Global Information Technology Architectures

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Changes in the environment of international business and advances in information technologies have limited the usefulness of existing information systems paradigms. Consequently, there is a paucity of both conceptual and empirical research focusing on information technology systems in a global context. In response, the overall goal of this paper is to develop a uniquely broad perspective on global information systems by establishing the concept of a global information technology architecture. Although the concept of an information technology architecture has existed for some time now, this study is among the first to move beyond anecdotes to embrace statistical testing and validation of a finite number of architectural types that may serve as a surrogate for capturing overall information technology capabilities. It is hoped that a parsimonious, architectural modeling of international information technology capabilities can serve as a map to guide and document the information systems decisions for globally competing organizations.

Overview of Global Information Technology

Until recently, information systems research has been conducted with inadequate consideration of the global environment. Some anecdotal and case study evidence has surfaced concerning the role of information systems in global firms (e.g., Freedman 1985, Carlyle 1988, Pantages 1989, Davenport et al. 1989, Reck 1991, Roche 1992), but few rigorous empirical investigations have been conducted. Both the international business and the strategic management disciplines have tended to ignore information systems issues and, as Neo (1991) observed, the literature from the information systems field on the role of information technology has implicitly or explicitly focused on competition in a domestic industry. A limiting factor in previous efforts to conduct global information technology research had been the absence of a conceptual model of sufficient scope and abstraction to tie together the various schools of thought and their research.

A decade ago, Buss (1982) concisely defined a global information system as a distributed data-processing system that crossed national boundaries—suggesting that components of systems developed for the domestic needs of American firms could be subsequently forced, unchanged, upon foreign subsidiaries. More recently however, Karimi & Konsynski (1991) stressed the overly simplistic nature of this definition by demonstrating that crossing national boundaries creates wide variations in business environments, resource availability, and regulatory constraints. Increasingly, published warnings (e.g., Roberts and Hickling 1989, Hopper 1990) have appeared suggesting that the global information systems community must change existing systems

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to comply with overall corporate goals within the context of a single world market.

For the purposes of this study, the task of relating information technology to international concerns was made tractable by accepting Mandell's (1975) premise that foreign subsidiaries constitute a basic building block of the organizational structure of a global firm, and his related assertion that it was therefore appropriate for researchers to focus on the interface between headquarters and foreign subsidiaries to determine the nature of international information systems. Mandell and Grubb (1979) conducted an empirical study of American multinational firms to determine the nature of the headquarters-subsidiary information systems relationship. Their results suggested that the development of an integrated worldwide system was dependent on the overall size of the parent firm, its industry, and the nature of the foreign firm's extent of internationalization. The focus of this study was limited to the headquarters-subsidiary dyad as the unit of analysis. Thus, it was possible to alleviate confounding concerns related to organization size and the complexity resulting from the occurrence of a variety of information systems within a single firm. This approach was supported by Håkansson & Snehota's (1989) endorsement of a dyadic research approach that was based on their observation that organizations often operate in business environments that could be fully characterized by a limited number of interrelated, identifiable entities.

An Architectural Approach

In separate publications, Fertuck (1992) and Best (1990) each differentiated between the information technology architect as a designer with concerns for effectiveness and the software engineer as a builder with concerns for efficiency. Clearly, the architect's definition of overall scope, specific frameworks and logical structure must precede the physical programming tasks in the development of an information system. This suggests that the achievement of an overall integrated structure for the information system is better understood by an architectural analogy than an engineering analogy. In like manner, Allen and Boynton (1991) reported that their research, case writing and consulting experiences illustrated the importance of the information systems architecture for globally competing firms.

The adoption of an architectural approach to information systems development has been recognized by several researchers (e.g., Brancheau & Wetherbe 1987, Latham 1990, Keen 1991, Moran 1992) as a key issue for information systems researchers during the next decade. In fact, Zachman (1987) contended that the increasing size and complexity of information technology implementations required that some logical construct be used for defining and controlling the interfaces and integration of the system components. Further, he suggested that the construct of an information technology architecture naturally emerged for the creation of such a descriptive framework. However, the search for a useful definition of an information technology architecture revealed not one, but several. Not surprisingly, there were nearly as many different definitions as there were studies of the topic. The popular use and frequent misuse of the term "architecture" have produced much ambiguity in the information systems research literature.

Sullivan (1982) suggested that an information systems architecture emerged slowly over time as organizations committed to some level of integration with an appropriate mix of form and context. As such, firms choose to concentrate, consecutively, on one of the information systems components: processing, data storage, communications or applications. Subsequent researchers chose to structure their approaches by targeting only one of these four components. Mano (1982), Ein-Dor & Segev (1982), and Aken (1989) defined the architecture strictly in terms of computing. Langefors & Sundgren (1975), Spencer (1985), Inmon (1989), and Meador (1990) focused on the data architecture. Barrett & Konsynski (1982) and Ahuja (1988) chose communications to define the architecture. Finally, Venkatraman (1991) and Keen (1991) defined the architecture in terms of applications.

More recently and perhaps most usefully, Karimi & Konsynski (1991) defined the corporate information systems architecture for a global firm as a high-level map of the information and technology requirements of the entire firm, composed of network, data, application and technology sub-architectures. This study extended their definition to incorporate planning, organization, and control techniques that Earl (1989) suggested would enable a complete information technology architecture to serve as a proactive forum for worldwide interaction.

Table 1 portrays six existing conceptual frameworks for information technology architecture classification that served to clarify and to justify this research framework for international information technology architectural capabilities.

By comparing these six frameworks, widespread support was found for describing information technology architectures by physical and logical component parts or elements. Also, compelling reasons emerged for

Sullivan (1982)	Processing-oriented	Data-oriented	Workstation-oriented	Integration-oriented	
Earl (1989)	Delayed	Dependent	Drive	Delivery	
Sankar, Apte & Palvia (1993)	1	2	3	4	5
Allen & Boynton (1991)	Low Road	Hybrid		High Road	
Madnick (1991)	Minimal	Partial	Full Mainframe	Full Distributed	
Roche (1992)	Centralized	Independent	Duplicated	Cooperative	

Table 1: Comparative Summary of Six Architectural Frameworks

conceptualization of the global information systems capabilities using a range of three to five generic architectures. However, there was less agreement on how these components could be described or measured to arrive at a finite number of types of information technology architectures. Although there was support in the literature for including business functions and contextual requirements in the architecture description, there was no guidance as to how the proposed synergy should be incorporated. This absence of consensus was considered typical of efforts at taxonomy construction in an emerging research area. By examining the various ways in which information technology architectures have been defined in the above research frameworks, it was possible to argue for a finite number of generic architectural descriptions.

The following sections highlight the research literature references that were used to develop stipulative definitions of the seven information technology architecture elements selected to facilitate measurement of the international information technology architecture construct.

Computing Compatibility. Senn (1992) contended that multinational firms were increasing their emphasis on uniformity through common computer systems in order to increase the compatibility required for global interoperability. Comparably, Roche (1992) asserted that preliminary measurements of the global distribution of the information technology infrastructure indicated that regardless of their strategy, multinationals tended to keep the bulk of their data processing capability in their home country—suggesting a high degree of centralization and associated compatibility of the computing hardware and operating system software. King and Sethi (1992) contended that this element could be appraised by degree (very low--very high) of compatibility, a measure that directly corresponded to Mandell's (1975) interest in the number of common systems. Steinbart and Nath's (1992) measured compatibility by establishing the existence of worldwide hardware standards manuals.

Data Transparency. Operationalization of the data element in this study was by degree of transparency--a measure of the ability of the distributed database management system to support access and retrieval of data that Ceri and Pelagatti (1984) suggested as an extension of the common notion of data independence. On the premise that the relative importance of data interchange would be reflected in increased data transparency, electronic data sharing was measured by adapting Sullivan's (1988) assessment of the importance of data exchange between headquarters and subsidiaries. Questions concerning headquarters access to subsidiary data and data structure standardization were adapted from Egelhoff's (1988) study of headquarters-subsidiary data integration. Goodhue et al. (1988) discovered that an alarming majority of firms focused data management efforts on a limited set of data files serving only a portion of the firm and served as the source for questions about replicated data, database control and data purpose.

Communications Connectivity. Madnick (1991) suggested that newly emerging, enhanced information technology architectures provided opportunities for the increased connectivity demanded by the forces of globalization. Egelhoff's (1992) discussion of routineness and interdependency formed the basis for questions on routineness of communication and associated directionality. These were Gutman-like scales in consideration of the somewhat obvious reality that a communications medium capable of supporting non-routine and/or reciprocal transmission could easily provide routine, sequential support as well. Madnick (1991) suggested several questions to capture the information technology communications platform features and these were combined to form an assessment of communication technologies.

Data transmission frequency and data transmission volume questions mirrored Steinbart and Nath's (1992) communication frequency and volume measures of data transmission in the international environment.

Applications Functionality. Roche (1992) explained that understanding the global distribution of applications was a very different issue than understanding global infrastructures. Applications were easily distributed through communication networks, but this did not guarantee their functional use. Li and Rogers (1991) considered the extent of practical business applications that a firm could utilize, ranging from simple cost reduction to competitive weapons. Runge (1988) conducted a study in which motivation for new applications could be measured. Questions about applications development and migration of subsidiary applications to headquarters were modifications of Selig's (1983) queries concerning whether software packages developed at headquarters were implemented by foreign subsidiaries. Best practices applications and joint application development questions were distilled from Ives and Jarvenpaa (1991).

Information Technology Planning. Several researchers have examined long range information technology planning. Mandell (1975) questioned the existence of formal, long range information technology plans for worldwide operations. Trippi and Salameh (1989) suggested scaled components for measuring information technology planning and decisions. Madnick (1991) contented that a flexible information technology architecture supported both reactive and proactive information technology planning. Selig (1983) questioned information systems planning issues such as planning horizon length, integration with business plans, and reasons for conducting planning. The strategic impact of information technology was measured by a modification of Deans' (1989) use of a seven-point scale ranging from extremely low to extremely high. Information technology objectives were measured like Lederer and Sethi (1991), who combined the findings of prior studies to develop a five-point scale for planning methodology assessment on issues of objectives, new project identification, overall hardware plans and planning horizons.

Information Technology Organization. Karimi and Konsynski (1991) used an oblique method for describing the continuum from decentralized to centralized extremes of information technology structural reporting. Sung (1988) questioned the contention that the complexities of international operation forced an increase in the sophistication of global information technology systems themselves and also required a corresponding increase in the degree of subsidiary autonomy. In like manner, Selig (1982) suggested that the complexities of international operation force a higher degree of decentralization. Henderson & Venktraman (1989) defined the organization of the information technology function as the degree of centralization of a particular internal arrangement of roles and resources.

Information Technology Control. Li & Rogers (1991) depicted headquarters control using measures of formality and issues such as pricing of services. Ives and Jarvenpaa (1991) suggested that information technology control may range from independent to integrated. Doz & Prahalad (1981) observed that as foreign subsidiaries mature they became autonomous with regard to resources controlled by headquarters. Selig (1983) open-endedly asked how firms monitored global information technology activities and also asked for a closed-end rating along a continuum from strongly centralized control to total autonomy.

Thus, the stipulative definition used in this study considered the international information technology architecture as a high-level map of the information and telecommunications technological capabilities of the firm as a global entity, composed of four physical elements of computing compatibility, data transparency, communications connectivity and applications functionality, and inclusive of three logical elements of planning, organizing and control. By combining the key characteristics of the architecture element descriptions derived from the extant literature it was possible to arrive at a composite representation scheme, parsimoniously reiterated in Table 2, to operationalize the elements of four generic architectural types. This concept of generic architecture types came from Targowski's (1990) premise that a finite number of architectures exist that could be described by an elementary definition of major components, which cannot be reduced to a more primitive level of description.

Although a full combinatorial approach using only three (low, moderate and high) labels for the relative capabilities of the seven elements would yield more than four architectural types, the justification for using a restricted number of chosen types clearly emerged from a careful study of the relevant literature. Prior studies, e.g., Sankar, Apte and Palvia (1993), invariably sought to focus on a limited number of feasible and optimal arrangements rather than all possible combinations. The overlapping reference literature characterization of three of the four architectures—Types I, III and IV—created the expectation of values ranging from low to moderate to high for levels of the seven elements. Conversely,

Element	Type I	Type II	Type III	Type IV
Computing Compatibility	Large headquarters systems incompatible with subsidiaries	Locally tailored, cooperative systems	Self-reliant, compatible functional unit systems	Fully compatible, integrated systems
Data Transparency	Low sharing of isolated data	Specialized Databases	Multiple local data systems, some sharing	Continuously shared, highly transparent data
Communication Connectivity	Very low frequency and volume of routine data transmission	Low volume of routine and non-routine data transmission	Moderate frequency and volume of routine data transmission	High frequency and volume of both routine and non-routine data transmission
Applications Functionality	Local, cost reduction applications	Innovative Applications	A few common functional area applications	Sharing of best practices applications
Information Technology Planning	Efficiency goals, non-strategic planning	Value maximization objectives	Resource-based planning	Integrated information technology and strategic planning
Information Technology Organization	Back room, no formal reporting	Middle Management Level	Functional business unit	Complex, hybrid
Information Technology Control	Tight control of subsidiary information technology	Headquarters support but local control by subsidiary	Headquarters-imposed budgetary control	Shared responsibility and control

Table 2: Comparison of Generic Architecture Types

there was little consensus, and several contradictions in the reference literature characterization of the Type II architecture. Ultimately it was decided that the Type II architecture could be distinctly characterized by its logical elements. Using major points of agreement in the literature, the capabilities of the four generic architecture types are summarized in next sections.

Type I Architecture Capabilities. Low levels of computing compatibility, data transparency, communications connectivity and applications functionality characterize the physical elements of the Type I architecture. Egelhoff (1992) contended that the resulting, limited information processing capabilities were appropriate only for transmission of financial data and for decisions such as a routine price change on an existing product to a foreign marketing subsidiary. In terms of the logical architectural elements, the planned objectives center on measurable financial benefits. Information technology has no strategic impact because related opportunities or threats are not yet perceived. Organization is by a backroom department, not formally noticed by higher level managers.

Type II Architecture Capabilities. The lack of agreement in the research literature required characterization of the Type II architecture primarily by its logical elements. The elevated status and influence of information technology planning, organization and control mirror the perceived importance of information technology to the firm's current and future business. Allen and Boynton (1991) explained that such an architectural arrangement was capable of serving as a catalyst for change. Firms attempt to reorient information systems to the pursuit of innovation, which results in several global systems co-existing, each tailored to local language and other regional needs. The information technology function is organized on a par with other business functions.

Type III Architecture Capabilities. This architecture type reflects the dependence of a foreign subsidiary on stable and reliable automation, processing and communications capabilities. Earl (1989) suggested that under these conditions technology solutions are pragmatic and follow *de facto* industry standards. The predominant requirement is for reliability, which makes technological risks inappropriate. Consequently, moderate levels are expected for the physical and logical elements of this architecture.

Type IV Architecture Capabilities. With information technology embedded in a core business activity, such as a foreign manufacturing subsidiary, a firm can be classified in McFarlan's (1984) strategic quadrant and can be expected to seek information technology opportunities to achieve the flexibility needed to adapt to new, dynamic environments. Thus, the information technology architecture, by definition, must be integrated with business plans. Traditional, tidy responsibility and authority give way to hybrid arrangements, with high subsidiary autonomy designed to drive and develop integrated information systems. In an effort to limit associated technological confusion, these organizations elevate information technology to top managerial levels in the organization. Adopting a “best practices” approach, ideal applications are identified and reengineered using automated development methodologies for worldwide adoption.

Research Method

Adapting the steps developed by Kerlinger (1964), a multi-step process for questionnaire development was utilized in order to maximize the reliability and validity of the results. As Step 1, stipulative and operational specification of the domain of the architecture construct preceded any attempt to develop survey questions. For Step 2, the existing literature was reviewed on the premise, supported by Lucas (1991), that concerns about data validity could be substantially reduced by the use of survey questions that were previously judged as valid. The literature review provided a source for potential questionnaire items and scales, as well as methodological treatments from related research efforts. These pre-existing questionnaire scales were modified to improve their international incisiveness. Several questionnaire items were developed for each of the seven architectural elements in order to conform to Venkatraman and Grant’s (1986) contention that multi-item measures are needed in order to examine within-group differences.

Finally, for Step 3, pretests of the survey instrument were conducted by use of a prototype questionnaire that was provided to eight information technology executives. These executives were asked to evaluate the questionnaire wording in terms of comprehension and content validity. The pretest measures provided both refinement of the questionnaire items and confirmation of content validity.

The survey was distributed by mail to a sample of firms selected by cross-referencing the World Trade Academy Press *Directory of American Firms Operating in Foreign Countries* with the *InformationWeek* list of the five hundred American firms considered to be the largest and best users of information technology. The survey questionnaire was initially mailed to an identified senior information technology executive for two hundred and seventy two American firms. It was expected that firms would have many subsidiaries, each with unique strategic roles and corresponding information technology resources. In consideration of this, and to maximize variability in responses, each survey participant was instructed to consider two typical foreign subsidiaries with information technology linkages to corporate headquarters that differed from one another in their strategic role, information technology sophistication and/or geographic location. The final response rate was nearly 23%.

Data Analysis

The central idea in the analysis of the survey data was to examine whether the seven elements of the information technology architecture construct captured distinct, generic architectural forms. In addition to the descriptive statistics and measures of association commonly associated with survey research, multivariate techniques were adopted as extensions of univariate and bivariate analysis because Hair et al. (1992) reported that researchers should use several variables as indicators to provide a better perspective on the differing facets of complex phenomena. Two pertinent, inferential multivariate techniques were utilized: cluster analysis and multiple discriminant analysis.

Cluster Analysis

Cluster analysis was selected for developing meaningful, mutually exclusive groups based on similarities among entities because it remains the dominant technique for taxonomic inquiries such as this. As a data reduction procedure, this technique objectively fashioned a concise, understandable description of the observations with minimal loss of information. As a first step, an agglomeration method was used to calculate the Euclidian distance between the two most dissimilar points of the clusters being combined at each stage. Small coefficients indicate that fairly homogeneous clusters are still undergoing the process of being merged. Large coefficients indicate that clusters contain quite dissimilar members. Thus, the coefficients served as a guide in deciding how many clusters are needed to represent the data. Hair et al. (1992) asserted that since cluster analysis is so sensitive to outliers--observations with substantial differences between actual and estimated values--that such observations may be discounted or even eliminated from the analysis as unrepresentative. Favorably, a specific empirical test to identify outliers in the research sample proved statistically insignificant. Cluster analysis validation was accomplished by a second, non-hierarchical analysis using the cluster centroids (group means) as seed values.

Jarillo and Martínez (1990) performed cluster analy-

	COMP	DATA	COMM	APPL	PLAN	ORGN	CONT
Between Group Mean Squares	8.32	11.75	6.8	16.8	16.1	13.2	4.6
Within Group Mean Squares	0.62	0.60	0.68	0.46	0.33	0.56	0.76
F ratio	13.2*	19.5*	10.1*	36.2*	48.0*	23.4*	6.0*

Significance of *F* * p <.001

Table 3: Cluster Characteristics--within group and between group mean square variance and *F*-ratio

Architectural Element	Type I	Type II	Type III	Type IV
COMP	1.83	2.32	3.70	4.48
DATA	1.82	1.69	2.38	3.40
COMM	1.91	2.02	2.80	3.99
APPL	1.41	2.27	2.17	3.32
PLAN	1.71	4.05	2.69	4.08
ORGN	1.47	2.88	2.57	3.12
CONT	1.93	2.39	2.43	3.28

Table 4: Elemental Mean Values Across Architectural Types

sis in order to classify the subsidiary strategies of fifty Spanish multinational manufacturing firms into three generic strategies. Following their approach, the survey results for this study presented in Table 3 showed a very good, highly significant clustering of the data into four information technology architecture types with variance among the elements *between* each type far greater than variance *within* each type. The seven architectural elements were treated as latent constructs and their corresponding operational labels were: computing compatibility (COMP), data transparency (DATA), communications connectivity (COMM), applications functionality (APPL), planning (PLAN), organization (ORGN) and control (CONT).

These results support the initial conjecture regarding the generic architecture types. As shown in Table 4, a cluster grouping clearly emerged with low values (1.41 to 1.93) for all seven elements with relatively low variability. A total of nineteen foreign subsidiaries were grouped as Type I architectures based on these values. A second cluster grouping emerged with a high value for planning and moderate values for organizing and controlling and with low to moderate values for the physical elements. Eleven subsidiaries were grouped as Type II architectures based on these values. A third cluster grouping emerged with moderate values (2.17 to 2.80) for six of the seven elements. The seventh element, COMP, was still moderate at a value of 3.7, but was relatively higher than the other elements. A total of sixty-three subsidiaries were grouped as Type III architectures based on these values, thus forming the largest single grouping. Finally, a cluster grouping emerged with moderate to high values for all seven elements. A total of twenty subsidiaries were grouped as Type IV architectures based on these values.

Discriminant Analysis

Multiple discriminant analysis was used to examine the differences in architecture types and to predict the likelihood that a subsidiary architecture would belong to a particular type based on the observed values of the seven architectural elements. Egelhoff (1988) utilized discriminant analysis to test how well multinational firms achieved a simultaneous fit between structure and strategy. Hair et al. (1992) suggested that if the total sample could be divided into groups based on a variable that was multichotomous then multiple discriminant analysis was appropriate and useful to explain group differences and to predict the likelihood that an entity belonged to a particular group.

As seen in Table 5, all seven elements had sufficient discriminating power to enter and remain in the function, and all three discriminant functions were significant based on Wilks' Lambda, which is the ratio of within-group sum of squares to the total sum of squares. Hair et al. (1992) suggest ignoring the sign, which denotes

Architecture Elements	Discriminant Functions 1	2	3
COMP	.54752*	.50959	.39862
DATA	.38083	.25147	-.60962*
COMM	.39077	.21837	-.39833*
APPL	.55817*	-.15434	-.34283
PLAN	.50579	-.68938*	.12896
ORGN	.38531	-.18782	.57749*
CONT	.28080*	.09880	-.21273
Canonical Correlation	.9175	.7403	.4624
Wilks' Lambda	.0562	.3553	.7862
Significance * p < .001			

Table 5: Discriminant Analysis of Architecture Elements

whether the variable makes a positive or a negative contribution, and focusing instead on the magnitude of the standardized discriminant weight. Given that the primary interest was on the contribution of the variables, interpretation of the discriminant loadings was done without regard for sign.

A complete understanding of the discriminant analysis findings required consideration of both discriminant loadings in Table 5 and the centroids of the groups measured along the three discriminant functions shown in Table 6, which presents the results of a discriminant analysis application of Bayes' rule for estimating the probability that the subsidiaries were grouped correctly. For each architecture type the number of subsidiaries that would be classified as that type on the basis of the discriminant loadings was calculated.

Compared to the cluster analysis groupings discussed earlier, the discriminant model predicted identical information technology architecture type classifications for 96% of the subsidiaries. More importantly, the standardized discriminant coefficients indicated the relative contribution of each of the seven architectural elements to the discriminant function. Table 5 showed that the first discriminant function primarily measured COMP, APPL and CONT and Table 6 showed that this first discriminant function was the best at discriminating among all four architecture types. Similarly, the second discriminant function, based on PLAN, uniquely discriminated Type II architectures from the other three types—thus supporting the initial premise that the logical elements best characterize Type II architectures. This fundamental uniqueness that materialized regarding Type II architectures parallels its characterization within the reference literature. The varied descriptions corresponding to the Type II architecture included labels such as: workstation-oriented, intellectual synergy, reactive and duplicated. Thus, not unexpectedly, the empirical results showed that the Type II architecture does not manifest itself as clearly as the other types.

Finally, the third discriminant function, predominantly measured DATA, ORGN and COMM, but failed to distinguish among the architecture types. Wilks' lambda, calculated for all three discriminant functions, indicated that the first discriminant function had the highest total variability attributable to the differences in the architecture types, whereas, the third discriminant

Generic Type	Discriminant Analysis Predicted Number in Group	Cluster Analysis Actual Number in Group	Discriminant Function 1	2	3
I	20	19	-3.48127	-.17459	.64091
II	13	11	- .61619	3.09619	-.38225
III	59	63	.143756	-.62103	-.37757
IV	21	20	3.76787	.19744	.65708

Table 6: Discriminant Analysis of Architecture Types

function remained far enough from a value of 1 that would have suggested no difference in architecture types. Nevertheless, the inclusion of all seven elements in the discriminant function at statistically significant levels supported the contention that the complexities of international operation force a consideration of all seven elements as dimensions for the international information technology architecture.

Limitations of this Research

Restriction of this study to the American headquarters-foreign subsidiary dyad of firms recognized as leaders in information technology use was undoubtedly convenience sampling. Of course, a limitation of this sample choice is the imprudence of extending these findings to firms with different corporate nationalities. Other significant, self-limiting, methodological choices directly affected the generalizability of the findings. The focus on information technology rather than information systems omits all consideration of human resources and related issues. Of course, attempts to overcome these limitations provide opportunities for future research.

The most obvious and natural extension of this work is a study of foreign headquartered firms with American subsidiaries. Presently, it is unclear whether the highly sophisticated and unregulated nature of the computer and telecommunications industries in America will be the primary determinant of architecture choices, or whether foreign management policy and practice will be the controlling determinant. In like manner, given the established differences in domestic and international information systems, it may be interesting to apply this survey questionnaire in an examination of the domestic information technology architectures of American firms. Furthermore, for completeness and for comparison, the information technology architectures of American firms that are not globally competing organizations (e.g., utilities, railroads) should be examined.

A second natural extension is the examination of international information technology architectures for inter-subsidiary and inter-organizational structural arrangements. It would be interesting to see if the same four types emerge. Furthermore, it would be worthwhile to study the evolution of architectures longitudinally, over time. For example, it would be useful to establish whether firms are using the Type II architecture as an end goal or as a transitional architecture.

Conclusion

The findings of this study can be summarized as two pivotal findings worthy of further discussion. First, the literature review permitted the stipulation of a clear, concise, and complete definition of the global information technology architecture construct. Rigorous testing of this multi-dimensional, seven-element definition produced statistically significant results. Second, the seven elements of the information technology architecture construct captured four distinct information technology configurations—generic architectures. Overall, the reported mean values of the critical elemental dimensions varied among the architectural types in ways that were consistent with the extant conceptual rationale and scant empirical evidence. Moreover, within each of the four generic architecture types, certain elements appeared to overshadow others in the resulting classification. Using the most significant elements, it is possible to categorize operational units of international firms into four generic architectural types.

Mandell's (1975) pioneering empirical study of the parent-subsidiary interface for global information systems revealed a comparable total of four foreign subsidiary information technology configurations ranging from autonomous to fully integrated. Although this work parallels his finding of a finite number of information technology arrangements, the results challenge his use of data linkage, firm size and industry as the only critical determinants of information technology configuration. Similarly, Zachman (1987) used only three perspectives: data, applications process, and communications network. Given that the discriminant analysis findings suggested the least significance for data and communications elements, attempts to differentiate among this sample of subsidiaries on only these three dimensions, would have produced highly confounded results.

These results support Sankar, Apte & Palvia's (1993) contention that global firms seek to compensate for the negative impacts and reinforce the positive impacts of information technology architectural alternatives. Allen and Boynton (1991) suggested that architectural choices vary between low road (decentralized) and high road (centralized) extremes. This study's discovery of several firms that utilized Type I architectures supported their description of the low road architecture as natural, fast, innovative, and local group-oriented. Moreover, their proposed low road drawbacks--problems with integration and integrity--may explain the more frequent observance of higher order architectures.

Earl (1989) treated the information technology architecture as a technology framework in which information technology activities cannot be implemented, or even formulated unless properly planned, organized, and controlled. The observed significance of the information technology planning, organization and control elements in this study provides empirical support for his framework. For example, findings about Type IV architectures demonstrate the need for consistent information technology frameworks that share a common base (high computing compatibility), provide shared information (high data transparency), and facilitate transnational processing (high applications functionality).

In sum, while this study has replicated many findings from previous studies, several new findings have also emerged and been established. It was especially appealing to consider these results in light of the criticism of the information systems profession as too often developing systems that only reflected the *status quo* and thus failed to anticipate future requirements. The results of this study have highlighted the value of a broader focus for identification of both optimal and feasible information technology architectural choices. Rather than treating these four generic architectural types as linear growth stages, perhaps it is more useful to adopt a contingency perspective--one that suggests that a single distinct architectural type is most appropriate for a given situation. As the situational factors change, so to must the choice of architecture type.

These findings offer a useful framework for global information systems professionals to use in deciding whether they are proceeding on the right course or whether a steering action is needed. Even a cursory look at the practitioner literature reveals that a more flexible, enterprise-wide type of information technology architecture has been the focus of considerable attention by many leading-edge business organizations. Although many of the firms in this study continue to utilize Type III architectures to concentrate on specific applications, an enlightened few firms are adopting Type IV architectures. These firms have apparently realized that capturing the real benefits of global information technology requires the existence of an enterprise-wide, integrated, strategic information technology architecture.

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