Journal of Business & Management
Volume 3, Issue 1 (2014), 01-12
ISSN 2291-1995 E-ISSN 2291-2002
Published by Science and Education Centre of North America

Impact of Information Technology Infrastructure Flexibility on the Competitive Advantage of Small and Medium Sized-Enterprises

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DOI: 10.12735/jbm.v3i1p1

Abstract

The purpose of this study is to investigate the impact of information technology infrastructure flexibility (ITIF) on competitive advantage (CA) of small and medium-sized enterprises (SMEs). For this purpose, this paper conducted multivariate analysis of covariance by using ITIF as an independent variable and four dependent variables for CA: production cost, fast and reliable delivery, product quality, and flexibility of product design, which are also essential factors in IT buying decision making for organizations. The results of this study show that having a flexible IT infrastructure positively influences all four variables of CA. Moreover, the result of the univariate analysis indicates that the SMEs' highest benefit of having ITIF is the improvement of product quality and an increased flexibility of product design. These results emphasize the importance of ITIF for SMEs and cloud computing, as a means for achieving this flexibility.

JEL Classifications: M11, M15

Keywords: IT, IT infrastructure, IT flexibility, cloud computing, product quality, product design

1. Introduction

In today's rapidly changing global economy, many organizations have adopted and leveraged advanced IT to gain competitive advantage over competitors. Several studies have been conducted for the purpose of identifying and measuring the relationship between IT and competitive advantage (CA) in organizations. However, most of these studies focused only on a single competitive advantage construct and did specify why the specific construct was used while other CA related dimensions were left out (Gebauer & Schober, 2006; Chung, Byrd, Lewis, & Ford, 2005; Palanisamy & Sushil, 2003; Weill, Subramani, & Broadbent, 2002). In addition, most assumptions about IT in these studies might not be appropriate anymore due to the fast-advancing IT environment. There have been major changes especially in terms of IT infrastructure flexibility (ITIF) due to many web based technologies such as XML, ASP, service oriented architecture (SOA), software-as-a-service (SaaS), virtualization, co-location, grid computing and cloud computing, to name a few. ITIF infrastructure provides organizations with the ability to pursue dynamic inter-organizational relationships (IORs), business process reengineering (BPR), diversification of products and services, and scalability. ITIF has become essential for improving strategic flexibility

of the organization.

Thus, it would be evocative to develop a comprehensive research model which reinforces the two above-mentioned shortcomings: (1) a multiple-dimension CA construct and (2) have ITIF as the key dimension of IT. Thus, in this study, we investigate the impact of ITIF on the four key dimensions of CA: production *cost*, speed and reliability of *delivery*, *quality* of products, and *flexibility* of product design. The paper is organized as follows: The next section presents a review of relevant literature concerning ITIF as a critical organizational resource. The research design and methodology section discusses the research model, variables, and data collection. The results section includes statistical analysis of the data to test the research model. The discussion section deals with managerial implications of the results. The conclusion section discusses the summary of the results, limitations, and future research needs.

2. Review of Relevant Literature

2.1 Information Technology Infrastructure Flexibility and Competitive Advantage

According to the Resource Based View (RBV), a resource is defined as "anything which could be thought of as a strength or weakness of a given firm" (Wernerfelt, 1984) and it could include brand names, in-house knowledge, skilled personnel, trade contracts, machinery, efficient procedures, capital, etc. The firm is analyzed in terms of its key resources rather than its products. Porter (1980)'s five competitive forces model is used to answer "Under what circumstances will a resource lead to high return over longer period time?". According to this theory, maintaining a balance between the exploitation of existing resources and development of new ones is of the utmost important.

We can find a theoretical background for the relationships between ITIF and CA from RBV for two main reasons. First, based on the definition of "resource" in RBV: ITIF can be an important resource since it could endow a firm with superior cost leadership, quality of product, speed of delivery, and flexibility design, which, in turn, create competitive edge over competitors (Gebauer & Schober, 2006; Palanisamy & Sushil, 2003; Rackoff, Wiseman, & Ullrich, 1985).

Second, RBV focuses on "how a firm can achieve diversification by effectively maintaining the balance between the exploitation of existing resources and the exploration of new one." In our study, flexible IT infrastructure contributes to a firm's diversification by not only strengthening internal capabilities for flexible operations but also supporting dynamic formation of value networks across the organization. Organizations are moving from being vertically integrated to "virtually integrated." By having ITIF, firms that have become more specialized and focused on their core competencies, enter more easily and often into short and long-term agreements with each other (Trimi, Faja, & Rhee, 2009). Partner organizations get together as a business-web (B-web) as a collection of modules where each participant focuses on a limited set of its core competencies (Tapscott, Ticoll, & Lowy, 2000). A flexible IT allows organizations to combine their resources with that of other organizations through dynamic IORs (Trimi *et al.*, 2009).

The relationship between ITIF and CA of organizations is supported by a number of previous studies (Table 1). These studies considered flexibility as the main capability of IT. Cloud computing (CC) is the current trend in providing organizations of all sizes with flexible and scalable IT, at a low cost and fast. However, currently CC is being used mainly for non-essential IT (applications and infrastructure) from organizations, and mostly from small to medium size firms. Part of the reason is because there are many (security, availability, standardization, integration) issues related to CC, which are beyond the scope of this study. However, lack of understanding the business value of CC is the main reason that businesses are not jumping yet into CC. Some believe it is a disruptive trend and others believe it is just another hype. Thus, it is important for businesses to know the

effect of IT flexibility in their competitive advantage. This is the reason that we chose ITIF as our independent variable.

Table 1. IT and competitive advantage of organizations

Studies	Types of IT Capability	Dimensions of Competitive Advantage Supported by IT
Gebauer and Schober (2006)	ITIF	Cost efficiency
Chung *et al.* (2005)	ITIF	Mass customization
Planisamy and Sushil (2003)	ITIF	Organizational flexibility
Weill *et al*. (2002)	IT Infrastructure	Strategic agility
Byrd and Turner (2001)	ITIF	Innovativeness Mass customization Difficulty to duplicate Market position
Zhang & Lado (2001)	Information Systems	Input-based competence Transform-based competence Output-based competence
Rackoff *et al.* (1985)	Information Systems	Differentiation, Cost, Innovation, Growth, Alliance

In addition, as Table 1 shows, previous studies separately indicate that IT capabilities have a positive impact on many aspects of CA, separately. However, there is no previous study that investigated the impact of IT capabilities on a multi-dimensional CA. Therefore, in this study we developed a comprehensive model that includes a multidimensional CA, with dimensions suggested by previous research, specifically: production cost, fast and reliable delivery, quality of the product, and flexibility of production, and empirically tested the impact of ITIF on them.

2.2 Information Technology Infrastructure Flexibility

Duncan (1995) viewed IT infrastructure as an enabler of strategic innovation. She suggested as tangible components of IT infrastructure technology: (1) Platform technology, (2) Network and telecommunication technology, (3) Key data, and (4) Core data-processing applications. She also proposed (1) compatibility, (2) connectivity, and (3) modularity as the most important infrastructure characteristics of ITIF. By including the above three characteristics, she introduced a framework for evaluating ITIF as shown in Table 2.

Table 2. Duncan's ITIF measurements

ITIF Components	Types of Indicators
Compatibility	Component characteristics
Connectivity	IS resource management practices
Modularity	IT capabilities

Byrd and Turner (2000) introduced two components of IT infrastructure flexibility: technical IT infrastructure, "the choice pertaining to application, data, and technology configurations," and human IT infrastructure, "the choices pertaining to the knowledge and capabilities required to

manage effectively the IT resources within the organization", and developed measurements for each (Table 3).

Table 3. Byrd and Turner's ITIF measurements

ITIF Components	Measurements
Technical ITIF	• IT connectivity • Application functionality • IT compatibility • Data transparency
Human ITIF	• Technology management • Business knowledge • Management knowledge • Technical knowledge

Gebauer and Schober (2006) assessed the impact of IS flexibility on cost efficiency of the business process. For this purpose, they defined IS flexibility in terms of: (1) flexibility in the pattern of use (flexibility-to-use) and (2) flexibility for further change (flexibility-to-change). As factors for measuring flexibility-to-use, they suggested: system functionality, scope of underlying database, user interface, and processing capacity. While for flexibility to change, they suggested: personnel, integration of data and functionality, and modularity of system components (Table 4).

Table 4. Gebauer and Schober's ITIF measurements

ITIF Components	Measurements
Flexibility to Use	• System functionality • Scope of database • User interface • Processing capacity
Flexibility to Change	• Personnel • Integration of data and functionality • Modularity of components

In this study, we adopted Duncan's (1995) definition of ITIF which focuses on compatibility, connectivity, and modularity as main factors because her study viewed ITIF as an enabler of strategic innovation for gaining competitive advantage. However, when we first used a pilot test, the results showed that the set of questions for "modularity" were too technical for the respondents to answer. Therefore, we dropped the modularity and adopted compatibility and connectivity as a measure of ITIF.

3. Research Design and Methodology

3.1 Research Model

As previously mentioned and as shown in Figure 1, this study empirically tests the impact of ITIF on multi-dimensional CA of the organization. Since we were trying to test the impact of ITIF on the four dimensions considered as a single group, while the organization size is controlled, multivariate

analysis of covariance (MANCOVA) analysis was selected for the analysis.

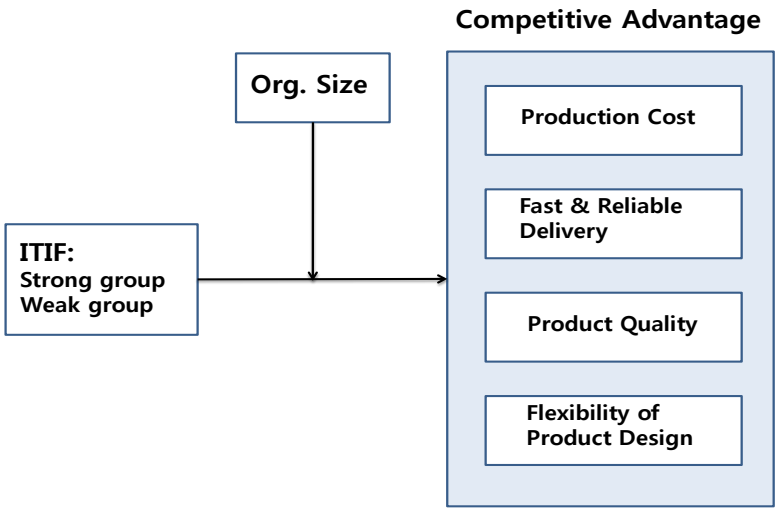

Figure 1. Research model for MANCOVA analysis

For the independent variable, based on the average score of ITIF dimensions, we separated the sample group into two groups: the high ITIF group and the low ITIF group. The size of the organization was used as a control variable. The four dimensions of CA were used as dependent variables: production cost, fast and reliable delivery, quality of product, and flexibility of production design. We used SPSS 15.0 for the analyses.

3.2 Research Variables

3.2.1 *IT Infrastructure Flexibility*

Based on the framework developed by Duncan (1995), we used eight items to measure ITIF (Appendix 1).

First, the average score of ITIF for each responding organization was calculated. Then, (based on this average ITIF score) each organization was assigned into either "high ITIF" group or "low ITIF" group as discussed earlier. Thus, the independent variable of this study includes a strong ITIF group and a weak ITIF group, separated by the median score as the division point.

3.2.2 *Competitive Advantage*

To measure competitive advantage of organizations, this study focused on four dimensions: cost, quality, speed of delivery, and flexibility in design. These factors were selected because they have been generally involved in the supplier selection decision by buyers (Goode & Gregor, 2009) and have been used by previous studies as the main dimension of CA for manufacturing firms (Duray, 2006; Lin, Moore, Kincade, & Avery, 2002; Schonsleben, 2004; Miller & Roth, 1994; Vastag & Narasimhan, 1998).

3.2.3 *Size of Organization*

Organizational size is important when analyzing the type of IT investments and the ability to derive strategic benefits of IT. As a measurement of the firm size, in this study we used we used the number of employees as it is most widely used resource-related indicator of organizational size (Goode & Gregor, 2009).

3.3 Sample Group

We selected a total of 190 suppliers of a single buyer as a sample group since we could control the compound effect of industries and various roles of industry value chains. Furthermore, we could focus on the industry where IT plays more critical roles than other industries by focusing on suppliers of a single global IT firm. The buyer is a major global firm which had been recently ranked as the largest IT firms in the world and one of the top 25 global brands (BusinessWeek, 2008). Sixty two supplier firms replied to our questionnaire, thus, response rate was 32%. As previously mentioned, suppliers were divided into two groups, strong ITIF and weak ITIF, according to the level of their ITIF.

4. Results of Data Analysis

4.1 Demographic Characteristics of the Sample Group

4.1.1. *Size of Organization*

Table 5 shows the distribution of responding organizations in terms of their size as determined by their number of employees. As shown, 94% of responding organizations have less than 500 employees. This means that most supplier organizations for the global IT giant can be classified as small- and medium-sized enterprises (SMEs). The average number of employees was 241.

Table 5. The size of responding organizations

Number of Employees	Frequency	Percent	Cumulative Percent
49 or less	5	8.1%	8.1%
99 or less	11	17.7%	25.8%
499 or less	42	67.7%	93.5%
999 or less	2	3.3%	96.8%
1000 or more	2	3.2%	100.0%
Total	62	100%	

4.1.2 *Type of Business*

As shown in Table 6, electronics was the most common business type of those that responded. This result is expected because all the responding organizations are suppliers of a single global IT firm.

Table 6. Types of businesses

Types of Business	Frequency	Percent	Cumulative Percent
Electronics	47	75.8%	75.8%
Metal, machine	6	9.7%	85.4%
Textiles & Chemical	3	4.8%	90.2%
Other	6	9.7%	96.8%
Total	62	100%	

4.2 Results of Reliability Analysis

Cronbach's alpha value was needed to measure internal consistency reliability which gave the

degree of relatedness of the individual items. A desirable value of Cronbach's alpha is 0.7 (Nunally, 1978). The result of the reliability test for the questions used for measuring ITIF related constructs showed the following: connectivity α = .778; compatibility α = .834. The high alpha values are explained with the fact that all items are extracted from the measurements which have been validated by previous studies (Duncan, 1995). Therefore, we skipped the confirmatory factor analysis.

4.3 MANCOVA Analysis

4.3.1 *Correlation among Factors*

Before conducting MANCOVA, correlation analysis was conducted among the dependent variables to check whether MANCOVA was a proper analytical tool. As shown in Table 7, MANCOVA can be used since four dependent variables showed significant relationships among them.

Table 7. Correlation among dependent variables

	Cost	Delivery	Quality	Flexibility
Cost	1	.577***	.314**	.213*
Delivery	.577***	1	.571***	.250**
Quality	.314**	.571***	1	.526***
Flexibility	.213*	.250**	.526***	1

*p <0.10; **p < 0.05; ***p < .01

4.3.2 *Equality of Covariance and Error Variance*

Box's M test was conducted to test the equality of covariance matrices between the two groups of ITIF, strong and weak. As seen in Table 8, the result (.226) was not significant. This means that we can conclude that covariance matrices of the dependent variables are equal across groups, and therefore, the MANCOVA analysis is acceptable to be conducted. The result of Levene's Test of Equality of Error Variances was not significant for all four variables. Thus, the error variance of the dependant variable is equal across the groups.

Table 8. Box's test of equality of covariance matrices (a)

Box's M	13.978
F	1.297
df1	10
df2	17039.662
Sig.	.226

4.3.3 *Result of MANCOVA Test*

As shown in Table 9, all relevant values including Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root were significant at the .10 level. The results show that there is a significant difference between the strong ITIF group and the weak ITIF group in terms of the four dimensions

of CA. This result suggests there is a significant effect of ITIF on the four dimensions of CA when they are considered as a factor.

Table 9. Result of MANCOVA

Effect		Value	F	Hypothesis df	Error df	Sig.
Number of Employee	Pillai's Trace	.035	.502(a)	4.000	56.000	.734
	Wilks' Lambda	.965	.502(a)	4.000	56.000	.734
	Hotelling's Trace	.036	.502(a)	4.000	56.000	.734
	Roy's Largest Root	.036	.502(a)	4.000	56.000	.734
ITIF	Pillai's Trace	.135	2.185(a)	4.000	56.000	.082*
	Wilks' Lambda	.865	2.185(a)	4.000	56.000	.082*
	Hotelling's Trace	.156	2.185(a)	4.000	56.000	.082*
	Roy's Largest Root	.156	2.185(a)	4.000	56.000	.082*

* $p < 0.10$

4.3.4 *Result of Univariate Tests*

To measure the effect of each ITIF group on each of the four dimensions in dependent variables, the univariate test was conducted. First, as presented in Table 10, results show that, overall, ITIF influences more the quality and flexibility dimensions of CA.

Table 10. Between-Subjects effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Number of employee	Cost	.765	1	.765	1.090	.301
	Delivery	.113	1	.113	.231	.633
	Quality	.036	1	.036	.096	.758
	Flexibility	.376	1	.376	.625	.432
ITIF	Cost	1.028	1	1.028	1.464	.231
	Delivery	.647	1	.647	1.320	.255
	Quality	2.463	1	2.463	6.636	.013**
	Flexibility	3.666	1	3.666	6.094	.016**

** $p < 0.05$

When test was conducted for each of the two groups of ITIF, as shown in Table 11, the strong ITIF group showed higher mean values than the weak ITIF group in all dimensions of CA. The gap between the two groups was even larger for product quality and flexibility of product design dimensions of CA, which we expected because of the MANCOVA test results.

Table 11. Descriptive statistics

	ITIF Group	Mean	Std. Deviation	N
Production Cost	Weak	3.3000	.74971	30
	Strong	3.5625	.91361	32
	Total	3.4355	.84195	62
Fast & Reliable Delivery	Weak	3.7000	.53498	30
	Strong	3.9062	.81752	32
	Total	3.8065	.69751	62
Product Quality	Weak	3.6333	.49013	30
	Strong	4.0313	.69488	32
	Total	3.8387	.63229	62
Flexibility of Product Design	Weak	3.2667	.63968	30
	Strong	3.7500	.87988	32
	Total	3.5161	.80454	62

5. Discussion

The results of MANCOVA analysis showed that ITIF influences the four dimensions of CA when they are considered as a single group. The result suggests that the stronger the ITIF, the higher the CA of SMEs. This result is in line with previous studies which focused on only single dimension of CA (Gebaurer & chober, 2006; Chung *et al.*, 2005; Palanisamy & Sushil, 2003; Weill *et al.*, 2002). However, the results of this study are more meaningful than the previous studies in the following aspects: (1) It tested the impact of ITIF by incorporating multiple dimensions of CA, (2) It proved that ITIF influences CA overall when multiple dimensions of CA are considered as a single factor and for each dimension, (3) It found that the product quality and flexibility of product design are most influenced dimensions of CA from ITIF, and (4) It focused on SMEs which are main suppliers of global IT firm. The results imply that SMEs could strengthen most dimensions of CA without any trade-offs among them when they have a strong ITIF.

On the other hand, the results of univariate test showed that the high ITIF group has higher CA than the low ITIF group, especially in terms of product quality and flexibility of product design. Higher flexibility of product design of the high ITIF group can be explained by the fact that ITIF supports the organization's capability to adjust operation processes to produce diverse and customized products according to rapidly changing demand of customers. Dell's "Assembly to the Order System" is a good example.

Higher product quality of the high ITIF group can be supported by the fact that ITIF supports the formation of dynamic IORs which are also referred as the business web (B-Web). Under B-Web, a leading organization focuses on its unique core competencies and outsources other processes to partners who have better competencies than the leader in those processes. Since each partner of B-Web only focuses on its core competencies and complement each other, a strong synergy from partnership would contribute to product quality improvement. Idea of B-Web has evolved into eco-systems and platform business. Information technology and communication are playing key role for this trend by helping organization effectively and economically coordinate widely dispersed

capabilities and knowledge of partners in the ecosystems (Williamson & De Mayer, 2012).

No significant result regarding the production cost dimension suggests that increased connectivity and compatibility of IT infrastructure do not support an organization's ability to reduce production cost. This result can be explained by the fact that the flexibility of product design was very significant (P value of .016). This implies that organizations were utilizing ITIF mainly for increasing flexibility of production capability in terms of product diversification and customization rather than reducing the cost of production for commodity.

It was surprising to observe no significant result regarding the fast and reliable delivery dimension since a seamless IOR supported by strong ITIF is supposed to improve delivery capability. This maybe could be because delivery was probably outsourced or organizations were part of SCM types, either arm-length type or hub-and-spoke types, where our sample's organization are one of the "spokes", therefore do not have much decision-making power in the IT purchasing and infrastructure. Further research is needed to find the answer for this result.

6. Conclusion

The purpose of this study was to investigate the impact of ITIF on CA of SMEs. For this purpose, a comprehensive model was created which included ITIF as an independent variable, size of the organization as covariate, and four CA dimensions including production cost, fast and reliable delivery, product quality, and flexibility of product design. The result of MANCOVA test showed ITIF influences the four dimensions of CA when they are considered as a group. The result of univariate analysis shows that ITIF has significant effects on product quality and the flexibility of product design.

The results of this study strongly suggest that IT flexibility has a significant positive impact on SMEs since it provides a source of CA in many aspects and when combined with strategic innovation and business processes of the organization. Emerging technologies and services such as on-demand computing, software as a service, infrastructure (computing and networking) as a service, and cloud computing can be used by organizations of all sizes to achieve CA. Cloud computing can provide computing resources to organizations at low cost, at high level of scalability, and flexibility, and on demand without any advance arrangements. Especially, cloud computing can be considered as a realistic option for SMEs that cannot afford huge capital investments in IT, but still need strong IT support for their strategic innovation and more effective operations of their business processes. Although, cloud computing services have many drawbacks like other IT, the benefits of cloud computing outweigh its negative aspects. The cloud computing is disruptive technology not only to IT, but to the business overall. Sample population in our study did not use cloud computing technology. Therefore, measuring the benefits of cloud computing can be further explored by future studies.

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Appendix

Items for ITIF Construct Measurement

I1	Compared to rivals within our industry, our organization has the best available IT systems and connections (ADSL, VDSL, ATM, Wireless Internet, 3G Wireless Communication, etc).
I2	Flexible electronic links exist between our organization and external entities.
I3	All remote branch and mobile offices are connected to the central office.
I4	New locations or acquisitions are quickly assimilated into our IT infrastructure.
I5	Remote branches and mobile offices do not have to perform any additional steps or procedures to access data from the home office.
I6	Our organization offers a wide variety of information to end users.
I7	The rapidity of IT change (e.g., revision level, release) in our organization is high.
I8	Information is shared seamlessly across our organization, regardless of the location.

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