# A CAPABILITY MATURITY APPROACH FOR CONSTRUCTION PROCESS IMPROVEMENT: USE OF CASE STUDIES APPROACH

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**ABSTRACT:** During the recent past, the effectiveness of process improvement strategies and the role of information technology have been discussed as a mechanism of achieving the performance improvements within the UK construction industry. However there are visible gaps within the current research status in process maturity and IT maturity studies in construction. This paper is based on an ongoing PhD research which is aiming at exploring the full potential of process capability and maturity approach and the role of IT as an enabler, as a method of improving the UK construction industry. In particular, this paper will concentrate on the methodological issues of the above study in justifying the applicability of the case study approach.

**Keywords -** Capability Maturity Model, Construction Industry, Process Improvement, SPICE

## 1. INTRODUCTION

The aim of this paper is to logically argue and justify the use of case study approach within PhD research study titled "Capability Maturity approach for the process improvement within the UK construction industry". Initially the background of the study concern is presented briefly to provide an insight, followed by the research problem of the study. This is followed by a literature review to identify and to establish the research gaps within the identified problem domain. Guided by this, the aims and objectives of the research is established and presented followed by a conceptual model for the research in question. The proposed methodology is presented with appropriate justification according to the nested model (Kagioglou et al, 1998). Firstly the philosophical stand of the research is established by considering the ontological, epistemological and axiological stands of the study. The selection of case studies and the appropriate research approaches are then presented and justified based on the assumptions established under the philosophical stand. This has used as the base to establish the appropriate research techniques for data collection and data analysis.

## 2. BACKGROUND

It is generally admitted that there is a need for change within the UK construction industry as it is unpredictable and under-achieving (Koskela et al, 2003; Santos and Powell, 2001; Egan, 1998; Love and Li, 1998; Latham, 1994). This has been an effective motivator for improvement initiatives within the construction industry (Samuelsson, 2003). Having identified this need for change, Egan (1998) highlighted that "focusing on the customer" and "integrating the process and the team around the product" as two of the key drivers to achieve the desired change within the UK construction industry. This emphasises the need of deviating from functionally oriented project structures towards a customer focused, process oriented project delivery mechanisms. It appears that the above recommendations from Egan are based on the view that the process improvement is the way forward to improve the performance of the UK construction industry (Sarshar et al, 2000).

Further it has been identified by Davenport (1993) that the information technology (IT) is a major enabler for process improvement. Being a labour intensive industry, the UK

construction industry has demonstrated a slow IT adoptability (O'Conner and Yang, 2004). Due to this nature it suggests that the construction industry lags the other industries in impact of IT to the business (Clark et al, 1999).

## 3. RESEARCH PROBLEM

Even though the performance improvements have been achieved through process improvement initiatives within the manufacturing and services sectors, the direct applicability of this strategy within construction is debated (see: Santos and Powell, 2001; Love and Li, 1998; Egan, 1998). It is argued that the principles of process improvement of the industries like manufacturing and services are not readily applicable within the construction context, due to the "unique" nature of the product. Further, the complex supply chain arrangements and project based product delivery systems have also been identified as inhibits for process improvement initiatives. As Lillrank (1995) have pointed out, the core idea of an innovation in one industry should be abstracted and then recreated in a form, which it fits in local conditions. The problem then becomes how to recreate process improvement initiatives and innovations of other industries within the UK construction environment.

This is similarly applicable when assessing the level of IT usage and its success synergistically with process improvements within construction. With the view of exploring this problem further, next section presents a summary of the literature review conducted as a part of this study.

## 4. A SUMMARY OF THE LITERATURE REVIEW

Recent construction literature indicates a clear focus on process improvement strategies within the construction industry. The main debate resides within the determination of the best approach to process improvement, the (revolutionary) radical approach or the (evolutionary) continuous incremental approach. (Green and May, 2003; Love et al, 2000; Santos et al 2000; Love and Li, 1998). Irrespective of the approach to process improvement, construction organisations need to embark on adopting quality management principles if the desired improvement to be achieved (Love and Li, 1998). Within this context, an underlying process improvement culture has to be established within construction organisations before embarking on process improvement initiatives (Holt et al 2000; Love and Li, 1998). Further, the theoretical base for this culture is to be laid by the principles of continuous improvement. It is commonly associated with the Plan-Do-Check-Act cycle, often referred to as the Deming Wheel or Shewhart Cycle (Santos and Powell, 2001). Statistical process controlling mechanisms are the key enablers of this cycle. Not every organisation can embark on such a cycle as organisations need a certain level of maturity to execute the requirements of each level of the cycle. This emphasises the importance of assessing major elements of processes: the people, procedures and tools (Sarshar et al, 1998) within construction organisations in terms of their capabilities of supporting process improvement initiatives. Despite the number frameworks proposed for construction process improvement initiatives (e.g.: Love and Li, 1998; Pheng and Wei, 1996), minimum attention has been given so far to study the impact of organisational capability and maturity aspects of the same.

Apart from statistical process control mechanisms explained above, the information technology (IT) has been identified as the major enabler of the process improvement (Davenport, 1993). However, the construction industry has been criticised for its slow IT adoptability in the past (O'Conner and Yang, 2004). Further more; the industry has become frustrated with the falling of IT as many companies have invested in the wrong technologies without addressing the business needs (Aouad et al, 1999). There are confusions in the

construction industry, up to a certain extend, in the applications of process improvements and use of IT. It is important to have matured processes that support IT integration to enhance the maximum benefits from IT capabilities, and at the same time, new IT capabilities lay solid foundations for successful process improvements Hinks et al (1998). The ultimate solution to this dilemma may reside within a synchronised process improvement and IT adoptability strategy (Hinks et al, 1998). Despite the number of researches carried out to investigate the relationship between the processes and IT in construction (Kagioglou et al, 1999; Aouad et al., 1997; Brandon and Betts, 1995) only few dedicated studies have addressed the issue above mentioned.

As highlighted above, the construction industry has had few recognised methodologies or frameworks on which to base a process improvement initiative (Sarshar et al., 2000), emphasising the importance of establishing a structured, common approach to construction process assessment and improvement based on the process capabilities of the organisation. One such approach which has proven its success within the software industry, where the same project based product delivery mechanisms are visible as same as in construction, is "The Software Capability Maturity Model (CMM)". CMM is based on a five levelled structure. Within this, organisations are ranked from level 1 to level 5 based on their maturity, level 1 being least matured and level 5 being most matured. In order to achieve a specific maturity level, organisations must satisfy all the key processes defined within the immediate below maturity level. The organisations are tested against "key enablers" to determine weather they have satisfied each key process. Through this framework, organisations are guided to adopt stepwise process improvements. Sarshar et al (1998) have attempted to apply the principles of this model within the construction industry within the 'Structured Process Improvement in Construction Enterprises (SPICE)" research. This research was carried out in stages, and the dynamics up to the level 3 of the CMM were explored and customised to the UK construction industry. While lower maturity levels of CMM establish the required capability and the background of the organisation, the higher maturity levels are responsible for dramatic and sustainable process improvements. But within the SPICE, the dynamics of higher maturity levels were not explored thoroughly, leaving its full potential unexplored.

Addressing the process-IT dilemma as mentioned above, Hinks et al (1998) have proposed a synchronisation between processes and IT through a co-maturation framework. This framework visualises the impact of various categories of technologies on processes, through the technology interface, while establishing that each technology has to become an established used technology to enhance the maximum potential of processes (Hinks et al, 1998). It further illustrates how communication and standard systems technologies contribute to this maturity of IT. Further they explain technology maturation in a stepwise structure taking CMM as the underlying concept:

1. Emerging
2. Initial – Ad-hoc use of technology (3D, VR)
3. Applied – Applied technology (CAD, Project planning, etc)
4. Integrated – Standard, consistent technology
5. Managed – Reliable technology
6. Matured – Continuously improving technology

Hinks et al (1998) have also tried to synchronise the process maturity and technology maturity, while defining technology push and process pull scenarios within the model. This creates a synergetic influence to the SPICE framework, as both the frameworks share a common platform. Further, the technology management has been discussed as a key process area within CMM higher maturity levels, where SPICE has not explored the impact within

the construction context yet. This highlights a need to explore the possibility dynamics of process – IT co-maturation phenomenon within SPICE higher maturity levels in particular. It is therefore visible that there is a clear requirement to study the construction process improvement within people, procedures and tools integrated environment. Further it has been already established that there is a need for a structured process improvement strategy within a construction environment and identified the Capability Maturity Model as a successful model tested within the software industry. The SPICE framework has been identified as an attempt to map the success of the CMM to the construction industry, but with visible gaps that need to be addressed to be successfully deployed as a full potential construction process improvement strategy. Further, the importance of maintaining the harmony between the information technological capabilities and the organisational processes has been identified as a key success factor for construction process improvements. With this it is the intention of the author to narrow down the original problem of "how to improve the performance of the UK construction industry" to more specific research aims as highlighted within the next section.

## 5. AIMS AND OBJECTIVES

As derived from the research problem and the literature synthesis above, the broader aim of this research is to understand the dynamics of higher maturity level characteristics (level 4 and level 5) of the Capability Maturity Model (CMM) as a mechanism for achieving process improvements within UK construction environments. In doing so, it is also intended to understand the interaction between higher maturity level dynamics and the use of IT tools as an enabler.

From the above synthesis it is visible that the SPICE framework (Sarshar et al, 2000) and the Process-IT co-maturation model (Hinks et al, 1998) have addressed the periphery of broader aim of this research independently, within a generic framework. Due to this nature, from the execution point of view, the author suggests that the enhancements and integration of the SPICE model and the Process-IT co-maturation model in combination provide a mechanism to achieve the broader aims specified above. Research as summarised in this paper tries to evaluate these models further in order to achieve the following objectives:

1. To evaluate the theoretical stand of the SPICE framework within the construction process improvement research paradigm and to understand its current research status within the UK construction industry.
2. To interpret the characteristics and concepts of higher maturity levels of the software capability maturity model within UK construction environments.
3. To develop a conceptual model to identify the dynamics of level 4 and level 5 of the SPICE framework.
4. To identify potential IT tools that can be used synergistically within the conceptual model above mentioned, for the effective achievements of higher SPICE maturity levels.
5. To evaluate the current usage of the above mentioned IT tools within the UK construction organisations while identifying the possible process maturity – IT maturity gaps, and to determine its effect towards the achievement of the higher maturity levels of the SPICE framework
6. To build a process IT – Co maturation framework, using the outcomes of the above objectives, to assist the achievement of higher SPICE maturity levels.

The following model illustrates the concept of the research.

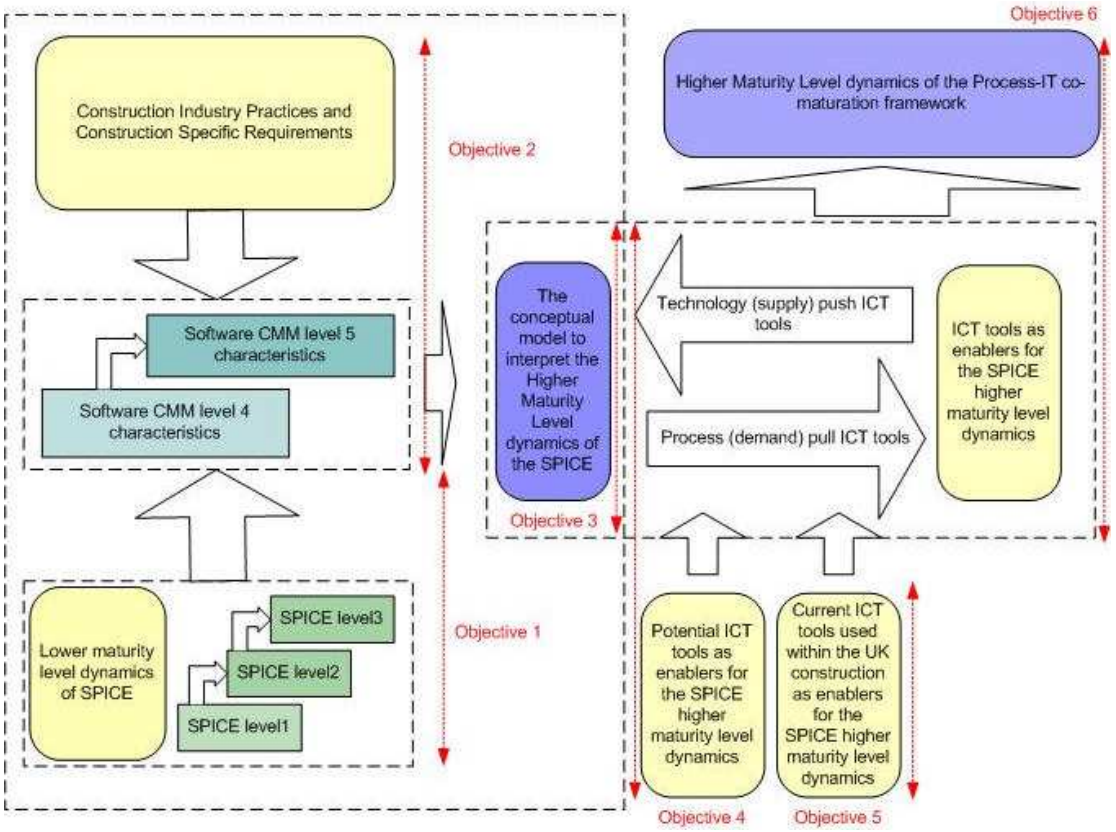


*Figure 1 - The Conceptual Research Model*

## 6. RESEARCH QUESTIONS

Based on the arguments put forward in section 3.4 of the paper, attempts will be taken to find answers for the following research questions, particularly to achieve the objectives listed in section 5:

1. What is the impact made by the current SPICE framework within the UK construction organisation?
2. How the characteristics of CMM higher maturity level dynamics can be characterised within UK construction organisations to enhance the existing SPICE framework?
3. What are the potential IT tools that can be used as an enabler to initiate the extension of the SPICE framework?
4. How the potential IT tools can be used synergistically to enable the effective achievement of SPICE higher maturity levels?

## 7. METHODOLOGY

This study follows the nested approach to determine the appropriate methodology to achieve the aims of the study (Kagioglou et al, 1998). Within this model the research techniques are guided and energised by the research approaches, and the research approaches are guided and energised by the research philosophy (Kagioglou et al, 1998). Each element of this model is discussed in subsequent sections.

## 7.1 Research Philosophies

According to the Easterby-Smith et al (2002), there are at least three reasons that emphasise the importance of understanding philosophical issues when conducting a research. Firstly, it helps to clarify the research design. Secondly, it helps the researcher to identify which research designs will work and which research designs will not work under different circumstances. Finally, it helps the researcher to identify and create research designs which may be outside his past experience. Easterby-Smith et al (2002) highlight two contrasting ends of the philosophical traditions continuum, about how social research should be conducted; the positivism and the constructionism (interpretivism). The positivists argue that the world exists externally and its properties should be measured through objective methods. The constructivists argue that the reality is not objective and exterior but is socially constructed and given meaning by people (Easterby-Smith et al, 2002). The difference between these two traditions is mainly based on their ontological, epistemological and axiological assumptions that the researcher need to be explicit about (Sexton, 2003). The positivism attached to the ontological assumption of reality being external and objective. This view is known as the traditional realism Easterby-Smith et al (2002). Further it carries an epistemological assumption of knowledge is only significant, if it is based on observations of this external reality Easterby-Smith et al (2002)Moreover, it is based on the axiological view that research is value free and unbiased. The constructivism is ontologically based on the view that the world is socially constructed and subjective. This represents the opposite end of the ontological spectrum, the idealism (Gummesson, 1991). Epistemologically it takes the view that the knowledge is subjective. Further, it carries the axiological view of research is value laden and biased. Easterby-Smith et al (2002) have presented a comparison between the positivism and social constructionism as presented within the table 1:

Table 1-Contrasting implications of positivism and social constructionism - Easterby-Smith et al (2002)

| **Item** | **Positivism** | **Social Constructionism** |
|---|---|---|
| The observer | Must be independent | Is part of what is being observed |
| Human interests | 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 | Hypothesis and deductions | 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 simplest terms | May include the complexity of "whole" situations |
| Generalisation through | Statistical probability | Theoretical abstraction |
| Sampling requires | Large numbers selected randomly | Small numbers of cases chosen for specific reasons |

The discussion above provide a basis to judge the philosophical base of the study in question. As set out by the aims and objectives, this research is largely a theory building attempt rather than a theory testing attempt. It involves the study of complex interactions between people, technological influences and construction processes in real-life settings.

Moreover, this study is largely context specific, demanding to focus on in-depth studies on small samples within uncontrolled environments. Objectives such as the development of the higher maturity level conceptual model and the development of the process – IT co-maturity framework demands the study to be of more exploratory nature. This nature of the study is undoubtedly contributing to establish its research philosophical base within the epistemological territory of the social constructionism (interpretivism), ontological stand of idealism and axiological view of being value laden and biased. This philosophical standing of the research influences the selection of appropriate research approach as described within the next section.

## 7.2 The Research Approach

Research approaches are about organising research activity, including the collection of data in ways that are most likely to achieve the research aims (Easterby-Smith et al, 2002). Bell (1993) suggests five major research approaches. Those are Action research, Ethnographic research, Surveys, Case studies and Experiments. Sexton (2003) discussed some these approaches as a continuum based on the ontological and epistemological stands of the study (figure 2):

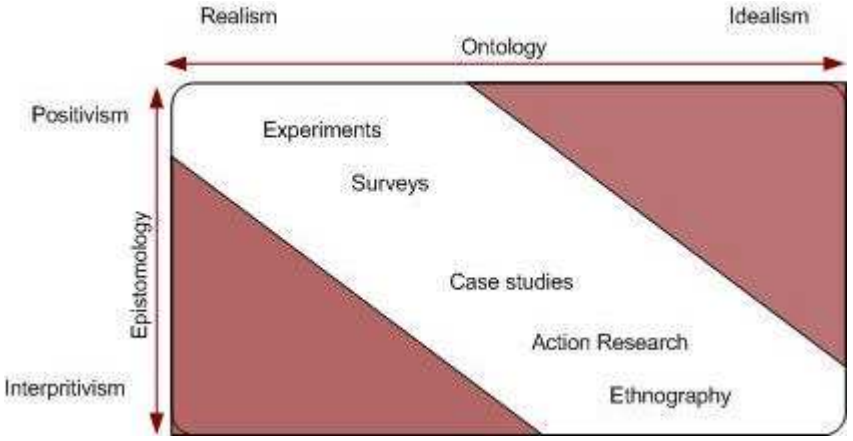


*Figure 2 - Research approaches continuum (Adopted from: Sexton, 2003)*

By examining this continuum, it is visible that experiments and surveys can be placed close to the positivism end of the epistemological stand and the realism end of the ontological stand, and the case studies, action research and ethnography occupies the interpretivism territory of the epistemological stand and idealism end of the ontological stand. Since the research in question resides mainly within the philosophical territory characterised by the interpretivism and idealism, the main research approach is a choice from ethnography, action research or case study research. Ethnography approach is better suited to understand the reasons for the behaviour of the subject over a prolonged period of time within a natural setting (Burns, 2000). In action research the researcher tries to solve the problem by being a part within the problem environment with a goal to change the status quo of the situation by changing the attitudes or the behaviour of the participants. Yin (2003) defines 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. Further Yin (2003) proposes three conditions when selecting the appropriate research approach:

1. the type of research question posed
2. the necessity of intervention to control variables
3. the focus on contemporary events

The study in question is built around "how" and "what" questions related to processes within organisations and does indent to study complex interactions between people, technological influences and construction processes within a sociological level but does not intend to observe behavioural patterns or the psychology of the participants where ethnographic approach would have been beneficial. Further, it concentrates on contemporary events, but does not demand to control the variables of the environment, and preferred to be conducted within an uncontrolled environment. These values when combined with the definition above, makes the case study approach the most preferred for the study in question. However, to achieve some objectives, it may require to adopt more than one research approach due to the nature of the objective. For an example, when evaluating the current usage of IT tools within the construction industry (the fifth objective), a survey approach would be more appropriate as the expected outcome is of less exploratory nature. In this context, section 8 discusses the application of "case study philosophy" within this research.

## 8. THE CASE STUDY DESIGN

### 8.1 Multiple verses Single case studies

Determining the choice between single verses multiple case studies and holistic verses embedded unit of analysis create the 2X2 matrix for the basic types of case study designs (Yin, 2003). Being either a critical, unique, representative, revelatory or longitudinal case provide the rationale to select the single case method over multiple cases. The study in question does not reflect any of these cases, thus the multiple case designs is preferred for the study in question. Selecting multiple cases further adds the distinct advantages of multiples sources of evidence and replication of findings. Since this intended to follow replication logic, rather than a sampling logic, each case is to be carefully selected, rather than randomly selected.

### 8.2 The unit of analysis

The second choice between holistic verses embedded case study designs is based on the selection of the unit of analysis of the study. Apart from the main unit of analysis, identification of the need of subunits within a single case provides the rationale for embedded case studies. The research questions of the study mainly reflect the requirement of a behavioural study at the organisational level, leaving organisation as the main unit of analysis. In addition, the research questions demand the investigation of higher maturity level dynamics and role of IT as an enabler within higher maturity level dynamics as investigatory phenomenon within the organisation. This poses the above two phenomenon to become subunits within the main unit of analysis. This makes the multiple-embedded design as the most appropriate case design for the study in question.

The research design should also establish the external validity of the study. This largely addresses the generalisation issues of the study (Yin, 2003: 37). Being adopting a case study approach, the study in question addresses the generalisation through analytical generalisation, rather than statistical generalisation. Further, being a multiple case study design, this aims at using replication logic, instead of theories as the mode of analytical generalisation. According to the Kagioglou et al (1998)'s nested model, research approach is the immediate influential factor for the selection of proper research techniques.

## 9. RESEARCH TECHNIQUES

Since the major research approach of this study is case studies, the research techniques are discussed largely within the remit of case study research approach. Research techniques can be described under two major phases of the study; the data collection techniques and data analysis techniques.

### 9.1 Data collection techniques

Yin (2003: 97) describes three principles for data collection. The first principle emphasises the importance of multiple source of evidence in case study research. Further he has identified six sources of data collection under case study approaches. Those are: documents, archival records, interviews, direct observation, participant observation and physical artefacts. The rationale for using the multiple sources of evidence has been described as the Triangulation (Yin, 2003). Specifically data triangulation leads to eliminate problems related to construct validity which is an important aspect when determining the quality of case study research. Apart from the emphasis on use of multiple evidence sources and data triangulation, Yin (2003) further highlights that, the benefits from the above six sources of evidence can be maximised, if the researcher adhere to another two principles. Those are; to cerate a case study database and maintain a chain of evidence. The main purpose of the case study database as Yin (2003) has identified, is that, it provides a critical reader with opportunity to go back to the raw data as and when required. The chain of evidence makes the case study more reliable where the case study reviewer is allowed to follow the derivation of the evidence from the research question formation to the case study conclusions.

Within the research in concern, interviews and the documents will be taken as the major sources to create the data triangulation for the first, second and third objectives (see section 5). Since the second research question demand specific, in detail information about processes of the case study organisation, documents like organisational process maps, process descriptions and process manuals will provide valuable information. When achieving the first objective of the study, past research archival records like case study database and questionnaires will become a main data source, as it specifically looks at the current status of the SPICE framework. Further, interviews with strategic and operational decision makers (especially top level and operational level managers) will be another channel of data, which will enable the data triangulation to take place. Apart from these data collection techniques, questionnaires and interviews will have to be used, specifically to evaluate the current usage of IT tools within the industry as a part of achieving the fifth objective of the study. There will be further steps taken to maintain case study databases and a chain of evidence of case studies related to this study.

### 9.2 Data analysis techniques

The next most important factor to be considered under the research techniques is the data analysis techniques. The analysis of case study evidence is one of the least developed and most difficult aspects of doing case studies (Yin, 2003). Mills and Huberman (1994) have summarised some analytical manipulation methodologies:

1. Putting information into different arrays
2. Making a matrix of categories
3. Creating data displays
4. Tabulating the frequency of different events

Even though these manipulation methodologies are available in terms of case study data analysis, establishing a data analysis strategy before collecting the data will be useful. Yin (2003) describes three such strategies. The first and most preferred strategy is relying on the theoretical propositions, where the original research questions were based on. The second strategy is thinking bout the rival explanations. And the third and least preferred strategy is to develop a case description. Further, Yin (2003) explains few data analysis techniques to be used within the above described strategies. Those are; pattern matching, explanation building and logic models. Pattern matching basically compares empirically based pattern with the predicted one (Yin, 2003). This strengthens the internal validly. The goal of explanation building is to analyse the case study data by building an explanation about the case. This procedure is mainly relevant to explanatory case studies rather than exploratory case studies (Yin, 2003). Within Logic model stipulates a complex chain of events over time. This matches empirically observed events to theoretically predicted events. The sequential nature of the stages distinguishes this approach from pattern matching. Under the given circumstances, this research adopts the pattern matching as the primary mode of data analysis for within case study analysis while considering explanation building for cross – case analysis to strengthen the external validity through replication logic (literal and theoretical).

## 10. CONCLUSION

Following a structured framework, the study discussed within this paper has managed to establish its methodology with appropriate justification. It has established its philosophical stand by justifiably selecting the ontological, epistemological and axiological stands. By establishing its stand within the social constructionism and idealism territories, it could justify the selection of case studies as the appropriate research approach. These stands then provided the foundation to establish its research techniques transparently.

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