agility under dynamic environment. This theorization aligns with the findings from previous studies that strategic use of IS competence can positively influence organizational performance [Tallon, 2008; Bhatts et al., 2010; Fink and Neumann, 2007]. Specifically, the current research suggests that if organizations possess ES technical competence, ES human competence, and ES management competence, they would create a digital platform to renew and develop unique and ES-enabled sensing and responding capabilities to improve their agility. Enterprise systems evolve after the implementation through system upgrades; thus the ES competence will continue to be maintained and developed.

Second, the research identifies a clear nomological structure linking enterprise systems with organizational agility. From the literature, we identified two views of organizational agility vis-à-vis the concepts of sensing and responding. While some [Overby et al., 2006] treat sensing and responding as components of agility, others take a process [Seo and Paz, 2008] and capability [Sambamurthy et al., 2003] view and treat sensing and responding separately from agility. The framework proposed in the current article shares Seo and Paz's [2008] and Sambamurthy et al.'s [2003] views that sensing and responding are separate from, and reside outside of, the domain of agility. This position challenges Overby et al.'s [2006] view which treats the two components as part of, and as located within, the scope of agility. While Sambamurthy et al. [2003] suggested the digitization of business processes and knowledge would generate digital options, they did not specifically address what type of business processes and knowledge contribute to digital options. This article extends Sambamurthy et al.'s [2003] framework by emphasizing the digitization of business processes involved in sensing and responding to changes and by theorizing how that contributes to organizational agility.

Further, we also identify three competencies of ES, that is, technical, human, and managerial. Then, drawing from the dynamic capability and process-based theories, in addition to the direct relationship between ES competence and OA that has been recognized in prior literature, we introduce two distinctive types of high-order ES dynamic capabilities i.e., enterprise system-enabled sensing capability and enterprise system-enabled responding capability and the alignment between the two as part of the nomology linking ES competence and organizational agility. This structure clearly defines our notion of ES-enabled organizational agility as distinct from those of Tan et al. [2010], Overby et al. [2006], and Sambamurthy et al.'s [2003]. Thus the article opens up the black-box of the role of ES in OA. Using the capability hierarchy, the research delineated different levels of ES capability which could support practitioners in managing their ES resources and capabilities more effectively.

Third, the current research proposes a framework that can be tested empirically. The seven propositions provide the mechanism to investigate ES-related contributions to, and variations in, OA. We believe that these propositions represent a valuable step.

Overall and directly addressing the research question posed at the beginning of the article, our theorization shows that organizations can achieve agility out of their ES investment in three ways: (1) by developing an ES technical, human, and managerial competence; (2) by exploiting their ES competence to build ES-enabled capabilities that digitize their key sensing and responding processes; and (3) when ES-enabled sensing and ES-enabled responding capabilities are aligned than when they are not and when organizations operate in a relatively turbulent environment.

However, we acknowledge one limitation of the article and proposed framework. In order to focus more on the ES capabilities, we did not include the self-learning aspects into the framework [Sambamurthy et al., 2003]. Self-learning or feedback looping between the capability and outcome can be critical for a sustainable OA.

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Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the article on the Web, can gain direct access to these linked references. Readers are warned, however, that:

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APPENDIX A. LIST OF JOURNALS AND ARTICLES

Table A–1: List of Journals and Articles

Journal title	No. of papers	Citations
European Journal of Information Systems	7	[Holmqvist and Pessi, 2006; Lim et al., 2007; Lyytinen and Rose, 2006; Mathiassen and Pries-Heje, 2006; Oosterhout et al., 2006; Overby et al., 2006] [Arnold et al., 2010]
Information and Management	5	[Byrd and Turner, 2001; Moitra and Ganesh, 2005; Zain et al., 2005] [Fink and Neumann, 2009] [Bhatt et al., 2010]
Journal of Information Technology	4	[Francalanci and Morabito, 2008; Ignatiadis and Nandhakumar, 2007; Konsynski and Tiwana, 2004] [Breu et al., 2002]
Communications of ACM	4	[David et al., 2003; Elfatatry, 2007; Montazemi, 2006; Seo and Paz, 2008]
Journal of Management Information Systems	3	[Byrd and Turner, 2000; Gosain et al., 2004] [Bardhan et al., 2010]
Journal of the Association for Information Systems	3	[Fink and Neumann, 2007; Gebauer and Schober, 2006; Tan and Sia, 2006]
Information Systems Journal	2	[Shang and Seddon, 2002] [Olsen and Sætre, 2007]
Decision Support Systems	2	[Chen et al., 2007] [Holsapplea and Sena, 2005]
Information System Research	2	[Fichman, 2004] [Pavlou and El Sawy, 2010]

Table A–1: List of Journals and Articles – Continued		
Communications of the Association for Information Systems	1	[Devadoss and Pan, 2007]
Harvard Business Review	1	[Sull, 2009]
Cited papers: Articles found based on forward and backward link		
Agile Information Systems Conceptualization, Construction and Management (book)	2	[Newell, 2007; Desouza, 2006]
ICIS 2009 and 2010 Proceedings	2	[Tan et al., 2009, 2010]
International Journal of Operations & Production Management	2	[Mondragon et al., 2004] [Swafford et al., 2008]
Journal of Information Technology Management	2	[Tallon, 2008; Gallagher and Worrell, 2008]
"Business Agility and Information Technology Diffusion" (book chapter)	1	[Dove, 2005]
Enterprise Interoperability III	1	[Izza et al., 2008]
International Journal of Information Management	1	[White et al., 2005]
International Journal of Production Economics	1	[Swafford et al., 2008]
MIS Quarterly Executive	1	[Goodhue et al., 2009]
MIT Sloan Management Review	1	[Weill et al., 2002]
"Strategic ERP Extension and Use" (book chapter)	1	[Gattiker et al., 2005]

ABOUT THE AUTHORS

Thao Trinh-Phuong is a doctoral candidate in the School of Business IT and Logistics at RMIT University. Her research interest is enterprise systems and organizational performance.

Alemayehu Molla is an Associate Professor, School of Business IT and Logistics, RMIT University. He researches in the areas of Green IT, digital business, and development informatics with more than 100 publications, including in the *European Journal of Information Systems, Information & Management, International Journal of E-commerce, Communications of the Association for Information Systems, Journal of Computer Information Systems, Journal of E-commerce Research, Journal of E-commerce in Organizations, Internet Research*, and *The Information Society Journal.*

Konrad Peszynski is a Senior Lecturer in the School of Business Information Technology and Logistics at RMIT University, Melbourne, Australia. Dr. Peszynski obtained his Ph.D. in 2006 exploring the role of power and politics in system selection and implementation. His specific research interests include supply chain management and associated technologies, e-business, e-procurement, and the social aspects of information.

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