Structural Modeling of Variation Orders Factors and Their Impacts on Performance of Roadway Construction Projects

by

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In the name of AllAH, the Most Gracious, the most merciful. All praise to Allah, The Lord of the universe and peace be upon the Holy Prophet MUHAMMAD .S.A.W

I dedicate the products of my work to Allah. I believe this is my calling to pursue knowledge and wisdom.

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LIST OF ABBREVIATIONS

Ad	Administration
AVE	Average Variance Extracted
R2	Coefficient of Determination
CI	Confidence Interval
CIDB	Construction Industry Development Board
CP	Construction Phase
CR	Composite Reliability
CVS	Comma Separated Value
CV Red	Cross Validated Communality
CV	Cross Validated Redundancy
DPP	Design and Planning Phase
F^2	Effect Size
GDP	Gross Domestic Product
LL	Lower Level
MS	Mean Score
MNSQ	Mean Square
PC	Path Coefficients
Q^2	Predictive Relevancy
PREF	Performance Related Effects
PLS	Partial Least Square
JKR	Public Works Department (Jabatan Kerja Raya)
RPCA	Rasch Principal Components Analysis
SEM	Structural Equation Modeling
SD	Standard Deviation
SSO	Sum of Squared Observations
SSE	Sum of Squared Prediction Errors
T	T-Statistics
UL	Upper Level
VIF	Variance Inflation Factor

Pemodelan Struktur Faktor-Faktor Var Pesanan Variasi Dan Kesannya ke Atas Prestasi Projek Pembinaan Jalanraya

ABSTRAK

Peningkatan pembangunan sosio-ekonomi negara berkait rapat dengan dengan industri pembinaan. Walau bagaimanapun, sentiasa wujud perhubungan yang rapat di antara variasi pesanan (PS) dan industri pembinaan. Pada hakikatnya, amalan pesanan variasi merupakan suatu kebiasaan dalam semua semua projek industri pembinaan di Malaysia dan merupakan fenomena yang diketahui umum. Perlu dititikberatkan bahawa perubahan yang tidak dijangka memberi cabaran kepada projek-projek pembinaan kerana perubahan tersebut memberi kesan yang tidak menyenangkan seperti kemerosotan kualiti, kelewatan projek dan penambahan kos. Oleh itu, tindakan peringkat pertama menangani isu pesanan variasi ialah mengenal pasti punca utama berlakunya pesanan variasi. Dan analisis faktor di dapafi telah mengabaikan kajian tentang hubungan saling bergantung antara sebab-sebab yang berbeza dan cara ia mempengaruhi pesanan variasi. Oleh itu, kajian ini bertujuan untuk membangunkan sebuah model struktur pesanan variasi dan menentukan kumpulan yang paling penting dalam menyumbang kepada berlakunya pesanan variasi serta menentukan pengaruh PS pada prestasi projek. Satu borang kaji selidik terdiri daripada 36 faktor penyebab yang kemudiannya dikelompokkan kepada 3 kumpulan dan 17 faktor kesan variasi pesanan yang dikelompokkan kepada 5 kumpulan telah digunapakai. Semua faktor dan kumpulan yang dikelompokkan telah disahkan oleh 26 kakitangan pembinaan (perunding, kontraktor, dan pelanggan) semasa kajian rintis. Kajian sebenar dijalankan dengan sejumlah 104 borang soal selidik yang diterima dengan kadar responden sebanyak 70%. Analisis data dijalankan menggunakan perisian SPSS; Analisis Rasch melalui perisian WINSTEPS versi 3.72.3 dan perisian analisis Smart PLS. Model struktur kejadian variasi pesanan telah dibangunkan berdasarkan 3 kumpulan faktor penyebab dan 5 kumpulan faktor kesan menggunakan teknik Pemodelan Persamaan Struktur-Kuasa Dua Terkecil Separa (PLS-SEM). Telah didapati bahawa model ini sesuai kerana nilai R^2 0.581 ($R2 \geq 0.26$ = tinggi). Model ini mengenal pasti bahawa kesemua 8 kumpulan penting dengan t-nilai ≥ 2.58 dari proses bootstrapping 5000 sampel rawak. Model ini menunjukkan bahawa sekumpulan "faktor fasa pembinaan" mempunyai kesan yang paling tinggi terhadap berlakunya pesanan variasi. Faktor kedua yang menyumbang kepada berlakunya pesanan variasi dalam projek pembinaan jalan raya adalah faktor reka bentuk dan perancangan yang berkaitan. Sementara itu, kesan tertinggi perubahan pesanan variasi adalah pada prestasi kos melalui “pertambahan kos". Di samping itu, tahap perancangan reka bentuk dan peringkat pembinaan mempunyai pengaruh negatif yang kuat terhadap kemerosotan kualiti apabila berlakunya pesanan variasi.

Structural Modeling of Variation Orders Factors and Their Impacts on Performance of Roadway Construction Projects

ABSTRACT

The improvement of a country's socio-economic development is highly attributed to the construction industry. However, a deep relationship between the variation orders (VOs) and the construction industry has always existed. As a matter of fact, variation orders practices are common in the construction industry of Malaysia- as a universally known phenomenon in all projects. It should be pinpointed that unexpected changes are challenging in the construction projects, despite such changes producing unpleasant effects such as quality degradation, project delays, and cost overruns. As such, the first stage of addressing variation orders issues is the identification of the major causes of variation orders. Previous researches which had concentration on the identification of main causes of variation orders had ignored the investigation of the interdependent relationship between different causes and the way they influence variation orders. Hence, this study focused on developing a structural model of variation orders occurring and determining the most important group that contributes to the occurrence of variation orders as well as determining the influence VOs on project performance. The questionnaire consisted of 36 causative factors which then clustered into 3 groups and 17 effects factors of variation orders which are clustered into 5 groups. These factors and assigned groups were validated by 26 construction personnel (contractors, consultants, and clients) during the pilot study. The actual survey was conducted with a total of 104 questionnaires were received by respond rate of 70%. The data analysis is carried out using software of SPSS; Rasch analysis via WINSTEPS version 3.72.3 software and Smart PLS analysis software. A structural model of occurrence of variation orders was developed based on 3 groups of causative factors and 5 groups of effect factors using Partial Least Squared-Structural Equation Modeling (PLS-SEM) technique. It was found that the model is fit due to the R^2 value of 0.581 ($R2 \geq 0.26$ = substantial). The model identifies that all 8 groups are significant with t-value ≥ 2.58 from bootstrapping process of 5000 random samples. The model indicates that a group of "Construction Phase- related factors" has the highest impact on the occurrence of variation orders. Factors related design and planning were considered as the second factors contribute to an occurrence of variation orders in roadway construction projects. While the highest impact of variation orders was on cost performance via "cost overruns". Also, the design planning stage" and "construction stage" has a large negative influence on quality degradation via occurrence of variation. For empirical testing, the case study including a questionnaire survey and collecting secondary data from document review was conducted for 6 projects among roadway construction projects in Penang State completed from 2013 to 2018. This exploratory model gives a better understanding of the occurrence of variation orders in Malaysian roadway projects by explaining the impact load of each factor of cause and effect of variation orders and the relationship among each other

CHAPTER 1 : INTRODUCTION

1.1 Background

The construction industry sector is a very significant sector; it is a major player in the socio economic growth of the countries. Economically, it is one of the main contributors to overall gross domestic product (GDP) growth of developing and developed country (Jamilus et al., 2013). Figure 1.1 illustrates the growth of the construction sector with GDP since 2005 in Malaysia (CIDB, 2016).

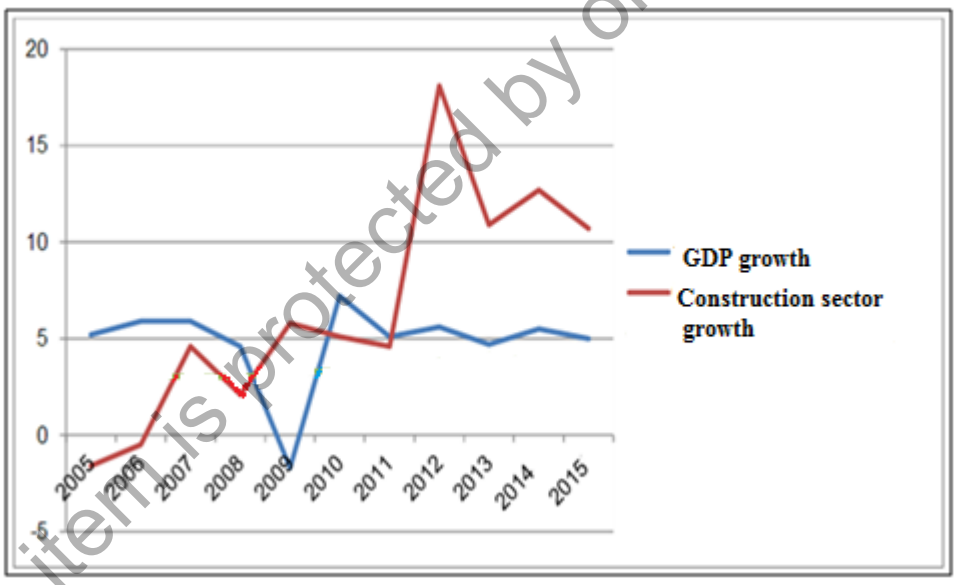

Figure 1.1 Construction Growth Trend in GDP Source: (CIDB, 2016)

It also contributes to improving the quality of life by providing substantial infrastructures such as highways, bridges, hospitals, tunnels, educational buildings, and others. However, the industry of construction has special characteristics in comparison to other types of industry. That means each construction project is different from other projects, a situation which comes from the project's own characteristics. a situation which comes from the characteristics of the project itself. For instance, the size of the

project, type of project, cost, geographical of location, site condition, participants parties, and subsystems within the industry. Traditionally, the failure to achieve project targets including scheduling, estimated budget, a quality required, and other objectives is due to inefficiency in the process of execution (Shebob et al., 2012). The nature of industry of construction is unique, fragmented, and complicated which often facing frequent challenges such as delays (i.e.70% of projects), cost overrun (i.e. around 15 % of estimated budget), and construction waste (i.e. 10% of material cost), low quality, low productivity, changes and variation orders etc. Of these, variation orders are the major problem, as a reason of many negative impacts on construction projects (Memon et al., 2014; Yusuph et al., 2017).

In a perfect construction world, there would be no variation orders. But there is no perfect construction world (O'Brien, 1998), variation orders is a global issue in the industry of construction projects and seldom project is finished without changes and variations (Alaryan & Dawood, 2014; Yusuph et al., 2017). The issue of variation orders in the industry of construction is very prevalent in both developing and developed countries, but such an issue is more influential in developing countries (Ismail et al., 2012). Variation orders (VOs) are a major reason for delay in large projects in developing countries (Assaf & Al-Hejji, 2006).

1.2 Problem Statement

The industry of construction is a major player in the socio-economic growth and development processes of a country if it is well understood (Shebob et al., 2012). Thus, to enable the construction industry in developing country to fulfil its important role, it

should be managed efficiently. Variation order is a common phenomenon in construction industry in developing countries, as reason for negative effects on the projects such as disputes, degradation of quality, cost overrun, and time overrun (Assaf & Al-Hejji, 2006; CII, 1990b; Haq et al., 2013; Ismail et al., 2012; Memon et al., 2014; Suleiman & Luvara, 2016). Variation orders (VOs) means any event which causes modification in the original scope, cost or time of work (CII, 1990b). Variation orders are the main reason why most construction firms could not able to meet their obligations at the time stipulated in the contract (Amu et al., 2005; Assaf & Al-Hejji, 2006; Hui et al., 2017; Ismail et al., 2012). Nonetheless, the construction industry still does not have effective solutions to deal with the issue so far. Therefore, to reduce potential variations and their negative effects in future construction projects, it is important to understand the roots of causes of VOs. When the roots of the causes behind the occurrence of variation orders are understood, their source can be identified accordingly. Moreover, learning from the variations is very important because the professionals could improve and apply their experience in the future (Ibbs & Kwak, 2001). Thus, developing an integrated methodology system for understanding the causes is required for categorizing the variations in order to recognize them efficiently. Via such a system can uncover where the highest amount of variations could be occurred and then, subsequently direct the focus and proceeding pro-active steps to prevent their negative influences in future projects.

Like other developing countries, Malaysia facing a serious issue of variation orders in construction projects (Hui et al., 2017; Ismail Abdul et al., 2013; Jamil & Memon, 2014; Memon et al., 2014; N. Mohammad et al., 2017; Noraziah & Rakmat, 2017). Many projects in Malaysia have suffered from the occurrence of variation orders

and hence, cost overruns (Hui et al., 2017; Ismail Abdul et al., 2013; Jamil & Memon, 2014; Memon et al., 2014). Overruns in schedule and cost in Malaysian construction projects always associated with variations and changes (Hui et al., 2017). This is in general agreement with the research study conducted in Malaysia (Memon et al., 2014). The findings of the study showed that variation orders always occur in Malaysia's JKR projects (Gobana & Thakur, 2017). Alarmingly, in some cases, the projects were severely delayed with a huge cost overrun of over 200% due to variation orders (Hui et al., 2017). 90% of Majlis Amanah Rakyat (MARA) known as Malaysian government agency projects have exceeded the schedule of the completion date, because of variations occurred when major changes arose in the contract during the construction phase as well as imposing additional works (Abdullah & Rahman, 2009; Memon & Rahman, 2011).

Clearly, the occurrence of variation orders is a frequent problem in many construction projects in Malaysia. It is vital to understand the problem of VOs in achieving successful construction projects which need serious awareness and more in-deep research to create solutions for this problem (Memon et al., 2014). Thus, there is an urgent need to control variation orders in a construction project. Thus, the primary step is to understand and uncover the factors of variation orders and their impacts deeply (Ismail et al., 2012; Memon et al., 2014).

Even though some experimental studies have addressed the issue of VOs in construction industry, a quite limited of studies performed in the sector of roadway construction projects, as a result of this, there are no sufficient information and data in the context of the extent and impact of VOs on the performance of the projects in this

area (Yap & Wang, 2015) especially, in the context of Malaysian's JKR projects (Memon et al., 2014). Furthermore, there are no adequate researches on the risk of VOs in the contracts of roadway construction projects. Thus, there seems to be a lack of in-depth knowledge related to the issue of VOs (Hui et al., 2017; Jamil & Memon, 2014; Memon et al., 2014; Mohammad et al., 2010).

Oetomo (2015) contend that variation orders are more severe and influential in roadway projects. Especially, JKR's projects (Memon et al., 2014). This gives a chance to the researcher to employing SEM Structural Equation Modelling methodology to evaluate and modelling the key factors that contribute to occurring of VOs and their impacts on roadway projects.

Via develop a causal model reveals the relationships of (causes-effects) factors which can then be used to reduce negative impacts on project performance through control of variation orders during life cycle of project in the context of Malaysian's JKR roadway projects only. By applying SEM methodology, the research can contribute to the expansion of knowledge from previous studies on the Malaysian construction industry that investigated the causes of variation orders using a structured questionnaire survey.

Substantially, when implementing any construction project, project manager need to maintain the performance of the project through several dimensions namely time, cost, quality, safety within the site and , good professional relations between the parties of the project. Aberration out of agreement objectives will impose additional time, additional costs and, defects in quality, which in turn lead to disputes among

involved parties. In line with this, the occurrence of variation orders directly leads to delay in completion of project works which influence on cost and quality of work. Subsequently, disputes arise between parties of the project (Assaf & Al-Hejji, 2006; Fisk, 1997; Jamil & Memon, 2014; Mitkus & Mitkus, 2014; Noraziah & Rakmat, 2017). Because of these, it is possible to decrease the occurrence of VOs in roadway construction projects and their negative impacts could be controlled, if the factors of variation orders and their impacts are identified and understood efficiently. Such identification provides beneficial information for involved parties to minimize the occurrence of VOs as well as to create more improvement on the performance of the roadway construction projects via controlling the negative impacts of VOs.

Based on the problems as discussed in the previous section, the following research gap is extracted:

i. There is quite limited research on development of an integrated methodology to understand the occurrence of VOs and their impacts on construction projects, especially, in the context of Malaysian's roadway projects;

ii. There is a lack of knowledge on the identification of critical factors of variation orders in roadway construction projects. especially, in the context of Malaysia's roadway projects;

iii. There is a lack of knowledge on the evaluation of the influence of phases of construction process (i.e. planning design stage, construction stage, administration) on occurrence of VOs in Malaysian’s roadway projects;

iv. There is a lack of knowledge on the evaluation of the influence of VOs on the project performance in the context of Malaysia's roadway projects;

v. There is a lack of knowledge on the examination of relationship between the phases of construction process and impacts of VOs, in the context of Malaysia's roadway projects; and

vi. Deep understanding of the roots of the issue will be helpful to stakeholders in decreasing the undesirable situation. Therefore, the absence of an established and organized knowledge-base of previous similar projects, professional teams may face planning problems effectively before the actual beginning of the project during the design planning stage or the construction stage to control and reduce the influence of variations.

The current study addressed the gap in the literature by providing an integrated SEM model that has the ability to reveals the underlying relationship between the factors and impacts of VOs. Thus, such information illustrates context significance and research purpose, hence providing direction and motivation for this study.

1.3 Research Questions

i. What are the main cause and effect factors of change orders in Malaysian's roadway projects?

ii. What is the influence of the phases of the construction process (i.e. planning design stage, construction stage, administration) on the occurrence of VOs in roadway construction projects?

iii. What is the influence of occurrence of VOs on roadway project performance (cost performance; time performance; quality performance; safety & health performance; professional relation performance)?

iv. Are there any significant relationships between phases of the construction process (i.e. planning design stage, construction stage, and administration) with performance-related effects when VOs occurred?

1.4 Aim and Research Objectives

Having identified the above knowledge gaps and research demands, the current study is aimed at developing a relationship model of cause-effect factors of variation orders for roadway construction projects in Malaysia, which can then be used to reducing the occurrence of change orders and control their negative impacts if existed. Moreover, the current study attempts to uncover the main causes of occurrence of change orders as well the influence of change orders in cost, quality, time, health & safety and, professional relations, which constitute the indicators of project performance. In order to achieve the abovementioned aim, the present study is conducted with the following objectives:

i. To assess hierarchically the cause and effect factors of VOs on roadway projects in Malaysia;