MEASURING PERFORMANCE AND THE IMPACT OF RESEARCH AND DEVELOPMENT IN CONSTRUCTION: RESEARCH METHODOLOGICAL PERSPECTIVES

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ABSTRACT: Research and innovation in construction industry have a significant role to play in performance improvement while providing benefits to the industry as well as to its stakeholders. However, it has been identified that the nature of Research and Development (R&D) work has become complex. Due to the rising cost, time and other resource constraints, much attention is paid on the successfulness of R&D and the managers are under pressure to monitor and improve the performance. In this context, the use of performance measurement (PM) systems benefits R&D organisations by evaluating the successfulness of related activities. Accordingly, this paper highlights the aspects which will be covered when designing a feasible research methodology for the study under consideration. The paper illustrates how the philosophical issues directed the use of case studies as the suitable research approach. The importance of case study design in gaining the maximum outcome from the research is also discussed.

Keywords- Case study, Research and development, Research methodology

1 INTRODUCTION

The main intention of any research is to add value to the accumulated knowledge through the means of identifying, investigating and producing solutions to an unsolved problem (Remenyi, 1998). The process of finding solutions to the research problem is "not a clear cut sequence of procedures followed by a neat pattern, but a messy interaction between the conceptual and empirical world" (Bechhofer, 1974, cited in Gill and Johnson, 2002, p: 3). Booth et al (2003, p: 5) also agree with this view state that "research follows crooked path, taking unexpected turns even looping back itself". Even though the research process is uncertain and risky, the appropriate research design would minimise the possibilities of any failures by identifying and forecasting any problems and pitfalls that the researcher may come across. Further more, such research design follows a procedure of work which determines the approaches, methods and strategies to be adopted during the study (Gittins, 1997). In addition to that, research design looks into the philosophical aspects of the research which intern helps to identify the overall research strategy (collecting, analysis, interpretation of data and drawing conclusions); evaluate various research methods and identify their limitations; increase the compatibility of research approaches and research techniques (Easterby-Smith et al, 2002).

This paper aims to outline the research design for a study based on identifying the impacts and influences of performance measurement (PM) towards research and development (R&D) activities within the construction process. Gill and Johnson (2002) state that there is no one best approach to research, but the approach is governed by number of variables. Further they argue that the "research methodology is a compromise between options in the light of tacit philosophical assumptions" (Gill and Johnson, 2002, p: 1). Accordingly, this paper discusses how the variables such as philosophical issues, nature of the research problem, resource constraints have led the way to select the appropriate research approach and techniques. The first section of the paper presents the background to the study followed

by addressing the need of PM to construction R&D activities. Next, the research methodological aspects of this study is discussed with particular reference to establishing the philosophical stand for the study, selection and design of the case study research approach, and data collection and analysing techniques. Finally the conclusion of the paper is presented.

2 BACKGROUND

The contribution from R&D for the development of the construction industry is immense as it leads the path to enhance the effectiveness of construction organisations and to raise the international competitiveness through technological advances and managerial developments (Hampson and Brandon, 2004; Gustavsson et al, 1999; Ernst, 1998). To remain competitive in the market, organisations should make sure their customer needs are properly met, and future demands of the customers are properly addressed. In this respect R&D acts as a valuable "input" for the development of the organisations (Business Link, 2005).

"R&D have become more complex, as they involve many parties and have a wide range of, often interrelated, technological, market and organisational options to choose from under constrained conditions" (Kerssens-van Drongelen et al , 2000, p:113). R&D activities require many resources ranging from human to technical which require proper utilisation. The accountability for these resources is being questioned by the management as well as by the shareholders (Wood, 1998; Nixon, 1998). As a result of that, a growing interest can be identified in managing, controlling and monitoring the R&D activities (Bone and Saxon, 2000). In this context, the use of PM mechanisms benefits the R&D activities by evaluating the successfulness of their activities.

3 NEED OF PERFORMANCE MEASUREMENT TO RESEARCH AND DEVELOPMENT IN CONSTRUCTION ORGANISATIONS

To get involved in high quality research, construction R&D requires resources such as necessary equipment, skilled individuals and funds (Seaden, 2002). Like in any other investment, the construction R&D investors expect reasonable returns from their investments (Seaden, 2002; Courtney, 1999). A low level of investment can be identified for UK construction R&D (DTI, 2005). One of the main reasons for the low investment is "improper reporting of R&D expenses" (Seaden and Manseau, 2001, p: 186). Therefore, Courtney (1999) argues that R&D returns should be "more calculable" by means of establishing certain and visible relationships between the investments and output of construction R&D activities. This can be done by implementing a PM system within the construction R&D. By doing so, proper utilisation of investments and clear links between investments and potential income for the investors can be identified.

Identifying new ways to access technical solutions and creating new and improved products in the construction industry requires not only sufficient investments, but also the commitment and time of the employees (Building Research Establishment, 2005). Thus, the time devoted for construction R&D should be justifiable. In addition, it is equally important to show that the results obtained through construction R&D activities are properly aligned with the expected objectives. This has demanded proper controlling and monitoring mechanisms, and a way to assess the R&D goals against the outcomes. This can be achieved by implementing a PM system within the construction R&D work as such a system continuously evaluate the successfulness of the activities and identifies the gaps between the goals and expected outcomes.

Cohen and Levinthal (1989, 1990) argue that R&D activities help to develop new information/ knowledge as well as improve the ability of the organisation's absorptive capacity. The absorptive capacity is highly dependent on the internal capabilities of the organisation such as availability of qualified staff, the nature of internal and external communication, coordination and feedback mechanisms (Cohendet and Steinmueller, 2000; Steinmueller, 2000). Therefore, the management of internal R&D capabilities is essential for effective and efficient R&D activities. Gann (2001) states that most of the construction R&D organisations do not have the required internal R&D capabilities. Further, Dulaimi et al (2002) recommend that the construction R&D activities should be coordinated to gain the maximum outcome. They emphasise the ability to develop superior products and services is significantly influenced by the level of cooperation between the parties involved within the process. The implementation of PM system increases the communication, coordination, and feedback mechanisms and directs the employees towards the common goals (Martinez, 2005; Neely et al, 2002). Thus, a PM system within construction R&D will improve the aforementioned internal capabilities and would generate successful results.

The need for training, participation in seminars, conferences has been identified to increase the skills and knowledge of people involved in construction R&D activities (Dulaimi et al, 2002). A properly designed PM system identifies such needs by looking into whether the R&D process is supported with the qualified people that are needed. Further, PM helps to control, monitor and allocate the organisational resources (Melnyk et al, 2004; Love and Holt, 2000). Accordingly, by implementing a PM system, construction R&D process can properly handle the resources which they are accountable for.

This section identified the important role PM plays within construction R&D. However, the concept of PM within the construction R&D is not adequately exploited. Therefore, this study is aimed at addressing the gap in R&D within the construction sector with particular reference to its PM application. Section below presents the research problem, aim and objectives pertaining to this study. Following research problem is formulated to address and reflect this need.

3.1 The research problem, aim and objectives

The following research problem is derived form the literature review which reflects the need of addressing PM within construction R&D.

Research and development has been identified as one of the main drivers for the development of the construction industry. For the success of R&D work, significant amount of resources such as money, time, and commitment of the people are being spent. But, whether these resources are utilised to their maximum capacity is in doubt. Further, it is a question whether the strategies, aims, and objectives of construction R&D process are properly met.

The aim of this study is to explore the applications of R&D within construction and to evaluate the influence of PM towards construction R&D. The following specific objectives have been formulated to address this aim:

- to identify the importance of R&D in the construction industry;
- to identify the current status of construction R&D;
- to determine the critical success factors for construction R&D process;
- to evaluate the importance of R&D performance measurement in construction R&D process;
- to develop a R&D performance measurement framework that enable the management to assess the successfulness of R&D process.

To address this research problem while fulfilling the aim and objectives, a mechanism has to be developed within which the research can be built upon. According to Nachmias and Nachmias (1996), a research methodology identifies the explicit rules and procedures which the research can be based upon. Accordingly, the section below discusses the development of suitable research methodology for this study.

4 RESEARCH METHODOLOGY

Research methodology is a procedural framework within which the research is constructed (Remenyi et al, 1998). Accordingly the "nested approach" presented by Kagioglou et al (1998) is used for this research. Kagioglou et al (1998) presents the research methodology as a hierarchical model where the research techniques are under the research approaches and the research approaches are under research philosophy (Figure 1). Within this "nested" model, research philosophy which is at the outer ring "guides and energises the inner research approaches and research techniques" while ensuring that the chosen research philosophy, approach, and techniques are compatible with each other (Kagioglou et al, 1998). The following sections further describe the research philosophy, research approach and research techniques pertaining to this study.

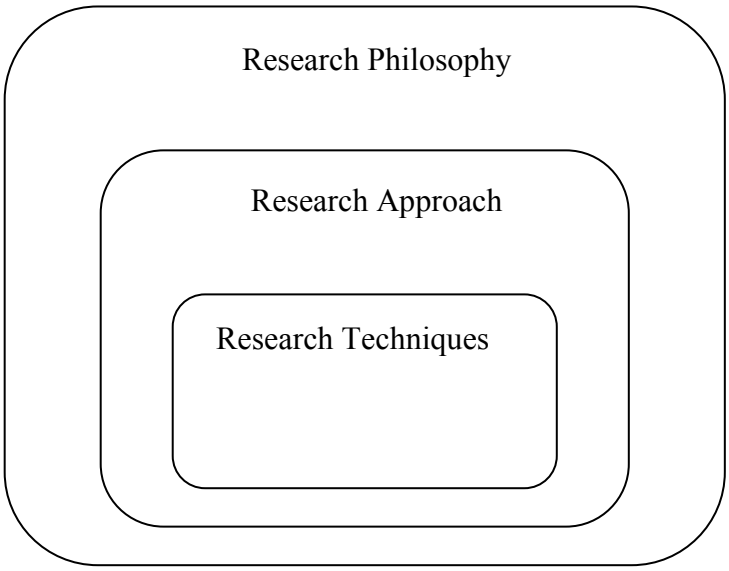

Figure 1: Nested approach

4.1 Research Philosophy

According to Guba and Lincoln (1994) and Healy and Perry (2000), a paradigm consists of fundamental assumptions in relation to the "world", the place of the individual in it, and the relationship between the world and the researcher. Researchers often operate in such a "paradigm" where the researcher's activities are guided by philosophies and methods (Kuhn, 1962). Easterby-Smith et al (2002) identifies research philosophies as the base for effective research design and argues that failure to adhere to philosophical issues can affect the quality of the research negatively. Easterby-Smith et al (2002) point out three reasons to highlight the importance of philosophical issues in research: firstly the research philosophies help to clarify the research design; secondly the researcher can recognise which designs will work and which will not work and thirdly, the knowledge about research philosophy will help to

identify and create designs which are out side the researcher's past experience. In addition to that, research philosophies guide the researcher to consider about research constraints of different subject or knowledge structures (Easterby-Smith et al, 2002).

Epistemology, ontology, and axiology are the three assumptions that are within the research philosophy (Collins, 1998; Guba and Lincoln, 1994) which can be further seen in Table I.

Table I: Assumptions of research philosophy (Sexton, 2003)

Epistemology (The how?)	General set of assumptions about how we acquire and accept knowledge about the world
Ontology (The what?)	Assumptions that we make about the nature of reality
Axiology (The why?)	Assumptions about the nature of values and the foundation of value judgments

4.1.1 Epistemology

Under the epistemological undertakings, Easterby-Smith et al (2002) identify two traditions of philosophies, "positivism," and "social constructionism (interpretivism)". They recognise that these philosophies can be placed in two extreme ends of continuum where "in the red corner is constructionism and the blue corner is the positivism" (Easterby-Smith et al, 2002, p: 28). Positivists argue that "the world exists externally and that its properties should be measured through objective measures rather than being inferred subjectively through sensation, reflection or intuition" (Easterby-Smith et al, 2002, p: 28). Moreover, positivist searches for causal explanations and fundamental laws and use the deductive approach for the research (Easterby-Smith et al 2002; Gill and Johnson, 2002; Remenyi, 1998). Conversely according to social constructionism, reality is determined by people rather than by objective and exterior factors (Easterby-Smith et al, 2002) where the social scientist should welcome and appreciate the different views and meanings that people place upon their experiences. Comparisons of the two epistemological paradigms are presentment in Table II.

Table II: Contrasting implications of positivism and social constructionism (Easterby-Smith et al, 2002)

	Positivism	**Social Constructionism**
The observer	Must be independent	Is part of what is being observed
Human Interest	Should be irrelevant	Are the main drivers of the science
Explanations	Must demonstrate causality	Aim to increase general understanding of the situation
Research progress through	Hypotheses and deduction	Gathering rich data from which ideas are induced
Concepts	Need to be operationalised so that they can be measured	Should incorporate stakeholder perspectives
Units of analysis	Should be reduced to the simplest terms	May include the complexity of 'whole' situation
Generalisation through	Statistical probability	Theoretical abstraction
Sampling requires	Large numbers selected randomly	Small numbers of cases chosen for specific reasons

Accordingly, "social constructionism" can be identified as the most appropriate epistemological undertaking for this research due to many reasons. First and foremost, this study requires the researcher to be a part of the environment and interaction is needed within the environment to identify the different views of people and to interpret them (For instance, the views about the importance of R&D within the construction sector, factors which is needed for the successful attainment of R&D work, suitable PM metrics and methods for R&D activities). Further, it requires appropriate understanding of the context and the process of R&D work, and to acquire knowledge by the use of reasoning, intuition, or perception. Thus the researcher cannot be independent from the environment under consideration as a positivist. Further, the research requires in depth analysis to gather detailed facts about the research environment. This requires the selection of a small number of samples, which is facilitated by the social constructionism stance. According to the above reasons, it can be argued that social constructionism is preferred over positivism stance for this research.

4.1.2 Ontology

Ontological assumption or the assumptions that are made about the reality of the nature is the other important aspect within the research philosophy. The ontological assumption is based on the external world is having a predetermined nature and structure is known as "realism" (Johnson and Duberly, 2000) and the assumption based on the external world is not having a pre determined nature or structure is known as the "idealism" (Gummesson, 1991).

According to Burrel and Morgan (1979, cited in Gill and Johnson, 2002) Nomothetic (realist) methodologies base the research on systematic protocols and techniques which is focus on testing hypothesis. In contrast, Ideographic (idealism) methodologies emphasise analysis of the subjective matters by getting involved in the everyday activities (Burrel and Morgan, 1979, cited in Gill and Johnson, 2002).

Gill and Johnson (2002) presents a comparison between the Nomothetic (realist) and Ideographic (idealism) as in Table III.

Table III: A comparison of Nomothetic (realism) and Ideographic (idealism) methodologies

	Nomothetic	**Ideographic**
1	Deduction	Induction
2	Explanation via analysis of causal relationships	Explanation of subject meaning systems and explanation by understanding
3	Generation and use of quantitative data	Generation and use of qualitative data
4	Use of various controls, physical or statistical, so as to allow the testing of hypothesis	Commitment to research in everyday settings, to allow access to and minimise reactivity among subjects of research
5	Highly structured research methodologies to ensure replicability of above 1,2,3 and 4	Minimise structure to ensure above 2,3 and 4

This research takes the "idealism" stance in terms of the ontological undertakings. As discussed earlier, the researcher will be analysing the subject matters by being a part of the environment. Due to this reason it self, this research is more towards the idealism stance. In addition, since the research requires developing explanations and theories form observations, the idealism stance will be more suitable. Further, the research environment is not expected to control and simplify with assumptions as in deductive research methodologies and the free flow of ideas, perceptions will be encouraged and studied. Hence, it can be seen that this research favour idealism than the realism stance.

4.1.3 Axiology

Within the research philosophy, axiology is the third aspect that has to be visited. Axiology concerns assumptions about the value that the researcher attaches to the knowledge. Social constructionism suggests that the research is value-laden (Healy and Perry, 2000; Silverman, 1998) whereas the positivism suggests the researcher should retain a value free view (Susman and Evered, 1978). Accordingly, in the value free research, the choice of what to study and how to study is determined by objective criteria and in Value laden research the choice is determined by human beliefs and experiences (Easterby-Smith et al, 2002).

In terms of the axiological undertakings, the research in question takes the value laden stance. Due to the exploratory nature of this research, it requires people to come up with different views. Accordingly, this research would take the Social constructionism stance in terms of the epistemological undertakings. Further, in terms of the Ontological and Axiological undertakings, the research will take the Idealism and Value laden stances respectively (

Figure 2).

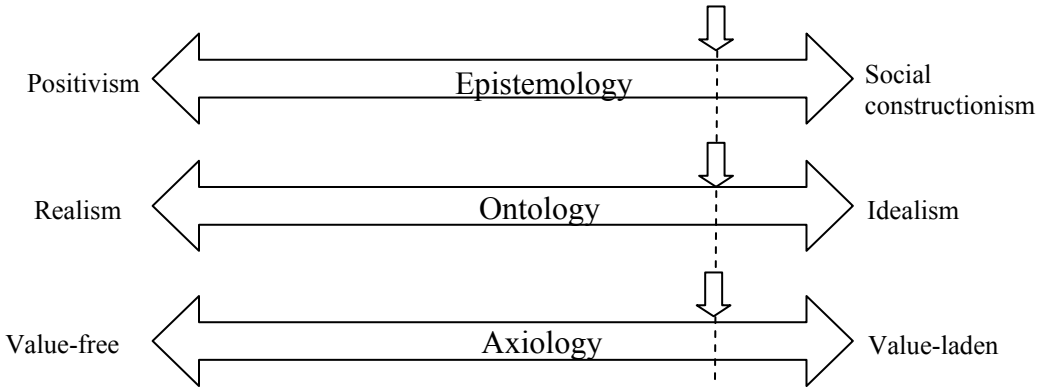

Figure 2: Research philosophy continuum (Collins, 1998)

4.2 Research Approach

There are number of different research approaches where ones research can be based upon (Yin, 2003; Gill and Johnson, 2002).

shows how the research approaches can be positioned within the epistemological and ontological continuums. It can be seen that how experiments and surveys are governed by positivist and realist stances where as case studies, action research and ethnographic approaches are towards social constructionism and idealism stances.

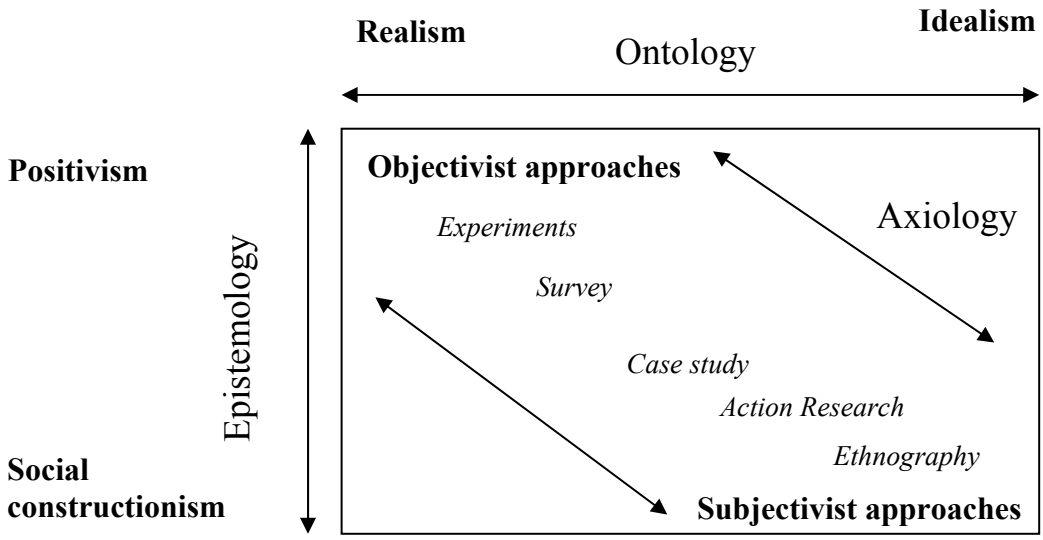

Figure 3: Research approaches (Sexton, 2003)

Yin (2003) identifies three conditions which have to be considered when selecting the appropriate research approach:

- the type of research question posed;
- the extent of control an investigator has over the actual behavioural events;
- the degree of focus on contemporary event.

According to

, experiments and surveys take the positivism and realism positions in terms of the epistemological and ontological undertakings respectively. Since this research takes the social constructionism and idealism with regard to the philosophical stances, use of experiments and surveys are unjustifiable. Experiments and surveys are conducted under controlled environments where in the former situation the phenomenon and the context is separated and in the latter situation investigating the context is difficult due to the limited number of variables set out (Yin, 2003).

Since this research falls under the social constructionism and idealism stances, the researcher has to make a choice between ethnography, action research, or case studies. According to Harvey and Myers (1995), the Ethnography approach provides the researchers insights into the beliefs and values of human, social, and organisational aspects of socio-cultural phenomenon. Further, Ethnography research takes a considerable time period (Burns, 2000; Van Maanen, 1982). In action research, the researcher will be a part of the environment under study, tries to solve practical problems (Waser and Johns, 2003; McNiff and Whitehead, 2002; Robson, 2002), and tries to influence and change the attitudes and behaviours of the participants (Waser and Johns, 2003).

Yin (1994, p: 13), describes a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident". Case studies are carried out in a way that it incorporates the views of the "actors" in the case under observation (Zonabend, 1992). Due to the open ended inquiry used in case studies, it is suitable to built theory and

generate hypothesis (Amaratunga et al, 2002). Further, case studies provide the opportunity of dealing with full variety of evidence such as documents, interviews, and observations (Yin, 2003).

The research under consideration does not intend to influence or change the attitudes or procedures of the participants or the environment. Further, it does not intend to study behavioural patterns or physiology of the participants as in the case of ethnographical studies. Hence, the use of case studies is preferred over action research and ethnography. The case study approach is therefore suitable for this research to explore the R&D within the context of construction industry and its PM aspects within the case study organisations. The case study approach too provides the opportunity of carrying out an in depth study about the links between R&D and its performance measurement.

This research has the characteristics of both the exploratory and explanatory case studies. According to Yin (2003), the nature of the research questions posed has an effect on the research approach. Yin argues that "how" "why" questions favour the use of case studies and the use of "what" question is suitable for the exploratory type of researches. Research under consideration has a combination of "how" "why" questions coupled with "what" questions. Following reasons could be listed as the key points for the selection of case study methodology for this research:

- does not intend to control/ manipulate the environment under examination;
- does not intend to interfere the attitudes, perceptions or the procedures of the environment (as in the case of action research);
- analysing contemporary events;
- requires to do an in depth study on the selected environment. Thus it will be advantages to rely on multiple sources of evidence and the selection of a small sample to allow an in depth study;
- requires to explore and analyse the "real life" context of PM concept within construction R&D.

Above section described the selection of the most appropriate research approach. Case studies were identified as the suitable research approach. Accordingly, the following section describes the design of the case study.

4.2.1 Case study design

A *research design* has been identified as the "logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study" (Yin, 2003, p: 19). Nachmias and Nachmias (1996) argue that the research design guides the researcher to collect, analyse and interpret the observations he made. There are four conditions where the development of a case study needs to be satisfied. The way the research under consideration satisfies these conditions are presented in Table 5.

Table 5: Validity and reliability of case studies (adopted from Yin, 2003)

Test	Description	The method of achieving	Stage
Construct validity	Establishing correct operational measures for the concepts being studied	Use of multiple sources of evidence Key informants review the draft case study	Data collection Composition
Internal validity	Establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguish from spurious relationships	Do pattern matching	Data analysis
External validity	Establishing a domain to which the study's finding can be generalised	Use replication logic	Research design
Reliability	Demonstrating that the operations of the study (such as the data collection procedure) can be repeated, with the same results	Use case study protocol Consistent interview guidelines Develop case study data base	Data collection Data collection Data collection

Four major types of case study designs exist according to the 2 x 2 matrix suggested by Yin (2003). They are single holistic, multiple holistic, single embedded, and multiple embedded. The use of single case studies is preferred when the study represents a critical case, extreme or a unique case, representative or typical case, revelatory case or a longitudinal case (Yin, 2003). The research in question does not fall under these categories, thus multiple case studies are preferred over a single case study. Herriott and Firestone (1983) argue that the evidence gathered form multiple cases studies are often considered as more compelling which resulted in a healthier and a strong study. Sampling logic will not be used to select the case studies i.e. to select a sample from the pool of respondents/whole population (like in the situation of surveys). Thus, analytical generalisation is preferred over the statistical generalisation where the findings will not reflect the whole population. However, it is intended to claim literal replication by comparing the findings from the multiple case studies.

The approach to case studies in this research involves theory building and verification. That is to build up research questions, hypothesis, propositions via the literature review and verification of them through multiple data collection methods, analysing the data within and across case studies and finally reaching at the conclusions. The section above discussed how the case studies will be designed to facilitate the theory verification process and explained the methods that will be used to ensure the reliability and validity of the research. The following section will highlight the research techniques.

4.3 Research Techniques

As discussed in section 4.1 this research takes the *social constructionism, idealism* and *value laden* stances in terms of the research philosophy. These philosophical stances together with

the characteristics of the research under consideration directed the use of *case studies* research approach which was discussed in section 4.2. Having identifying the research philosophy and research approach, the next step is to determine the appropriate research techniques for the study. Accordingly, below section will look into this.

4.3.1 Data collection

Yin (2003) identifies three principles of data collection;

- use of multiple evidence
- creating a case study data base
- maintaining a chain of evidence

Yin (2003) further identifies six main sources of evidence which can be used for case study data collection procedure. They are documents, archival records, interviews, direct observations, participant observations, and physical artifacts. Accordingly, for this research, review of documents, semi structured interviews, and direct observation will be used to understand the context of R&D and the applicability of PM concept within the R&D process under observation. When the same results are obtained through different mechanisms, the confidence of the results is high (Stoecker, 1991) as the weaknesses of one method will be compensated by the strengths of another method. Thus results obtained from this research will be more convincing and accurate, increasing the "construct validity" of the research.

In addition to the use of multiple sources, a case study data base will be created which consists of case study notes (resulted from the interviews, observations and documents reviews), documents related to the case study, tabular material obtained from the case study or created from the researcher, narratives produced by the researcher. The data base will be used to store and retrieve the aforementioned sources of evidence in a presentable manner. Further, during the data collection stage, it is expected to use case study protocol which consist of interview procedures, general rules that will be followed during the case studies. In addition to that, consistent interview guidelines are expected to use. The use of case study data base, case study protocol and consistent interview guidelines will increase the "reliability" of the research.

Having discussed the data collection methods, section below will discuss the data analysing methods of this research.

4.3.2 Data analysis

It is important to have a data analysing strategy as it will guide the researcher to select the appropriate data analysing tools, to make sure that the evidence is treated well, to generate sound and convincing analytical conclusions while discarding the alternative interpretations (Yin, 2003). The objectives, research questions, and hypothesis of this study are developed through the identification of theoretical propositions. Accordingly, this study is intended to rely on the theoretical propositions. This will focus the study more by guiding to identify the relevant data while avoiding the other.

Within case and cross case data analysis is expected to carry out during the data analysing stage by using Pattern matching; a technique which compares the theories and observed data (Yin, 1994; Eisenhardt, 1989). Accordingly, this research will match the data gathered from semi structured interviews and through observations with the theoretically predicted data. Content analysis will be used to code the textual data gathered from the semi structured interviews. Content analysis is a method that compresses many words into fewer content categories (Krippendorff, 1980). To display and identify the relationships of concepts derived from the interviews and observations, cognitive mapping technique will be used. This is a

method that enables recording qualitative data in a structured manner to enhance the understanding and analysis of data (Ackermann et al, 1992). To facilitate the data analysis process, computer software packages are expected to use namely NVivo and Decision Explorer for content analysis and cognitive mapping respectively.

Arriving at conclusions for the study involves interpretation and drawing meanings from the displayed data (Miles and Huberman, 1994). The data from this research will be summarised and conclusions will be drawn which will justify or falsify the research hypothesis of the research.

5 CONCLUSION

This paper identified the need of developing a research methodology in fulfilling the aims and objectives of a study and thereby addressing the research problem. The investigation of PM concept within construction R&D process demanded the social constructionism, idealism and value laden stances in terms of the research philosophy. The aforementioned philosophical understandings and need of carrying out an in-depth analysis without interfering to the research environment led the way to select case study as the most appropriate research approach. It can be concluded that the proper understanding of the philosophical issues followed by a clear definition and design of research strategy are essential elements in developing successful research. The philosophical understanding of the research ensures the compatibility and consistency between research philosophy, approach and techniques while the clear definition and design of research strategy would generate unbiased and more convincing research outcomes.

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