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An Exploratory Study on Benifits and Success Factors of Information Technology Applications

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AN EXPLORATORY STUDY ON BENEFITS AND SUCCESS FACTORS OF INFORMATION TECHNOLOGY APPLICATIONS

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ABSTRACT

This paper aims first, to explore the extent of benefits at different levels of IT applications in developing nations have realized. Second, this paper identifies those factors and/or processes associated with relative success and failure. This study collected data from fifty-seven firms in Taiwan using the mail survey method. Based on the Venkatraman's (1994) levels of IT applications, six archetypes were developed to measure IT implementation (the first three stages represent evolutionary levels, while the last three represent revolutionary levels). Results indicated that a majority of firms are at the evolutionary levels of IT applications but over ninety percent of sample firms advanced IT applications within a three-year time frame. Despite the transformation, respondents perceived a low degree of variation in the realized benefits from IT applications and no significant differences existed between benefits derived from evolutionary and revolutionary levels of IT applications. Exceptions to this were benefits derived from reengineering the mix of internal value chain activities and IT applications on operations. Results from regression analysis indicated that success of IT applications was best determined by behavioral and organizational variables rather than by technical variables.

INTRODUCTION

The world is becoming smaller as boundaries are removed through open economies with less restricted flow of goods/expertise and information across national boundaries and geographic distance. The development of information technology (IT) [1] in the past four decades has further shrunk the world through electronic commerce (e-commerce) and electronic business (e-business). According to industry figures, e-commerce in the US will reach $41bn by 2002 compared to $7bn in 1998. Forrester, the US research group, estimates that US e-business will reach $1.4 trillion in 2003 compared to $19bn in 1997. This equates to e-business's share of US GPD rising from 0.2 percent to 9.7 percent over the six-year period.[2] IT has contributed significantly to a seamless business environment that requires quick response, flexibility and intellectual resources.

In developed countries, cutting-edge companies are increasingly employing IT to enhance their competitive advantage in the global marketplace. IT has the potential to change companies' competitiveness, to change the industries in which they operate, and to fuel innovation [7, p. 40]. For firms to survive and prosper they may rely on IT to establish niches, or to facilitate reengineering processes in order to optimize the internal value chain, or to provide links and collaborative connections to upstream (suppliers)

[1] Throughout this paper, the term IT is used to refer to the embodiment of information systems (hardware and software) and communication technologies including communication hardware and software, transmission and receipt of data, voice, graphics, and full motion video. Thus, IT is viewed in a broad sense as it refers to any artifact whose underlying technological base is comprised of computer or communications hardware and software. [14, p. 123]

[2] Source: http://specials.ft.com/ln/ftsurveys/industry/sc6736.htm

and downstream (customers) components of the value chain. More and more firms rely on IT to leverage their resources either within the firm or to collaborate with other businesses. Specifically, they may have to consider a good mix or tradeoff across these activities. For example, they may spend more resources on design and save considerably more on manufacturing and marketing; increase market value and/or market share by promoting higher quality. The development of Internet and management tools (such as i2, Manugistics and SAP's Advanced Planning and Optimization) has provided a common platform to create virtual organizations or agile manufacturing. In turn, IT applications facilitate collaboration among businesses all over the world for enhancing strategic alliance, exchanging data and knowledge, extending the supply chain and introducing electronic procurement.

The potential of IT to enhance a company's competitive advantage suggests that enterprises in developing countries will inevitably have to undertake IT-based initiatives, if they are to respond to the threats and opportunities of an increasingly open and competitive marketplace. The Digital Opportunity Initiative [3] recently released a report demonstrating the critical role that information and communication technologies (ICT) help generating sustainable economic development and achieving a range of social goals in developing nations. Given the limited resources and infrastructure in developing countries, it is especially important for their enterprises to learn more about the preconditions for successful IT applications, as well as how to realize the full potential of such technology. As a majority of extant studies in the IT literature were mainly conducted in the United States, it is important for researchers to add an international perspective to the IT investment-performance relationships [15] [33]. In particular, to uncover the experience of organizations in developing countries in Asia will shed new insights to IT applications. This paper aims first, to explore the extent of benefits at different levels of IT applications in developing nations have realized. To the extent that many of these have realized net benefits, the findings can help non-adopters to evaluate whether they should also seriously consider IT implementation. Second, there will undoubtedly be both successes and failures within the existing IT adopters. This paper identifies those factors associated with relative success and failure. The findings can help firms to manage their IT implementation by minimizing their costs/mistakes or maximizing the net benefits from such initiatives. Findings of such research can also inform policy makers about the needed levels and forms of support for enterprises in developing nations to become more effective global competitors in the IT arena. Our study focuses on Taiwan firms as they are unique in their own work-related culture, institutional arrangements and environment, perhaps also stages of economic development and supply of skilled personnel [11] [12]. The findings from local firms should be especially informative on the issues of interest.

This paper is organized as follows. The following section reviews the extant literature on IT implementation-performance and the theoretical models of success factors. The data collection methods and variable measurement are then presented, followed by results of data analysis and discussions of findings. The last section concludes with implications of results and direction for future research.

LITERTURE REVIEW AND PROPOSITIONS DEVELOPMENT

Levels of IT Applications

An early model of the evolution of IT applications was the stage of growth theory, first developed by Gibson and Nolan [1974] and later expanded by Nolan [1979]. According to this theory, the growth of IT applications in business organizations follows a pattern which can be divided into six stages - initiation, contagion, control, integration, data administration, and maturity. The first three stages refer to as a

[3] The Digital Opportunity Initiative was launched in July 2000 in response to last year's Group of Eight (G8) summit, which adopted the Okinawa Charter on the Global Information Society and created the G8 Digital Opportunity Task Force (Dot Force). The Dot Force encourages the G8 leaders to continue their commitment last year to harness the unique potential of ICT to meet developing countries' needs (http://www.accenture.com).

period of managing computers and the last three as a period of managing information (data) resources. Each stage is marked with specific features, problems, and organizational changes. This theory was later augmented by a number of studies by other researchers (for example, [3] [24] [32]).

As advances in IT technologies accelerated explosively in the 1980s and 1990s, the speed and scope of IT applications also kept pace, and the stage of growth theory began to lose its relevancy. Researchers began to focus on the potential of IT to provide new sources of advantage for business operations [28] [36] [40] [43] [52]. In 1994, Venkatraman presented a synthesis of the action research as a descriptive theory, which later was developed to a 5-level IT applications model. Other researchers (for example [20] [38] [42] [51]) also have proposed similar models of IT applications.

The benefits of IT can only be fully realized when firms complement IT investment with organizational restructuring, reengineering, and redesign [33]. As suggested by Venkatraman's [1994] theory, "the benefits of IT deployment are marginal if only superimposed on the existing organizational condition (especially strategies, structures, processes, and culture.)" (p. 74). Benefits intensify in those cases where IT investments are accompanied by corresponding changes in organizational characteristics. Venkatraman's [1994] theory has two dimensions: the range of IT potential benefits and the degree of organizational transformation. These two dimensions are embedded in five distinct IT application levels: localized exploitation, internal integration, business process redesign, business network redesign, and business scope redefinition. The first two levels of IT deployment are evolutionary in nature, while the last three are revolutionary. Venkatraman's five-stage model is used for this study as it exemplifies specific characteristics associated with different levels of IT applications.

Regardless of the number of IT application levels that are conceptualized, they should not be taken to represent progressive stages of evolution [52, p. 74]. There may be firms that advance from level zero to level five without going through the intermediate stages. In particular, as technologies advance and as other firms expand their IT applications, there would be more opportunities, role models, available technology, and competitive pressures for leapfrogging to much higher levels of application. IT application is more than just a technological change, as associated with it there may be changes in the boundaries across function, or strategies, or human skill requirements. As suggested by Venkatraman [1994], higher levels of transformation may indicate higher potential benefits, but they also require a correspondingly higher degree of organizational changes. Analysis of the costs and benefits at different levels of IT application and their success factors are the central thrust of this paper. It is important for firms to identify first the level of IT applications where the potential costs of the required organizational changes are justified for the benefits derived. Whether to advance to a higher level may be driven by competitive force in the marketplace.

Benefits of IT Applications

Benefits of IT applications in firms have ranged from being narrowly focused to being enterprise-wide. For example, B2E (business to employees) has become more important because businesses can realize the benefits quickly. Evidence revealed hard cost savings by replacing paper processes used for human resources management and staff training with cheaper electronic equivalence. The Boston Consulting Group (BCG) cites an example from Ford which published the healthcare brochure online instead of printing and distributing to staff at a cost of US$ 1 million. [4] Pfizer, one of the largest pharmaceutical companies in the world, has developed an electronic-based drug submission system that can shorten the approval cycle by the United States (U.S.) Food and Drug Administration, resulting in cost savings of US$142 million thus far [4]. Cisco Systems Inc. reportedly has saved US$2 billion over the past four years by implementing Net-based ordering [7, p. 37]. Rolls-Royce Motors, the car manufacturer, is moving towards full integration

[4] Source: http://globalarchive.ft.com/

of its suppliers into its design process by sharing the data in its IBM-managed Catia computer-aided design package. This approach has reduced the design cycle time by 25 per cent and the number of design changes per component and, in turn, has saved approximately 30 per cent of the cost of each component.[5]

Despite the anecdotal evidence as discussed above, to determine the benefits of IT applications in the real world has proven extremely difficult. Management always presumes that IT investment will enhance financial or economic performance, but they do not know how to measure the actual impact of such investment. Research to date has indicated inconclusive and elusive relationships between the IT investments and organizational performance/productivity, or so-called productivity paradox [5] [31] [33] [48] [50]. Equivocal findings of IT investment-performance studies are mainly due to research methodological problems, including the time-frame of the data collected and the measurement of performance [5] [29] [33].

How to measure benefits or success has always been widely discussed in the IT literature. Traditional IT investment-performance studies have mainly relied on financial data including profitability measures, such as growth in sales, profit margin, return on assets, return on sales, return on equity; or efficiency measures (such as fixed assets turnover, total assets turnover, and inventory turnover); or stock price [2] [17] [25] [33] [34] [46] [47] [48] [54]. Other studies have measured performance in terms of market share gain, new market penetration, measures of quality improvement and productivity [31] [55]. However, it has been argued that over-reliance on profitability or financial market measures indicate too much emphasis on maximization of stockholders' wealth without considering other stakeholders [9]. Other researchers have called for performance measures beyond the conventional techniques. These include analysis of hidden costs and benefits such as human resources; soft IT value measures and qualitative measures including quality changes, product innovation, improved timeliness of delivery and personalized customer services [5] [10] [25] [41].

In addressing the importance of qualitative measures, Tallon, Kraemer and Gurbaxani [2000] have adopted a process-oriented model to examine executives' perceptions of the possible impacts of IT on critical activities within the value chain. Similarly, our study measures benefits of IT applications in terms of the value added derived from IT application on each value-chain activity. This approach is based on Michael Porter's [1985] value chain analysis that involves identification of separate activities within and around an organization and assessing its ability to provide value-for-money products or services.

Although it may be possible for benefits of IT to be realized in the same year when the investment is made, it is common for such benefits to be in the nature of longer term returns. Some studies (for example, [1] [2] [33] [35]) only examined cross-sectional data and reported positive and significant effects of IT investment. However, these results have been commented as not convincing since their research design ignores the lag effects of IT investment. More recent studies have improved the research design by examining multi-year cross-sectional data or adopting a longitudinal approach of analysis [16] [25] [34] [48]. These studies have found strong empirical validity in supporting the propositions that relationships do exist between IT investment and firm performance. In particular, Devaraji and Kohli [2000] examined eight hospitals over a three-year period using monthly data, and found a positive lag effect of IT investment on organizational profitability. In our study, we focus on the change in levels of IT applications based on a two-time frame (namely at the current point in time and three years ago). We aim at exploring whether firms advance their technology over time by comparing the level of IT applications in current year and that of three years ago. If such transformation exists, what would be the value-added of the firm's current IT applications relative to that three years ago on each of the Porter's [1985] value chain activities?

[5] Source: http://specials.ft.com/ln/ftsurveys/industry/sc673e.htm

Success Factors of IT Applications

While many firms have used IT with success, there also are many cases of reported failures, or at least failing to obtain as much net benefit as initially expected (the so called productivity paradox). Gartner Group and its subsidiary, TechRepublic, Inc. (a technology consulting company) interviewed 1,375 IT professionals in North America in their September 2000 survey. Results indicated that approximately 40% of IT projects do not produce their intended results. On average, companies spent an average of $1 million a year for unsuccessful projects, on top of wasted professional resources that could not be easily quantified. Failure of IT investments was mainly due to mismanagement of available workers; lack of project management training; lack of supervisor charged with ongoing evaluation of project viability and, where appropriate, their timely termination and reassignment of staff to other activities [*Journal of Accountancy*, February 2001, p.24]. In some cases, the anticipated benefits fail to materialize within the project time frame. The reasons for delay in obtaining the benefits are due to management's failure to apply strategical leverage to the full potential of IT and their failure to overcome resistance to change [17]. In particular, firms fail to realize that IT implementation is more than just a technical change, but rather a wide ranging organizational change. To function effectively, IT has to be fully and successfully integrated into users' activities. Also, management has to consider the organizational culture and human factor in assessing the likelihood the workforce will be able to accept and absorb the technology [8] [13] [22] [26] [27] [33]. While these studies provide evidence in developed countries, our study examines whether the success factors of IT applications in developing nation will differ.

Specifically, successful IT implementation depends on the ability of firms to adapt to the potential disruption in work processes, together with co-ordination of different stakeholders that are involved with technological transformation. In the behavioral accounting literature [44] developed a comprehensive theoretical model about the implementation of cost management systems. Although the model has been mainly applied to examine success factors of activity-based costing (ABC) systems, it is based on an extensive review and analysis of the literature on the implementation of administrative and technical innovations in organizations [44]. The underlying assumption of this model is that cost systems are administrative rather than technical innovations and as such behavioral and organizational variables (instead of economic and technical considerations) can be important determinants of success. The model identified seven success factors, namely organizational culture, controls, champion, change process, commitment, compensation, and continuing education. In our study, IT applications are considered as administrative innovations, as their success depends on how strong the top management supports the initiative and how well it creates a dominant or powerful coalition with employees, so as to make them accept and work with the innovations. To this end, we adopted the Shields and Young [1989] model as it is more appropriate to the scope of our study while it has been tested and validated in prior research [44] [45].

Propositions

Based on the empirical evidence, Venkatraman [1994] IT application model, Porter's [1985] value chain analysis, and Shields and Young [1989] success factors model, the propositions for this study are presented below:

Proposition 1: There is a significant variation in benefits at different levels of IT applications. Firms at evolutionary levels are expected to generate a lower range of benefits than that at revolutionary levels.

Proposition 2: The levels of IT application explain the variation in the benefits derived.

Proposition 3: Behavioral and organizational variables explain the variation in benefits of IT applications more than technical variables.

RESEARCH METHODS

Data Collection Method

A mail survey was used due to its cost-effectiveness in collecting data from a relatively larger sample than field studies. It was also considered appropriate to provide initial analysis for an exploratory study of this kind. Data was collected by mail survey with 80 firms. The questionnaire was sent to the appropriate managers through the Chief Executive Officer (CEO) of each firm. Fifty-seven usable responses were received giving a 71% response rate.

The questionnaire was designed based on prior literature and the theoretical models as discussed under the literature review. It contains three main sections. The first section explores firms' current level of IT applications and that of three years ago in order to evaluate whether they have advanced their technology over time. It is expected that firms should expedite IT applications within a short period of time in order to meet the innovative challenges and competitiveness in the rapidly changing business environment. The second section solicits whether firms have achieved their expectations of the IT applications, the associated benefits as well as the success factors. The final section collects descriptive information about the firm and the respondents.

Measurement of Variables

Levels of IT Applications

The typology approach was adopted to measure levels of IT applications based on the premise that technological changes should complement with strategic and organizational changes in order to realize or maximize benefits. Based on the Venkatraman [1994] model, six archetypes were developed to measure different levels of IT application.[6] The model is adopted as it is well accepted in the U.S. literature and incorporated in textbooks. Each of the six archetypes exemplifies specific objectives and characteristics of technological transformation, organizational structuring, functional relationships, information flow and management guidelines for deriving maximum benefits (see Appendix 1). Taking a retrospective longitudinal approach, respondents were asked to indicate which levels of the six archetypes most closely reflects their firm's use of IT at the current point in time and as of three years ago.

Benefits of IT Applications

Based on Porter's value chain activities, nineteen questions were used to measure benefits of IT applications. For each of the value-chain activities, respondents were asked to rate the value added of their firm's current IT applications relative to that three years ago on a seven-point scale with 1= A lot lower, 4=About the same, and 7=A lot higher.

Success Factors of IT Applications

The Shields and Young [1995] instrument for activity-based costing system implementation was adapted to measure the success factors of IT applications. Sixteen questions were included to ask the respondents to rate the degree to which each of the behavioral, organizational and technical variables is present in their IT. A seven-point scale was used to measure the degree with 1=Not at all and 7=To a very great extent. Behavioral and organizational variables include top management support; linkage of IT applications to competitive strategy, operational quality and speed; training in designing, implementation and using IT; non-IT ownership as compared to IT ownership; consensus about and clarity of IT applications objectives; and sufficient internal resources. Technical variables include canned software, customized software; stand-alone vs. integrated system, and external consultants.

RESEARCH FINDINGS

Characteristics of the Firms

Table 1 presents the characteristics of the 57

[6] The six IT application archetypes include the five levels (labeled as Level 1 – 5) as suggested in the Venkatraman [1994] model and an additional level (labeled as Level 0) that represents little or no IT application.

sample firms. Thirty percent of these firms were in the servicing sector, 29 percent in manufacturing and 28 percent in electronic communication. In terms of number of employees, 26 percent fell within the range from 1-100, 45 percent from 101–500 employees, and 29 percent of firms employed over 500. Ninety-six percent of the firms assigned employees to be responsible for IT applications.

Characteristics of the Respondents

Table 2 presents the characteristics of the respondents. Fifty-eight percent of respondents reported that they were members of high-level management and 37 percent at middle level. Fifty percent of the respondents' job nature was primarily related with information systems, 20 percent financial, 20 percent were operational. Forty-two percent of the respondents were involved in their firms' IT applications as managers, 16 percent as members, and 32 percent as non-members. The respondents' experience in the firms ranged from 1-25 years with a mean of 6.82 years and a median of 4 years. Their experience in the current position ranged from 0.5-18 years with a mean of 3.39 years and a median of 2.25 years.

Firms' Levels of IT Applications

Two percent of the firms selected Level "0" as their current archetype of IT application, 23 percent at Level 1, 36 percent at Level 2, 34 percent at Level 3, 3 per cent at Level 4, 2 percent at Level 5. These statistics also suggest that 58 percent were at evolutionary levels while 39 percent were at revolutionary levels.

Compared to three years ago, only five firms' current IT applications (9 percent) remained at the same level and fifty-two firms (91 percent) had advanced IT applications. In particular, eight of these firms had advanced IT applications by more than one level. Among this group, one firm even moved from Level 1 to Level 5. Although these levels might not necessarily be sequential, it implied a higher degree of transformation if firms advanced IT applications from evolutionary to revolutionary levels within a three-year time frame. When compared levels of IT applications with firms' size, eight firms with over 500 employees (referred to large firms) were at evolutionary levels. On the contrary, fourteen firms with less than 500 employees (referred to small and medium firms) were at revolutionary levels.

Respondents were asked to compare their firms' current IT applications with what their firms had targeted when it embarked on increasing IT use three years ago. Sixty-five percent of respondents considered it as about the same while 35 percent considered it as higher than targeted. Regarding the costs incurred for transition from the levels of three years ago to the current level of IT applications, 5 percent of the respondents considered it as much lower, 69 percent considered it as about the same, 26 percent considered it as much higher. Sixty-seven percent of the respondents regarded the benefits derived the current level of IT applications as about the same as that of three years ago, while 33 percent indicated much higher benefits than that of three years ago. In terms of the time involved in transiting from the level of three years ago to the current level of IT applications, 9 percent considered it as much shorter, 66 percent considered it as the same, while 25 percent considered it as much longer.

Benefits of IT Applications

To measure benefits, respondents were asked to compare the value-added of their firm's current IT application on each of the value chain activity with that of three years ago. A seven-point scale was used anchored by 1=A lot lower, 4=About the same, and 7=A lot higher. Table 3 shows that the means of value added or benefits on each activity arising from IT application changes ranged from 4.46 to 5.32. The mean scores indicate that certain degree of benefits were derived from the IT transformation. Specifically, benefits realized from sharing and coordination within the organization (mean=5.32); changes in IT applications on inbound logistics (mean=5.11); technology development (mean=4.91); reengineering the mix of internal value chain activities (mean=4.91); marketing and sales (mean=4.91); and operations (mean=4.91) are relatively higher than that from other activities.

Table 1
Characteristics of Firms

	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Total
Industry							
Electronic	0%	7%	9%	9%	3%	0%	28%
Communication							
Transport	0%	0%	0%	2%	0%	0%	2%
Manufacturing	0%	7%	9%	14%	0%	0%	29%
Service	0%	2%	7%	7%	0%	2%	17%
Banking	0%	0%	2%	0%	0%	0%	2%
Air Service	0%	0%	0%	0%	0%	0%	0%
Office Equipment	0%	0%	0%	0%	0%	0%	0%
Non- Banking Financial	0%	0%	2%	0%	0%	0%	2%
Institution							
Sales Product	0%	2%	3%	0%	0%	0%	5%
Discount/ Volume Sales	0%	0%	0%	0%	0%	0%	0%
Medical Care	0%	0%	2%	0%	0%	0%	2%
Food	0%	0%	0%	0%	0%	0%	0%
Others	2%	5%	2%	2%	0%	0%	13%
	2%	23%	36%	34%	3%	2%	100%
Firm Size							
1 - 100	0%	12%	5%	7%	0%	2%	26%
101 - 500	2%	9%	19%	16%	0%	0%	45%
501 - 1000	0%	2%	3%	7%	0%	0%	12%
1001 - 5000	0%	0%	3%	3%	2%	0%	8%
5001 - 10000	0%	0%	3%	0%	0%	0%	3%
Over 10000	0%	0%	2%	2%	1%	0%	5%
	2%	23%	36%	34%	3%	2%	100%
Employee responsible for IT Application							
Yes	2%	21%	34%	34%	3%	2%	96%
No	0%	2%	2%	0%	0%	0%	4%
	2%	23%	36%	34%	3%	2%	100%

Table 2
Characteristics of Respondents

	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Total
Level of Management							
High- Level	2%	12%	16%	26%	0%	2%	58%
Mid- Level	0%	2%	16%	14%	5%	0%	37%
Others	0%	0%	2%	2%	0%	0%	5%
	2%	14%	35%	42%	5%	2%	100%
Job Nature							
Finance	0%	2%	11%	7%	0%	0%	20%
Administration	0%	2%	0%	4%	0%	0%	6%
Engineering	0%	0%	0%	2%	0%	0%	2%
Information System	2%	11%	20%	13%	4%	0%	50%
Sales	0%	0%	0%	4%	0%	2%	6%
Manufacturing	0%	2%	2%	2%	0%	0%	6%
Others	0%	4%	4%	3%	0%	0%	10%
	2%	20%	37%	35%	4%	2%	100%
Level of Participation							
Management	2%	11%	11%	14%	2%	2%	42%
Member	0%	2%	8%	7%	0%	0%	16%
Non- member	0%	2%	11%	16%	2%	0%	32%
Others	0%	0%	2%	8%	0%	0%	10%
	2%	15%	32%	45%	4%	2%	100%

Sample firms were divided into two groups based on their current levels of IT applications. Archetypes 1-3 were classified as evolutionary levels while Archetypes 4-6 revolutionary levels. Median tests were performed to compare the benefits realized from changes in IT applications between these two groups. Results indicated that no significant differences existed except on reengineering the mix of internal value chain activities (median=5.00, *chi-square*=5.17, $p<0.05$) and operations (median=5.00, *chi-square*=7.165 $p<0.05$). These results offered weak support to Proposition 1 that there was a significant variation in benefits of IT application between the evolutionary and revolutionary levels.

Success Factors of IT Applications

To measure the success factors, respondents were asked to rate the degree to which each of the behavioral, organizational and technical variables was present in IT applications. A seven-point scale was used anchored by 1=Not at all and 7=To a very great extent. Table 4 presents the mean values of these variables in descending order. There was no wide dispersion among these variables ranging from 4.23 to 5.77. The top five variables that were present in IT applications included top management support (mean=5.77), IT department ownership (mean=5.50), a clear and concise objective (mean=5.47), training in use (mean=5.13) and training in implementation (mean=5.07).

Impacts of Levels of IT Applications and Success Factors on Benefits

To examine the impacts of levels of IT applications and success factors on benefits derived, we estimated the following multiple regression model. We created a dummy variable to represent the evolutionary and revolutionary levels of IT applications based on Venkatraman [1994] model and classified the success factors into behavioral/ organizational and technical variables based on Shields and Young [1989] model.

$$BENEFITS = \hat{a}_0 + \hat{a}_1 D + \hat{a}_2 SF1 + \hat{a}_3 SF2 + \hat{a}_4 DSF1 + \hat{a}_5 DSF2 + \mathring{a} \quad (1)$$

Where
Dependent Variable
BENEFITS = mean of benefits of IT Applications

Independent Variables
D = 1 if the firm is at revolutionary levels
= 0 if the firm is at evolutionary levels
SF1 = mean of behavioral and organizational success factors
SF2 = mean of technical factors

The regression model was significant ($p<0.00$). Table 5 – Panel A shows that the adjusted R^2 was 37.6 percent. Only the behavioral/ organizational factors provided statistically significant ($p<0.05$) explanations of benefits of IT applications.

We further regressed the individual behavioral and organizational success factors (independent variables) on Benefits of IT application (dependent variable).

$$\begin{aligned} BENEFITS = {} & \hat{a}_0 + \hat{a}_1 Support + \hat{a}_2 Objective \\ & + \hat{a}_3 Consensus + \hat{a}_4 Link(Strategy) \\ & + \hat{a}_5 Link(Quality) + \\ & \hat{a}_6 Link(Speed) \\ & + \hat{a}_7 Training(Design) \\ & + \hat{a}_8 Training(Implementation) \\ & + \hat{a}_9 Training(Use) \\ & + \hat{a}_{10} Ownership(Dept) \\ & + \hat{a}_{11} Ownership\ (Users) \\ & + \hat{a}_{12} Resource + \mathring{a} \end{aligned} \quad (2)$$

Results indicate that the adjusted R^2 was 62.8% and three variables provided statistically significant explanations of benefits of IT applications ($p< 0.05$): linkage to speed, training in using IT systems and human resource adequacy (see Table 5 – Panel B). The regression results supported Proposition 3 that the variables representing behavioral and organizational success factors explained the benefits of IT applications more than technical success factors.

Table 3
Benefits of IT Applications

	A lot Lower			About the same			A lot higher		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Mean**	**SD**
Sharing and coordination	2%	0%	3%	17%	26%	40%	12%	5.32	1.18
Inbound logistics	2%	2%	7%	12%	33%	39%	5%	5.11	1.21
Technology development	2%	2%	4%	21%	44%	25%	4%	4.91	1.09
Marketing & sales	2%	2%	4%	23%	39%	27%	4%	4.91	1.16
Operations	2%	2%	2%	20%	52%	20%	4%	4.91	1.03
Re-engineering the mix of internal value chain activities	2%	2%	5%	21%	39%	25%	5%	4.91	1.11
Organizational learning	4%	4%	4%	23%	35%	28%	4%	4.81	1.29
Customer support	2%	5%	4%	26%	32%	28%	4%	4.79	1.25
Procurement	2%	0%	4%	36%	32%	25%	2%	4.79	1.04
Managing customers	4%	4%	4%	30%	30%	26%	4%	4.72	1.29
Infrastructure	2%	4%	4%	26%	47%	14%	4%	4.71	1.10
Innovation	2%	9%	9%	14%	37%	30%	0%	4.65	1.33
Outbound logistics	2%	2%	7%	36%	32%	20%	2%	4.61	1.11
Managing supplies	4%	2%	9%	31%	30%	24%	0%	4.54	1.22
HR Management	2%	4%	9%	39%	28%	19%	0%	4.46	1.11

Based on Porter' s value chain activities, nineteen questions were used to measure benefits of IT applications. For each of the value-chain activities, respondents were asked to rate the value added of their firm' s current IT applications relative to that three years ago on a seven-point scale with 1= A lot lower, 4=About the same, and 7=A lot higher.

Table 4
Success Factors of IT Applications

	Extremely Low						Extremely High		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Mean**	**SI**
Management support	0%	3%	3%	9%	9%	48%	28%	5.77	1.25
Ownership (Department)	2%	0%	7%	7%	23%	43%	18%	5.50	1.25
Objective	0%	2%	5%	12%	23%	40%	18%	5.47	1.18
Training (Use)	0%	2%	5%	18%	38%	29%	9%	5.13	1.10
Training (Implementation)	0%	2%	2%	29%	30%	30%	7%	5.07	1.06
Consensus	2%	0%	11%	14%	42%	21%	11%	5.00	1.22
Ownership (Users)	0%	2%	11%	23%	27%	29%	9%	4.96	1.22
Training (Design)	0%	2%	7%	28%	28%	28%	7%	4.95	1.14
Canned Software	0%	5%	7%	23%	29%	30%	5%	4.88	1.24
Customized Software	2%	5%	7%	23%	33%	21%	9%	4.79	1.35
Link (Strategy)	4%	0%	14%	16%	39%	19%	9%	4.79	1.35
Resource	2%	4%	16%	15%	31%	27%	5%	4.72	1.36
Stand- alone	2%	6%	7%	26%	35%	17%	7%	4.67	1.32
Link (Quality)	4%	0%	13%	25%	38%	20%	2%	4.59	1.20
Link (Speed)	2%	5%	14%	21%	30%	21%	5%	4.59	1.36
Assistance (external)	9%	14%	9%	23%	14%	24%	7%	4.23	1.81

The Shields and Young (1995) instrument for activity-based costing system implementation was adapted to measure the success factors of IT applications. Sixteen questions were included to ask the respondents to rate the degree to which each of the behavioral, organizational and technical variables is present in their IT. A seven-point scale was used to measure the degree with 1=Not at all and 7=To a very great extent. Behavioral and organizational variables include top management support; linkage of IT applications to competitive strategy, operational quality and speed; training in designing, implementation and using IT; non-IT ownership as compared to IT ownership; consensus about and clarity of IT applications objectives; and sufficient internal resources. Technical variables include canned software, customized software; stand-alone vs. integrated system, and external consultants.

Table 5
Regression Results

Panel A - Regression 1				
Independent Variables	**â**	**S.E. â**	**t**	**p**
Dummy (Levels of Applications)	-1.054	-0.580	-0.844	0.403
SF1 (Behavioral and organizational factors)	0.373	0.367	2.313	0.025
SF2 (Technical factors)	0.228	0.239	1.482	0.144
DSF1	0.216	0.634	0.617	0.540
DSF2	0.001	0.040	0.040	0.968
Adjusted $R^2 = 0.38$, $F = 7.75$, $p<0.001$				
Panel B – Regression 2				
Significant Independent Variables	**â**	**S.E. â**	**t**	**p**
Link (speed)	0.287	0.426	2.219	0.033
Training (Use)	0.531	0.632	2.693	0.010
Resource	0.205	0.312	2.323	0.026
Adjusted $R^2 = 0.63$, $F = 8.02$, $p<0.001$				

Both the regression models 1 and 2 were estimated using "Benefits of IT Applications" as the Dependent Variable. Regression 1 included 3 independent variables: Dummy variable which represents Levels of IT Applications with a value of "1" if the firm is at revolutionary levels and a value of "0" if the firm is at evolutionary levels; SF1 which represents the mean value of behavioral and organizational variables; and SF2 which represents the mean value of technical factors. Regression 2 included all behavioral and organization factors as independent variables.

DISCUSSION AND IMPLICATIONS OF RESULTS

Evidence suggest that firms' level of IT applications may not necessarily correspond with their size. Five small firms with less than 100 employees were at revolutionary levels, indicating the need of IT to sustain growth of the businesses. Although the majority of firms advanced their IT application over three years' time, the costs involved with IT was not reduced while the benefits remained the same.

In terms of benefits, there was a small diversion among the value-added of firms' current IT applications relative to that of three years ago. IT applications improved in internal value-chain activities more than external activities. In particular, IT added value mostly to sharing and communication within the organization; inbound logistics such as receiving, storing and disseminating input to production; technology development; and operations. External activities such as sales and marketing also benefited from IT advancement. However, the increasingly competitive environment has shifted the role of IT from enhancing efficiency to creating and maintaining a business global network. With IT functionality, firms are expected not just to improve their management information systems in order to facilitate internal communication, reporting, logic of structuring, operations and performance measurement. They need to rely on IT to build up their competitive edge in the global market.

Contrary to Proposition 1, the benefits derived from the evolutionary levels of IT applications did not differ significantly from the revolutionary levels. This is inconsistent with the Venkatraman [1994] IT applications model, that potential benefits intensified at higher levels of transformation. The results suggest that firms might not have undergone correspondingly a high level of organizational changes with IT advancement. Benefits cannot be maximized if IT functionality was just superimposed on the existing business processes. From a methodological perspective, the disappointing results may be due to respondents' self-classification of IT application levels based on the archetypal descriptions. This selection may be biased due to variance among managers' perception of distinct characteristics at each level of IT applications. One may improve the classification by objective means such as using external raters.

Results from multiple regression analysis refuted Proposition 2 that levels of IT applications explained variation in benefits. This is consistent with the findings from prior research relating to IT productivity paradox [5] [6] [46] [47]. Consistent with Proposition 3, behavioral/ organizational factors have significant impacts on the variation in benefits. This implies that whichever level of transformation undertaken by the firms, potential benefits may be realized as long as they are consistent with their exploitative capability. Regardless of levels of transformation, success of IT applications was determined by behavioral and organizational attributes more than technical attributes. This supports the findings from prior research [13] [21] [22] [45] [53]. Specifically, certain behavioral and organizational attributes provided significant explanation of the variation in benefits. The success of IT applications is much determined by linking IT to speed initiatives such that they can be marketed timely to meet customers' demand. Training in using must be provided in order to enhance users' skills. Sufficient human resources also play an important part in facilitating IT transformation. In our study, it is not surprising to observe that a majority of managers were involved in different areas of IT applications. It is most important for employees to be given the chance to participate so as to enhance their acceptance to changes, especially those related with business process redesign, business network redesign and business scope.

CONCLUSION

This study explored the benefits and success factors of IT applications in Taiwan based on the Venkatraman [1994] IT application model, Porter's value chain and Shields and Young [1989] success factors model. This study collected data from firms in Taiwan using mail survey. Based on the Venkatraman's [1994] levels of IT applications, six archetypes were developed to measure IT implementation (the

first three stages represent evolutionary levels while the last three represent revolutionary levels). Each of the six archetypes exemplified specific objectives and characteristics of technological transformation, organizational structuring, functional relationships, information flow and management guidelines for deriving maximum benefits. Survey results of 57 sample firms indicate that benefits derived from the evolutionary levels of IT applications did not differ significantly from that of the revolutionary levels. However, behavioral/ organizational success factors explained significantly the variation of benefits derived.

The findings can help firms to manage their IT implementation by minimizing their costs/mistakes or maximizing the net benefits from such initiatives. In particular, evidence from a developing nation such as Taiwan does not differ from that of the developed country such as the U.S.. While we selected Taiwan firms as they are unique in their own work-related culture, institutional arrangements and environment, perhaps also stages of economic development and supply of skilled personnel, the findings should be especially informative on the issues of interest to the policy makers of Asian countries. Too often, managers, especially in Asia, think too much in functional and technical terms and fail to see that IT needs to be considered from the behavioral and organizational perspectives. Accordingly, firms cannot simply delegate IT design and implementation to functional specialists, but also to the employees who are using IT. The success of IT transformation has to be complemented by radical organizational changes such as strategy, structures and processes. Future research may extend to field study so as to investigate how firms advance IT applications. Specifically, investigating the reasons for any failure cases would be a worthwhile research agenda for the IT literature.

Appendix 1

Extract of Questionnaire

Section A

Below are six descriptions, or archetypes, of a firm's use of information technology (IT). These descriptions are arranged in an order that goes from mostly independent, functional and narrowly-focused systems, to integrative systems that cut across the boundaries of companies to link (at least part of) their operations together. The ordering of these archetypes does not imply that one archetype is necessarily superior to another, since each company needs to select the practices that best fit its needs. Please read through these descriptions of the archetypes. After you have read through these descriptions, you will be asked to indicate which of the archetypes most closely reflects your firm's use of IT at the current point in time, and as of three years ago.

Level 0

Your firm has little or no IT application supporting functional areas. Each functional area has established its own manual procedures in order to help address operational problems. Business practices are based on these manual systems. IT may be applied to situations which are required by Government agencies such as IRD, or Customs and Excise.

Level 1

Your firm deploys IT to respond to operational problems and challenges. IT application is limited to standard or off-the-shelf transaction processing systems (for example, a customer order entry system, a payroll system, an inventory control system). Decisions to deploy these isolated systems are decentralized to the appropriate functional, operational managers. Accordingly, IT applications are independent of each other, each serving a specific functional area. This level of IT applications involves minimal changes to business processes.

Level 2

Your firm deploys IT for internal integration

with an objective to improve efficiency, enhance customer service or co-ordinate decision-making. This level involves a more systematic attempt to leverage IT capabilities throughout the entire business process. Your firm uses a common IT platform to integrate different standard systems into a single system that produces coordinated responses to your firm's environment. Your IT systems create interdependence across functional areas as well as provides seamless inter-connection for exchanging structured data on transactions. Changes in business processes are minimal and carefully monitored due to the interdependent nature of the systems.

Level 3

Your firm's primary objective is to redesign business processes in conjunction with IT systems development in order to achieve strategic advantages. A flattened organization structure and increased concurrent activities among team members are the result of this level of IT application. To complement this IT application, your firm has undergone radical changes in organizational structure, personnel responsibilities and reporting relationships.

Level 4

Your firm's primary objective of IT applications is strategic (for example, enhanced decision making, providing distinctive value-added services, etc.). IT applications in your firm enable business transformation which extends beyond your organizational boundaries to form inter-organizational systems (IOS) with suppliers, buyers, and other intermediaries. Specifically, IT applications trigger inventory movement across organizations based on predefined conditions without human intervention and may provide process linkages for unstructured tasks (such as design and manufacturing). Your business (operational) managers (not just the IT managers) are required to learn about, and are made responsible for the IOS or inter-organizational applications.

Level 5

Your firm's primary objective of IT application is to expand business scope in order to maintain your competitive advantage through product leadership or combining your competencies with those of your outside partners. Your information systems enable you to redefine your business scope, in other words, expanding your market, product or service scope. Associated with the IT applications, there have been dramatic changes in organizational routines such as strategies, structure, processes and skills.

Please indicate which level of these six archetypes most closely reflects your firm's use of IT at the current point in time, and as of three years ago. (Please be sure to provide TWO answers, one for the current point in time, and another one for three years ago.)

The archetype that most closely reflects my firm's use of IT at the current time is LEVEL_____

The archetype that most closely reflects my firm's use of IT three years ago is LEVEL_____

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