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Digital Transformation to Real-Time Enterprise to Sustain Competitive Advantage in the Digitized World: The Role of Business Intelligence and Communication Systems

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This study aims to explain digital transformation of firms to real-time enterprises (RTE) that can successfully sense and manage important business events that appear as opportunities and threats in the digitized business world. We define RTE capabilities as the organizational ability to sense and act to important business events in a timely manner. Furthermore, we define sensemaking and acting capability as two dimensions of RTE capabilities and business intelligence and communication support as two key information technologies for digital transformation into RTE. Using 191 survey responses from 96 firms in diverse industries, we find that the different roles of BI and communication support technologies in achieving high RTE capabilities and firm performance across different environmental velocities. IT enables firms to achieve competitive advantage indirectly by enhancing RTE capabilities in fast environments. In slow environments, RTE capabilities appear not to enhance performance, but instead frequent actions to reconfigure resources and structures seem to deteriorate competitive advantage.

Key Words: Digital Transformation, Real-Time Enterprise (RTE), Business Intelligence, Communication Systems

Ⅰ. Introduction

Digital transformation defined as the use of digital and information technologies in transforming user experience and business processes and models to significantly improve performance or reach of enterprise (Leonardi, 2020; Westerman, Lee and Yoo, 2018; Ahn, Kim, Kim, 2016; Choi, Choi, Lee, 2016; Bonnet, and McAfee, 2014) has been radically changing competitive dynamics in the increasingly digitized business environment. Companies improve traditional technologies such as ERP and CRM as well as adopt new digital technologies such as business intelligence and analytics, mobile and smart devices to change and enhance business processes, customer

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relationships and the ways to innovate produces and services, thus transforming competitive landscapes in all economic sectors (Bharadwaj, El Sawy, Pavlou, and Venkatraman, 2013; George, Osinga, Lavie, and Scott, 2016; Malhotra, Gosain, and El Sawy, 2007; Yoo, Boland Jr, Lyytinen, and Majchrzak, 2012).

In such digitally transforming environments organizations are facing a number of challenges that they should overcome to survive and thrive. For example, the speed at which new opportunities emerge or new products and services are introduced (Burgelman and Grove, 2007; Davis, Eisenhardt, and Bingham, 2009; Ferrier, Holsapple, and Sabherwal 2010; Nadkarni and Narayanan, 2007) is continually increasing over time in a broad range of industries, not only in high technology industries but also in non-high technology industries (D'Aveni, Dagnino, and Smith 2010; Wiggins and Ruefli, 2005). Furthermore, organizations cannot process the rapidly increasing amount of big data generated from the digitally connected world in a timely manner, market information becomes obsolete quickly, and windows for strategic opportunities and threats close quickly. Thus, organizations often fail to sense and respond to critical changes in a timely fashion (McAfee and Brynjolfsson, 2012; Park, El Sawy, Fiss, 2017). The cost of failure in timely sense-response can become enormous like unwanted exits from the market.

Therefore, in the pervasively digitized world, the organizational capabilities for timely sensing and managing important business events that turn into opportunities and threats become a key issue for organizations in sustaining competitive advantage (Ferrier, Holsapple, & Sabherwal, 2010; Park et al., 2017; Sambamurthy, Bharadwaj, and Grover, 2003; Teece et al., 1997; Eisenhardt and Martin, 2000). In this study, we define the capability of timely sensing and managing important business events as real-time enterprise (RTE) capability. RTE capability is a type of organizational agility (Overby et al., 2006; Sambamurthy et al., 2003), which is also a type of dynamic capability (Teece et al., 1997; Pavlou and El Sawy, 2006). We introduce this new specific term instead of using the extant terms because we want to emphasize the importance of a time buffer concept in the sense-response process. We assume that each task has a time buffer --- the amount of time given for organizations to finish the task without delaying other tasks that are dependent on it, which we explain in further detail in the following sections.

Prior strategic management research argued that in highly turbulent environments, organizations need to continually reconfigure tasks and resources in a way to shorten the cycle of experiments that aim to create a series of temporary competitive advantages (Bourgeois and Eisenhardt, 1988; D'Aveni, 1994; Eisenhardt and Martin, 2000). However, they largely ignore the role of digital and information technologies in developing RTE capabilities that enable firms to sustain com-

petitive advantage. For example, only 2.8% of the research articles published in the leading management journals have explored the relationship between technologies and organizations (Orlikowski, 2009; Zammuto et al., 2007). The omission of IT can be a mistake because IT is one of the most important factors that can determine organizational capabilities to cope with environmental turbulence (Bharadwaj et al., 2013; Ferrier, Holsapple, and Sabherwal, 2010; George, Osinga, Lavie, and Scott, 2016; Pavlou and El Sawy, 2006, 2010; Malhotra et al., 2007; Bensaou and Venkatraman, 1995).

Some IS studies argue that IT helps organizations successfully compete in turbulent environments by enhancing organizational capabilities to sense and seize opportunities in real-time (Overby et al., 2006; Park et al., 2017; Sambamurthy et al., 2003). However, we generally lack empirical studies that show what kinds of information technologies and how they can help organizations to develop RTE capabilities to sense and manage critical business events emerging from environments. This study explores the dynamics of latency reduction in a firm's event management in turbulent environments and the role of information technologies in developing RTE capabilities, which enhance eventually firm performance. Thus, this study intends to contribute to the management literature for organizational dynamics of coping with turbulent environments by empirically exploring how and what kinds of information technologies can enhance organizational capabilities to sense and manage opportunities and threats generated from rapidly changing environments and thus can achieve sustainable competitive advantage. Practically, this study helps managers understand how to design and manage information technologies to transform into RTE that can successfully cope with rapidly changing environments.

II. Conceptual Development and Hypotheses

2.1 Conceptualizing Environmental Change

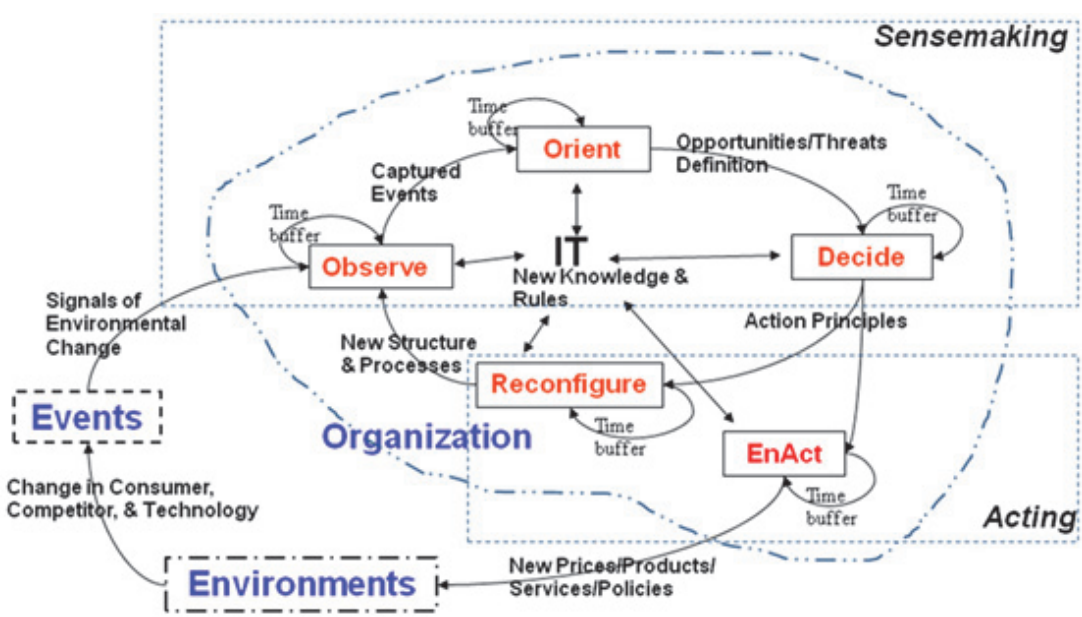
The organizational theory and strategic management literature defines a number of different business environmental factors, for example, customers, products, competitors, suppliers, regulators, technologies, and economics, to name but a few. Some of these environmental factors are more directly related to organizational tasks, while others constitute a broader contextual environment. For example, customers, technologies and competitors are considered task environmental factors, while economics, regulation, and social-culture are considered general environmental factors (Daft et al., 1988). General environments affect all industries as the global economic crisis in 2008 did, while task environments describe more specifically the characteristics of an industry. This study focuses on sensing

and managing changes in task environments (i.e., customers, technologies, and competitors).

2.2 Two Aspects of RTE Capabilities for Business Event Managemen

Organizational sensemaking and acting on critical business events that turn into opportunities and threats in turbulent environments are so complex that studies on this topic cut across multiple disciplines including strategic management, organization theory, marketing, and entrepreneurship (Ardichvili et al., 2003). Building on studies of sensing and managing environmental changes from multiple disciplines (Houghton et al., 2003; Kiesler and Sproull, 1982; Thomas, Clark, and Gioia, 1993), we suggest the event management model developed with an open-system approach (Emery and Trist, 1965), which shows how organizations sense and respond to environmental change and also enact new change as depicted in Figure 1.

We introduce the concept of an event as a boundary object that links environmental changes with organizational sensing and managing tasks for the environmental change. We view events as the iterative manifestation of continuing environmental changes which are otherwise too messy and complex to describe. The concept of an event is common in the context of complex event processing in computer science (e.g., Chandy and Schulte, 2009). Architectures that are suitable for real-time computing, for example, event-driven architecture and service oriented architecture



〈Figure 1〉 Open-System Event Management Model

have been invented based on event processing.

The concept of an event is also amenable to observability and can be grounded in organizational practice and managerial work. Thus, we can capture the observable manifestation of an environmental change as an event. Events carry with them signals to managers in organizations that may suggest impending opportunities and threats.

A better practice would suggest that by understanding opportunities and threats embedded in environmental events, organizations would reconfigure resources to maximize the effect of opportunities and minimize the effect of threats. Further, organizations could enact environmental change by introducing new competitive actions such as new products and pricing models into the market (D'Aveni et al., 2010; Ferrier et al., 2010; Smircich and Stubbart, 1985). These enacted competitive actions can trigger further changes that are manifested as new environmental events for other actors such as competitors, consumers, and regulators. Organizations enacting those changes can observe the effects of their actions through open loop feedbacks by capturing and interpreting new environmental events that appear to be connected to their enactment of changes. Thus, introducing the notion of events as a boundary object helps us make a simple connection between environmental dynamics and organizational dynamics.

A number of models have been proposed to describe how organizations and managers sense and manage environmental changes. For example, some propose a model of organizational adaptation consisting of scanning, interpreting, and responding processes (Daft and Weick, 1984; Milliken, 1990), and some suggest a sensemaking model consisting of information seeking, meaning ascription, and action (Gioia and Chittipeddi, 1991; Weick, 1999). Thomas et al. (1993) explore a sequential relationship of scanning, interpretation, action and performance.

This study adopts the idea of observe, orient, decide, and act (OODA) loop (Boyd, 1986; Houghton et al., 2004). By developing this OODA concept, US Air Force Colonel John Boyd could understand how pilots with inferior aircraft could win air combat (dog fights) against pilots with superior aircraft. He found that the winning pilots completed the OODA cycle more quickly than their adversaries. We choose this OODA framework because we think it can capture the nuance of more live, urgent activities to cope with fast environmental change and can be comprehended by practicing managers, thus making the yield from field data collection more likely to be of higher quality.

We extend the OODA model framework by dividing the act task into reconfigure and enact sub-tasks to show specifically not only how organizations adapt to environmental changes but also how they enact new environmental changes. Table 1 explains each task briefly.

The five key organizational tasks to sense

〈Table 1〉 Event Management Tasks

Task	Explanations	Outputs
Observe	Scan, monitor, and filter events regarding customers, competition, and technologies in which opportunities and threats are manifested	Events that can significantly influence firms' performance
Orient	Gather, aggregate, structure, and evaluate relevant information from diverse sources to understand the implications of the captured events to organizations	Opportunities and threats definition
Decide	Make action principles to guidelines to reconfigure resources and to initiate new competitive actions to the market in a way to maximize the effects of opportunities and to minimize the effects of threats	Action principles (e.g., new configuration plan, new product/service plan)
Reconfigure	Reconfigure organizational resources, and modify process, product, strategy, and structure based on action principles	New configuration of resources; New structure and processes
Enact	Introduce new competitive actions to the market, such as new products/services and new pricing models, and modify policies with strategic partners based on action principles	New price, products, services; New policies for customer and supplier relationship management

and manage events are a series of continuous and interconnected activities to identify and manage opportunities and threats, which give rise to the formation of a new business and new combinations of resources (Ardichvile et al., 2003; Teece et al., 1997).

With this model, we define two RTE capabilities regarding event management tasks: sensemaking and acting capabilities. These two task capabilities are complementary to each other for explaining how organizations successfully transform into real-time enterprise that can sense and manage events in a timely manner that appear as opportunities and threats in a rapidly and unpredictably changing environment. The literature supports this argument (Houghton et al., 2003; Park et al. 2017; Sambamurthy et al., 2003; Overby et al., 2006).

According to the literature, sensemaking is an organization's response to environmental events in which they develop some sort of sense regarding what they are up against, what their own position is relative to what they sense, and what they need to do (Weick, 1999:42). Thus, scanning and interpreting events and capturing opportunities and threats embedded in events, and deciding action plan can be tasks for organizational sensemaking. Thus, in this study, we define sensemaking capability as "organizational ability to significantly reduce the time latency in observe, orient, decide tasks."

Reconfiguring resources and enacting new competitive moves are organizational actions that execute plans made through sensemaking.

We define acting capability as "organizational ability to significantly reduce the time latency in reconfiguring resources and enacting new competitive actions."

Sensemaking and acting capabilities together can shorten the cycle of experiments to sense and manage opportunities and threats from environmental change, and thus RTE capabilities allow organizations to introduce innovations more frequently than competitors so that reflect the changing environment in a timely fashion and help to achieve competitive advantage.

Theories of competitive actions explain that the rapid and frequent competitive actions enable a firm to outperform its competitors in high-velocity and hyper-competitive environments (Chen and Miller 2012; D'Aveni et al. 2010; Ferrier et al., 1999, 2010). For example, organizations that promptly respond to market opportunities and threats achieve high performance (Grewal and Tansuhaj, 2001). Frequent responses to the market with new products/services increase the profit of airlines (Smith et al., 1991) and of hospitals (Shortell et al., 1990; Zajac and Shortell, 1989). Thus, we propose the following hypothesis about acting RTE capabilities:

H1a: Acting capabilities are positively related to performance in rapidly changing environments.

Furthermore, by definition, sensemaking capabilities can help organizations successfully capture and interpret important events so that they can understand in a timely fashion the trends of changing environments (Daft and Weick, 1984; Overby et al., 2006; Park et al. 2018; Thomas et al., 1993; Weick, 1999). Thus, sensemaking RTE capabilities enable organizations to make right actions in a way that focuses on handling changing environments. So, we propose a hypothesis of sensemaking RTE capabilities as follows:

H1b: Sensemaking capabilities enhance acting capabilities.

2.3 Information Technologies to Enhance RTE Capabilities

The information systems (IS) literature defines a variety of information and digital technologies by considering specific task contexts, because according to the task-technology fit theory, some IT can better support specific tasks than other ITs (Goodhue and Thomson, 1995; Zigurs and Buckland, 1998; Daft and Lengel, 1986). For example, Sabherwal and Kirs (1994) define four information technologies in the context of academic institutions: information retrieval, electronic communication, computing facilities for students, and computer-aided education technologies. Zigurs and Buckland (1998) define three ITs for group decision making tasks: information processing, communication support, and process structuring technologies. Pavlou and El Sawy (2006) define three ITs specific to the new product

development context: project and resource management, knowledge management, and cooperative work technologies.

In this study, we focus on two ITs specific to the event management context in which IT can help develop task-specific RTE capabilities (i.e., sensemaking and acting capabilities), based on the IS literature about the IT functionalities for task capabilities to cope with turbulent environments (Houghton et al., 2004; Pavlou and El Sawy, 2006, 2010; Overby et al., 2006; Sambamurthy et al., 2003). To complement the literature, we had a number of interviews with managers and IT consultants in charging of event management in high velocity industries. We also conducted a pilot study with a small real-time enterprise in the IT service industry. The interviews and pilot study help us better understand how organizations sense and manage important events from a firm's task environments and what kinds of information technologies can help them effectively do such tasks.

The first IT for event management is business intelligence (BI). BI technology provides several key functions that enable organizations to successfully make sense of environmental change and respond to it in a timely manner (Park et al., 2017; Wixom and Watson, 2001). "Business intelligence involves collecting data, analyzing the data to detect patterns and meanings within the data, extracting information from these analyses, and turning this information into actionable knowledge" (Carte et al., 2005), thus accelerating the cycle of experiments to sense and respond to environmental changes. Specifically, BI allows firms to monitor events by supporting access to multiple data sources, including internal databases, 3rd party data (e.g., financial market information, GPS information, and consumer report), customers, partners, and competitors in real-time. A rule-based exception handling function embedded in BI technologies scans and filters environmental events based on predefined rules. A publish-subscribe function of BI proactively and reactively sends out information about events to relevant people whose work can be related to the captured events (Chandy and Schulte, 2009; Chen et al., 2012; Watson and Wixom, 2007). This function also handles both routine expected events and emergent unexpected events. Digital dashboard, balanced scorecard, rule-based systems, business event monitoring systems, web analytics, and data warehouse are good examples that provide these functions.

Business intelligence also includes such functions that give decision makers easy access to an enterprise-wide, consistent and integrated database like data warehouse (Carte et al., 2005; Cooper et al., 2000). A knowledge map like a metadata directory/map shows "which information is available where." It enables decision makers to analyze data in various ways, such as graphs, tables and adhoc query with natural language processing and visual metadata presentations. Statistical analysis, what-if analysis, and visual representation of data help effective interpretation

of events and decision making.

BI technologies provide relevant information to a right person in a right time and in a right format and thus help effectively execute event management tasks. BI systems support the event management tasks, resulting in faster OODA loop depicted in Figure 1 for learning and acting with more vigilance in a high velocity environment (Chen et al., 2012; Houghton et al., 2004; Park et al. 2017). BI technologies also can provide real time information about a firm's operations or environment, for which there is little or no time lag between occurrence and reporting. Thus, we propose:

H2a: Business intelligence systems enhance both sensemaking and acting capabilities.

The IS literature argues that information technologies indirectly impact on firms' performance by enhancing organizational capabilities to cope with turbulent environments (Pavlou and El Sawy, 2006; Sambamurthy et al., 2003). For example, learning occurring through the five event management tasks depicted in Figure 1 can enhance an organization's absorptive capacity by adding new knowledge about changing environments (Schreyogg and Kliesch-Eberl, 2007). Absorptive capacity enables organizations to sustain entrepreneurial orientation to sense and manage opportunities and threats (Zahra, Filatotchev, Wright, 2009), thus enabling organizations to successfully evolve through turbulent environments over time. Business intelligence helps enhance a firm's absorptive capacity by storing and managing its new knowledge of environments like sensemaking rules and patterns of customers' preference change, which at last help effective real-time sensemaking and acting, which in turn support to achieve high firm performance (Mithas et al. 20111; Pavlou and El Sawy, 2006, 2010). Thus, we have the second hypothesis about BI:

H2b: Business intelligence systems indirectly enhance a firm's performance through sensemaking and acting capabilities.

The second IT for the event management tasks is communication support. Communication support technology refers to a set of IT-enabled capabilities that support real-time information dissemination, two-way communications between stakeholders or team workers, and information sharing within an organization and between a focal organization and external market players, such as supply chain partners, regulators, and key customers. It also supports a transactive or organizational memory, i.e., who knows what information (Anand et al.,1998; Majchrzak, Jarvenpaa, and Hollingshead, 2007) and virtual conference with real-time video and audio.

The real-time and rich communication functionalities help managers increase information use, reduce communication barriers, and increase interaction among members (Daft and

Lengel, 1986; Thomas et al., 1993; Zigurs and Buckland, 1998). Such frequent and rich communication can reduce task, process, and relationship conflicts (Jarvenpaa et al., 2004), enhance trust (Jarvenpaa et al., 2004), and help all stakeholders collectively understand the implications of events to their businesses (Majchrzak et al., 2005). It also helps organizations develop stronger links with suppliers and consumers, thus increasing the efficiency and flexibility of information sharing (Malhotra et al., 2007; Sabherwal and Chan, 2001). Thus, communication support technology can complement business intelligence technology in a firm's event management by enabling seamless, spontaneous, two-way information flow within an organization and between organizations. We propose a hypothesis about communication support as follows:

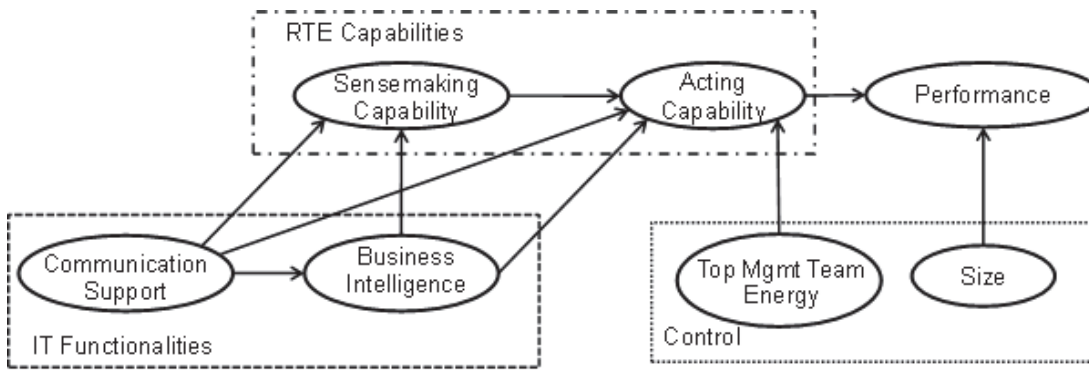
H3: Communication support systems directly enhance both sensemaking and acting capabilities as well as indirectly by complementing business intelligence.

2.4 RTE Capabilities in Slow Clockspeed Industries

Because, in slowly changing environments (i.e., slow clockspeed industries), there is enough time to gather and process relevant information and do rational analysis, organizations are less likely to fail in sensemaking and responding to environmental change in a timely manner (Fine, 1998; Fredrickson and Mitchell, 1984; Mintzberg, 1973; Nadkarni and Narayanan, 2007). Competitive advantage gained through a specific position, a combination of resources, or a technology innovation can be sustained for a long time (Eisenhardt and Martin, 2000; Porter, 1980). Firms in such a position can introduce more cost-effective products/services than their competitors. So they do not need to move from such a position in a hurry. Rather, they should enjoy such benefits for a long time until the position does not give more competitive advantage. Thus, moving from such a position can result in the loss of competitive advantage. For example, in such stable environments, companies with efficiency-oriented structures can introduce more cost-effective and high quality products/services than their competitors (Miles and Snow, 1978; Porter, 1980). Thus, in slowly changing environments, organizations do not need to often reconfigure their resources and too frequent changes in their strategic actions and structures possibly result in low performance. So, we have the last hypothesis as follows:

H4: A high level of RTE capabilities in slowly changing environments does not have a positive effect on a firm's performance.

These hypotheses are presented in Figure 2, the proposed research model.



〈Figure 2〉 The Proposed Research Model

Ⅲ. Data and Methods

3.1 Data

We administered full-scale survey questionnaires to different levels of managers of companies across diverse industries in Korea. Existing studies on sensemaking typically use data collected from top managers because they assume top managers play the most important role in sensing and managing environmental change (Hambrick, 1981; Thomas et al., 1993; Zajac and Shortell, 1989). However, in turbulent environments, organizational sensemaking of environmental change occurs over all levels of organizational hierarchy (Meyer et al., 2005). Different levels in the hierarchy may focus on different types of events. For example, top executives may focus on competitors′ new actions, while middle online-marketing managers may focus on consumers′ preference and behavioral change. Thus, we tried to collect multiple data points from different levels of managers. However, if there was only one response, we made sure that it was from senior manager. We found that IT solutions, like Web Analytics (e.g., Omniture, Google Analytics) are used intensively in the core business processes, for example, sensemaking and acting on rapidly changing customer preferences. Information technologies enable organizations to do experiments continually and quickly to capture important business events that turn to opportunities and threats.

Before administering the full-scale survey, we conducted a pilot survey from industry managers and business major PhD students in the U.S. to test face and content validity of the survey and correct any problems, such as equivocal wording, syntax errors, overuse of jargon, overtime-to-finish the questionnaire, difficult-to-complete the questionnaire, and any biasing factors in the scale.

To translate English to Korean, we used a

translation committee approach (van de Vijver and Leung 1997), i.e., committee of bilinguals consisting of three professors in business schools and one business major PhD student who are fluent in English and Korean. Then, we tested the translated survey from managers of companies in Korea and correct any problems.

Our sample includes companies associated with university research centers in Korea that span diverse industries and environments and are diverse in size. We also used our social networks. We contacted companies to explain the purposes of the study, and if they agreed to participate in the survey, we emailed an online-survey URL to the person to whom we met. Then, the person sent the URL to managers in the company. When a paper survey was preferred, we used a printed questionnaire. For the return, they were given an executive summary of the survey. We contacted 92 firms and 86 firms participated in the survey, meaning the response rate is 93%. Total 201 managers finished the survey. We deleted 10 incomplete responses, 5% of the total response, so we have 191 responses from 86 firms. Some companies can consists of several business divisions which are actually companies, like a company consisting of memory manufacturing division and mobile phone manufacturing division. We treat such a business division as a company, which divided a firm into multiple divisions, resulting in 96 firm-level data points and 191 responses from the firms. The average working experience of the respondents was 12.9 years, ranging from a middle manager to the CEO. The final sample included firms with considerable variation in terms of size, industries, and revenue which are the requirements for our sample. Thus, our sample has no critical problem in representativeness

3.2 Measurement

All variables were measured by multiple-items with a seven-point Likert scale. We used existing scales as many as possible to increase reliability and validity.

Performance was measured by five self-report items in terms of relative success, market share, growth rate, profitability and innovativeness compared to major competitors which can represent a firm′s competitive advantage (Pavlou and El Sawy, 2006). Subjective performance measures have been shown to correlate strongly with objective performance (Dess and Robinson, 1984).

To measure the speed of environmental change, we used the four items that measure the speed of change in task environmental sectors -- customers, competitors, and technologies, which were developed by Daft et al. (1988). We define a firm′s business environments as either fast or slow. If the speed of environmental change is greater than 4, a firm′s environment is defined as fast, otherwise slow. The speed of an environmental change is calculated by averaging the sum of all answers for the four speed items from all

respondents of the firm.

RTE capabilities are not a dichotomous variable like "exist" or "not-exist", but a matter of degree (Overby et al., 2006). All individual firms have RTE capabilities but at different levels. Thus, we define a firm's RTE capabilities as a continuous measure rather than present or absent. Importantly, RTE capabilities do not mean the organizational ability to make time latencies for all tasks towards zero. Rather, a task may have a time buffer --- the amount of time allowing organizations to finish the process without delay. Thus, RTE capabilities are the organizational ability to finish a task within the time buffer given for the task without delay on other tasks related to a process. Depending on the task, the time buffer can be a minute, hour, day, or month (Anderson-Lehman et al., 2004). Accordingly, we developed items to measure two dimensions of RTE capabilities, that is, sensemaking and acting capabilities based on the tasks we defined. The sensemaking capability was measured by five items for the three sensemaking tasks while the acting capability was measured by seven items for the reconfigure- and enact-tasks. Existing scales (Jaworski and Kohli, 1993) were referenced for developing these items.

Likewise, business intelligence and communication support technologies were measured by six items individually based on the key functions as we defined in the conceptual development.

Lastly, we controlled the effect of firm size on performance. Firm size was measured by the number of employees and then transformed with a logarithm function. We also controlled the effect of top management team leadership and energy on acting capabilities, because top managers are generally in charge of sensemaking for important business events and making strategic decisions with respect to the captured events, and their leadership and energy can determine whether organizations reconfigure resources and enact new competitive moves and how often.

3.3 Analysis

Table 2 shows statistics for the variables and controls, and their correlations. All constructs greater than 0.7 indicate internal consistency (Nunnally, 1978). Exploratory factor analysis (see Appendix) showed that each of the measurement items was loaded only on its latent construct. All items were loaded on their latent constructs with a significant t-value, proving convergent validity. All square roots of AVEs were greater than any correlations and greater than 0.5, also proving convergent and discriminant validity (Fornell and Larcker, 1981).

To test the common method bias, we did Harmon's single-factor test (Podsakoff and Organ, 1986). Seven factors had an eigenvalue greater than one, and no one factor accounts for the majority of the covariance in all variables, indicating no common method bias.

A multilevel regression analysis was used

〈Table 2〉 Correlation Matrix and Composite Factor Reliability Scores for Principal Constructs

Construct	Item#	Mean	STD	Reliability	Perf	ACT	Sense	BI	Comm	TMT	Speed
Performance	5	4.52	1.40	.90	**0.85**						
Acting Capabillity	7	4.24	1.40	.89	0.48	**0.78**					
Sensemaking Capability	5	4.37	1.42	.92	0.36	0.38	**0.86**				
Business Intelligence	6	4.07	1.39	.93	0.48	0.60	0.30	**0.86**			
Communication Support	6	4.48	1.46	.91	0.42	0.43	0.19	0.58	**0.83**		
Top Mgmt Team Energy	4	5.07	1.44	.91	0.51	0.48	0.40	0.46	0.45	**0.88**	
Speed	4	5.07	1.41	.88	-0.05	0.22	0.10	0.15	0.19	0.15	**0.86**

* Correlation greater than 0.18 is significant at the 0.01 level; Correlation greater than 0.12 is significant at the 0.05 level (two-tailed).
** Items on the diagonal (in bold) represent the square root of AVE.

for testing our hypotheses. We used the HLM (Hierarchical Linear Modeling) statistics software to handle multiple data points from a firm. HLM is suitable for analyzing a nested data set, in which individual responses can be nested within the same group being studied. HLM connects multiple data points from a same firm in the second level, so we do not lose any information, which can be lost if we use the average of multiple data points for the same firm.

Ⅳ. Analysis Results

The results are summarized in Table 3. Figure 3 represents only the significant relationships among constructs in high velocity environments, which succinctly shows the test results for the proposed hypotheses.

All the hypotheses, except for H4, we proposed for high velocity environments are supported. RTE capabilities enable organizations to reduce the cycle-time of experiments to sense and manage environmental changes, and thus can maximize the effect of opportunities and minimize the effect of threats generated from turbulent environments. Sensemaking RTE capabilities can help organizations make sense of the changing trends of the market, while acting RTE capabilities can respond to such changing trends in a timely manner. Thus, sensemaking capabilities indirectly enhance a firm′s performance by showing firms the right way to act. A firm′s

〈Table 3〉 Summary of HMLM Analysis Results

I.V. and Control Variables	D.V. (Performance) H1 supported	D.V. (Acting Capability) H1 and H2 supported	D.V. (Sensemaking Capability) H2 supported	D.V. (BI) H3 supported	Performance in Slowly Changing Environments H4 supported
Sensemaking Capability	0.089 (1.114)	0.162* (2.387)			0.203 (1.351)
Acting Capability	0.284** (2.690)				-0.722* (-2.383)
BI	0.204 (1.157)	0.366** (3.325)	0.370** (0.297)		0.079 (0.648)
Communication Support	0.115 (1.051)	0.035 (0.279)	-0.027 (-0.178)	0.565** (7.018)	0.786** (3.738)
Top Mgmt Team Energy	0.175 (1.353)	0.204* (2.140)			-0.360** (-5.502)
Firm Size	0.241* (2.433)				-0.123 (-0.567)
Number of Data Points	162 responses from 78 firms	162 responses from 78 firms	162 responses from 78 firms	162 responses from 78 firms	29 responses from 18 firms

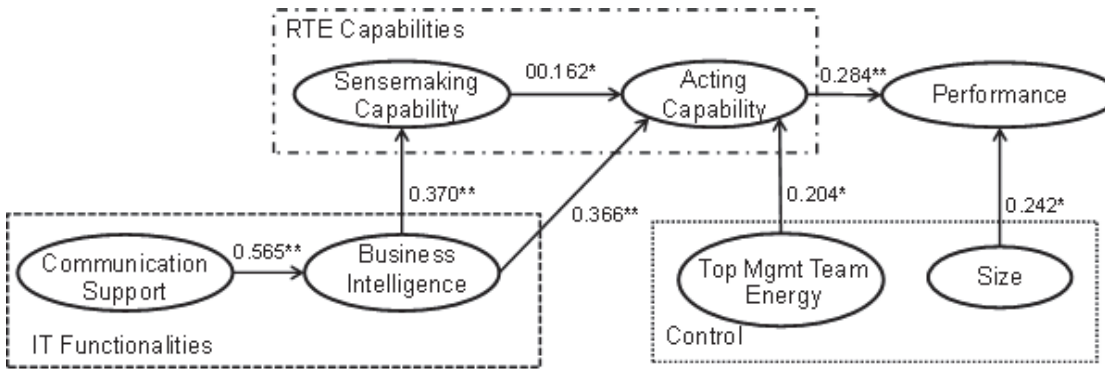
** $p < 0.01$; * $p < 0.05$; t values in parentheses.

competitive actions can directly increase competitive advantage and performance, which supports a stream of research on competitive actions (Ferrier et al., 1999, 2010; D'Aveni, 1994; D'Aveni et al., 2010).

The finding demonstrated that the effect of IT on a firm's performance in turbulent environments is mediated by organizational RTE capabilities, which was conceptually argued by extant studies (Overby et al., 2006; Sambamurthy et al., 2003).

Further, different types of information technologies play different roles depending on the types of tasks, supporting an argument by the task-technology fit theory (Daft and Lengel, 1986; Goodhue and Thomson, 1995). In a high velocity environment, BI technology directly enhances both sensemaking and acting capabilities, but communication support technology only indirectly enhance RTE capabilities by complementing BI.

In a slowly changing environment, as we expected, RTE capabilities do not become a key driver for competitive advantage. Firms in slowly changing environments have enough time to gather and process relevant information and do rational analysis to cope with the slowly changing environment in a timely manner (Fine, 1998). A competitive advantage gained through a combination of resources and efficiency-oriented structures can be sustained for a long time (Eisenhardt and



〈Figure 3〉 Relationships between Key Variables in High Velocity Environments

Martin, 2000). Therefore, changing such a configuration possibly results in the loss of competitive advantage. As supported in the hypothesis 1, since acting capabilities directly influence a firm's performance, only acting capabilities have a significant negative effect on performance. Energetic leadership can initiate too frequent changes in organizational structure and strategic actions, so top management team leadership and energy may have a negative effect on competitive advantage in a low velocity environment.

Ⅴ. Discussion and Conclusion

5.1 Implication

In this study, we showed that superior business intelligence and analytics accompanied by communication technologies enable organizations to achieve high level of sensemaking and acting capabilities and such real-time enterprises can achieve competitive advantages by acquiring information regarding customer preference change, new technology emergence, and potential competitive moves of rivals in a timely fashion. Due to the increasing ubiquity of digital transformation with information and digital technologies such as big data analytics, mobile communications, and connected devices as well as traditional enterprise systems, managers can easily access more diverse types of data, which support managers for timely sensing and responding to rapidly changing digitized environments (George, Osinga, Lavie, & Scott, 2016; McAfee & Brynjolfsson, 2012; Park et al. 2017) by introducing new products and services that reflect changing customer preferences (Havakhor, Sabherwal, Steelman, & Sabherwal, 2019; Pavlou and El Sawy 2006).

Thus, this study contributes to the literature in digitally-enabled organizational capabilities by developing a theory that explains the role of information and digital technologies in enhancing RTE capabilities to sense and man-

age important business events that turn into opportunities and threats generated from rapidly changing environments. This study also contributes to the IS and management literature by empirically exploring how and what kinds of IT can help organizations to transform into RTE that can keep sustainable competitive advantage. The IS agility literature generally lacks an empirical demonstration of the effect of agility on a firm's performance, and has encouraged researchers to develop an empirical method (Overby et al., 2006; Sambamurthy et al., 2003). Furthermore, this study further advances the extant IS agility literature by conceptually developing a conceptual model of RTE that introduces time buffer concept and thus differentiates RTE from organizational agility.

Furthermore, our findings show that different types of RTE capabilities play different roles in developing competitive advantage. Right time competitive actions enabled by digitally-enabled acting RTE capabilities can directly improve competitive advantage. Digitally-enabled sensemaking RTE capabilities enable organizations to detect and understand the trends of the market change and thus find the opportunities and threats embedded in environmental events. Therefore, sensemaking capabilities help organizations do the right actions. This finding based on empirical data explains the more detailed dynamics within the black box of digital transformation into RTE. On the other hand, we found that in a slowly changing environment, firms may not need to frequently execute the experiments of sensing environmental change and reconfiguring resources and enacting new products. It may cause the loss of competitive advantage. Rather, in slow environments firms may need to focus on developing efficiency-oriented structures that enable them to make cost-efficient and high quality products, which can sustain competitive advantage in a slow environment.

Other interesting finding is that different types of information technologies play different roles in developing RTE capabilities. In high velocity environments both BI and communication technologies indirectly enhance a firm's performance through RTE capabilities, while in slowly changing stable environments, communication technology helps organizations enhance performance. This finding suggests us to consider a fit theory among IT, task, and environment, which means there could be different configurations of IT functionalities, tasks, and environments which lead to high performance. For instance, Pavlou and El Sawy (2010) demonstrate that for different types of environmental turbulences there are different types organizational dynamic capabilities, which are supported by different types of information technologies in the new product development context.

Practically, this study shows a specific type of digital transformation into real-time enterprise with business intelligence and communication technologies. It emphasizes the importance of transforming to RTE to achieve and sustain competitive advantage in a rap-

idly changing environment. The findings with respect to RTE in this study imply that firms should change their strategies built on traditional strategy theories such as positioning strategy with five market forces (e.g., Porter 1980) and resource-based view strategy (e.g., Barney 1991). These strategies assume stable environment and thus do not work in the rapidly changing environment. In increasingly digitized environment, an experiment-based strategy with RTE makes firms to sense and respond to environmental changes in a timely fashion and thus may work more effectively as we showed in this study. Thus, firms should put business intelligence and analytics and communication technologies in the center of the event management so that they play a never system role in transforming to real-time enterprises with the experiment strateg

5.2 Limitation and Future research

The topic of this study, the role of information and digital technologies in the dynamics of latency reduction in a firm's event management for handling opportunities and threats in high-velocity environments, is not theoretically well developed yet. For example, the main concept of this topic, real-time enterprise (RTE) has been used in practice, but the IS and management literatures do not have relevant theories and empirical findings about digital transformation into RTE. The literature has argued that information technologies can help an enterprise become RTE, but there is a lack of empirical studies that conceptualize and measure RTE capabilities and guide companies in transforming to RTE, in particular using IT. The theory and method suggested in this study are efforts to advance our knowledge about this under-developed but important topic in nowadays increasingly digitized business environments. At the same time, as usual for research study, this study has also several limitations. For example, the number of sample firms in slowly changing environments in this study could be larger enough to statistically test hypothesis, although firm-level studies sometimes use such a small sample. We encourage further research to use more empirical cases to compare different dynamics among different configurations of RTE capabilities, IT functionalities, and environments, especially delving into the multifaceted role of information technologies in transforming organizations to RTE.

One of the most interesting findings in this study is that organizations need to have different configurations of RTE capabilities and information technologies depending on the types of environments. Especially, in a slowly changing environment, organizations may not need a high level of RTE capabilities, or even high RTE capabilities possibly hurt organizational competitive advantage. As we explained earlier, organizations may lose competitive advantage by frequently reconfiguring resources and structures in a stable environment. A different perspective to possibly explain this

finding is suggested by Davis et al. (2009). Firms in slow environments can have many alternative paths to effectively cope with slow changes. Thus, firms investing in more cost-efficient alternatives can outperform their competitors. Every company has limited resources. Spending such resources for flexibility-oriented structure in a stable environment thus can be a waste of resources, meaning that the firm cannot allocate enough resources the places which can sustain the efficiency-oriented structure. Further empirical theories need to be developed to explain these complex dynamics around digital transformation to RTE and the role of information and new digital technologies in the pervasively digitized world.

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〈Appendix〉 Exploratory Factor Analysis

Rotated Component Matrix

	Component						
	SPEED	SENSE	ACT	TMT	BI	COMM	PERF
SPCU	.803	.008	.137	.110	.062	-.039	-.030
SPCO	.782	.066	.040	.004	.113	.098	-.174
SPTE	.767	.029	.141	-.008	.088	.102	-.089
SPGE	.758	-.015	.042	.013	-.086	.059	.010
SEN1	.177	.821	.101	.043	.020	.006	.115
SEN2	.078	.855	.160	.048	.004	.008	.099
SEN3	-.051	.830	.187	.171	.071	.087	.080
SEN4	-.086	.830	.133	.226	.152	.010	.098
SEN5	-.004	.791	.079	.129	.106	.044	.125
ACT1	-.086	.090	.670	.255	.236	.045	.084
ACT2	.057	.120	.737	.253	.160	.118	.094
ACT3	.109	.168	.680	.042	.187	.248	.081
ACT4	.108	.127	.698	.059	.171	.211	.130
ACT5	.077	.106	.719	.077	.144	.044	.148
ACT6	.219	.092	.737	.049	.141	.070	.057
ACT7	-.024	.151	.646	.149	.058	.090	.247
TMT1	.148	.177	.134	.837	.097	.141	.199
TMT2	.086	.196	.180	.760	.174	.135	.213
TMT3	-.006	.174	.172	.757	.055	.111	.116
TMT4	-.051	.125	.230	.756	.143	.250	.175
BI1	.098	.087	.180	.112	.741	.325	.126
BI2	.050	.057	.247	.121	.743	.149	.158
BI3	.155	.117	.202	.016	.790	.193	.192
BI4	.038	.082	.267	.160	.706	.318	.139
BI5	-.051	.076	.250	.259	.567	.190	.073
BI6	-.078	.120	.311	.116	.566	.111	.162
COMM1	.126	.039	.077	.249	.115	.728	.135
COMM2	.168	.018	.086	.296	.122	.722	.143
COMM3	.062	-.014	.100	.126	.147	.783	.129
COMM4	-.048	-.054	.067	-.038	.140	.681	-.013
COMM5	.052	.066	.204	.103	.168	.795	.116
COMM6	.003	.144	.167	.053	.219	.745	.169
PERF1	-.124	.210	.111	.145	.127	.154	.806
PERF2	-.121	.168	.022	.090	.064	.112	.807
PERF3	.050	.120	.230	.248	.150	.155	.719
PERF4	-.066	.015	.251	.077	.172	.044	.804
PERF5	-.005	.136	.293	.329	.145	.269	.638

디지털 세계에서 경쟁우위를 지속하기 위한 실시간 기업으로의 디지털 트랜스포메이션: 비즈니스 인텔리전스와 통신시스템의 역할

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요 약

본 연구에서는 기업이 실시간 기업(Real-Time Enterprise: RTE)로의 디지털 트랜스포메이션을 통해 디지털 비즈니스 세상에서 기회와 위협으로 나타나는 중요한 비즈니스 이벤트를 성공적으로 감지하고 관리할 수 있다는 것을 설명하는데 있다. 본 연구에서는 RTE 능력을 중요한 비즈니스 이벤트에 시기적절하게 감지하고 반응할 수 있는 조직의 능력으로 정의한다. 더 나아가서, 센스메이킹과 실행 능력을 RTE 능력의 두 축으로 설정하고, 비즈니스 인텔리전스와 통신지원을 디지털 트렌스포메이션을 통한 RTE로 도달하는 두 개의 중요한 기술로 정의한다. 다양한 산업에서 총 96개 기업을 대상으로 191개의 설문조사 자료를 사용하여 비즈니스 인텔리전스와 통신지원기술이 RTE 능력과 기업 성과를 달성하는데 있어서 각기 다르게 역할을 하고 있음을 실증분석을 통해 제시하였다. 정보기술은 빠르게 변화하는 환경에서 RTE 능력을 확장하여 간접적으로 기업이 경쟁우위를 달성할 수 있게 할 수 있음을 본 연구에서 제시하였다. 느린 환경에서는 RTE 능력이 기업 성과를 높이지 않는 것으로 분석되었으며, 재설정된 자원과 구조에 대한 잦은 대처는 오히려 경쟁우위를 감퇴시기는 것으로 분석되었다.

주제어: 디지털 트랜스포메이션, 실시간 기업, 비즈니스 인텔리전스, 통신시스템

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