

DEVELOPING A DEFERRED MAINTENANCE MODEL FOR PUBLIC
UNIVERSITY IN MALAYSIA

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DEDICATION

To Almighty Allah

My mother;

Engku Fatimah Binti Engku Daeng

My beloved wife;

Siti Farizah binti Abdul Mutalib

My children;

Nur Amanina Safiah

Nur Amni Safra

Nur Amila Sahira

Aaron Sahli

Adam El Shaarawy

My brother and sisters

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ABSTRACT

Deferred maintenance has been regarded as a critical issue in maintenance management and has created negative impacts toward the performance of buildings and organization. This issue has become worldwide especially in most developing countries including Malaysia. If this issue is not resolved, the stakeholders may suffer from possible risks of poor organization performance. Similarly, deferred maintenance has also become a pressing issue and has adversely affected the management of public universities in Malaysia. Hence this study is intended to investigate the relationship between causes and effects of deferred maintenance and subsequently, a structural model is developed specifically for public universities in Malaysia. In order to achieve the aim, preliminary expert interviews, questionnaire survey and Partial Least Squares Structural Equation Modelling (PLS-SEM) had been carried out. A total of 220 sets of questionnaires has returned and has been analysed using Statistical Package for Social Science (SPSS) version 22 and Smart PLS-SEM version 3.0 software for modelling the causes and effects relationship. The outcome of the model proved that seven (7) hypotheses found to be positively related. This model consists of 21 deferred maintenance indicators of causes that categorized into 3 groups. The group of causes are “Organization” with 12 indicators, “Resources” with 5 indicators and “Financial” with 4 indicators. The study also identified 23 indicators of effects which are categorized into 4 groups. The groups of effects are “Social” with 8 indicators, “Environment” with 7 indicators, “Technical” with 5 indicators and “Economic” with 3 indicators. The developed model provides useful information and better knowledge to the maintenance of organization and is vital to curb the deferred maintenance problem. It also gives an in depth understanding towards deferred maintenance by explaining the impact load of each indicator involved. The model has also fulfilled the need to visualize the causes and effects of deferred maintenance in a holistic manner. The validation of the model by 14 experts was undertaken to determine its appropriateness and relevancy in enhancing the knowledge and understanding of the relationship. In conclusion, this study has successfully modelled the relationship between the causes and effects of deferred maintenance of public university buildings in Malaysia.

ABSTRAK

Penyenggaraan tertanggung dianggap sebagai salah satu isu kritikal dalam pengurusan penyenggaraan dan telah mewujudkan kesan negatif terhadap prestasi organisasi. Isu sejangat ini telah menjadi cabaran kepada banyak organisasi terutama di negara membangun termasuk Malaysia. Sekiranya isu ini tidak ditangani dengan baik, pihak berkepentingan mungkin akan menghadapi risiko kelemahan prestasi dalam organisasi. Dalam konteks yang sama, penyenggaraan tertanggung juga telah menjadi isu yang mendesak dengan kesan ketara terhadap pengurusan bangunan universiti awam di Malaysia. Oleh itu, kajian ini berhasrat untuk mengkaji hubungan antara punca dan kesan penyenggaraan tertanggung dan seterusnya membina model struktur khusus untuk universiti awam di Malaysia. Untuk mencapai matlamat ini, temuduga bersama pakar, kaji selidik dan pemodelan 'Partial Least Squares Structural Equation Modelling (PLS-SEM)' telah dilakukan. Sejumlah 220 set borang kaji selidik telah berjaya dikumpul dan dianalisis menggunakan perisian Pakej Statistik untuk Sosial Sains (SPSS) versi 22 dan perisian 'Smart PLS-SEM' versi 3.0 telah digunakan untuk membangunkan hubungan di antara punca dan kesan. Penghasilan model membuktikan bahawa tujuh (7) hipotesis mempunyai kaitan yang positif. Model ini terdiri daripada 21 penunjuk punca penyenggaraan tertanggung yang dikategorikan kepada 3 kumpulan. Kumpulan punca ini adalah "Organisasi" dengan 12 penunjuk, "Sumber" dengan 5 penunjuk dan "Kewangan" dengan 4 penunjuk. Model ini juga merangkumi 23 penunjuk kesan penyenggaraan tertanggung yang dikategorikan kepada 4 kumpulan. Kumpulan kesan ini adalah terdiri daripada "Sosial" dengan 8 penunjuk, "Persekitaran" dengan 7 penunjuk, "Teknikal" dengan 5 penunjuk dan "Ekonomi" dengan 3 penunjuk. Model yang dibangunkan ini memberikan maklumat berguna dan pengetahuan menyeluruh kepada organisasi penyenggaraan dimana ianya sangat penting untuk menyelesaikan masalah penyenggaraan tertanggung. Model ini juga memberikan pemahaman mendalam dengan menjelaskan beban impak setiap penunjuk yang terlibat. Ia juga memenuhi keperluan untuk membayangkan punca dan kesan penyenggaraan tertanggung secara holistik. Pengesahan model oleh 14 pakar juga telah diambilkira untuk menentukan kesesuaian dan perkaitan hubungan. Sebagai kesimpulan, kajian ini telah berjaya membangunkan hubungan antara punca dan kesan penyenggaraan tertanggung bangunan universiti awam di Malaysia.

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LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
ANN	-	Artificial Neural Network
ANP	-	Analytic Network Process
AVE	-	Average Variance Extracted
BIM	-	Building Information Modelling
BS 3811	-	British Standard 3811
CA	-	Cronbach's Alpha
CB-SEM	-	Covariance-based Structural Equation Modelling
CI	-	Confidence Interval
CIOB	-	Chartered Institute of Building
CR	-	Composite Reliability
DM	-	Deferred Maintenance
ECO	-	Economic
ENV	-	Environment
FINC	-	Financial
FMEA	-	Framework and Failure Mode and Effect Analysis
HTMT	-	Heterotrait-Monotrait Ratio of Correlations
IIUM	-	International Islamic University
KMO	-	Kaiser-Meyer-Olkin
MOHE	-	Ministry of Higher Education Malaysia
ORG	-	Organisation
PFI	-	Private Finance Initiative
PLS	-	Partial Least Square
PLS-SEM	-	Partial Least Square Structural Equation Modelling
RESC	-	Resources
SD	-	Standard Deviation
SEM	-	Structural Equation Modelling
SOC	-	Social
SPSS	-	Statistical Package for Social Science
TEC	-	Technical

TMA	-	Text Mining Approach
UKM	-	Universiti Kebangsaan Malaysia
UM	-	Universiti Malaya
UPM	-	Universiti Pertanian Malaysia
USM	-	Universiti Sains Malaysia
UTM	-	Universiti Teknologi Malaysia
UUM	-	Universiti Utara Malaysia
VIF	-	Variance Inflation Factor
10MP	-	10 th Malaysia Plan

LIST OF SYMBOLS

M_r	-	Mean Score
R	-	Total Mean Score of each scale
N	-	Total number of respondents
B	-	Path Coefficient
R^2	-	Coefficient of Determination
f^2	-	Effect Size
Q^2	-	Predictive Relevance

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CHAPTER 1

INTRODUCTION

1.1 Background

Typically, when buildings have been completely constructed, they are expected to operate for a certain period. Therefore, a building has to be maintained so that it can work optimally since it affects the building's performance (Au-Yong et al., 2016). The maintenance has multiple meanings. Abdulazeez et al. (2015) in his study defined the maintenance as the essential process that needs to be conducted in order to protect and repair a building after the completion of the construction phase in order to sustain its function for entire life span without interrupting its function and features.

Besides that, the focus should be emphasised on the safety of premises, equipment, machinery and work environment. Lack of maintenance can be dangerous, and lead to dangerous circumstances and can even cause accidents. Au-Yong et al. (2016) in his study stated that maintenance of a building and safety are closely associated. Therefore, as an organisation that provides such facilities, it is one of the university's priorities to provide a conducive environment to support all campus activities.

Other than that, university buildings are a factor of production Ali et al. (2016) as they are producing the future leaders, managers, engineers and industry players. Generally, the quality of teaching, learning, research and innovation activities is the focus of universities. Therefore, a well-maintained building is essential in ensuring that the core goals of the university as a corporate entity are achieved. It is possible to replace or rebuild every single building in the area. Maintenance is therefore important for ensuring a successful service or operation of the university building. In Malaysia, there is no distinction between the management of buildings in the public university with other public buildings in terms of precautions, corrective and condition, but most

of them currently depend on the corrective maintenance (Au-Yong et al., 2016). It can therefore be assumed that public universities in Malaysia are still practising conventional management for their buildings Zakiyudin et al. (2014).

Whereas for deferred maintenance, this associated with maintenance and repair operations that are unable to be carried out as planned as the result of delaying servicing. Wuni et al. (2017) in his study indicated that among the reasons that led to this problem are because of insufficient of funds and human resources, or other issues and causes during the fiscal year, either planned or unplanned, which causes it to be postponed to the next fiscal year until the issue is resolved. Moreover, the deferred maintenance will not only reduce the lifespan of a building but at the same, it potentially will result in increased costs in the long term (Oiga, 2016). The deferred maintenance takes place because the management of buildings maintenance is inefficient. Moreover, improper practices in building maintenance management can adversely affect the building and the environment (Nah et al., 2015).

1.2 Problem Statement

In order to promote and encourage teaching and learning, innovation and research activities, universities must have sustainable and conducive infrastructure while meeting the physical needs of world-class. Therefore, to meet their purpose and ensuring the building is functional (Aliyu et al., 2016), it is important to ensure that every university building functions properly (Bidi and Ayob, 2015). This favourable university climate would deliver a strong outcome and significant impact. Hence, for optimum results, in this case, building users should not be exposed to any potential risk due to the building itself (Khalil et al., 2016).

The building users not only want the building's best quality but at the same time, they also want the function of the building (Khalil et al., 2015) whereby it contributes to the conducive environment in the campus. Past studies indicate that the efficiency of education buildings has a major impact on students and staffs (Faremi et al., 2017). Nevertheless, university building management is also influenced by issues

such as inadequate maintenance (Suffian, 2013), increasing maintenance backlogs and insufficiency of budget allocation (Wing et al., 2016). According to Wing et al. (2016) one of the most common areas that often suffering a budgetary reduction in the maintenance.

The problems are constantly reported in the most local newspaper and they can be seen by the condition of buildings and facilities (Mazlan and Mohammed, 2008). The problem of inadequate funds to sustain the existing building's management has been highlighted as the greatest challenge by the Senator Datuk Seri S.K. Devamany, as the allocation of budget only sufficient to focus on the new building and infrastructure (The Sun Daily, 2017). He stated that the government is serious about transforming the maintenance culture into an essential component of the financial asset management system.

Ali (2009) in his study stated that the provision for maintenance and repair work has been expanded from RM296 million in the Eighth Malaysia Plan, to RM1,079 million during the Ninth Malaysia Plan. Meanwhile, Khalil et al. (2016) in his study mentioned that the government has allocated about RM12 billion for higher education in 2012. Besides that, RM10 billion of the overall allocation was reserved for operational spending, while RM2 billion was reserved for construction expenditures (Tenth Malaysia Plan, 2011-2015). This shows that the government is concern regarding the maintenance and operation of the government buildings including the public university. Kalu Ebi et al. (2014), pointed out that insufficient maintenance is one of the greatest problems in economically developing nations. According to (Wing et al., 2016) in their study, more than 90 per cent of the building life cycle needed maintenance after the construction was completed with approximately 75 per cent of them were allocated for purpose of maintenance. It, therefore, shows that repair and maintenance is a key aspect for every organisation and its requirements should be increased and strengthened in the future in order to prevent any adverse effects if ignored. Simultaneously, public university's top management and maintenance also acknowledged that their buildings across the campuses, involved services and systems had degrading physically.

Public universities have been working over the years to upgrade their facilities, including repair or replacement of campus's building which involving mechanical and electrical equipment, utility building components, walkways, landscaping, and roadways to a satisfactory level (Ropi and Tabassi, 2014). It is a university priority to preserve and improve the existing buildings in the campus to facilitate teaching and learning activities at the faculties as well as to the researchers and students working in their discipline. Many of these buildings required significant repairs or upgrade to accommodate leading-edge activities. In some cases, these maintenance activities have been deferred due to some constraints reason. Understanding the debt from the deferred maintenance activities needs a cause and effects that need to be highlighted in relevant documentation (Hamid et al., 2010).

Unfortunately, there was no established study from the researcher in the field of deferred maintenance as well as causes and their effects. Most of the past studies have concentrated on factors of maintenance priority and methods as mentioned by Wing et al. (2016) in their study, and there were 184 publications published from 1990 to 2015 which has been summarised in Table 1.1. Meanwhile, in the previous studies conducted by Wuni et al. (2017), Faremi et al. (2017), Naji et al. (2016), and Blessing et al. (2015), the primary concern of study are more concentrated on maintenance management and studies conducted by Au-Yong et al. (2016) and Kamaruzzaman et al. (2013) are more focused on the performance measure

Table 1.1 Previous Study of Research Methods.

Year	Factors	Methods
1990 to 2015	Technical, Financial, Social and Political	AHP, FMEA, ANN, Matrix, Ranking, Index, System, Model and Framework

Surprisingly, only one of the studies focused on deferred maintenance conducted by Kamaruzzaman et al. (2013) that identified causes and effects related to the higher education buildings by reviewing previous papers which did not consider

the relationships. This indicated that less attention is given especially on developing a proper model to show the correlation between cause and effects for the deferred maintenance of Malaysia's public university buildings. Hence, in order to support the team of building maintenance, the deferred maintenance issues must be well addressed. According to Abdulai and Owusu-Ansah (2014), the research gap could be investigated by conducting research activities on related topics, since it has never been carried out yet.

Interviews with experts revealed that over the years, there were indeed occurring deferred maintenance in Malaysia's public university. The situation is exacerbated as a model of the solution to solve this problem has not yet been developed. The problem has persisted and will occur year after year without understanding the causes and effects of deferred maintenance. The importance of this model lies in implementing a new theoretical or framework to overcome or minimise the deferred maintenance and will also provide the building maintenance team with some knowledge and empirical data in maintenance organisations and management or in practising the maintenance process, which at the same time will offer guidance for the determination of strategies in the building maintenance management. Hence, this study focuses on a relationship model between the causes and effects of the deferred maintenance of public university buildings in Malaysia.

1.3 Research Question

The research questions have been constructed according to the problem statement of the study, in order to assist researchers in achieving the aim and objectives. This study focuses on the research questions as listed below:

- i) What are the issues and challenges related to the deferred maintenance of public university buildings in Malaysia?
- ii) What are the causes and effects of the deferred maintenance of Malaysia's public university buildings?

- iii) What is the established group of causes and effects of the deferred maintenance of Malaysia's public university buildings?
- iv) What is the appropriate and reliable model that can be developed for the causes and consequences of the deferred maintenance for Malaysian's public university buildings?

1.4 Aims and Objectives

The aim of this study is to investigate the relationship between causes and effects of the delay in the maintenance of public university buildings specifically in Malaysia. The objectives of this study are described below in order to achieve the aim of the study.

- i) To explore the current issues and challenges for the deferred maintenance related to public university buildings in Malaysia.
- ii) To determine the causes and effects of the deferred maintenance of public university buildings in Malaysia.
- iii) To establish groups of causes and effects of the deferred maintenance focusing on the public university buildings in Malaysia.
- iv) To develop a model of relationships between causes and effects of the deferred maintenance for buildings in the public university of Malaysia.

1.5 Scope of Research

This study will be focused on the development of relationships model for causes and effects that led to the deferred maintenance of the public university

buildings in Malaysia. These institutions were chosen because they have the largest portfolios of buildings and facilities. The data derived from public universities encompasses the maintenance of buildings on the main campus by the university itself but not the branch campus. The target respondents were selected based in their expertise on the subject matter of the study and this involved the maintenance department of public universities in Malaysia including the engineers and assistant engineers (civil, mechanical and electrical). The structured questionnaire form has been used as a quantitative tool for the collection of data by distributing it to all public universities in Malaysia.

1.6 Significant of Research

Through this research, it is intended to establish a stronger relationship between the causes and effects of deferred maintenance of Malaysia's public university buildings. Consequently, a model based on Partial Least Squares Structural Equation Modelling (PLS-SEM) approach was developed. This study contributes to the topic by providing maintenance managers with a way to integrate knowledge and understanding at a strategic and operational level to eliminate or reduce the deferred maintenance that can offer the organisation added value. The findings of this study also could provide some form of empirical data for future research in this area of interest. Moreover, this study will also provide stakeholders with proven information about building maintenance and some guideline on how systematic or strategic for building maintenance process can be increased. The model also addresses the gaps in existing deferred maintenance studies of Malaysia's public university buildings.

1.7 Structural of Thesis

For the structure of this study, it is divided and presents into five chapters covering specific subjects as follows:

- i) Chapter One: This chapter consists of a brief introduction of the contents of the study. This included the development of the background of the research, the problem statement, research question, the aim and objectives, scope of the research, the significance of the research and structure of the thesis.
- ii) Chapter Two: This chapter covers the literature on deferred maintenance. Other contents are included building maintenance and a public university in Malaysia. It also contains the description, indicators and groups of causes and effects of deferred maintenance. This chapter also comprised of explanation on issues and challenges related to deferring building maintenance.
- iii) Chapter Three: This chapter discussed the research methodology, the important aspect of the study. A detail explanations on the research process, design, method and procedure for the data collection are further explained along with the reliability and validity and also the analysis method of the data as well as statistical tools used for the study to be employed.
- iv) Chapter Four: This chapter includes the findings of the compilation of data from the respondents' questionnaire. It consisting of preliminary and descriptive analysis along with discussion. The data analysis on the distributed questionnaire to the 20 public universities in Malaysia that participated in this study will be further analysed and discussed in this chapter. The PLS-SEM model has been used to analyse the data and to visualise the hypothetical model for data that have been collected and stored in the SmartPLS3.0 software. The data is presented in form of tables and graphs in Chapter four.
- v) Chapter Five: In this chapter, explained the results of structural equation modelling (SEM) as the statistical analysis method for the testing of the proposed hypothesis band research model and was systematically according to Partial Least Square Structural Equation Modelling (PLS-SEM) analysis procedure before the process of validation for the proposed model is also presented in the chapter.
- vi) Chapter Six: This chapter contains the reassessment of the research questions and objectives. This chapter also highlights the contribution of the study to

justify the importance of the research. The limitation and recommendation for future research are suggested in this chapter.

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