2010

Differences in IT effectiveness among firms: An empirical investigation

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***Abstract*—**Information is a critical asset and an important source for gaining competitive advantage in firms. The effective maintenance of IT becomes an important task. In order to better understand the determinants of IT effectiveness, this study employs the Industrial Organization (I/O) and Resource Based View (RBV) theories and investigates the industry effect and several major firm-specific factors in relation to their impact on firms' IT effectiveness. The data consist of a panel data of ten-year observations of firms whose IT excellence had been recognized by the *CIO Magazine*. The non-profit organizations were deliberately excluded, as explained later. The results showed that the effectiveness of IT management varied significantly across industries. Industry also moderated the effects of firm demographic factors such as size and age on IT effectiveness. Surprisingly, R & D investment intensity had negative correlation to IT effectiveness. For managers and practitioners, this study offers some insights for evaluation criteria and expectation for IT project success. Finally, the empirical results indicate that the sustainability of IT effectiveness appears to be short in duration.

***Keywords*—**firm effect, industry effect, IT effectiveness, sustained IT effectiveness,

I. Introduction

INFORMATION has become a critical factor for business success. The advances in the information technologies have significantly improved the businesses' capabilities related to information collection, storage, interpretation and exchange. The wide adoption of the personal computers, database technologies and the Internet technologies have revolutionized the way that business is conducted: the changes in the business processes, organization structures and management practices reach an unprecedented level in both magnitude and speed [1].

The priority that managers attach to IT management couldn't be better demonstrated by the fact that new executive positions were created under the titles such as Chief Information Officer, Technology or even Knowledge Officers. Functional departments were accordingly established and staffed with expertise hired to undertake the responsibilities of information management [2].

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Meanwhile, academia has been engaged in the research with an attempt to provide theoretical and empirical guidance for practice. Existing research had evolved around several topics, including project studies from the technological approach, individual technology acceptance investigations grounded in behavioral theories and the business strategic focus on IT investment payoff. As the rising IT investment calls for justification to ensure future budgeting, researchers are increasingly concerned about the IT – performance relationship. However, empirical studies had been producing equivocal results as to the economic payoff of IT investment. Various methodology defects had been discussed in great details and suggestions were given on measurement, data collection and statistic to improve such studies [4],[5]. However, relatively little effort was made to seek theoretical evidence for understanding the issue.

In order to achieve a breakthrough in understanding the dynamics between the effectiveness of IT management and firm performance, it is important that researchers sharpen both methodological and theoretical capabilities. As noted in [6], the theoretical products from other fields had enabled the growth in the IT research to a large degree. A review of the theoretical and empirical evidences from the strategic management field indicates that there exists the possibility to understand the effectiveness of IT management under the theoretical umbrella of Industrial Organization (I/O) framework and Resource-based view (RBV) [6].

A central debate throughout the evolution of strategy studies has been the on-going predominance of internal versus external effects on the firm performance [7]. Previous studies had shown that industry and firm characteristics would determine the effectiveness of various strategic practices including foreign market entry, the adoption of quality management programs and many more [8]-[10]. Despite the uniqueness of IT management, as a strategic practice serving the business needs, its functionality could only be thoroughly understood under the context of the industry and firm environments. It is imperative to find out whether industry, given the varying natures of industries, and/or various firm endowments would play a role in the successful adoption of information technologies.

Grounded in the strategic management field, the purpose of this study is to investigate the industry and firm characteristics as the potential antecedents of the effectiveness of IT adoption in business organizations. An empirical analysis is based on a panel data compiled from the annual 100 Honorees elected by the *CIO* magazine from 1995 to 2004. It examined the industry effect and idiosyncratic firm characteristics that might modify the effectiveness of IT management. This paper attempts to: (1) contribute to a better understanding of the determinants of IT effectiveness, and (2) provide an empirical testing of the industry and firm effects analysis in the context of IT management.

II. Literature Review

A. IT adoption and performance implications

Due to the considerable investment in IT by today's business

organizations, studies at the firm level are primarily concerned about the implication of IT adoption to firm performance. Although the information technologies are designed to deliver value to firms through either improving quality or lowering costs, empirical studies had provided equivocal results regarding the IT payoffs [4],[5]. While some authors reported positive relationship between IT investment and the firm's productivity growth, a lot more found otherwise [11],[12],[4]. Although methodological issues have been quoted as accounting for a majority of the lack of consistence in the findings, evidence was also available that the IT investment – firm performance relationship is far more complicated than intuitively anticipated [4].

A growing body of literature reports that the contribution of IT to the firm performance is actually contingent on external and internal factors to the firm [13]. A contingency relationship between IT investment and firm performance was found in [5]. It is possible that some other factors may influence the effectiveness of IT management. This may also complicate the relationship between IT investment or the physical technology assets and the firm performance.

Existing studies had provided sufficient evidence to draw the conclusion that heterogeneity across industries and in firm capabilities could account for a portion of the variance in the IT performance across business organizations. Furthermore, the limited but successful attempts to apply the RBV concepts and arguments to IT management studies implies the fruitfulness of applying strategic management theories in the investigation of the economic value of information technologies. The behavioral theories have contributed to the individual level IT adoption studies. In the same manner, it is proposed that the theoretical and empirical evidences produced by the strategic management research would improve our understanding of managing IT effectively at the organizational level.

B. Theoretical tenets

Strategic management field is most concerned with firm performance. There are primarily two streams of thoughts regarding the determinants of firm performance throughout the evolution of the field; those who believe the factors external to the firm determine the firm performance and those who argue for the importance of the firm's internal characteristics in shaping the operating outcome [14], [15],[7].

Industry effect. The well-known Structure-Conduct-Performance (SCP) structure proposed by the industrial organization school emphasized the role of industry structure, which, in turn, determines the conduct of individual firms in the industry and hence their performance. Many of Porter's works laid the theoretical foundations for the I/O framework. His five-force model [16] is an essential representation for the determinant characteristic of industry structure on firm performance. Any firm has to operate within the context that is set up by the joint forces of the industry's suppliers, customers, potential entrants and the substituting industries as well as the competitive landscape within the industry. Since it is assumed that these forces affect all the firms within the industry in a homogeneous manner, the variance in firm performance is attributed to the differing industries but not the firms. The rigor of the I/O framework in explaining firm performance variance was reflected in a recent study [7]. Based on the empirical evidences drawn from more than 500 companies across 55 industries, the authors concluded that, except for a few outstanding leading companies and those lagging behind; industry determines the economic value that a firm can produce. It is suggested that industries with more favorable structures and higher growth potential will produce higher market values.

Researchers have explored the significance of industry effect in determining IT strategy and its performance. Intuitively, the nature of production activities and products/services delivered would enable some industries to benefit from information technologies more than the others. Information technologies in general have more implications to industries whose business operations rely heavily on the information and its exchange, including but not limited to financial services, healthcare industry, software industry and electronics industry [2]. Even where the same technologies were adopted, the level of complexity remained different [17]. Supply chain, for instance, has been one of the operational areas that witnessed IT-enabled revolutionary changes. Nonetheless, researchers have observed widening gap between investments in installing digitalized supply chain and supply chain performance. Fisher [18] attributed the performance failure to the mismatch between products and supply chain design and argued that depending on the nature of products, functional or innovative, a business should devise cost-efficient or market responsive supply chain respectively. Researchers had also conducted comparative studies and claimed that the IT investment in service sectors had yielded less performance improvement than that in the manufacturing sectors [19],[20]. In addition to the nature of products, the competitive pressure and regulatory environment, which are likely to vary across industry sectors, have implications to firm-level IT strategy [20],[21].

Firm-specific characteristics. It seems inevitable that opposing voices were heard not long after the I/O gained dominance in strategic management field. It could not be missed that some firms, within the same industries, outperformed their competitors and some went bankrupt. Strategic groups provided the first theoretical framework for understanding the intra-industry heterogeneity. Then the RBV approach stressed the importance of the resource bundle of a company in shaping the operational outcome. Since each company starts with differential resources and/or develops them differently, the variance in the firm performance is therefore explained by the resource endowed on the firm and the capabilities developed thereafter [14],[22].

The effectiveness of management strategies also varies due to firm heterogeneity. Despite of the promising effects of any strategy or technology, only the presence of the resources and capabilities that support the effective implementation will enable the firm to derive the desired level of benefits. Multinationality provides the theoretical benefits of economy of scale/scope; however, its actual impact upon firm performance was moderated by the R&D and marketing capabilities of the firm [10]. It is argued that R&D expenditure contributes to enhance a firm's technological capability [23], which, as an intangible asset, is difficult for competitors to imitate. A firm's R&D investment enhances its absorptive capacity [24] concerning absorbing, assimilating, interpreting, and utilizing external knowledge to enhance the effectiveness of IT management. The other study on the effect of total quality management (TQM) [9] found that firm characteristics such as size and capital intensity affected the success of quality program adoption and moderated this program's impact on the ultimate firm performance.

Realizing the importance of understanding firm heterogeneity, a number of recent IT studies applied the RBV theories to investigate whether different firm characteristics would impact the capabilities of their IT to deliver values to firm performance [6]. Researchers found that, instead of having direct impact on performance, the effectiveness of IT relies on the firm capabilities to deploy IT infrastructures to enhance the firm's core competency [25]. For example, researchers found that technological competencies as embedded in quality and qualification of employees are important antecedents to IT adoption; in addition, unique firm structure that

encourages employee participation is also crucial for implementing IT investment [20],[21]. In order for the online value chain transformation to actually improve firm performance, a firm should be equipped with critical resources/capabilities such as technologies, internal digitization initiatives and digitization initiatives of business partners (suppliers and customers) [26]. Similarly, IT-complementary intangible assets including unblocked communication between departments and members of organization, low levels of conflict, explicit support of top management and IT staff's learning and creative skills have significant implications for improving the speed and extent of IT adoption [27]. Based on their empirical analysis of an international dataset, factors external to the firm, e.g. political and industry factors, were found to moderate the firm's IT management [28]. However, these authors acknowledged that internal and firm-specific factors have more implication for the efficiency of e-Business; particularly, technology readiness, financial resources, global scope have positive impact while size has a negative impact on e-Business transformation efficiency.

Firm size is one of the most studied firm-specific characteristics that often function as contextual moderators. However, there is no agreement arrived as to its direct impact on firm performance or strategic practice. In view of the resource benefits associated with the size, large firms appear to be advantageous since they usually boast more financial resources, intelligent resources and general slacks, which provide firms with deep pockets for investment [29]. On the other hand, when speed and flexibility are under study, small firms were favored in that they have more flat structures, less bureaucracy and shorter communication channels and smooth information flow [9]. In initiating unique and diverse competitive attacks, the small firms are at advantage with its flexibility and nimbleness [8],[1],[30].

Firm size effect was frequently debated in innovation studies because the adoption and use of most information technologies require both capital investment, agility and adaptive capabilities. Some perplexing results had been found with regard to the size effect on IT or other innovation adoption [28]. Researchers found that continuous investment in IT infrastructure lends a firm significant technological edge over their competitors, leading to superior performance [19]. The ability to institute heavy investment, however, is directly related to firm size. In addition to capability consideration, smaller firms also experienced less normative pressure to adopt technologies in general [12],[31].

Nevertheless, once a small business becomes devoted to IT adoption, it's not necessary that they would be less efficient than their large counterparts in the process [32]. In a study of the assimilation of ITs that support collaboration, it was reported that companies with limited resources (in terms of revenue and IT budgets) actually diffused these technologies to a higher level than those with abundant resources [33]. Firm size was found to be negatively related to the effect of e-Business and anticipated that it was the structure inertia associated with large firms that prevent the firm to effectively undertake a transformation [28]. Alternatively, firms of different sizes may rely on different organizational structures (centralized vs. decentralized) to achieve the effectiveness of IT management [34].

Age is another demographic characteristic of the firm that has been extensively examined in relation to firm performance in general and the adoption of innovations in particular. Industry, size and age are indicators of the innovation introduction; in particular, new entrant in the market showed especially high probability of innovating [35]. Based on 150 magazine-publishing firms, [36] investigated the business process digitalization through the Internet and found that small and young firms are more likely to embark on such a project at strategic level. An investigation of the general characteristics of firms in the Swedish IT industry discovered that, while operating in the same industry, small, young and private firms experience extraordinary growth than their counterparts respectively [37].

Previous studies had revealed positive implication of Research and Development (R&D) intensity to firm performance. R&D function serves as a major source of competitive advantages for business organizations by developing new products or new processes of manufacturing to improve the efficiency of production [10]. The R&D intensity also represents the innovativeness of the firms and improves their technological capability. As one of the most important sources of sustainable competitive advantage [38], a firm's technological capability has a high degree of causal ambiguity so that it is inimitable. In this sense, high R&D intensity enhances a firm's technological capability so as to achieve above-normal returns [23]. However, studies in finance indicated otherwise. Although R&D effort is theoretically beneficial to firm performance, the level of R&D spending should be in line with the firm's actual needs. When R&D budgeting was not scrutinized within the overall strategic plan of the company, over expenditure in R & D may preclude the potential of investment in other functions [39].

Even though some pioneer researchers tried to distinguish between the industry and firm factors for identifying the dominant effects on firm performance [38],[40], recent studies shifted to recognizing the effects at both levels and discerning their respective explanatory powers [7]. In this study, two-level analysis was done in an attempt to find whether IT adoption level varies across industries in general and, additionally, whether firm characteristics would impact the effectiveness of IT management. To distinguish from most IT adoption studies, IT effectiveness was adopted as the dependent variable that stressed the decision-making aspect but did not necessarily delineate firm performance effect. The IT effectiveness emphasizes the outcome of IT adoption, including not only the firm's adoption of certain technologies, but also the process of implementing, using and evaluating the technology. Other than looking for what factors would prompt the firm to adopt technologies, this study focused on factors that determine the effectiveness of the IT function at a firm, which has an immediate and direct effect on the firm performance. Figure 1 illustrates our theoretical framework.

III. Methodology

Both time series and cross-sectional data were used. Using time series could eliminate the idiosyncrasies in the dependent variable associated with certain time period while cross-sectional data allows for generalization across industries [7],[10].

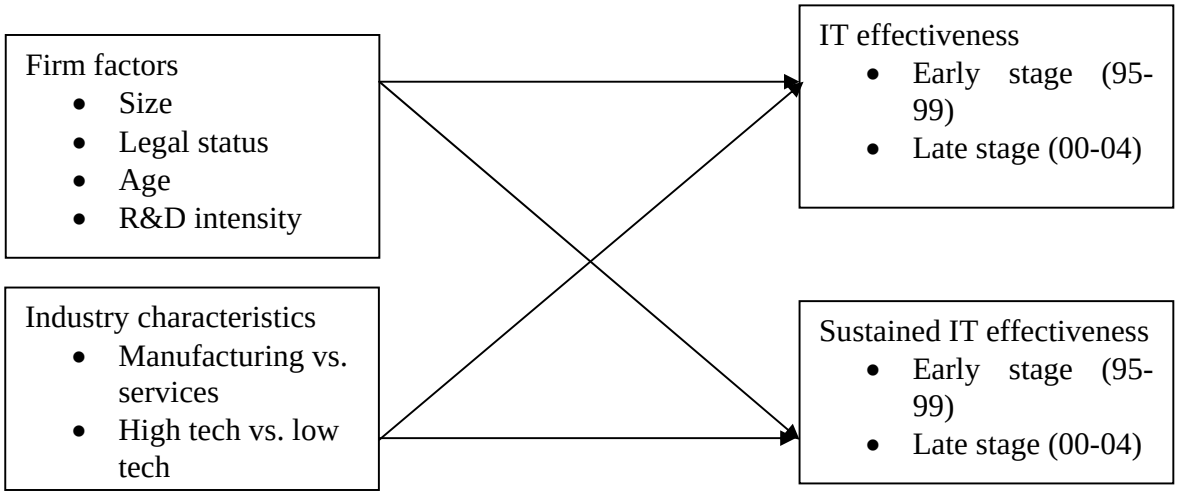

Fig. 1 Firm factors and industry characteristics—IT effectiveness Framework

A. Sample

The population of the companies that were selected were the annual 100 honorees by *CIO* magazine as the sampling base. This decision was made based on the following considerations: (1) Inaugurated in 1987, and *CIO* serves an audience of more than 140,000 CIOs and senior executives who are responsible for steering and managing their companies' technology and management; (2) Starting 1988, *CIO* annual 100 Honorees are awarded to the firms that demonstrate superior achievement in a specific aspect of IT management that is chosen by the magazine in correspondence to the contemporary IT management needs (see Table 1 for a summary of the 100 Honoree themes for the last ten years); (3) Each year, the honorees are selected through a structured process and criteria from a wide range of candidates by judges with sufficient IT expertise. The selection process is usually initiated by the open nomination to the business world to invite both applications and referrals, followed by the second stage where a panel of experts and veteran *CIO* magazine editors and writers split into teams to consider each entry. Ones which made through the first review were reviewed again by the editors and writers. The candidates were evaluated according to a few pre-determined criteria that were developed around the theme of the year.

Even though the CIO 100 Honorees had been in place for 17 years, only the honorees in the 10 years ending 2004 were used to compile the sample for this study due to the constrained access to the data source. Due to the existence of repeated winners, less than 518 firms were included in the winners lists for the 10-year period, covering a wide range of industry lines in both manufacturing and services. Even though the invitation of application for the award was open to companies of all nationalities. The dominance/predominance of the U.S. companies in the audience and the superior access to IT enjoyed by US companies in general, a majority of the winners are U.S-based with a small fraction of international companies.

The original sample was subsequently screened in several ways. First, the non-profit organizations were dropped from the sample. Even though a number of government agencies, education institutions and international organizations had been successful in adopting IT functions and provided great lessons to the business world, nonprofit organizations demonstrate distinctive characteristics from the business firms. As this study aims to investigate the firm characteristics' implication to its effective IT management, the exclusion of the non-profit organizations will improve the homogeneity of the sample and thus the validity of the research results.

Secondly, the demographic and financial information for the 4 remaining 486 companies were obtained from the COMPUSTAT database (See the next section for the information served as the measures of the independent variables). The longitudinal data presented some unique challenges for data collection. Some of the firms do not exist at the end of the 10-year period due to mergers and acquisitions or simply due to operational failure while some others reporting missing values for the major variables. Such firms were eliminated from the sample.

Lastly, after reviewing the industry range represented by the 2-digit SIC codes, it was found that some industries were only represented by a limited number of firms. Based on the number of companies in an industry that ever won the award during the period, eight industries (chemical, computer equipment, electronic, transportation equipment, wholesale trade, financial institutions, insurance and business services) that boasted most winning companies were selected. After excluding the firms from other industries, a final sample composed of 1,380 observations for 138 firms across eight distinct industries at 2-digit SIC codes over the 10 years period was obtained (Table 2). To account for the bias that might occur during the selection process, t-test on key variables was conducted. No significant differences were found between selected and non-selected companies on the firm size and honoree lists

TABLE I
SUMMARY OF THE CIO 100 HONOREE THEMES (1995-2004)

Year	Theme for CIO 100 Honorees
1995	Excellence in five key business categories
1996	Successful globalization efforts
1997	Excellence within five categories of best practices
1998	Value chain management
1999	Well positioned to succeed beyond 2000
2000	Customer connection
2001	Innovation generation
2002	Creativity and wisdom, robustness and ROI, impact and lessons learnt
2003	Resoursefulness
2004	IT & enterprise agility, impact, ROI

TABLE II
THE OVERALL IT EFFECTIVENESS STATUS ACROSS EIGHT INDUSTRIES BY FIRMS CHARACTERISTICS (N=138)

Description of the Industry	Number of Companies	Number of Honorees	Legal Status (Public=1)	Legal Status (Private=0)	R&D Intensity	Number of Years	Number of Honorees (94-99)	Number of Honorees (00-04)	One-time winner	Sustained winner
Chemical	18	46	17	0	4.04	10	27	19	10	8
Machinery & Computer Equipment	23	54	21	2	5.06	10	34	20	12	11
Electronic	14	32	14	0	5.12	10	17	15	5	9
Transportation Equipment	13	25	11	2	8.72	10	14	11	5	8
Wholesale trade	12	17	8	4	.	10	7	10	8	4
Financial Institutions	17	43	15	2	.	10	29	14	6	11
Insurance	17	30	10	7	.	10	16	14	9	8
Business Services	24	35	22	2	4.60	10	21	14	19	5
Total	138	282	118	19	5.5	10	165	117	74	64

Since a majority (54%) of the sampled firms are one-time award winners and the rest won the award about 3 times in average during the 10-year period, the observations for the years when the sampled firms did not win the award formed a proxy of the control group, in contrast to the observations in which the firms were award winners. Therefore, based on the sample consisting of both award-winners and non-award-winners, the effects of industry and firm factors on the effectiveness of the firm's IT practices could be investigated. In addition, this sampling base also excluded the companies that don't adopt IT practices at all.

IV. Measures

IT Effectiveness: measured as a binary variable with 1 representing that firm *i* won the *CIO* award in year *t* and 0 otherwise. In the past IT adoption studies at both individual and organization level, the dependent variables – the adoption decision, degree of adoption, system use, satisfaction and intention to adoption – are usually self-reported measures by a representative of the organizations, while the current measure present a relatively more objective measure.

Sustained IT effectiveness: Since evaluating criteria were developed each year around different themes in selecting the winners, those who won the award for one year might excel at a different aspect of their IT practice from the next year's winners. It is proposed that the IT effectiveness that one-time winners achieved is more accidental in nature while those who won at least two awards during the period are considered consistent good performers. A comparison between these two cohorts may reveal the differences between the actual good IT adopters and the rest of the business population. Accordingly, a binary variable was created for each observed company, 0 representing its membership in the one-time winner group and 1 those achieving sustained effectiveness of IT management.

Industry: It was measured by a categorical variable with values corresponding to the distinct 2-digit SIC codes represented by the companies in the sample. The 4-digit SIC codes were originally obtained for the companies from the *Business and Company Information Center* database. Since a great amount of distinct industry lines were covered with only a few companies in each category, these SIC codes were aggregated into 2-digit codes, which represent industry sectors with appropriate specificity for interpreting the data analysis results.

Firm size: It was measured as the annual sales and the number of employees of the sampled firms. Even though some strategic management research used market share as the proxy of firm size [7], the annual sales and the number of employee were used in this study due to its higher relevance to the adoption of IT processes. Both measures had been used in previous studies on innovation or IT adoption studies [28]. The data were retrieved from *CompuStat*.

Legal status: The ownership structure of the firm was measured as a binary variable: 1 representing publicly traded companies, and 0 private companies. The information was extracted from the *Business and Company Information Center* database.

Firm age: This was measured as a numeric variable. The information was extracted from *Business and Company Information Center* database.

R&D intensity: It was measured as a numeric variable which was calculated by dividing the firm's annual R&D investment by its revenue over the 10-year period. The data was obtained from *CompuStat*.

V. Model and Statistics

The following models were postulated for statistical analysis:

Equations one (main effect):

Model:

$$Y = \beta_0 + \sum \beta_1 D_t + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + \beta_6 X_{6it} + \mu_{it} \quad (1)$$

Where:

D_t = dummy variables for ith SIC (7 dummies for 8 industries)

X_{2it} = Age of firm i in time period t (Age)

X_{3it} = Legal status of firm i in time period t (Legal)

X_{4it} = Employees of firm i in time period t (Emp)

X_{5it} = R & D intensity of firm i in time period t (RDI)

X_{6it} = Revenue of firm i in time period t (Rev)

μ_{it} = Random error of firm i in time period t

β_1 to β_6 = Parameters to be estimated

Equation two (interaction effect):
Model:

$$Y = \beta_0 + \beta_2 X_{2it} + \beta_6 X_{6it} + \sum \beta_1 D_t X_{1it} + \sum \beta_2 D_t X_{2it} + \sum \beta_3 D_t X_{3it} + \mu_{it} \quad (2)$$

Where:

Y=binary, indicating the probability of "I" (honoree selected=1, 0 otherwise)

$D_t X_{1it}$ = Industry effect interaction with age

$D_t X_{2it}$ = Industry effect interaction with revenue

$D_t X_{3it}$ = Industry effect interaction with employee size

and

Equation three (one-time winner vs. sustained leader):
Model:

$$Y = \beta_0 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_t \quad (3)$$

where:

Y=binary, indicating the probability of "I" (sustained leader=1, temporary performer=0)

X_2 = dummy variables for ith SIC (7 dummies for 8 industries)

X_3 = age of the firm

ε_t = random error

TABLE III
THE LOGISTIC REGRESSION MODEL WITH MAIN EFFECTS AND INTERACTION EFFECTS ON IT EFFECTIVENESS

	Wald statistics	df	Sig.	Exp(coefficient)	Resid. Dev	Deviance
Main Effect					18.1904	
Industry						
SIC 2800	7.09	1	0.0077***	-0.669		
SIC 3500	5.96	1	0.0146**	-0.5862		
SIC 3600	4.1	1	0.0427**	-0.5513		
SIC 6000	9.01	1	0.0027***	-0.7667		
Age	1.0595	1	0.3033	-0.00207		
Revenue	6.68E-06	1	0.0152**	-0.00002		
Employee	4.2046	1	0.0403**	0.0062		
R&D Intensity	3.5116	1	0.060*	-0.005648		
Interaction Effect					11.4807	6.7097
Industry*Age		1				
SIC 2800	4.69	1	0.0303**	-0.00397		
SIC3700	2.86	1	0.0907*	0.00661		
SIC6000	4.17	1	0.0411**	-0.00344		
Industry*Emp		1				
SIC 2800	6.2151	1	0.0127**	-0.00181		
SIC 3600	3.47	1	0.0622*	-0.00649		
SIC 3700	3.99	1	0.0457**	0.0042		
Industry*Rev		1				
SIC 2800	4.05	1	0.0071***	0.0061		
SIC 3600	1.37	1	0.0112**	-0.0044		
SIC3700	2.82	1	0.0571*	0.0059		

p<.1,**p<.05,p<..01***

VI. FINDINGS AND DISCUSSIONS

Equation 1 was estimated using the Fuller and Battese method (implemented by the TSCS procedure in SAS) and the results are given in Table 3.

First of all, *employee size*, *firm revenue*, and *R&D intensity* are found to have significant (α= 0 .10 level) impacts on firms IT effectiveness. Even though *age* effect is not significant across all industries, it has a negative relationship towards IT effectiveness. Our analysis indicates that employee size has a positive effect on firms' IT effectiveness.

In general, the odds of a firm being named as honoree, or achieving IT effectiveness, increases by 6% (obtained by [exp (0.0620) -1] x 100%) for every 10 thousand increase in the number of employees. On the other hand, the chance that a firm achieves high IT effectiveness decreases by 6% for every additional 10 million increase in a firm's annual revenue. While the reasons for the conflicting effects of the employee size and annual revenue on the firm's IT effectiveness remain unknown, we suspected other moderating factors exist that might complicate the size – IT effectiveness relation. Detailed discussion can only be made after those factors were incorporated (see model 2).

On the other hand, firms' R&D intensity has a significant negative impact on their IT effectiveness. As the analysis indicates, the chances of not being named honoree increase by 4.78 time for every one-percent increase in R&D intensity, all else variables being *equal. This finding is consistent with early studies.*

For instance, the announcement of increases of R&D expenditure was found to be associated with systematic decreases in the announcement of firms stock price [41]. Jensen [39] further reconciled the conflicting negative effect of R&D expenditure and firms performance by applying agency theory of free cash flows . The author argued that when managers are provided with large cash flows, they are more likely to undertake low-benefit or even value-destroying activities. Thus, it is reasonable to explain that the overall effect of R&D intensity on IT effectiveness could be negative if the investment surpasses a certain threshold. In other words, R&D investment can be very beneficial, but only in the situation that it is directly linked to effective IT practice; premature use of R&D expenditure may harm firms' performance.

Second, it was examined whether industry effect play an important role in determining firms IT effectiveness. Excluded were firms that are considered strategic leaders in our industry analysis to ensure the overall industry effect is not skewed by individual firms. First the standardized residual was computed to identify potential outliers that performed extremely well over the 10-year period and then repeated the outlier test until no more outliers were detected.

These findings indicate that there are significant differences among industries in determining IT effectiveness (table 3). Specifically, based on the logistic regression analysis, chemical

industry, computer industry, electronic industry, and financial institution, performed significantly differently from the average industries (using business services as a reference category) because its honoree frequency is close to the mean value of honoree winners among all the industries (Mean$_{honoree}$= 35, business services $_{honoree}$ = 35.25). Unique to the current study about external effects on firms' IT effectiveness, the function indicates that, holding other terms constant, the odds of a firm in chemical, computer, and electronic and financial institutions to achieving IT effectiveness is higher than in others. An exploration of the causes for their superior IT achievement in a later analysis provides more evidence.

Subsequently, it was estimated that equation 2 would identify interaction effects between industry and firm characteristics (Table 3). To ensure that two-way interaction effect adds power to the main effect model, residual deviance test was conducted which is equivalent to the residual sum-of –squares in the usual regression analysis. Thus the present results indicate that interaction effect significantly adds explaining power to the prediction of firms IT effectiveness (Table 3).

First, chemical industry and electronic industry experienced significantly negative effect of employee size on IT effectiveness, whereas transportation equipment industry experienced significantly positive effect of employee size on IT effectiveness. For instance, for every additional 10 thousand employees in the transportation equipment industry firms, the odds of achieving IT effectiveness increased by 4.3% (obtained by [exp (0.042)-1] x 100%).

Previous studies had found negative relations between employee size and the innovation adoption behavior at financial services industries [28]. It was suspected that as most innovations in business processes involve a wider range of employee users in such industries as financial service and electronics than in the transportation equipment industry, the inertia to change is likely to exist given a large employee body.

Further, the result indicates that IT effectiveness varies across the companies of similar age in different industries. To be specific, the function implies that, holding other terms constant, the odds for any chemical firm and financial institutions to achieve IT effectiveness decrease by 3.8% (obtained by [Exp. (-.0397)-1)] x 100%) for every 10-year increase in firms' age. On the other hand, for firms in transportation equipment industry, the odds of a firming being honored increase by 6% for every 10 additional years in firms' age.

Meanwhile, it was confirmed that revenue has significant effect on firm-level IT effectiveness and the relationship varied across different industries. It is interesting to find that the odds of a chemical industry or transportation equipment firm achieving IT effectiveness increase by 6% for every additional 10 million dollar increase in revenue. However, for the firms in the electronic industry, revenue appears to negatively impact firm-level IT effectiveness.

In examining the difference between one-time honorees and two-time and above honorees, a MANOVA analysis was conducted. This was followed by a post-hoc Scheffe test. The result of the MANOVA and the follow-up Scheffe test both indicate factors differentiating the two groups.

As demonstrated by Figure 2, the numbers of the two types of performers are significantly different among different industries. Of most interest is the fact that *electronic* (SIC 3600), *transportation equipment* (SIC 3700), and *computer industries* (SIC 3500) have more firms than other industries that had been repeatedly honored for their IT excellence (time of award winning >= 2). In the previous industry effect analysis, chemical, electronic, financial institutions and computer industries were found to have achieved above-average IT effectiveness. Firms that have achieved persistent IT effectiveness might have tilted the balance toward such industries as electronic and computer.

Finally, to fully investigate the time effect, the study examined the differences between the early stage (from 1995 to1999) and the late stage (from 2000 to 2005) concerning firms IT effectiveness, using a two-group MANOVA. Again, there are significant differences among industries in terms of the time period that they achieved IT effectiveness. Figure 2 suggested that, chemical industry, computer industry, financial institutions, and business services had more honorees during the first half of the 10-year period. On the other hand, electronic, trade, transportation and insurance industries did not experience much variation in their IT effectiveness level over time.

There is a two dimension cross tabulation as illustrated in Table 4. While along the horizontal dimension there are two values – one-time winner and sustained leader, the vertical dimension was anchored by early and late stages respectively. After assigning the industries to the corresponding quadrants, it is interesting to note that most industries are either one-time winners in the recent years or sustained winners in the last decade of 20th century, and there is no sustained winner in the 21st century, so far. Whether this phenomenon is attributable to the fact that it is becoming more difficult for companies to catch up with technological advances or sustainability per se is not important in today's competition requires further investigation.

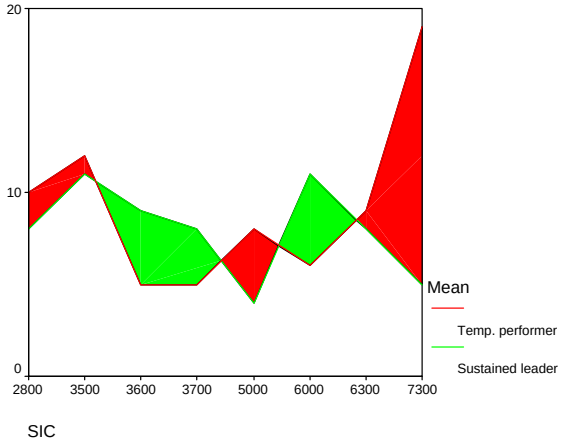

Fig. 2 One-time winners and sustained winners across industries

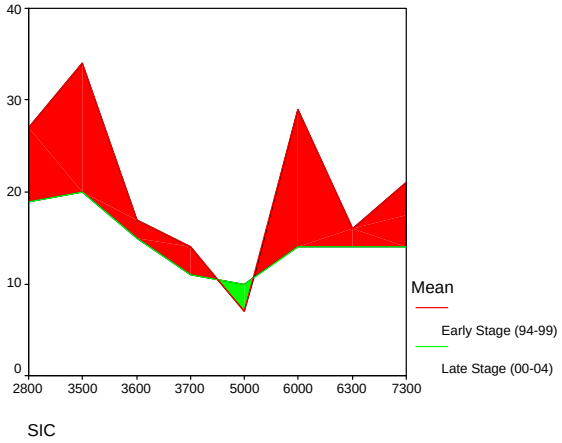

Fig. 3 Early Stages and Late Stage IT effectiveness across industries

TABLE IV
FIRMS IT EFFECTIVENESS SUSTAINABILITY OVER 10—YEAR PERIOD ACROSS INDUSTRIES (1995-2004)

	One Time Winner (One-time Honoree Winner)	**Sustained Winner** (Tw times or above honorees Winner
Early Stage (1995-1999)	Chemical Industry Business Services	Financial Institution Transportation Equipment Electronic
Late Stage (2000-2004)	Wholesale Trade	?

VII. CONCLUSION

The main purpose of this paper is to investigate whether there are industry and firm effects on the effectiveness of firm-level IT management. The findings of this study provide another empirical testimony of the central arguments of the I/O theory and RBV. While the previous empirical examination of the industry and firm effect usually used firm performance (even though measured in different ways) or certain strategic management practices (such as the adoption of TQM), this study applied the framework in the IT adoption context and received some results confirming the effects of the industry certain firm attributes argued by I/O and RBV. These findings further confirmed the I/O theory that there are variations across the industrial environment for the organization to achieve IT effectiveness. Further, in exploring the relationship and interactions between the organizational environment and firm characteristics, firm age, revenue, R&D intensity, and employee size, also contributes to the explanation of achieving IT effectiveness within a specific industry context. For all industries in general, too much R&D investment may harm firms' effective IT management, which indicates that management should be cautious about the fact that, even though it is occasionally expected by the society, excessive R&D investment might lead to inefficient resource allocation,. It is also critical to acknowledge that the stronger the competition in the industry, the larger the divergence from efficiency and social optimum [42]. Hence, management in highly competitive industry should pay special attention to the firm characteristics, such as age, size, and revenue, among others combined to enhance their IT effectiveness.

This study has implications for practitioners in that it amended previous IT adoption studies at the end-user level and contributed to a better conceptual understanding of the IT adoption in business organizations. The results could help the managers to form appropriate expectation of IT projects and develop proper evaluation criteria. Since industry media are intuitively enthusiastic about successful stories of innovative practices or technologies, managers that are to adopt the innovative strategies sometimes form their expectation based on those successful experience without knowing the drivers of the success. Understanding the variance in IT effectiveness and some of the driving forces will enable the managers to develop grounded expectation and effective IT budgeting.

Nevertheless, the study suffered a number of limitations that call for improvement in the future studies. One question that frequently arises in data analysis is whether or not one variable can help forecast another economic variable. In other words, does changes in one variable result in changes in the other variable or the relationship is working in the reversed way? After identifying the positive relationship between firm revenue and IT effectiveness, the question remains whether more R&D investment results in better performance (measured by revenue), or higher revenue enables more investment into R&D expenditure. This question has very significant implication in directing the R&D investment.

One way to address this question is to test whether lagged information on one variable (say Y) provides any statistically significant information about the other variable (X) in the presence of lagged X. If not, then "*Y* does not Granger-cause *X*." In this sense, to do further research on the causality between the revenue and honoree frequency by running the regression of honoree frequency on revenue and lagged revenue is hoped. Therefore, the problem in testing the causality is how to choose the proper lag on major variables. More analysis will be done on this issue in a later research.

The selection of independent variable forms another source of limitation. This study examined a small number of company characteristics, which only provided limited explanation to the variance in IT effectiveness. This decision was made based on the scale of the current study but at the cost of the robustness of the model. Another cause for this unexhausted list of firm characteristics is the absence of established theories regarding the effectiveness of IT management in business firms. While the factors examined here are most quoted in previous IT studies, other firm-specific features such as the diversity of business, the innovativeness of the firm, and the technological self-efficacy were also mentioned. Future studies should include more IT oriented firm factors and examine their capability of explaining the variance in IT effectiveness across firms.

Future studies could also expand the scope of analysis by incorporating individual-level factors. The executives of the firms, particularly those charged with the essential IT responsibilities, were considered the "change agents" who play an important role in the adoption of innovative practices. For example, the CIOs' characteristics, including demographic data, career paths as well as personalities, would determine the effectiveness with which they carry out their job responsibilities, which, in turn, would impact the overall quality of the IT function to certain extent. The findings from previous studies targeting the end-users could also be incorporated to provide explanation jointly with firm-level factors. Given appropriate timelines and budget, future research could collect detailed information through multiple channels and conduct a multi-level (industry-, firm- and individual-level) effects analysis.

Research agenda could also be developed to investigate the implication of the sustainability of IT effectiveness to firm outcome. The unique pattern of the sustained IT effectiveness demonstrated in Table 4 provides some inspiring information as to the demands on IT management from today's business world. Has it become to an age when no sustainability is necessary for successful competition? The emergence of new themes that the *CIO* magazine uses to select their annual winners every year indicates a highly dynamic business environment for IT management. Eisenhardt & Martin [43] once pointed out that, considering the velocity of market change and competition, sustained competitive advantages, that were once valued, might not be as effective as a series of short-term advantages that adapt to the market demands constantly. Future studies could investigate whether this statements holds true in the IT adoption in the business organizations.

Finally, it is noteworthy that effective information/knowledge management depends not merely on information-technology platforms but more broadly on building an effectiveness social ecology so that people are willing to share their knowledge [44]. The notion of managing IT that creates competitive advantages needs to be extended beyond the "hardware" side of IT management. Indeed, if a firm can create and manage an information/knowledge-sharing network, in addition to an effective IT management, it will be superior at sustaining its competitive advantage.

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