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An International Empirical Examination of Technology Architecture[i] in the United States, United Kingdom, Taiwan and India

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Abstract

This study examines information technology architecture by replicating a North American survey in Taiwan, India and England and evaluates the impact of each nation's economic status on information technology architecture used by that nation's businesses. The results suggest that the original taxonomy of information technology architecture (centralized, decentralized, cooperative centralized, and cooperative distributed) is valid and unaffected by national economic status.

Introduction

International businesses have historically had to contend within almost insurmountable barriers of time and space. However, computer based information systems have altered the meaning of traditional communication and coordination. Advances in data storage, processing and telecommunications have created new opportunities for resource sharing and communication. The international availability of sophisticated information technology has made global opportunities possible and global competition inevitable. In turn, increased competition forces companies to further exploit the use of information technology. This relationship makes understanding the structure of information systems in a global environment a vital pursuit. The importance of this revolution has been recognized by senior information systems executives, whom have identified the planning and development of corporate information technology structure (architecture) as one of the key issues of international business (Watson, Kelly, Galliers & Brancheau 1997). This study addresses information technology architecture by replicating a North American survey in Taiwan, India and England. The paper will explore the validity of the earlier North American work and evaluate the impact of national economic status on information technology architecture.

Review of Information Technology Architecture

The high technology industry has continually provided the world with access to quantum improvements in technological efficiency and cost for the past thirty years. Any purchaser of hardware or software has felt that their state-of-the-art equipment was usurped before it could be installed. Most can clearly remember when they would have been satisfied with hard disk drive storage equal to their current RAM requirements or will soon be concerned that 10 gigabytes of storage can be exhausted in minutes with ADSL or coaxial modems. While computing capabilities have expanded beyond the most optimistic projections information technology can still be defined in terms of its basic functions of communication, processing and storage. The escalating rate of change of individual technologies has forced executives to focus on the relatively stable architecture instead of the underlying technologies.

Even as computing technology has changed considerably since the first vacuum tube based machines, the number of possible IT structures has increased gradually. The first computers were isolated processors that were accessed, either directly, or through the use of dumb terminals. This centralized computing was the mainstay information technology structure for over thirty years. As information technology became less expensive and more powerful in the late 1970's and early 1980s, end users gained control of some of their computer applications. Many firms found that there was a processing migration forming isolated islands of decentralized computing throughout their organizations. Enabled by improvements in the cost and performance of information technology, computer networks were developed that would allow direct interaction between the computing islands which enabled a distributed computing architecture in the late 1980s. The later advancement in computer based telecommunication, processing and the development of open nonproprietary equipment enabled the relatively recent creation of cooperative computing, which is reflected in terms, such as, client/server and peer-to-peer systems, which have emphasis on shared access to dispersed data and applications.

Based on nonsystematic observation, a variety of generally accepted architectural topologies have suggested these architectures (centralized, decentralized, distributed and cooperative). To empirically evaluate the appropriateness of these groupings, a 1996 North American study used statistical cluster analysis to produce an architectural taxonomy (Fiedler, Grover, Teng, 1996). The first step in empirically deriving a taxonomy is recognizing the dimensions of the architecture. The primary constituents are information technology and structure. Structure has been characterized, by the degree of centralization of processing and the pervasiveness of networking (Leifer, 1988; Ahituv, Numann, Zviran, 1989). The task is then to develop a framework in which to meld these two accepted perspectives, while capturing the more recent importance place on sharing application programs and data found in cooperative systems. From these observations they produced 3 dimensions which they used to derive a structural taxonomy using statistical cluster analysis (1.The extent that computer processing is centralized, 2. The degree that computers support communication, 3. The ability of computers to share data and application programs).

Evaluation

The North American study produced four distinct architectures. The first was characterized by highly centralized processing, low communication and low data and application sharing capabilities (**centralized computing**). The second classification had dispersed processing with low communication, data and application sharing capabilities (**decentralized computing**). The third classification has centralized processing, but high capabilities for communication, data and application sharing (**centralized cooperative computing**). It could be speculated that this architecture might be using mainframe computers as super servers. The last group is characterized by decentralized processing with high communication and sharing (**distributed cooperative computing**) and would be consistent with a classic peer-to-peer and client server environment (Fiedler et al, 1996). To evaluate the stability of this taxonomy the study will attempt to replicate these findings in various national settings.

While a myriad of national factors would have the potential to impact technology architecture, this paper will initially focus only on economic status. Architecture is enabled by the availability of information technology, it is therefore reasonable to assume that nations that had higher per-capita GNPs (US = $25,800 and UK = $17,980) would have greater access to more modern technology than lower per-capita GNPs (Taiwan = $12,070 and India = $1,360) (Watson et al.). It is anticipated that the UK and US will have relatively more cooperative systems than India and Taiwan.

Research Methodology

The original United States study sent a survey instrument to a sample of 900 U.S. IS executives in firms having revenue greater than $50 million. With 45 returned as undeliverable, a total of 313 completed responses were received yielding an effective response rate of 36.6%. The questionnaire was then mailed to 400 Indian IS Executives. 67 were returned as undeliverable, with a total of 106 surveys returned and a response rate of 32%. The survey instrument was also delivered to 800 English IS executives with 82 invalid addresses returned and an effective response rate of 14% with 101 surveys returned. The instrument was then translated into Chinese and sent to chief IS executives in the 900 largest firms in Taiwan. Eventually 319 questionnaires were received, resulting in a response rate of 35.4%.

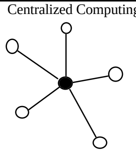
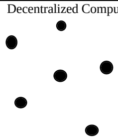
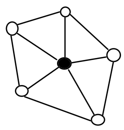
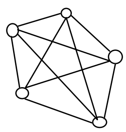
A test for non-response bias was conducted by comparing the early and late respondents' answers, and no significant difference was detected in the variables used in this presentation. The response rates were consistent in the United States, India and Taiwan which would allow increased confidence in comparability of samples. The United Kingdom's response rate was disappointing and may represent an increased opportunity for sample noise.

Validation Analysis

Cluster analysis was used to empirically derive the IT structural taxonomy for all four country samples. Each sample was subjected to a multiple step cluster analysis. Cluster analysis is a multivariate technique for identifying similar entities. The first step of the analysis was to determine the number of clusters using the Ward Method of hierarchical cluster analysis. All four samples showed evidence to support a 4 cluster model. Each of the groups' observed F statistic revealed differences significant at the 0.001 level. To gain further confidence in the chosen clusters, non-hierarchical cluster analysis, or K-means clustering, was used to recalculate group membership. The next section will further discuss the results of the study.

Results

The cluster analysis produced four IT structure types that were consistent with those produced in the original United States Study as shown in Table 1. The study showed that the economic status of the surveyed country did not seem to effect the relative number or percentage of organizations that had cooperative (either centralized cooperative or distributed cooperative) architectures. 56% of the US and 69% of the UK firms had cooperative systems which was similar to the 56% of Indian and 59% of the Taiwanese firms.

Table 1.						
Cluster	Processing Decentralization	Intercomputer Communication	Shared Data & Applications	Number Cases	Percent	Country
Centralized Computing 	Low (2.0)	Low (3.7)	Low (2.4)	82	27%	USA
	2.5	3.8	2.9	73	23%	Taiwan
	3.4	3.7	3.7	27	25%	India
	2.3	3.4	2.5	23	23%	UK
Decentralized Computing 	High (5.4)	Low (4.3)	Low (3.3)	53	17%	USA
	6.1	2.9	2.8	55	18%	Taiwan
	6.1	2.0	1.7	20	19%	India
	6.0	3.0	2.9	8	8%	UK
Centralized Cooperative 	Low (1.9)	High (5.7)	High (5.2)	105	34%	USA
	2.8	5.5	6.4	83	27%	Taiwan
	1.9	6.4	6.4	19	18%	India
	2.0	5.5	5.3	28	28%	UK
Distributed Cooperative 	High (4.9)	High (6.1)	High (5.7)	69	22%	USA
	6.4	5.5	5.4	104	32%	Taiwan
	5.9	5.8	5.4	40	38%	India
	5.6	6.0	5.2	42	42%	UK

Conclusions

The four groupings of the derived IT taxonomy appear to be exhaustive, mutually exclusive, stable and unrelated to national economic status. The groups consisted of *centralized computing* (centralized processing and low communication and sharing), *decentralized computing* (dispersed processing and low communication and sharing), distributed *cooperative computing* (dispersed processing and high communication and sharing), and *centralized cooperative computing* (centralized processing and high communication and sharing). These findings suggest that the architecture taxonomy may be a valid instrument for classifying information systems in diverse national environments. It should be noted that caution should be exercised in extrapolating from the UK sample (response rate was 14% compared to over 32% for the other countries). However, it is reasonable to assume that any increased noise associated with possible sampling inconsistency would tend to cause the UK sample to differ from the other countries samples instead of supporting them.

Great care should be taken in generalizing the finding that national economic status has little impact on technology architecture or implicitly technology access. The study focused on large relatively successful firms. Smaller more nationally average firms might have greater financial constraints. The results do suggest that large successful firms may have equal opportunity to develop their information technology architecture.

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