Leadership in Sustainable Infrastructure
*Leadership en Infrastructures Durables*

Vancouver, Canada
May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

# EXPLORING INNOVATION INFLUENCING FACTORS IN CONSTRUCTION PROJECTS

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**Abstract:** Innovation is essential to maintaining competitiveness, improving performance, increasing national economic growth, and contributing to a knowledge-based economy. Competitive success is dependent upon the innovation process and factors that relate to its successful management. Different factors, internal or external to the organization, can influence the innovation process. The construction industry is mainly project-based, and project level innovation plays a key role in enhancing the innovation performance of project-based companies. Therefore, further studies are needed to investigate project level innovation, considering that innovation is often hidden and co-developed by different participants. This research explores the factors that influence innovation in construction projects by holistically taking into consideration the multi-party environment. Semi-structured interviews were conducted with industry professionals and experts in construction project management. Data analysis identified 8 drivers, 5 inputs, 22 barriers, and 11 enablers towards innovation. Understanding these identified factors and their role in influencing innovation will allow industry professionals to be aware of how innovation can be enhanced in construction projects.

## 1 Introduction

Innovation plays an essential role in the construction industry, and more specifically, it promotes and sustains competitiveness within the industry, improves a firm's performance, increases national economic growth, and contributes to a knowledge-based economy (Akintoye et al. 2012; Aouad et al. 2010; OECD 2005; Panuwatwanich 2008). Firms have recognized that innovation is a vital source of competitive advantage for the construction industry. Different organizations (i.e., designers, consultants, suppliers, contractors, and manufacturers), in realizing that critical role, have invested substantial resources in an effort to obtain innovative products, solutions, and services (Dulaimi, Nepal, & Park, 2005; Panuwatwanich et al 2009).

Furthermore, innovation is essential for successful project delivery (Dulaimi et al. 2005). In addition to the three conventional objectives (time, cost, and quality) of any construction project, innovation is considered a fourth competitive dimension (Newton 1999; Panuwatwanich et al. 2009). Adapting or generating innovation can result in successful project performance that may meet or exceed cost, quality, schedule, and safety goals (Gambatese and Hallowell 2011a). Beyond these traditional measures of project level benefits, innovation may result in client and end-user satisfaction, improved quality of life, knowledge transfer which informs future decisions, and environmental sustainability (Ozorhon 2010).

Still, when compared with other industries, construction has been criticized for its conservatism and lack of innovation (Kissi et al. 2012; Ozorhon 2010) and is regarded as a traditional or low-technology sector with low levels of innovation investment activities (Reichstein et al. 2011). According to Bosch-Sijtsema and Postma (2009) the low level of innovation performance is attributed to the fragmented nature of the projects, the uniqueness of construction projects as a product, the division between design and construction phases, the roles of consultants, and procurement methods in delivering projects. Furthermore, the increased complexity in the construction environment challenges a firm's ability to sustain competitiveness and improve processes (Akintoye et al. 2012). Therefore, past researchers have recognized the need to enhance innovation and have studied it in various contexts and from different perspectives (Kissi 2012). Despite the different viewpoints on innovation, the construction industry is mostly project-based, whereby much innovation remains hidden and is co-developed at the project level (Aouad et al. 2010; NESTA 2007). Literature within this domain has been criticized for having a biased focus at the organizational level (Ozorhon et al. 2016; Ozorhon et al. 2014), being empirically disjointed and limited based on conceptual models and case studies (Najafian and Colabi 2014), and lacking a holistic approach that considers the multi-party environment (Xue et al. 2014).

Unlike previous research, this study plays a significant role in promoting construction innovation by further comprehensive work that puts together different theoretical perspectives on innovation. It also takes into consideration the multi-party environment at the individual project level, where most of the innovation is hidden and co-developed. The research will account for both the market-based and resource-based views, as well as stakeholders and their interrelationships in identifying the factors influencing the project level innovation.

This paper is organized into five parts. The following section describes the literature relevant to the research. Then, Section 3 describes the research method. Section 4 presents an analysis and discussion of the findings. Conclusions are presented in Section 5.

## 2 Background

### 2.1 Innovation in Construction

There is no single and complete definition of innovation and trying to create one is meaningless (Aouad et al. 2010). However, it is meaningful to adopt and understand what accounts for innovation within a specific context (Sexton and Lu 2012). The body of knowledge within this discourse covers a wide range of different definitions and classifications. Innovation is broadly defined, according to the OECD Oslo Manual (2005), as "...the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or new organizational method in business practices, workplace organization or external relations."

Innovation within the construction perspective, in general, is consistent with the general literature in terms of the different definitions with a common theme focussed on the development and implementation of a new idea in an applied setting (Sexton and Lu 2012). Slaughter (1998) defined innovation as "...the actual use of a non-trivial change and improvement in a process, product, or system that is novel to the institution developing the change."

Alternatively, Stewart and Fenn (2006) defined innovation as the profitable exploitation of new ideas in seeking a competitive advantage. A more common definition among scholars, however, has conveyed innovation in the construction industry as the successful development and/or implementation of new ideas, products, processes, or practices in order to increase an organization's efficiency and performance (Akintoye et al. 2012; Egbu et al. 1998; Ling 2003; Panuwatwanich et al. 2009; Sexton and Barrett 2005). Successful innovation is defined as "the effective generation and implementation of a new idea, which enhances overall organizational performance" (Sexton and Barrett 2003b).

Within construction literature, innovation in terms of the different multi-dimensionality (i.e., incremental vs. radical, technological vs. administrative, and product vs. process) has been divided into three domains: product, process, and organization (Stewart and Fenn 2006). However, there are various advocates who argue that innovation in the construction sector occurs and is co-developed at the project level and tends to be process and organization based (Aouad et al. 2010; NESTA 2007; Ozorhon 2010). Moreover, innovation in projects is due to the adoption of new practices as a result of improvements in technological and business processes, rather than the generation of new ideas through the scientific approach, since construction companies tend to invest less in R&D and rarely create new patents. In other words, innovation in construction is not synonymous with research and extends beyond that to be developmental, grounded around individual projects, and stimulated in reaction to particular challenges throughout collaborative problem-solving between businesses, suppliers, contractors, and clients and customers (NESTA 2007).

### 2.2 Factors Affecting and Influencing Innovation

Competitive success is dependent upon the innovation process and influencing factors that relate to its successful management. These influences are the key factors driving, enabling, or hindering business innovation. Factors are mainly classified as internal (endogenous) or external (exogenous) to the organization (Liu et al. 2012). Internal factors represent the variables within the boundaries of an organization and control, while external factors are the variables outside those boundaries (Hartmann 2006; Panuwatwanich 2008). This distinction between external and internal factors influencing firms' innovation stems from two arguments on what drives innovation: the market-based view and the resource-based view (Sexton and Barrett 2003a). Resource-based view supporters contend that organizations recognize and nurture resources that enable them to generate the needed innovation to shape market conditions; on the other hand, market-based view proponents argue that market conditions "shape" the resources that firms develop and exploit to respond to opportunities and threats (Sexton and Lu 2012).

In line with the resource-based view, many researchers have focused on internal factors rather than external factors, arguing that they are more important in influencing the decision of firms on whether or not to innovate (Kissi 2012; Kissi et al. 2012; Manley and Mcfallan 2006). Research has identified the key internal factors as leadership, innovation championing behavior, organizational climate, and organizational structure (Damanpour and Gopalakrishnan 1998; Dulaimi et al. 2005; Kissi 2012; Kissi et al. 2012; Kissi et al. 2013; Panuwatwanich, 2008). However, firms can rely not only on their capabilities to develop innovation at the project level, but also on the capabilities of other firms in situations where innovation can only be attained through collaboration among those involved stakeholders (Aouad et al. 2010; Blayse and Manley 2004). Every stakeholder within the value chain has a different influence and role in promoting and achieving innovation (Aouad et al. 2010).

In contrast to the resource-based view, several researchers have examined innovation from a market-based view. The main debate here is that organizations orient themselves through innovation to adequately adapt to continuous change in external market conditions, which creates the context or initial conditions that enable or hamper the direction and quantity of innovation (Sexton and Barrett 2003a). In a broad sense, market-based conditions embody the business environment and the interaction environment, whereas the general business environment encompasses the full range of social, legal, economic, political, and technological forces and configurations, while the interaction or construction-specific business environment includes industry structures, clients, suppliers, competitors, financiers, and regulators (Sexton and Lu 2012). In line with this, theorists have identified the key external factors influencing innovation to be regulations, clients, manufacturers, technology, and inter- organizational relationships (Blayse and Manley, 2004; Hartmann, 2006; Kissi et al. 2012; Panuwatwanich 2008).

Neither the independent market-based view nor the resource-based view can adequately explain the diversity of factors affecting the innovation process and output where innovation needs both (Barrett and Sexton 2006). According to Barrett and Sexton (2006), Sexton and Lu (2012), and Sexton and Barrett (2003a) what is required is a more holistic, dynamic approach that appropriately balances technology-push and market-pull, based on the specific conditions encountered.

## 3 Methodology

In this study, a grounded theory design was used. The design is a systematic qualitative procedure that generates a general explanation of a process, action, or interaction among people, which is grounded in the participants' views (Creswell, 2012). Semi-structured interviews were carried out using a list of open-ended guiding questions focused on identifying the key drivers, barriers, enablers, and inputs influencing innovation at the project level. The semi-structured interviews allowed the participants' point of view to be fully expressed by not only using questions suggested by the researcher, but also by asking questions that arose naturally during interviews and discussions to elaborate more on a particular point or answer (Zaidi 2011). This effort involved 37 knowledgeable participants within the Canadian construction industry. According to Creswell (2007), **20-30** interviews are enough to gather information that saturates the categories. The participants were recruited and chosen using snowball sampling (purposeful sampling) to select good key informants who contributed to the researchers' understanding of the given phenomenon. Interviews targeted project participants such as project managers, project team members, executive managers, consultants, contractors, engineering firms, owners, suppliers, construction industry professionals and experts in projects management, and key academic figures in the field (See Table 1 for demographic info). The interviews were conducted face to face; however, telephone calls were also used as per the participants' convenience and schedule.

Table 1: Demographic information for interviews

| Interviewee | Category | Frequency | Interviewee | Category | Frequency |
|---|---|---|---|---|---|
| Position | Assistant Professor | 2.22% | Experience | 6-9 years | 11.11% |
| | Automation Specialist | 2.22% | | 10-14 years | 13.89% |
| | Construction Engineer | 4.44% | | 15-19 years | 25.00% |
| | Construction Manager | 6.67% | | 20 & above | 50.00% |
| | Contact Admin. | 2.22% | Industry | Buildings | 24.07% |
| | Cost Engineer | 2.22% | | Industrial | 3.70% |
| | Design Lead | 6.67% | | Infrastructure | 35.19% |
| | Director | 11.11% | | Manufacturing | 1.85% |
| | Founder | 4.44% | | Mining | 1.85% |
| | General Manager | 2.22% | | Oil & Gas | 29.63% |
| | General Supt. | 2.22% | | Petrochemical | 1.85% |
| | Owner Rep. | 2.22% | | Residential | 1.85% |
| | Planning Specialist | 2.22% | Frim | Engineering/Architecture | 17.07% |
| | President | 4.44% | | Design-Build | 2.44% |
| | Principal | 4.44% | | Management Company | 2.44% |
| | Process Engineer | 2.22% | | EPC/EPFC/EPCM | 34.15% |
| | Construction Manager | 4.44% | | General Contactor/CM | 21.95% |
| | Project Engineer | 8.89% | | Owner | 14.64% |
| | Project Specialist | 2.22% | | Prefab Manufacturer | 2.44% |
| | Project Manager | 11.11% | | Project Consultant | 2.44% |
| | Regional Manager | 2.22% | | Sub-Contactor | 2.44% |
| | Vice President | 8.89% | | | |
| Qualification | Bachelor | 37.50% | | | |
| | Technologist | 5.00% | | | |
| | Diploma | 12.50% | | | |
| | M.B.A. | 7.50% | | | |
| | M.Sc. | 25.00% | | | |
| | Ph.D. | 12.50% | | | |

The qualitative analysis process was undertaken in several stages consisting of organizing, categorizing, synthesizing, analyzing, writing about the data in a continual effort, and cycling through stages more than once to narrow down and understand the data (Gay et al. 2012). More specifically, the investigation started with transcribing text from audiotaped interviews into word processing files for further analysis. After the first step of the analysis, reading the transcripts and writing memos about all notes and transcripts were done to get an initial sense of the data (Creswell and Clark 2011). Writing memos in the margins of transcripts in the form of short phrases, ideas, or concepts helped in the initial exploration of the data. The next step was coding the data by dividing the text into small units such as phrases, sentences, or paragraphs and assigning a label to each unit. Labels came from the exact words of the participants or phrases or concepts combined by the researcher. The codes were examined for overlap and redundancy and then grouped into broad themes and categories.

Based on the codes that emerged, a content analysis was used to calculate the frequency of each coded driver, barrier, enabler, and input. The content analysis allowed words to be condensed into fewer content-related categories. Data were analyzed using Microsoft Excel.

## 4 Findings and Discussion

This section discusses and emphasizes themes that emerged during the analysis of 37 interviews. The interview findings centered on four areas based on the questions asked: drivers; inputs; barriers; and innovation enablers. The findings of this study are indented to describe the factors influencing innovation at project level context in depth and holistically, not to generalize to a context or population. One of the fundamental principles of qualitative research is that each research setting is unique in its mix of people and contextual factors (Gay et al. 2012). Accordingly, grounded theory does not seek to be generalizable and the degree to which it is transferable is obtained through the participant “views” and the thick descriptions reflected (Creswell, 2012).

### 4.1 Innovation Drivers

Drivers are the main reasons or motives for the project participants to invest in innovation. Within this theme, 8 drivers (Figure 1) were identified. Project performance improvement was the most cited (53 occurrences) driver by interviewees through directly saying “to improve project performance” or indirectly implied through mentions of cost and time saving, improving quality and safety, increasing productivity and efficiency, client satisfaction, and value for clients. The second revealed driver (17 occurrences) was environmental and sustainability improvement in terms of the use of sustainable and recyclable materials, reducing energy consumption, waste reduction, and gas emission minimization. Moreover, competiveness level was mentioned a significant number of times (14 occurrences) through comments such as “to stay competitive in market”, “to differentiate our self from competitors”, “to maximize existing assets” and “first mover advantage.” Market/client demand was regarded extensively (12 occurrences) as a motive for innovation in construction projects such as asking for specific innovative requirements. Process improvement was also considered (6 occurrences) by some interviewees as a driver for innovation to simplify and make the process more efficient. Public impact/end users were also deemed to be drivers for innovation to provide ease of traffic and higher degrees of safety and protection for the end-users. Regulations, and corporate social responsibility (CSR) were cited the least among previous drivers.

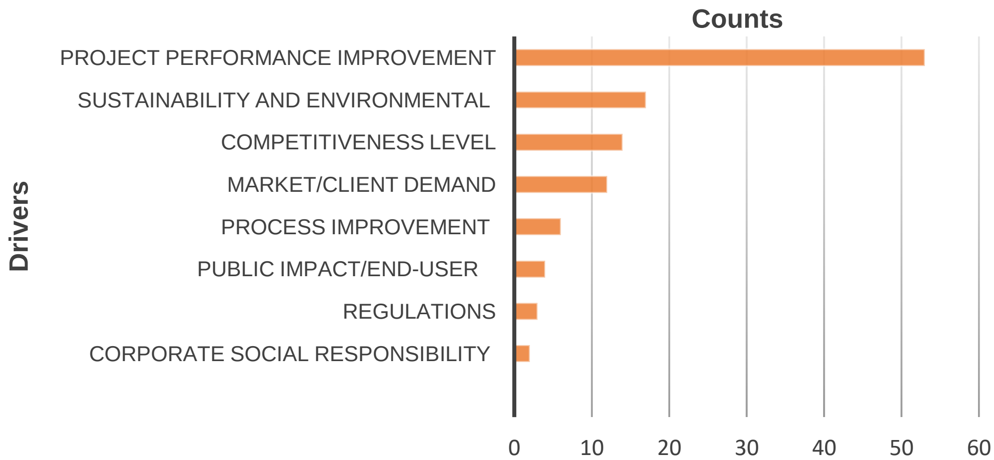


Figure 1: Frequency of innovation drivers

### 4.2 Innovation Inputs

Inputs are the required resources to implement innovation in construction projects, whether human, financial, or organizational. Within this part, five main inputs were categorized and tallied (Figure 2). The inputs for innovation in their descending order encompassed human capital (24 occurrences) representing the involvement of highly skilled, motivated and experienced staff; structure capital (22 occurrences) representing formalized structures, procedures, systems, processes, and tools or equipment to develop and implement innovation activity; external knowledge sources (15 occurrences) such as consultants, suppliers, clients, and other enterprises and institutions like universities and government research institutions; R&D investment (11 occurrences) representing R&D expenditures and R&D personnel (i.e., R&D unit/team); and capital investment (11 occurrences) representing fiscal expenditures on purchasing new machinery or equipment and materials devoted to innovation activities.

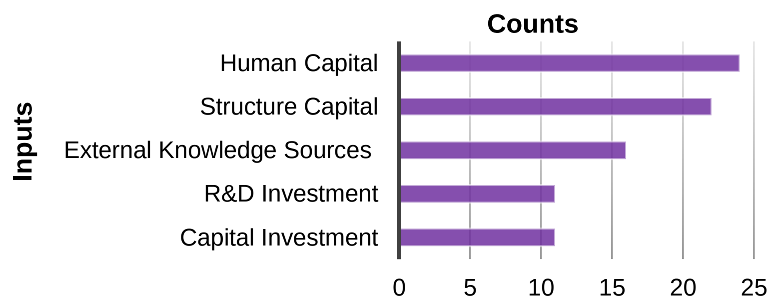


Figure 2: Frequency of innovation inputs

### 4.3 Innovation Barriers

Barriers are the challenges and problems encountered when implementing or investing in innovation on construction projects. Based on the content analysis, 22 barriers were identified (Figure 3), coded, and quantified by frequency of occurrence. Three domains—organizational (n = 9 barriers), project specific (n = 10 barriers), and resource constraints (n = 3) emerged from the 22 barriers.

Of the organizational barriers, risk aversion culture due to uncertainties associated with investment in innovation was the most prevalent cited barrier (19 occurrences) to innovating. A typical example of risk aversion derived from interviews was “nobody is prepared to take the risk of innovation if innovation fails”. In addition to risk aversion, resistance to change (6 occurrences), lack of supportive organizational culture (3 occurrences), and misalignment with organizational values (2 occurrences) were identified as barriers to innovative organizational culture. Other organizational barriers discussed throughout interviews were a lack of knowledge (6 occurrences), a lack of experienced and qualified staff (6 occurrences) with emphasis on qualified construction managers, bureaucracy (2 occurrences) such as “rigid processes and practices”, a lack of collaboration (1 occurrence), and a lack of leadership (1 occurrence).

The project domain of construction entailed specific barriers such as a lack of effective communication and coordination (7 occurrences), the fragmented and one-off nature of projects (4 occurrences), unproven benefits (4 occurrences), buy-in by project stakeholders (4 occurrences), a lack of proper logistics management (2 occurrences), inadequate risk allocation and project strategy (2 occurrences), and short-termism (1 occurrence). In addition, participants discussed other barriers related to the project environment such as strict regulations (2 occurrences), environmental conditions and restrictions (2 occurrences), and public opposition (1 occurrence).

In terms of the resource constraint barriers, budget constraints due to limited financial resources and high initial cost was obvious (10 occurrences). Participants also considered time constraints (7 occurrences) and lack of R&D investment (2 occurrences) as barriers.

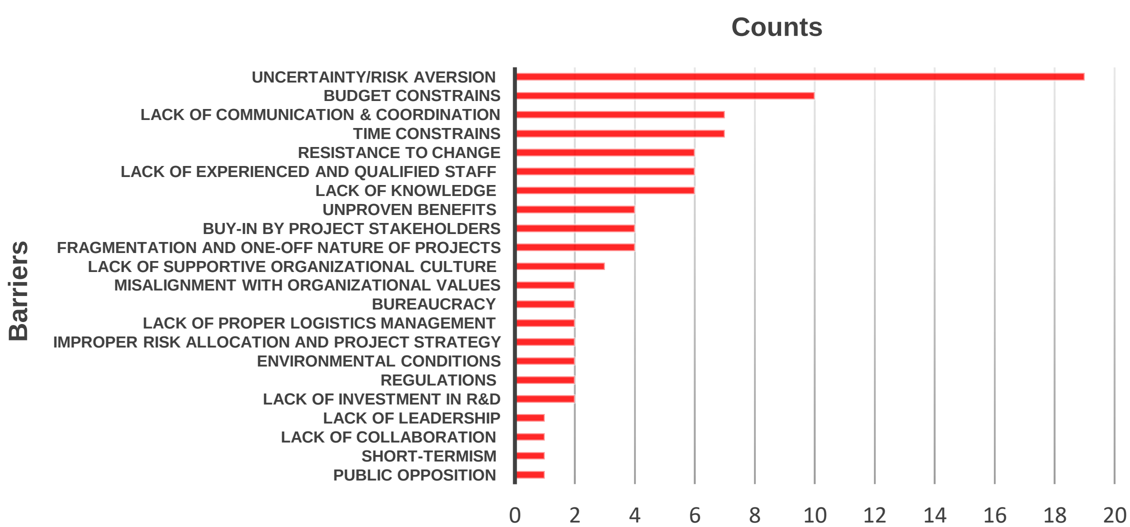


Figure 3: Frequency of innovation barriers

### 4.4 Innovation Enablers

Enablers are the factors that facilitate the introduction or development, implementation, and diffusion of innovation in construction projects. The analysis of the interview transcripts resulted in the identification of 11 innovation enablers, which were coded and quantified (Figure 4). They are clustered around organizational (n = 4 enablers), project (n = 5 enablers), and inter-organizational (n = 1 enabler) enablers.

Among organizational enablers, the organizational culture (48 occurrences) was the leading cited enabler. This included direct citation by participants as “organizational culture” or secondary implications such as “trust and openness”, “openly sharing information”, “no blame culture”, “freedom to try new things and make mistakes”, “availability of adequate resources”, “encouraging risk taking”, “rewarding system in place”, “values and polices,” etc. Knowledge management (KM) (38 occurrences) was the second most frequently revealed enabler. KM included the employment of techniques (i.e., workshops, training, coaching, brainstorming, mentorship, and communities of practice) and the use of IT-based KM technologies (i.e., intranet, groupware, internal portals). Leadership (37 occurrences) also possessed high attention during discussions. Examples of leadership as enablers were the senior executives' role and involvement in supporting innovation, change oriented people at all levels, and innovation champions. Many participants mentioned the importance of team climate (12 occurrences) as an enabler for innovation. Organizational climate (4 occurrences) was also considered as enabler. However, it is important to note here that organizational climate is an overarching theme for organizational climate, leadership, and team climate, following the lead of Panuwatwanich et al. (2008).

The clustered enablers around the project were: 1) project delivery system (16 occurrences) in terms of overlapping strategies and early involvement of contractors, the selection of technically qualified contractors, and forms of payments; 2) the utilization of advanced and best practices (11 occurrences) such as value engineering, lifecycle analysis, and team building; 3) modern methods of construction (5 occurrences) like modularization and offsite construction; 4) the employment of advanced technologies (8 occurrence) including visualization such as building information modeling (BIM) and computer aided design (CAD), the use of drones for site monitoring and control, geographic information system (GIS) guided laser machines; and 5) project coordination and communication (5 occurrences) regarding how open and effective the communication shall be. In terms of inter-organizational enablers, collaboration (4 occurrences) was cited and implied as partnering and strategic alliances between two or more of the project parties towards a strategic goal.

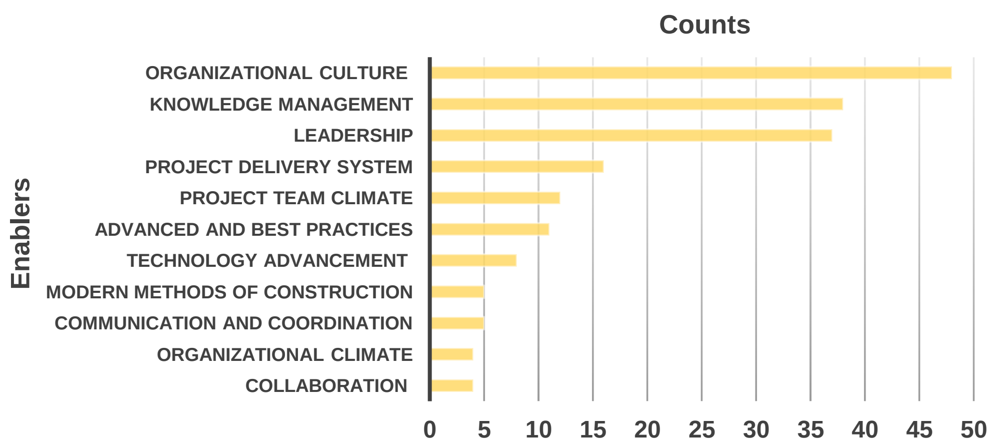


Figure 4: Frequency of innovation enablers

## 5 Conclusions

This paper explored the factors influencing innovation at the construction project level. It took into consideration the diversity of internal and external factors influencing the innovation process and the multi-party nature of projects. Based on the qualitative content analysis of 37 semi-structured interviews, 8 innovation drivers, 22 innovation barriers, 11 innovation enablers, and 5 innovation inputs were identified, coded, and quantified by frequency of occurrence.

The overall conclusion is that innovation does not happen by chance or coincidence, rather there are motives behind investment in innovation on construction projects. Whether the motive is to improve performance or competiveness, or respond to client demand, that is still only the seed. This seed needs to be nurtured with the adequate resources, such as human capital, structure capital, financial investment, R&D investment, or networks of information and co-operation. Furthermore, innovation needs to overcome barriers and be enabled to flourish. For example, risk aversion was revealed as the most prevalent barrier in this study; on the other hand, organizational culture was cited as the most prevalent enabler. Having a culture that supports innovation and is built on trust, teamwork, risk taking, openness, and effective communication could overcome such barriers, resulting in a culture that is not risk averse, and where innovation is celebrated and rewarded. Leadership, support, and involvement, especially from senior management, play critical roles in enabling innovation and creating an innovative climate around projects. Moreover, project collaborative procurement strategies that employ the early involvement of contractors, long-term contracts, fair profit margins for all, and partnering and alliance are efficient methods of enabling innovation and overcoming barriers such as the lack of teamwork, collaboration, and trust. The list of how innovation can be enabled and barriers overcome is extensive. Therefore, the point here is to deliver a message to managers and professionals who are involved with projects that the drivers and recourses may vary from one project to another. What does matter is how to configure the adequate resources and capitalize on them. Also, it is their call to determine what the applicable enablers are in order to overcome innovation barriers that may be encountered.

Additional research into the influencing factors at the project level should be approached more holistically, and consider that projects are not an island by themselves involving different stakeholders. Further studies are needed to continue to quantitatively evaluate the extent of those factors and the magnitude of their impacts within the project context.

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