THE EFFECTS OF INFORMATION TECHNOLOGY INFRASTRUCTURE CAPABILITY ON PROJECT PERFORMANCE IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract

Information Technology (IT) has been widely applied across many economic sectors in order to increase performance, productivity and competitiveness. In particular, an improvement in the applications of information technology in construction is a major international research endeavour in scientific establishments and industry. This paper investigate the level of IT usage in construction consulting companies as well as exploring various information technology tools being utilized in the process of managing project performance during construction activities. The study was divided into two phases. First, quantitative research method was conducted to collect data from 143 consulting companies and second, a qualitative research method was conducted on seven practitioners to explore how IT affect project performance as well as various IT tools being used in construction through semi structured interviews and observation. The study revealed a positive link between IT and project performance. Finally, a framework is presented which identifies factors and tools by which IT impacts project performance in construction.

Keywords: Information Technology Infrastructure Capability, Project Performance, Construction Consulting Industry

1. Introduction

Though many of the construction contractors including consulting companies are progressive enough to aspire to automate their processes, the numerous subcontractors and partners working under them often lack the necessary resources, and sometimes are not technologically advanced enough to embrace the essential elements of automation (Neelamkavil et. al, 2008). The US National Institute of Standards and Technology (NIST) published a study that identified and estimated the efficiency loss of $15.8 billion in 2002 in the US capital facilities industry resulting from poor interoperability, wrong and inefficient IT implementation among computer-aided design, engineering, and software systems (Gallaher, 2004). According to FIATECH, a sub-organization of American Construction Industry Institute (CII), among the major problems on IT implementation in the construction industry include: (1) difficulty to access accurate data, information, and knowledge in a timely manner in every phase of the construction project lifecycle; (2) lack of interoperability between systems, with several standards competing for managing data; (3) suitable software tools are not exist; (4) tools for project planning and

enterprise management are maturing, but an integrated and scalable solution that delivers all needed functionalities for any kind of projects is not available; (5) lack of risk management; and (6) lack of security concerns (FIATECH, 2004).

In 2004, FIATECH focused on IT implementation in construction and has created a Capital Projects Technology roadmap to integrate various functions and required information in a unified project/facility management environment (O'Brien et al., 2004). Based on a review of the construction IT literature in general Boddy et al. (2007) proposed a process driven vision for the integration of construction processes. Isikdag et al. (2007) presented some historical background of building information modelling (BIM) and particularly reviewed the storage and exchange mechanisms for building information models. Bakis et al. (2007) conducted a comprehensive literature review on the development of standard building data models and model mapping languages. O'Brien et al. (2008) discussed key challenges and approaches for distributed construction process integration and particularly presented the SEEK – Scalable Extraction of Enterprise Knowledge toolkit as a mechanism to discover semantically heterogeneous source data. Being complementary to all these review and overview articles, this paper seeks to present a framework of IT Support System in Consulting Industries by integrating Information Technology Infrastructure Capability (ITIC) which includes Integration Capability, Collaboration Capability, Data Management Capability, Data Security Capability, Utility Capability and Basic IT Services Capability (Kim, 2001) with project performance by taking into consideration contextual factors in the form of barrier management as well as internal and external push factors. The proposed framework is designed to solve issues on integration and interoperability which was raised by FIATECH (2004) as well as integrating with the latest relevant software tools to be used as a guide to construction companies including consultants and contractors to improve their IT implementation.

2. Infrastructure Capability

Figure 1 shows the initial ITIC concepts introduced by Kim (2001) which combine, integrate and coordinate IT infrastructure components with the most important factor for competitive advantage which is human skills.

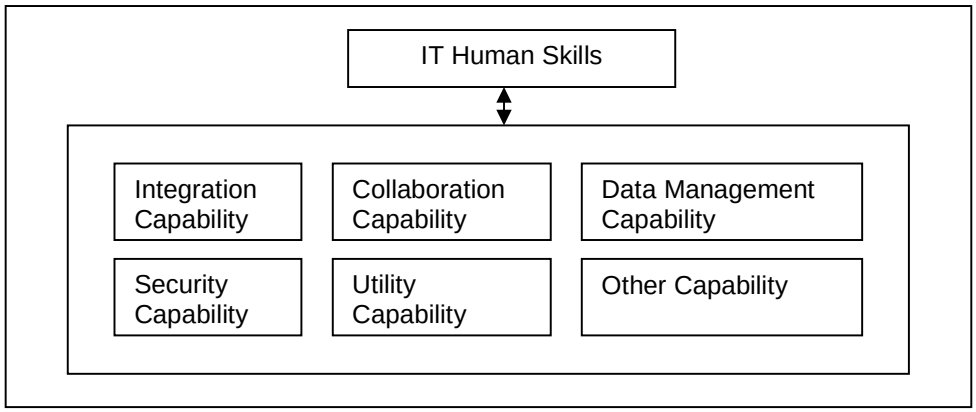

Figure 1. ITIC Concepts (Adapted from Kim, 2001)

2.1 Integration Capability

Integration refers to the connection of individual IT components and services for the intention of sharing software, communications and data resources and the degree to which information can be directly and automatically shared across systems and services (Keen, 1991). O'Connor et al. (2004) introduced The Industry-Wide Mid-Tech Work Function (WF) Index to measure the technology integration utilization among industry pertaining to the following 15 work functions: access to supplier product information, analyze construction methods, link supplier quotes to cost estimate, transmit requests for proposal to suppliers and subs, prepare & submit shop drawings, compile quotes into bid, communication construction progress, develop short-term work schedules, update as-built drawings, evaluate subsurface conditions, acquire & record laboratory test information, track equipment maintenance history, develop equipment maintenance plans, train facility operators and update as-built drawing. In another study of IT integration, Kraft et al. (2007) developed the "Toaster Model", which outlines the functionality required to support the integration process. The dimensions of functionality addressed by the model include: data integration, repository manager; control integration, subsystem interaction manager, presentation integration, user interaction manager, process integration and the development manager.

2.2 Collaboration Capability

Collaboration refers to efforts by two or more individuals in order to perform certain tasks. People work together on tasks from designing products to teaching each other. Collaboration capability improves group working and knowledge sharing. Collaboration capability allows for groups of people to work together. Keen (1991) explained this concept as linking people and allows collaboration between them beyond space barriers. Nowadays, collaboration capability is commonly applied in electronic intermediaries (EIM) which is focused on electronic marketplaces. Muylle and Basu (2008) identify three market-making functions that can be supported by electronic markets, i.e., identification of potential trading partners, selection of a specific partner, and execution of the transaction. In an Internet-based setting, Bakos (1998) describes two functions that are provided by Internet-based electronic marketplaces: (1) matching buyers and sellers; and (2) facilitation of transactions. The process of matching buyers' demand with sellers' product offerings involves buyers' determination of product features offered by sellers as well as the aggregation of different products by the marketplace, search of buyers for sellers and of sellers for buyers, and price discover; while the facilitation of transactions comprise of logistics, payment settlement, and the establishment of trust. In another study on collaboration capability by Held and Blochinge (2009), collaborative workflow system has been introduced. There are three sub-processes of collaborative workflow, which Kambil and Heck (1998) term as coordination, production and decision-making. As such, coordination denotes the planning and assignment of tasks to collaborators, while production means collaborative development. Decision-making is the base of coordination and requires analysis of the outputs.

2.3 Data Management Capability

Data has become an important organizational resource shared by multiple users at different levels of management and across various functions. Data is also shared by multiple IT

applications. Data resource itself is an integral part of ITIC implying a database management system is the most critical component of any data management capability (Perks and Beveridge, 2003). The value of an Information System (IS) is directly related to the quality of the data. Garbage-in-garbage out is a popular cliché in the IS field. The popular KM technologies such as data warehousing, data mining and knowledge mining cannot be possible without proper data captured.

2.3 Security Capability

Security refers to the policies, procedures and technical measures used to prevent unauthorized access, alteration, theft or physical damage to information system. This became a critical issue in ITIC with the advent of the internet. In a broader sense, security includes disaster management and recovery planning management (Weil and Broadbent, 1998). Currently, the Model-Driven Security system is conceived as a new approach towards building secure information systems, in which designers specify high-level system models along with their security properties and use tools to automatically generate system architectures from the models, including security infrastructures. The model focuses on three aspects: (1) the system models are enriched with primitives and rules for integrating security into the development process; (2) the model transformation techniques are extended to ensure that these security details are also transformed; and (3) the system is obtained, including the security properties and the corresponding security mechanisms (Alam et al., 2009).

2.3 Utility and Other Capability

IT Utility and other capability refers to supporting services including technological advice and support services for internal requirement, provide training services for new technologies (e.g., software training, etc), utilize Information System (IS) for project planning, project management, manage and negotiate with suppliers and subcontractor (by tenders, quotations in buying or dealing) (Kim, 2001). It includes electronic linkages to suppliers or customers (e.g., website, E-mail address, etc) and common systems environment for all users.

3. Project Performance

In recent years, significant research advancements have highlighted that the typical project performance indicators are still cost, time, scope and quality (Gomar et al. 2002; Feng et al. 2000; El-Rayes 2001; El-Rayes and Moselhi 2001; Hegazy and Ersahin 2001; Hegazy andWassef 2001; Leu and Hwang 2001; Jaraiedi et al. 1995; Ellis and Amos 1996; El-Rayes and Hyari 2004). Project cost is one of the main performance indicators for construction project. The construction cost includes both the initial capital cost and the subsequent operation and maintenance costs (Hendrickson, 2000, El-Rayes and Hyari 2004).

Project time is to match the resources of equipment, materials and labor with project work tasks over time. Good timing or scheduling can eliminate problems due to production bottlenecks, facilitate the timely procurement of necessary materials, and otherwise insure the completion of a project as soon as possible. In contrast, poor scheduling can result in waste of laborers and equipment. Delays in the completion of an entire project due to poor scheduling can also create

havoc for owners who are eager to start using the constructed facilities (Hendrickson, 2000, El-Rayes and Hyari 2004).

Project scope refers to all the work involved in creating the products of the project and the processes used to create them (Schawalbe, 2010) in order to deliver within the specified features and functions based on the scope baseline document. According to Bainey (2004), the major components of a scope baseline document that formally authorize the project and align with the deliverables from business management, IT management and project management are: (1) project value justification which consists of the project requirements/business needs, objectives/benefits, strategy/approach/principles and critical success factor; and the (2) product scope which consists of the business requirements, database requirements, data requirements, application requirements and technology requirements.

Project quality is one of the important concerns for project owners and managers. With the attention to conformance as the measure of quality during the construction process, the specification of quality requirements in the design and contract documentation becomes extremely important. Quality requirements should be clear, measurable and verifiable, so that all parties in the project can understand the requirements for conformance (Hendrickson, 2000, El-Rayes and Hyari 2004).

4. Methodology

4.1 Initial Research framework

Triangulation was used as the main research methodology in this study to support the initial research framework as shown in Figure 2. According to Altrichter et al. (2008), triangulation gives more detailed and balanced overview of the situation studied. In addition, O'Donoghue and Punch (2003) view triangulation as a "method of cross-checking data from multiple sources to search for regularities in the research data" (p. 78). In this study, qualitative findings are used to support and complement quantitative findings to give more insight of the situation studied.

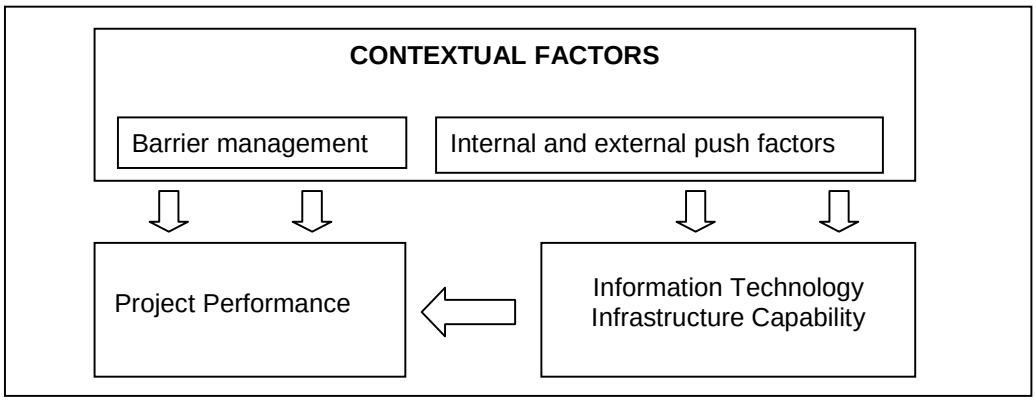

Figure 2. Initial Research Framework

4.2 Quantitative Research Method

Data is collected based on a survey questionnaire which incorporates the four project performance constructs and the 23 attributes as well as five constructs representing IRIC comprising of 24 attributes which were summarized from the literature review. In the questionnaire, the respondents were asked to rate each item based on a five point Likert scale ranging from (1) strongly disagree to (5) strongly agree.

The sampling which consists of the construction industry consultants were obtained from various construction consulting bodies such as Board of Engineers, Architect and Quantity Surveyor. The list includes 500 active consultants comprising of engineering, quantity surveying, architectural and project management consulting companies (refer Table 1). Based on recommendation by Israel (1992), a minimum target of 132 was determined to be adequate for the study by using random sampling technique. Factor analysis and reliability coefficients will be conducted and determined respectively. Construct validity using factor analysis was used to reduce and summarise data in which redundant items are combined and inappropriate items were deleted (Hair et al., 1998). For purpose of this study, a reliability coefficient above .70 will be used to gauge statistical reliability (Rasli, 2006). Subsequently, correlation analysis will be conducted to determine the relationship between project performance and ITIC.

Type of Consulting Companies	**No of companies**
Engineering	200
Quantity Surveyor	125
Architecture	125
Project Management	50

Table 1. Population of the Study

4.3 Qualitative Research Method

A case study methodology was used to collect the information. The approach allowed the collection of data not only through interviews with the consultants involved with the process, but also through written documentation that contained the stories, knowledge, experience used or written by these experts as part of the project and organizational knowledge related to ITI implementation. The data were collected from two main sources. First, all consultants have been interviewed based on the interview protocol prepared earlier. The interview protocol which comprises of 31 closed and open ended questions was developed to focus on the key issues on ITIC and project performance. These interviews were conducted over a three-month period, in tandem with our analysis of archival data. Second, we examined online and offline archival data concerning the projects undertaken. Most of the consultants maintained a comprehensive and voluminous archive. Data collected comprises of company profile, project-proposal reports, project reports, policy minutes and system documentation and promotional documents. The period covered was from 2005 to 2009, and this wide range of documents were especially useful in enabling us to understand how these consultants implement ITIC in their companies.

4.4 Sample

The sample was identified from members of Malaysian Board of Engineers, Malaysian Board of Architects and Malaysian Board of Surveyors and further recommended by the Malaysian

Construction Industrial Development Board (CIDB). The main criterion used for the selection of the consultants is the level of IT implementation in their companies as well as position and experience. Seven consultants were selected for the case study which comprise of architects, civil engineers, quantity surveyors and project managers with high position and highly experienced (refer Table 2).

Consultant	Position, Experience and Education	Scope of Business	Products and Services	IT Initiatives
A	Senor Designer with 9 years experience and bachelor degree	Architecture	Design services	Integrated Network System and Latest Software
B	Architect with 12 years experience and bachelor degree	Architecture	Design services	Integrated Network System and Latest Software
C	Senior Engineer with 5 years experience and master degree	Civil Engineering	Design and engineering services Structural analysis	Integrated Network System and Latest Software
D	Senior Engineer with 12 years experience and bachelor degree	Civil Engineering	Design services Engineering services	Intranet, Server System and Latest Software
E	Managing Director with 15 years experience and Master degree	Civil Engineering	Engineering services Project management	Server System and Latest Software
F	Technical Manager with 7 years experience and bachelor degree	Quantity Surveyor	Estimation services	Latest Software
G	Project Manager with 8 years experience and bachelor degree	Project Management	Project management Engineering services Estimation services	Integrated Network System and Latest Software

Table 2: Background of the Consultants Interviewed

5. Results

5.1 Quantitative Analysis

5.1.1 Descriptive Analysis

One hundred and thirty two consultants from the construction consulting companies were participated in the survey. Table 2 shows the background of the consultant. Based on Table 3, of 132 consultants, 83 are working with Civil Engineering companies and 76 of them are civil engineers, 22 architecture and 19 other position, 106 of them hold bachelor degree engineers, thus align with the sampling frame. Furthermore, most of the consultants are experienced with high level of, where 61 having more than 10 years experience and 106 of them are degree holders.

TYPE OF COMPANY	Frequency	Cumulative Percentage
Quantity Surveyor	10	7.6
Civil Engineering	83	70.5

Architecture	19	84.8
Others	20	100.0
COMPANY OWNERSHIP		
100% Malaysian ownership	128	97.0
Joint venture with foreign company	3	99.2
100% Foreign ownership	1	100.0
POSITION		
Quantity Surveyor	15	11.4
Civil Engineer	76	68.9
Architecture	22	85.6
Others	19	100.0
WORKING EXPERIENCE		
Less than 5 years	42	31.8
5-10 years	29	53.8
More than 10 years	61	100.0
EDUCATION LEVEL		
Diploma	11	8.3
Bachelor's degree	106	88.6
Others	15	100.0

Table 2. Background of Questionnaire Respondents

5.1.2 Factor Analysis and Reliability Test

Factors for IT infrastructure Capability are IT Integration Capability, IT Collaboration Capability, IT Data Management Capability, IT Security and Utility Capability and Other IT Capability, whereas factors for Project Performance are Project Time, Project Cost, Project Quality and Project Scope. Scale reliability coefficients using Cronbach's alpha was used to assess the consistency of homogeneity among items (Cooper and Schindler, 1988). Tables 3 and 4 show the Cronbach's alpha for ITIC and PP constructs to be greater than 0.7, all the items provide evidence of reliability.

5.1.3 Correlation Analysis

A Pearson correlation analysis was performed between project performance and five constructs of ITIC (refer Table 5). Based on correlation analysis between constructs of ITIC and project performance, the results shows that all the correlation coefficients are moderately large with p-values all achieve a high level of statistical significance at $p<0.05$. Therefore, all the constructs for ITIC are significantly and positively correlated with the four constructs representing project quality. The highest Pearson correlation value (r) is .421 for Security and Utility Capability against Scope, while the lowest Pearson correlation value is .180 for Collaboration Capability against Cost.

PROJECT PERFORMANCE Attributes	Factor Loadings			
	Scope	Quality	Cost	Time
The time limit for the project is clearly stated.				.831
Project activities are executed in accordance to time schedule.				.848
Project activities are carried out exactly as planned.				.645
The financial limit for the project is clearly stated.				.480
The project is normally finished on time.			.769	
The project meetings have well-planned agenda.			.522	
The final date of project completion is clearly defined.			.634	
The project is normally completed within budget.			.749	
Projects conform to the planned cost schedule for all activities.		.464		
Project executor maintain all activities within quality parameters		.542		
All key participants were involved in the detailed project planning.		.491		
Project superiors (Top management, Steering Committee, etc) are reachable for the key executors whatever necessary.		.505		
The project has met its planned quality standard		.616		
All experiences gained through this project have been discussed in a special meeting and /or in a final evaluation report.		.828		
All relevant documents from this project are or will be compiled in a separate end-of-project report or file.		.772		
The project has clear and exact goals	.770			
The project missions are clearly stated.	.731			
The goal of the project is accepted by those involved in the project.	.734			
The project that fulfils its goals will benefit for the end users.	.769			
The master plan is regarded as mandatory for all project participants (e.g., contractor, supplier, etc).	.565			
The master plan clearly indicates who will be responsible for various activities in the project.	.605			
Project quality is well clearly outlined during its execution.	.636			
The quality parameters for the project are clearly stated.	.541			
Cronbach's alpha	.9278	.9119	.8378	.8207

Table 3. Principal Component Analysis of Project Performance Attributes

ITIC Attributes	Factor Loadings				
	DMC	IC	CC	OC	SUC
Manage communication network service (e.g., phone contact, fax).		.805			
Manage messaging service (e.g., E-mail, Notice board, etc).		.813			
Manage business unit workstation networks (e.g., LAN/stand alone PC).		.721			
Manage business applications (e.g., software applications: Microsoft office, Microsoft Project, Primavera, etc).		.761			
Recommend standards for IT architecture components (e.g., hardware, operating systems, and communications).		.537			
Enforce IT architecture.		.597			
Provide multimedia operations and development (e.g., video conferencing).			.700		
Provide intranet capability for document management.			.740		
Provide intranet capability for collaboration (e.g., local resource sharing).			.738		
Provide electronic support for groups (e.g., documents, tutorials, CD software, etc).			.670		
Provide data management advisory and consultancy services.	.709				
Manage business-unit data, including standards (e.g., oracle, database system).	.789				

Manage database management system.	.831				
Manage, maintain and support large scale data processing facilities.	.816				
Utilize Information System (IS) for project management.	.687				
Utilize IS planning of business units.	.678				
Provide security for firm-wide database and applications (e.g., file/data backup, anti-virus software, etc).					.771
Implement disaster planning and recovery system for business units (e.g., backup, disk tools, etc).					.763
Provide technological advice and support services for internal requirement.					.531
Provide training services for new technologies (e.g., software training, etc).					.602
Utilize IS to manage and negotiate with suppliers and subcontractor (by tenders, quotations in buying or dealing).				.556	
Provide management information electronically (e.g., EIS).				.804	
Develop and manage electronic linkages to suppliers or customers (e.g., website, E-mail address, etc).				.804	
Develop a common systems environment.				.652	
Cronbach's alpha	.9094	.9248	.8885	.8529	.8724

Table 4. Principal Component Analysis of ITIC Attributes

	Project Performance construct			
ITIC Construct	QUALITY	SCOPE	COST	TIME
Integration Capability (IC)	.299(**)	.362(**)	.271(**)	.375(**)
	.000	.000	.002	.000
	132	132	132	132
Collaboration Capability (CC)	.278(**)	.232(**)	.180(*)	.248(**)
	.001	**.008**	**.039**	.004
	132	132	132	132
Data Management Capability (DMC)	.378(**)	.297(**)	.276(**)	.304(**)
	.000	.001	.001	.000
	132	132	132	132
Security & Utility Capability (SUC)	.394(**)	.421(**)	.269(**)	.357(**)
	.000	.000	.002	.000
	132	132	132	132
Other Capability (OC)	.407(**)	.284(**)	.212(*)	.266(**)
	.000	.001	**.015**	.002
	132	132	132	132

** Correlation is significant at the 0.01 level (2-tailed).

Table 5. Correlations Between ITIC and PP Constructs

5.2 Qualitative Analysis

5.2.1 Revised Research Framework

Based on the transcribed data collected, significant patterns and themes were identified and as shown in Figure 3. As in the quantitative results, the qualitative analysis confirms that ITIC are correlated to project performance. However, there are internal and external push factors to be

considered that influence the implementation of ITIC. Furthermore, barriers to the implementation as well as internal and external push factors were also identified which can influence the ITIC-PP relationship.

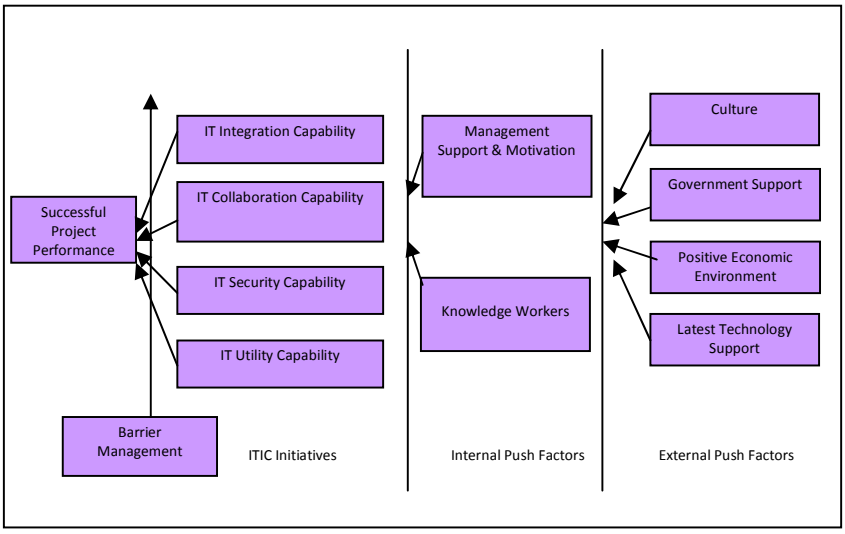

Figure 3. Revised Research Framework

5.2.2 ITI Capability Support

Based on Figure 3, ITIC facilities are categorized into integration capability, data management capability, collaboration capability, security capability and utility capability. For integration capability, majority of the companies use email to communicate with their suppliers and clients, servers to store and share data, of which some of the interviewees have integrated network system, notice board and integrated server system. For data management capability, among the database used in consulting construction industry are Construction Unit Rates Database, Subsurface Information Database, Developers Database, Specialists Database, Accredited Contractors Database, Specifications database, Bills of Quantities Database and Galleries database. For Collaboration capability, the company use electronic resources sharing system, Digital Library for technical and research journals, conference papers, academic references and technical videos. For Security software, some of the construction consulting companies in Malaysia practice backup, computer password, anti-spy ware and uninterrupted power supply. Finally, the company implements IT training and establish IT policy as part of IT utility capability.
The findings of the qualitative analysis as shown in Figure 3 indicate that management support and motivation as well as knowledge workers are the main internal push factors that influence the implementation of ITIC to support the project performance.

i. Internal Push Factors

Management Support and Motivation

Management support and motivation factors are often viewed as important factors in the implementation of ITI capability to support project performance in the construction industry.

Management support is also focus on establishing a knowledge infrastructure and support system than enhances and facilitates the sharing of information at the appropriate levels. Among the suggestions which relates to management support and motivation are: top management should initiate and drive the ITIC projects, ITIC implementation should be enforced in terms of policy and procedures, organization structure of the company should support the implementation of ITIC projects, management should provide incentives for staffs who involve in ITIC implementation, management should provide enough budget for ITIC projects and management should motivate all staffs to utilize ITIC for project performance.

ii. External Push Factors

Beside the internal push factors, there are four external push factors that influence the implementation of ITIC to support successful project performance as shown in Figure 5. The external push factors are positive culture, government support, positive economic environment and latest technology support.

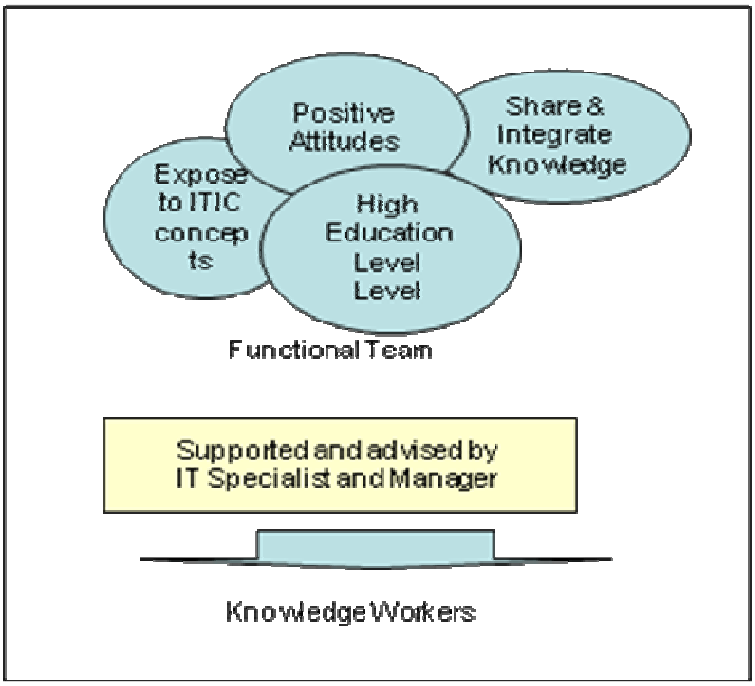

Figure 5: Model of IT Knowledge Worker for Construction Consulting Industry

Positive Culture

Based on the above qualitative study, it is found that positive culture can improve project performance. The study has identified three cultures which should be cultivated in the organization. First, learning and sharing culture in which it encourages staffs to share knowledge, learn new things and improve the existing routine works through ITIC. Second, a competition culture in which staffs are encouraged and rewarded whenever they contribute to the knowledge network through ITIC. Third, an education culture through ITIC where long life learning and continuing study is encouraged, thus increase the education level of the staff.

Finally, the above culture will create knowledgeable society where expertise is appreciated and rewarded, thus contributes to the successful implementation of ITIC in organization (O'Dell and Grayson, 1998). The summary of the above culture is illustrated in Figure 6.

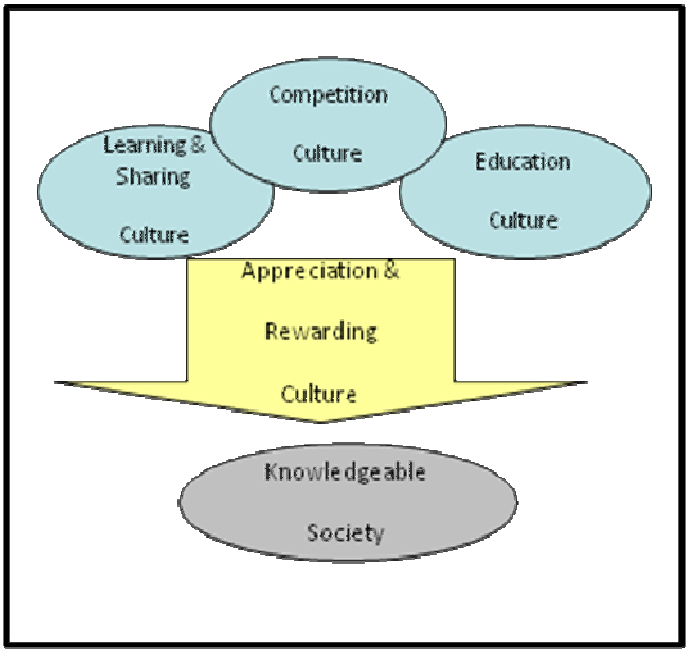

Figure 6: Positive Culture

Government Support

Figure 3 shows that government supports such as policy, tangible and intangible incentives is another important factor which can influence the implementation of ITIC among the construction consulting companies. Analysis of data also found that positive economic environment is one of the external factors affecting the implementation of ITIC to support project performance. Based on the findings, to create positive economic environment, the new knowledge and technology should be employed in the process. This demands the construction players to improve their business strategy with new knowledge and technology to allow them to be more innovative and competitive. Essentially, the investment decisions in the construction industries are conceived to meet market demands. Various possibilities may be considered in the implementation of ITIC initiatives in the firm.

Latest Technology Support

Based on Figure 3, latest technology support is found to be one of the important external factors to facilitate ITIC to support project performance. The demand for a more technology-based systems approach to manage construction project including planning, design, construction, maintenance and rehabilitation has motivated significant advances in the development of construction-related software. The technology-based system not only increase the automation of the work processes, but at the same time facilitate the knowledge management activities during the whole project life cycle. Based on the interviews, the consultants focus on the establishment

of Information and Technology network and server to support the system, the establishment of databases system to facilitate knowledge archiving and sharing (especially for the previous projects: design, analysis, documentation etc), utilization of latest application software such as software for technical drawing and design, Bill of Quantity (BQ) and project management and utilization of communication tools such as portal, email or websites for collaboration activities. The technology support tools are summarized in Table 6.

No	Construction Technology tools	Components
1	Hardware Technologies	o Integrated Network System o Integrated Server System o Backup System o Uninterrupted Power Supply o Security System
2	Software	Design Software. Example: o AUTOCAD for technical drawing o Adobe Photoshop for design o 3D-Revit for 3D design o Staadpro & Strap for structural drawing o Structural analysis & design software (ETABS, SAP 2000, STAAD Pro, ADAPT) o **ESTEEM** - a reinforced concrete structural analysis, design o **PROKON** - a compete package of structural design and analysis software o **RAD** - Rigid Airfield Design (RAD) Project Management Software. Example: o Microsoft Project for project management o Accounting System for financial management o Primavera for project management Cost Management Software. Example: o Integrated Cost Management System (CMIS) for BQ management o **MCACES - Gold** - Micro-computer Aided Cost Engineering System Simulation & Modeling Software. Example: o Multiple reservoir operation simulation models software o PDS (Highway, Infrastructure & Ground Modelling) o Plaxis (2D and 3D Finite Element) o SAFE 2000 (Soil-Structural Finite Element) o MIKE 11 (River Modelling Software) o Digital photographic equipment Knowledge Based, Automation & Analysis Software. Example: o Geotechnical and water resources software (**GEOPRO)** o Steady and unsteady state open channels network hydraulic analysis software o Water reticulation network analysis software o Water hammer analysis software o Hydrological models software o **WaterCAD**- a complete water distribution analysis and design tool o GPS systems o **SHOCK -** Blast load analysis program to calculate the impulse and pressure

		on blast surface o **NONLIN V 1.0 -** Structural Dynamical and Earthquakes Engineering Analysis program o **FRANG -** Calculates gas pressure inside a room generated from internal explosion
	Databases	o Construction Unit Rates Database o Subsurface Information Database o Developers Database o Specialists Database o Accredited Contractors Database o Specifications database o Bills of Quantities database o Galleries database
3	Collaboration Tools	o Email System o Notice/Bulletin Board o Electronic meeting systems o Video-conferencing o GroupWare o Electronic bulletin boards
4	Intelligent Tools	o Decision support tools using neural network. o Virtual reality. o Genetic algorithms o Intelligent agents o Internet search engines o Knowledge mapping

Table 6. Construction Management Technology Tools

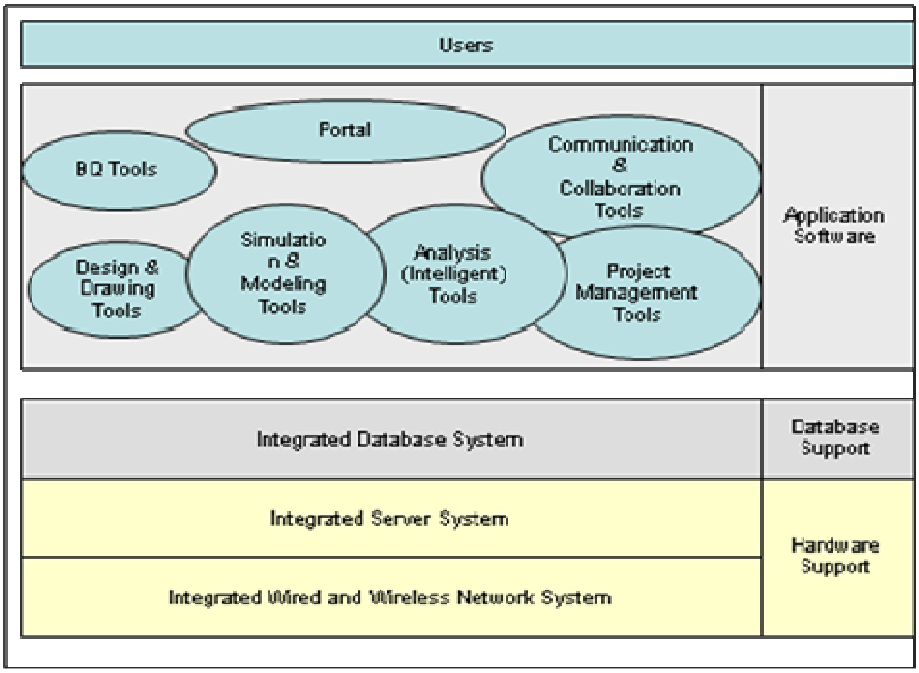

Figure 7: Latest Technology Support for Construction Consulting Industry

Barrier Management

As shown in Figure 3, the implementation of ITIC to support project performance depends on internal push factors (management support and motivation and positive knowledge workers) and external push factors (Culture and Government Support, economic and technology). However, there are several barriers to the implementation of ITIC. Before an organization can achieve project performance goals through the support from a successful ITIC, the company must understand the barriers to ITIC and develop methods in their planning to manage and overcome them. The findings show that the main barriers to the implementation of ITIC in Malaysian Construction Consulting Companies are not enough time, lack of money, lack of management support, lack of team working culture among the consultants, lack of willingness to share problems, culture and political interference, lack of staff readiness and lack of expertise.

Finally, with regards to lack of management involvement and support, the organization should create environment for the management to give their commitment and support such as regular meeting between employees and managers. In the meeting, the employees present methods to improve their ITIC in the business processes and their managers must make a decision to implement the recommendation. This self directed approach will create more support from all level of staff. This process encourages management support and helps the organization to create a learning environment by facilitating the information transfer. Furthermore, reward system should be established to illustrate the management appreciation to the ITIC efforts. The summary of the above barrier management is illustrated in Figure 8.

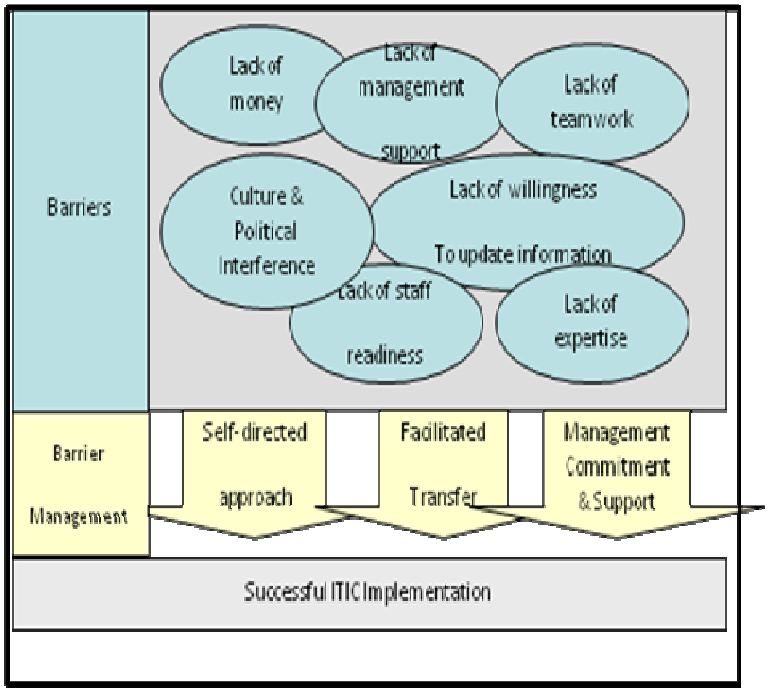

Figure 8: Barrier Management in ITIC Implementation in Construction Consulting Company

6. Discussion

Based on the quantitative and qualitative research methods, the results of this study have a higher degree of consistency and statistical accuracy that helps in having a better understanding of not only the important elements ITIC Infrastructure and Project Performance required for Construction Consulting Companies, but also as to how they inter-relate with each other.

The final ITIC and PP framework is presented in Figure 9. The framework shows that the level of all ITI variables which are IT Integration Capability, Collaboration Capability, IT Data Management Capability, IT Security and Utility Capability and Other IT Capability are highly significant. The framework in Figure 8 also illustrates the level of importance of the independent variables in supporting the Project Performance whereby IT Security and Utility Capability is the most important factors that influencing the Project Performance, followed by IT Integration Capability, IT Data Management Capability and Other IT Capability. However, IT Collaboration Capability is not proven to be an important factor that influences the project performance. This is supported by the fact that the consulting companies in Malaysia are relatively small and face-to-face collaboration is still found to be more effective than the IT-based collaboration. This finding is supported by Egbu (2002).

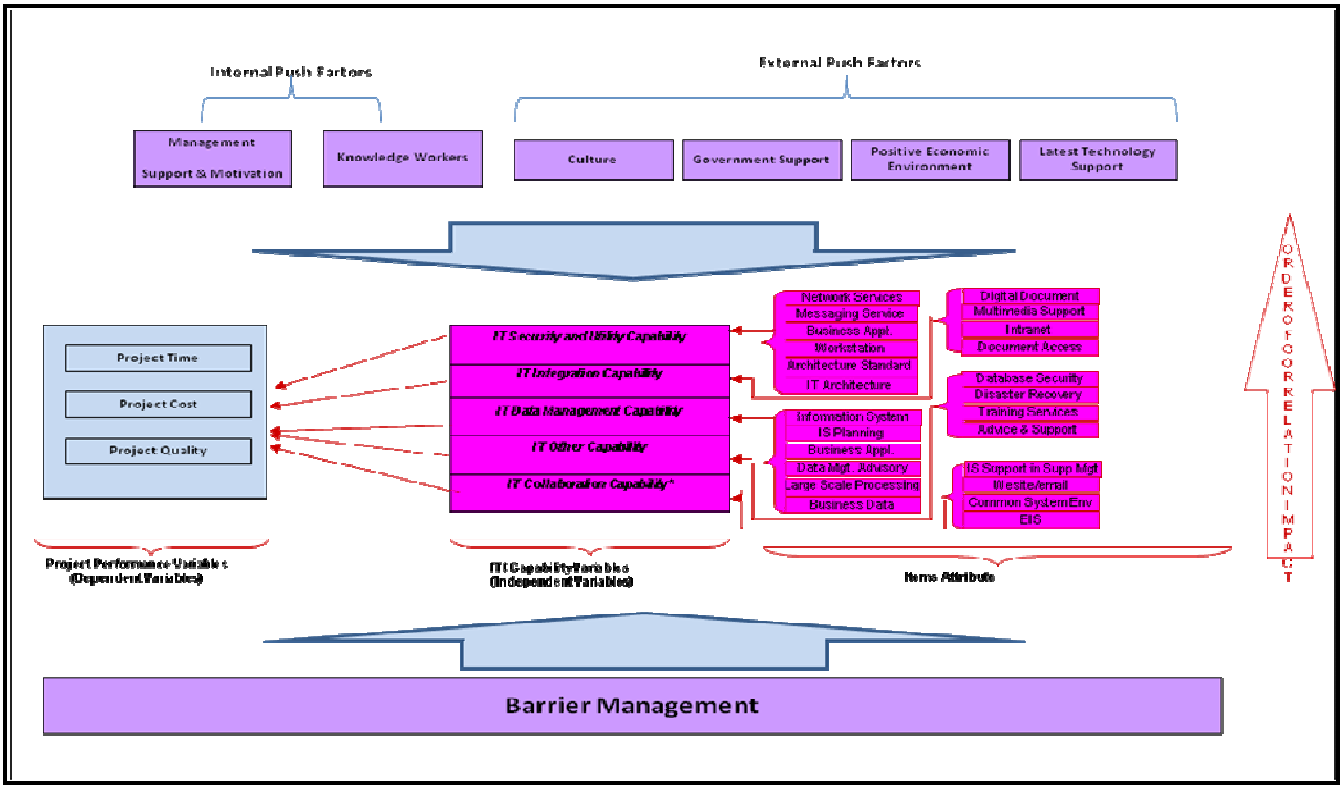

Figure 9. The Finalized ITIC-PP Framework for Construction

7. Conclusion

This paper has attempted to address the issues of IT infrastructure capability contribution to project performance in construction consulting industry. The link between IT infrastructure capability and project performance was conceptualized in a way that IT infrastructure contributes to project performance. Then, a factor analysis, impact ratio and correlation were used to investigate the relationship between IT infrastructure capability and project performance. The quantitative findings was further supported and complimented by qualitative study to explore how the companies implement ITIC practically and successfully.

There are many areas that warrant further studies. For the present study, the sample was chosen from Construction Consulting Companies. Further comparative works may be conducted across different industries and cultures such as manufacturing, utility, agriculture etc. Comparisons among different industries can help to understand the pattern of ITIC strategies implemented across different industries, so that more focused research attention on ITIC and PP can be made. A possible study can be carried out on the private and public sectors in Malaysia. On the other hand, cross-cultural comparisons can provide better understanding on the influence of the socio-cultural interactions on the development and implementation of ITIC to support PP. For example, applying the conceptual model to the manufacturing sector or a public institution will provide further understanding on the impacts of these internal and external factors, as the core business and orientation may differ from that of a construction company.

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6. Discussion of Finding

The data was tested using the linear regression analysis to look at the influences of justice to the commitment of the respondent. The results are shown in tables below.

Table 1: Regression Result for Continuance Commitment

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	28.658	2.493		11.496	.000
	PROSJUST	.079	.076	.139	1.033	.304
	INTRJUST	-.056	.135	-.054	-.414	.680
	DISTJUST	.071	.096	.092	.748	.456

Table 1 have shown the result of regression analysis for continuance commitment as dependent variable. It's revealed that procedural justice has strongly influence the development of continuance commitment. According to Teprstra and Honoree (2003) the fairness of the decision making process itself seems to be more important than the actual amount of compensation that is received by individual. The employees feel more secured if the procedures that lead to a decision by the management are clear. The fair procedure such as promotion criteria, benefit distribution and so on make them prepared and able to forecast the benefits that they will receive from the organization. Thus, they will stay with the organization to meet the criteria determine by the management for the benefits that they aim. Cropanzano *et.al.* (2007) argued that fair process lead to intellectual and emotional recognition, thus in turn, creates the trust and commitment that build voluntary cooperation in strategy execution. Therefore, hypothesis 1 is rejected.

7. Conclusion

It is revealed that procedural justice is more important in developing the continuance commitment and normative commitment while the interactional justices strongly influence the affective commitment. In this study, the distributive justice has no significant effect to any dimension of organizational commitment. This probably due to the samples concern more towards the procedural justice compared to distributive justice. Different employees have different kind of motivation factor. For employee with material motivation factor, they will more concern on distributive justice, however, employee with non-material motivation factor fair procedure is more important. The supervisor or manager must be able to manage their staff motivation factor and it is important for organization to maintain justice in their practice. Justice provides an excellent business opportunity from reaping specific returns such as stronger employee

commitment to gaining an overall tough-to-copy competitive edge that resides in a "culture of justice" (Cropanzano *et.al.* 2007).

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