ORGANIZATIONAL CHARACTERISTICS, ENVIRONMENT UNCERTAINTY & CONSTRUCTION INNOVATION: EVIDENCE FROM MALAYSIAN CONSTRUCTION INDUSTRY

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ABSTRACT

Constructions industry has increasingly becoming more dynamic, demanding the adoption of innovative methods, and greater technological advancement. The complexity of the industry, generally has been described as multi-faceted and highly fragmented with significant problems such as communication breakdown, conflicts, and disputes. The uniqueness of projects, the organization itself and the management role in coping the changing demands can apparently influence the effort in adopting the new technologies and innovation in the construction sector. In addition, the construction environment which is known as dynamic and full with uncertainties posed difficulty for the management to understand their organization's ability to function in the future. Hence, this paper interested to identify the effects of organizational characteristics and the perceived level of environmental uncertainties towards the implementation of construction innovation. In order to fulfill the research objectives, online survey has been conducted among the construction companies in Malaysia. The on-line questionnaires have been send to randomly selected contraction companies that operating in Malaysia and registered as G7 contractor with CIDB. The number of returned questionnaires was totaled to be 383, yielding an effective response rate of 54.4%. The result showed all the variables proposed have been found

to be positively correlated with construction innovation. Apart from suggesting the direction of future construction industry study, this paper is valuable in providing insights for the contractors in implementing innovative construction technologies that can be used to devise strategic marketing plans and ultimately for enjoyment of the competitive advantages.

Keywords: innovation, construction, organization characteristics, uncertainty, Malaysia

INTRODUCTION

It is generally known that construction industry as an enabling service, has significantly contributed to supporting the growth of other sectors in the economy. As they are closely linked, the demand for construction companies has been generated by these sectors because of the need to increase capacity and the need to cope with the higher demand in future markets. Hence, the construction industry represents one of the largest and most important sectors of the Malaysia economy development. Unfortunately, construction engineering also represents one of Malaysia most tradition-bound, risk-averse industries. One of the crucial strategies that can increase the construction industry's competitiveness and productivity is to implement and adopt proven innovative technologies [1]. Therefore, the deployment of innovative construction technologies are expected to increase from time to time as the market responds to the increased scarcity of high technologies components produced from large diameter and higher quality technologies that has traditionally been obtained [2]. The innovation in integration of engineering, design and construction, can simplify the construction process and decrease cost [3]. With regards to the positive improvements from the innovation, many companies have the attempt to implement innovation. Nevertheless, different innovation orientation necessitates the use of various strategies, skills and resources and there would be many possible reasons to the failure for the innovation implementation. In addition, the difficulties in offering a package of standardized products and inhomogeneous demands of customers hindered the realization of potential gains of the construction innovation[4];[5, 6]. There will always be a challenge for the construction companies to identify those factors that substantially influence the rate of implementation, adoption and diffusion. Companies can apply various innovations, however, some strategies may not encourage for further innovation [7]. Hence, this paper aims to investigate the effects of organization characteristics of the constructions companies namely the companies location and size; environment uncertainties towards the construction innovation.

INNOVATION IN MALAYSIAN CONSTRUCTION INDUSTRY

According to [8], [9], [10], innovation may be defined as the first use or adoption of the new idea. An implied feature of innovation is that it must be useful [11]. This distinguishes an innovation from an invention, especially in a business sense, it is desired that an innovation contribute to the company's performance in some way. Another way of classifying innovations is based on the focus of the innovative effort on the production output or the means of production. Process innovations are advances in technology that enable a greater output per unit of input; these generally involve new production methods or new machinery. Contrasted with process innovation are product innovations which result in qualitatively superior output, these bring new products into the market [12]. Further, a third type has been added to product and process

innovations by some investigators to account for the improvement of support activities to manage the company or its projects such as planning, scheduling, organization, quality control, information systems, etc. This is called service innovation and some researchers call it management innovation [13]. Recognizing innovation as the focal driver for advanced economic growth, Malaysia has been aiming to boost the nation's innovation as part of the nation's transformation strategy [14].

The empirical evidence of this study is derived from the construction technologies in the heavy construction sector in Malaysia. In fact, the process of exploring the determinants of technological innovation in Malaysia's construction industry is a task that stirs passion. This is simply because the success of the industry is resulted by its own dynamic in integrating all the available resources and relevant supporting industries into their business environment [15].

Malaysia has achieved significant progress in its economy and a better quality of life as compared to the situation in the 70s. The government has made a big effort to transform the economy from being highly dependent on agriculture products into an industrialized country [16]. Permodalan Nasional Berhad (PNB) is an important engine of the Malaysian economic development and further understanding of companies invested by PNB is essential for the nation's future [14]. The Malaysian construction industry registered an average annual growth rate of 7.9%, during 2010–2016. This growth was supported by the 10th Malaysian Plan 2011–2015, under which the government invested heavily in infrastructure, industrial parks, and residential buildings. The similar trend continued in 2017 where construction industry contributed 5.9 % to the GDP, while total industry growth for the year stood at 6.7%. In addition, the government's vision 2020 project has also boosted the subsector construction projects in the next few years supported by the government's plan to improve the country's transport network and tourism infrastructure and increase the volume of renewable projects. (Malaysian Construction Market, https://www.mordorintelligence.com/industry-reports/ malaysia-construction). Apparently, Malaysia progress to expand and modernized in its infrastructures throughout the country provide reflections that there are huge opportunities for the construction companies to excel in the market.

Unfortunately, the Covid-19 Pandemic started at the end of year 2019 has created new challenges and the new norms to the global economic growth. This has a downside risk to the growth of the Malaysian economy especially the construction industry. Many factories have been shut down which had caused shortages or delays in building material, such as lumber, drywall, plumbing, electrical fixtures, and mechanical equipment resulting in delays in construction. Banks have become more risk adverse and strict to fund construction projects until the economy shows signs of improvement. This uncertain environment has obviously affected the Malaysian constructors.

ORGANIZATIONAL CHARACTERISTICS

Operation Location

[17] opinions that the character of the environment that a firm operates within is speculated to affect the firm's innovative behavior. Specifically, it is hypothesised that a distance-decay effect exists between the business operation location and innovation, whereby increasing distance from concentrated population centers tends to have a negative effect on firms' innovativeness. [18] has pointed out the need to consider the

organisational location in context in of innovation adoption. [19] finds that construction firms located in urban settings are able to interact with a greater number of competitors, suppliers, designers, and other actors in the construction industry than firms located in rural settings. Therefore, construction firms in urban settings, relative to those in rural settings, are suspected to have a greater probability of possessing a larger network of contacts for gaining information and learning of new construction technologies. If the propositions that increased network size has a positive influence on innovative behavior [20] and that urban settings are characterised by a more concentrated and sophisticated labor and management force [21] are accepted, then a distance-decay effect should be evident in an examination of the relationship between firm location and firms' innovativeness.

The literature on a distance-decay effect relationship between firms' operation location and innovative behavior is sparse. [22] utilize a rural-urban dummy variable in a regression model that is used to predict the percent of manufacturers' work that is produced in metric units. Within the context of their study, their results do not support a significant distance-decay relationship as it relates to innovation adoption. [23] investigate the relationship between American machine industry firms' metropolitan location and their adoption of innovative high technology products and systems of products. These researchers find that firms located in the medium-sized metropolitan locations are found to exhibit the greatest level of innovative behavior, followed by firms located in urban and rural areas. Conversely, [24] indicate that the diffusion in the Canadian construction industry is attributable to metropolitan location.

To determine whether a significant distance-decay relationship exists between construction firm location and innovation, the following hypothesis is posited:

H1a: The degree of urbanization of the firm's primary operating location is positively associated with construction firms' innovativeness with respect to construction technologies.

Firm Size

In the diffusion of innovations, company size has been the most powerful predictor of new technology adoption [25]. In fact, the positive association between company size and innovation adoption is so pervasive within the literature. The diffusion of innovations literature suggests that larger companies are more likely to adopt innovations in respect to small companies due to greater technical expertise of their employees, larger scale, more efficient organisational structure, slack resources, and their differential ability to endure risk [24] [26]; [27] [28]; [29] The economics and industrial organisation literature is in general agreement that if there are economies of scale involved, innovation adoption will appear more profitable to a large company since the cost of learning how to utilize the innovation will be spread over a greater number of output units [30]. As a result, large scale economies can potentially result in a faster return on initial investment costs relative to small scale economies. Therefore, other factors being held constant, it is claimed that learning costs are less likely to make an innovation unprofitable when the adopting company is large, and the larger company will be more likely to recover initial innovation investment costs than a small company. Given the empirical evidence, it is argued that the association between company size and innovativeness of construction companies is not monotonic; namely, company size is positively associated with innovation implementation and adoption up to a point, increases in company size after this point result in a decrease in companies' innovativeness. Formally stated, it is hypothesised that:

H1b: The firm size is positively associated with the construction firms' innovativeness with respect to construction technologies.

PERCEIVED ENVIRONMENTAL UNCERTAINTY

The concept of environmental uncertainty has been investigated within the organisational theory literature [31]. This literature stream suggests that environmental uncertainty is dysfunctional to maintaining stability and satisfactory firm performance [32]. According to [33], three commonly used definitions of environmental uncertainty exist in the organizational theory literature; these being: (1) an inability to assign probabilities as to the likelihood of future events, (2) a lack of information concerning cause-and-effect relationships, and (3) an inability to predict accurately what the outcomes of a decision might be as they relate to the firm.

[33] suggests that three unique types of environmental uncertainty affect the nature of firm strategy development, action, and performance. These three types of environmental uncertainty include 1) state uncertainty, 2) effect uncertainty, and 3) response uncertainty. A brief review of each of these types of environmental uncertainty follows, based primarily on Milliken's conceptualisations. State uncertainty occurs when a manager perceives the environment, or a particular component of the environment, to be unpredictable. The actions of relevant organisations and constituencies may be uncertain to a manager. In addition, the manager may be uncertain as to the probability and/or nature of general changes in state of the relevant environment. It has been hypothesized that as environmental volatility, complexity, and heterogeneity increase, managers' state uncertainty increases. [34]finds a manager's inability to understand how components in the state of the environment might be changing leads to his inability to predict the future behavior of organisations and constituencies that affect his firm. In the same line, [35] claimed that firms use their flexibility and discretion to better adapt to the external environment.

Despite the fact that risk and environmental uncertainty are used interchangeably in the literature, they are conceptually not identical constructs [36]. Specifically, the probability distribution of an outcome is assumed to be known under risk. The risk paradigm assumes that choices are made between a sure outcome and a risky outcome, not knowing which is going to occur [37]. Under environmental uncertainty, the probability distribution of an outcome is unknown. In extreme cases, no probability distributions for an uncertain outcome can be excluded and all outcomes are still possible. Given the nature of its probability structure, environmental uncertainty has been referred to as second-order risk [38] or perceived risk.

The literature examining innovation in the construction industry has produced no studies that have empirically tested the relationship between levels of risk or environmental uncertainty and innovation [39]. However, there are numerous studies indicate that high levels of risk and environmental uncertainty in the construction industry play a crucial role in inhibiting the implementation and adoption of innovative products and processes [40] study intends to empirically test whether contractors' perceptions of environmental uncertainty influence their degree of innovativeness. Therefore, the following hypothesis is proposed in the context of the firm's level of state uncertainty:

H2: The low level of state uncertainty is positively associated with construction firms' innovativeness.

METHODOLOGY

This study employed a survey which has been conducted among the construction companies in Malaysia. A total of 703 questionnaire surveys were send by mails and via online to randomly selected contraction companies that operating in Malaysia and registered as G7 contractor with CIDB. The survey helps to produce quantifiable measures of the main variables namely the construction innovation, organization characteristics and perceived environment uncertainty that can be statistically analysed to generate reliable observations. Thus, the main drivers included in the survey were to explore the respondents' perception on the influence of these variables towards construction innovation. The number of returned usable surveys totaled 383, yielding an effective response rate of 45.52%. This response rate of approximately 54.48% was significantly greater than other recent survey where the mail survey respond rate in Malaysia is approximately 25% [41].

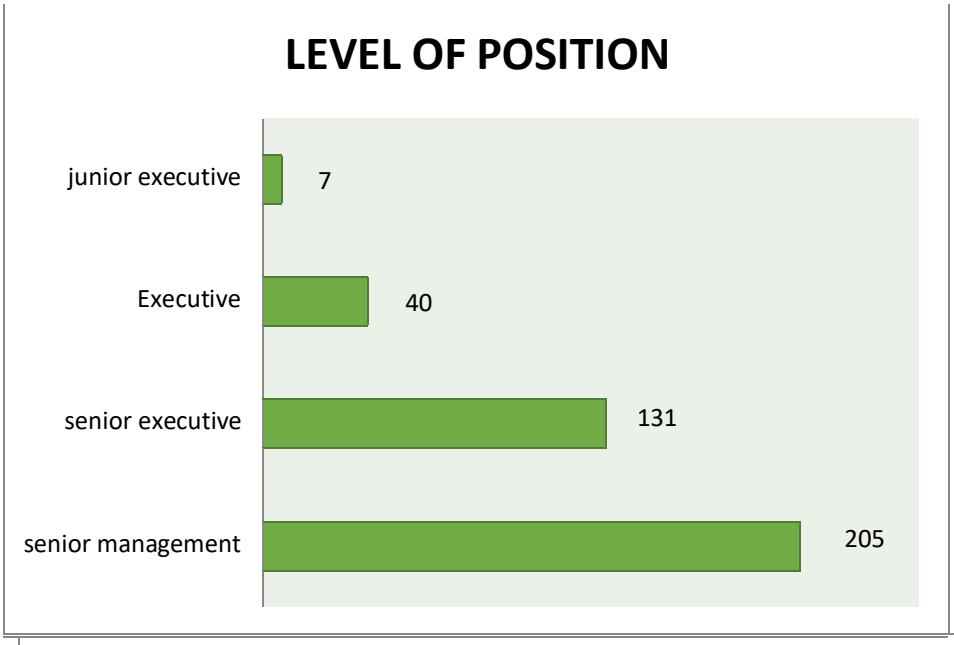
RESULTS

Survey responses are relying on voluntary participation, and there is always the possibility that respondents and non-respondents differ in some significant manner [42]Therefore, the difficulty associated with the identification on non-respondent's characteristics in anonymous researches is counterpart by an alternative test of non-response bias test. Non-respondents were assumed to have

similar characteristics to late respondents. However, the initial and follow-up mailings were gathered within the very close timing difference of only one month, and have exceeded the samples size requirements of 281, therefore, it can be concluded that no issues of non-response bias affected the generalizability of the findings of this study and no non-response bias test was required.

Profile of the Respondents

The descriptive statistics in this section are divided into four sections. The responding companies are demographically profiled in this section. The respondents were companies registered with CIDB as G7 contractors. The questionnaires were addressed to the organization leaders of company randomly selected from the list of contractors G7 registered with CIDB. Therefore, accurate insights of the companies' innovativeness could be gathered in more reflective way based on their level of position in the companies. The level of position and companies categories of registration is shown in Figure 1. The majority of the respondents were senior management with record of 53.50%, followed by senior executive with record of 34.20% and executive with record of 10.40%. It is a very good indication that the responses are accurate as the person in this level of managerial post has contributing to a total of 98.2% and they would be in the best position to know and affect the companies' needs in innovation, With regards to the companies' catergory of registration, 35.50% of the respondents were registered for all catregories of construction, which included building construction, civil engineering construction and mechanical & electrical construction. Meanwhile, the smallest proportion was only 3.1%, from registered as mechanical & electrical contractor only.



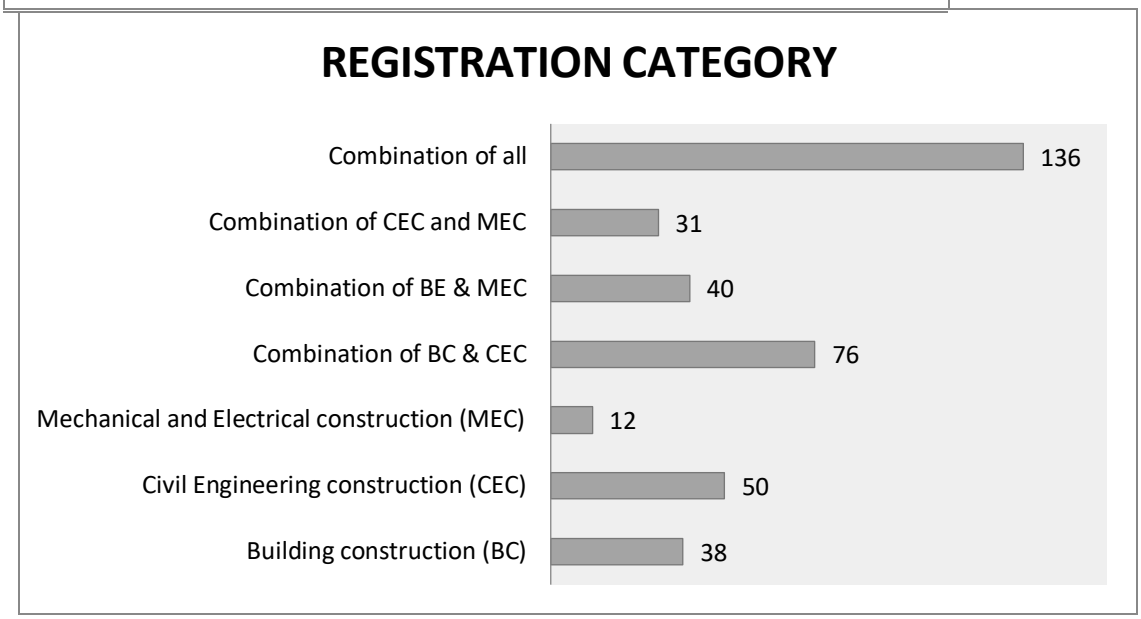


Figure 1: Respondents profile

Descriptive Analysis

In the descriptive analysis, the minimum and maximum value, means, range, standard deviation and variance for the interval-scaled variables were derived. Descriptive statistics for the final list of variables of the study are shown in Table 1 and the scale measurements used is a seven point Likert scale.

Table 1

Descriptive analysis of industrial fragementation, operation location , company size and

Variables	Mean	Std. Deviation
Ind Fragmentation 1	4.05	1.489
Ind Fragmentation 2	4.69	1.524
Ind Fragmentation 3	4.85	1.403
Ind Fragmentation 4	4.68	1.568
Operation Location 1	5.08	1.441
Operation Location 2	4.95	1.430
Firm Size 1	4.61	1.482
Firm Size 2	4.56	1.581
Firm Size 3	4.60	1.542
Innovation imple 1	4.83	1.338
Innovation imple 2	4.86	1.369
Innovation imple 3	5.12	1.302
Innovation imple 4	4.88	1.308

correlation analysis

[43] suggested that if r score is above 0.50 the correlation between the two variables are considered largely correlated. 3 group of variables are strongly correlated above 0.70 i.e. OL and IF (0.732), CS and OL (0.719) and CS and IF (0.685), While other group of variables are very weak correlated with all other variables i.e. ranging between 0.240 to 0.271.

Table 2

Pearson's Correlation between the variables

	CI	IF	OL	CS	
Construction Innovation (CI)	1				
Industrial Fragmentation (IF)	.240**	1			
Organization Location (OL)	.273**	.732**	1		
Company Size (CS)	.271**	.685**	.719**	1	

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

*. Correlation is significant at the 0.05 level (2-tailed)

Table 2: Pearson's Correlation between the variables

Multiple Regression Analysis

Hypotheses Testing

In order to answer the research question, which addressed the relationship between the various determinants of firms' innovativeness in technological innovation implementation and adoption, linear regression analyses were conducted. In light of the results of the regression analysis, some amendments have to be made, if it is not supported by the statement of hypotheses stated earlier. The hypotheses tested in this study are as follow:

H1: Industry fragmentation is negatively associated with construction firms' innovativeness with respect to construction technologies implementation and adoption.

Based on the 383 firms, the following results were recorded. Table 4.12 shows the result which indicates the two variables are positively associated; $R^2 = 0.058$, Adj. $R^2 = 0.055$ and $F = 23.080$, $p<0.01$. This means 5.8% of the variance increase in the degree of technological innovation implementation and adoption was explained by the industrial fragmentation. Approximately 5.8% of the variance of the construction technologies innovation implementation and adoption is accounted for by its linear relationship with the industrial fragmentation in the regression equation for predicting the construction technology implementation and adoption.

Table 3: Results of regression analysis for industrial fragmentation

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.240[a]	.058	.055	4.47690

a. Predictors: (Constant), IF
b. Dependent Variable: CFI

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	462.589	1	462.589	23.080	.000[a]
	Residual	7536.035	376	20.043		
	Total	7998.624	377			

a. Predictors: (Constant), IF
b. Dependent Variable: CFI
Therefore, hypothesis is not supported

Therefore, hypothesis is not supported and the regressing is written as follow;

$$CFI = 15.505 + 0.229X + e$$

…..Formulae 4.5

H2: The degree of urbanisation of the firm's primary operating location is positively associated with construction firms' innovativeness with respect to construction technologies.

Based on the 383 firms, the following results were recorded. Table 4.13 shows the result which indicates the two variables are positively associated; $R^2 = 0.075$, Adj. $R^2 = 0.072$ and $F = 30.338$, $p<0.01$. This means 7.5% of the variance increase in the firms' innovativeness was explained by the degree of urbanisation of the firm's primary operating location. Approximately 7.5% of the variance of the construction technologies innovation implementation and adoption is accounted for by its linear relationship with the urbanisation of the firm's primary operating location in the regression equation for predicting the firms' innovativeness.

Table 4.13 Results of regression analysis for operation location

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.273[a]	.075	.072	4.43922

a. Predictors: (Constant), OL
b. Dependent Variable: CFI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.905	.902		16.522	.000
	OL	.480	.087	.273	5.508	.000

a. Dependent Variable: CFI

Therefore, hypothesis is supported and the regressing is written as follow;

$$CFI = 14.905 + 0.480X + e \quad \text{…..Formulae 4.6}$$

H3: The innovativeness of firms with respect to construction technologies implementation and adoption in the construction industry is positively affected by the firm size.

Based on the 383 firms, the following results were recorded. Table 4.14 shows the result which indicates the two variables are positively associated; $R^2 = 0.073$, Adj. $R^2 = 0.071$ and $F = 29.957$, $p<0.01$. This means 7.3% of the variance increase in the innovativeness of firms was explained by the firm size. Approximately 7.3% of the variance of the construction technologies innovation implementation and adoption is accounted for by its linear relationship with the firm size in the regression equation for predicting the firms' innovativeness.

Therefore, hypothesis is supported and the regressing is written as follow;

$$CFI = 15.755 + 0.287X + e \quad \text{…..Formulae 4.7}$$

Table 4.14 Results of regression analysis for firm size

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Errorof the Estimate
1	.271[a]	.073	.071	4.43699

a. Predictors: (Constant), FS
b. Dependent Variable: CFI

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	589.754	1	589.754	29.957	.000[a]
	Residual	7441.644	378	19.687		
	Total	8031.397	379			

a. Predictors: (Constant), FS
b. Dependent Variable: CFI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15.755	.756		20.833	.000
	FS	.287	.052	.271	5.473	.000

a. Dependent Variable: CFI

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