Effect of Business Intelligence and IT Infrastructure Flexibility on Organizational Agility

Completed Research Paper

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Abstract

There is a growing use of business intelligence (BI) for better management decisions in different industries. However, empirical studies on BI are still scarce in academic research. This research investigates BI from an organizational agility perspective. Organizational agility is the ability to sense and respond to market opportunities and threats with speed. Drawing on systems theory and literature on organizational agility, business intelligence, and IT infrastructure flexibility, we hypothesize that BI use and IT infrastructure flexibility are two major antecedents to organizational agility. We developed a research model to examine the effect of BI use and IT infrastructure flexibility on organizational agility. Survey data were collected and used to assess the model. The results support the hypothesis that BI and IT infrastructure flexibility are two significant antecedents of organizational agility. This research is a pioneering work that empirically investigates the significance of BI in business context.

Introduction

There is a growing use of business intelligence (BI) for better management decisions in different industries. However, empirical studies on BI are still scarce in academic research. Idea entrepreneurs (such as consultants, gurus, journalists, and vendors) have made substantial efforts to promote its use. Organizations have spent millions, if not billions, of dollars and sometimes made significant organizational structure changes to implement BI. While BI is popular in industries and practices, BI research in academic is still in its early stage. Existing BI studies focus on defining the field and terminologies, case studies on BI best practices in leading companies (Wixom and Watson 2010), identifying critical success factors (Yeoh and Koronios 2010), and developing maturity models (Lahrmann et al. 2011). Empirical studies on the significance of BI are clearly lacking. The fundamental question of whether or not BI has important or critical business values is left unanswered in academic. This question is especially pertinent when prior research shows inconsistent results of BI impacts on business performances.

To study the significance of BI, we need a theoretical lens to build theories that connect BI with business values and empirically test them. After reviewing the IS and strategic management literature, we found organizational agility perspective is a promising lens to study the significance of BI. Agility is an organizational trait (Christopher and Towill 2002) and is an organization's ability to sense and respond to market opportunities and threats in a timely manner (Sambamurthy et al. 2003; Overby et al. 2006; and Watson and Wixom 2007). Organizational agility has been studied in the IS discipline for many years (El Sawy and Pavlou 2008; Fink and Neumann 2007; Gallagher and Worrell 2007; Hobbs 2010; Lee and Xia 2010; Lyytinen and Rose 2006; Sambamurthy et al. 2003; Seo et al. 2010; Tallon and Pinsonneault 2011; Tiwana and Konsynski 2010; Zaheer and Zaheer 1997; Zaheer and Zaheer 1997). There is an established positive link between organizational agility and firm performance in the IS literature (Benaroch 2002; Sambamurthy et al. 2003; Fichman 2004; Benaroch et al. 2006). Organizational agility provides a logical connection to connect BI with an organization's competitive advantage.

Systems theory states that systems are composite things and possess properties (Von Bertalanffy 1968; Ackoff 1971; Checkland 1981). System properties can be properties of individual system components or properties of interacting relationships among system components. The latter properties are called emergent properties (Nevo and Wade 2010). Organizations are complex social systems. Organizational agility is one of the emergent properties. The sources of emergent properties come from both the components and their relationships (Holland 1998; Jackson 2000). Organizational agility is the ability to sense and respond to market opportunities and threats. Therefore, there are two source components that can help improve organizational agility: (1) the component that can help sense and detect market opportunities and threats in a timely manner, and (2) the component that can help act on or respond to market opportunities and threats in a timely manner. Prior literature shows that business intelligence (BI) can help sense market opportunities and threats (Elbashir et al. 2011; Mithas et al. 2011; Trkman et al. 2010; Wixom and Watson 2010); and flexible IT infrastructure can help respond to market opportunities and threats by facilitating the integration and reconfiguration of existing resources to develop new capabilities (Bharadwaj 2000; Bhatt and Grover 2005; Byrd and Turner 2001; Tiwana and Konsynski 2010). Therefore, business intelligence and IT infrastructure flexibility are two enabling components that can help improve organizational agility.

Drawing on systems theory, dynamic capabilities framework, and literature on organizational agility, business intelligence, and IT infrastructure flexibility, we hypothesize that BI use and IT infrastructure flexibility are two antecedents of organization's agility. We developed a research model to examine the effects of BI use and IT infrastructure flexibility on organizational agility. The research model is based on theories in the IS and strategic management fields. It examines the relationships between business intelligence, IT infrastructure flexibility, and organizational agility.

Literature Review

Organizational Agility

Based on the prior definitions of agility from D'Aveni (1994) and Goldman et al. (1995), Sambamuthy et al. (2003, p. 245) defined agility as "the ability to detect opportunities for innovation and seize those competitive market opportunities by assembling requisite assets, knowledge, and relationships with speed and surprise". Li et al. (2008) reviewed the agility literature and defined agility based on two factors: "the speed and the capabilities of the firm to use resources to respond to changes". Holsapple and Li (2008) also identified two dimensions of agility: alertness and responsiveness. In short, these definitions of agility in the business context indicate that agility is an organization's ability to sense/detect (alertness) and act/respond (responsiveness) to changes with speed. The two key dimensions of agility are the ability to detect environmental changes with speed and the ability to respond to environmental changes with speed.

Sambamurthy et al. (2003) theoretically argued that organizational agility comprises of three interrelated capabilities: customer agility, partnering agility, and operational agility. Sambamurthy et al. (2003, p. 245) defined customer agility as "the co-opting of customers in the exploration and exploitation of opportunities for innovation and competitive action moves." Their definition of customer agility is narrowly related to the co-creation of new ideas, products, and services. We see customer agility in a broader sense as an organization's ability to sense and respond to customer changes in demand for products and services. Based on Venkatraman and Henderson (1998)'s research, Sambamurthy et al. (2003, p. 245) defined partner agility as the "ability to leverage the assets, knowledge, and competencies of suppliers, distributors, contract manufacturers, and logistics providers through alliances, partnerships, and joint ventures." Operational agility is about the ability of an organization's operation processes to innovate and compete with speed, accuracy, and cost effectiveness. Tallon and Pinsonneault (2011) devised a set of indicators to measure the three dimensions of organizational agility. Our measurement indicators are based on the measurement indicators from Tallon and Pinsonneault (2011).

Research on dynamic capability from the strategic management field provides the theoretical foundation on why organizational agility, which has been studied in the IS field for decades, is a critical competitive factor and is a source for competitive advantage (Benaroch 2002; Sambamurthy et al. 2003; Fichman 2004; Benaroch et al. 2006). These studies demonstrate the role of organizational agility in creating strategic business values. We choose organizational agility as the dependent variable in this study because we want to illustrate the strategic values of the two studied IS/IT components by arguing for the connections between business intelligence and IT infrastructure, and the strategically important organizational property: agility.

IT Infrastructure Flexibility

In many operations management and IS research works, there is no distinction between agility and flexibility; or when those terms were used, no definitions were provided. Often, those two terms were used interchangeably in many research papers. Nevertheless, agility and flexibility are defined differently in many other research papers (see agility definitions in D'Aveni 1994, Goldman et al. 1995, Sambamuthy et al. 2003; see flexibility definitions in Duncan 1995, Byrd and Turner 2001).

Flexibility is broadly defined as the degree to which a thing is malleable. It refers to the ability to quickly and economically adapt the IS applications to changing business requirements in the IS context (Kumar 2004; Schlueter 2006). Flexibility has been viewed as one of the firm's capabilities that have influences on the firm's speed to act or respond (Yusuf et al. 1999; Zhang and Shariff 2000; Tiwana and Konsynski 2010) and as an antecedent of agility (Swafford et al. 2006). Although flexibility could lead to quick action, flexibility has other aspects that are not related to speed. For example, an inflexible IT system can be quickly reconfigured to respond to changes, but with significant cost to do so. Thus, agility and flexibility are two different constructs. Agility is about the speed to detect/sense or respond to opportunities and threats in the business context. Flexibility is about malleability and the ability to help respond to change requests both quickly and economically, and is a key antecedent of agility in a business context (Li et al. 2008; Tiwana and Konsynski 2010).

IT infrastructure is consistently defined in literature as a set of shared IT resources that are a foundation for enabling communication across an organization and enabling present and future business applications (Niederman et al. 1991; Duncan 1995; Byrd and Turner 2001). IT infrastructure flexibility refers to the degree to which the firm's IT resources are malleable (Duncan 1995). The definition of IT infrastructure flexibility from Byrd and Turner (2001) and Byrd (2001) emphasizes IT infrastructure's ability to easily

and readily support a wide variety of hardware, software, and communication technologies, to distribute information to anywhere inside an organization and beyond, and to support the design, development, and implementation of a heterogeneity of business applications. Four key components of IT infrastructure flexibility have been identified in the literature: connectivity, compatibility, modularity, and IT personnel competency (Duncan 1995; Byrd and Turner 2001). But most commonly accepted technical (static) dimensions of IT infrastructure flexibility are connectivity, compatibility, and modularity. Because we investigate the malleability of IT infrastructure, we measured the static dimensions of IT infrastructure in this study.

Scholars in IS field has studied IT infrastructure flexibility as an independent variable (Broadbent et al. 1999; Byrd and Turner 2001; Chung et al. 2003; Tiwana and Konsynski 2010) as well as a moderator (Lin 2010; Tallon and Pinsonneault 2011). But to the best of our knowledge, there is no empirical study in the IS research that directly investigates the relationship between IT infrastructure flexibility as a whole and organizational agility, especially from organizational agility perspective. Kumar (2004) proposed that the real values of IT infrastructure flexibility lie in the flexible interaction between an IT infrastructure and its organizational context. This study extends that proposition by specifying to what organizational capability IT infrastructure flexibility contributes. This study emphasizes that IT infrastructure flexibility is one of two contributing factors that improve organizational agility: flexibility contributes to the responding dimension of agility. Therefore, IT infrastructure flexibility has strategic values through organizational agility.

Business Intelligence

Business Intelligence (BI) is a new business-driven phenomenon that can add values to organizations. Watson (2009) defined BI as "a broad category of applications, technologies, and processes for gathering, storing, accessing, and analyzing data to help business users make better decisions." At the conceptual level, BI is an umbrella term for systems and procedures that transform raw data into useful information for managers to make better decisions (Wixom and Watson 2010). At the operational level, BI is an information system that has three elements (Laursen and Thorlund 2010): (1) a technological element that collects, stores, and delivers information, (2) a human competencies element on the abilities of human beings to retrieve data and deliver it as information, to generate knowledge, and to make decisions based on the new knowledge, and (3) a third element that supports specific business processes that make use of the information or the new knowledge for increasing business values. BI systems are different from IT infrastructure. At the operational level, BI systems are applications built on top of IT infrastructure. IT infrastructure includes shared services and hardware a BI application can use, such as network services, database services, security services, etc.

Jourdan et al. (2008) reviewed the BI research published before 2006. One finding of their study is that BI research before 2006 focused primarily on exploratory research: formal theory and literature review, and very few empirical studies. The other intriguing finding is that prior research only addressed new technologies and issues in BI without attempting to explain the fundamental issues of IS research as it relates to BI, such as generalizability (external validity), precision of measurements (internal and construct validity), and realism of context.

Although competitive intelligence (CI) was used in Wright et al. (2009)'s study, we believe CI is part of BI. Some other BI specific issues have been studied in recent years: critical success factors (Yeoh and Koronios 2010); intelligence strategy (Johannesson and Palona 2010); and intelligence maturity model (Lahrmann et al. 2011). Prior literature also includes a few studies on BI and its contextual factors. For example, Muller et al. (2010) studied BI functions and how service-oriented architecture could help those functions. Seah et al. (2010) conducted a case study on culture and leadership's role in BI implementation. Trkman et al. (2010) performed a survey study on the impact of BI on supply chain performance. Elbashir et al. (2011) researched organizational capabilities that help BI assimilation. Marjanovic and Roose (2011) carried out a case study to investigate how to integrate BI into business process improvement. Laursen and Thorlund (2010) provided an excellent illustration on what business intelligence is and how it should be carried out at different levels of organization: strategic level (strategic initiatives) and operational level (business process changes). These papers, however, did not address how complementary resources affect BI contribution to an organization's competitive performance and/or general firm performance, and therefore did not address the question of why organizations need to be BI-based.

When studying the diffusion of IT innovation and impact of IT fashion on organizations, Wang (2010) suggests the middle stage of the diffusion of an IT innovation is critical. This middle stage is when an IT innovation is in fashion among business managers. In this stage, an IT fashion has not been proven to deliver its full benefits and the majority of adopters are still trying to realize the claimed benefits. It is still uncertain whether BI implementation can deliver and how BI delivers the benefits that idea entrepreneurs (such as consultants, gurus, journalists, and vendors) claim it can deliver. Early studies show that some companies benefited from the investment in BI (Watson et al. 2006) and some did not (Gessner and Volonino 2005). The question for organizations engaging in BI is "Is BI an enduring fashion (next big thing) or a passing fad?" This is a critical question since BI requires large financial and human capital investment and business process changes.

Wang (2010) stated that prior studies of IT fashions, such as the study on business process reengineering (BPR) by Newell et al. (1998) and the study on ERP by Wang and Ramiller (2009), were primarily focused on the emergence and evolution of the IT fashions, but the studies fell short in demonstrating the significance of the IT fashion. As pointed out by Jourdan et al. (2008) and our own literature review, BI research is still in its infancy (exploratory) stage. Theoretically, BI has been argued as the next big thing in information technology, but empirical research is very limited on the significance of BI. Wang (2010) argued that to justify an IT fashion as a worthy innovation to study, the organizational consequences of the IT fashion must be studied.

The aim of this study is to investigate the significance of BI by empirically demonstrating the way BI can help organizations. From the organizational agility perspective, this study proposes that BI is a contributing factor to agility. BI can help increase an organization's ability to sense and detect environmental changes. With agility, BI can help increase an organization's competitive performance.

Theoretical Foundation

Systems Theory and Organizational Agility

Nevo and Wade (2010) systematically reviewed the systems theory and asserted (p. 165) that (1) the world is made up of things; (2) things possess properties; and (3) each property is represented by some value at any point in time. The systems theory defines systems as composite things. Systems possess properties that are derived from the interaction among the composing components (Von Bertalanffy 1968; Ackoff 1971; Checkland 1981). Extending the systems theory, Nevo and Wade (2010) proposed "some system properties may be properties of their components but with new values" while "other system properties are new in the sense that no individual component possesses them in isolation." (p. 166). Those system properties are called emergent properties (Nevo and Wade 2010). This study uses the systems theory and the concept of emergent properties from Nevo and Wade (2010) to propose that organizational agility is an emergent property and its value comes from two anteceding components as well as the interacting relationship between the two antecedents. One of the anteceding components is sensing and detecting environmental changes and the other is acting on and responding to environmental changes.

Awareness-Motivation-Capability (AMC) Framework

AMC framework was first introduced by Chen (1996). It is traditionally used in competitive dynamics research to study the antecedents of competitive actions. The awareness-motivation-capability perspective suggests that three behavioral drivers influence a firm's decision to act or respond: awareness, motivation, and capability (Chen, 1996). Chen at al. (2007) argued that in competitive dynamics research (Smith et al., 1991), individual awareness-motivation-capability components are manifested in a range of variables, including action visibility and firm size (Chen and Miller, 1994) for awareness; territorial interests in different markets (Gimeno, 1999) for motivation; and execution difficulty and information processing (Smith et al. 1991) for capability. This lens provides us a theoretical hoop to integrate the digital systems into the competitive dynamics: what are the roles of IT systems and its characteristics in competitive performance. It also provides theoretical supports on why business intelligence systems and IT infrastructure flexibility have the potential impact on competitive advantage through organizational agility. Business intelligence can help raise the awareness of opportunities and threats in marketplaces, then motivations of responding follows. IT infrastructure flexibility can help an organization's capability to respond opportunities and threats in marketplaces. It is a part of an organizational capability to

respond. AMC framework further illustrates the roles of business intelligence and IT infrastructure flexibility in building agile organizations that can compete effectively and successfully.

Research Model and Hypothesis Development

Research Model

Drawing on dynamic capability framework and current literature on BI, IT flexibility, organizational agility, and competitive performance, this study developed a research model as shown in Figure 1.

Figure 1: Conceptual Model (Structural Model)
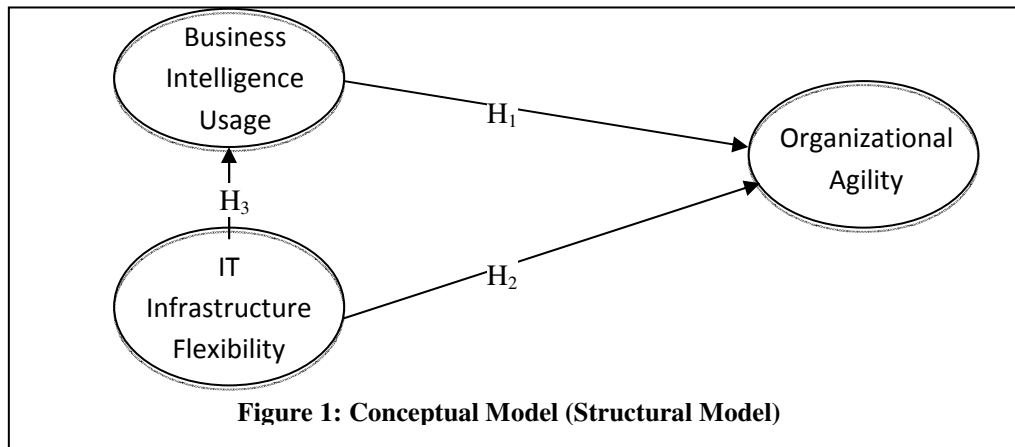
Hypotheses Development

Relationship between Business Intelligence Use and Organizational Agility

Based on systems theory, organizations are systems. Organizational agility is an emergent property of organizations. According to the definition of organizational agility, the value of organizational agility comes from two dimensions: one is sensing/detecting and the other is acting/responding to environmental change. We further argue that the use of BI in organizations will help increase organizational agility by improving an organization's ability to sense/detect environmental changes. AMC framework provides supports for us to further assert that BI use can make organizations aware of opportunities and threats and be motivated based on the awareness for changes in business environments.

The BI's contribution to organizational agility can also be found in the current IS research on the topic. The construct of information management capability (IMC) by Mithas et al. (2011) is an encompassing construct that includes functions provided by BI. They defined IMC as the ability to (1) provide data and information to users with appropriate levels of accuracy, timeliness, reliability, security, and confidentiality; (2) provide universal connectivity and access with adequate reach and range; and (3) tailor the infrastructure to emerging business needs and direction. BI can play a pivotal role in enabling the first ability. Mithas et al. (2011) found significant positive influences of IMC on three organizational capabilities: performance management capability, customer management capability, and process management capability. In this research, we studied the relationship between BI and organizational agility, which includes customer agility, partner agility, and operation agility (Sambamurthy et al. 2003). Customer agility is an essential part of customer management capability and operational agility is a part of Mithas et al. (2011)'s process management capability. Therefore, we have reasons to postulate that BI use can enhance an organization's agility. Furthermore, business intelligence collects, analyzes, and presents interpreted information to organization managers to help them make the right decision at the right time. Business intelligence can help organizational agility by detecting customer event patterns, identifying operational opportunities and bottlenecks, and revealing changes in partners' assets and competencies to managers so that they can sense, act, or make timely decisions.

The strategic IT alignment literature also provides support on the positive effect of business intelligence on organizational agility. For example, knowledge creation, sharing, and use have been studied as enablers of strategic IT alignment (Reich and Benbasat 1996; Kearns and Lederer 2003; Preston and Karahanna 2009). Due to knowledge sharing between business and IT executives, an organization can quickly respond to changes in market places, and thus increase an organization's agility. Knowledge creation, sharing, and use are the underlined arguments for the positive effect of strategic IT alignment on agility (Tallon and Pinsonneault 2011). Since business intelligence is an information system that helps managers make the right decisions at the right times, it is used across business units. It can create an environment for sharing newly found/created knowledge.

Therefore, theories suggest the following hypothesis:

H₁: Business intelligence use will positively impact an organization's agility.

Relationship between IT Infrastructure Flexibility and Organizational Agility

Because contemporary organizations are mostly IT enabled, organizational capabilities are often inseparable from IT (Ferrier et al. 2007; Pavlou and El Sawy 2010). Today organizational actions are rarely executed without information technology. IT infrastructure flexibility provides a means for IT departments to quickly respond to change requests from functional lines of business. From the systems theory perspective, IT infrastructure flexibility is another IT-related antecedent to organizational agility because a flexible IT infrastructure can help organizations integrate and reconfigure internal and external resources quickly and economically to respond to change requests. IT infrastructure flexibility, together with business functional lines' process agility can improve an organization's ability to respond to or act on changes in competitive environments whether the changes are from customers, partners, or operations. Prior research works (Rai et al. 2006; El Sawy and Pavlou 2008; Bush et al. 2010) support this view about the positive role of IT infrastructure flexibility to quickly integrate and reconfigure internal and external resources to respond to changes.

Theoretically, Sambamurthy et al. (2003) argued that there is a positive relationship between IT infrastructure flexibility and organizational agility. Although there is a lack of empirical studies in the IS literature on the direct relationship between IT infrastructure flexibility and organizational agility, there are research works that established the direct link between flexibility and agility in general (Yusuf et al. 1999; Zhang and Shariff 2000; Tiwana and Konsynski 2010).

Therefore, our theoretical argument from the organizational agility perspective and the IS literature suggest the following hypothesis:

H₂: IT infrastructure flexibility will positively impact organizational agility.

Relationship between IT Infrastructure Flexibility and Business Intelligence Use

Business intelligence systems are information systems built on top of existing IT infrastructure in digitally enabled organizations. Business intelligence systems require access to data from a variety of sources and distribute data to different users and data interfaces, such as web browsers on desktop computers, small screens on mobile devices, or as a data feed to other information systems. A flexible IT infrastructure can help business intelligence systems easily and quickly access or integrate existing and new data sources. Therefore, a flexible IT infrastructure can make implementation of BI systems much easier and help make functions of BI systems available to use faster than a rigid IT infrastructure.

When business environments change, information requirements change. A flexible IT infrastructure can be easily reconfigured to produce required new information and help distribute data and information to different distributing channels and receiving devices. It will cost more and take longer to make changes in a highly rigid IT infrastructure to produce newly required information and deliver it to right places and people. Therefore, a rigid IT infrastructure could reduce the usefulness of a BI system in a constantly changing business environment and slow/stop the use of the BI system. It is reasonable to argue that a flexible IT infrastructure can increase business intelligence use because with a flexible IT infrastructure more information can be readily available when needed and coveted information can be available where it is needed and when it is needed. The rich and accurate information can make business intelligence systems perceived to be more useful. The established technology acceptance model (TAM) (Davis 1989;

Venkatesh & Davis 2000) suggests that perceived usefulness of an information system will encourage the use of the information system. Therefore, our next hypothesis is:

H_3: IT infrastructure flexibility will positively impact BI use.

Research Method

A cross-sectional survey study was employed to test the research model. This section discusses the survey instrument developed to measure the constructs in the research model, the sample group, the participants' characteristics, the data collection process, and the statistical analysis technique used to analyze the data.

Survey Instrument Development

This study uses the existing survey instruments whenever it is possible. The existing measurement scales were examined according to well recognized and standard scale development procedure, such as the procedure proposed by Churchill (1979). Specifically we examined if an instrument's reliability has been properly checked in the study that developed the instrument. Then we checked if the instrument's validity check had been performed in the study, which should include content validity, determinant validity, and convergent validity.

For the new instrument developed in this study, we followed the same procedure proposed by Churchill (1979). We developed the instrument for the business intelligence system usage construct. All instruments for other constructs used in this study are adapted from existing measures.

Scale for Business intelligence Use

To develop the BI usage instrument, we refer to Burton-Jones and Straub (2006)'s discussion on system usage. They proposed that system usage is an activity that involves three elements: a user, a system, and a task. A staged approach was recommended for conceptualizing system usage. The first is definition stage. The second is select stage. There are two steps in the second stage:

Step 1: Select the elements of usage that are most relevant to the research model and context.

Step 2: Select measures for the chosen elements that are tied to other constructs in the nomological network.

The exploitive usage can be captured by two subconstructs: cognitive absorption that represents the extent to which a user is absorbed, and deep structure usage that represents the extent to which features in the system that relate to the core aspects of the task are used (Burton and Straub 2006, p. 236). We believe that cognitive absorption is more related to individual task performance than the extent to which a system is used by a user. Our measurement indicators for BI use are mostly in the deep structure usage category. We first selected features of BI information systems that would be used by users. Then we combined the selected features with corresponding tasks to measure the extent of BI use in an organization. The selected features are based on the inputs from both academic researchers and industrial trade papers. We developed the instrument based on the features provided by industrial groups, such as the features discussed in the report provided by The Data Warehousing Institute (Eckerson 2009). We further refined the features and the instrument with helps from several academic researchers who had done various studies on BI and taught BI classes in universities.

A convenience sample of 22 business and IT staff from various industries as well as three IS researchers were selected to pilot test the questionnaire to further refine the measurement scale. We also used the pilot study to ensure the survey website was functioning as expected.

The reliability of the developed scale for business intelligence use was assessed using Cronbach's Alpha and composite reliability scores. The determinant and convergent validities of the measurement scale were also assessed using recommended statistic tests.

Scale for IT Infrastructure Flexibility

We developed our indicators for measuring IT infrastructure flexibility based on the scales from Duncan (1995), Byrd and Turner (2000), Tiwana and Konsynski (2010), and Tallon and Pinsonneault (2011). IT infrastructure flexibility has been measured as a second order variable in the literature. There are three

dimensions in IT infrastructure flexibility. The three dimensions of IT infrastructure flexibility are connectivity, hardware compatibility, and IT modularity.

Scale for Organizational Agility

Organizational agility refers to speed with which a firm can sense/detect market opportunities and threats and act/respond to those opportunities and threats by assembling and integrating internal and external resources including assets, knowledge, and relationships (Hitt et al. 1998; Sambamurthy et al. 2003; Tallon and Pinsonneault (2011). Sambamurthy et al. (2003) first argued that there are three dimensions of organizational agility. Tallon and Pinsonneault (2011) devised a set of eight indicators to assess the organizational agility in each of these three dimensions. We developed the measurement scale for organizational agility based on Tallon and Pinsonneault (2011)'s scale.

Participants

The population of interest for this study is business leaders whose companies are using business intelligence. 18000 senior business leaders were selected from U.S. companies that had at least 20 million dollars in annual revenue. These senior business leaders include CEOs, CFOs, CTOs, CIOs, VPs for business functions, and senior business directors or managers.

We received email addresses along with other information, such as the title of a contact in a company, the company name, and the company's annual revenue through a commercial direct marketing company, ConsumerBase, LLC. ConsumerBase is one of the top email mailing companies. It is ranked #1 for data card quality by NextMark, a multi-channel target marketing company. All emails from ConsumerBase are 100% opt-in and 100% guaranteed deliverable within 30 days of purchase.

Data Collection

We used Qualtrics.com to host our survey. The authors' university has a site license from Qualtrics, which is a leading web-based marketing research provider. With that license, we built a survey website that meets all of our research needs. It provides easy-to-use tools to build and manage a survey.

The initial invitation email and several rounds of reminding emails were sent out to the selected executives. The data collection period was one month.

Data Analysis Technique

There are two techniques to assess a regression structural model: one is the covariance-based SEM as represented by LISREL and the other is component based (or variance-based) as represented by Partial Least Square (PLS) modeling (Henseler et al. 2009).

Covariance-based SEM attempts to minimize the difference between the sample covariance and those predicted by the model using maximum likelihood (ML) function (Chin and Newsted 1999). Overall model fit indices are provided for the estimation. Since covariance-based SEM reproduces the covariance matrix of all indicator measures, it requires a very large sample size (Chin and Newsted 1999; Kline 2005). Kline (2005) suggested that a desired sample size would be 20 times the number of free parameters.

The alternative technique in SEM is PLS modeling. PLS is a component or variance-based SEM technique. PLS modeling has been used by a growing number of researchers from various disciplines including management information systems. Unlike covariance-based SEM technique, PLS explicitly creates constructs scores by weighting sums of measuring indicators underlying each latent variable. Regressions are carried out on the LV scores for estimating the structural equations (Chin 2010).

PLS was employed in this study to assess the measurement model and the structural model. PLS is appropriate for this study because it is variance-based and places minimal restrictions on measurement scales, sample size, and residual distribution (Chin et al. 2003). PLS does not require multivariate normality (Birkinshaw et al. 1995; Henseler et al. 2009). We choose PLS technique for this study mainly because of the sample size requirement issue with covariance-based SEM technique. The sample size

required for our model could reach more than 700 (7 first order constructs, 2 second order constructs, and a total of 35 indicators) if a covariance-based SEM technique was used. Chin et al. (2003, p. 197) stated "the model complexity increases beyond 40 -50 indicators, the LISREL software may not even converge". This study uses SmartPLS, a PLS software developed by Ringle et al. (2005).

Results, Findings, and Discussions

Data Screening and Sample Size

A total of 237 completed entries were collected during the four weeks data collection period. Twenty-one cases were eliminated from the sample because they were either incomplete responses or the organizations were not using any business intelligence system. One case had one and the other had seven response for all the questions. They were removed from the sample too. Our final sample size in this study is 214.

We did a power analysis to pre-determine the sample size for this study using G*Power developed by Erdfelder et al. (1996). Forty-three is the calculated minimum sample size from G*Power 3 for this study using the following criteria: One tail, effect size=0.10 (small effect), 95% confident level, power=80%, and number of predictors=2. The required sample size increases to 73 if confident level is changed to 99%.

Thus, the sample size of 214 is more than the minimum number of cases needed to assess the whole model using PLS.

Demographics of Participants

The population of interest for this study includes business executives from U.S. companies that have minimum annual revenues of 20 million dollars. Tables 1 through 4 display the demographic information of the participants in this study.

Table 1: Industries represented by participants		
Industry	**Number of Subjects**	**Percentage**
Basic material (basic resources, chemicals)	5	2.3%
Consumer goods (auto & parts, food beverage, personal & household goods)	22	10.3%
Consumer services (media, retail, travel & leisure)	7	3.3%
Education (K-12 and higher education)	4	1.9%
Financials (banks, financial services, insurances)	31	14.5%
Government (federal and local governments)	7	3.3%
Health care	39	18.2%
Industrials (construction & materials, industrial goods & services)	22	10.3%
Oil & Gas	4	1.9%
Technology (software & computer services, technology hardware & equipment)	46	21.5%
Telecommunications	3	1.4%
Utilities	1	0.5%
Professional services	18	8.4%
Manufacturing	5	2.3%
Total	214	100%

Table 2: Total number of years in Management positions		
Number of years in Management Positions	**Number of Subjects**	**Percentage**
Missing data	1	0.5%
Less than 1 year	0	0%
Between 1 – 5 years	0	0%
Between 6 – 10 years	14	6.5%
Between 11 – 15 years	27	12.6%
Between 16 – 20 years	45	21.0%
Between 21 – 25 years	43	20.1%
More than 25 years	84	39.3%
Total	214	100%

Table 3: Number of employees in participants' companies		
Number of employees	**Number of Subjects**	**Percentage**
Missing data	2	0.9%
1 – 49	26	12.1%
50 – 499	53	24.8%
500 or More	133	62.1%
Total	214	100%

Table 4: Annual revenue of participants' companies		
Annual revenue	**Number of Subjects**	**Percentage**
Missing	11	5.1%
Less than 50 million dollars	38	17.8%
50 – 100 million dollars	27	12.6%
100 – 250 million dollars	23	10.7%
250 – 500 million dollars	18	8.4%
500 – 1 billion dollars	23	10.7%
1 – 2 billion dollars	15	7.0%
More than 2 billion dollars	59	27.6%
Total	214	100%

Common Method Bias Check

Common method bias is a potential problem in research, especially in survey research (Podsakoff et al. 2003). Several post hoc statistical analyses can help to determine if there is an excessive common method variance in data.

Harman's Single-Factor test is one of the most widely used Post hoc method to determine if there is a common method variance in data (Podsakoff et al. 2003). Podsakoff et al. (2003, p. 889) suggested if a substantial amount of common method variance is present, then "either (a) a single factor will emerge from the factor analysis or (b) one general factor will account for the majority of the covariance among the measures." We performed the principal components factor analysis using SPSS. Eleven factors emerged from the analysis. There is no single factor that has excessive variance. This suggests that no excessive common method bias exists in the data.

Partial correlation method is another method to check common method bias in data (Podsakoff et al. 2003). Following Pavlou and El Sawy (2006)'s practice for this method, we added the highest factor from the principal component analysis to the PLS model as a control variable on dependent variables. This factor did not produce a significant change in explained variance in the dependent variables in the model.

Correlation analysis can also help to determine if there is an excessive common method variance in data (Bagozzi et al. 1991). Table 5 presents the correlation matrix of the main constructs in this study. Bagozzi et al. (1991) suggested that a correlation that is > 0.9 would indicate evidence of common method bias. The highest correlation among the second order constructs is 0.44 and that is between organizational agility and IT infrastructure flexibility. This analysis also suggests no excessive common method bias in the data.

Table 5: Correlations among the main Constructs			
	BI Use	IT Infrastructure Flexibility	Organizational Agility
BI Use	1	0	0
IT Infrastructure Flexibility	0.33	1	0
Organizational Agility	0.25	0.44	1

These statistical tests suggest there is no excessive common method variance in our data.

Measurement Reliability and Validity

We used SmartPLS (Ringle et al. 2005) to perform the confirmatory factor analysis. Based on the loading scores of the indicators, we dropped several indicators from the IT infrastructure flexibility scale. The Cronbach's Alpha values for all constructs, except for Partner Agility, are above the recommended threshold value of 0.7 (Nunnally and Berbstein 1994; Kline 2005). The Cronbach's Aplha for Partner Agility is 0.61, which is still acceptable (Robinson et al. 1991). Furthermore the construct as well as all other constructs has a composite reliability score above 0.83. The composite reliability scores are above the recommended threshold value of 0.7 for composite reliability (Nunnally and Berbstein 1994). These scores indicate reliable measurement scales.

All the kept indicators have loading scores of 0.6 or higher on their corresponding constructs and have at least one magnitude lower scores on other constructs. Table 6 presents the AVE values and constructs correlations for all the first order constructs in the proposed model after we dropped the indicators that cause discriminant and convergent validity issues for their theoretical constructs.

From Table 6, we can see that the square roots of all constructs' AVE are larger than any correlation among any pair of latent constructs.

From the analysis above, we can assume that the modified measurement scale for all first order constructs in this study have discriminant and convergent validity. Therefore, we can continue with our model assessments.

Table 6 Constructs' Average Variance Extracted (AVE) and Correlation									
AVE	SQRT of AVE	Construct Correlation							
			BI Use	Cust agil	Oper Agil	Part Agil	IT Conn	IT Hard	IT Mod
0.56	0.75	BI Use	1.00						
0.67	0.82	Cust Agil	0.25	1.00					
0.64	0.80	Oper Agil	0.20	0.68	1.00				
0.72	0.85	Part Agil	0.21	0.59	0.65	1.00			
0.63	0.79	IT Conn	0.27	0.43	0.33	0.33	1.00		
0.63	0.79	IT Hard	0.25	0.39	0.35	0.36	0.72	1.00	
0.71	0.84	IT Mod	0.32	0.29	0.25	0.27	0.57	0.52	1.00

Model Test Results

The full structural model was assessed using SmartPLS (Ringle et al. 2005). The model was estimated with company size as a control variable. Company size was operationalized by annual revenue. Company size is insignificant for organizational agility. The resulted path coefficients with controlled company size are displayed in Figure 2. The significance of the path coefficients are tested with 300 bootstrap runs. All the path coefficients are significant. Table 7 summarizes the hypothesis test results.

Table 7: Hypothesis Test Results				
Hypothesis	**Independent Variable**	**Dependent Variable**	**Path Coefficient**	**Hypothesis Supported?**
H1	BI Use	Organizational Agility	0.14*	Yes
H2	IT Infrastructure Flexibility	Organizational Agility	0.37**	Yes
H3	IT Infrastructure Flexibility	BI Use	0.33**	Yes

Figure 2: Test Results of Full Structural Model
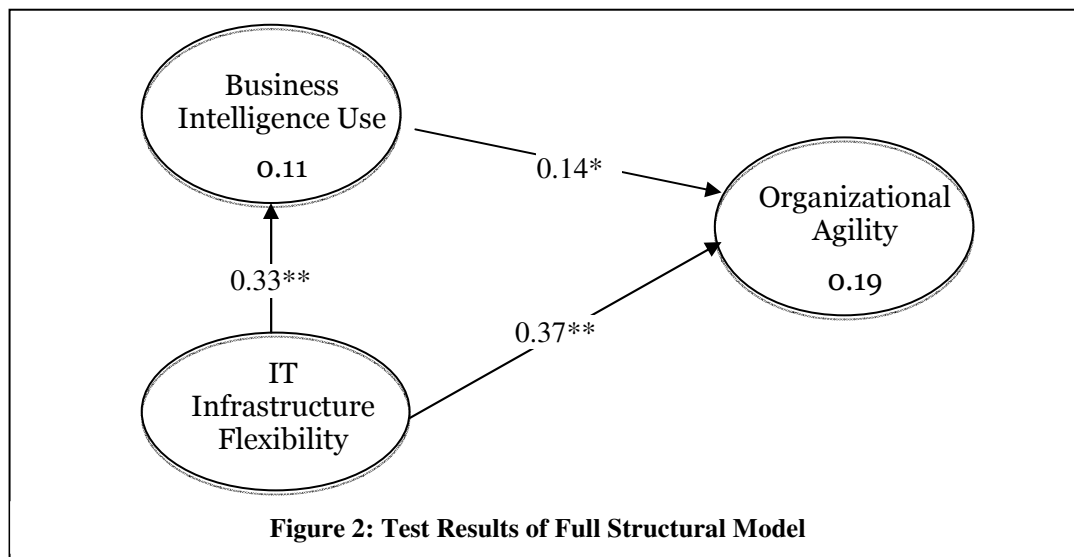
Notes: Number in a construct is the variance explained by its predictor(s)
**Significant at *p < .01*
*Significant at *p < .05*

Discussions

Business Intelligence Use and Organizational Agility

This study empirically tests the contribution of business intelligence use to organizational agility. Business intelligence can help increase organizational agility by improving the sensing and detecting dimension of organizational agility. Hypothesis 1 (H_1) is supported. The PLS tests in Figure 2 show that the path coefficient for the impact of business intelligence use on organizational agility is 0.14 and that is significant at the *0.05* significant level. This finding provides the first empirical support that business intelligence has strategic values. Business intelligence should be treated as a critical component of an organization because of its contribution to organizational agility.

IT Infrastructure Flexibility and Organizational Agility

IT infrastructure flexibility has been extensively studied in IS research. It has been studied as an independent variable (Sambamurthy et al. 2003; Kumar 2004; Tiwana and Konsynski 2010) as well as a moderator (Lin 2010; Tallon and Pinsonneault 2011). But this is the first study that theoretically argues the direct contribution of IT infrastructure flexibility to organizational agility and empirically investigates the relationship between IT infrastructure flexibility and organizational agility. The PLS test results in Figure 2 show that there is a significant impact of IT infrastructure flexibility on organizational agility: the path coefficient is 0.37, which is significant at the 0.01 significant level.

This finding suggests the real business values of IT infrastructure flexibility lie in the flexible interaction between IT infrastructure and its organizational context (DeJarnett et al. 2004; Kumar 2004; Lee et al. 2011). This finding provides the empirical support for Hypothesis 2 (H_2) that IT infrastructure flexibility is one of the key contributing components for organizational agility. Combining this finding and the finding on the relationship between business intelligence use and organizational agility, this study lends supports to the claim that IT still does matter (Kumar 2004). Although some IT components may be commodity and not scarce any more, the IT infrastructure flexibility is not just a simple combination of those components. IT infrastructure is not just a black box. From the subconstructs and their indicators of IT infrastructure flexibility, we can see that many characteristics of IT infrastructure flexibility cannot be bought. They need to be carefully cultivated so that other organizational capabilities can benefit from a flexible IT infrastructure. A flexible IT infrastructure is a strategic source that can help increase an organization's strategic business values by enhancing its organizational agility.

The 19% of variance in organizational agility can be explained with business intelligence use and IT infrastructure flexibility. These findings show the important roles of BI and IT infrastructure in enabling an agile organization. Future studies need to further examine how organizations build business intelligence systems and how organizations can leverage a flexible IT infrastructure to maximize the values of these IT and IS components to stay ahead of competitions.

IT Infrastructure Flexibility and Business Intelligence Use

Hypothesis 3 (H_3) is supported by the empirical evidence of this study. 0.33 is the path coefficient for the positive relationship between IT infrastructure flexibility and business intelligence use. The path coefficient is significant at the *0.01* significant level. The hypothesis 3 (H_3) in this study is the first proposition in the literature that connects business intelligence use with IT infrastructure flexibility. Although only 11% of variance in business intelligence use can be explained by IT infrastructure flexibility, the impact of IT infrastructure flexibility on business intelligence use is significant. We argue that business intelligence systems are IT enabled information systems. A flexible IT infrastructure can help to quickly integrate heterogeneous data sources, provide accurate information to decision makers where it is needed and when it is needed, and make deployed business intelligence systems useful. The usefulness of an information system can encourage its use in organizations. This finding shows that to maximize the use of business intelligence, a flexible IT infrastructure should be built in organizations.

Limitations and Future Research

This study used cross-sectional data at one point of time. This does not provide historical information on how the independent variables (IT infrastructure flexibility and business intelligence use) impact the dependent variable (organizational agility) over time. This study supports the claim that IT infrastructure flexibility and business intelligence have strategic values because they are major antecedents to organizational agility that directly impact strategic capabilities. But to answer the question of whether IT infrastructure flexibility and business intelligence can help organizational agility in a long run, a longitudinal study is required to compare the impacts of IT infrastructure flexibility and business intelligence use on organizational agility over times. This cross-sectional design also makes it necessary to treat the results with caution because causality cannot be inferred from cross-sectional data. But a solid cross-sectional study provides a strong foundation for future longitudinal studies.

A single subject filled up a questionnaire. This may suggest that the results are subjected to common method bias. We used statistical tests, such as the Harman's One-Factor test, partial correction analysis, and correlation analysis, as the post hoc tests to check for common method bias. The results show that common method bias in this study is minimal. Future studies could use a matched-pair design that uses

two informants from each organization. For example, one can be a technical executive and the other can be a business function executive to further alleviate common method bias.

The model in this study is general and it is not confined to a specific business activity. Therefore, we believe that this model is generalizable to various aspects of organizational activities. Future research can look at specific business contexts. For example, future research can study the model in operation or custom relationship management to verify or falsify the model for a specific business context.

Contributions of Research

Implications for Research

This study is one of the few empirical studies that investigate the importance of business intelligence. It uses a sound theoretical lens to argue that IT and IS components can help increase organizational agility. The theoretical contributions of this research are several folds.

First, using the lens of organizational agility, we theoretically argued and empirically tested the effect of BI on organizational agility. This pioneer work provides a theoretical foundation to argue for the importance of business intelligence and convince organizations to be BI-based. As a pioneering research that empirically examines the effects of business intelligence from the organizational agility perspective, this research paves the way for more empirical research on business intelligence.

Second, by theorizing that IT infrastructure flexibility can help the responding dimension of organizational agility, we suggest an alternative way to view IT infrastructure as a strategic component for organizations. Through the lens of organizational agility and AMC framework, we argued that a flexible IT infrastructure is an essential part of an organization's responding capability. We suggest that future research investigates approaches and ways to build a flexible IT infrastructure. From this study, it is clear that IT infrastructure flexibility is a major antecedent to organizational agility and organizational agility has a direct impact on organizational performance (Sambamuthy et al. 2003; Lee et al. 2008).

Third, we extend the existing research on IT values by providing insights on how BI and IT infrastructure flexibility can be integrated into organizational agility. This study answers the call to promote studies on specific information systems and their idiosyncratic effects (Mukhopadhyay et al. 1995). It also answers the call for studies "to unlock the mysteries of an increasingly important, but complex, set of relationships between IT investments and firm performance" (Sambamurthy et al. 2003, p. 256).

Implications for Practice

In addition to research, this study has implications for practice. First, it provides insights on how BI interacts with other organizational resources to enhance organizational agility. BI can create values with the right conditions. As an information system, the values of BI will be affected by IT infrastructure. Therefore, business intelligence needs to be viewed as a part of the big picture so that the benefits of business intelligence systems can be fully realized.

Second, the findings remind organizational executives that IT infrastructure is not only a valuable platform that helps to enable communication internally and externally, and to enable present and future business applications, but IT infrastructure is also a strategic component because it can contribute to organizational agility. Attention should be allocated to various areas of IT infrastructure, such as IT infrastructure flexibility, to fully take advantage of IT to enhance an organization's agility.

Third, although prior research shows inconsistent results of implementing business intelligence systems, business intelligence has strategic values because of its contribution to organizational agility. Some companies may not have garnered the fruits from their investments in business intelligence because they have not created the right conditions for implementing and using business intelligence systems. Business leaders need to continually investigate the factors affecting the performance of their business intelligence systems and provide resources to tackle the problems and issues that hinder the successful implementation of business intelligence systems.

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