CHAPTER 9

RESEARCH CONCLUSION

9.1 Introduction

This study has developed a goal-based IT Infrastructure Flexibility (ITIF) Maturity Model and has applied it to the construction organizations assessment in IT implementation as a case study. This final chapter now presents and discusses the overall findings and summary of the study. This research started with overall chapter summary and the key findings that will be the main contributions of the study. The objectives were verified through revisiting research objectives sub-heading. In a later part, limitation of the study is highlighted and continued with future recommendations.

9.2 Chapters Summary

The technology revolution – traditional communication by the landline telephone is now being replaced with the cellular, the Internet and wireless technology – it is now changing the way we live and work. The establishment of e-business in the construction industry such as electronic tendering, electronic procurement, electronic portal, and other electronic transaction process is a proof that there has been a technological shift in construction sector from IT driven solutions, to making IT as an enabler. IT continues to change in a rapid pace with no sign of slowing down. A technological change is accelerating and it is continually impacting and reshaping the Malaysian economy. As discussed in ***Chapter 2***, statistics (up to June 2012) show that the world's inventions of new technologies were 1,847 yearly in average, and it marks 5 new technology inventions per day, whist, the construction industry only have 70 new technology inventions per year (MyIPO, 2012). This represent the lack of IT innovation in the industry and business must react quickly to seize the opportunities resulting from IT change.

The construction industry must now cope to an ever more complex set of economic conditions. Technology could contribute towards positive impacts. If technological change is not properly managed, it will give negative implications in terms of profits and productivity from the large amount spent on IT in the construction industry. In Malaysia, the local construction industry only started investing in IT since the launching of Multimedia Super Corridor (MSC) in 1996 (Kaliannan, Raman, & Dorasamy, 2009). Unfortunately, IT project failures were increasingly reported (Samah, et al., 2010). This situation raised some fundamental question how the Malaysian construction industry to successfully manage technological change (Macredic & Sandom, 1999).

Finding the best solution for this challenge is not easy as there limited IT solutions suited for the industry. Currently, the ad hoc method is the most convenient approach taken by Malaysian construction organizations to face the rapidity of technology change. This approach is controversial and has limited benefits (Carrillo, Ruikar, & Fuller, 2012). Outsourcing, on the other hand, offers a better solution in promising organizations to keep up with the latest technology changes. A major drawback is the high cost of the service. Therefore, the benchmarking approach helps the organization to find out the best IT solutions, and being able to identify their current status and set targets for the future. Based on the literature reviews, there are available tools used in assisting to select the right technology, but there are no tools that list them in a framework in holistic view, such as the adaptability of infrastructure, people, and business environment to face the hasty technological changes. Thus, this shows that construction organizations are looking for tools, models, or methodologies to help them improve their IT implementation.

Moving to ***Chapter 3***; adaptability in technology change involves a careful balance between changing the technology to fit the organization, and changing the organization to fit the technology (Veryard, 2011). To cope with the rapidity of technology changes, various aspects should be managed, which include the IT infrastructure, people, process, and business environment. "Flexibility" – that is a word that describes ability to react to changes. In recent years, this concern has attracted the world's attentions, as reported by Forrester (2011) and KPMG (2010). In Malaysia context, ITIF is still a new concept but the companies' interest on it is growing, both the public and private sector have started to embark in ITIF. ITIF has drawn remarkable benefits, especially in lowering IT acquisition and management costs, time saving, improving communication, and enhancing effectiveness and competitive advantage. Hence, this study will use the concept of IT Infrastructure Flexibility (ITIF) introduced by Duncan (1995) and ideas by Byrd & Turner (2000) and Fink (2009), with maturity modeling and critical success factor techniques to address the challenges of rapid technology change and adoption for the construction organizations.

A two-phase approach was used in the development process of ITIF Maturity Model, as described in ***Chapter 4***. In the first phase, a questionnaire survey was conducted to determine Critical Success Factors (CSF) from the list of thirty-eight ITIF success factors. The list was compiled from a combination of literature and the pilot study results, which involved seven construction organizations. The questionnaire instrument for this research was adopted from Byrd & Turner (2000) and Fink's (2009) ITIF research. The instrument has four sets of technical elements that consist of 16 items, four sets of people elements that bring 14 items, and two sets of management dimension that have 8 items. The instrument's contents was validated and pre-tested by fifty construction organizations. The pre-tested descriptive analyses concluded that the methodology of a postal mail can be employed in this study, and secondly, the questionnaire items demonstrated good measurement qualities and responses usually covered the whole range of the scale.

Chapter 5 presents the survey's findings. One thousand questionnaires were sent to construction organizations that have established an IT Department, and 211 respondents were collected. Majority of the respondents have had more than 10 years working experience in IT department within construction, which accounted 52.6% of them, 18% have worked for 7 to 10 years, 19% have worked 3 to 6 years, and only 10.4% of the respondents have had less than 3 years working experience. The coverage reflects the diversity in the construction industry. Data ranking was computed using mean score, Severity Index and Kendall mean rank through the statistical software SPSS Version 19.0 and Microsoft Excel. The significance correlations of the shortlisted variables were then tested using the Spearman Rho correlation coefficient for checking the association between them. From the thirty-eight factors, the results remark a list of fourteen CSF for ITIF from the construction industry perspective, that fall under technical, people, and management dimensions. Having the results of questionnaire and knowledge obtained from the review of literature as the basis, the criteria for each level that should be ultimately included in the preliminary ITIF Maturity Model were determined. The preliminary model was a result from the manipulation of various models and literature through data extraction process. The discussion is presented in ***Chapter 6***.

In ***Chapter 7,*** the model was validated through carefully selected case studies. The organizations' involvement in construction IT have achieved more than ten years experience and have been rewarded with significant awards for their achievement in valuing IT in the organization and local construction industry. System P, System Q and System R have been developed under two versions throughout its implementation. System P is an electronic tendering system. Its purpose is to digitalize the tendering processes from the advertising stage, tendering evaluation, to tender award. The target users are public clients and contractors in all over Malaysia. It has partly been used but it is still under ongoing development. System R is a cost database that keeps historical construction cost information and able to forecast the future cost of projects. The users are authorized staffs from all organization's offices in the country. The system has started been used but content and function improvements were needed. System Q is a web-based workspace combining of collaboration, project management, knowledge management, office and workflow management, and document management technologies into a single system. It is developed for internal and is considered achieves full success. System P and System R were developed from existing systems by in-house expertise with vendor assistance, while System Q is customized from third party packages with full in-house expertise utilization. Based on the commonalities appeared in all case studies, the ITIF criteria requirements were modified.

The ITIF Maturity Model was extracted, adopted, combined, and modified in conformance to the real situation existing in case studies. In ***Chapter 8***, it presents the details of model's adjustments and modifications. The modifications involve terms used and description in certain maturity ladders. A refined ITIF Maturity Model is presented with a guideline for the model's practical implementation provided.

9.3 Key Findings

9.3.1 Literature Findings

- In general, 1,847 new inventions per year, and it equals to 5 new inventions per year (Patent statistic up to June 2012). In construction industry, 70 new inventions per year, accounted within the same period (MyIPO, 2012). This shows how rapid the technology has changed.
- Malaysia was allocated USD7.15 billion for IT infrastructure (88.7%) and USD0.91 (11.3%) for IT services by year-end of 2012 (Bernama, 2012). In previous years, the total Malaysian IT spending was USD7.35 billion in 2011, and USD5.9 billion in 2010 (Chin, 2011).
- The local construction industry spent USD36.5 million in 2000 for IT, USD41.1 million in 2005, and increased USD 44 million in 2010.
- Despite the huge amount of IT expenditure and investment, IT project failure was increasing reported in Malaysia, and also around the world, due to incapable IT infrastructure to cope with new technological changes.
- Current common approaches taken by Malaysian construction organizations to address technology changes were by the deterministic way or ad hoc, outsource the

IT department to transfer technology obsolete and failure risks, and also ad hoc product benchmarking.

- There is a lack of published models or tools that addresses the issue of managing technological change.
- Inspired by Duncan's (2005) research, this study found 33 success factors of ITIF, which fall under technical, people, and management dimension. From the Malaysian context, the list was extended to 38, which were found suitable for the construction industry.

9.3.2 Survey Findings

- Based on the consistent means and severity indices that were more than 70.00% and above 3.50, six factors were consistently ranked in the highest indicators under technical dimension, eight highest factors under people dimension, and four top-ranked factors under management dimension. They are listed in the following table:

Table 9.1: Highest ranked ITIF factors.

Dimension	ITIF Success Factor	Mean	Severity Index (%)
Technical	Design to be reconfigurable	3.76	77.17
	Standardization of file formats	3.75	75.07
	Common operating system	3.73	74.69
	Quick integration of new system	3.65	73.08
	Real-time	3.60	71.94
	Utilization of IT communication	3.55	70.90
People	Updated	3.91	86.16
	Commitment to learn	4.05	81.04
	Self-directed and pro-active	4.02	80.38
	Willingness on change	3.93	78.58
	Able to interpret management and technical needs	3.75	74.98
	Teamwork in multidisciplinary environment	3.71	74.22
	Awareness of critical success factors	3.56	71.28
	Cross-trained	3.53	70.62
Management	Connectivity	3.85	76.97
	IT security & management	3.78	75.55
	Data management	3.73	74.60
	IT project management	3.51	70.14

- All the shortlisted factors were positively correlated, with $r>0.200$, p (two-tailed)<0.05. The factors that were not significant correlated with four variables and above were considered have low confidence that there were genuine relationships between them.
- In summary, fourteen factors were marked as critical success factors (CSF) of ITIF. They are (1) standardization of file formats, (2) quick integration of new system, (3) design to be reconfigurable, (4) teamwork in multidisciplinary environment, (5) self-directed and pro-active, (6) commitment to learn, (7) updated, (8) willing to change, (9) able to interpret management and technical needs, (10) awareness of CSF, (11) connectivity, (12) IT security management, (13) data management, and (14) IT project management.
- The fourteen factors were then renamed as follows, (1) file format standardization, (2) integration interval, (3) system design, (4) teamwork, (5) independence and pro-activeness, (6) IT learning commitment, (7) IT awareness, (8) willingness of change, (9) hybrid skills, (10) CSF awareness; and the rest remains the same name.
- With this, two new success factors of ITIF were found significant in the construction industry perspective, in addition to the factors that were discovered from the literature. They are (1) hybrid skill and (2) willingness of change.

9.3.3 Case Studies Findings

- When applying the ITIF Maturity Model in the case studies, the CSF under technical dimension's maturity were constant, with all three cases indicates the existence of the CSF's characteristics constantly according to the maturity.

- People dimension shows a good consistency according to the levels of maturity. An almost matured people-related framework was formed in all case studies, reflecting that this is the key factor in business success.
- Despite of high maturity in other factors, IT project management was found to be neglected in all case studies. However, a strong existence of consistency in its improvement process according to the maturity level. This is probably because the element adapted the concept from the Project Management Maturity Model, which proven industry-based model. The other factors under management dimension show a consistency in each levels of maturity.

9.4 Revisiting Research Objectives

The achievement of research objectives are listed as follows:

- To identify the importance of the ITIF factors from the construction industry perspective – *achieved in **Chapter 2, Chapter 3,** and **Chapter 5***.
- To define the relationship between ITIF factors to be measured in the maturity model development – *achieved in **Chapter 5***.
- To develop the preliminary maturity model by determining the ITIF maturity levels– *achieved in **Chapter 6***.
- To establish the ITIF Maturity Model that suits with its practicality in the Malaysian construction industry – *achieved in **Chapter 7** and **Chapter 8***.

9.5 Limitations of the Study

In view of the fact that the time and resources were limited, a number of limitations occurred throughout the study period, as listed as follows:

- During the questionnaire survey, the Researcher called more than once thousand organizations to confirm the existence of IT Department in order to identify the right respondents. Regrettably, there is no database for construction organizations with IT Departments. Therefore, the survey coverage was limited to contacted organizations only.
- The information extracted from the case studies depends solely on the capacity of the interviewees. In some cases, the perception and experience of the interviewees were based on an assumption or personal views due to lack of documentations and its confidentiality.
- The observational method is a good way to review the people dimension, but was not applied in this study due to time limitation.

9.6 Future Research

The ITIF Maturity Model developed and presented in this study was a result from the researcher's utmost effort, but due to limitations highlighted above, the followings are few recommendations for future works:

- *Model enhancement*

  The ITIF Maturity Model was developed according to the current technology during the time of study. Thus, the model may be improved and updated in the following years to suit with the latest technology, which has different requirements, implementation, and business objectives. The present research includes a detailed methodology, which describes how the model was built; therefore this research may be replicated for further enhancement.

- *Empirical validation*

  As accord to Beecham *et al.* (2005), the empirical validation should be proposed to validate the practicality of the model; some independent feedback is required to know how well the model meets its purpose and objectives. The questionnaire is based on the objectives of building the model, the elements measured, and the components of the model to define a list of criteria. The target respondents should be respected experts in their domain. The results might affect the objectives in order to decide to re-engineer the model.

- *Internationalization*

  The ITIF Maturity Model was built considering only Malaysian construction experts. In order to increase the confidence in the model, it is recommended to consider the opinions of international experts.

- *Industrial trial*

  In agreement with Tapia, *et al.* (2007), the model should be further improved through an industrial trial. It will be useful when the industry uptakes this framework, make their self-assessment and report back. With this set of results, we are able to draw-up a ranking table for the organizations in Malaysia. This table will be the benchmark the participating organizations, and also a target for other organizations. Other tables could be multi-industry rankings or international ranking tables.

During the assessment, the appraised organizations can use the model to evaluate the maturity of their business-IT alignment with the various groups of construction organizations, ranging from the highest group to the lowest group of companies. The results is useful the knowledge about how they perceive the assessment process, the model, and the results. With such information, new versions of the model can be improved and produced.

- *Crosscheck between the elements*

  The horizontal requirements and characteristics of the vertical steps of maturity levels may be matched and synchronized in the future works, because this ITIF Maturity Model was developed to only focus at the vertical ladders of maturity levels.

9.7 Closure

This research made fundamental contributions in two areas: 1) CSF of ITIF was determined for the Malaysian construction industry, and 2) ITIF Maturity Model was developed as a tool to assess the advancement of ITIF. In completing this research, a substantial amount of information regarding the Malaysian construction industry to the concept of ITIF was collected and analyzed. The ITIF in the Malaysian construction industry consists of three components, which technical dimension, people dimension, and management dimension. Factors for each of these three dimensions was determined after a literature review and applied in a survey that involved 211 respondents from various construction organizations in Malaysia. Resulting to this, fourteen ITIF factors were found as CSF; hence became an important measurement in the ITIF Maturity Model. The ITIF Maturity Model was validated using three case studies. A final-refined ITIF Maturity Model was a result from modifications and adjustment made based on case studies findings. Finally, this research provides a foundation for future research, in a number of related areas, offering new and exciting directions for the research and practice of IT in construction industry.

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