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Construction Innovation: Information, Pr
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Journal:	*Construction Innovation: Information, Process, Management*
Manuscript ID	CI-01-2023-0004.R1
Manuscript Type:	Research Article
Keywords:	Construction contracting firms, Exploratory-exploitative learning, Incremental innovation, Learning, Organisational ambidexterity, Radical innovation

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Abstract

Purpose: This study explores the innovation deployment of construction contracting firms through exploratory-exploitative learning and organisational ambidexterity.

Design/methodology/approach: First, a literature-based conceptual framework was developed to explain innovation implementation through exploratory-exploitative learning and organisational ambidexterity. A prominent Hong Kong construction contracting firm was then selected as the case study to explore its innovation deployment at different organisational levels (i.e., firm and project levels). Qualitative data was attained by conducting twelve semi-structured interviews with industry experts and document analysis. The thematic analysis using NVIVO 12 software was adopted to analyse data.

Findings: Findings reveal that the case study firm successfully fosters innovation when ambidexterity is achieved through the balance between exploratory learning (i.e., radical innovation) and exploitative learning (i.e., incremental innovation).

Research implications: Establishing uniform ambidexterity (i.e., 50:50) at the firm or project level is not mandatory to deploy innovation successfully. The ratio can vary based on the characteristics and requirements of construction firms.

Practical implications: This paper shall motivate construction practitioners to adopt radical-incremental innovation ambidexterity in firms and ultimately enhance the productivity and efficiency of the construction industry.

Originality/value: Previous construction innovation research has frequently explored firm or project-level innovation separately. This study identified a multi-level focus on innovation. Through the lens of exploratory-exploitative theory, different forms of innovation ambidexterity for different levels are suggested rather than one specific ambidexterity.

Author keywords: Construction contracting firms; Exploratory-exploitative learning; Incremental innovation; Learning; Organisational ambidexterity; Radical innovation.

Paper type: Research paper

Introduction

Compared to other industries, the construction industry has frequently been criticised for its inherent issues of productivity and efficiency (Blayse and Manley, 2004; Bygballe and Ingemansson, 2014). Innovation implementation is an important medium to overcome performance issues in the construction industry (Gann, 2003).

The construction industry being project-oriented and relying on temporary project-based organisations reduces the industry's chances of innovation due to low investment in research and development (R&D) and academia-industry collaborations (Gann, 2003). As a result, traditional assessment criteria, such as the number of patents, R&D allocation and profit in contracting firms, hardly measure the innovation implementation. Similarly, Bygballe and Ingemansson (2014) and Loosemore (2015) mentioned the hidden nature of construction innovations and emphasised the necessity of contemporary measures. As a contemporary approach, studies have adopted the concept of organisational ambidexterity– a strategy to balance organisations' learning activities to explore innovation in organisations (March, 1991; O'Reilly and Tushman, 2008; Eriksson, 2013). Ambidextrous firms stimulate both exploration or exploratory learning (search for new knowledge) and exploitation or exploitative learning (use of existing knowledge with improvement) simultaneously (Levinthal and March, 1993). Drawing on the project-based nature, Eriksson (2013) suggested that ambidextrous construction firms tend to be more innovative. However, other than a few exceptions (e.g., Eriksson, 2013; Duodu and Rowlinson, 2021), ambidexterity at different levels in construction contracting firms have rarely been examined as most prior research focused on project-level

ambidexterity (e.g., Liu *et al.*, 2012). Previous research on construction innovation has focused on the firm (e.g., Winch, 1998; Drejer and Vinding, 2006; Duryan and Smyth, 2019) and project levels (e.g., Barlow, 2000; Ozorhon, 2013; Ozorhon *et al*., 2014; Zhang *et al*., 2021). Geraldi (2008) developed a model to direct project-based firms (PBFs) to balance order and chaos, which suggested the implementation of project-specific innovation. Nevertheless, explanations of different innovation management approaches are yet to be explored in large construction contractors at different levels to analyse their contribution to innovation in the construction industry. To bridge this gap, this study explores the innovation deployment of construction contracting firms at multi-levels. Hence, the learning theory—explanatory learning and exploitative learning, and organisational ambidexterity are adopted as theoretical lenses. Considering the outcome of each learning type, exploratory learning is conceptualised as radical innovation, while exploitative learning is conceptualised as incremental innovation. Organisational ambidexterity is perceived by radical-incremental innovation ambidexterity (Gupta *et al*., 2006; Lennert *et al*., 2020).

As methodological approaches, a comprehensive literature review has been conducted, and a conceptual framework is developed which suggests structural ambidexterity at the firm level and contextual ambidexterity at the project level. Through the subsequent case study, the framework is validated and modified further.

Innovation Management Research in Construction

Studies on innovation in construction go back way to the 1960s. Bowley (1960) has been recognised as one of the first researchers who explored product and process innovation in construction. Similarly, Tatum's (1986, 1989) multiple works and Toole's (1998) works frequently focussed on technological innovation in construction. Earlier studies often perceived construction innovation through technological innovation in construction. However, researchers such as Slaughter (1993) then adopted a much broader definition by explaining construction innovation as a phenomenon with an ability to improve and change significantly.

Studies were then carried out in the organisational context, exploring the potential for construction innovation towards organisational survival and development (e.g., Subramanian and Nilakanta, 1996; Manley and Mcfallan, 2006). Researchers shifted their attention to the project level to explore the innovation process in construction projects (e.g., Winch, 1998).

Despite various research directions, the scope of work and the adoption of different theories, studies on construction innovation frequently hint at the lack of innovativeness in the construction industry (e.g., Blayse and Manley, 2004; Reichstein *et al*., 2005). Lack of investment in R&D, project-based or fragmented and temporary nature of the industry and distance from academia have been recognised as innovation-hindering factors (Dubois and Gadde, 2002; Gann, 2003). Hence, innovation management in the construction industry has substantial differences compared to industries such as manufacturing. For instance, the heterogeneous nature, immobility, and less predictability of demand make the innovation process in construction complex and non-linear (Reichstein *et al*., 2005). Similarly, researchers argue that discontinuous and project-based nature disrupts innovation diffusion and management in construction firms (Gann and Salter, 2000).

As a contemporary view, researchers such as Winch (2003) and Bygballe and Ingemansson (2014) put forward a counterargument that traditional measurements of innovation, such as R&D allocation, number of patents and profit, poorly reflect certain innovations which are hidden. Hence, researchers are taking action to recognise and promote construction innovations, particularly in the organisational context. For instance, examining innovation process and management through strategic management and learning theories to emphasise

benefits such as competitive advantage for organisations is an important development in the construction management research (e.g., Zollo and Winter, 2002; Calantone *et al*., 2002; Crossan *et al*., 1999).

Innovation in Construction Contracting Firms

Compared with manufacturing firms, construction firms are stigmatised for lack of innovativeness. Innovation implementation of operations-based organisations, such as manufacturing firms, whose business model that produces the same output in volume, is rather straightforward compared to construction PBFs, whose business model is comprised of complex processes to deliver unique outputs (Greco *et al*., 2021).

Nevertheless, strategic management theory suggests that innovation in construction contracting firms has become a prerequisite for achieving and sustaining competitive advantage (Seaden *et al*., 2003). As the income is generated through profits from projects, contracting firms must explore new solutions through innovation implementation and sustain development (Gann and Salter, 2000). According to Slaughter (1993), construction innovation often emerges at the execution stage as resolutions for problems arising from construction activities. Winch (1998) proposed that innovation in construction firms appears to have two approaches: top-to-bottom and bottom-to-top. The former approach comes from R&D activities stimulated at the firm level, whereas the latter approach fits with Slaughter's (1993) explanation of resolution to the problems arising from construction activities. Thus, the idea of 'problem-solving' creates innovation and change (Gambatese and Hallowell, 2011a). While emphasising the requirement to innovate, Lijauco *et al.* (2020) pointed out the importance of cultural manifestations such as market orientation, business relationships, workforce capacity and leadership to enhance the innovation capability of construction SMEs. Jin *et al.* (2022) also highlighted factors such as experience in mega projects, having a strong knowledge base and networking to expand technical innovation capability in construction.

Fostering innovation and change in contracting firms is challenging due to projects' autonomous and unique nature and lack of potential for repetition (Drejer and Vinding, 2006). From the learning perspective, one-off projects are good opportunities for construction firms to learn and acquire new knowledge (Ayas and Zeniuk, 2001). However, it is somewhat unusual for contracting firms to use new knowledge in future projects (Dubois and Gadde, 2002). Therefore, construction contracting firms must adopt contemporary approaches enabling innovation at the project and firm levels. Accordingly, this study defines innovation in construction contracting firms considering multi-levels as the implementation of a new or significantly improved product, process, system, strategy, policy, or service in a contractor firm that substantially changes the existing organisational procedures and delivers economic or social benefits to the firm (c.f., Damanpour and Evan, 1984).

Research Methodology

The methodology in this study is designed first to develop a theoretical foundation on innovation implementation in large contracting firms and then to test the theory and provide empirical findings in this regard. Accordingly, a comprehensive literature review was carried out exploring different aspects, such as innovation and learning in construction. Literature on learning (i.e., exploration and exploitation), ambidexterity and knowledge management theories were also reviewed (March, 1991; O'Reilly and Tushman, 2008; Simsek, 2009).

Phase 1: Theory building

Exploratory Learning, Exploitative Learning and Organisational Ambidexterity

The learning concept–exploration and exploitation (exploratory learning and exploitative learning) is adopted to explain organisational learning behaviour and its consequences (March, 1991; He and Wong, 2004). March (1991), in his seminal work, defined exploratory learning as activities such as "search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation" (p.71), and exploitative learning refers to activities such as "refinement, choice, production, efficiency, selection, implementation and execution" (p.71). Exploration and exploitation have been conceptualised as contradictory and orthogonal learning modes yet emphasise their significant role in organisational survival and development (Gupta *et al*., 2006; Lennerts *et al*., 2020).

The most frequently perceived conceptualisation of exploratory-exploitative learning is based on the 'process' of each approach (e.g., March, 1991). As a contemporary approach, conceptualisations have considered these two learning modes as 'orthogonal' constructs based on the nature of their 'outcome' (e.g., Eriksson, 2013; Lennerts *et al*., 2020). Following the latter, radical and incremental innovation classification has been used to conceptualise exploratory and exploitative learning (Tushman and O'Reilly, 1996; Gibson and Birkinshaw, 2004).

Faems *et al*. (2005) differentiated radical and incremental innovations as follows:

> "The notions of incremental versus radical innovation, innovation as continuous improvement via learning by doing versus innovation as creative destruction, flexibility to keep innovation options open versus commitment to well-defined innovation pathways, divergent versus convergent behavior, exploitation versus exploration or path creation versus path dependence…" (p.3).

Raisch and Birkinshaw (2008) explained radical innovation as the "fundamental changes leading to a switch from existing products or concepts to completely new ones" (p.378). In contrast, incremental innovation is explained as "relatively minor adaptations of existing products and business concepts" (p.378). Studies conducted by Bierly III *et al*. (2009) and Hernández-Espallardo et al. (2011) also highlight radical innovation by 'new' and 'significant' characteristics while linking incremental innovation with 'already known'.

Several studies examine their manifestation in organisations, the benefits of balancing the two learning activities, their impact on organisational performance, and how organisations facilitate exploration and exploitation (e.g., Turner *et al*., 2016; Eriksson and Szentes, 2017). However, the contrasting nature and paradoxical complications make it difficult for their application in organisational settings. Therefore, balancing strategies and integrating mechanisms between the two learning modes are suggested (Raisch *et al*., 2009). Resource scarcity was initially viewed as an issue to implement and balance out both learning modes (March, 1991). Consequently, the capability of organisations to implement both has been recognised, and mechanisms to do so have even been presented (He and Wong, 2004). For instance, recent studies have highlighted that ambidextrous organisations can undertake both learning activities (Chang, 2015; Turner *et al*., 2016).

The term 'ambidextrous' refers to the ability of humans to use both hands equally and simultaneously, which has been used to recognise the ability of organisations to explore and exploit simultaneously (O'Reilly and Tushman, 2008; Simsek, 2009). In the literature, ambidexterity at a particular level, such as the business unit, team, and individual, has been explored (Brix, 2019). The attention is now shifted to multi-level analysis in organisational studies (e.g., Chang, 2015). In these studies, ambidexterity is conceptualised as the balance

between exploration and exploitation, radical and incremental innovation interactions, width and depth, and adaptation and alignment (Katila and Ahuja, 2002; Lennerts *et al*., 2020; Gibson and Birkinshaw, 2004). These interactions counterbalance each mode's weaknesses. If ambidexterity is not established and maintained, organisations can end up either as an extreme explorative entity that is likely to suffer from losses from continuous experiments that are unable to provide short-term benefits; or as a pure exploitative entity that is likely to lose its market due to a lack of competence. Moreover, this approach hinders survival and development in the long run (March, 1991).

Different forms of ambidexterity have been identified in the literature. The three major ambidexterity types−Temporal (sequential), structural, and contextual− are the most common approaches frequently identified in previous research (e.g., Gupta *et al*., 2006; Raisch *et al*., 2009; Turner *et al*., 2014). When organisations explore and exploit different periods cyclically, temporal/sequential ambidexterity is formed. Structural ambidexterity refers to allocating different organisational units, competencies, systems, processes, incentives and cultures to perform exploration and exploitation separately (Benner and Tushman, 2003). The third form, contextual ambidexterity, allows individuals and teams at departments or projects to simultaneously explore and exploit (Gibson and Birkinshaw, 2004).

Even though innovation in contracting firms has already been studied through the lens of ambidexterity, empirical findings that confirm ambidexterity-based innovations, considering the firm as a unit of analysis, are limited. Hence, this study contributes to innovation in construction firms by suggesting different ambidexterity forms at different levels (i.e., firm and project).

Development of the Conceptual Framework

Ambidexterity theory (O'Reilly and Tushman, 2013) suggests various forms of ambidexterity can emerge in multi-level settings such as construction contracting firms (Eriksson, 2013). Following this view, as well as the frameworks developed by Brady and Davies (2004) and Bygballe and Ingemansson (2014), this study argues that firm-level exploration and project-level exploitation also exists, in addition to project-level exploration and firm-level exploitation in the context of contracting firms. Consequently, an initial conceptual framework is developed, as shown in Figure 1.

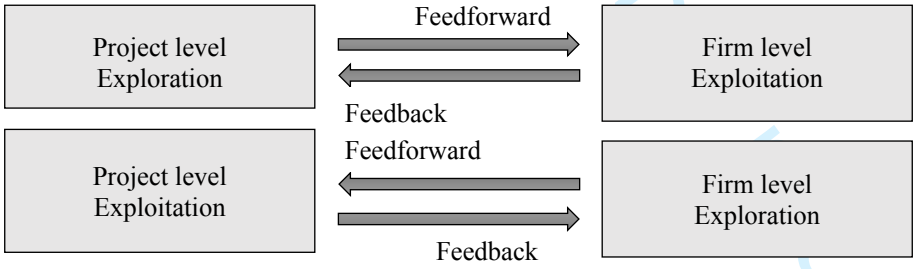

Figure 1: Initial conceptual framework to explain innovation in construction contracting firms.

According to the ambidexterity theory, ambidexterity occurs at the firm and project levels. Contextual ambidexterity is the most effective form of managing highly dynamic and complex settings such as projects (Gibson and Birkinshaw, 2004). Norms such as trust, adaptability and risk-taking are inherent within contextual ambidexterity that enhances interactions and synergies across different individuals and units in projects and the firm (Raisch *et al*., 2009). Both structural and temporal ambidexterity forms are suggested for the firm level (O'Reilly and Tushman, 2013). Figure 2 further illustrates these ambidexterity forms.

In addition, knowledge transfer between project level-to-firm level, firm level-to-project level and within projects are included in the proposed conceptual framework (see Figure 2). When a single level is concerned, exploitation outcomes become inputs for exploration. When the firm is considered the unit of analysis, exploration at the project level becomes exploitative learning for the firm level and vice versa. Accordingly, the result (i.e., outcome) of exploration, which is radical innovation, occurs at the firm and project levels. At the same time, the result of exploitation (i.e., outcome), which is incremental innovation occurs at the firm and project levels too. Hence, both radical and incremental innovations can be observed at the same level. The radical innovation of one level can be an incremental innovation of the other level. The framework further suggests a balance between these two (i.e., ambidexterity) to firms to be successful. Robust communication strategies are suggested as knowledge-transferring mechanisms within the same level and across different levels.

Green *et al*. (1995) recognised radical innovation as a multi-dimensional construct based on four dimensions: technological uncertainty, technical inexperience, business inexperience, and technology cost. Based on Green *et al*.'s (1995) conceptualisation of radical innovation, excluding its context in technological innovation, it is used to distinguish radical and incremental innovations in contractor firms. Hence, this study defines radical innovation as a new or significantly improved product, process, system, strategy, policy or service that requires massive financial commitments, which involves significant benefits, riskier and uncertain outcomes, and makes organisations move from existing procedures.

Eriksson *et al*. (2017) described exploitative learning or incremental innovation as the continuous usage of existing knowledge or strategies, and accordingly, incremental innovation is perceived as the utilisation of radical innovation. Advancing this view, this study suggests that exploitative learning involves using and refining existing knowledge in construction contracting firms. Hence, this study defines incremental innovation as using and improving implemented radical changes to the organisation, which involves less risky and defined outcomes.

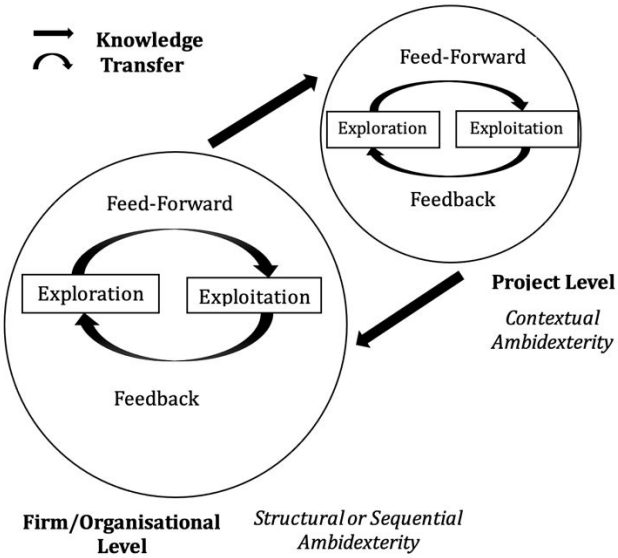

Figure 2: The proposed conceptual framework to explain innovation in construction contracting firms.

Phase 2: Empirical study and data collection

The case study approach was selected as the study attempts to explore the innovation deployment of construction contracting firms, which requires an in-depth and holistic

investigation. Elman *et al*. (2016) defined a case study as a strategy that "focuses intensively on a single case. Generally, the chosen case is regarded as emblematic of a larger population of cases, a case of something" (p.375). Furthermore, a case is usually selected based on its potential to enhance the researcher's theoretical views on the phenomenon; in this study, it is the contractors' innovation deployment. This case study is exploratory rather than explanatory, as the case study findings are subjected to interpretations (Liamputtong, 2020).

Several measures have been adopted to ensure the validity and reliability of the findings. Qualitative validity, which has three attributes (internal validity, construct validity and external validity), is ensured through the accuracy of the qualitative findings. First, internal validity has been achieved by providing logical and reasonable interpretations through an accurate and comprehensive data analysis. Furthermore, having a compelling conceptual framework that illustrates the interrelationships between constructs (Figures 1 and 2), comparison of findings with previous findings (in the discussion section), and theory triangulation through adaptation of different perspectives (i.e., exploration-exploitation, ambidexterity and knowledge transfer) ensure the internal validity of the findings. Second, construct validity, conceptualisation and operationalisation of the theory are achieved by adopting a clear chain of data (evidence) and data triangulation through multiple data collection techniques and sources. Third, external validity, generalisability of findings is ensured by applying the findings and interpretations to different contexts (Creswell, 2009). However, analytical generalisability is allowed rather than statistical generalisation, as findings contribute to the theory rather than a population (Yin, 2018). The reliability of the findings is maintained by conducting the research according to the standard procedure suggested by Yin (2018) and Creswell (2009).

Case study firm

A large contracting firm in the Hong Kong Special Administrative Region (HKSAR), which belongs to category C (i.e., contractors can bid for contracts of value exceeding HK$ 300 million) as classified by the Hong Kong Development Bureau (HKDB), is selected as the case study. This firm is the largest contracting firm in Hong Kong and does business in Mainland China, Macau SAR and Singapore. The case study firm is renowned for fostering innovation in the Hong Kong construction industry and the East Asian region. However, most Hong Kong contracting firms do not engage in innovation implementation. Hence, the case study is influential rather than typical (Seawright and Gerring, 2008). Despite being a large organisation with more than five thousand permanent employees, the culture of the case study firm is flexible and facilitates learning and innovation. When the organisational structure is concerned, it is not solely organic as it contains mechanistic features. The firm consists of six major units (i.e., civil engineering, buildings, foundations, E&M, structural steel, and concrete plant department), and the director is responsible for the innovation implementation of each unit. The firm also has an innovation team that facilitates innovation across different units and levels. In addition to the innovation team, Virtual Design and Construction (VDC) and Digital Transformation (DT) teams are also involved in implementing the firm's digital innovations. These teams, including the innovation team, function as cross-functional teams in which the firm and project-level actors are included. The actors are responsible to the functional manager (Head of Innovation) at the firm level and project managers at the project level. When a project team under a particular business unit develops an innovation, the team informs the innovation team. The innovation team facilitates the innovations and develops them with the project team. Since the case study firm is large and its multi-levels are observable, it has been selected to examine innovation implementation and deployment within and across multi-levels.

Data Collection: Semi-structured interviews and document analysis

Semi-structured interviews: Professionals in the case study firm and the external organisations involved in the innovation deployment were selected as the interviewees. Interviewees hold positions as top and middle managers who represent both firm and project levels. Interviewees were selected based on their job position (contribution) and knowledge of innovation (purposive sampling technique) (Padgett, 2017). An interview guideline was used to raise questions regarding the firm's radical and incremental innovation developments, innovation, VDC and DT teams, funding arrangements, collaborations, and knowledge transfer across different levels. A total of 12 interviews, lasting 1 hour each, were carried out in English medium. The following Table I presents the demographic information of the interviewees.

-Table I-

Document analysis: The information such as background, structure, and revenue/profit of the firm over the years, which were missed or not explicit from the interviews, were obtained via this technique. Furthermore, publications such as company manuals, the official website, news articles and even YouTube (verified) videos made available by the case study firm and other reliable sources were reviewed to validate the data collected from the interviews. In addition, information on recent innovation developments launched by the case study firm was collected through visits to an HKSAR government-funded organisation that facilitates and exhibits innovations developed by construction firms in Hong Kong.

Data analysis and testing of the conceptual framework

All the interviews were conducted in English, audio-recorded and transcripts were produced. Thematic analysis technique and NVIVO 12 software were adopted to analyse qualitative data. The analysis process was based on the general analysis process suggested by Creswell (2009). The guideline with six steps was followed, such as organising and preparing data for analysis, reading through all data, coding the data, generating themes and descriptions using the coding process, interrelating themes and descriptions, and making interpretations of data (Creswell, 2009). Main themes were produced based on the constructs of the conceptual framework (e.g., radical innovation, incremental innovation, knowledge transfer). In addition, themes such as sources of innovation, strategies and mechanisms emerged.

Findings: Sources of Innovation, Strategies and Mechanisms

As the sources of innovation, the firm has two main directions: internal and external. As stated by Interviewee I03 as follows, firm's employees are key internal sources:

> *"We started a campaign called 'innovator of the month', which any employee can participate in. Then, the most innovative ideas are recognised, and even cash rewards are given. So, every month around 10-20 proposals are received and all of them are shared among the innovation team. Every year we receive more than two hundred proposals, and we store them in our database."* *I03*

In addition to the internal sources, the case study firm has some external sources of innovation, such as local and international universities. As stated by Interviewee I01*, "Currently, we have been paired with many universities. Sometimes it is hard to say "it is us" or "it is our employees."*

Moreover, Interviewee 04– manager of the external organisation that facilitates construction innovation in HKSAR, explained the case study firm's approach that is purchasing innovation developments from external organisations as follows:

> "*Most of the innovations were not developed by the firm. They purchased those from other countries like the United States. Their business model is to keep looking at the market, understand the available technologies, and purchase them. I don't think they develop (technological) innovations by themselves."* *I04*

As for the strategies, Interviewee–03 explained the specific areas, such as Artificial Intelligence and Digital Construction, that the firm is interested in terms of innovation development as follows:

> "*We analyse the areas in terms of business opportunities. There are five areas: Digital, Virtual, Artificial Intelligence, Blockchain and Clean Energy. These innovations are applicable not only in the construction industry but also in other business opportunities (driven by the firm)."* *I03*

Having continuous and sufficient funding has been a firm's mechanism for innovation deployment. Interviewee I10–Head of Engineering, Innovation and Digital Transformation, explained the source of funding of the firm as follows:

> "*We have a central fund which is around fifteen million. We have many innovations coming in. What we usually do is, do projects to self-finance (innovation in projects). A project could get up to fifteen innovations, and we allocate money to project from the central fund.*". *I10*

Furthermore, Interviewee I01–Director of Safety and Sustainability, explained that the budget allocated for innovation developments is more than the figures (central innovation fund) shown as each business unit absorbs a part of the cost rendered for innovations.

> *"There is a huge number of employees outside the innovation team. That cost is absorbed within the business. Therefore, we could not really tell you exactly what the cost is because we do not account for people's hours and so on. But we could tell you the cost of that we have to buy resources, hardware, and software, but normally we do not cost for hours of our people because they have other jobs to do."* *I01*

The firm considers tangible and intangible outcomes as a strategy for deciding on a particular innovation. Interviewee I01 stated that "*the case study firm takes each opportunity to implement innovation despite the cost-benefit, as the firm believes in intangible benefits, such as a firm's reputation and competitive advantage in the long run, are the tangible benefits*".

According to interviewee I10–Head of Engineering, "*on innovation and digital transformation, the firm's innovation strategy is ad-hoc and spontaneous. The firm allows business units and project directors to make decisions on innovation implementation. Enhancing clients' awareness is also a part of the firm's innovation strategy*". Interviewee I10 further explained the firm's cultural norms and mechanisms that encourage innovation implementation as follows:

> *"We did a lot of like culture work around encouraging innovation. Therefore, we ran like an annual competition. We got some key customers on the voting panel, and it was pretty successful."* *I10*

Refer to the supplementary_material_appendix_1 for the NVIVO codes.

Findings: Incidence of radical and incremental innovations and knowledge transfer

Concerning radical innovations of the firm, Interviewee I12–Safety Manager of the firm, explained a top-down radical innovation, which is developed by the firm's IT department (firm-level), as follows:

"*Wearing PPE (personal protection equipment) is a mandatory safety requirement on site. What if we include CCTV in the front of the safety helmet? It provides multiple observations. Following this method, all these CCTV and TVs on site are connected to the developed AI system. It provides twenty-four-hour observation. If a worker comes onto the site without a safety helmet, the system will detect it, and they will give a signal back to the central controlling point on your iPhone. Then, the worker is alerted.*" *I12*

Furthermore, Interviewee I06–the project manager of a marine reclamation project explained the clutch pipe system, as a radical innovation developed at the project level as follows:

"*The clutch pipe piles system is a game-changer. Certainly, without the clutch pipe pile, we would have been forced, probably, to do diaphragm walls in the Marine section particularly. We could not have made traditional pipe holes. Because the Victoria Harbour, in any shape or form, you can only get permission for temporary reclamation if you go through a judicial review.*" *I06*

Also, Interviewee I01 elaborated on the innovation team that facilitates both radical and incremental innovations and effectively transfers the knowledge among different levels as below:

"We have an innovation steering group made up of representatives from all (six) businesses. Moreover, we have a Head of Innovation (firm level) who facilitates innovation. He is not responsible for fostering innovation but for the directors of each business unit (project level). But directors of business units (project level) are responsible for innovation." *I01*

"We come together at that innovation steering group to make sure we are not duplicating, make sure we are sharing good lessons across the business." *I01*

As an example of yet another radical innovation, which was developed by the innovation team, *Integrated Digital Project Delivery (IDPD) was explained by* Interviewee I10 as below:

"*We have developed a digital transformation platform called Integrated Digital Project Delivery (IDPD). And that is something that we have developed by visiting markets and contractors in Japan, Europe and North America. I think in that area, on IDPD, we are probably the most advanced contractor firm (in Hong Kong).*" *I10*

Regarding the use of the Design, Fabrication, Manufacturing and Assembly (DfMA) approach and Modular construction (MiC) as radical innovations at the firm level, Interviewee I10 put forward the insights as below:

"*We completed a particular project through DfMA and MiC, and it was quite radical. It would be impossible to complete that project in that time using traditional methods.*"

I01

Interviewee I10 explained the transfer of knowledge obtained from exploratory and exploitative learning among different levels of the firm as below:

"We have a steering group, and then we will meet. This has been monthly until recently have moved it up to every two months. This meeting is chaired by the Chief Executive Officer (CEO), and it has been checked by the CEO until recently. I am (head of engineering and innovation) chairing it. I think that is the steering point" *I10*

"We use platforms like Teams (Microsoft 365). You can touch a lot of people from your desk easily. I think communication and sharing are much easier now than they used to be" *I10*

Refer to the supplementary_material_appendix_2, 3 and 4 for the NVIVO codes of radical and incremental innovations and knowledge transfer mechanisms of the firm, respectively.

Discussion of Findings

Sources of Innovation, Strategies and Mechanisms

As the internal sources, the employees can directly participate in innovation implementation by submitting proposals, and the firm selects the best proposals. In addition, as the external sources, the firm collaborates with local and international universities to develop innovations. Construction firms having both internal and external innovation drivers/sources has already been discussed by prior studies such as Meng and Brown (2018).

The firm's innovation strategy is rather ad-hoc, yet focusing on the areas such as Digital, Virtual, Artificial Intelligence, Blockchain and Clean Energy. Contrary to Meng and Brown's (2018) innovation strategies-technology, resource, marketing and management, or to the product-process classification, the firm aims to implement 'digital innovation' whether product, process, service or market innovation.

As the primary innovation mechanism, firm's innovation team has been identified. It facilitates innovation and prevents duplicating innovations by communicating different levels and business units. In addition, VDC and DT teams facilitate digital innovation and transformation of the firm. Provisions for innovation implementation are primarily from the central funding scheme of the case study firm. Being a large contracting firm with around US$2 billion annual turnover, the approximate allocation for innovation developments is around one percent of the annual turnover. The case study firm has adopted several methods to explore knowledge outside the firm, even outside the country or region. These are frequent site visits to foreign construction firms or factories, participating in international conferences or seminars, hiring foreign experts, collaborations with academic institutes, and collaborations with clients and other supply chain stakeholders (Reichstein *et al*., 2008). The decision to implement innovation is made at the tendering stage. In collaborative procurement approaches, bidders are usually allowed to submit alternative innovative solutions that are cost-effective and beneficial to both parties (Sidwell *et al*., 2001). In such situations, the case study firm submits an innovation proposal. However, the tender selection is heavily based on the price proposal; the innovation proposal only gets around ten to fifteen percent of the total bid (Loosemore and Richard, 2015). The case study firm frequently collaborates with local and international academic institutions and professional bodies to learn and develop innovations.

Incidence of radical and incremental innovations and knowledge transfer

The firm engages in top-down (firm-level exploration-radical innovation and project-level exploitation-incremental innovation) and bottom-up (project-level exploration-radical innovation and firm-level incremental innovation) innovation strategies. This observation aligns with Winch's (1998) top-down and bottom-up innovation model and conforms to the proposed framework. As top-down radical innovations, the development of PPE with an AI system and the stress-level detector that predicts the stress level of workers have been identified in the case study firm. The case study firm's bottom-up strategy was also evident through innovations such as the clutch pipe pile system.

Innovation deployment of the case study firm is also a problem-solving approach (Slaughter, 1993). For example, issues such as a labour shortage and an ageing workforce have been addressed by the DfMA and MiC approaches which have been identified as radical innovations at the firm level. Another example of problem-solving that emerged as a project-level radical

innovation is the clutch pile pipe system. The project team developed this innovation for a marine reclamation project. As per the HKSAR regulations regarding marine reclamation, a judicial review is required for any marine section construction. This innovation helped continue construction without a judicial review and saved extensive money, which was meant to happen through a traditional pipe excavation method.

When the firm level is concerned, a separate structural unit and systems (e.g., IT department) are allocated for exploration (radical innovation), and the structural ambidexterity format is observed (Benner and Tushman, 2003). However, temporal ambidexterity was not evident as the firm does not explore and exploit exploitation at separate times. Also, the existence of the innovation team indicates an integrated level (i.e., firm+project levels) of the firm. Among the three levels (i.e., firm, project, integrated), the integrated level of the case study firm produces the highest number of innovations (radical and incremental). At the project and integrated levels, contextual ambidexterity was observed (Gibson and Birkinshaw, 2004), as actors of each level can develop radical innovations and utilise former radical innovations with minor improvements (incremental innovation) when and where necessary. Accordingly, the conceptual framework suggested by the study has been validated and modified, where contextual ambidexterity is suggested for both project and integrated levels, and structural ambidexterity is recommended for the firm level. In contrast, temporal ambidexterity is removed from the modified framework due to the absence of empirical evidence from the case study. Figure 3 presents the modified framework.

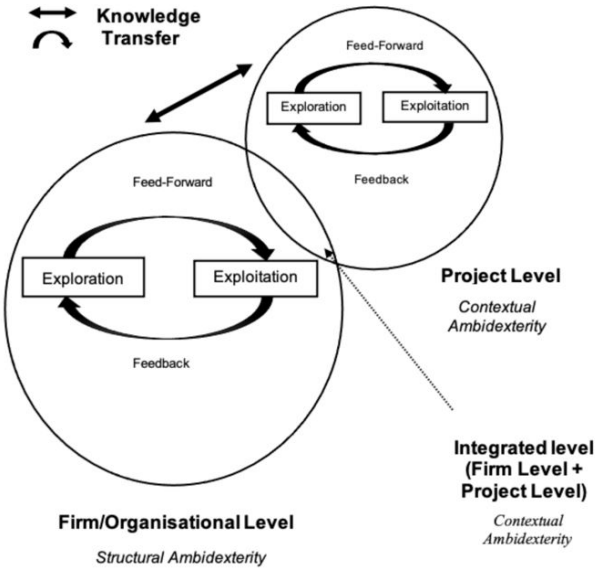

Figure 3: The modified framework after validation.

The findings also reveal that the case study firm is more exploitative than exploratory. Even though equal prioritisation is not explicit in the firm, the management has strived for an appropriate mix of exploration and exploitation (ambidexterity) (c.f. Lavie and Rosenkopf, 2006). As an innovation strategy, each project is usually evaluated initially, and the project directors and managers determine the appropriate mix. Also, these project-level ambidexterity strategies complement the firm-level strategies through robust integrating mechanisms such as establishing the integrated level/innovation team and frequent communication among different levels (Du Plessis, 2007).

The case study firm successfully employs different platforms for communication between different levels. However, rather than mere communication, the firm 'shares' and 'utilises' knowledge (Du Plessis, 2007); the best example is the innovation team that discusses each innovation implemented and even attempted in different projects and departments (e.g., IT). Another vital aspect explicit in the firm is using technology for learning, knowledge transfer and innovation. These discussions prevent duplications and support further developments of existing innovations (Du Plessis, 2007).

Conclusions

This study aimed at exploring innovation deployment of construction contracting firms through the lens of exploratory-exploitative learning and organisational ambidexterity. As the theories suggest, construction contracting firms that explore new knowledge to produce radical innovations and utilise and improve existing knowledge to develop incremental innovations (i.e., ambidextrous firms) are more innovative and successful. Based on this, a conceptual framework was developed, suggesting different ambidexterity forms for different levels. Unlike most conventional frameworks and mechanisms, the framework does not merely rely on tangible factors such as financial outcomes, R&D allocation and the number of patents for innovations. In contrast, innovation is measured by factors such as significance, newness, the severity of financial commitments, the level of uncertainty of outcomes, and the extent that the firm moves from existing strategies. If these are greater, it was identified as a radical innovation. On the contrary, small-scale innovations with less significant outcomes with less impact were conceptualised as incremental innovations. Rather than weighing only radical and breakthrough innovations, the proposed framework recognised hidden innovations (i.e., incremental innovations) missed by conventional frameworks.

A single case study was conducted to validate the conceptual framework. Hence, a large contracting firm in the Hong Kong construction industry, reputed for innovation implementation, was selected as the case. The ambidexterity (i.e., radical and incremental balance) at different firm levels was observed. In addition to the project and firm levels suggested in the conceptual framework, a new level called the 'integrated level' combined with the project and firm-level actors (i.e., innovation team) was observed. The case study firm maintains structural ambidexterity at the firm level by establishing the IT department for innovation implementation. The project and integrated levels are managed through contextual ambidexterity as the innovation team facilitates each innovation. Overall, the firm explores and exploits at the firm and project levels. Firm-level exploration (radical innovation) becomes project-level exploitation (incremental innovation) and vice versa. Hence, the firm is enriched with top-down and bottom-up innovation strategies.

The most radical innovations are the digital procurement approach (i.e., IDPD), alternatives for traditional on-site construction methods (i.e., DfMA, MiC) and AI-based technological innovations (i.e., IoT safety helmet). In addition, incremental innovations have become a part of the firm's business strategy. Findings confirmed that the case study firm successfully maintains radical-incremental innovation-based ambidexterity at the firm, project and integrated levels, which drives the firm towards innovation while engaging in the day-to-day business activities. The modified framework does not indicate a universal cut-off level to measure contractors' innovation. Instead, it recommends maintaining an appropriate mix (ambidexterity) between exploration (i.e., radical innovation) and exploitation (incremental innovation) to be innovative.

Research Implications

This research contributes to learning, construction innovation and project management literature. More importantly, findings contribute to the exploratory-exploitative learning and organisational ambidexterity theories in the context of construction contracting firms. As knowledge transfer within and across multi-levels in contracting firms has been examined, the findings of the study contribute to the knowledge transfer literature.

The explorative and exploitative concept is widely used to conceptualise these learning activities based on finding new knowledge and utilising and improving existing knowledge (March, 1990; He and Wong, 2004). This study, however, follows the outcome view, which has been rarely discussed and conceptualised other than a few exceptions (e.g., Lennerts *et al*., 2020). The present study contributes to bridging this theoretical gap by conceptualising and operationalising exploratory and exploitative learning by their outcome: radical and incremental innovation (c.f. Eriksson, 2013; Lennerts *et al*., 2020). Furthermore, findings contribute to the organisational ambidexterity theory by linking radical and incremental innovation balance. This study also provides empirical findings on construction contractors' practices to create and maintain structural ambidexterity (at the firm level) and contextual ambidexterity (at the project level).

Moreover, this study has considered the unique and complex nature of project-based settings (i.e., contractor firms as PBFs) to examine innovation deployment within and across multi-levels (i.e., project, firm and integrated levels). Thus, the findings contribute to the project management literature as well. This study indicates that construction innovation is client-driven as the client's prior approval is mandatory for the innovation implementation in the design and construction (c.f. Gambatese and Hallowell, 2011b). Nevertheless, the construction contractor has the capability of initiating innovation through the submission of innovation proposals at the tendering stage. Compared with prior innovation management strategies, the findings of this study also align with 'top-down' and 'bottom-up' approaches (Winch, 1998).

The findings of this study also align with the implications of previous empirical studies. For example, Eriksson's (2013) and Eriksson *et al*.'s (2017) ambidexterity and knowledge-sharing suggestions for construction PBFs are validated by this study. Even though the theoretical basis of this study was from March's (1991) seminal work on exploratory-exploitative learning, this study complements He and Wong's (2004) argument-organisational capability to explore and exploit simultaneously. Most importantly, findings of the studies carried out by Tushman and O'Reilly (1996), Gibson and Birkinshaw (2004) and Raisch *et al*. (2009) on organisational ambidexterity are complimented. In particular, the present study confirms the necessity of establishing structural ambidexterity for the organisational (i.e., firm) level and contextual ambidexterity for the project level. It extends the organisational ambidexterity theory to the context of construction contracting firms. However, this study does not support the existing notion of establishing temporal/sequential ambidexterity (c.f. Turner, 2014) at the firm level in the context of construction contracting firms.

Limitations and Future Research Directions

The conceptual framework was validated by a single case study, a large construction contracting firm in the Hong Kong construction industry. Even though the selected contractor as the case study is known for fostering innovation, the study results may not be generalisable due to context-specific information. However, the findings would still be reliable in similar research contexts. Although an in-depth and holistic examination of the selected firm's innovation and learning process is accomplished using a single case study, a multiple-case study approach would have enabled a cross-case analysis and comparison in different contexts.

Data Availability Statement

All data generated or used during the study are available from the corresponding author by request.

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Table I: Demographic information of interviewees

Interviewee code	Job position	Level of education	Years of experience within the firm	Years of experience in the construction industry
I01	Director	Higher National Diploma	10 years	16 years
I02	Head of Innovation	Diploma	01 year	13 years
I03	Innovation Manager	M.Sc.	07 years	19 years
I04	Manager	B.Sc.	-	15 years
I05	Temporary Works Systems Manager	M.Sc.	10 years	44 years
I06	Project Manager	M.Sc.	08 years	13 years
I07	Engineering Development Manager	M.Sc.	9.5 years	21 years
I08	BIM Engineer	M.Sc.	4 years	6 years
I09	Senior Safety Officer	M.Sc.	9 years	26 years
I10	Head of Engineering, innovation and digital transformation	M.Sc.	26 years	31 years
I11	Head of Digital Transformation	B.Sc.	9 years	9 years
I12	Safety Manager	B.Sc.	11 years	30 years

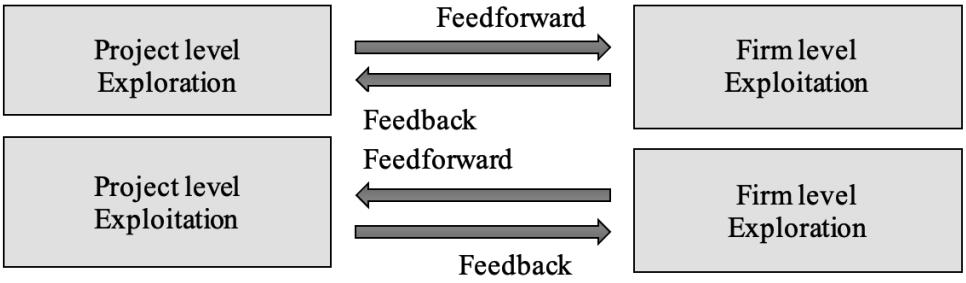

Figure 1: Initial conceptual framework to explain innovation in construction contracting firms.

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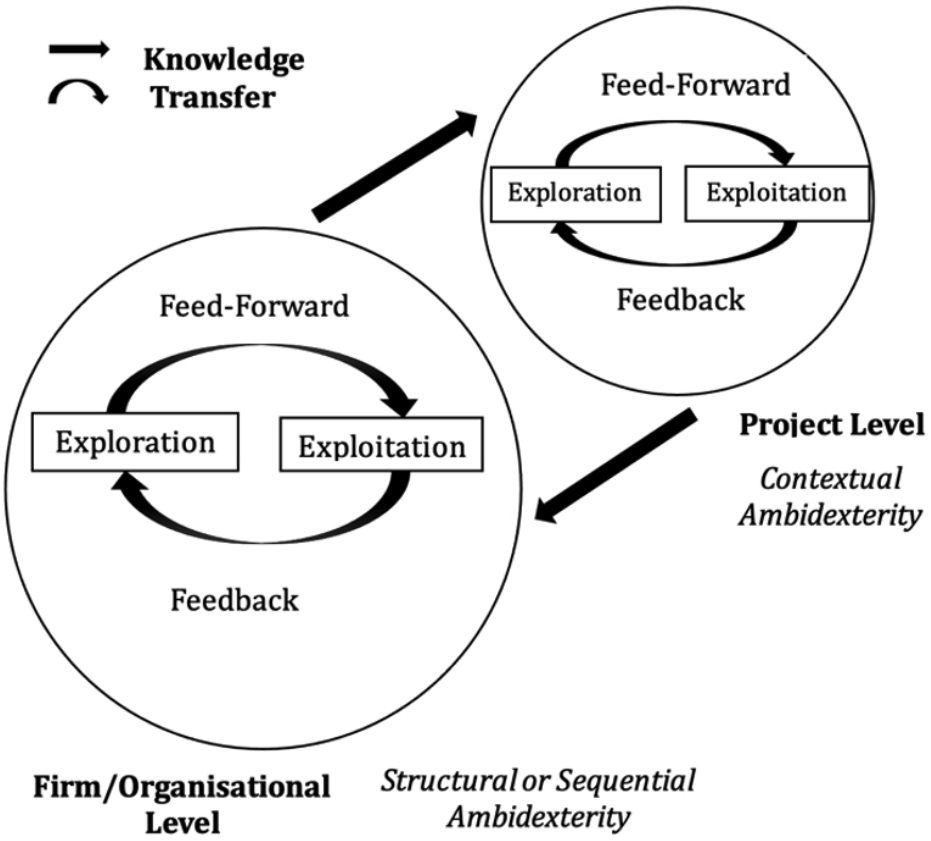

Figure 2: The proposed conceptual framework to explain innovation in construction contracting firms.

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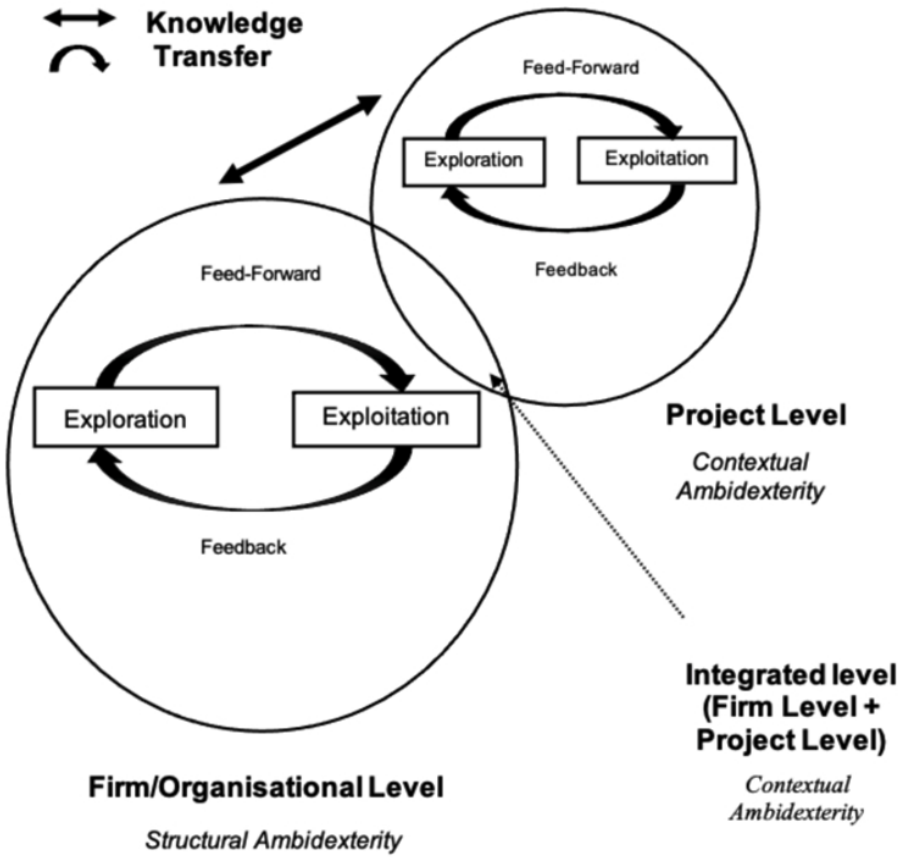

Figure 3: The modified framework after validation.

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Exploring innovation deployment of construction contracting firms through the lens of exploratory-exploitative learning: A Hong Kong case study

Abstract

Purpose: This study explores the innovation deployment of construction contracting firms through exploratory-exploitative learning and organisational ambidexterity.

Design/methodology/approach: First, a literature-based conceptual framework was developed to explain innovation implementation through exploratory-exploitative learning and organisational ambidexterity. A prominent Hong Kong construction contracting firm was then selected as the case study to explore its innovation deployment at different organisational levels (i.e., firm and project levels). Qualitative data was attained by conducting twelve semi-structured interviews with industry experts and document analysis. The thematic analysis using NVIVO 12 software was adopted to analyse data.

Findings: Findings reveal that the case study firm successfully fosters innovation when ambidexterity is achieved through the balance between exploratory learning (i.e., radical innovation) and exploitative learning (i.e., incremental innovation) ~~balance~~.

Research implications: Establishing uniform ambidexterity (i.e., 50:50) at the firm or project level is not mandatory to deploy innovation successfully. The ratio can vary based on the characteristics and requirements of construction firms.

Practical implications: This paper shall motivate construction practitioners to adopt radical-incremental innovation ambidexterity in firms and ultimately enhance the productivity and efficiency of the construction industry.

Originality/value: Previous construction innovation research has frequently explored firm or project-level innovation separately. This study identified a multi-level focus on innovation. ~~By adopting the~~Through the lens of exploratory-exploitative theory, different forms of innovation ambidexterity for different levels are suggested rather than one specific ambidexterity.

Author keywords: Construction contracting firms; Exploratory-exploitative learning; Incremental innovation; Learning; Organisational ambidexterity; Radical innovation.

Paper type: Research paper

Introduction

Compared to other industries, the construction industry has frequently been criticised for its inherent issues of productivity and efficiency (Blayse and Manley, 2004; Bygballe and Ingemansson, 2014). Innovation implementation is an important medium to overcome performance issues in the construction industry (Gann, 2003).

With ~~the nature of~~ the construction industry being project-oriented and relying on temporary project-based organisations, it reduces the industry's chances of innovation due to low investment in research and development (R&D) and academia-industry collaborations (Gann, 2003). As a result, traditional assessment criteria, such as the number of patents, R&D allocation and profit in contracting firms, hardly measure the innovation implementation. Similarly, Bygballe and Ingemansson (2014) and Loosemore (2015) mentioned the hidden nature of construction innovations and emphasised the necessity of contemporary measures. As a contemporary approach, studies have adopted the concept of organisational ambidexterity– a strategy to balance organisations' learning activities to explore innovation in organisations (March, 1991; O'Reilly and Tushman, 2008; Eriksson, 2013). Ambidextrous firms stimulate both exploration or exploratory learning (search for new knowledge) and exploitation or exploitative learning (use of existing knowledge with improvement) simultaneously (Levinthal and March, 1993). Drawing on the project-based nature, Eriksson (2013) suggested that ambidextrous construction firms tend to be more innovative. However, other than a few exceptions (e.g., Eriksson, 2013; Duodu and Rowlinson, 2021), ambidexterity at different levels in construction contracting firms have rarely been examined as most prior

research focused on project-level ambidexterity (e.g., Liu *et al.*, 2012). Previous research on construction innovation has focused on the firm (e.g., Winch, 1998; Sexton and Barrett, 2004; Drejer and Vinding, 2006; Duryan and Smyth, 2019) and project levels (e.g., Barlow, 2000; Vakola and Rezgui, 2000; Ozorhon, 2013; Ozorhon *et al*., 2014; Zhang *et al*., 2021). Geraldi (2008) developed a model to direct project-based firms (PBFs) to balance order and chaos, which suggested the implementation of project-specific innovation. Nevertheless, explanations of different innovation management approaches are yet to be explored in large construction contractors at different levels to analyse their contribution to innovation in the construction industry. To bridge this gap, this study explores the innovation deployment of construction contracting firms at multi-levels. Hence, the learning theory—explanatory learning and exploitative learning, and organisational ambidexterity are adopted as theoretical lenses. Considering the outcome of each learning type, exploratory learning is conceptualised as radical innovation, while exploitative learning is conceptualised as incremental innovation. Organisational ambidexterity is perceived by radical-incremental innovation ambidexterity (Gupta *et al*., 2006; Lennert *et al*., 2020).

As methodological approaches, a comprehensive literature review has been conducted, and a conceptual framework is developed which suggests structural ambidexterity at the firm level and contextual ambidexterity at the project level. Through the subsequent case study, the framework is validated and modified further.

Innovation Management Research in Construction

Studies on innovation in construction go back way to the 1960s. Bowley (1960) has been recognised as one of the first researchers who explored product and process innovation in construction. Similarly, Tatum's (1986, 1989) multiple works and Toole's (1998) works frequently focussed on technological innovation in construction. These earlier studies often perceived construction innovation through technological innovation in construction. However, researchers such as Slaughter (1993) then adopted a much broader definition by explaining construction innovation as a phenomenon with an ability to improve and change significantly.

Studies were then carried out in the organisational context, exploring the potential for construction innovation towards organisational survival and development (e.g., Subramanian and Nilakanta, 1996; Manley and Mcfallan, 2006). Researchers shifted their attention to the project level to explore the innovation process in construction projects (e.g., Winch, 1998).

Despite various research directions, the scope of work and the adoption of different theories, studies on construction innovation frequently hint at the lack of innovativeness in the construction industry (e.g., Blayse and Manley, 2004; Reichstein *et al*., 2005). Lack of investment in R&D, project-based or fragmented and temporary nature of the industry and distance from academia have been recognised as innovation-hindering factors (Dubois and Gadde, 2002; Gann, 2003). Hence, innovation management in the construction industry has substantial differences compared to industries such as manufacturing. For instance, the heterogeneous nature, immobility, and less predictability of demand make the innovation process in construction complex and non-linear (Reichstein *et al*., 2005). Similarly, researchers argue that discontinuous and project-based nature disrupts innovation diffusion and management in construction firms (Gann and Salter, 2000).

As a subsequent contemporary view, researchers such as Winch (2003) and Bygballe and Ingemansson (2014) put forward a counterargument that traditional measurements of

innovation, such as R&D allocation, number of patents and profit, poorly reflect certain innovations which are hidden. Hence, researchers are taking action to recognise and promote construction innovations, particularly in the organisational context. For instance, examining innovation process and management through the lens of strategic management theory and learning theory to emphasise benefits such as competitive advantage for organisations is an important development in the construction management research (e.g., Zollo and Winter, 2002; Calantone *et al.*, 2002; Crossan *et al.*, 1999).

Innovation in Construction Contracting Firms

Compared with manufacturing firms, construction firms are stigmatised for lack of innovativeness. Innovation implementation of operations-based organisations such as manufacturing firms, whose business model is producing the same output in volume is rather straightforward, compared to construction PBFs, whose business model is built with complex process to deliver unique outputs (Greco *et al.*, 2021).

Nevertheless, strategic management theory suggests that innovation~~Innovation~~ in construction contracting firms has become a prerequisite for achieving and sustaining competitive advantage (Seaden *et al.*, 2003). As the income of contracting firms is generated through profits from projects, firms must explore new solutions through innovation implementation and sustain development (Gann and Salter, 2000). According to Slaughter (1993), construction innovation often emerges at the execution stage as resolutions for problems arising from construction activities. Winch (1998) proposed that innovation in construction firms appears to have two approaches: top-to-bottom and bottom-to-top. The former approach comes from R&D activities stimulated at the firm level, whereas the latter approach fits with Slaughter's (1993) explanation of resolution to the problems arising from construction activities. Thus, the idea of 'problem-solving' creates innovation and change (Gambatese and Hallowell, 2011a). While emphasising the requirement to innovate, Lijauco *et al.* (2020) pointed out the importance of cultural manifestations such as market orientation, business relationships, workforce capacity and leadership to enhance the innovation capability of construction SMEs. Jin *et al.* (2022) also highlighted factors such as experience in mega projects, having a strong knowledge base and networking to expand technical innovation capability in construction.

Fostering innovation and change in contracting firms is challenging due to projects' autonomous and unique nature and lack of potential for repetition (Drejer and Vinding, 2006). From ~~a~~ the learning perspective, one-off projects are good opportunities for construction firms to learn and acquire new knowledge (Ayas and Zeniuk, 2001). However, it is somewhat unusual for contracting firms to use new knowledge in future projects (Dubois and Gadde, 2002). Therefore, construction contracting firms must adopt contemporary approaches enabling innovation at the project and firm levels. Accordingly, this study defines innovation in construction contracting firms considering multi-levels as the implementation of a new or significantly improved product, process, system, strategy, policy, or service in a contractor firm that substantially changes the existing organisational procedures and delivers economic or social benefits to the firm (c.f., Damanpour and Evan, 1984).

Research Methodology

The methodology in this study is designed first to develop a theoretical foundation on innovation implementation in large contracting firms and then to test the theory and provide empirical findings in this regard. Accordingly, a comprehensive literature review was carried out exploring different aspects, such as innovation and learning in construction. Literature on learning (i.e., exploration and exploitation), ambidexterity and knowledge management theories were~~was~~ also reviewed (March, 1991; O'Reilly and Tushman, 2008; Simsek, 2009).

Phase 1: Theory building

Exploratory Learning, Exploitative Learning and Organisational Ambidexterity

The learning concept–exploration and exploitation (exploratory learning and exploitative learning) is adopted to explain organisational learning behaviour and its consequences (March, 1991; He and Wong, 2004). March (1991), in his seminal work, defined exploratory learning as activities such as "search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation" (p.71), and exploitative learning refers to activities such as "refinement, choice, production, efficiency, selection, implementation and execution" (p.71). Exploration and exploitation have been conceptualised as contradictory and orthogonal learning modes yet emphasise their significant role in organisational survival and development (Gupta *et al*., 2006; Lennerts *et al*., 2020).

The most frequently perceived conceptualisation of exploratory-exploitative learning is based on the 'process' of each approach (e.g., March, 1991). As a contemporary approach, conceptualisations have considered~~been made considering~~ these two learning modes as 'orthogonal' constructs based on the nature of their 'outcome' (e.g., Eriksson, 2013; Lennerts *et al*., 2020). Following the latter, radical and incremental innovation classification has been used to conceptualise exploratory and exploitative learning (Tushman and O'Reilly, 1996; Gibson and Birkinshaw, 2004).

Faems *et al*. (2005) differentiated radical and incremental innovations as follows:

> "The notions of incremental versus radical innovation, innovation as continuous improvement via learning by doing versus innovation as creative destruction, flexibility to keep innovation options open versus commitment to well-defined innovation pathways, divergent versus convergent behavior, exploitation versus exploration or path creation versus path dependence…" (p.3).

Raisch and Birkinshaw (2008) explained radical innovation as the "fundamental changes leading to a switch from existing products or concepts to completely new ones" (p.378). In contrast, incremental innovation is explained as "relatively minor adaptations of existing products and business concepts" (p.378). Studies conducted by Bierly III *et al*. (2009) and Hernández-Espallardo et al. (2011) also highlight radical innovation by 'new' and 'significant' characteristics while linking incremental innovation with 'already known'.

Several studies examine their manifestation in organisations, the benefits of balancing the two learning activities, their impact on organisational performance, and how organisations facilitate exploration and exploitation (e.g., Turner *et al*., 2016; Eriksson and Szentes, 2017). However, the contrasting nature and paradoxical complications make it difficult for their application in organisational settings. Therefore, balancing strategies and integrating mechanisms between the two learning modes are suggested (Raisch *et al*., 2009). Resource scarcity was initially viewed as an issue to implement and balance out both learning modes (March, 1991). Consequently, the capability of organisations to implement both has been recognised, and mechanisms to do so have even been presented (He and Wong, 2004). For instance, recent studies have highlighted that ambidextrous organisations can undertake both learning activities (Chang, 2015; Turner *et al*., 2016).

The term 'ambidextrous' refers to the ability of humans to use both hands equally and simultaneously, which has been used to recognise the ability of organisations to explore and exploit simultaneously (Duncan, 1976; O'Reilly and Tushman, 2008; Simsek, 2009). In the literature, ambidexterity at a particular level, such as the business unit, team, and individual, has been explored (Brix, 2019). The attention is now shifted to multi-level analysis in organisational studies (e.g., Chang, 2015). In these studies, ambidexterity is conceptualised as

the balance between exploration and exploitation, radical and incremental innovation interactions, width and depth, and adaptation and alignment (Katila and Ahuja, 2002; Lennerts *et al*., 2020; Gibson and Birkinshaw, 2004). These interactions counterbalance each mode's weaknesses. ~~However, a uniform mix of each approach is not necessary to achieve and maintain ambidexterity in organisations, as the appropriate mix depends on the R&D intensity of the industry and the learning capabilities of the organisation (Simsek *et al*., 2009).~~ If ambidexterity is not established and maintained, organisations can end up either as an extreme explorative entity that is likely to suffer from losses from continuous experiments that are unable to provide short-term benefits; or as a pure exploitative entity that is likely to lose its market due to a lack of competence. Moreover, this approach hinders survival and development in the long run (March, 1991).

Different forms of ambidexterity have been identified in the literature. The three major ambidexterity types–Temporal (sequential), structural, and contextual– are the most common approaches frequently identified in previous research (e.g., Gupta *et al*., 2006; Raisch *et al*., 2009; Turner *et al*., 2014). When organisations explore and exploit different periods cyclically, temporal/sequential ambidexterity is formed. Structural ambidexterity refers to allocating different organisational units, competencies, systems, processes, incentives and cultures to perform exploration and exploitation separately (Benner and Tushman, 2003). The third form, contextual ambidexterity, allows individuals and teams at departments or projects to simultaneously explore and exploit~~perform exploration and exploitation~~ (Gibson and Birkinshaw, 2004).

Even though innovation in contracting firms has already been studied through the lens of ambidexterity, empirical findings that confirm ambidexterity-based innovations, considering the firm as a unit of analysis, are limited. Hence, this study contributes to innovation in construction firms by suggesting different ambidexterity forms at different levels (i.e., firm and project).

Development of the Conceptual Framework

Ambidexterity theory (O'Reilly and Tushman, 2013) suggests various forms of ambidexterity can emerge in multi-level settings such as construction contracting firms (Eriksson, 2013). Following this view, as well as the frameworks developed by Brady and Davies (2004) and Bygballe and Ingemansson (2014), this study argues that firm-level exploration and project-level exploitation also exists, in addition to project-level exploration and firm-level exploitation in the context of contracting firms. Consequently, an initial conceptual framework is developed, as shown in Figure 1.

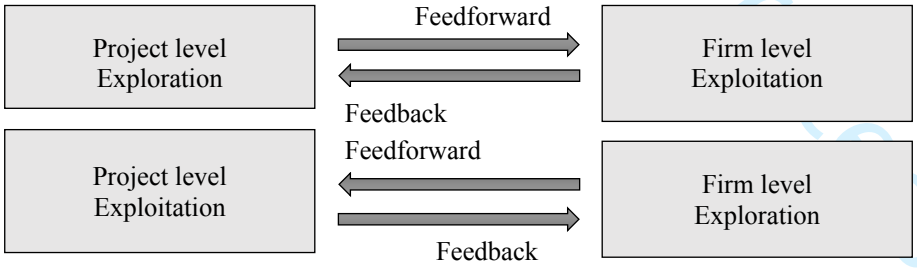

Figure 1: Initial conceptual framework to explain innovation in construction contracting firms.

According to the ambidexterity theory, ambidexterity occurs at the firm and project levels. Contextual ambidexterity is the most effective form of managing highly dynamic and complex settings such as projects (Gibson and Birkinshaw, 2004). Norms such as trust, adaptability and risk-taking are inherent within contextual ambidexterity that enhances interactions and

synergies across different individuals and units in projects and the firm (Raisch *et al*., 2009). Both structural and temporal ambidexterity forms are suggested for the firm level (O'Reilly and Tushman, 2013). Figure 2 further illustrates these ambidexterity forms.

In addition, knowledge transfer between project level-to-~~organisation~~firm level, ~~organisation~~firm level-to-project level and within projects are included in the proposed conceptual framework ~~as indicated~~ (see Figure 2). When a single level is concerned, exploitation outcomes become inputs for exploration. When the firm is considered the unit of analysis, exploration at the project level becomes exploitative learning for the firm level and vice versa. Accordingly, the result (i.e., outcome) of exploration, which is radical innovation, occurs at the firm and project levels. At the same time, the result of exploitation (i.e., outcome), which is incremental innovation occurs at the firm and project levels too. Hence, both radical and incremental innovations can be observed at the same level. The radical innovation of one level can be an incremental innovation of the other level. The framework further suggests a balance between these two (i.e., ambidexterity) to firms to be successful. Robust communication strategies are suggested as knowledge-transferring mechanisms within the same level and across different levels.

Green *et al*. (1995) recognised radical innovation as a multi-dimensional construct based on four dimensions: technological uncertainty, technical inexperience, business inexperience, and technology cost. Based on Green *et al*.'s (1995) conceptualisation of radical innovation, excluding its context in technological innovation, it is used to distinguish radical and incremental innovations in contractor firms. Hence, this study defines radical innovation as a new or significantly improved product, process, system, strategy, policy or service that requires massive financial commitments, which involves significant benefits, riskier and uncertain outcomes, and makes organisations move from existing procedures.

Eriksson *et al*. (2017) described exploitative learning or incremental innovation as the continuous usage of existing knowledge or strategies, and accordingly, incremental innovation is perceived as the utilisation of radical innovation. Advancing this view, this study suggests that exploitative learning involves using and refining existing knowledge in construction contracting firms. Hence, this study defines incremental innovation as using and improving implemented radical changes to the organisation, which involves less risky and defined outcomes.

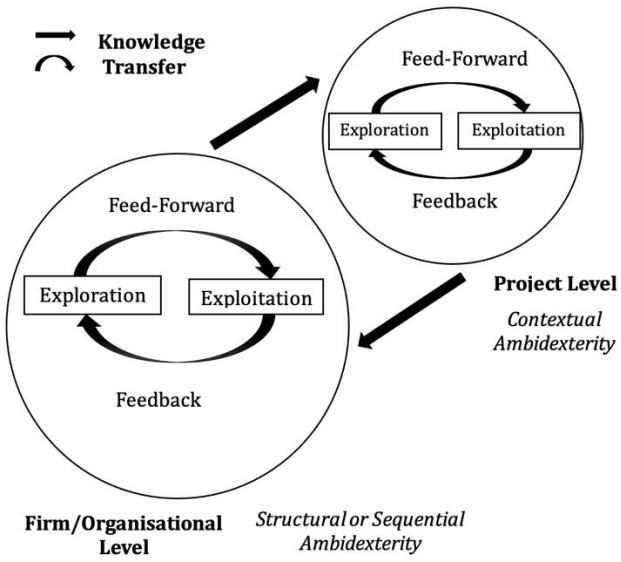

Figure 2: The proposed conceptual framework to explain innovation in construction contracting firms.

Phase 2: Empirical study and data collection

The case study approach was selected as the study attempts to explore the innovation deployment of construction contracting firms, which requires an in-depth and holistic investigation. Elman *et al*. (2016) defined a case study as a strategy that "focuses intensively on a single case. Generally, the chosen case is regarded as emblematic of a larger population of cases, a case of something" (p.375). Furthermore, a case is usually selected based on its potential to enhance the researcher's theoretical views on the phenomenon; in this study, it is the contractors' innovation deployment. This case study is exploratory rather than explanatory, as the case study findings are subjected to interpretations (Liamputtong, 2020).

Several measures have been adopted to ensure the validity and reliability of the findings. Qualitative validity, which has three attributes (internal validity, construct validity and external validity), is ensured through the accuracy of the qualitative findings. First, internal validity has been achieved by providing logical and reasonable interpretations through an accurate and comprehensive data analysis. Furthermore, having a compelling conceptual framework that illustrates the interrelationships between constructs (Figures 1 and 2), comparison of findings with previous findings (in the discussion section), and theory triangulation through adaptation of different perspectives (i.e., exploration-exploitation, ambidexterity and knowledge transfer) ensure the internal validity of the findings. Second, construct validity, conceptualisation and operationalisation of the theory are achieved by adopting a clear chain of data (evidence) and data triangulation through multiple data collection techniques and sources. Third, external validity, generalisability of findings is ensured by applying the findings and interpretations to different contexts (Creswell, 2009). However, analytical generalisability is allowed rather than statistical generalisation, as findings contribute to the theory rather than a population (Yin, 2018). The reliability of the findings is maintained by conducting the research according to the standard procedure suggested by Yin (2018) and Creswell (2009).

Case study firm

A large contracting firm in the Hong Kong Special Administrative Region (HKSAR), which belongs to category C (i.e., contractors can bid for contracts of value exceeding HK$ 300 million) as classified by the Hong Kong Development Bureau (HKDB), is studied as the case study. This firm is considered the largest contracting firm in Hong Kong and~~that also~~ does business in Mainland China, Macau SAR and Singapore. The case study firm is renowned for fostering innovation in the Hong Kong construction industry and the East Asian region. However, most Hong Kong contracting firms do not~~contracting firms in Hong Kong do not essentially~~ engage in innovation implementation. Hence, the case study is influential rather than typical (Seawright and Gerring, 2008). Despite being a large organisation with more than five thousand permanent employees, the culture of the case study firm is flexible and facilitates learning and innovation. When the organisational structure is concerned, it is not solely organic as it contains mechanistic features. The firm consists of six major units (i.e., civil engineering, buildings, foundations, E&M, structural steel, and concrete plant department), and the director is responsible for the innovation implementation of each unit. The firm also has an innovation team that facilitates innovation across different units and levels. In addition to the innovation team, Virtual Design and Construction (VDC) and Digital Transformation (DT) teams are also involved in implementing the firm's digital innovations. These teams, including the innovation team, function as cross-functional teams in which the firm and project-level actors are included. The actors are responsible to the functional manager (Head of Innovation) at the firm level and project managers at the project level. When a project team under a particular business unit develops~~comes up with~~ an innovation, the team informs the innovation team. The innovation team facilitates the innovations and develops them with the project team. Since the case study

firm is large and its multi-levels are observable, it has been selected to examine innovation implementation and deployment within and across multi-levels.

Data Collection: Semi-structured interviews and document analysis

Semi-structured interviews: Professionals in the case study firm and the external organisations involved in the innovation deployment were selected as the interviewees. Interviewees hold positions as top and middle managers who represent both firm and project levels. Interviewees were selected based on their job position (contribution) and knowledge of innovation (purposive sampling technique) (Padgett, 2017). An interview guideline was used to raise questions regarding the firm's radical and incremental innovation developments, innovation, VDC and DT teams, funding arrangements, collaborations, and knowledge transfer across different levels. A total of 12 interviews, lasting 1 hour each, were carried out in English medium. The following Table I presents the demographic information of the interviewees.

-Table I-

Document analysis: The information such as background, structure, and revenue/profit of the firm over the years, which were missed or not explicit from the interviews, were obtained via this technique. Furthermore, publications such as company manuals, the official website, news articles and even YouTube (verified) videos made available by the case study firm and other reliable sources were reviewed to validate the data collected from the interviews. In addition, information on recent innovation developments launched by the case study firm was collected through visits to an HKSAR government-funded organisation that facilitates and exhibits innovations developed by construction firms in Hong Kong.

Data analysis and testing of the conceptual framework

All the interviews were conducted in English, audio-recorded and transcripts were produced. Thematic analysis technique and NVIVO 12 software were adopted to analyse qualitative data. The analysis process was based on the general analysis process suggested by Creswell (2009). The guideline with six steps was followed, such as organising and preparing data for analysis, reading through all data, coding the data, generating themes and descriptions using the coding process, interrelating themes and descriptions, and making interpretations of data (Creswell, 2009). Main themes were produced based on the constructs of the conceptual framework (e.g., radical innovation, incremental innovation, knowledge transfer). In addition, themes such as sources of innovation, strategies and mechanisms emerged.

Findings: Sources of Innovation, Strategies and Mechanisms

As the sources of innovation, the firm has two main directions: internal and external. As stated by Interviewee I03 as follows, firm's employees are key internal sources:

> *"We started a campaign called 'innovator of the month', which any employee can participate in. Then, the most innovative ideas are recognised, and even cash rewards are given. So, every month around 10-20 proposals are received and all of them are shared among the innovation team. Every year we receive more than two hundred proposals, and we store them in our database."* *I03*

In addition to the internal sources, the case study firm has some external sources of innovation, such as local and international universities. As stated by Interviewee I01, *"Currently, we have been paired with many universities. Sometimes it is hard to say "it is us" or "it is our employees."*

Moreover, Interviewee 04– manager of the external organisation that facilitates construction innovation in HKSAR~~,~~ explained the case study firm's approach that is purchasing innovation developments from external organisations as follows:

> "*Most of the innovations were not developed by the firm. They purchased those from other countries like the United States. Their business model is to keep looking at the market, understand the available technologies, and purchase them. I don't think they develop (technological) innovations by themselves."* *I04*

As for the strategies, Interviewee–03 explained the specific areas, such as Artificial Intelligence and Digital Construction, that the firm is interested in terms of innovation development as follows:

> "*We analyse the areas in terms of business opportunities. There are five areas: Digital, Virtual, Artificial Intelligence, Blockchain and Clean Energy. These innovations are applicable not only in the construction industry but also in other business opportunities (driven by the firm)."* *I03*

Having continuous and sufficient funding has been a firm's mechanism for innovation deployment. Interviewee I10–Head of Engineering, Innovation and Digital Transformation, explained the source of funding of the firm as follows:

> "*We have a central fund which is around fifteen million. We have many innovations coming in. What we usually do is, do projects to self-finance (innovation in projects). A project could get up to fifteen innovations, and we allocate money to project from the central fund.*". *I10*

Furthermore, Interviewee I01–Director of Safety and Sustainability, explained that the budget allocated for innovation developments is more than the figures (central innovation fund) shown as each business unit absorbs a part of the cost rendered for innovations.

> *"There is a huge number of employees outside the innovation team. That cost is absorbed within the business. Therefore, we could not really tell you exactly what the cost is because we do not account for people's hours and so on. But we could tell you the cost of that we have to buy resources, hardware, and software, but normally we do not cost for hours of our people because they have other jobs to do."* *I01*

The firm considers tangible and intangible outcomes as a strategy for deciding on a particular innovation. Interviewee I01 stated that "*the case study firm takes each opportunity to implement innovation despite the cost-benefit, as the firm believes in intangible benefits, such as a firm's reputation and competitive advantage in the long run, are the tangible benefits*".

According to interviewee I10–Head of Engineering, "*on innovation and digital transformation, the firm's innovation strategy is ad-hoc and spontaneous. The firm allows business units and project directors to make decisions on innovation implementation. Enhancing clients' awareness is also a part of the firm's innovation strategy*". Interviewee I10 further explained the firm's cultural norms and mechanisms that encourage innovation implementation as follows:

> *"We did a lot of like culture work around encouraging innovation. Therefore, we ran like an annual competition. We got some key customers on the voting panel, and it was pretty successful."* *I10*

Refer to the supplementary_material_appendix_1 for the NVIVO codes.

Findings: Incidence of radical and incremental innovations and knowledge transfer

Concerning radical innovations of the firm, Interviewee I12–Safety Manager of the firm, explained a top-down radical innovation, which is developed by the firm's IT department (firm-level), as follows:

> "*Wearing PPE (personal protection equipment) is a mandatory safety requirement on site. What if we include CCTV in the front of the safety helmet? It provides multiple observations. Following this method, all these CCTV and TVs on site are connected to the developed AI system. It provides twenty-four-hour observation. If a worker comes onto the site without a safety helmet, the system will detect it, and they will give a signal back to the central controlling point on your iPhone. Then, the worker is alerted." I12*

Furthermore, Interviewee I06–the project manager of a marine reclamation project explained the clutch pipe system, as a radical innovation developed at the project level as follows:

> "*The clutch pipe piles system is a game-changer. Certainly, without the clutch pipe pile, we would have been forced, probably, to do diaphragm walls in the Marine section particularly. We could not have made traditional pipe holes. Because the Victoria Harbour, in any shape or form, you can only get permission for temporary reclamation if you go through a judicial review." I06*

Also, Interviewee I01 elaborated on the innovation team that facilitates both radical and incremental innovations and effectively transfers the knowledge among different levels as below:

> *"We have an innovation steering group made up of representatives from all (six) businesses. Moreover, we have a Head of Innovation (firm level) who facilitates innovation. He is not responsible for fostering innovation but for the directors of each business unit (project level). But directors of business units (project level) are responsible for innovation." I01*

> *"We come together at that innovation steering group to make sure we are not duplicating, make sure we are sharing good lessons across the business." I01*

As an example of yet another radical innovation, which was developed by the innovation team, *Integrated Digital Project Delivery (IDPD) was explained by* Interviewee I10 as below:

> "*We have developed a digital transformation platform called Integrated Digital Project Delivery (IDPD). And that is something that we have developed by visiting markets and contractors in Japan, Europe and North America. I think in that area, on IDPD, we are probably the most advanced contractor firm (in Hong Kong)." I10*

Regarding the use of the Design, Fabrication, Manufacturing and Assembly (DfMA) approach and Modular construction (MiC) as radical innovations at the firm level, Interviewee I10 put forward the insights as below:

> "*We completed a particular project through DfMA and MiC, and it was quite radical. It would be impossible to complete that project in that time using traditional methods." I01*

Interviewee I10 explained the transfer of knowledge obtained from exploratory and exploitative learning among different levels of the firm as below:

> *"We have a steering group, and then we will meet. This has been monthly until recently have moved it up to every two months. This meeting is chaired by the Chief Executive Officer (CEO), and it has been checked by the CEO until recently. I am (head of engineering and innovation) chairing it. I think that is the steering point" I10*

"We use platforms like ~~teams~~ Teams (Microsoft 365). You can touch a lot of people from your desk easily. I think communication and sharing are much easier now than they used to be"
I10

Refer to the supplementary_material_appendix_2, 3 and 4 for the NVIVO codes of radical and incremental innovations~~,~~ and knowledge transfer mechanisms of the firm, respectively.

Discussion of Findings

Sources of Innovation, Strategies and Mechanisms

As the internal sources, the employees can directly participate in innovation implementation by submitting proposals, and the firm selects the best proposals. In addition, as the external sources, the firm collaborates with local and international universities to develop innovations. Construction firms having both internal and external innovation drivers/sources has already been discussed by prior studies such as Meng and Brown (2018).

The firm's innovation strategy is rather ad-hoc, yet focusing on the areas such as Digital, Virtual, Artificial Intelligence, Blockchain and Clean Energy. Contrary to Meng and Brown's (2018) innovation strategies-technology, resource, marketing and management, or to the product-process classification, the firm aims to implement 'digital innovation' whether ~~it could be~~ product, process, service or market innovation.

As the primary innovation mechanism, firm's innovation team has been identified. It facilitates innovation and prevents duplicating innovations by communicating different levels and business units. In addition, VDC and DT teams facilitate digital innovation and transformation of the firm. Provisions for innovation implementation are primarily from the central funding scheme of the case study firm. Being a large contracting firm with around US$2 billion annual turnover, the approximate allocation for innovation developments is around one percent of the annual turnover. The case study firm has adopted several methods to explore knowledge outside the firm, even outside the country or region. These are frequent site visits to foreign construction firms or factories, participating in international conferences or seminars, hiring foreign experts, collaborations with academic institutes, and collaborations with clients and other supply chain stakeholders (Reichstein *et al*., 2008). The decision to implement innovation is made at the tendering stage. In collaborative procurement approaches, bidders are usually allowed to submit alternative innovative solutions that are cost-effective and beneficial to both parties (Sidwell *et al*., 2001). In such situations, the case study firm submits an innovation proposal. However, the tender selection is heavily based on the price proposal; the innovation proposal only gets around ten to fifteen percent of the total bid (Loosemore and Richard, 2015). The case study firm frequently collaborates with local and international academic institutions and professional bodies to learn innovation d, develop~~evelop, and purchas~~e innovations.

Incidence of radical and incremental innovations and knowledge transfer

The firm engages in top-down (firm-level exploration-radical innovation and project-level exploitation-incremental innovation) and bottom-up (project-level exploration-radical innovation and firm-level incremental innovation) innovation strategies. This observation aligns with Winch's (1998) top-down and bottom-up innovation model and conforms to the proposed framework. As top-down radical innovations, the development of PPE with an AI system and the stress-level detector that predicts the stress level of workers have been identified in the case study firm. The case study firm's bottom-up strategy was also evident through innovations such as the clutch pipe pile system.

Innovation deployment of the case study firm is also a problem-solving approach (Slaughter, 1993). For example, issues such as a labour shortage and an ageing workforce have been addressed by the DfMA and MiC approaches which have been identified as radical innovations at the firm level. Another example of problem-solving that emerged as a project-level radical innovation is the clutch pile pipe system. The project team developed this innovation for a marine reclamation project. As per the HKSAR regulations regarding marine reclamation, a judicial review is required for any marine section construction~~to do any construction in the marine section~~. This innovation helped continue~~managed to continue~~ construction without a judicial review and saved extensive money, which was meant to happen through a traditional pipe excavation method.

When the firm level is concerned, a separate structural unit and systems (e.g., IT department) are allocated for exploration (radical innovation), and the structural ambidexterity format is observed (Benner and Tushman, 2003). However, temporal ambidexterity was not evident as the firm does not explore and exploit exploitation at separate times. Also, the existence of the innovation team indicates an integrated level (i.e., firm+project levels) of the firm. Among the three levels (i.e., firm, project, integrated), the integrated level of the case study firm produces the highest number of innovations (radical and incremental). At the project and integrated levels, contextual ambidexterity was observed (Gibson and Birkinshaw, 2004), as actors of each level can develop radical innovations and utilise former radical innovations with minor improvements (incremental innovation) when and where necessary. Accordingly, the conceptual framework suggested by the study has been validated and modified, where contextual ambidexterity is suggested for both project and integrated levels, and structural ambidexterity is recommended for the firm level. In contrast, temporal ambidexterity is removed from the modified framework due to the absence of empirical evidence from the case study. Figure 3 presents the modified framework.

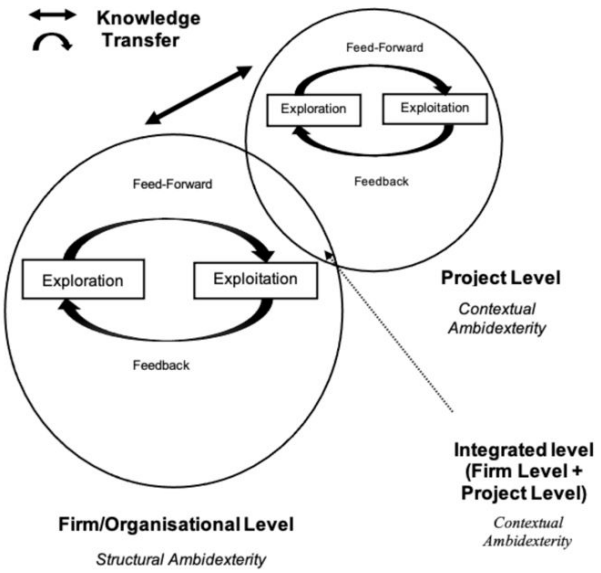

Figure 3: The modified framework after validation.

The findings also reveal that the case study firm is more exploitative than exploratory. Even though equal prioritisation is not explicit in the firm, the management has strived for an appropriate mix of exploration and exploitation (ambidexterity) (c.f. Lavie and Rosenkopf, 2006). As an innovation strategy, each project is usually evaluated initially, and the project

directors and managers determine the appropriate mix. Also, these project-level ambidexterity strategies complement the firm-level strategies through robust integrating mechanisms such as establishing the integrated level/innovation team and frequent communication among different levels (Du Plessis, 2007).

The case study firm successfully employs different platforms for communication between different levels. However, rather than mere communication, the firm 'shares' and 'utilises' knowledge (Du Plessis, 2007); the best example is the innovation team that discusses each innovation implemented and even attempted in different projects and departments (e.g., IT). Another vital aspect explicit in the firm is using~~the use of~~ technology for learning, knowledge transfer and innovation. These discussions prevent duplications and support further developments of existing innovations (Du Plessis, 2007; Ribeiro, 2009).

Conclusions

This study aimed at exploring innovation deployment of construction contracting firms through the lens of exploratory-exploitative learning and organisational ambidexterity. As the theories suggest, construction contracting firms that explore new knowledge to produce radical innovations and utilise and improve existing knowledge to develop incremental innovations (i.e., ambidextrous firms) are more innovative and successful. Based on this, a conceptual framework was developed, suggesting different ambidexterity forms for different levels. Unlike most conventional frameworks and mechanisms, the framework does not merely rely on tangible factors such as financial outcomes, R&D allocation and the number of patents for innovations. In contrast, innovation is measured by factors such as significance, newness, the severity of financial commitments, the level of uncertainty of outcomes, and the extent that the firm moves from existing strategies. If these are greater, it was identified as a radical innovation. On the contrary, small-scale innovations with less significant outcomes with less impact were conceptualised as incremental innovations. Rather than weighing only radical and breakthrough innovations, the proposed framework recognised hidden innovations (i.e., incremental innovations) missed by conventional frameworks.

A single case study was conducted to validate the conceptual framework. Hence, a large contracting firm in the Hong Kong construction industry, reputed for innovation implementation, was selected as the case. The ambidexterity (i.e., radical and incremental balance) at different firm levels was observed. In addition to the project and firm levels suggested in the conceptual framework, a new level called the 'integrated level' combined with the project and firm-level actors (i.e., innovation team) was observed. The case study firm maintains structural ambidexterity at the firm level by establishing the IT department for innovation implementation. The project and integrated levels are managed through contextual ambidexterity as the innovation team facilitates each innovation. Overall, the firm explores and exploits at the firm and project levels. Firm-level exploration (radical innovation) becomes project-level exploitation (incremental innovation) and vice versa. Hence, the firm is enriched with top-down and bottom-up innovation strategies.

The most~~Most~~ radical innovations are the digital procurement approach (i.e., IDPD), alternatives for traditional on-site construction methods (i.e., DfMA, MiC) and AI-based technological innovations (i.e., IoT safety helmet). In addition, incremental innovations have become a part of the firm's business strategy. Findings confirmed that the case study firm successfully maintains radical-incremental innovation-based ambidexterity at the firm, project and integrated levels, which drives the firm towards innovation while engaging in the day-to-day business activities. The modified framework does not indicate a universal cut-off level to measure contractors' innovation. Instead, it recommends maintaining an appropriate mix

(ambidexterity) between exploration (i.e., radical innovation) and exploitation (incremental innovation) to be innovative.

Research Implications

This research contributes to ~~the literature on~~ learning, construction innovation and project management literature. More importantly, findings contribute to the exploratory-exploitative learning and organisational ambidexterity theories in the context of construction contracting firms. As knowledge transfer within and across multi-levels in contracting firms has been examined, the findings of the study contribute to the knowledge transfer literature.

The explorative and exploitative concept is widely used to conceptualise these learning activities based on finding new knowledge and utilising and improving existing knowledge (March, 1990; He and Wong, 2004). This study, however, follows the outcome view, which has been rarely discussed and conceptualised other than a few exceptions (e.g., Lennerts *et al*., 2020). The present study contributes to bridging this theoretical gap by conceptualising and operationalising exploratory and exploitative learning by their outcome: radical and incremental innovation (c.f. Eriksson, 2013; Lennerts *et al*., 2020). Furthermore, findings contribute to the organisational ambidexterity theory by linking radical and incremental innovation balance. This study also provides empirical findings on construction contractors' practices to create and maintain structural ambidexterity (at the firm level) and contextual ambidexterity (at the project level).

Moreover, this study has considered the unique and complex nature of project-based settings (i.e., contractor firms as PBFs) to examine innovation deployment within and across multi-levels (i.e., project, firm and integrated levels). Thus, the findings contribute to the project management literature as well. This study indicates that construction innovation is client-driven as the client's prior approval is mandatory for the innovation implementation in the design and construction (c.f. Gambatese and Hallowell, 2011b). Nevertheless, the construction contractor has the capability of initiating innovation through the submission of innovation proposals at the tendering stage. Compared with prior innovation management strategies, the findings of this study also align with 'top-down' and 'bottom-up' approaches (Winch, 1998).

The findings of this study also align with the implications of previous empirical studies. For example, Eriksson's (2013) and Eriksson *et al*.'s (2017) ambidexterity and knowledge-sharing suggestions for construction PBFs are validated by this study. Even though the theoretical basis of this study was from March's (1991) seminal work on exploratory-exploitative learning, this study complements He and Wong's (2004) argument-organisational capability to explore and exploit simultaneously. Most importantly, findings of the studies carried out by Tushman and O'Reilly (1996), Gibson and Birkinshaw (2004) and Raisch *et al*. (2009) on organisational ambidexterity are complimented. In particular, the present study confirms the necessity of establishing structural ambidexterity for the organisational (i.e., firm) level and contextual ambidexterity for the project level. It extends the organisational ambidexterity theory to the context of construction contracting firms. However, this study does not support the existing notion of establishing temporal/sequential ambidexterity (c.f. Turner, 2014) at the firm level in the context of construction contracting firms.

Limitations and Future Research Directions

The conceptual framework was validated by a single case study, a large construction contracting firm in the Hong Kong construction industry. Even though the contractor selected for the case study is reputed for fostering innovation, the study results may not be generalisable due to context-specific information. However, the findings would still be reliable in similar research contexts. Although an in-depth and holistic examination of the selected firm's

innovation and learning process is accomplished using a single case study, a multiple-case study approach would have enabled a cross-case analysis and comparison in different contexts.

Data Availability Statement

All data generated or used during the study are available from the corresponding author by request.

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Dear reviewer and editors,

We would like to express our sincere gratitude to the editors and the reviewer for their insightful comments and suggestions, which have greatly helped to improve the quality of our manuscript. We have carefully considered all the comments and have made the necessary revisions to address each of the issues raised. We believe that these revisions have significantly strengthened the manuscript.

Please find the reviewer's comments and response for each comment as below.

Reviewers Comments to Author	**Authors Response to Reviewers Comments** (Please refer to the version without track changes/cleaned version to tally the page number)
1. Originality: Does the paper contain new and/or significant information adequate to justify publication?: Yes. The innovation management of construction firms is very crucial and significantly important. However, this paper still has some issues before its publication.	Thank you for the feedback. We addressed the mentioned issues/concerns to our fullest capacity.
2. Relationship to Seminal Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: Yes. This paper should consider how innovation management develops in construction management literature.	Thank you for the comments. Please see below for the responses of each comment. Regarding how innovation management develops in construction management literature, we included the section, "Innovation construction firms" on page 2. Yet, we understand that the development of innovation management in construction management should have been elaborated more. Hence, while keeping the manuscript under the word limit, a new section called "**Innovation Management Research in Construction"** is added prior to the aforementioned section. the new section, **"Innovation Management Research in Construction",** on (pp. 2-3).

What is construction innovation?	Construction innovation is explained under the newly added section, "Innovation Management Research in Construction", on pp. 2-3. The study follows the explanation provided by Slaughter (1993) that construction innovation is a phenomenon with an ability to improve and change significantly. Aligning with Slaughter's (1993) definition, we defined innovation in construction firms based on the innovation definition of Damanpour and Even (1984). Hence, innovation in construction firms is defined as "the implementation of a new or significantly improved product, process, system, strategy, policy, or service in a contractor firm that substantially changes the existing organisational procedures and delivers economic or social benefits to the firm (c.f., Damanpour and Evan, 1984)".
What are the differences in innovation management between construction firms and manufacturing firms?	We added a new section called "**Innovation Management Research in Construction"** to explain developments of innovation management in construction management research. In this section, we explained the differences in innovation management between the construction and manufacturing firms as well as industries, as below. "Compared with manufacturing firms, construction firms are stigmatised for lack of innovativeness. Innovation implementation of operations-based organisations, such as manufacturing firms, whose business model is producing the same output in volume is rather straightforward, compared to construction PBFs, whose business model is built with complex processes to deliver unique outputs (Greco *et al*., 2021)." **"**Hence, innovation management in the construction industry has substantial differences compared to industries such as manufacturing. For instance, the heterogeneous nature, immobility, and less predictability of demand make the innovation process in construction complex and non-linear

	(Reichstein *et al*., 2005). Similarly, researchers argue that discontinuous and project-based nature disrupts innovation diffusion and management in construction firms (Gann and Salter, 2000)".
So please show us the contribution and motivation of your study.	Thank you for the comment. Even though we didn't use the terms 'contribution' and 'motivation' as subheadings, we've mentioned the contribution of the study under 'research implications' and the motivation under 'introduction' with elaborations on research gap. To be more specific, we have emphasised the contribution and motivation of the study in several places of the manuscript. For instance, in the abstract the originality is explained below. "Previous construction innovation research has frequently explored firm or project-level innovation separately. This study identified a multi-level focus on innovation. By adopting the exploratory-exploitative theory, different forms of innovation ambidexterity for different levels are suggested rather than one specific ambidexterity". In the introduction, we have pointed out the research gap as follows. "Nevertheless, explanations of different innovation management approaches are yet to be explored in large construction contractors at different levels to analyse their contribution to innovation in the construction industry. To bridge this gap, this study explores the innovation deployment of construction contracting firms at multi-levels. Hence, the learning theory—explanatory learning and exploitative learning, and organisational ambidexterity are adopted as theoretical lenses". Hence, the motivation to conduct this research was to address this research gap of not having a multi-level study to explain innovation implementation and deployment at multi-levels in construction firms. How innovation diffusion is designed in a large construction firm is explained by developing a research framework using exploratory-

	exploitative theory. Also, structural and contextual ambidexterity forms are suggested for successful innovation management. These aspects have been discussed with prior literature findings under the 'Research implications' section on p. 14.
Second, make sure that you understand what exploration and exploitation are. In the literature on innovation management, these two are totally different constructs compared with incremental and radical innovation. In my opinion, you should not consider incremental and radical innovation in your paper.	Thank you for the comment. As we explained under the subheading, Phase ***1: Theory building section,*** the contemporary view which is the 'outcome view' of exploratory and exploitative learning has been considered to conceptualise innovation. It is true that in most research, including March's (1991) seminal work, exploration and exploitation are defined considering their 'process'. Yet, researchers have considered the 'outcome' of each learning type where exploration produces 'radical innovation' and exploitation delivers 'incremental innovation'. We explained this conceptualisation and cited research which had considered the same approach, as below. Please see, Theory building section, p. 4, para 2, lines 2-4. "As a contemporary approach, conceptualisations have been made considering these two learning modes as 'orthogonal' constructs based on the nature of their 'outcome' (e.g., Eriksson, 2013; Lennerts *et al*., 2020). The exploration-exploitation balance was further discussed as ambidexterity (which is very common in past literature). By linking the outcome view of these learning types, we conceptualised ambidexterity through a 'balance of radical and incremental innovations'. This was justified below. "In these studies, ambidexterity is conceptualised as the balance between exploration and exploitation, radical and incremental innovation

Third, some important references are missing. If you want to consider the differences in innovation between construction firms and others, please consider these papers. Jin, Z., Zeng, S., Chen, H., & Shi, J. J. (2022). A configurational approach to explaining the expansion of technological capability of megaproject participantsTechnological Forecasting and Social Change, 181, 121747 Lijauco, F., Gajendran, T., Brewer, G., & Rasoolimanesh, S. M. (2020). Culture's influence on the proclivity for innovation in small and medium-sized construction businesses, Journal of Construction Engineering and Management, 146(3), 04019116	interactions, width and depth, and adaptation and alignment (Katila and Ahuja, 2002; Lennerts *et al*., 2020; Gibson and Birkinshaw, 2004)". Thank you for the comment. These references are added to the manuscript to discuss the differences in innovation between construction firms and others. We added the following lines to the 2nd para of 'Innovation in construction firms' section. "While emphasising the requirement to innovate, Lijauco *et al.* (2020), pointed out the importance of cultural manifestations such as market orientation, business relationships, workforce capacity and leadership to enhance the innovation capability of construction SMEs. Jin *et al.* (2022) also highlighted the factors such as experience in mega projects, having a strong knowledge base and networking as a method of expanding technical innovation capability in construction".
3. Research Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed, robust, defendable and appropriate?: It is reasonable. However, the transparency of your case study method should be strengthened. First, you should explain why these cases are suitable. What's the role of your case in explaining the phenomenon?	Thank you for the comments. We added NVIVO codes as supplementary files (i.e., appendices) which are evidence of the transparency of the research. The suitability of the case study and the reliability of the research method has been explained under ***Phase 2: Empirical study and data collection,*** pp. 6-7. To emphasise the role of the case study firm, the following line is added at the end of above-mentioned paragraph below.

	"Since the case study firm is large and its multi-levels are clearly observable, it has been selected to examine innovation implementation and deployment within and across multi-levels".
Second, the data that you used in your paper should be compiled into a table that shows the numbers and roles of participants, the duration of interviews, and the second-hand data.	The numbers and roles of participants are shown in Table 1. Please see the following sentence under the subheading, case study firm, on p. 7. "A total of 12 interviews, lasting 1 hour each, were carried out in English medium. The following Table I presents the demographic information of the interviewees". Also, the analysis of qualitative findings (i.e., NVIVO codes) is attached as supplementary materials (i.e., appendices).
Third, how you construct the main logic of your paper should be more clear.	The main logic of the paper is explained under the section, '*Development of the Conceptual Framework' on* pp. 5-6. The 3rd para, is revised as below. "Knowledge transfer between project level-to-firm level, firm level-to-project level and within projects are included in the proposed conceptual framework (see Figure 2). When a single level is concerned, exploitation outcomes become inputs for exploration. When the firm is considered the unit of analysis, exploration at the project level becomes exploitative learning for the firm level and vice versa. Accordingly, the result (i.e., outcome) of exploration, which is radical innovation, occurs at the firm and project levels. At the same time, the result of exploitation (i.e., outcome), which is incremental innovation occurs at the firm and project levels too. Hence, both radical and incremental innovations can be observed at the same level. The radical innovation of one level can be an incremental innovation of the other level. The framework further suggests a balance between these two (i.e., ambidexterity) to firms to be successful. Robust communication strategies are suggested as knowledge-transferring mechanisms within the same level and across different levels".

4. Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together all elements of the paper?: Yes. But the contribution should be more clear. And it is better to use learning in your paper rather than incremental innovation or radical innovation. These two are different constructs.	Thank you for the comments. We have addressed the issue of contribution under the response to Q. 2. Please see above. Also, the conceptualisation of exploration and exploitation linking radical and incremental innovations using 'the outcome view' has been explained as the response to Q. 2. Please see above.
5. Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: The contributions should compared with construction innovation management literature.	Thank you for the comment. The findings and their implications have been compared with the innovation management literature. Please see the section, 'research implications', on p. 14, 2nd, para, last 5 lines, as below. "This study indicates that construction innovation is client-driven as the client's prior approval is mandatory for the innovation implementation in the design and construction (c.f. Gambatese and Hallowell, 2011b). Nevertheless, the construction contractor has the capability of initiating innovation through the submission of innovation proposals at the tendering stage". Further, we added the following sentence to indicate the innovation management of the case study firm. "Compared with prior innovation management

	strategies, the findings of this study also align with 'tow-down' and 'bottom-up' approaches (Winch, 1998)". Also, references to the innovation management literature were put in the 'discussion of findings' as below. "The firm engages in top-down (firm-level exploration-radical innovation and project-level exploitation-incremental innovation) and bottom-up (project-level exploration-radical innovation and firm-level incremental innovation) innovation strategies. This observation aligns with Winch's (1998) top-down and bottom-up innovation model and conforms to the proposed framework…." "When the firm level is concerned, a separate structural unit and systems (e.g., IT department) are allocated for exploration (radical innovation), and the structural ambidexterity format is observed (Benner and Tushman, 2003)…" We understand that adding more references to the prior innovation management findings would strengthen the manuscript. However, the word limit has been a constraint. We tried our best to tackle the word count and include references to each phenomenon (i.e., exploratory-exploitative learning, knowledge sharing, ambidexterity, construction innovation and project management) as much as we can.
6. Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc. Do the figures/tables aid the clarity of the paper?: Yes.	Thank you for the positive comment.