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ABSTRACT

For SMEs, responsiveness to changes is a critical survival capability. Practitioners believe that IT infrastructure flexibility contributes to responsiveness, yet empirical evidence is sparse. The purpose of this research is to empirically test the relationship between IT infrastructure flexibility, which is measured on four dimensions, and IT responsiveness. Two research questions are answered by this study: first, are all the flexibility factors needed to achieve IT responsiveness and second, how does each IT flexibility dimension affect IT responsiveness. According to resource-based theory, we speculate that among the four IT flexibility dimensions, only modularity and IT personnel competency have direct impact on IT responsiveness. Industrial data were collected and analyzed using PLS. The findings support our hypotheses.

Keywords

IT infrastructure flexibility, IT responsiveness, Small and Medium Enterprises (SMEs), Resource-based theory

INTRODUCTION

Small and medium enterprises (SMEs) make significant contributions to the global economy. In the United States alone, SMEs represent 99.7 percent of all employer firms and account for 60-80 percent of new jobs annually over the last decade (SBA Office of Advocacy, 2007). Compared to big companies, SMEs have limited resources and little influence on the market. Their survival depends on their ability to quickly find and adjust to a market niche. Therefore, in SMEs, responsiveness to change is one of their critical survival capabilities.

It is generally assumed that a flexible IT infrastructure would allow firms to quickly respond to changes, yet empirical evidence is sparse. This paper empirically tests the relationship between IT infrastructure flexibility and IT responsiveness in the context of SMEs. More importantly, this paper investigates different dimensions of IT infrastructure flexibility including compatibility, connectivity, modularity, and IT personnel competency. The following questions are answered by this research: first, are all the flexibility factors needed to achieve IT responsiveness and second, how does each IT flexibility dimension affect IT responsiveness.

IT infrastructure flexibility is expensive (Duimering, Safayeni, & Purdy, 1993). Flexible technology requires higher financial investment compared to less flexible equipment. In SMEs, cost is the number one concern. Pinpointing the most important flexibility factors would allow SMEs to spend their limited financial resources only on necessary IT dimensions while still ensuring the benefit of a flexible infrastructure – high responsiveness.

BACKGROUND

Previous literature related to IT infrastructure flexibility, IT responsiveness, and resource-based view theory provides the conceptual foundation for this study.

IT infrastructure flexibility

IT infrastructure flexibility is defined differently based on different IT infrastructure foci. Duncan (1995) focuses on technology components of IT infrastructure and defines it as a set of shared tangible IT resources forming a foundation for business applications. IT infrastructure flexibility is characterized by compatibility, connectivity, and modularity. In other research (Broadbent & Weill, 1997; Byrd & Turner, 2000), IT infrastructure is considered to include both technical IT infrastructure and human IT infrastructure. Because of the special focus on human IT infrastructure, Byrd and Turner (2000) added IT personnel flexibility as an important dimension while combining connectivity and compatibility into one dimension called integration. This research adopted a parsimonious yet comprehensive view of IT infrastructure flexibility which includes four dimensions: connectivity, compatibility, modularity, and IT personnel competency.

Connectivity

Connectivity refers to the quality or condition of being connected or connective, which focuses on the degree of connectivity among technology devices inside and outside of the organizational environment (Byrd & Turner, 2000; Duncan, 1995). Connectivity may be enhanced by firms investing in networking components and telecommunication equipments.

Compatibility

Compatibility is the ability to share any type of information across any systems throughout the organization, no matter what the software and hardware base is (Duncan, 1995; Keen, 1991). Compatibility allows information flow seamlessly throughout the organization. Connectivity and compatibility together determine the level of integration of the system. They define the scope of the sharability of the infrastructure.

Modularity

Modularity is an effective way to manage complexity. Modular systems are divided into smaller pieces that can then communicate and interact with each other. While Duncan (1995) defines modularity as the ability to easily reconfigure (add, modify, or remove) technology components, she also emphasizes the modularity of business processes. Business processes, such as routine data calls, can be standardized and can then be shared and reused in other systems or services.

IT personnel competency

IT personnel competency refers to the capability of IT professionals to deal with IT related technical problems and business demands. Infrastructure flexibility depends on the skills of IT professionals (Duncan, 1995). Chung, Rainer, and Lewis (2003) define IT personnel as skilled IT professionals working cooperatively in cross-functional teams using many technologies. Being explicitly defined as one dimension of IT infrastructure flexibility (Byrd & Turner, 2000), IT personnel flexibility refers to the depth and breadth of IT professionals' technology management skills, business knowledge, management knowledge, and technical knowledge.

IT flexibility's strategic value is supported by option theory (Dai, Kauffman, & March, 2007; Kumar, 2004). Furthermore, the impact of IT flexibility on IT alignment (Tan, 1995), competitiveness (T.A. Byrd & Turner, 2001), and firm performance (Schwager, Byrd, & Turner, 2000) demonstrate the importance of a flexible IT infrastructure. Without exception, previous literature all assumes that different flexibility dimensions are independent from each other. This study, on the other hand, recognizes the dependency among IT flexibility dimensions.

Resource-based Theory

According to Barney (1991), "resources include all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness." Resource heterogeneity and immobility determine that some firms have sustainable competitive advantages while others don't. The resources that contribute to the sustainable competitive advantages must be valuable, rare, imperfectly imitable, and unsubstitutable. Resources are valuable when they enable firms to exploit opportunities or neutralize threats from the environment. Such resources are necessary but not sufficient for creating competitive advantages. Resources must also be rare, imperfectly imitable, and unsubstitutable so that the same advantage cannot be easily obtained or copied by the competitors.

Amit & Schoemaker (1993) further split the previously called resources into *resources* and *capabilities*. Resources are defined as stocks of available factors that are owned or controlled by the firm. They are tradable and non-specific to the firm. Capabilities refer to a firm's capacity to deploy resources to affect a desired end. Compared to resources, capabilities are firm-specific and are often developed over a long time by combining physical, human, and technological resources.

Based on resource-based theory, IT infrastructure, in general, has been considered as a source of competitive advantage (Byrd & Turner, 2001). This study investigates the dimensions of IT infrastructure and speculates that some dimensions of IT infrastructure can be considered capabilities while other dimensions are tradable and easily obtained, and therefore, are not sources of competitive advantages.

IT responsiveness

Duncan (1995) states that IT responsiveness should reflect a system's ability to meet users' demands to do things that they were not designed to do. Dans (2001) examines IT responsiveness in terms of two environmental changes: the millennium bug problem (*Y2K*) and the introduction of euro. He surveys 437 SMEs and discovers that SMEs with high IT responsiveness tend to generate more revenue. In this research, IT responsiveness refers to the capability of IT to meet the requirements driven by the changes from both inside and outside of the organization. While only half of SMEs survive more than four years, being able to quickly adjust to changes is critical to their survival. Responsiveness, as one competiveness advantage, contributes to SMEs' sustainability and growth. Although practitioners tend to regard flexibility as the underlying cause of an infrastructure's responsiveness to business requirements, the relationship has not been empirically tested.

THEORETICAL MODEL AND HYPOTHESES DEVELOPMENT

The relationship among different dimensions of IT infrastructure flexibility

Based on Amit and Schoemaker's definition of resources and capabilities, the connectivity and compatibility dimensions of IT infrastructure flexibility represent tradable resources rather than capabilities that contribute to sustainable competitive advantages of SMEs. Connectivity refers to the ability of technology components to connect to each other inside and outside of the organization. Because of the advance and wide adoption of Internet technology and the low cost of telecommunication equipment and services, connectivity can be easily and inexpensively obtained and extended. Compatibility refers to the ability of information to flow seamlessly throughout the organization. The popularity of modular software and standardization of hardware, the availability of integration systems and middleware, and the inherent compatibility of interface technologies allow firms to easily achieve information sharability across different platforms. In general, both connectivity and compatibility are neither rare nor inimitable for SMEs; therefore they are not sources of competitive advantage.

Nevertheless, connectivity and compatibility allow information sharing within and even among organizations. Such sharability enables and enhances modularity and IT personnel competency which are firm-specific capabilities. Firm-specific capabilities are often beyond IT infrastructure and relate closely to organization and people dimensions of information systems such as the way an organization chooses to produce a product, the skill level of employees, etc. Modularity requires complex systems to be broken down into reusable pieces of technical components and/or business processes. Such reusability depends on the compatibility and connectivity of infrastructure components (Duncan, 1995). IT personnel's ability to work effectively and cooperatively also depends on the sharability of information and connectivity of IT components.

Therefore, we propose that:

H1: IT infrastructure compatibility is positively related to modularity.

H2: IT infrastructure compatibility is positively related to IT personnel competency.

H3: IT infrastructure connectivity is positively related to modularity.

H4: IT infrastructure connectivity is positively related to IT personnel competency.

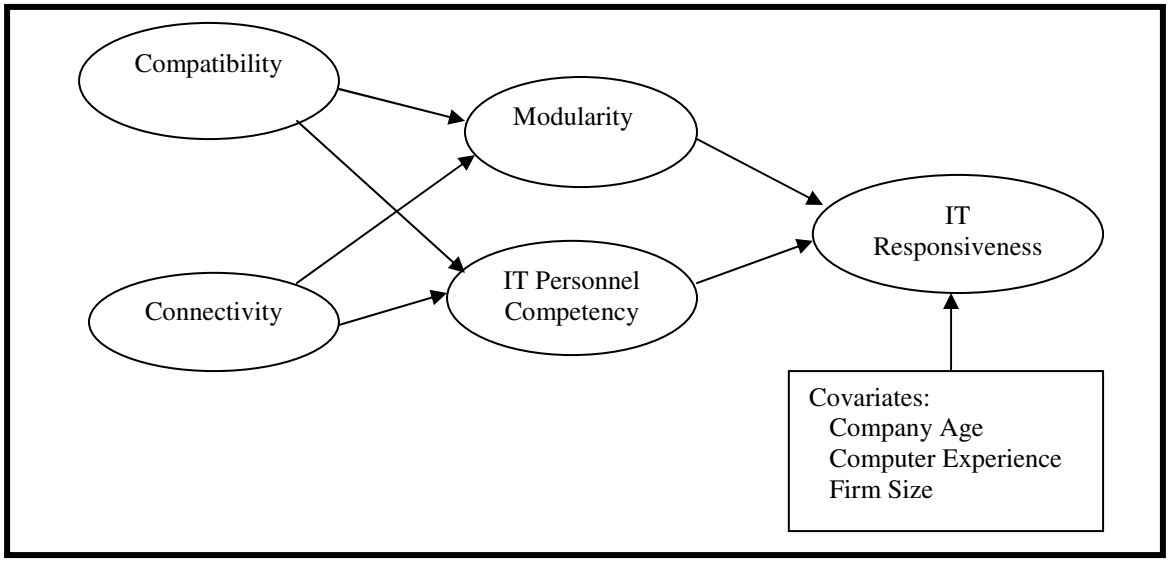

Figure 1. Research Model

The relationship between IT infrastructure flexibility and IT responsiveness

Previous research suggests that IT infrastructure flexibility facilitates IT responsiveness (Allen et al. 1991) and affects organizational responsiveness to environmental changes (Palanisamy, 2005). However, we propose that not all dimensions have direct impact on responsiveness. In this study, connectivity and compatibility are considered as resources rather than capabilities. These dimensions may not directly impact IT responsiveness. Rather, they create a foundation for building firm-specific capabilities such as modularity and IT personnel competency examined in this study. Weill (1992) argues that human skills transform IT into productivity, which confirms that human skills mediate the impact of IT on firm performance. IT professionals' knowledge and skills are captured by the IT personnel competency dimension which measures how well IT personnel are prepared for unplanned changes in IT-related needs. Therefore, IT personnel competency should have positive impact on IT responsiveness. Modularity is also proposed to have positive impact on responsiveness. When IT demands or requests change, modularity allows technology components to be easily reconfigured and business processes to be easily modified. Since business processes determine how resources are deployed and how the business is conducted, modularity will increase IT responsiveness through flexible business process designs.

Therefore, we propose that:

H5: Modularity is positively related to IT responsiveness.

H6: IT personnel competency is positively related to IT responsiveness.

Covariates

In addition to the four independent variables, the research model includes three control variables: company age, computer experience of the firm, and firm size.

METHODOLOGY

The research was conducted using a survey instrument[1], which was primarily based on previous validated scales. The survey was administrated online and distributed through a commercial mailing list. The data were then analyzed using Partial Least Square (PLS) analysis.

Instrument development

The four independent variables in the research model were measured using existing published scales. Three IT flexibility dimensions, including connectively, compatibility, and modularity, were measured using the items developed and tested by

[1] The questionnaire is available upon request.

Tallon and Kraemer (2003). IT personnel competency was adapted from the instrument developed and tested by Chung, Rainer, and Lewis (2003). All measurement items for IT infrastructure flexibility were five-point Likert-type scales with 1 being strongly disagree and 5 being strongly agree. IT responsiveness was measured by items especially designed for this research. The IT responsiveness scale measures IT responsiveness to changes in users' needs, to business process changes, and to environmental changes. The measurement items were five-point Likert-type scales with 1 being "very responsive" and 5 being "not responsive at all".

Data collection

An online survey was used to validate our research model. The survey was distributed to an industrial panel consisting of owners and managers of small to medium-sized firms. A total of 233 usable responses were received and used in the data analysis.

Data analysis and hypothesis testing

Demographic Characteristics

The respondents of the survey are primarily company owners and IT managers of firms less than 50 employees (See Table 1). These individuals should have the direct knowledge necessary to answer survey questions on IT planning and its impact. In addition, in the demographic data demonstrate that we have a good mix of companies across the control variables.

Company Age (Year)		Computer Experience (Year)		Firm Size (# Employees)		Respondent Title	
< 1	1.7%	< 3	15.0%	1-10	74.2%	Company Owner	65.7%
1-3	12.4%	3-5	20.6%	11-50	10.3%	IT Manager	8.2%
3-5	15.5%	6-10	27.9%	51-100	6.4%	IT Director	1.3%
6-10	17.2%	11-15	17.6%	101-150	1.7%	CEO	0.9%
10-15	12.0%	> 15	18.9%	151- 500	7.3%	CFO	1.3%
15-20	10.7%					CIO	0.4%
> 20	30.5%					Other Managers	22.3%

Table 1. Demographic Characteristics

Measurement Model

We assessed the convergent validity, reliability and discriminant validity of all latent constructs before testing the research model. Results of testing the measurement model are available with the authors. Overall, these results indicate that our measurement model has adequate convergent and discriminant validity.

Hypotheses testing results

Figure 2 and Table 2 summarize the results of testing the hypotheses. The research model is strongly supported by the data analysis results. IT compatibility and connectivity jointly explain 69.2% of variance in IT modularity and 51.7% variance in IT personnel competency. IT modularity and personnel competency together explain 51.7% of the variance in IT responsiveness. All hypothesized paths were found to be significant ($p<0.01$, two tailed). IT compatibility and connectivity significantly increase IT modularity and personnel competency which further enhance the responsiveness of a firm's IT infrastructure. None of these three control variables were found to be significant.

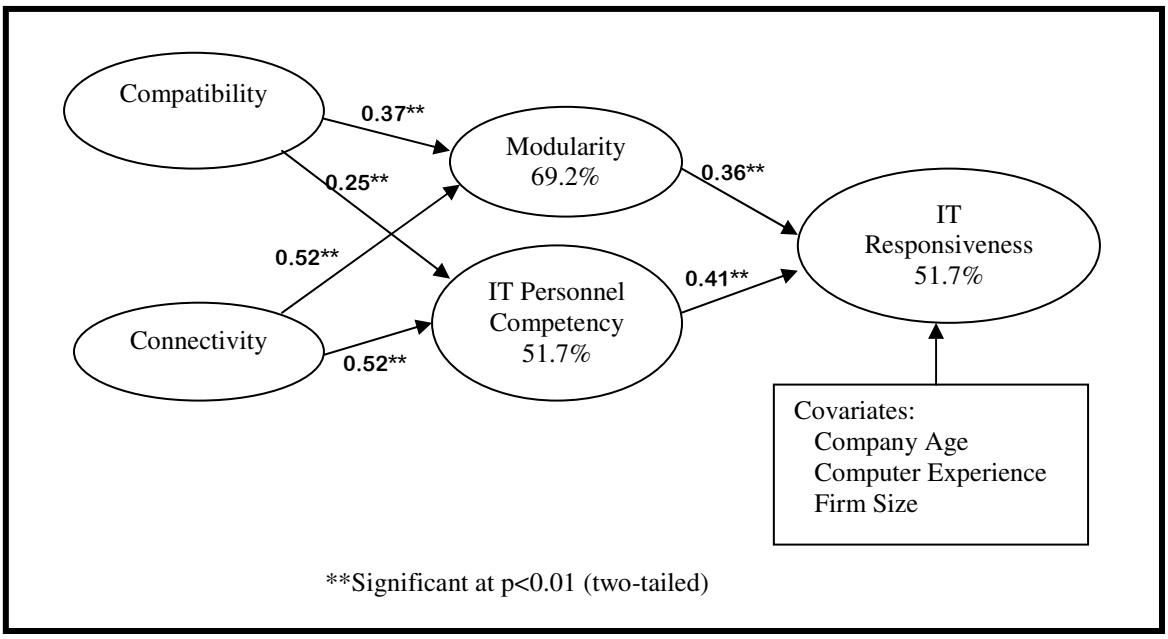

Figure 2. Results of testing hypotheses using PLS analysis. Completely standardized estimates, controlled for covariates in the research model.

Hypotheses	Path Coefficients	t Value	p value
Compatibility -->Modularity	0.37	5.82	p<0.01 (supported)
Compatibility -->IT Personnel Competency	0.25	3.20	p<0.01 (supported)
Connectivity --> Modularity	0.52	8.57	p<0.01 (supported)
Connectivity --> IT Personnel Competency	0.52	6.62	p<0.01 (supported)
Modularity --> Responsiveness	0.36	5.05	p<0.01 (supported)
IT Personnel Competency--> Responsiveness	0.41	6.36	p<0.01 (supported)

Table 2. Summary of hypothesis testing results

DISCUSSION AND CONCLUSION

Although it is widely believed by practitioners that IT infrastructure flexibility would increase firms' responsiveness to changes, such statement has not been empirically tested. This research examines the impact of each dimension of IT flexibility on IT responsiveness. The results of this study show that IT responsiveness of SMEs is enhanced by modularity and IT personnel competency. Modularity and IT personal competency are further dependent upon the connectivity and compatibility or the sharability of the IT infrastructure. Connectivity and compatibility, as firm-specific capabilities, mediate the impact of connectivity and compatibility on IT responsiveness.

This research has significant academic implications. Previous research has identified IT infrastructure dimensions. Based on the resource-based theory, this research further investigates the relationship among those dimensions and confirms that they have different impacts on IT responsiveness due to the dependency among them. While modularity and IT personnel competency are sources of competitive advantage and directly affect IT responsiveness, connectivity and compatibility are not. We conducted a post hoc analysis and added two more links to the model: one from connectivity to IT responsiveness and another from compatibility to IT responsiveness. Both paths are insignificant. The result confirms that the impact of connectivity and compatibility on IT responsiveness is fully mediated by modularity and IT personnel competency.

The findings have significant managerial implications. SMEs owners or managers should be aware that without improved modularity and IT personnel competency, connectivity and compatibility cannot significantly increase IT responsiveness. When it comes to IT infrastructure investment, purchasing networking or telecommunication equipment and buying integration software may not necessary lead to higher responsiveness. Improvement in business process modules and IT personnel competency are the direct sources of high responsiveness.

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