

THE EFFECTS OF ORGANIZATION CHARACTERISTICS TOWARDS INNOVATION IN CONSTRUCTION INDUSTRY

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ABSTRACT

Construction industry needs to be dynamic in order to keep pace with the changes that the world is constantly facing. The use of innovative construction technologies particularly in the heavy construction industry is expected to enhance the contractor's ability in producing cost-competitive, resource-efficient, and price-stable projects. Diverse abilities, capitals and organizational cultures are required to foster innovation orientation and adoption. The Malaysian construction industry is apparently one of the imperative sectors of the economy, however, the rate of adopting innovative products and processes are relatively low. The dilemma facing construction companies when introducing new construction technologies is identifying those factors that substantially influence the rate of implementation, adoption and diffusion. 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. Furthermore, the relationship between the characteristics and innovation orientation of construction companies is relatively unexplored. Hence, this paper aims to discuss the effects of organization characteristics of the constructions companies namely the industry fragmentation, companies location and size towards the construction innovation. A study has been conducted on 703 contractors that registered as G7 contractor with Malaysian Construction Industrial Board (CIDB). The study found out that the industry fragmentation, location and size have some influence yet very small on the construction companies innovation implementation and adoption behavior. The results suggest that increasing the rate of implementation and adoption may be enhanced to a greater degree by other factors such as increasing external cooperation, perceived environmental uncertainties and competitive rivalry attributes. The findings contribute significant insight on both theoretical development and practical implications on the issue of the innovativeness in Malaysian construction industry, with particular reference to the heavy construction sector.

Keywords: innovation, construction, organization characteristics, Malaysia

1.0 INTRODUCTION

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 (Marcel, 2011). The construction industry needs to be dynamic in order to keep pace with the changes that the world is constantly facing. In addition to responding to the pressing social, economic and technological challenges, the needs and demands of clients will keep changing which required the companies to search for a better and effective technological construction materials and methods that will improved the way the built environment is designed, built and maintained. 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 (Oliva, 2011). The innovation in integration of engineering, design and construction, can simplify the construction process and decrease cost (Budiawan & Sidwell, 2004). 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. 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 (Ernawati, Nor Aini & Mohammad, 2016). Hence, this paper aims to investigate the effects of organization characteristics of the constructions companies namely the industry fragmentation, companies location and size towards the construction innovation.

According to Aouad, Ozorhon and Abbott (2010), it is a need for studies to explore and understand the mechanism that drive innovation in construction. Through the implementation and adoption of innovative products and processes, it is claimed that the construction industry would benefit via increased productivity. Furthermore, the prospective users would benefit by way of increased affordability and improved quality (Goldberg *et al.*, 1989; Oster, Sharon & Quigley, 1977; Spall, 1971). Nonetheless, the construction technologies have little market information for the construction industry to develop strategic plans to enhance the adoption and diffusion of their construction technologies. The market analyses of the construction industry performed by companies and academics alike are typically based on one-dimensional econometric models that generate ambiguous information and evaluations that are counterintuitive (Rosenberg *et al.*, 1990). Therefore, understanding how the innovation can be directed successfully especially in the construction industry is highly imperative.

2.0 LITERATURE REVIEW

2.1 Innovation in Construction Industry

According to Freeman (1974), Layton (1977), Rogers (1983), and Kuczmarki (2006) 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 (Anthony, 2011). 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 (Rosenberg, 1982; Tatum, 1984; Anthony, 2011). In addition, 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 (Stata, 1989; Anthony 2011).

In literature, it is difficult to capture all of the factors that contribute to construction companies' innovativeness with regard to the adoption of construction technologies in Malaysia due to the difficulties and insufficient support on available local support. Similar to the majority of innovation adoption models developed in the innovation and diffusion literature, the model of construction companies' innovativeness in this study is based in large measure on Rogers' (1995) innovations adoption process, Shook's (1997) companies' innovativeness, Andrew's (2005) promoting innovation, Ghassan's (2011) facilitating innovation, Bhattacharyya's (2011) Innovation for competitive excellence, Hardie's (2011) factors influencing technical innovation, and Anthony's (2011) determinants of successful organizational innovation. However, this research focuses on innovation implementation and adoption as a process that occurs over time.

2.2 Industry Fragmentation

Industry fragmentation is critically viewed as the level of company integration, within a particular industrial sector. Currently, very little research exists specifically evaluating the influence of industry fragmentation in regard to companies' innovativeness (John, 2011). Furthermore, most of the researches that examined the relationship between industry fragmentation and companies' innovativeness have been concentrated within highly fragmented industries such as construction industry. The production in construction is typically not performed by a single integrated company. In general contractor relies heavily on specialized subcontractors and other professionals in the production of the final product (Goldberg & Shepard, 1989). It is not uncommon for a main contractor to hire individual companies that specialize in foundation, masonry concrete, carpentry, structural steel, mechanical, electrical, etc. on a single project. In many circumstances, the main contractor may act only as the financing and/or management agent of the entire construction project. As a result of this fragmented industry structure, construction companies tend to group by the stage of production, each group

tends to operate as a separate industry segment of the construction sector (Goldberg & Shepard, 1989; Ventre, 1979; Brochner, 2008).

Industry fragmentation is also believed as a barrier to the adoption of innovative products for two primary reasons (John, 2011). First, increasing fragmentation within an industry is believed to lead to discontinuities in the transfer of information concerning the installation, use, and maintenance of particular process innovations. For example, subcontractors in the construction industry are commonly cited as a weak link in the transfer of innovation information since they are often isolated from the assessment of final needs. Additionally, subcontractors frequently fail to transmit critical process information to other intermediate producers of structures (Goldberg & Shepard, 1989; NAHB Research Center 1991; Poitras, Andre & Duff, 1988; John, 2011). Second, it is hypothesised that companies specialising in particular processes are unlikely to implement and adopt system improvements that involve larger subcomponents or that integrate processes from other trades (NAHB Research Center, 1991).

Two forms of fragmentation can exist within any industry; namely, vertical fragmentation and horizontal fragmentation.

i. Vertical Fragmentation

There is an overwhelming dependence of construction companies on subcontracted plant and machineries, equipment, labor, materials etc. The dependence with companies creates a vertically fragmented industry structure that tends to complicate the hierarchical flow of communications. As a result, a construction company is likely to experience discontinuities in the flow of information, specifically in information that would tend to indicate that the company should explore specific process improvements (Brochner, 2008).

ii. Horizontal Fragmentation

Due to specialization by trade in the construction industry, companies often experience discontinuities in their communication with one another. As a result, many companies fail to coordinate their respective tasks on a project (Friedman, 1989b; NAHB Research Center, 1991). Companies in the industry tend to maintain restrictive rules pertaining to their particular responsibilities on a project, which is partly an outgrowth of union and open shop rules that dominate the commercial and industrial construction industries (Northrup, 1984). A direct result of these conditions is horizontal fragmentation within the construction industry lead to the tendency among tradesmen to resist those innovations that could change and/or consolidate their work allocations and methods. It is speculated that horizontal fragmentation in the construction industry hinders a systems approach to innovation, as well as limits both the scope and the benefit of all the innovations that could be adopted (Friedman, 1989b; NAHB Research Center, 1991; John, 2011). Goldberg & Shepard (1989) claimed that those contractors who are more horizontally integrated will exhibit the greatest amount of innovative activity.. Given Goldberg & Shepard's (1989) findings on the significant negative effect of horizontal

fragmentation on innovation within the construction industry, the hypothesis is formulated as follow:

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

2.3 Operation Location

The character of the environment that a company operates within is speculated to affect the company's innovative behavior (Hardie, 2011). Specifically, 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 companies' innovativeness. Harty (2005) has pointed out the need to consider the organizational location in context in of innovation adoption. Borje (2006) finds that construction companies located in urban settings are able to interact with a greater number of competitors, suppliers, designers, and other actors in the construction industry than companies located in rural settings. The literature on a distance-decay effect relationship between companies' operation location and innovative behavior is sparse. Phillips, Lakhani & George (1984) and Borje (2006) 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. Rees, John, Briggs, & Oakey (1984) find that companies located in the medium-sized metropolitan locations are found to exhibit the greatest level of innovative behavior, followed by companies located in urban and rural areas. To determine whether a significant distance-decay relationship exists between construction company location and innovation, the following hypothesis is posited:

H2: The degree of urbanization of the company's primary operating location is positively associated with construction companies' innovativeness with respect to construction technologies.

2.4 Company Size

In the diffusion of innovations, company size has been the most powerful predictor of new technology adoption (Keefe, 1991; Rogers, 1995; Hardie, 2011). In fact, the positive association between company size and innovation adoption is so pervasive within the literature (Rogers, 1995). 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 (Damanpour, 1987 & 1991; Dewar & Dutton, 1986; Ettl, 1983; Latreille, 1992; Teece, 1987; Manley, 2006). 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 (NAHB Research Center,

1991; Porter, 1980; Scherer, 1980; Spall, 1971; Teece, 1987). 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:

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

3.0 RESEARCH METHODOLOGY

A mail survey has been conducted among the construction companies in Malaysia. A total of 703 questionnaire surveys were mailed to randomly selected contraction companies that operating in Malaysia and registered as G7 contractor with CIDB. 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% (Ismail and King, 2007).

4.0 RESULTS

Survey responses are relying on voluntary participation, and there is always the possibility that respondents and non-respondents differ in some significant manner (Matteson *et al.*, 1984). 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 (Armstrong & Overton, 1977). 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.

4.1 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' category of registration, 35.50% of the respondents were registered for all categories 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.

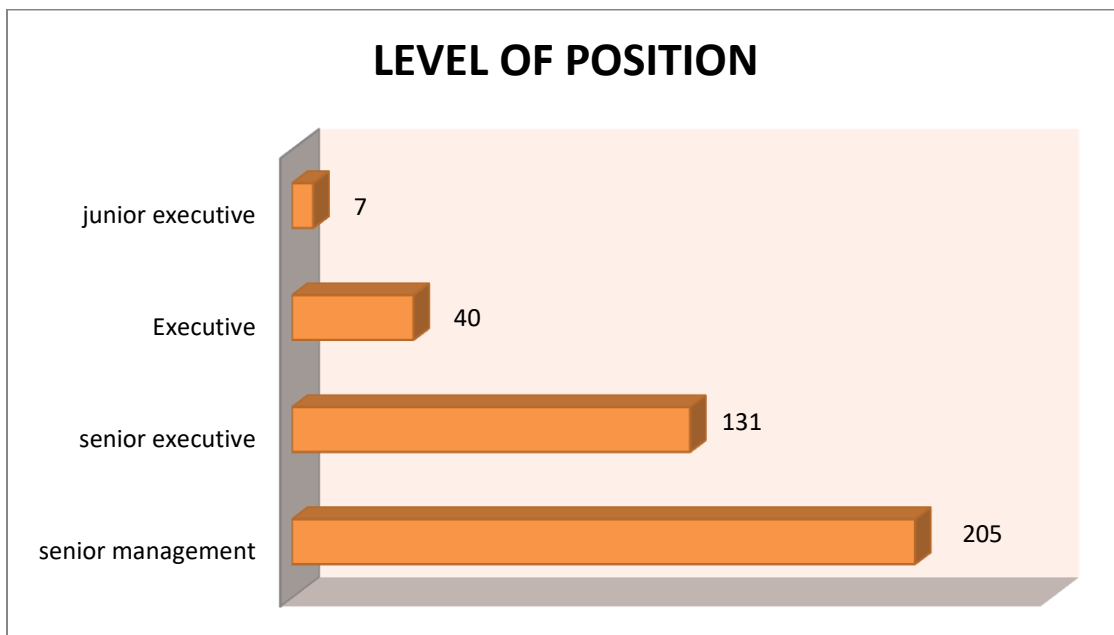


Figure 1: Level of Position

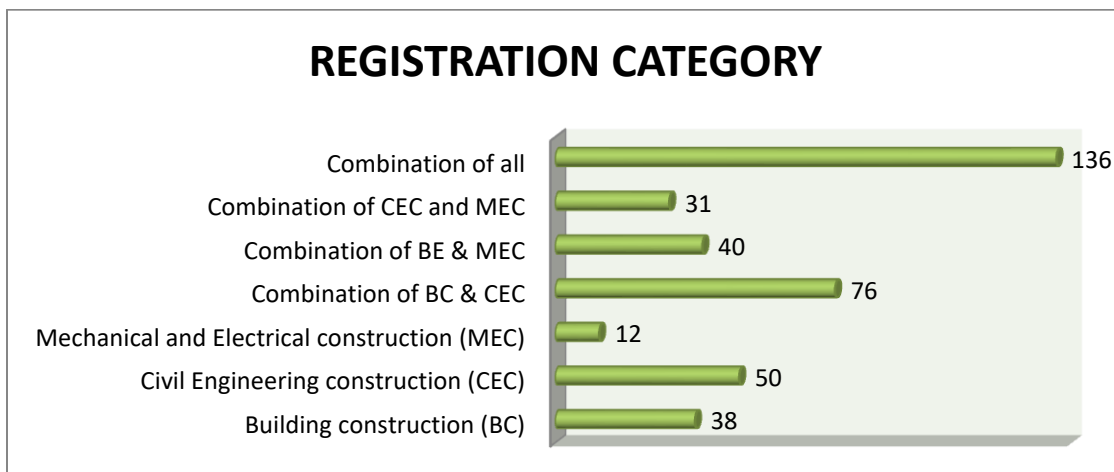


Figure 2: Registration Category

4.2 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 fragmentation, operation location, company size, and innovation implementation*

Variables	Mean	Std. Deviation
Industrial Fragmentation 1	4.05	1.489
Industrial Fragmentation 2	4.69	1.524
Industrial Fragmentation 3	4.85	1.403
Industrial 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 implementation 1	4.83	1.338
Innovation implementation 2	4.86	1.369
Innovation implementation 3	5.12	1.302
Innovation implementation4	4.88	1.308

4.3 Correlation Analysis

Cohen (1988) 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 and 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)

4.4 Multiple Regression Analysis

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 3 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	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.240 ^a	.058	.055	4.47690

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;

$$CFI = 15.505 + 0.229X + e \quad \dots\text{Formulae 4.5}$$

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 shows the result which indicates the two variables are positively associated; $R^2 = 0.075$, $\text{Adj. } R^2 = 0.072$ 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: *Results of regression analysis for operation location*

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

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

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 5 shows the result which indicates the two variables are positively associated; $R^2 = 0.073$, $\text{Adj. } R^2 = 0.071$ 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;

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

Table 5: Results of regression analysis for firm size

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.271 ^a	.073	.071	4.43699

Model		Sum of Squares	df	Mean Square	F	Sig.
1	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

5.0 CONCLUSION

This research aims to investigate and evaluate issues related to the nature of technological innovation implementation and adoption within the Malaysian construction industry, specifically to the heavy construction sector. The literature review reveals innovation as, to challenge the current paradigms and this form the basis to look, accepted logic and seek changes. These changes become innovative when the solutions are win-win for all involved. This research has given contractors guide on general determinant factors in implementation and adoption of innovative construction technologies that can be used to devise strategic marketing plans and ultimately for enjoyment of competitive advantages.

The findings of the research suggest to specify market structure characteristic such as industry fragmentation, operation location and firm size. The finding showed that, huge organization was more innovative rather than small companies. As discussed in this research, several differences exist between construction and others industries: 1) the construction industry is responsive to externally derived demand, highly fragmented, geography and project based and highly competitive; 2) most construction products include immobility, durability, costliness and a high risk of failure; 3) most construction processes are dependent on unique designs, constantly reconfigured and performed under highly variable environmental conditions; 4) most construction process require complex and diverse technology. Therefore, these differences suggest several important advantages that should encourage construction innovation. Advantages such as project organization, engineering and construction integration, low capital investment, capability and experience of personnel, process emphasis and flexibility. In order to utilize those advantages, Malaysian construction firms should formulate and implement processes based on the findings of this research i.e. the determinants of firms' innovativeness in innovation implementation and adoption in construction industry, and more specifically heavy construction sector.

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