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Dr. Andrew Chan PhD

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**Knowledge Transfer in International Projects:
An Institutional Theory Approach**

John Mortensen

Student ID No.:2134211

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1. Introduction

a. Research Background

International construction projects are characterized by their complexity. Large, multi-national, teams of consultants providing highly specialized services on projects which are frequently highly technical. The project-based nature of construction contributes significantly to the complexity of the process. Projects are temporary organizations of groups with defined and demarcated job descriptions each inter-dependent with others for the delivery of their own services and the creation of a one-off final product (Gann and Salter, 1998). The complexity arises not only through the sophistication of design, but through the coordination of vast volumes of highly technical information, between and within the teams which make up the temporary organization of a project. Those teams may be located anywhere in the world and have little or no previous experience working in the location of a project they are tasked with delivering.

Increasing technical sophistication in demands from end users and owners create a continuing demand to transmit data between project stakeholders to ensure the finished structure is fit for purpose. For example, the introduction of proton therapy cancer treatments to Hong Kong presented the dual challenges of a new technology in an environment with limited land available for development. The solution required a world first in the form of a vertical, multi-basement floor construction to accommodate the linear accelerator. The design required collaboration of designers in the US, and Hong Kong.

Knowledge transfer has been identified as a root cause of project failure (Lam, 1997) the impact on the economy and on the environment is considerable when we consider that, even during Covid, the construction sector of China constitutes nearly 6.5% of GDP as shown in Figure 1 and employs approximately 60 million workers. According to the United Nations Environment Programme (UNEP, 2022), buildings and construction are responsible for 34% of global energy use and 37% of global carbon emissions. The construction process is still very labour intensive and resource wasteful. Consequently, the implications of any errors and omissions due to failure of knowledge transfer, tend to result in amplification of the inherent inefficiencies of the process, abortive works and repetitive work requiring more materials and construction work. Conversely, improvements in efficiency can have a significant positive impact on construction's environmental footprint.



Figure 1. Construction Sector as % of GDP

This study originated from the development of a new campus in Tianjin, Mainland China for The Juilliard School, the world's leading music and performing arts higher education institution. This writer was involved with the project for nine years from its inception and preliminary negotiations. As a leading international institution being invited and funded by the Chinese Government, this project had a vast and diverse stakeholder group of powerful and influential actors, including China's First Lady, Peng LiYuan, a powerful Party Secretary of Beihai area and the entourage of political appointees who were assigned to the project. On the American side were the Emeritus President of the University, the Board of Governors and faculty members. Before any design work started there was already a complex arrangement of stakeholders with either direct or indirect influence over the project. A leading American architect, and over 10 specialist consultants from the US, were appointed for the design. A mirror team of Chinese consultants was appointed to localize the project in China. Cultural and language differences, time zones and institutional norms needed to be managed in order to share technical specifications which were extremely sophisticated to meet the acoustic requirements of the project. This study is a step towards making sense of the extreme complexity that was encountered in delivering this project.

In international construction projects, large inter-disciplinary, multi-cultural, multi-institutional teams form a temporary organization with a single objective. The behaviour of that organization or of the component parts follows the tenets described in institutional theory and maintains three areas of influence (Javernick-Will and Scott 2014). Firstly, regulatory, the legal and prescriptive code issues which constrain the actions of the actors these include the contracts, building codes, and ordinances which are clearly enshrined. These may determine the relationships between consultants who are partnered on a project or between the owner of the project and the consultants and contractors responsible for construction. Secondly, are the

normative influences which may influence behaviour within a professional organization or between consultant groups and include the customs and codes of ethical behaviour expected of members, work practices and specific issues pertaining to the contextual environment of the project, such as logistics and relationships. Thirdly, are the cognitive or cultural influences which are the implicit codes and signifiers of a culture or a social group and include language and cultural habits and aesthetic judgements.

Construction contracts are strictly governed by schedule. Failure to complete on time is a potential cost to either the owner who is unable to start operations, or to the contractor who must pay for equipment and labour, and pay possible punitive damages to the owner. In a large and complex project, with teams physically located in different geographies and time zones, ineffective knowledge transfer, between members of the project organization, has been identified as a cause of project failure with costly consequences (Qiu et al. 2019).

b. Research Objectives

The objective of this study is to contribute to the understanding of how knowledge transfer is performed across and within complex international project teams. Building Information Management (BIM) is a process and a technology. It is capable of digitally capturing all the building design information, in 3 dimensions, and presenting a single digital model which holds all interdisciplinary detail down to the last screw and nail (Al-Saeed et al. 2020). The implications of this are profound in construction. The single biggest cause of repeat work in construction is clashes between different services. Clashes between structure and façade, or between architecture and air conditioning or plumbing and so on. All result from drawings which have not been coordinated. BIM coordinates information and identifies clashes before they are built. Beyond drawing coordination, BIM also has the capacity to coordinate the resource schedule or labour and machinery, and it can produce costing of the project up to date with every change. Eliminating clashes, coordinating resources and managing the cost of design changes, all reduce waste, of time, resources and money. So why is this software tool, which has been readily available since the 1990s, so poorly implemented on projects when there are quantifiable benefits to users, clients and the environment?

A study by the Construction Industry Council of Hong Kong in 2019 indicates that only 44% of construction industry professionals have adopted BIM and that 36% only implemented BIM on 4.4 projects over the course of a year (CICCHK, 2019). Two of the primary reasons given for not implementing BIM are identified as “locally accepted practices” and “a dismissive mindset”

(Construction Industry Council HK 2019) Seen through the lens of institutional theory, this is consistent with an argument supporting the impact of normative and cognitive forces influencing the behaviour of professional institutions in ways which may be neither beneficial to the industry as a whole, nor to the individual professional institutions.

Studies of Chinese Foreign joint ventures by Tsang, (2001), also highlight the difficulties of overcoming cultural differences in management to achieve desired outcomes. Tsang's (2001) interview-based studies, identify values and motivational differences which conflict to affect the outcome of joint-venture partnerships. However, it should be noted that the study was conducted in 2001, and with the rapid transformation of the Chinese economy this study may present different outcomes today.

The impact of construction projects has been recognized as extending beyond the client contractor relationship, into a larger social stakeholder group which has seen a greater focus on the concept of the project as a temporary organization brought together for a singular purpose (Stretton 2018). The phenomenon of temporary organization focuses attention on critical mechanisms of knowledge transfer within and between project entities. This study focuses on the drivers that influence the adoption of the industry standard knowledge management programme, BIM, and on the influence that BIM may have on project success.

c. Research Contributions to Knowledge and Practice

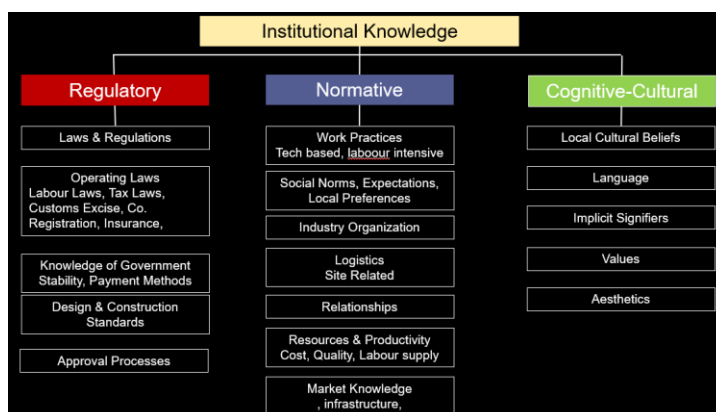
Knowledge transfer between institutional entities has a direct and measurable impact on the performance of a project through the mechanism of coordination, which alleviates inter-disciplinary clashes and improves the efficient use of time and resources. This is both economically and environmentally sustainable to a point that regulated, mandatory use is justified, for the benefit of the community. But, of greater significance to the individual practitioner or professional body, is the impact on the sustainability of a firm. Argote et al. (2000) highlight the importance of knowledge transfer in improving productivity and assuring longevity of the organization. Knowledge transfer between projects, and retained knowledge from previous project experience, is the differentiating edge which defines the competitiveness of a professional practice for future bids. The inability to accurately evaluate costs, to anticipate risks or allocate resources undermines competitiveness. In the project-based economy of the construction industry, in which project knowledge may be held by individuals who are site based and possibly professional journeymen, knowledge management is sustainability, from the individual, industry and environmental perspectives.

2. Theoretical Foundations and Hypotheses

Projects are composed of three components of influence (Morris and Geraldi, 2011): firstly, the Technical or operational aspects of delivery of the project, design and construction. Secondly, the strategic aspects of the project, seen as an holistic entity, with stakeholder involvement, financing, end user requirements and social implications. And, thirdly the institutional component which is the project in a temporal context of other projects, and the sustainability of the institutions (professions, trades, unions etc) which contribute to projects.

Critical to the concept of institutional theory is the transfer of knowledge and experience from one project to another and from one institutional entity to another, which is affected by the regulations, norms and practices of each institution (architectural, construction, government, union, suppliers etc). Argote et al. (2000) note that “Organizations that are able to transfer knowledge effectively from one unit to another are more productive and more likely to survive than those that are less adept at knowledge transfer.” Despite the incentives of higher productivity and lower risk, knowledge transfer is difficult to achieve. Knowledge transfer at the institutional or organizational level requires: sharing interpreting and integrating information which must also be stored and readily accessible in the event of staff turnover. In a project-based industry staff turn-over is high, a departing senior specialist engineer will carry the knowledge of the project away from the firm unless the information has been effectively stored in a cloud-based web site.

Institutional theory identifies three dimensions: the regulatory, normative and cognitive/cultural which stabilize and provide meaning to its members (Javernick-Will and Scott 2014). Multi-national project-based organizations, operating in different countries, confront a multitude of diverse institutional forces. To operate with legitimacy an organization must understand and attend to the multi-dimensional institutional forces. To be competitive,



the organization must be able to transfer knowledge from one location to the next.

In an international project-based environment, an organization might be interacting, co-operating or partnered with various

organizations which follow different and possibly conflicting institutional regulations and norms. To enable efficient operations a firm must be able to understand the institutional foundations of its partners and adapt to them. Levitt (2007) applied institutional theory to the study of international projects in Germany which involved French and US consultants. In delineating the institutional aspects of conflict into Regulatory, Normative and Cognitive/Cultural, Levitt (2007)'s qualitative study provides a valuable foundation for a quantitative study of international projects in Hong Kong.

Institutional knowledge, be that tacit or explicit (Nonaka and Takeuchi, 1995), is managed and transferred by means of codification in the form of reports, specification, instructions, drawings and so on, which can be stored and retrieved electronically, filed as hard copies or transferred socially through personal interaction. Levitt and Javernick-Will (2009) looked specifically at the prioritization of knowledge transfer methods, in a qualitative study of 113 consultants in the construction industry, using Institutional Theory as a framework. They concluded that Social methods of transfer, rather than Formal, were preferred and within the Social category, Face to Face discussion predominates.

In this study the means of knowledge transfer is BIM (building information management) programme which is a web-based programme and a process which relies on the close integration of all project organization members working collectively on a single digital model, which is also calculates schedule and cost impact of design decisions.

BIM requires a new model of working. Before the design process starts there is an essential journey of establishing the parameters of the project and agreement on the protocols to be used on the programme. This process is collaborative and it is essential that full organization participation is achieved. This process is significantly different to traditional project starts in which the architect takes a client brief and working in relative isolation, develops a sketch design which is then sequentially given to the structural engineer, drainage, electrical, façade and so on. It is not unusual, in fact it is probably more common than not, that design issues are identified during the DD Design Development stage by an engineer, which then requires redesign by the architect and so on and so forth.

As all projects now-a-days are run on 'fast-track' schedules, there is very limited time for a sequential re-design programme. Because BIM is a collaborative programme in which all parties are working in parallel on problem solving, solutions can be identified more quickly and incorporated into a single model swiftly. However, in an institutionally conservative, and

regulated environment, such as the institutional environment in Hong Kong, there is resistance to normative change. Implementation of BIM as an effective means of knowledge transfer between institutional entities conflicts with the standard means of operating in the institutional environment.

We therefore expect high response in regulatory and normative variables will correlate with low responses in BIM as a means of knowledge management. The hypothesis is therefore:

H_{1null} = High responses in Institutional Regulatory and Normative do not correlate to low responses in BIM implementation.

H_{1alt} = High responses in Institutional Regulatory and Normative correlate to low responses in BIM implementation.

Despite the low rates of BIM adoption, where BIM is implemented we expect to see a significant correlation with Project Success

H_{2null} = BIM implementation is not correlated with Project Success

H_{2alt} = BIM implementation is correlates well with Project Success

The impact of construction projects has been recognized as extending beyond the client contractor relationship, into a larger social stakeholder group which has seen a greater focus on the concept of the project as a temporary organization brought together for a singular purpose (Stretton 2018). The phenomenon of temporary organization focuses attention on critical mechanisms of knowledge transfer within and between project entities. This study focuses on the drivers that influence the adoption of an industry standard knowledge management programme, BIM, and on the influence that BIM may have on project success.

Baccarini (1996) argues that the construction industry is the most complex production process in modern economies. Increased applications of technology and influence of globalization have made projects more complex (Flyvbjerg 2014). Complex projects need bigger specialist teams which frequently means multiple nationalities. Bigger teams operating under different institutional norms, standards of practice, languages and cultures increase complexity (Mahalingam and Levitt 2007).

Complexity in construction can be observed on several levels: technical complexity of the requirements, organizational complexity of the firms required to undertake the work and social complexity in the impact that large scale construction has on the community stakeholders who

are not commercially involved with the project but who are affected in tangible ways. The temporary project organizations which are formed to undertake these projects operate in both vertically and horizontally differentiated dimensions, in which the greater the differentiation, the higher degree of complexity.

Vertical differentiation defines the depth of hierarchical layers and is often determined by the size of the project. Horizontal complexity is the diversity and number of organizational units and task structure, which is defined by the number of specialists required to undertake the project. One of the key roles of the project manager is coordination of communication between the professional entities of the temporary project organization. As such, the project manager has a central role in directing the transfer of knowledge within the organization and between the organization and outside stakeholders.

Despite the introduction of potentially disruptive technologies which could perform knowledge management roles, project management is predominantly conducted using clearly prescribed templates of actions and responses which are, by definition, closed hierarchical management systems. Templates which fail to account for the networked complexity of the dynamic interactive forces typical of complex projects today, and specifically typical of international projects which add the element of cognitive and cultural complexity to project performance. According to Artto and Kujala (2008) a complex, dynamic environment requires an open system response.

H_{3null} = Project Management Effectiveness is not strongly correlated to Project Protocols

H_{3alt} = Project Management Effectiveness is strongly correlated to Project Protocols

H_{4null} = Project Success is not correlated with Project Management Effectiveness

H_{4alt} = Project Success is strongly correlated with Project Management Effectiveness

Uniqueness is regarded as a desirable feature of modern architecture, it demonstrates creativity, and originality, two measures of design competence. Uniqueness requires unique solutions which in architecture and construction requires the integration of specialist disciplines working together develop design solutions. Without the benefit of a robust digital model, the role of the project manager becomes more critical in bridging the institutional divides that exist between professional entities.

H_{5null} = Uniqueness is not correlated Project Management

H_{5alt} = Uniqueness is strongly correlated with Project Management

Studies of isolated projects, undertaken by a single company are not representative of the current industry conditions (Engwall, 2003) which involve multiple specialist actors directly interacting on the output of the project and a diverse non-business group of stakeholders whose interests may be contradictory, but who none the less wield power to alter the course of a project.

Complexity Theory posits that systems are in a continual state of evolution which is unpredictable and prone to patterns of fluctuation (Psychogios and Garev, 2012). Complexity Theory regards organizations as complex adaptive systems, of which construction projects are a class of temporary organization in which numerous actors are engaged in ‘non-linear, unpredictable and constantly emergent behaviour’ (Baruti, 2015). In a study by Swan et al. (2010) it was observed that tighter project management frameworks and the associated adoption of expedient forms of learning, facilitated an expanded pool of competencies within project-based firms. We expect to observe a correlation between project complexity and project management effectiveness.

H_{6null} = Complexity is not correlated Project Management Effectiveness

H_{6alt} = Complexity is strongly correlated with Project Management Effectiveness

3. Research Methodology

a. Research Design

The data for this study has been gathered through formal invitation to industry professionals known to the writer. Initial expressions of interest were solicited by personal email to the potential candidates. Candidates were asked whether they would like to participate in the Knowledge Transfer research study and whether they agreed to receive a Letter of Consent form and a 12-point questionnaire. A response rate of 80% was achieved, largely due to the personal contact and familiarity. Several respondents expressed interest in the study due to its relevance to the industry. The respondents were all either construction industry professional consultants (architects, engineers, quantity surveyors, specialists, clients/end-users or investor developers. All are in management or leadership roles and none of the respondents has less than 10 years-experience, the mean for years of experience is over 15 years. All respondents have experience working on international projects in Hong Kong or Mainland China.

CLIENT	2	Construction industry professionals, clients and investor/developers were the focus of this study due to the on-going industry dilemma over knowledge transfer in the project-based economy of the construction industry. Consultants on highly technical projects frequently rely on specialists who are engaged on a contract basis, journeymen, who are so
END USER	2	
INVESTOR/DEVELOPER	4	
ARCHITECT	5	
ENGINEER	3	
QUANTITY SURVEYOR	3	
PROJECT MANAGER	1	
TOTAL N=	20	

highly sort after for their experience that they are not committed to single employer but to an industry. This professional transience is an existential risk to consultant practices which are unable to retain and manage the knowledge gained from each project, to be applied to future projects. The competitive edge that unique experience affords an architect, engineer or specialist is only effective if it can be managed and applied in future bids. The current dilemma faced by the industry is that the technology and processes exist to capture data on every aspect of a project in the form of Building Information Management, but, despite the benefits to individuals and industry, the process and the technology, which has been available for over a decade, have been poorly applied. The Construction Industry Council of Hong Kong reported an adoption rate of only 43%, in its annual report of 2019 (Construction Industry Council HK, 2019).

The types of projects engaged in by the respondents include: natural history museum, hospital, school, university, theatre, commercial buildings, data-centre and industrial projects.

Respondents were asked to consider projects which had an international composition of consultants and prioritize complex projects. Evaluations of project success were intentionally and stated as being open to the interpretation of the respondent. Environmental, social, and governance considerations have expanded the breadth of interpretations of success in an industry which, it is accepted, has a significant impact on the community beyond the traditional measures of, time, cost and quality. Stakeholders with varying agenda, naturally perceive success from varying perspectives (Davis, 2014).

b). Expert Review

The study was reviewed by two expert reviewers, the first is the Assistant Dean of an Architectural Design School in South China. The respondent led the consortium of three foreign universities which were involved in the design, construction and foundation of the new university department in a local campus, a considerably complex undertaking. The project was

funded by the China Government for the benefit of Chinese students. The second reviewer is a registered architect and managing director of an architectural practice. He is a specialist exponent of building information management systems. Both reviewers provided input into the content of the questionnaire and expressed interest in the subject:

“As a business we have spent a lot of time deliberating information sharing and how best to achieve this. In reality, it will only happen when AI is deployed fully (and you no longer need architects) as only AI has the ability to connect the randomness of needs and knowledge.”

“The BIM process (it is a process, not only 3D virtual design) is in my opine, the answer to information management and improved client decision making but again not necessarily the right people doing the right things at the right time. You have to know which questions to ask to get people working super efficiently. Everyone just wants to jump to an answer without going on the journey (Lack of evidence based analysis and design).”*

“The Topic is very interesting. Is this Sheet just a starting point for deeper questioning at a later stage? I would be interested to understand how key information on a project gets communicated more in detail during a project and where the stakeholders can identify issues occurring. In my observation it is often a lack of alignment in the basic understanding of the design that can cause a chain reaction of errors.”

“Would it make sense to have a closer look at specific cases/projects?”

The reviewers provided both useful advice for alternations to some of the questions and also encouragement that the study was focused on an area of importance to the industry.

c)Variables

i) Dependent Variables

To measure whether *knowledge transfer* was either operable or had taken place the respondents were asked if *BIM programming* was implemented during the project: Was a BIM program (including an integrated inter-disciplinary 3D model) implemented by all project stakeholders during the project? BIM is the industry standard for the capture and management of project data which is foundational tool and process from project inception throughout the life of the building if it is used in its entirety.

In addition to the transfer of knowledge variables, the dependent variable of *project success* was included to evaluate whether there was any beneficial impact to the project of independent variables. A Cronbach's alpha test was conducted to confirm reliability which returned a p value of 0.733 when previous project knowledge was reverse scaled to account for the questionnaire phrasing. [fig]

ii) Independent Variables

The *complexity of the project* was addressed in three separate items, each through a 5-point Likert question. The first regarding the number of partners the respondent's firm contracted with, or were engaged with, for this project, from None to > 5. Communication is a primary source of complexity on an international project, the greater the number of parties to coordinate with the higher the probability of errors or omissions in the communications as highlighted by Zhong and Low (2012), applying Lorenz's (1963) 'butterfly effect', small errors can become exaggerated catastrophes in a non-linear complex system of a large construction crisis scenario.

The second item on complexity addressed *uniqueness*, 'How would you rank the level of design innovation or uniqueness which might make the project particularly challenging?' Unique problems require unique solutions which therefore require higher levels of coordination to execute. Thirdly, *Project complexity* is a potential mitigant of knowledge transfer as the process of knowledge management is made proportionally more challenging with the increase in complexity, 'How would you rank the level of project complexity using any aspects including: technical specifications, for example, a hospital or in structural form or stake holder engagement, or project constraints?' Complexity was measured on a 5-point scale from 'Not At All' to 'Extremely'.

Previous Project Knowledge: Did the project utilize lessons learned, design details or operating procedures from previous projects which were easily accessible to the team on a *cloud based data storage* site or similar? This is an indication of alternatives to the use of building information management (BIM) as a knowledge transfer mechanism within a project.

Table 1

		Parameters	Explanation
Dependent Variables	BIM Implementation	1-5 scale	not at all - extensive
	Project Success	1-5 scale	unsuccessful - completely successful
Independent Variables	Multi-Parties	1-5 scale	none - >5partners
	Previous Knowledge	1-2 scale	no - yes
	Uniqueness	1-5 scale	not unique - very unique
	PM Effectiveness	1-5 scale	not effective - completely effective
	Protocols	1-5 scale	not provided - total compliance
	Administrative Regulatory	7 items on a 1-5 scale	no agreement - total agreement
	Institutional Norms	7 items on a 1-5 scale	no agreement - total agreement
	Complexity	1-5 scale	not complex - extremely complex
	Face to Face Communication	1-5 scale	never - 75-100%

A formalized structure which defines the division of labour, scope of services, warranties, indemnities remuneration and time frame has been identified by Cacciatori et al. (2012) as have a positive impact on codification of knowledge transfer within a project.

Project Management is a mechanism which can enforce or facilitate formal organizational structures on projects, a question addressing project management effectiveness was included to capture this aspect of project management. Additionally, questions addressing the administrative and the institutionalized conditions of the project are also capturing the institutional structure of the project. These questions address the regulatory and normative structure of the project, as these are also identified as have a facilitating impact on codification of knowledge transfer (Cacciatori et al. 2012). Codification includes: reports, statistics, databases, drawing files, specifications and manuals, these are items which are also held in the BIM information management programme. If the regulatory and normative structures support codification of knowledge, it is expected that they also show correlation with the BIM system.

Seven items were included in each of the administrative regulatory and institutional normative questions and respondents were asked to assess each item on a 5-point Likert scale. The responses for each of these were aggregated and averaged.

Project protocols are also an organizational structure issue which serve to formalize the behaviour of participating stakeholders on the project a 5-point question from ‘*no protocols in place*’ to ‘*full compliance*’ captures the existence of protocols.

Face to Face Communication, a standard fixture of project coordination, increases the probability of knowledge and experience transfer in an informal setting. Extent of communication was captured with ‘*To what extent were interactions between project consultants held face to face?*’ with a 5-point response from ‘Never’ to ‘75-100%’

4. Results and Discussion

A test of internal reliability test of data indicated a Cronbach’s alpha scale of 0.726, excluding the Organization data which was not scaled.

Scale Reliability Statistics

	Mean	SD	Cronbach's α
scale	3.37	0.452	0.726

Projects which were deemed *successful* correlated significantly with *BIM* implementation, 0.614, p-value .004, and with cloud-based availability of previous project knowledge, 0.0489 with a

Scale Reliability Statistics

	Mean	SD	Cronbach's α
scale	2.33	0.783	0.473

significance of 0.029 (see appendices for correlation matrix). A Cronbach's alpha test of reliability does not present a level of significance between the two items.

Project success is also correlated with project management effectiveness 0.547 with a significance of 0.013 and with the existence of project protocols, 0.541 with a significance of 0.014. This correlation is to be expected and

Scale Reliability Statistics

	Mean	SD	Cronbach's α
scale	2.67	1.16	0.819

the reliability test demonstrates a significant level of equivalence between project management effectiveness and the

implementation of project protocols. *Project management effectiveness* also correlates significantly with *uniqueness*, 0.5 and a significance of 0.025, which is accounted for by the service scope requirements of highly unique projects, which anticipate the need for effective project management. The same is also reasonably expected of *complex projects*, however the results fail to support that hypothesis and this could be due to the non-linear nature of complexity which can arise during the course of a project. Qiu et al. (2019) observe that when incompatible cognitive systems confront organizations on a project, institutional complexities emerge which exacerbate the complexity and reduce the probability of finding consensus.

A One-way Anova test of BIM Implementation against *Institution/Organization*, *Job*

One-Way ANOVA (Welch's)

	F	df1	df2	p
BIM IMPLEMENTATION	69.8	2	34.3	< .001

Group Descriptives

	GROUP	N	Mean	SD	SE
BIM IMPLEMENTATION	JOB DESCRIPTION	20	1.75	0.639	0.143
	EXPERIENCE	20	4.30	0.801	0.179
	INSTITUTION	20	4.90	2.198	0.492

Post Hoc Tests

Tukey Post-Hoc Test – BIM IMPLEMENTATION

		JOB DESCRIPTION	EXPERIENCE	INSTITUTION
JOB DESCRIPTION	Mean difference	—	–2.55 ***	–3.150 ***
	p-value	—	< .001	< .001
EXPERIENCE	Mean difference	—	—	–0.600
	p-value	—	—	0.371
INSTITUTION	Mean difference	—	—	—
	p-value	—	—	—

Note. * p < .05, ** p < .01, *** p < .001

Description and Years of Experience undertaken to evaluate whether there was any difference between the disciplines or the job grade levels and years of experience in their aptitude to implement BIM. The ANOVA presents a high degree of significance between the means of the three variables. A further post-hoc Tukey Test to establish what is generating the difference demonstrated that between both Institution/Organization and Years of experience

there is a negative difference with high degrees of significance, <.001, possibly indicating a higher propensity amongst younger practitioners to engage with BIM. A further test between disciplines lacked sufficient data to establish a result. However, it was noted by Cacciatori et al. (2012) that engineering showed a higher aptitude for data codification over creative professions. Further tests are required to determine the generalizability of their results in the Hong Kong, Mainland China environments.

The results supported the hypothesis that PM effectiveness is strongly correlated, on the Spearman rho test, with the implementation of project protocols, with a significance of <0.001. This is consistent with expectations which predict that projects which demonstrate high rates of compliance to project protocols, which include forms of knowledge management, will also demonstrate low rates of BIM implementation. For the same reason, that is, the existence of a highly structured operating environment defined by *regulatory codes* and *industry normative* behaviour, which, it was also expected would be negatively correlated with BIM implementation. The expectation of a negative correlation was correct, -0.229 and -0.242, but not statistically significant to support the hypothesis, 0.332 and 0.264 respectively.

Regarding the effect of *institutional norms* and *administrative regulations*, the responses were highly correlated and presented a high rate of significance 0.901 and a <0.001.

Scale Reliability Statistics

	Mean	SD	Cronbach's α
scale	4.17	0.437	0.945

The expectation that the *regulatory and normative items* would correlate significantly with *BIM implementation* was not supported, with significance coefficients of 0.33 and 0.26 respectively. Hong Kong's highly litigious construction industry (Chau, 2007) is based on an adversarial arbitration system which is expensive and reputationally damaging for all parties and has been identified as a cause of project failure due to the time and cost of the process. The construction environment is consequently conservative by nature it relies heavily on contract law. Additionally, practitioners are dependent upon the institutions of their profession for protection and support. A conservative environment does not encourage the implementation of new ways of working which may expose the practitioner to fault, which explains both the low rates of BIM and the high rates of normative and regulatory response. "It

Model Fit Measures

Model	R	R ²	Adjusted R ²
1	0.753	0.567	0.452

Model Coefficients - SUCCESS

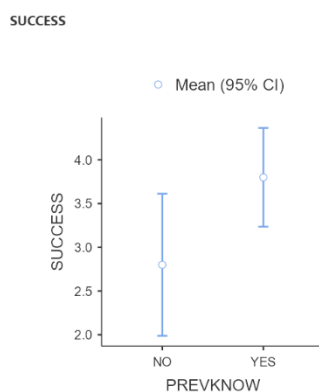
Predictor	Estimate	SE	t	p
Intercept *	1.00	0.800	1.25	0.231
BIM:				
LIMITED – NONE	1.86	0.856	2.17	0.046
SOMEWHAT – NONE	2.50	0.895	2.79	0.014
MOSTLY – NONE	2.25	0.895	2.51	0.024
EXTENSIVELY – NONE	3.50	0.895	3.91	0.001

is argued that, although less obvious in their influence, normative and cognitive institutions are no less important than the relatively more visible regulatory institutions.”(Munir 2002)

A linear regression test of the relationship of BIM implementation to the success of the project indicates a 45% predictability of project success, (adjusted $R^2 = 0.45$). When BIM is used extensively, a highly significant correlation of 0.001 is observed, provided some support for its implementation, although it should be noted that the size of the sample group is very small and the overall rates of BIM implementation are not high.

	F	df1	df2	p
SUCCESS	5.23	1	16.0	0.036

Plots



A one-way ANOVA test of the statistical significance of variance between the *project success* dependent variable and the *previous knowledge*, present a high level of significance, as is expected and also adds further support for importance of knowledge transfer and information management to the successful outcome of the project.

5. Conclusions

This study looks at the adoption of BIM as a knowledge transfer vehicle in the institutionalized environment of the Hong Kong and Mainland Chinese construction industry. The rates of adoption in this survey are consistent with those reported from the Construction Industry Council HK (2019) Construction Industry Council , that approximately only 40% of the industry is implementing the programme, despite the demonstrable benefits and the advisory support for it. However, the results of this survey suggest that when BIM is implemented project success is reported at significant levels.

From an institutional perspective it appears that resistance to BIM adoption exists at a normative level, indicated by the inverse correlations between Regulatory/Normative and BIM implementation. This would also lend support to the Construction Industry Council HK (2019) report which states that “locally accepted practices” and “dismissive mindset” are the two leading reasons given for failing to implement BIM. This suggests that steps towards

industry acceptance need to include an inclusive education programme involving a cross section of disciplines and mandating the use of BIM and the extent to which it must be applied, on all projects not limited to government projects.

6. Challenges, Limitations and Future Research

The sample size, while offering a perfect opportunity to experiment with the research method and analysis of data, is probably insufficient to make generalizable assumptions about the broader industry.

Metrics of *Project Success* were once limited to the simple iron triangle of time cost and quality. Today, the broader appreciation of constructions impact on environment and community makes the metrics of success more subjective. Identifying terms of success would control variance in that variable. Lai and Lam (2010)'s survey study of owners, contractors and consultants, on Hong Kong projects, looks at how these three stakeholder groups prioritize a list of criteria of project success. This is a useful study in providing a format for a quantitative study based on a questionnaire survey. As regard for the impact of a project on a bigger stakeholder group has been recognized, the criteria of success have expanded to include: satisfaction of workers, end users and suppliers and effectiveness, from the perspectives of both the commercial and functional performance of the project (Müller et al. 2012).

Adoption levels of BIM in Hong Kong are very low and in Mainland China even lower. Full use of the platform is limited and finding projects which have used the platform is challenging. A separate study on identifying why it has not been taken up would be a valuable future study.

Hong Kong has a number of extremely complex projects, West Kowloon Cultural District, the Third Runway at Chek Lap Kok, the MTR connection to South China, the Zhuhai Bridge project and the pending New Territories development. Qiu et al. (2019) undertook a relevant case study of the governance of institutional complexity on mega-projects focused on the Macao-Zhuhai Bridge. The study provides a valuable insight into internal and external institutional forces which effect a major public project. The high cost of project dysfunction that Hong Kong has experienced on projects like the MTR, Chek Lap Kok and West Kowloon demands scholarly attention to how these projects can be delivered more effectively.

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8. Appendix 1 Spearman rho Correlation Matrix

Correlation Matrix

		MULTIPART	PREVKNOW	BIM	UNIQ	PMEFFECT	PROTOCOLS	REGS	NORMS	COMPLEXITY	F2F	SUCCESS	ORG	JOBDE
MULTIPART	Spearman's rho	—												
	p-value	—												
PREVKNOW	Spearman's rho	-0.069	—											
	p-value	0.774	—											
BIM	Spearman's rho	0.274	0.448 *	—										
	p-value	0.242	0.047	—										
UNIQ	Spearman's rho	-0.014	-0.083	0.237	—									
	p-value	0.954	0.727	0.313	—									
PMEFFECT	Spearman's rho	0.004	0.255	0.252	0.500 *	—								
	p-value	0.986	0.278	0.284	0.025	—								
PROTOCOLS	Spearman's rho	0.124	0.073	0.157	0.337	0.708 ***	—							
	p-value	0.603	0.760	0.509	0.146	<.001	—							
REGS	Spearman's rho	0.016	-0.201	-0.229	0.132	0.242	0.238	—						
	p-value	0.947	0.397	0.332	0.578	0.303	0.312	—						
NORMS	Spearman's rho	0.051	-0.253	-0.262	0.139	0.194	0.158	0.901 ***	—					
	p-value	0.830	0.282	0.264	0.558	0.413	0.505	<.001	—					
COMPLEXITY	Spearman's rho	0.462 *	-0.340	0.133	0.197	0.056	-0.021	0.187	0.291	—				
	p-value	0.040	0.143	0.576	0.406	0.816	0.931	0.431	0.214	—				
F2F	Spearman's rho	0.129	-0.400	0.293	0.477 *	0.254	0.108	0.183	0.077	0.419	—			
	p-value	0.589	0.080	0.210	0.033	0.280	0.650	0.439	0.745	0.066	—			
SUCCESS	Spearman's rho	0.059	0.489 *	0.614 **	0.239	0.547 *	0.541 *	0.164	0.057	-0.016	0.040	—		
	p-value	0.805	0.029	0.004	0.311	0.013	0.014	0.491	0.810	0.946	0.865	—		
ORG	Spearman's rho	-0.026	0.132	-0.050	-0.008	-0.055	-0.029	-0.108	-0.193	0.286	0.116	0.087	—	
	p-value	0.914	0.579	0.834	0.973	0.818	0.904	0.651	0.415	0.222	0.626	0.715	—	
JOBDESCRP	Spearman's rho	-0.058	-0.263	-0.566 **	-0.182	0.173	0.356	0.028	0.062	-0.172	-0.195	-0.380	-0.186	-
	p-value	0.808	0.262	0.009	0.443	0.465	0.124	0.907	0.795	0.469	0.411	0.099	0.432	-

Note. * p < .05, ** p < .01, *** p < .001

Appendix 2 Questionnaire

[illegible]