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Project Performance in Construction Consulting Companies based on Knowledge Management, Information Technology Infrastructure

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Abstract: Construction consulting companies are among the critical players in ensuring the success of construction projects. This study has attempted to address the issues of Knowledge Management (KM) and IT infrastructure contribution to Project Performance (PP) in construction consulting industry. The link between knowledge management, IT infrastructure and project performance was conceptualized in a way that KM, IT infrastructure contribute to PP. Then, a factor analysis, impact ratio, correlation as well as multiple regressions were used to model the relationship between KM, IT infrastructure and PP. The analytical result shows positive relationship between knowledge management, information technology infrastructure and project performance, through the analysis of regression function, i.e. PP for construction consulting company can be predicted from the implementation of KM and IT Infrastructure. The proposed method provides best model for construction industry to implement effective KM initiatives and information technology infrastructure, to support project performance.

Key words: Knowledge management, information technology infrastructure, construction project performance

INTRODUCTION

Construction industry plays an important role in the development of a country. The importance of the construction industry lies in the function of its products which provide the foundation for industrial production and its impacts on the national economy cannot be measured by the value of its output or the number of persons employed in its activities alone (Donald *et al.*, 1991). Despites the importance of the industry, it faces many problems such as not receiving enough co-operation, limited trust and ineffective communication often resulting in an adversarial relationship among all project stakeholders. This type of adversarial relationship is likely to result in construction delays, difficulty in resolving claims, cost overruns, litigation and a win-lose climate (Moore and Birknshaw, 1998). The construction industry's problems seem to be universal. For example, a survey done by Wei (2006) revealed that about 33% of architecture/engineering projects miss cost and schedule targets. These show that the construction projects are facing major problems in achieving its targeted budget and time. Furthermore (Egbu and Botterill, 2002) stated that construction industry in UK was still under-achievement since there were growing dissatisfaction among both private and public sector clients. Construction projects were hardly seen to be on time, budget and meet standards of quality expected. In addition, highlighted in the report that one of the main problem in world construction industry is poor project organization; a lack of attention to the details relating to project structure, communication and execution.

As such, more strategic approach in managing construction projects should be derived and knowledge management and IT infrastructure are seem to be among the future determinants for a successful construction project (Hansen *et al.*, 1999; Wiig, 1997).

The purpose of this study is to investigate whether knowledge management and IT infrastructure could influence the project performance in construction consulting industry. First, a conceptual framework has been established based on the existing literature and then

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a predetermined instrument was developed to collect data for analysis. Then, the research hypotheses were developed prior to conducting the research. The first part of data analysis is to test the reliability and normality of the data collected. Since, the data was reliable and normally distributed, the parametric test was adopted. First, single mean t-test was conducted to investigate whether the level of KM, Information Technology Infrastructure (ITI) and PPis highly significant. Second, the relationships between KM and PP and ITI and PP were tested using Pearson correlation analysis. Finally, multiple regression analysis was performed to find the best model to predict PP based on KM and ITI.

MATERIALS AND METHODS

Knowledge management in construction consulting industry: There are 2 types of KM approaches; centralized and decentralized (Hansen *et al*., 1999). Decentralized approach is focusing on unique problems or issues which need special and strategic solution, whereas centralized approach focus more on operational, routine or general issues. Beside the centralized and decentralized approach, mature consulting firms with more experience and knowledge usually adopt codification approach whereby most of knowledge is stored in electronic database and is easily assessable, whereas, small and new companies mainly rely on tacit knowledge in individuals, thus applying 'personalization' approach. In Hansen *et al*. (1999), found that adopting a wrong approach of knowledge management could cause serious problems in an organization; thus, choosing the appropriate approach is crucial for the success of knowledge management implementation. The major application of KM in Construction Industry is initiated by a research on Construction Knowledge Areas sponsored by American Construction Industry Institute (CII). CII is a research organization that was formed in October 1983 with the mission of improving the competitiveness of the construction industry (CII, 2001). The knowledge areas are developed to measure the level of knowledge management implementation of project life cycle in the construction consulting companies. The knowledge areas identified by CII are Knowledge related to Frond-end Planning, design, procurement, construction, startup and operation, people, organization, project processes, project controls, contract, Safety, Health and Environment and information management (CII, 2006).

Information technology infrastructure capability: Various studies show the impact of IT Infrastructure to KM in managing a company's knowledge. For example (Wiig, 1997) stated that KM interacts with and is supported by IT infrastructure capability, which involving network and shared groupware application. Since, knowledge management is about transmitting and sharing, it needs the access sharing, dissemination, communication and collaboration of knowledge. To manage the knowledge, the company requires a specific set of IT infrastructure and knowledge should be easily transferred through communications network. A well-defined architecture and standard of data and applications ensures enterprise-wide compatibility of system.

Project performance: In recent years, significant research advancements have highlighted that the typical project performance indicators are still cost, time and quality (Hansen *et al*., 1999; Wiig, 1997). 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 (Hair *et al*., 1998). 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 (Hair *et al*., 1998). 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.

MATERIALS AND METHODS

Sampling: 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. A stratified sampling technique was used to ensure that all types of companies are selected. Through the stratified sampling technique, the sampling frame was categorized into engineering, quantity surveyor, architectural and project management.

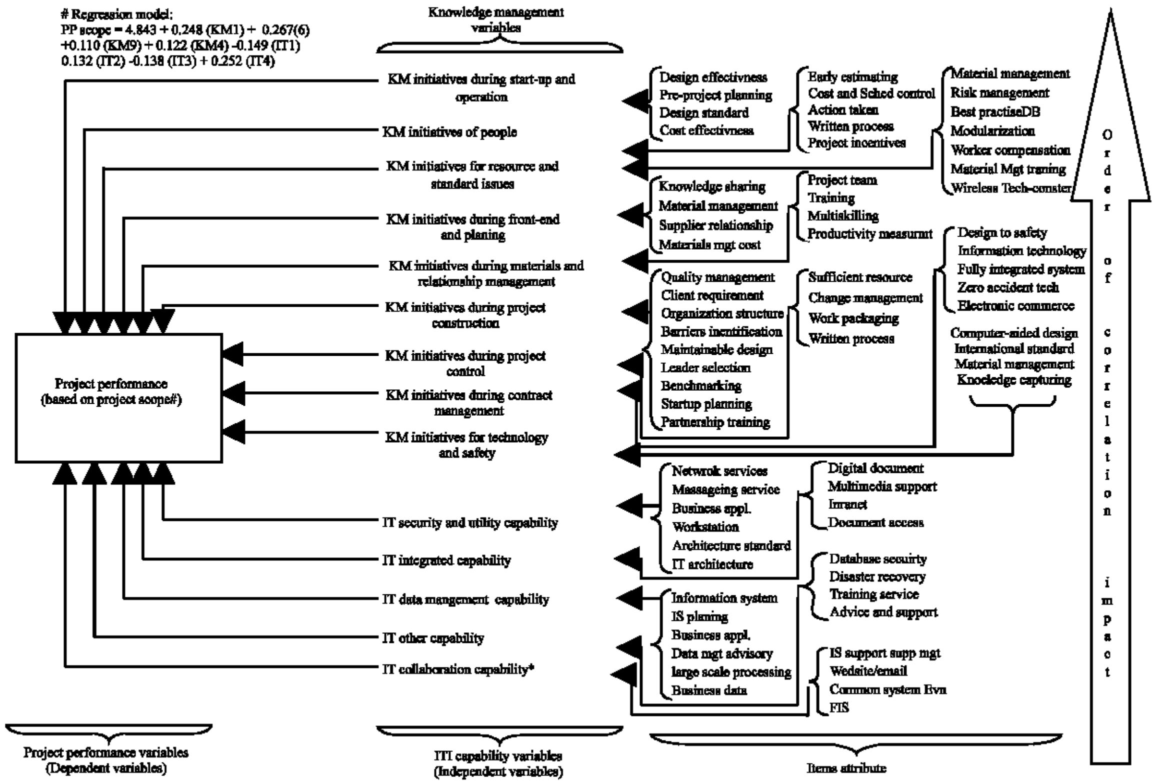

Fig. 1: KM-IT infrastructure-PP framework for construction consulting industry

Table 1: Sampling Frame

Type of consulting companies	No. of company	Percentage
Engineering	200	40
Quantity Surveyor	125	25
Architecture	125	25
Project Management	50	10

Subsequently, based on sample size defined by Israel (1992), a minimum target of 143 was determined adequate for the study by using random sampling technique. The final sampling frame is shown in Table 1.

KM-ITI-PP framework: The framework (Fig. 1) shows that the level of all KM variables including KM Front-end Planning, KM contract management, KM construction, KM relationship and material management, KM people, KM operation, KM control, KM technology and safety and KM resource and standard are highly significant. Similarly, the framework also 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 significantly. Also illustrates, the level of importance of the independent variables in supporting the project performance whereby KM initiatives during start-up and operation is shown to be the most important factors influencing the project performance, followed by KM initiatives of people, KM initiatives for resource and standard issues, KM initiatives during front-end planning, KM initiatives during materials and relationship management, KM initiatives during project construction, KM initiatives during project control, KM initiatives during contract management and KM initiative for technology and safety. Whereas for ITI, the framework shows that 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.

RESULTS AND DISCUSSION

Descriptive analysis: One hundred and thirty two consultants from the construction consulting companies were participated in the survey. Table 2 shows the

Table 2: Background of the consultants

Type of company	Frequency	(%)	Valid (%)	Cumm (%)
Quantity Surveyor	10	7.6	7.6	7.6
Civil Engineering	83	62.9	62.9	70.5
Architecture	19	14.4	14.4	84.8
Others	20	15.2	15.2	100.0
Company ownership				
100% Malaysian ownership	128	97.0	97.0	97.0
Joint venture with foreign company	3	2.3	2.3	99.2
100% Foreign ownership	1	0.8	0.8	100.0
Position				
Quantity Surveyor	15	11.4	11.4	11.4
Civil Engineer	76	57.6	57.6	68.9
Architecture	22	16.7	16.7	85.6
Others	19	14.4	14.4	100.0
Working experience				
<5 years	42	31.8	31.8	31.8
5-10 years	29	22.0	22.0	53.8
>10 years	61	46.2	46.2	100.0
Education level				
Diploma	11	8.3	8.3	8.3
Bachelor's degree	106	80.3	80.3	88.6
Others	15	11.4	11.4	100.0

Table 3: Reliability statistics for KM, ITI and PP

	Cronbach's alpha	No. of items
Knowledge Management (KM) factors		
Front-end Planning	0.7129	4
Contracts	0.8300	5
Construction	0.8572	7
Material and relationship management	0.7175	4
People	0.8412	4
Start-up operation	0.9080	9
Project control	0.8367	4
Technology and safety	0.8658	5
Resource and standard issues	0.7935	4
IT Infrastructure (ITI) factor		
Integration capability	0.9248	6
Collaboration capability	0.8885	6
Data management capability	0.9094	4
Security and utility capability	0.8724	4
Other capability	0.8529	4
Project Performance (PP) factor		
Time	0.8207	4
Cost	0.8378	4
Quality	0.9119	7
Scope	0.9278	8

background of the consultant; most of the consultants are experienced with high level of education, where 61 having more than 10 years experience and 106 of them are degree holders.

Reliability test: Scale reliability coefficients using Cronbach's coefficient alpha was used to assess the consistency of homogeneity among items. Table 3 shows the Cronbach's alpha for KM and ITI factors. Since, the Cronbach's alpha for all factors are greater than 0.7, all the items are considered reliable.

Normality test: Since, the data collected has demonstrated statistically reliable, the probability plot was used to determine the distribution of the 18 variables. Probability Plot (P-P Plot) plots a variable's cumulative proportions Cum Prop against the cumulative proportions of any of a number of test distributions. Based on probability plots, the 18 variables demonstrated normal distribution whereby the points cluster around a straight line indicates that the distribution of the all variables of KM, IT and PP are normal and thus parametric method can be used in further analysis.

Impact ratio: In order to determine, the relative degree of impact the consultants had on a particular item, an impact ratio analysis was conducted. Based on the impact ratio, all items of KM, ITI capability and PP show greater degree of impact.

Factor analysis: Construct validity using factor analysis was used to reduce and summarise data in which redundant items are combined and inappropriate items were deleted (Newma, 1997). After the analysis, factors for knowledge management are classified as KM front-end planning, KM contracts, KM construction, KM material and relationship management, KM people, KM start-up operation, KM project control, KM technology and safety, KM resource and standard issues and 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.

Correlation analysis: A pearson correlation analysis was performed between project performance and the other nine variables of KM and 6 variables of ITI Capability. The result of correlation analysis between the project performance and KM shows that all coefficient are moderately large with p-values all achieve a high level of statistical significance at $p<0.000$ (which means $p<0.005$). Therefore, all nine variables of KM are significantly and positively correlated with project performance. The highest Pearson correlation value is 0.531 for KM initiatives during project operation, while the lowest Pearson correlation value is 0.380 for KM initiative for technology and safety. The correlation analysis showed that the order of correlation for variables from highest to lowest, is as follows: KM initiatives during project operation (Pearson value = 0.531), KM initiatives of the people (0.476), KM initiatives for Resource and Standard issues (Pearson value = 0.470), KM initiatives during front-end and planning (Pearson value = 0.458), KM initiative during relationship and material management (Pearson value = 0.449), KM initiatives during project construction (0.436), KM initiatives during project control (Pearson value = 0.410), KM initiatives during contract

Table 4: Multiple regression analysis

Dependent	Independent	Regression function	Durbin watson
Project time	KM contract management, KM Relationship and material management, IT integration, IT collaboration, IT security and utility.	PP Time = 17.608 + 0.255 (KM contract management) + 0.278 (KM relationship and material management) + 0.176 (IT integration) -0.118 (IT collaboration) + 0.206 (IT security and utility)	1.887
Project cost	KM front end planning, KM operation, KM relationship and material management, IT integration	PP cost = 18.401+ 0.181 (KM front end planning) + 0.175 (KM operation) + 0.243 (KM relationship and material management) + 0.129 (IT integration)	1.737
Project quality	KM front end planning, KM people, KM technology and safety, KM relationship and material management, IT collaboration, IT security and utility	PP quality = 7.183 + 0.155 (KM Front end planning) + 0.105 (KM people) + 0.176 (KM Technology and safety + 0.346 (KM relationship and material management) -0.089 (IT collaboration) + 0.201 (IT security and utility)	1.929
Project scope	KM front end planning, KM operation, KM Resource and Standard, KM Relationship and material management, IT integration, IT collaboration, IT data management, IT Security and utility	PP scope = 4.843 + 0.248 (KM front end planning) + 0.267 (KM operation) + 0.110 (KM resource and + 0.122 (KM relationship and material management) -0.149 (IT integration) -0.132 (IT collaboration) -0.138 (IT data management) + 0.252 (IT security and utility) (1)	2.017

management (Pearson value = 0.398) and KM initiative for technology and safety (Pearson value = 0.380).

With regards to correlation analysis between IT infrastructure and project performance, the results shows that all coefficient are moderately large with p-values all achieve a high level of statistical significance at $p<0.000$ (which means $p<0.005$), except IT Collaboration capability with Pearson correlation value of 0.008. Therefore, four variables of IT infrastructure are significantly and positively correlated with project quality. However one variable, which is IT collaboration capability is not significantly and positively correlated. The highest pearson correlation value is 0.421 for IT security and Utility Capability, while the lowest Pearson correlation value is 0.284 for other IT capability. The correlation analysis showed that the order of correlation for variables from highest to lowest that affected project scope is as follows: IT security and utility capability (Pearson value = 0.421), IT integration capability (Pearson value = 0.362), IT data management capability (Pearson value = 0.297) and other IT capability (Pearson value = 0.284).

Regression analysis: To find the best relationship model, multiple regression analysis has been conducted. Based on the multiple regression analysis as shown in Table 4, there is an apparent statistically significant linear relationship between the combination of KM and ITI variables of the dimensions of project performance. Furthermore, all 4 models recorded absence of multicollinearity problems among the independent variables. However, based on Durbin Watson's value (<2.00), 3 regression models (Project Time, Project Cost and Project Quality) show some model misspecification. The misspecification error might due to the fact that the independent variable which is not positively correlated with the dependent variable has also been included in the multiple regression process. The future research shall consider the correction of the misspecification issues. For the purpose of this study, the regression function of dependent variable with no misspecification error which is project scope is identified as the function to be used to predict project performance based on knowledge management and IT infrastructure capability.

The framework in Fig. 1 shows that project scope is identified as the dependent variable, which can be used to reflect the project performance. Project scope refers to the project master plan which consists of project goals, missions and the quality parameters. Regression function of project scope (Eq. 1 in Table 4) provides us with valuable information on the contribution of each knowledge management and IT infrastructure entities to project performance. Based on the theory behind the Eq. 1, it is found that KM front end planning, KM operation, KM resource and standard, KM relationship and material management, IT security and utility and level of education show an increasing return to scale. On the other hand, IT collaboration capability and IT data management capability show decreasing returns to scale.

CONCLUSION

Based on the use of quantitative 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 of knowledge management, IT infrastructure and project performance required for construction consulting companies, but also as to how they inter-relate with each other. The management of construction consulting companies should take the advantage of KM and ITI infrastructure to support project performance. However, more efforts should be initiated to improve the significance of IT collaboration in construction consulting companies since the study does not show a significant benefits to the companies. Therefore, it is recommended that construction consulting companies should develop strategies for change of organizational policy and culture to stimulate the implementation of knowledge management and IT infrastructure to facilitate project performance. As such, government bodies together with companies should work together to derive methodologies and approaches to facilitate the creation of Knowledge and IT environment in consulting company.

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