Measuring the impact of global information technology applications

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Abstract:
The objective of this study is to develop a means of assessing the impact of global information technology applications. Building on the prior work of Pal via (1997), Sethi and King (1994) and Mahmood and Soon (1991) a multi-factor global IT impact measurement model is developed. This model exhibits a high degree of reliability and validity. From a theoretical perspective, this study develops a measurement model that can be used to evaluate the impact of IT in a global environment. From a practitioner's point of view, the study provides a better understanding of the factors that should be considered when assessing the impact of global IT applications.
Keywords: information technology; global information technology; information technology impact; international global information technology impact; measurement of information technology impact.

Article:
1 Introduction
In recent years, the application of Information Technology (IT) to support and drive globalisation of business has received increased attention. IT provides the ability to coordinate the activities of globally dispersed employees, customers and suppliers; increase the efficiency and effectiveness of important organisational functions and processes; and manage data, information, and knowledge across borders. This study recommends a means of assessing the impact of Global Information Technology (GILT) applications. The multi-year window used in the study provides a long-term view of the subject.

Information technology is a broad domain that not only includes information and data processing but also voice, video and image applications and systems. For purposes of this study, information technology is defined to include all aspects of computing and communication including the hardware and software for: management information systems, office support, transaction processing systems, decision support systems, executive information systems, telecommunication networks, internet, multimedia applications, databases, and data warehouses. Information technology provides the means for the preparation, collection, transport, retrieval, storage, access, presentation, and transformation of information in all forms (voice, graphics, text, video, and image) (Boar. 1994).

Global information technology (GIT) applications are defined as IT applications that are used across national borders, in two or more countries or regions of the world. This includes IT applications designed to provide a global infrastructure (for example, a global extranet), global interorganisational systems, as well as functional intraorganisational systems used on a global basis. Such IT applications facilitate or make it possible for a business to be efficient, effective, and competitive in a global environment.

The ability to measure the impact of global IT applications is important for businesses today. Information technology is an essential ingredient for business expansion, providing strategic competitive advantage in worldwide markets (Ives and Jarvenpaa, 1991) and facilitating globalisation (Palvia, 1995). It also serves as a

magnifier of business competitive strategy and as a vehicle for building new strategies and new business (Bakos and Treacy, 1986). Information technology can dramatically compress time and distance, facilitate the coordination and movement of worldwide goods and services, allow for the sharing of human expertise and other resources, and provide the infrastructure necessary for operating new services that generate real competitive advantage (Huff, 1991). In the past three decades, major strides in the use of IT have been made in the USA, Europe, and Asia. As multinational, international, global and transnational companies continue to invest in IT infrastructure and GIT applications, it becomes increasingly important to develop a means of assessing their impact. The objective of this study is to develop a valid and reliable measurement model that can be used to evaluate the impact of information technology applications in a global environment.

2 Prior research

There is a large body of literature on the role of information technology in business. Clarke (1994) describes how IT applications have evolved over the years — from the initial role of IT in the 1960's as a way of automating business processes, through recognition in the 1970's of the role of IT in helping to better manage and control an organisation, to the ideas in the 1980's of using IT for strategic advantage.

Over the last decade, the literature has emphasised the role of IT in fundamentally changing the way firms operate and in generating a strategic impact. One of the more important roles of IT is in 'extending' the enterprise. IT can be used to transform organisational boundaries, interorganisational relations, and marketplace competitive and cooperative practices (Konsynski, 1993; Simon and Grover, 1993). Other examples in the literature that describe ways in which IT can be used to transform the enterprise include the strategic opportunities matrix (Benjamin *et al.,* 1984), the information intensity matrix to assess the role of IT (Porter and Miller, 1985), the strategic thrusts framework of Wiseman (1985), and McFarlan's Strategic Grid (Applegate, Austin and McFarlan, 2003). These studies address the issues of strategic IT applications in a general way without explicit consideration of the global environment and strategic global IT applications.

A study that specifically addresses global IT applications and the alignment of IT applications with global business strategy is the 1993 study by Ives. Jarvenpaa and Mason. In this study, examples of global business drivers for strategic IT applications are developed. These drivers include the use of global IT on internal value chain activities to make it possible to share valued human resources on a global scale, disperse operations around the world (to capitalise on economies of scale and cost savings), reduce risk by globally managing cash flow and assets, develop global products, and improve quality by benchmarking against world-class standards. In addition, the study stresses the importance of using global IT to help manage relationships with external entities on a worldwide basis, including those with suppliers (making worldwide procurement possible) and customers (providing global customer service and support).

A common thread in the literature is the use of IT as a competitive strategy. The global competition theory of Porter (1986) and his use of the value chain concept to highlight the role of IT in competitive strategy (Porter and Miller, 1985) provide some useful insights. Porter writes:

"Competition is at the core of the success or failure of firms_ and competitive advantage is at the heart of a firm's performance in competitive markets. Today, the importance of competitive strategy could hardly he greater. Firms throughout the world face slower growth... and global competitors are no longer acting as if the expanding pie were big enough for all." (Porter and Miller, 1985)

Global IT applications will clearly play a role in shaping global competition.

3 Measuring the impact of global Information Technology

Most research on the subject of IT stops short of looking at impact measures. Studies are often limited to addressing the question of `fir (Jarvenpaa and Ives, 1993; Gibson, 1996; Sankar, Apte and Palvia, 1993; Karimi and Konsynski, 1991; Gordon, 1993; Deans and Ricks, 1993) or, in some cases, analyzing the correlation between economic performance/productivity and IT investment (Brynjolffson and Hitt, 1996; Mahmood and

Mann, 1993). Three studies that address the subject of measuring the strategic impact of IT are Palvia (1997), Sethi and King (1994), and Mahmood and Soon (1991). These studies have shown that the strategic impact of IT is a multidimensional, latent construct worthy of more research. These three works provide the foundation for developing the instrument used in this study.

Mahmood and Soon (1991) developed an instrument for measuring the strategic impact of IT. They included both firm and industry level variables in their model. However, their model was primarily limited to domestic issues and did not consider the broader global environment. Although their study was comprehensive and identified many significant components of IT strategic impact, the measurement instrument they developed cannot be used to examine global IT impact without some modification.

Palvia's work in 1997 extended the Mahmood research to the global environment. He developed an instrument to measure the strategic use of IT and to identify strategic opportunities for using IT in a global environment. Although Palvia's instrument was developed using a relatively small sample (-40), it has undergone extensive statistical testing and exhibits a high level of reliability. The overall model is a 3-level hierarchy.

The first level describes the total strategic impact of IT on a global business. The second level subdivides the total impact into 20 latent variables identifying how IT can be used. The third level breaks each variable down into constituent items or indicators that make up the actual measurement model. The Palvia study does not provide any specific data or conclusions regarding the use of IT by global firms, but recommends an approach that can be used to measure the strategic value of IT to firms operating in a global environment.

The Sethi and King (1994) study is the most comprehensive of the three and has the largest sample set (-130). Sethi and King developed a set of measures for the latent construct they labelled 'Competitive Advantage Provided by an Information Technology Application' (CAPITA). A confirmatory factor analysis was performed using structural equation modelling to assess the measurement properties of CAPITA. This study, which focused on the analysis and evaluation of specific IT applications, was domestic in scope and did not explicitly cover the global environment.

Although these three studies have some limitations, they provide a strong base for this study and establish the validity of IT impact as a multi-dimensional construct that is important and worthy of further research. With the exception of these studies, little quantitative research has been done on the subject of global IT strategic impact. There are works on individual components of the subject — for example, the impact of telecommunication networks, EDI, electronic commerce, *etc.* — but no research to date has taken a macro-level view of the impact of global IT.

The primary focus of this study is on the impact of global IT applications at the organisational level. The Sethi and King (1994) study describes two fundamental approaches to measuring IT impact. The one most commonly used is called the outcome approach. This approach relates the use of IT to outcome measures at the enterprise level, such as revenue growth rate, return on assets, profits, net worth, *etc.* A limitation of this approach is that these outcome variables are aggregate and thus insensitive to the effects of a single IT application. The second approach, labelled the trait approach, identifies traits or attributes that reflect how an IT application impacts an organisation. The advantage of the trait approach is that it is more likely to measure first order impacts while the outcome approach is more likely to reflect second and higher order impacts (Barna, Kriebel and Mukhopadhyay, 1995). The trait approach was used in the Sethi and King, Palvia, and Mahmood and Soon studies and will also be used in this study.

The Mahmood and Soon, Palvia, and Sethi and King studies identified a number of important variables that need to be considered in measuring IT impact. The earlier work by Mahmood and Soon (1991) identified 12 variables (see Table 1). Recall, however, this study considered only a domestic environment. Palvia, in extending the work of Mahmood and Soon to a global environment, identified 20 variables (see Table 2). Sethi and King, using confirmatory factor analysis, developed a measure with seven factors (see Table 3). Although

Sethi and King attempted to go one step further and reduce the number of factors to three (efficiency, functionality, and sustainability), their data did not support this three-factor model. In our study, the variable of interest is global IT impact (GITI). It attempts to measure (at the firm level) the impact of global IT applications used by companies worldwide. Variables identified in all three of the previous studies were included in the instrument used to measure global IT impact.

Table 1 IT impact variables used in the Mahmood and Soon study

New entrants	Search costs & switching costs	Internal organisational
Entry barriers	Market	efficiency & effectiveness
Customers	Products and services	Inter-organisational efficiency
Competitive rivalry	Economies of scale	Pricing
		Suppliers

Table 2 IT impact variables used in the Palvia study

Customers	Learning curve
Competitive rivalry	Flexible operations
Suppliers	Resources
Market	Government and county requirements
Products and services	Human resources
Economies of scope	Alliance and growth
Internal organisational efficiency	Time zones
Interorganisational efficiency	Coordination
Business risk reduction	Integration
Downsizing/outsourcing	Information systems

Table 3 IT impact variables used in the Sethi and King study

Primary activity efficiency	Threat
Support activity efficiency	Preemptiveness
Resource management functionality	Synergy
Resource acquisition functionality	

4 Research methodology

This study utilised both archival and survey data. The archival data was collected by the Smithsonian Institute and is stored at the Smithsonian National Museum of American History. Information technology applications in the archival data set were nominated for the Computer World/Smithsonian Award for innovative and creative applications of IT. These nominations were made by a panel of more than 100 senior executives representing companies that are world leaders in the use and development of IT. The sample used in this study is drawn from this archival data set. Specifically, the sample is comprised of the 278 global IT applications nominated for the Smithsonian Award in the following categories: Business and Related Services; Finance; Insurance; Real Estate; Manufacturing; Media, Arts and Entertainment; Transportation; and Science and Medicine. The companies whose IT applications were nominated answered a detailed set of questions related to the IT application including benefits, importance, originality, success and difficulty.

In addition to the Smithsonian archival data, a questionnaire was developed to measure the impact of global IT applications. The starting point for this task was the prior research of Palvia (1997), Mahmood and Soon (1991) and Sethi and King (1994). Questionnaire items used to measure global IT impact are a composite from these earlier studies. Because the Palvia study is the only one of the three that explicitly considered the global environment, most of the items were from his study.

The survey was mailed in 1999 to the 278 firms in the sample drawn from the Smithsonian data set. To increase quality, each survey was addressed to the specific individual identified in the Smithsonian database as the key contact person for the particular IT application. 90 responses were received, of which 85 were complete enough to be suitable for the study, yielding an effective response rate of 30.1%.

5 Sample characteristics

Sample demographics are shown in Tables 4 through 7. Table 4 shows the distribution of firms headquartered in various parts of the world. The majority of firms are headquartered in USA. Table 5 shows the number of the firms that were privately owned versus public stock corporations. The majority of the firms were publicly owned corporations. Tables 6 and 7 show the distribution of firms by size and industry type. Most of the firms were large (>10,000 employees) and were primarily from the service and manufacturing sectors.

Table 4   Location of firm headquarters

Location	Frequency
USA	66
Europe	9
Canada	3
Asia	2
South Africa	1
Did not respond	4

Table 5   Firm ownership

Type of ownership	Frequency
Private	21
Publicly owned (stock)	45
Other	19

Table 6   Firm size

Size	Frequency
Large (>10,000 employees)	44
Medium (1,000–10,000 employees)	19
Small (< 1000 employees)	20
Did not respond	2

Table 7   Industry type

Type	Frequency
Service	36
Manufacturing	28
Wholesale	5
Retail	3
Others	6
Did not respond	7

6 Data analysis and results

The survey instrument used in this study contained 99 items taken primarily from studies that have previously undergone extensive statistical analyses for reliability and validity. The first step in the data analysis was to use factor analysis to determine if the data support the concept of a smaller number of underlying factors. The objective was to reduce the number of items necessary to measure global IT impact to as small as possible, while still retaining high reliability, high factor loading and high explained variance.

Of the 99 questions on the survey, 65 pertained to the impact of global IT. The remaining items captured sample demographics and information regarding global IT use. The 65 survey items pertaining to global IT impact were measured on a 5-point Likert scale with '1' representing no impact and '5' representing high impact. The measure of sampling adequacy (MSA) was examined for each of the 65 items. MSA values of 0.60 or less are considered unacceptable (Hair *et al.,* 1998). Using this criterion, 21 items with MSA values below 0.60 were excluded from further analysis.

The overall MSA for the remaining items was 0.822 and the Bartlett test of sphericity was significant at 0.0001, indicating that a factor analysis on these 44 items was meritorious (Hair *et al.,* 1998). Principal components

analysis was performed on these items in SPSS 11.5 for Windows. Using percentage of variance explained served as the criterion for identifying the number of factors to include, a five-factor model explaining more than 60% of the variance was chosen. Based on a minimum-loading criterion of 0.60 (Hair *et* al., 1998), 19 items did not load on any factor and were omitted from further analysis.

The overall MSA for the remaining 25 items was 0.810 and the Bartlett test of sphericity was significant at 0.0001, indicating that factor analysis on these 25 items was supported. In addition, the sample size is sufficiently large compared to the number of variables (more than 3:1) to use factor analysis (Hair *et al.,* 1998). The five-factor solution using the 25 items was computed using principal components analysis. This five-factor model explains 69.2% of the variance. The solution was interpreted using a varimax rotation with Kaiser normalisation. The results are presented in Table 8.

Table 8   Global IT impact model – rotated five-factor solution

Factor	*Factor name*	*Variance explained*
1	**Enterprise expansion and globalisation**	**21.86%**
	Items loading on Factor 1:	
	Increases the number of markets that can be served with existing resources.	
	Assists in overcoming the home court advantage of local firms in other countries.	
	Makes new business technologically feasible worldwide.	
	Increases the number of countries business can be conducted in with existing resources.	
	Helps the firm discover/develop new and profitable worldwide markets.	
	Helps serve customers in different countries with different needs.	
	Aids in selling products/services in different parts of the world.	
	Improves the firm's communication and coordination with world wide customers.	
	Eliminates duplication of effort in other country subsidiaries	
2	**Global supply chain management effectiveness**	**21.46%**
	Items loading on Factor 2:	
	Facilitates working with multiple global suppliers.	
	Enhances the firm's ability to evaluate and choose the best suppliers.	
	Helps the firm identify alternative supply sources on a worldwide basis.	
	Enhances the firm's ability to threaten vertical integration.	
	Facilitates the formulation of spin off companies in other countries.	
	Allows the firm to profitably contract/outsource activities to firms in other countries.	
	Facilitates the making of worldwide financial investments.	
	Reduces the cost the firm would incur if it changed suppliers.	
	Helps the firm to learn about subsidiaries much faster.	

Table 8   Global IT impact model – rotated five-factor solution (continued)

Factor	Factor name	Variance explained
3	**Global resource coordination and cost management**	**10.27%**
	Items loading on Factor 3:	
	Reduces cost of receiving, storing and disseminating inputs to the firm's products (*e.g.* material handling, warehousing).	
	Allows foreign subsidiaries to learn technical and business knowledge much faster.	
	Reduces cost of coordinating different activities such as purchasing, marketing, sales, and production	
4	**Firm financial performance**	**9.89%**
	Items loading on Factor 4:	
	Has a direct impact on profit	
	Has a direct impact on sales	
	Provides a competitive advantage to the firm	
5	**Resource management**	**5.74%**
	Items loading on Factor 5:	
	Assists the firm in insuring the most productive use of resources	
	Total variance explained by five factor solution	**69.23%**

Table 9   Reliability measures (U\using Cronbach's Alpha)

Factor	Number of items	α
1. Enterprise expansion and globalisation	9 items	.9189
2. Global supply chain management effectiveness	9 items	.9172
3. Global resource coordination and cost management	3 items	.7295
4. Firm performance	3 items	.8629
5. Resource management	1 item	NA
All 25 items together		.916

The multitrait-multimethod matrix (MTMM) approach was used to evaluate the construct validity of the factor model. To demonstrate construct validity, both convergent validity (the extent to which measures of constructs that theoretically should be related to each other are, in fact, observed to be related) and discriminant validity (the extent to which measures of constructs that theoretically should not be related to each other are, in fact, observed to be unrelated) are needed. Convergent validity is examined by determining whether correlations between measures of the same factor are higher than zero and large enough to proceed with a discriminant validity analysis. In this study, for every factor with more than one item the correlations of the items within the factors were greater than zero. All of the correlations between items within the factors were positive and significant at the .01 level. The smallest within-factor correlations for the first four factors were .362, .372_433, and .639, respectively. Together, these correlations suggest that the model exhibits convergent validity.

In the MTMM approach, discriminant validity for each item is tested by counting the number of times (k) an item correlates more strongly with items of other factors than with items within its own factor. For example, the lowest within-factor correlation for Factor 1 (Enterprise Expansion and Globalisation) is .362, yet only 12 of the 144 correlations with items of the other factors are greater than .362. Therefore, the number of violations for this case is k = 12. Campbell and Fiske (1959) suggest that for discriminant validity the number of violations for an item should be no more than 50% of the potential comparisons. The k values and percentages of the potential comparisons for each of the factors are shown in Table 10. Because none of the factors violate the 50% criteria, the model also demonstrates discriminant validity.

Table 10 Discriminant validity analysis

Factor	k-Values (number of violations)	% of Potential comparisons
Enterprise expansion and globalisation	24	16.7%
Global supply chain management effectiveness	29	20.1%
Global resource coordination and cost management	9	13.6%
Firm performance	0	0 %
Resource management	NA	NA

The five-factor model developed here has been shown to have excellent reliability, construct validity, and explained variance characteristics. However, a logical simplification that does not significantly degrade the model would be to drop the Resource Management factor and combine the single item loading on this factor with the Global Resource Coordination and Cost Management factor.

7 Discussion

An important contribution of this study is the development of a way to measure the impact of global IT applications. Building on the prior work of Palvia (1997), Sethi and King (1994) and Mahmood and Soon (1991), a five-factor global IT impact measurement model was identified. This new model exhibits a high degree of reliability and validity, and has several implications for theory and practice.

First, the results of this study support the notion that Global Information Technology Impact (GITI) is a multidimensional construct. To adequately measure the impact of a global IT application you have to look at more than its impact on financial performance. The data in this study shows that enterprise expansion and globalisation, global supply chain management effectiveness, and global resource coordination and cost management contribute more significantly to global IT impact than the 'firm's financial performance. This may give some insight into the complex issues surrounding the IT productivity paradox (Brynjolfsson and Hitt, 1996) that has received a lot of attention over the last ten years. The results of our study suggest that trying to capture the impact of IT by focusing solely on productivity — an outcome measure — may be an oversimplification of the problem. Similarly, in the recent article entitled IT Doesn't Matter', Carr (2003) suggests that IT has become a commodity and may no longer be strategically important to anyone. Carr's views are controversial and have been hotly debated in the IS literature. It may be that one of the fallacies in the position Carr has taken is that you can measure the value of IT by considering only the financial impact of IT. In some of the discussions on the subject it has been suggested that the real strategic advantage comes from the creative ways in which IT is used. This lends support to the argument that IT impact should be closely analysed in conjunction with IT use.

This study suggests a number of avenues for further research. First, a confirmatory factor analysis of the global IT impact model is needed. The measurement model should be applied to an independent data set to further evaluate its discriminant ability. Second, the global IT impact model developed in this study could also be used to evaluate the strengths and weaknesses of a firm and to assess the role global IT could play in global competitiveness. Thirdly, content analysis of the complete Smithsonian database would establish a rich data set for continued exploratory research and provide a larger and more representative sample for investigating model fit.

Given the reliability and validity of the GITI measurement model, a logical next step in theory development is to investigate independent variables that might influence GITI. An example of one possible framework to guide this research is shown in Figure 1. The dependent variable in Figure 1 is Global Information Technology Impact (GM), The independent variables, some of which have been suggested in other studies (Palvia *et al.,* 2002) are: global business strategy (international, global, multinational, transnational); political and regulatory issues; national cultural issues; level of economic development of the country in which the firm is located; the manner in which UT is used (for transaction processing, knowledge management, business process reengineering, *etc.);*

competitive strategy (low cost provider, product differentiation, niche market, *etc.*); and industry and firm characteristics. Further research is planned to see if there are significant relationships between these variables and GITI. We plan to explore carefully the potential relationship between GIT use and GITI. As discussed earlier, it is possible that rather than acting as an independent variable, the manner in which GIT is used may be a mediating variable between the other independent variables and GITI.

Figure 1 Framework for research on Information Technology impact in a global environment
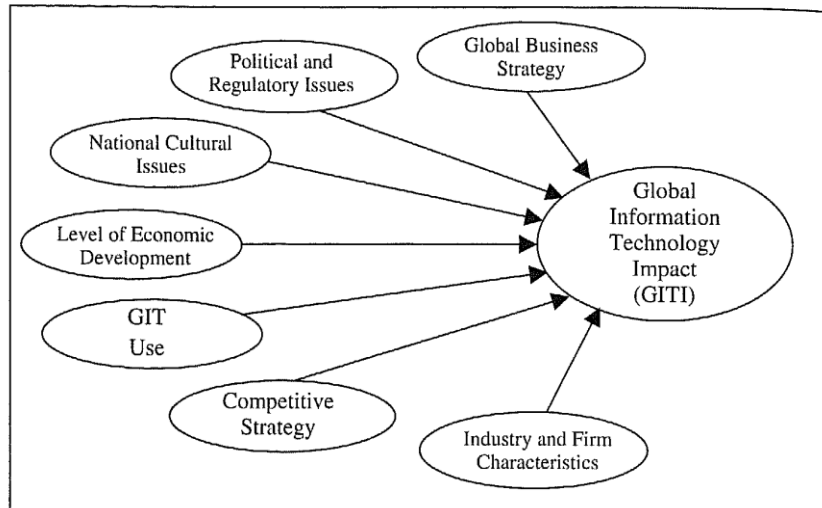
This study was limited by the relatively small sample size and sample characteristics. The small sample size resulted in a relatively low observation to variable ratio. As a result, the findings from this factor analysis may not be able to be generalised due to overfitting of the data.

Although the sample included firms from four different continents, most of the firms in the sample were headquartered in the USA. It is also important to note that the data collected was not a randomised sample. The data frame consisted of firms nominated for the Smithsonian Award for innovative and creative use of IT. These firms represent top users of IT, thus limiting the external validity of the results. However, because this study was exploratory in nature and no attempt was made to infer the results to a more general population, it is not a serious limitation. The primary objective was to develop a method of measuring the impact of global IT. For this type of study, using firms representing `best practices' is appropriate.

An additional limitation stems from the fact that the survey data was primarily perception-based. However, this limitation is mitigated by the fact that the questionnaire focused on specific information technology applications and was addressed to the individuals identified as being the most qualified to answer the questions.
In summary, the major contribution of this study is the development a five-factor measurement model that can be used to evaluate the impact of IT in a global environment. Additionally, this study provides practical insight into the factors that should be considered when assessing the impact of global information technology. A number of promising avenues for further research in this area have also been identified.

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