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THE IMPACT OF INFORMATION TECHNOLOGY INFRASTRUCTURE FLEXIBILITY ON STRATEGIC ALIGNMENT AND APPLICATIONS IMPLEMENTATION

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ABSTRACT

IT infrastructure flexibility is now being viewed as an organizational core competency that is necessary for organizations to survive and prosper in rapidly-changing, competitive, business environments. Using data from 200 U.S. and Canadian companies, this study examines the impact of the four components of IT infrastructure flexibility (compatibility, connectivity, modularity, and IT personnel) on strategic IT-business alignment and the extent to which various applications are implemented within an organization. The "extent" of implementation refers to the the organization's experience with the particular application and the degree to which the application is implemented and used throughout the organization.

The findings from analysis of a structural model provide evidence that connectivity, modularity, and IT personnel (among other considerations that we discuss in the paper) make significant, positive impacts on strategic alignment and that all four components result in significant, positive impacts on the applications implementation. The study reinforces the importance of IT infrastructure flexibility to organizations as one source for sustainable competitive advantage.

Key Words: IT infrastructure flexibility, strategic IT-business alignment

I. INTRODUCTION

In the early 1990s, Johnson & Johnson faced new business pressures when large customers, such as Wal-Mart and K-mart, made new demands on the company, such as cost savings and just-in-time stock replenishment. Johnson & Johnson's business and IT managers acted in partnership to develop a new set of information technology (IT) infrastructure capabilities which enabled the company to provide the necessary services for its large customers while, at the same time, reducing costs for the firm [Weill & Broadbent, 1998].

In the late 1990s, Charles Schwab focused on delivering timely, customized information to its investors. Using the company's IT infrastructure and applications aligned with its business focus, Schwab became a full service brokerage firm. The firm was able to provide information and process transactions in meeting its business objectives. Customers could retrieve stock quotes and place orders via Schwab's Web site. As a result, the corporation continues to be an industry leader.

These two examples demonstrate that an organization's IT infrastructure can provide tangible benefits and a continuity of business practices [Kettinger, Grover, Subanish, & Segars, 1994]. However, IT infrastructure alone is not sufficient to provide these advantages. IT infrastructure consists of IT components (computer and communications technologies and IT personnel), which provide shared IT services (e.g., managing enterprisewide transaction processing, providing electronic data interchange capability, and managing corporate databases). The IT infrastructure provides the functionality delivered by business applications (e.g., point-of-sale data capture, order entry, sales analysis, purchasing systems, etc.). These business applications perform the many, varied processes of the business (Broadbent & Weill, 1997). We see, then, that the IT infrastructure at Johnson & Johnson and Charles Schwab provided the functionality for the business applications at the two firms that enabled them to meet changing business conditions successfully.

However, an organization might not make effective use of its IT infrastructure to produce effective business applications. That is, an organization's IT infrastructure could be effective while its business applications are poor, In this case the organization's strategic alignment between IT and the business units would not bed effective. For example, an organization with all IT components in place and an effective IT staff, might suffer a breakdown in communications between systems analysts and prospective users of a new system. Such a breakdown could produce poorly defined user information requirements, resulting in an application that does not adequately meet user needs. Therefore, Johnson and Johnson and Schwab needed both effective IT infrastructures and effective applications so that delivered functionality to be successful.

A particularly important characteristic of IT infrastructure is flexibility [Byrd & Turner, 2000]. IT infrastructure flexibility should be viewed as an organizational core competency and IT infrastructure flexibility (along with other components [Luftman et al., 1999 which we will address] is necessary to handle increased customer demands without increased costs [Davenport & Linder, 1994; Weill, 1993].

As discussed in Section II, in developing the theoretical framework for our study, two important aspects of IT infrastructure flexibility emerge from previous research:

- core business applications of an organization and
- strategic IT-business alignment.

That is, an organization's IT infrastructure flexibility should be reflected in its implementation of core business applications and the extent of its strategic IT-business alignment. Therefore, the purpose of this study is

- to examine empirically the relationship between IT infrastructure flexibility and the extent of applications implementation in the organization and
- the relationship between IT infrastructure flexibility and strategic IT-business alignment.

II. THEORETICAL FRAMEWORK

We develop our theoretical framework by first reviewing definitions of IT infrastructure and its components. We then define the concept of IT infrastructure flexibility and its relationship to strategic IT-business alignment and to applications implementation in the organization.

INFORMATION TECHNOLOGY INFRASTRUCTURE

The topic of IT infrastructure is a key issue for both researchers and practicing managers [e.g., Brancheau, Janz, & Wetherbe, 1996]. Although at a simple level the organization's IT infrastructure basically integrates technology components to support business needs, the IT infrastructure concept is more complicated.

The definition of IT infrastructure encompasses a variety of components. Based on previous studies, Duncan [1995] stated that IT infrastructure includes a group of shared, tangible IT resources that provide a foundation to enable present and future business applications [Broadbent & Weill, 1997; Davenport & Linder, 1994; Earl, 1989; Keen, 1991; McKay & Brockway, 1989; Niederman, Brancheau, & Wetherbe, 1991; Weill, 1993]. These resources include:

- computer hardware and software (e.g., operating systems);
- network and telecommunications technologies;
- key data;
- core data-processing applications;
- shared IT services.

Duncan [1995] also stated that IT infrastructure includes the alignment of IT plans to business objectives, the IT architecture, and the skills of IT personnel. Broadbent and Weill [1997] noted that IT infrastructure capabilities enable the various types of IT applications required to support current and future business objectives, and enable the competitive positioning of business initiatives.

Although the IT infrastructure is important for business-IT strategic alignment, other factors are equally important for alignment. Luftman et al. [1999] developed a model for strategic alignment consisting of twelve components, grouped into four major categories:

- business strategy (business scope, distinctive competencies, and business governance);
- organization infrastructure and processes (administrative structure, processes, and skills);
- IT strategy (technology scope, systemic competencies, and IT governance);
- IT infrastructure and processes (architecture, processes, and skills). The relationships among these twelve components define IT-business alignment.

Luftman et al. [1999] described the key enablers of IT-business alignment, which include

- senior executive support for IT;
- IT involved in strategy development;
- IT understands the business;
- partnership between IT and the business units;
- IT projects are well-prioritized;
- and IT demonstrates leadership.

Luftman et al. [1999] also noted the key inhibitors of IT-business alignment. These inhibitors are almost precisely the opposite of the key enablers.

Our study concentrates on four of the 12 components proposed by Luftman et al. [1999]:

- technology scope: the important information applications and technologies;

- architecture: the technology priorities, policies, and choices that allow applications, software, networks, hardware, and data management to be integrated into a cohesive platform;
- processes: those practices and activities carried out to develop and maintain applications and manage IT infrastructure;
- skills: IT human resource considerations such as how to hire/fire, motivate, train/educate, and culture.

McKay and Brockway [1989] described IT infrastructure as the enabling foundation of shared IT capabilities upon which the entire business depends. This foundation is standardized and shared by business functions within the organization, and typically used by different organizational applications.

Byrd and Turner [2000, p. 172] provided a thorough definition of IT infrastructure as:

> *"… the shared IT resources consisting of a technical physical base of hardware, software, communications technologies, data, and core applications and a human component of skills, expertise, competencies, commitments, values, norms, and knowledge that combine to create IT services that are typically unique to an organization. These IT services provide a foundation for communications interchange across the entire organization and for the development and implementation of present and future business applications."*

As can be seen from these definitions, the IT infrastructure is composed of two components:

- a technical IT infrastructure and a
- human IT infrastructure.

The technical infrastructure consists of the applications, data, and technology [Broadbent & Weill, 1997; Broadbent, Weill, O'Brien & Neo, 1996; Henderson & Venkatraman, 1993].The human IT infrastructure consists of the knowledge and capabilities required to manage organizational IT resources [Broadbent & Weill, 1997; Lee, Trauth & Farwell, 1995]. Davenport and Linder [1994] suggested that a robust IT infrastructure enables employees to be able to perform their respective jobs, both from having the available technology and the necessary technological skills.

INFORMATION TECHNOLOGY INFRASTRUCTURE FLEXIBILITY

Early work on IT infrastructure flexibility described the concept without actually defining it. Weill [1993] asserted that an IT infrastructure should be flexible to be able to handle increased customer demands without increased costs. Davenport and Linder [1994] stated that IT infrastructure flexibility should be viewed as a core competency of the organization and suggested that an effective IT infrastructure is flexible and robust.

Duncan [1995] observed that one organization's IT infrastructure may enable strategic innovations in business processes, while another's IT infrastructure may limit such innovations. She referred to this characteristic as IT infrastructure flexibility and suggested that both business and IT application development capabilities reflect the flexibility of infrastructure components. She suggested that infrastructure flexibility improves systems developers' ability to design and build systems to meet organizational business objectives.

She described IT infrastructure flexibility through the characteristics of connectivity, compatibility, and modularity. She maintained that an organization with high modularity, compatibility, and connectivity would have high technical IT infrastructure flexibility.

Compatibility is the ability to share any type of information across any technology component throughout the organization [Duncan, 1995; Keen, 1991]. Tapscott and Caston [1993] noted that IT compatibility helps span organizational boundaries, empower employees, and make data, information, and knowledge readily available in the organization.

Connectivity is the ability of any technology component to communicate with any of the other components inside and outside of the organizational environment [Duncan, 1995]. Tapscott and Caston [1993] emphasized that IT connectivity enables seamless and transparent organizations that are independent of time and space. Connectivity facilitates the sharability of IT resources at the platform level.

The World Wide Web, with TCP/IP, XML, and browsers providing common protocols and interfaces, provides seamless connectivity not only within organizations but also among organizations (e.g., along a supply chain). In fact, the WWW has made sharing IT resources easier, cheaper, and faster.

Modularity is the ability to easily reconfigure (add, modify, or remove) technology components [Duncan, 1995]. She also stated that modularity is the standardization of business processes for sharability and reusability (e.g., structured programming and component-based software architectures). Schilling [2000] suggested that modularity is a continuum describing the degree to which a system's components can be separated and recombined.

Byrd and Turner [2000, p. 172] defined IT infrastructure flexibility as "…the ability to easily and readily diffuse or support a wide variety of hardware, software, communications technologies, data, core applications, skills and competencies, commitments, and values within the technical physical base and the human component of the existing IT infrastructure." Historically, the flexibility of the IT infrastructure has been viewed as necessary to accommodate a rapidly changing business environment [Byrd & Turner, 2001]. This flexibility enables businesses to effectively use IT to prosper in dynamic environments.

The literature review points out that IT infrastructure flexibility is one important component of strategic IT-business alignment. A flexible IT infrastructure can respond rapidly and easily to changing business conditions. Strategic business-IT alignment means "applying IT in an appropriate and timely way, in harmony with business strategies." [Luftman et al., 1999; p. 2] Therefore, a flexible IT infrastructure will facilitate applying IT quickly and appropriately. If organizations can apply IT in this manner, then the alignment between IT strategies and organizational strategies should be enhanced.

The literature review also points out that IT infrastructure flexibility enables organizations to build or modify business applications quickly and easily. As a result, a flexible IT infrastructure plays an important role in the extent of implementation of various applications in a firm.

However, the relationships between IT infrastructure flexibility and strategic IT-business alignment and between IT infrastructure flexibility and business applications have not been empirically tested. We test these relationships through our conceptual model.

III. CONCEPTUAL MODEL

IT INFRASTRUCTURE FLEXIBILITY AND STRATEGIC IT-BUSINESS ALIGNMENT

Strategic IT-business alignment refers to the extent to which the IT mission, objectives, and plans support, and are supported by, the organization's mission, objectives, and plans [Hirscheim & Sabherwal, 2000]. This alignment creates an integrated organization in which every function, unit, and person are focused on the organization's competitiveness. Sambamurthy and Zmud [1992] suggested that IT management is a problem of aligning the relationship between the business and the IT infrastructure to take advantage of IT opportunities and capabilities.

Duncan [1995] first included the alignment of IT plans to business objectives in her description of IT infrastructure. She continued by noting that an organization's IT infrastructure could be considered flexible if it enabled strategic innovations in business processes. Broadbent and Weill [1997] stated that IT infrastructure capabilities provide the foundation for "…competitive positioning of business initiatives."

From this discussion, we propose the following hypothesis:

Hypothesis 1: Each component of an organization's IT infrastructure flexibility will positively (or negatively) affect the organization's strategic IT-business alignment.

IT INFRASTRUCTURE FLEXIBILITY AND APPLICATIONS IMPLEMENTATION

Today, IT applications do not only process data and provide management information reports. Corporations now use IT applications to gain competitive advantage [Earl, 1989; Porter & Millar, 1985; Powell, 1992; Saunders & Jones, 1992; Smith & McKeen, 1993]; to create new business opportunities [Earl, 1989; Rockart & Scott-Morton, 1984; Smith & McKeen ,1993]; to improve customer service; to enhance product and service quality; and to integrate supplier and customer operations [Luftman, Lewis, & Oldach, 1993].

Several studies include business applications as part of IT infrastructure [see e.g., Broadbent & Weill, 1997; Byrd & Turner, 2000; Duncan, 1995]. Duncan [1995] addressed business applications when she asserted that IT infrastructure flexibility enabled organizations to build applications that more closely satisfy business objectives. Broadbent and Weill [1997] stated that IT infrastructure capabilities are the "base for computer applications." Byrd and Turner [2000] noted that IT infrastructure flexibility enabled organizations to "…easily diffuse and support…core applications."

For this study, we use the extent to which organizations implemented a variety of business applications to examine the concept of "applications implementation." The eleven business applications in our study include:

- transaction processing systems
- management information systems
- executive information systems
- decision support systems
- expert systems
- data warehousing
- data mining
- inter-organizational information systems (e.g., electronic data interchange),
- knowledge management
- network management
- disaster recovery

.

From this discussion, we propose the following hypothesis:

Hypothesis 2: Each component of an organization's IT infrastructure flexibility will positively (or negatively) affect the organization's extent of applications implementation.

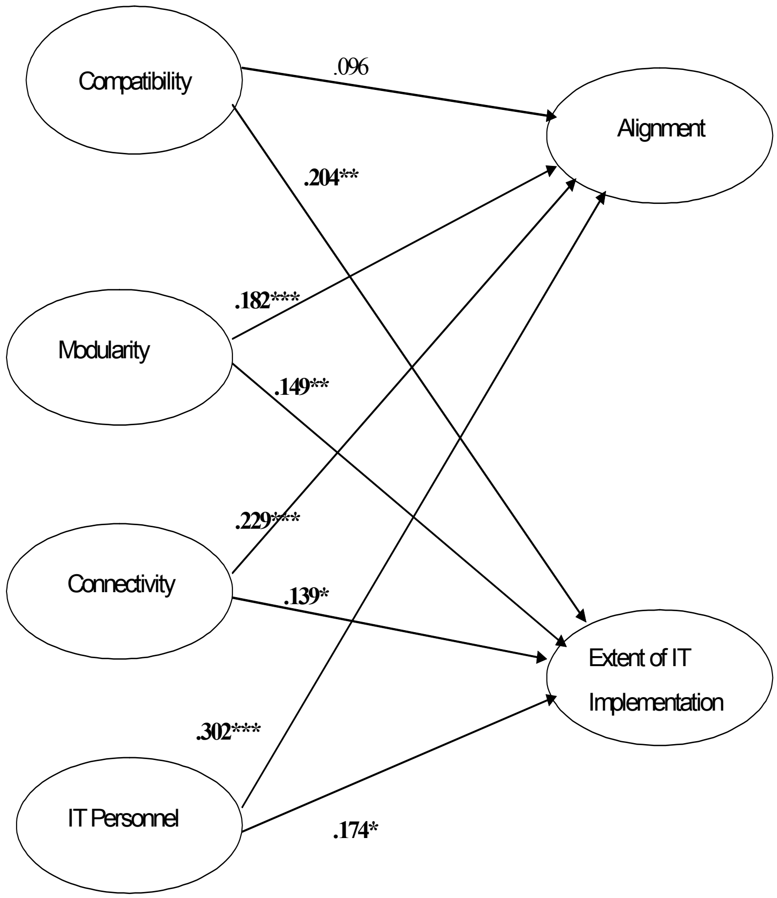
CONCEPTUAL MODEL

This study uses four previously identified measures of IT infrastructure flexibility: the technical components of modularity, compatibility, connectivity, and IT personnel skills [Duncan, 1995; Byrd & Turner, 2000]. The conceptual model representing the relationships addressed in this study is presented in Figure 1.

IV. RESEARCH METHODOLOGY

INSTRUMENT DEVELOPMENT

The survey instrument was derived in part from two studies [Lee, Trauth, and Farwell, 1995; Byrd and Turner, 2000], and is presented in Table 1. Each



* p<.05 ** p<.01 *** p<.001

Figure 1. Conceptual Model

construct is shown with its items. Respondents answered all items on 7-point Likert scales ranging from "1" meaning "not at all" to "7" meaning "to a great

Table 1. Factors And Items

Compatibility	1. To what extent does your IT department provide multiple interfaces or entry points (e.g., web access, EDI) for external suppliers and customers to share all kinds of information? 2. To what extent does your IT department offer a wide variety of information to end users (e.g., multimedia)? 3. To what extent does your IT department provide access to a large variety of data types, including text, voice, and graphics?
CONNECTIVITY	1. To what extent does your IT department have flexibility in its links and connections? 2. To what extent does your organization have electronic links and connections throughout the entire firm? 3. To what extent are end users in your organization electronically linked with other end users?
Modularity	1. To what extent are reusable software modules used in new systems development in your IT department? 2. To what extent do IT personnel use object-oriented and pre-packaged modular tools to create software applications? 3. To what extent can computer software modules easily be added to, modified, or removed from the existing IT infrastructure with minimal problems
IT Personnel	1. To what extent do IT personnel work effectively in cross-functional teams addressing business problems? 2. To what extent do IT personnel have the ability to work cooperatively in a project team environment? 3. To what extent are IT personnel skilled in multiple technologies and tools? 4. To what extent are IT personnel encouraged to learn new technologies?
Strategic Alignment[1]	1. To what extent is the IT department's strategic plan aligned with your organization's strategic plan? 2. To what extent do users participate in information technology planning? 3. To what extent are IT investments and expenditures aligned with your organization's business objectives and priorities? 4. To what extent is your IT department structure integrated into the organization structure?
Extent of Applications Implementation	To what extent has your organization implemented the following types of information systems? 1. Transaction processing systems 2. Management information systems 3. Decision support systems 4. Executive information systems 5. Expert systems 6. Data warehouse 7. Data mining 8. Interorganizational systems 9. Network management 10. Knowledge management 11. Disaster recovery

[1] As discussed in the literature review, strategic IT-business alignment involves many more enablers and inhibitors. However, the overall length of our survey instrument prevented the inclusion of all possible items

extent." For example, the extent of applications implementation reflects the mean of 11 observed variables representing 11 different types of applications (e.g., TPS, MIS, DSS, etc.).

After a series of pre-tests with MIS faculty and Ph.D students, a pilot test was conducted. The instrument was administered to seven members of a state Society for Information Management chapter in the U.S. and three Canadian CIOs. Respondents were asked to complete the questionnaire and offer any suggestions about the existing items as well as suggestions for items that should be added or deleted. All respondent comments to the pilot were incorporated into the final version of the instrument.

DATA COLLECTION

A mailing list of senior IT managers was compiled from the Directory of Top Computer Executives, published by Applied Computer Research in Phoenix, Arizona (www.acrhq.com). The study used proportionate stratified random sampling to select the sample. Proportionate stratified random sampling ensures that every population segment is proportionately represented, thus preventing the selection of extreme samples [Parasuraman, 1986].

The population was sorted by industry. Every fifth record was selected to generate the target respondent list that received the questionnaire. This sampling procedure produced a target of 800 senior IT executives (400 in the U. S. and 400 in Canada), stratified by industry.

The first mailing was sent to all target respondents. Each mailing included a cover letter that explained the purpose of the study, the questionnaire, and a postage-paid return envelope. As an encouragement to complete the questionnaire, respondents were offered a summary of the study results. A second mailing was sent to non-respondents four weeks after the first mailing.

As a check on non-response bias in the sample, the industry distribution reported on the returned questionnaires was compared to the industry distribution of the entire population. A Chi-square test of homogeneity determined that the industry distribution in the sample did not differ significantly from the industry distribution in the population [Daniel & Terrell, 1983].

Responses were received from 202 IT managers. Eleven responses were unusable, resulting in effective response rate of 24 percent. Respondents represented nine industries including banking, financial, government, health services, manufacturing, insurance, real estate, retail, and transportation. Ninety-nine (49%) of the respondents were CIOs or Vice-Presidents of IT, 88 (44%) of the respondents were upper-mid level IT managers, and 15 (7%) were IT professionals. Their average IT field experience was 21.1 years. The majority were from large companies, with 59.6 percent employing more than 1000 people and 45.7 percent reporting revenues in excess of one billion dollars.

V. DATA ANALYSIS AND RESULTS

The descriptive statistics of all the research constructs are shown in Table 2. In addition, Table 2 shows the Cronbach alphas for each of the research constructs.

Table 2: Descriptive Statistics

Research Constructs	**Mean**	**SD**	**Number of Items**	**Cronbach α**
Compatibility	4.76	1.20	3	.70
Modularity	4.08	1.30	3	.81
Connectivity	5.52	1.04	3	.78
IT personnel	5.28	.911	4	.83
Alignment	5.23	1.02	4	.82
Extent of applications implementation	2.87	1.02	11	.85

Structural equation modeling using the partial least squares (PLS) technique was used to test the research model and hypotheses. The PLS approach allows for the simultaneous assessment of the structural research model, as well as the measurement model underlying the research model. PLS uses partial least squares and estimates the relationships among latent variables and between latent variables and their indicators to reduce error variance. PLS is well-suited for analyzing exploratory models with little rigorous theory grounding and where explaining relationships among a set of constructs is desired [Fornell, 1987]. In addition, PLS requires minimal assumptions about the statistical distributions of data sets.

The purpose of our study was to assess the relationships among the IT infrastructure flexibility constructs and strategic IT-business alignment and the extent of applications implementation. PLS applies particularly well in examining the strength of such predictive relationships [Wold, 1986].

Therefore, PLS is suitable for our study and we used the PLSGRAPH software (version 3.0) for the data analysis. Table 3 presents the inter-correlations among the constructs. Table 4 shows the results of the structural model and Table 5 shows the results of the measurement model.

Table 3: Construct Intercorrelations and AVEs

	1	2	3	4	5	6
1. Compatibility	**.62**					
2. Modularity	.28	**.73**				
3. Connectivity	.36	.20	**.78**			
4. IT personnel	.50	.33	.45	**.65**		
5. Alignment	.38	.35	.43	.51	**.66**	
6. Extent of applications implementation	.38	.29	.30	.36	.25	**.42**

All correlations significant at $p<.01$

Table 4: Results of the Structural Model

Paths	Path coefficients	Standard error	T-statistic
Compatibility – align	.096	.08	1.20
Compatibility – extent	.204	.08	2.55
Modular – align	.182	.05	3.37
Modular – extent	.149	.05	2.98
Connect – align	.229	.07	3.27
Connect – extent	.139	.07	1.99
ITper – align	.302	.09	3.36
ITper – extent	.174	.09	1.93

Note: align = strategic business - IT alignment
extent = extent of applications implementation

We assessed unidimensionality using the factor loadings of items of their respective constructs. As seen in Table 5, all loadings (except transaction processing systems and network management) were above 0.55, the criterion value suggested by Falk and Miller [1992]. These loadings confirmed that 26 (out of 28) items loaded satisfactorily on their constructs. Although the loadings for transaction processing systems and network management were below 0.55, they were significant ($p<.001$), and were retained for data analysis.

We examined convergent validity by examining the average variance extracted (AVE) of each of the research constructs [see Fornell and Larcker, 1982]. The AVEs of all the constructs (except for extent of applications implementation) were above the suggested level of 0.50, implying that five of the constructs were responsible for more than 50 percent of the variance in their respective measurement items. The AVE for extent of applications implementation was

Table 5: Results of the Measurement Model

Constructs and Indicators	Loadings	Standard error	T-statistic
Compatibility			
Item 1	.756	.06	13.55
Item 2	.841	.03	30.30
Item 3	.764	.06	12.65
Modularity			
Item 1	.888	.02	53.28
Item 2	.866	.03	31.41
Item 3	.800	.05	17.63
Connectivity			
Item 1	.716	.04	16.29
Item 2	.908	.02	39.67
Item 3	.890	.02	36.87
IT Personnel			
Item 1	.812	.03	29.65
Item 2	.846	.03	31.73
Item 3	.807	.02	33.32
Item 4	.771	.03	25.62
Alignment			
Item 1	.867	.02	37.37
Item 2	.781	.04	20.30
Item 3	.870	.01	64.71
Item 4	.715	.05	14.18
Extent of implementation			
Transaction Processing System	.287	.09	3.04
Management Information System	.650	.05	12.43
Decision Support System	.690	.04	18.91
Executive Information System	.621	.05	11.31
Expert System	.554	.05	10.24
Data Warehouse	.710	.05	14.49
Data Mining	.695	.05	17.30
Interorganizational Systems	.568	.04	11.93
Knowledge Management	.666	.05	16.08
Network Management	.489	.08	6.12
Disaster Recovery	.636	.07	7.34

0.42. In addition to the AVEs, the Cronbach alphas (Table 2), all greater than 0.70, confirmed the reliability of the constructs [see Nunnally, 1978].

For acceptable discriminant validity, the shared variance between any two constructs should be less than the AVEs extracted by the items measuring the constructs. Table 3 shows that the shared variances are all less than the corresponding AVEs, suggesting that the constructs exhibit discriminant validity.

PLS, being a nonparametric estimation procedure, does not offer significance tests based on statistical distributions. The bootstrapping approach was used to produce estimates of parameters, standard errors, and t-values [Mooney & Duval, 1993]. We used the bootstrapping approach to generate 250 random samples of observations from the original data set, by sampling through replacement where each sample size is similar to the number of cases in the original data set. The path coefficients, standard errors, and t-vales are shown in Table 4.

All path coefficients are significant, except the one between compatibility and strategic alignment. The R-squared value for the strategic alignment construct is 0.356, meaning that the IT infrastructure flexibility constructs account for 35.6 percent of the variance in alignment. Similarly, the R-squared value for the extent of applications implementation construct is 0.217, meaning that the IT infrastructure flexibility constructs account for 21.7 percent of the variance in the extent of applications implementation.

Hypothesis 1, relating each dimension of IT infrastructure flexibility and strategic IT-business alignment, was supported for modularity, connectivity, and IT personnel, but not for compatibility. Hypothesis 2, relating each dimension of IT infrastructure flexibility, and the extent of applications implementation, was supported for all four dimensions.

VI. DISCUSSION

Three components of IT infrastructure flexibility (connectivity, modularity, and IT personnel) impact strategic IT-business alignment significantly and positively. That is, these three components contribute to strategic alignment. A major characteristic of modern business environments is rapidly changing conditions. Therefore, organizations themselves must be adaptable to respond effectively to these conditions.

For IT infrastructures to be able to facilitate organizational responses to dynamic environments, the IT strategy must be tightly aligned with the organizational strategy. This close alignment means that IT infrastructures must also be flexible..

Connectivity means that every person, every functional area, and every application in the organization are linked to one another. As a result, communications throughout the organization are enhanced, and users can share information rapidly across organizational boundaries. This sharing enables rapid response to necessary changes in the firm's strategy, thus increasing strategic alignment.

Modularity is the ability to build or modify business applications quickly to meet new business conditions. For example, modularized middleware provides interoperability among various applications (particularly between legacy applications and newer applications) across an enterprise. A high degree of modularity means greater speed in developing new applications or modifying existing applications. As with connectivity, this speed will enable rapid response to changes in organizational strategy, thus increasing strategic alignment.

IT personnel are skilled at working cooperatively in cross-functional teams using many technologies. Consequently, they facilitate boundary spanning and help the organization react to changes in its environment. In addition, IT personnel provide the necessary connectivity and modularity that enable rapid organizational response to changes. They also may be members of strategy teams whose mission it is to formulate IT strategy in accordance with organizational strategy. In these ways, IT personnel contribute to strategic alignment.

An interesting finding was that compatibility did not have a significant impact on strategic IT-business alignment. Compatibility is the ability to share any type of data or information across an organization or between organizations along the supply chain. The items comprising the compatibility construct refer to technical aspects of IT, and respondents may have considered this construct as more technical and not particularly related to the business context of strategic alignment.

All four components of IT infrastructure flexibility impact the extent of applications implementation in an organization significantly and positively. *Compatibility.* Open systems such as PC-based plug-and-play platforms, Common Object Request Broker Architecture (CORBA), Web Services (e.g., Microsoft .NET), and Extensible Markup Language (XML) were introduced to enhance the compatibility of differing applications and platforms. Firms may benefit from a number of open systems components when new applications are implemented. Chau and Tam [1997] stated that open systems represent an approach to implement a suite of interface standards between software/hardware and communications systems for compatibility purposes. Therefore, compatibility facilitates the extent of applications implementation.

*Connectivity.*The concept of connecting all users, functional areas, and applications within and across organizations to enable seamless sharing of information impacts the extent of applications implementation. The information shared by users is provided by the organization's various applications and these applications are much less valuable (as we have observed historically) if they are constructed and used as "silos." Therefore, our findings suggest that connectivity plays a role in the extent of applications implementation.

Modularity. Modularity gives organizations the ability to quickly build new applications and modify existing applications more quickly and easily than ever before. Modularity is based on the concept that software applications are more manageable when required routines are processed in separate modules. For example, modularized middleware can be used to achieve interoperability between different components or applications. Enterprise Java Beans can provide reusable modules to manage interfaces among applications.

Highly-skilled IT personnel are the essential ingredient of applications implementation. These professionals know the firm's set of IT resources and of other technologies in the firm's external environment [Duncan, 1995]. IT professionals' also have knowledge of the firm's business processes to be able to facilitate business strategies with new and existing applications.

VII. CONCLUSIONS

IT infrastructure is important for almost all business functions and business processes within an organization. The organization's IT infrastructure primarily deals with the integration of technology components to support business needs. The organization's competitiveness depends on the flexibility of the IT infrastructure, because the infrastructure allows the company to develop new processes and applications quickly. The speed with which an organization can implement those processes and applications improves its competitiveness in the market.

The results of our study show that the components of IT infrastructure flexibility impact strategic IT-business alignment and the extent of applications implementation in the organization. That is, IT infrastructure flexibility enables an organization to more closely link its IT strategy to the organization's strategy. This alignment is critical because it allows an organization to respond more quickly to dynamic business environments. We note that IT infrastructure flexibility does not facilitate strategic IT-business alignment by itself, but rather as one component in the presence of other components, such as interpersonal communications, IT governance, demonstrating IT value, and IT-business partnership.

IT infrastructure flexibility also enables an organization to develop new applications and modify existing applications more quickly and easily. Again, such rapid development and modification helps the organization react to changing business conditions. The findings of our study, therefore, suggest that a flexible IT infrastructure is a key to an organization's sustainable competitive advantage.

LIMITATIONS

Our study has one notable limitation. We use single-source data for each organization, where multiple sources of data (e.g., matched responses to the survey from each firm) would be preferable. Ideally, these matched responses would be from senior-level business managers and senior-level IT managers. Our study does not include responses from senior-level business managers. However, we feel that our respondents have the experience and position in their companies to address the strategic questions in our survey.

FUTURE RESEARCH

An interesting direction for future research would be to examine the recursive relationship between alignment and the extent of applications implementation and IT infrastructure flexibility; i.e., to examine the impact that alignment and the extent of applications implementation have on the four components of IT infrastructure flexibility. Another direction for further study would be to examine the impact of IT infrastructure flexibility on the extent of implementation of other IT initiatives, such as enterprise resource planning systems, business-to-business and business-toconsumer electronic commerce systems, sales force automation systems, and customer relationship management systems.

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