Introduction

In the publication *Growth Platforms for a Competitive Australia*, McKinsey & Co. (1995) compared Australia’s relative economic prosperity with those of leading countries such as the United States. The report highlighted that Australia’s GDP per capita is 30 percent behind the best performing country, the United States. Most of this gap is due to lower labour productivity. The report was based on research which measured differences in labour productivity and employment in five industries – food processing, construction, retailing, retail banking and aviation – and identified reasons for the differences between the Australian industries’ performance and their international counterparts.

In four of the five industries investigated, Australia’s labour productivity is significantly below that of the United States. In food processing, Australian productivity is 68 percent of the US level; in general merchandise retailing, it is 81 percent; in retail banking, it is 60 percent; and in aviation, it is 84 percent. In contrast, in the remaining industry, construction, Australia is near best practice, achieving 95 percent of the US productivity (Figure 1). This figure is comparable with France and Germany, and is more than 25 percent ahead of Sweden and Japan (Figure 2).

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1 This report is a summary of the PhD thesis by Dedi Budiawan “Determinants of Process Innovation on Construction Projects from Contractors’ Perspective” Queensland University of Technology 2003
McKinsey identified the reason for the Australian construction industry being near best practice is that it has been quick to adopt many innovative production processes. This phenomenon has been encouraged by low barriers to entry in the construction industry, which results in a highly competitive industry with a large number of players. Another reason for the industry’s relatively high labour productivity is the dramatic improvement in industrial relations since the late 1980s. For example, the number of days lost to industrial action (by 1995) had fallen by more than 90 percent since 1989.
The adoption of many innovative production processes in the Australian construction industry implies that the industry is not, despite being often criticised, technologically stagnant. This is comparable to the condition in the US construction industry, where innovation and its adoption comes about consistently throughout the sectors of the industry. Innovations appear to be ubiquitous in design and construction, appearing in virtually all of the construction activities and stages, from early design through to the selection of materials, methods and equipment. Innovation may appear subtle, and if the job is done well, perhaps even unnoticed.

There are several features of the construction industry as advantages for innovation, which may be attributed to the innovation rate being as high as that in other industries. Each construction project is unique, presenting high levels of necessity and challenges for results, which fosters innovative approaches or methods to come about. Integration of engineering, design and construction, when made possible by project organisation, can simplify the construction process and decrease cost. The low capital investment typical of construction firms allows high flexibility for the adoption of new technologies. The technologically capable and experienced personnel that most construction companies have can provide a depth of knowledge related to the subtle methods required for productive field operations. The strong emphasis on process limits barriers to imitation, because new processes can spread rapidly without patent restraints (but this may also discourage innovation). Finally, construction production processes do not create rigid restraints; the unique elements of each construction project require the use of differing methods for many operations.

With respect to conditions in construction markets, there are increasing demands for innovation on engineering and construction projects. Construction facilities are increasingly becoming more complex, demanding increased innovative methods and greater technological advancement to build them. Owners are heavily focusing on quality or value for money to get the most out of their investments in constructed facilities. In other words, they need “more construction for the money”. Contractors must build these facilities at the lowest possible capital cost to remain competitive. They must place more emphasis on technological advancement in developing advanced technology in response to the challenges of those specific projects and in using advanced technology effectively as a basis for competition such as bidding.
In addition to improved productivity and increased competitiveness, innovative products or processes can be attributed to market growth. Mechanisation of many construction tasks, for example, has reduced the cost of construction through decreasing labour hours required. Moreover, construction innovation can also result in social benefits. When the cost of construction is less costly, the constructed facilities themselves become more affordable and in turn, more accessible to a greater proportion of the population.

In view of the increasing demands for and all the benefits of construction innovation, it is clearly a vital ingredient for the industry. The strong performance of Australia’s construction industry resulting from its quickness in adopting many innovative production processes should be no cause for complacency. The industry must maintain or increase the rate at which it develops and transfers new techniques and innovations to further improve productivity and stimulate growth.

**Innovation defined**

Innovation is often used loosely and interchangeably with terms such as creativity, invention and change. In contrast to an invention, an innovation does not require a detailed design or physical manifestation, and it does not have to be novel with respect to the existing arts, but only to the creating institution. Innovation can be defined as any idea, technique and/or process, old or new, that is uniquely applied to any aspect of the production of goods and services, such that it either directly or indirectly generates measurable benefits in the form of system or process efficiency, product quality or product type. Three concepts of innovation are product vs. process; radical vs. incremental; and technical vs. administrative.

Product innovation may be the development of a new product or modifications to an existing product through introduction of new features to enhance its value. Process innovation may be the application of a new element into an organisation’s production or service operations – input materials, task specifications, work and information flow mechanisms, and equipment used to produce a product or render a service. Another distinction between process and product innovation is that process innovation enables a greater output per unit of input while product innovation results in a qualitatively superior product. In construction, product
innovation includes design innovation, while process innovation is an improvement in construction methods designed to accomplish usual construction operations or to improve the efficiency of a standard operation.

Another distinguishing characteristic is the degree of change that the adoption of innovation can make to the structure and functioning of an organisation, which is not the same for all innovations. Radical innovative change is indicated by clear departure from existing practices as they produce fundamental changes in the activities of an organisation or an industry. In contrast, incremental innovations only require minor departure from existing practices; they primarily strengthen the existing capabilities of organisations.

Another distinction of innovations, from an organisational focus, is between technical and administrative innovations. Technical innovations bring change to the organisation by introducing changes in the technological core. They are concerned with products, services, and production process technology; they are related to basic work activities and can be associated with either product or process. Administrative innovations, on the other hand, are changes that occur to an organisation’s structure or its administrative processes. These administrative innovations are directly related to the management of the organisation and indirectly to the basic work activity of the organisation.

Adoption of innovation consists of two main stages: initiation and implementation. Innovations belong to the implementation stage when they are adopted and are in use by organisational members or clients; they belong to the initiation stage when they have been proposed but are not actually in use. The initiation stage is characterised by three sub-stages: awareness of an innovation; formation of an attitude towards it; and its evaluation from an organisational standpoint. The decision to adopt the innovation marks the beginning of the implementation stage, which includes two substages: trial implementation and sustained implementation. Although this operational definition does not fully reflect the complexity of the processes of the initiation and implementation of innovation, it appropriately distinguishes between the two stages in multiple-innovation studies. The success of the adoption process is determined by the extent of integration of the innovation into the organisation and its contribution to organisational conduct and outcome.
Procurement induced Innovation

The investigation by McKinsey identified the price competitive nature of the construction industry a factor in its high level of productivity. One way of pursuing innovation in the procurement process of construction projects is for the owner to encourage contractors at the tendering stage through alternative tenders to propose more efficient and cost effective methods of construction. However, recent international case law, which suggests the emergence of the so-called “tendering contract” or “process contract”, has raised doubts about the ability of owners to seek alternative bids without placing themselves at risk of compensation to those who only submit the conforming tenders. On the other hand, owners are also increasingly using a variety of alternative procurement methods aimed at reducing cost, achieving time schedules and milestones, shortening duration, reducing claims or disputation, and promoting innovation by contractors as part of the team to develop innovative solutions. The implication of this trend for innovation is the procurement process environment that is conducive to innovation.

Innovation through Tendering Process – Further Exploration

Recent case law decisions\(^2\) have established the owner’s duty of fairness to all bidders. This international case law has changed the traditional position, raising doubts about the ability of owners to seek alternative tenders without placing themselves at risk of litigation. It has indicated that a “tendering contract” or “process contract” may arise between the tenderer and the owner upon the submission of a conforming tender. Under the “tendering contract”, owners have a contractual duty to treat all tenderers equally and fairly in the selection process. This duty is usually breached when owners accept an alternative tender, which does not conform to the tender conditions. Bids that do not comply with the tender call must therefore be rejected. The principle behind the so called “tendering contract” lies in the fact that if the owner accepts an alternative tender which is not clearly defined in the tender documents, then it would be unfair to tenderers who only submit conforming tenders all in accordance with the tender requirements. Therefore, any departure from the conditions of the tender by the owner risks allegations of unfairness to the tenderer(s).

To mitigate the risks of breaching the contractual obligations arising out of the tendering contract, tender conditions must define the scope of alternative tenders as such so that the departure does not result in a proposal for a scheme quite different to the one originally tendered for. This issue implies that the scope for innovation in the tendering process is very limited. As a matter of fact, the process of finding novel ways through an alternative tender is always confined by the boundary of the owner’s design. The traditional tendering process was not intended to encourage innovation by tenderers, in fact the very opposite was intended.

The issues on innovation in the tendering process were further explored in this research through interviews with a number of industry practitioners. They are summarised as follows:

- It was evident that a problem often encountered by the client when awarding a contract on the basis of an alternative tender is the complaints by other tenderers that the alternative tender lies outside the scope of what the conforming tender asks for. This highlights the issue against the principle that client must treat all tenderers fairly and equally in the selection process, that is to evaluate all tenders on an equal basis against pre-nominated criteria.

- Consensus was apparent that the scope for innovation in the traditional tendering process is very limited because contractors’ creativity is always confined by the boundary of the owner’s design. In fact, clients using the traditional method indicate that they are not interested in innovation as the extent of contractor-led innovation through this method is primarily concerned with alternative materials.

- It was pointed out by respondents that the fact that when the lowest tenderer wins the job, the successful tenderer may use inferior quality of materials to reduce the production cost to maximise their profit as much as possible, hence resulting in a lesser quality product.

- It was also stressed by respondents that the time that contractors have for pricing the job before they submit the tender is too short for them to come up with “real” innovative ideas and by the time they reach the construction stage, it is too late for innovation; all they have to do is just finish the project according to all the documentation and specifications. As a matter of fact, “real” innovative ideas require a lot of hard work and perseverance to develop.

- It was also strongly emphasised that the issue often quoted by contractors is the risk that innovative ideas may be hawked around by clients to other bidders to secure better prices.
• Consensus was also apparent that the ability of contractors to propose innovation diminishes if they are excluded from the early project stage. It also suggested that a greater opportunity for innovation would be achieved if the contractor works together in a collaborative project team.

Too often the adage applies:

“a bid is a wild guess calculated to two decimal places, and the low bidder is a contractor who is wondering what he left out”

The above issues have indicated that the traditional tendering process has some inherent shortcomings, making it less favourable with respect to encouraging innovation. It was perceived that rather than driving innovation through the traditional tendering process, creating a procurement process environment that is conducive to innovation is more favourable as it does not restrict the extent to which owners can exploit the contractors’ innovative ideas. This established the point of departure for further investigation in the area of innovation process in the context of project organisation. It involved the examination of those determining factors in breadth and the relationship between those factors and the innovativeness of the project.

Innovation in the Context of Project Organisation – the Background

As described previously, innovation is defined as the actual use of nontrivial change and improvement in a process, product, or system that is novel to the organisation developing the change. Past research has argued that distinguishing types of innovation is required for understanding an organisation’s adoption behaviour and identifying the determinants of innovation in them. Innovations have usually been categorised into sets of contrasting types, such as product vs. process.

The interviews conducted in this research confirmed that innovation from the construction team is primarily associated with constructability or construction methodologies. Hence, the focus of this primary research is in line with that brought up in the traditional tendering process which is associated with more efficient and cost effective methods of construction.
The background literature indicated that the adoption of innovation is viewed as a process that includes activities that lead to a decision to adopt as well as activities that facilitate putting an innovation into use and continuing to use it. The adoption process consists of two stages: initiation and implementation. The initiation stage is characterised by all activities related to a problem perception, information gathering, attitude formation and evaluation, and resource attainment leading to the decision to adopt. The implementation stage consists of all events, actions, and decisions involved in putting an innovation into use. There are five major activities based on case studies of innovation on construction projects which can be seen to encompass the initiation and implementation stages. The five major activities are:

- recognising forces to innovate,
- planning to identify options for methods,
- selecting and defining construction methods,
- implementing and developing the innovation, and
- transferring the innovation to future projects.

However, the nature of the process goes beyond these seemingly discrete and systematic phases. Activities are repeated and information flows in all directions to get the job done. Even on a project, with its comparative agreement and focus on objectives, the process of innovation will be confusing, highly iterative, and involve extensive feedback. As described in investigations of innovation in other industries, the process is iterative, messy, unpredictable, opportunistic, tumultuous, and interactive.

Previous research has provided useful insights into the factors in the process of innovation on construction projects. A number of variables derived from these factors as well as the interviews with the construction industry practitioners were all taken into account in the preliminary data analysis involving t tests. As a result, significant variables as shown in Figure 3 were identified.

However, previous studies have not taken the innovativeness of the respective projects into consideration. By implication, all the innovations occurred were of the same degree (level). We wanted to understand and assess how much more innovative of idea might be from another. To serve this objective, measure of innovativeness must incorporate time dimension. This is because timing of innovation is generally reflective of an organisation’s quickness in generating or adopting an innovation relative to its competitors within the industry. When
innovation is considered as a means towards organisational effectiveness and competitiveness, differences in the timing of generation or adoption could have a marked influence of the success of innovation and its impact on organisational effectiveness. Accordingly, the measure of radicalness was chosen as it incorporates time dimension.

By definition, radical innovation is risky. With radical innovation, the organisation is venturing into uncertain areas where knowledge is underdeveloped or lacking and the undertaking is costly. Under these conditions, it is not surprising that a more radical innovation project is more likely to fail than an incremental project. In addition, previous studies have also argued that radical innovation is characterised by its impact on the organisation, e.g. demanding greater change in the organisation’s existing practices.

This research indicated that the concept of radicalness can be operationalised by four aspects, namely:

- Degree to which the innovation broke new ground in the construction industry
- Progress in knowledge area of the specified innovation within the general construction community
- Knowledge/skill required to implement satisfactorily the specified innovation
- Degree of difficulty of integrating the specified innovation into existing practices.

Two ancillary propositions were also incorporated in this research study, namely the relationship between the radicalness of the process innovation adopted and the relative advantages associated with it; and the complexity of the project in which it occurs respectively. Relative advantage of innovation indicates the extent to which an innovation is perceived as being better than the one which it supersedes. Relative advantage of a technological process innovation refers to its ability to:

- Foster superior quality of the constructed facility;
- Enhance productivity of the construction process;
- Improve performance efficiency in the construction process;
- Reduce costs/labour;
- Ensure greater reliability and consistency in performance of the construction process; and
- Result in indirect/intangible benefits (e.g. higher market share, improved company’s image, etc.).
The types of project complexity identified as prompting innovations in this research study include those associated with inherent site conditions, large size structures combined with many unique and severe design criteria (design constructability), and congested conditions making access to or within site extremely complex, design coordination and quality management.
CONTRACTOR'S CHARACTERISTICS
- Commitment of personnel resources
- Willingness to be innovative
- Preparedness and capacity to absorb risk
- Trustworthiness
- Non-adversarial approach
- Degree of specialisation
- Diversity of technical capability
- Past-project-related experience
- Capability of personnel

QUALITY OF DOCUMENTATION
- Clarity and conciseness of project brief
- Appropriateness of contract conditions
- Clarity of specifications

CONTRACT STRATEGY
- Use of performance-based specifications
- Involvement of the construction team in the design development phase

CLIENT'S CHARACTERISTICS
- Involvement in the project
- Willingness to accept effective and positive ideas

PROJECT PERFORMANCE/TEAM CHARACTERISTICS
- Project team cohesiveness
- Customer focus of the design team
- Customer focus of the construction team
- Commitment of the design team towards project goals & objectives
- Commitment of the construction team towards project goals & objectives
- Level of trust among team members
- Working relationship between the construction team and the client
- Working relationship between the construction team and the design team

PROJECT TEAM MANAGEMENT
- Leadership of the construction team leader
- Leadership of the design team leader
- Integration & coordination:
  - Teamwork involving the design team and the construction team
  - Clarity of roles of team members
  - Interaction & open communication between the construction team and the design team
  - Interaction & open communication between the construction team and the client
  - Alignment of parties to project's goals

CONSTRUCTION MANAGEMENT ACTIONS
- Planning construction methods and equipments
- Analysing construction methods
- Analysing resource movement to and within site
- Analysing work sequencing to achieve and maintain work flow
- Monitoring and updating plans to appropriately reflect work status
- Responding to recover from problems or taking advantage of opportunities presented
- Coordinating resources
- Developing an appropriate organisational structure to maintain work flow

PROCESS INNOVATION ON CONSTRUCTION PROJECT

Figure 3 Variables Influencing Process Innovation
The research results

The purpose of the research was to identify the key factors driving innovation in the construction delivery process by answering the primary research question: “Providing that the contractor is given the freedom and scope to innovate, what are the determinants conducive to process innovation in the process of procuring construction projects?” Background research of the literature and that of the CIIA industry-led task force using semi-structured interviews identified a large number of potential variables. Three sets of industry questionnaires were disseminated, soliciting 173 responses overall with a response rate over 30%. The questionnaires were sent predominantly to contractors. The first analysis was performed to filter those potential variables so as to identify relatively more significant variables. The result was illustrated in Figure 3. These variables were used in the subsequent questionnaire and a range of statistical techniques were employed to analyse the data, including t tests, factor analysis and linear regression. These analyses resulted in 11 project-context determinants of process innovation on construction projects and their correlations with innovation radicalness (Figure 4).

Legend:

- First order of significance
- Second order of significance
- Third (& fourth) order of significance

SC: Significant correlation exists with innovation radicalness
PC: Partial correlation exists with innovation radicalness
NC: No correlation with innovation radicalness

Figure 4 Project-Context Determinants of Process Innovation
The first order of significance group suggests that contractors view process innovation in mechanistic terms of planning and analysis of construction operations. The success of the innovation process is enhanced by allowing the construction team to be involved early enough in the design phase, resulting in a high level of design and construction integration. In addition, the leadership role of the construction team leader as a champion must not be neglected in making the innovation happen. Equally important is the construction team climate for innovation (commitment and willingness to be innovative) that supports the process of innovation. All these elements constitute the most significant determinants of process innovation on construction projects. In brief, these are essentially about the effectiveness of the construction management team given the opportunity to be involved in the design.

The next order of significant aspects of the innovation process on construction projects are effective collaboration with project participants, particularly with the design team, which we have called project chemistry. This is possible through the early construction involvement in design. To be able to identify, select, define and implement an innovative construction method, resources need to be properly managed. Equally important is the capacity of the construction team to absorb risk so as to offset the natural tendencies to emphasise risk. These three aspects constitute the second most significant determinants of process innovation on construction projects. However, most distinctive of all in this second-order group is project chemistry, which encapsulates almost all variables concerning the project team.

In the third (and the fourth) order of significance group, information flow management is important because process innovation is complex and iterative in nature; the flows of information must be properly managed so as to enable the project team to communicate and interact effectively. The contractor’s capability and credibility is needed to observe and solve challenging problems as well as to enable the contractor to work effectively as part of the team. Client-contractor relationship and client’s participation establish a supportive environment for innovation, which is important to allow project team members to collaborate effectively; perhaps it is the most distinctive of all in this group.

It would appear that contractors view that their capability and credibility is important but ranks relatively lower than those in the first- and the second-order groups. This is likely to be
due to the fact that the response of this survey was based on completed projects and those participating in this survey believed they were awarded the job after they had undergone a contractor selection process, which might include a prequalification process. Thus, they perceived themselves as already qualified. As for the client-related aspects ranking lower than those in the first- and the second-order groups, the reason is likely that this survey focused on seeking responses only from contractors and the study focuses on process innovation. This might be contrasted with design innovation which requires greater participation by the designer and possibly the client.

Most interesting of the findings is that all variables pertaining to “client” i.e. client-contractor relationship and client’s participation have no significant relationship with the radicalness of innovation. Further examination indicated that there is a threshold below which successful innovation adoption will not be achieved. This suggests that in the contractors’ point of view, the client’s role is merely related to that of creating a platform that supports the establishment of a favourable climate for innovation such as willingness to look at and accept new ideas, the provision of incentive forums for open and constructive dialogue among project team members, and the provision of teambuilding programs.

The contractor’s capabilities and credibility has a partial relationship with the radicalness of innovation. This is because three of its five variables, namely past-project-related experience, trustworthiness and non-adversarial approach were found to be not correlated with the radicalness of innovation.

A radical innovation, in addition to being new to the organisation, is very different from what the organisation has done previously. Respondents with considerable experience and capability might view an innovation as modest, incremental, or not particularly radical, whereas respondents with less experience might view the same innovation as exceptional. The lack of correlation between past-project-related experience and the radicalness of innovation is therefore more a reflection of the perception and background experience of individuals than a measure of the actual nature of the innovation. On the other hand, the lack of correlation between the radicalness of innovation and respectively trustworthiness and non-adversarial approach is likely to be due to the fact that these “soft” competencies are fundamental for contractors to demonstrate that they can be open and honest, and therefore can work together as part of the project team. Once an open and trusting climate has been
established, the effectiveness of project team collaboration in the innovation process depends on how effectively they communicate with one another.

The fact that some variables were found to be not correlated with the radicalness of innovation might give the impression that these variables are not important. Such interpretation should not be made. All the above aspects are in fact subsets of those determining factors summarised in Figure 3, hence they are all integral to the process of adopting process innovation flowing from the contractor.

**Procurement-Strategy Related Aspects**

Other aspects investigated in this research were related to procurement strategy. The findings are based on the data obtained through the first and the third sets of questionnaire and summarised as follows.

- The relative frequency ratio analysis provides clear evidence that Design and Build is the most favourable procurement system for contractor-led process innovation. In contrast, Traditional is the least favourable system. This finding is in line with that of previous studies, which highlighted the disadvantages of the fragmented approach of the traditional procurement system, which appear to be a major factor limiting the size and rate of innovation; and therefore emphasised the importance of design and construction integration, which appears easiest to achieve on design-build projects. The rank order of the procurement systems with respect to being favourable for process innovation is depicted in Figure 5.

![Figure 5 Rank Order of Procurement Systems Conducive to Process Innovation](image-url)
• The finding that the traditional procurement system is the least favourable system for process innovation was also reinforced by the fact that a very small proportion of innovations were actually brought up through an alternative tender in practice. This gives a strong indication that the alternative tender is not a favourable way of bringing up process innovation. It is also relevant to consider the influence of the “tendering contract” concept which may be inhibiting the inclusion of alternative tendering requests in the traditional process.

• The existence of financial incentive arrangements and the use of performance-based specifications are conducive to encouraging process innovation flowing from the contractor.

• Another significant finding derived from this investigation is that Value Engineering and constructability program present an important mechanism for construction innovation.

**Project Complexity Prompting Process Innovation**

What initially prompts the construction team to suggest innovative construction methods is the fact that there are technical requirements to complete a specific operation that are not feasible using existing construction technology; or that the performance requirements for a project, expressed as schedule or cost, may exceed existing capabilities; or the combination of both. The challenge of these requirements becomes a major force to innovate. Project complexity is one aspect that defines these requirements. The significant finding derived from this research in this respect is that more radical process innovation is likely to be prompted by relatively greater complexity associated with the design of constructed facility.

**Relative advantage in Relation to Innovation Radicalness**

The analysis of the contractors’ perception towards the relationship between the radicalness of innovation and the relative advantage provided clear evidence that in general, more radical process innovation was perceived to result in relatively more overall-advantage. However, the relative advantage with respect to productivity of the construction process was perceived as being the greatest of all other relative advantages (fostering superior quality of the constructed facility, improving performance efficiency in the construction process, reducing
costs, ensuring greater reliability and consistency in performance of the construction process, and resulting in indirect / intangible benefits). This is in line with the fact that this research has concentrated on process innovation, which was defined in previous studies as an innovation that enables a greater output per unit of input.

**Practical Implications for Construction Clients**

A major weakness of the traditional construction procurement process is its fragmented approach towards the delivery of construction projects which does not effectively encourage the integration, coordination and communication between participants, leading to adversarial relationships. With the separation of the design and construction processes, much of the construction production expertise is ostracised from the design process. Consequently, the lack of interaction inhibits the scope for creativity and the chance of innovation throughout the procurement process.

The results show that process innovation is essentially a contractor-focused issue. Therefore a prerequisite is a contractual and procurement process environment conducive to encouraging process innovation flowing from the contractor. The major determinants in this process are *effectiveness of the construction management team involved in design*, *project chemistry*, and *client involvement* (roles of the client in the process). However, in terms of client involvement, this needs only be a threshold commitment.

There are implications for clients associated with the findings. They are as follows.

- Clients seeking to improve innovation performance on specific projects should choose a non-traditional procurement route and allow project participants, particularly contractors, the time, resources, and freedom to consider innovative approaches.
- Several actions by clients are needed to foster new ideas, such as setting challenging demands, assembling the capabilities needed to identify and evaluate multiple alternatives, decreasing liability concerns, providing teambuilding among the parties, and creating an organisational climate that encourages innovation.
- In selecting a contractor, clients should set out criteria that reflect the requirements represented by those determinants summarised in Figure 4. These criteria include, but are
not limited to, commercial and technical competence. Less tangible aspects associated with attitudes and receptiveness to collaboration should be emphasised, such as:

- Making available key personnel and their personal commitment to achieving project goals;
- Continuous performance improvement programme;
- Demonstrated ability to add value and bring innovation to the project;
- Demonstrated ability to work in a non-adversarial and collaborative manner;
- Demonstrated ability to achieve outstanding workplace relations; and
- Eliminating inefficiencies at all interfaces.

**Implications for Construction Industry Professionals**

Gaining a competitive advantage is a primary motivation for pursuing construction innovation. If innovation is well implemented, it can provide a contracting firm with unique capabilities or performance advantages for specific construction operations. This will give an advantage in winning and performing projects involving these operations. Moreover, a demonstrated capability to innovate is itself a major competitive advantage. However, one of the many risks of innovation is the threat to an organisation’s reputation and their credibility. Failure may only mean losing profit in manufacturing, but in construction, failure often means going out of business. The risk of failure is higher in construction as a trial-and-error approach is not acceptable. Another paramount concern is professional liability. Attempts to innovate can bring about unexpected problems or dangerous results.

The results of this research provide an insight on determining factors that affect the process of innovation flowing from the contractor on construction projects. Hence, understanding the significance of these determining factors would assist professionals in contracting firms to influence and improve the possibility of success of the innovation and lead to achieving its potential benefits. In turn, successful project innovation can influence the business planning and long-term direction of the firm if it provides a technology which can give a competitive advantage.

Innovation on individual construction projects, as investigated in this research, places several demands on the contracting firm. These include:
• Appropriate context for innovation
• Increased integration of functional activities
• Leadership roles as champions
• Establishing commitment to innovation and information flow
• Willingness to look at the details in an integrated way; look beyond just putting a price on several different methods; and
• Breadth and depth of technical capability.

Adequately responding to these demands is necessary to take advantage of the opportunity for improved performance on a specific project.

Specifically, to increase the extent of and benefits from innovation, construction industry professionals should take the following actions.

Managers in a contracting firm
- Bringing a strong desire for improvement;
- Probing the opportunities for innovation and improvement, which are often not obvious;
- Making expectations regarding adequate consideration of innovation clear to technical personnel and monitoring the investigation of alternatives for construction methods;
- Balancing risk and potential benefits in selecting construction methods;
- Persisting in implementation and refinement of the innovation;
- Assigning persons with appropriate technical capability and allowing them the time, necessary resources, and freedom to consider innovative approaches; and supporting the operations and technical personnel who are solving the problems (e.g. tolerating numerous problems in development);
- Establishing effective interdisciplinary coordination within the design team to allow the early identification and resolution of problems in one discipline resulting from changes in another;
- Integrating the separate functional parts of the organisation and activities required for innovation;
- Expenditure significant personal effort to identify available technologies and keep a file of possible applications on future projects.

Designer
Cooperating with other personnel involved in the innovation process, which includes:
• Fully communicating the design intent and technically evaluating proposed methods against the acceptance criteria of the design;
• Revising the design approach to allow the use of an innovative construction method.

**Construction engineer**

• Keeping aware of new technologies with potential application;
• Suggesting alternatives for innovative construction methods and providing practical criteria for their evaluation;
• Technically supporting experimentation, refinement, and implementation.

**Conclusions**

An international survey by McKinsey in 1995 identified the Australian construction industry as being highly productive, benchmarked at 95% of the productivity in the USA – assumed to be worlds best practice. A major element of the productivity was the innovative nature of the Australian industry, and the adoption of prefabrication componentisation. However two very important components were the fiercely price competitive nature of the industry and the dramatic drop (during the period of the survey) in industrial disputes. Clearly in order to build a long-term sustainable industry we need to encourage more technical process innovation which will deliver better value in quality and efficiency rather than cutthroat competition.

Clients in particular have the opportunity to encourage innovation on behalf of the design and construction team by recognising the three key drivers identified by this research of *effectiveness of the construction management team involved in design, project chemistry, and client involvement*