Complexity in Projects

A Study of Practitioners’ Understanding of Complexity in Relation to Existing Theoretical Models

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Acknowledgement

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Summary

Purpose

To evaluate how the understanding of complexity in projects amongst practitioners fit with the complexity models suggested in theory.

Design/Methodology/Approach

In order to achieve the above, the literature was initially reviewed. Through this review the six models of complexity as proposed by management writers were identified. Thereafter using the grounded theory approach, interviews with nine project managers who have been involved in complex projects were comparatively analyzed and their responses were coded. A simple questionnaire with a list of factors which might cause complexity was sent across for respondents to grade on a Likert scale.

Findings

The findings were broadly classified between Organizational Change projects and IT & Engineering projects. One of the major findings was that the number of elements in a project and its interdependence seem to be a key factor influencing complexity. Managing people seems to be a far greater challenge than technical issues faced in a project. Finally, communicating clearly seems to play a vital role in determining the level of complexity in a project.

Limitations

This research does have its limitations. It is essentially exploratory. Even though the cross section of interviewees represents several sectors, but it does not cover all the possible sectors which could have complex projects. This factor along with the small number of sample interviewees which were selected based on their availability rather than randomly limits the possibilities for generalization of findings.

Originality/Value

This study can serve as a framework for further research and more extensive studies.

Paper Type

Masters thesis – Research paper

Keywords

Complex projects, complexity models, Grounded theory, structural complexity, technical complexity, uncertainty, IT and Engineering projects, Organizational change projects.
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Outline of the thesis

Section 1
Introduction

The thesis starts with an introduction which provides the background of the work. The purpose of this work, the benefits of this research and the research question have been discussed in this section. The possibility of further research stemming from this piece of work has also been considered in this chapter.

Chapter 2 deals with the literature review. In this chapter, the present status of the topic, i.e. what the management thinkers of today say about complexity has been elaborated. The role of complexity in project management today specifically in some selected sectors has been examined. Finally, some models of complexity suggested by academicians have been described in detail.

Section 3
Methodology

All the research tools used in the investigation for this study have been discussed in Chapter 3 – Methodology. The grounded theory approach, the benefits and limitations of the semi-structured interview and the questionnaire for quantitative data analysis have been discussed. This chapter gives a clear understanding of how the research was designed and the action plan for implementing the design.

Section 4
Findings and Analysis

In this chapter, the results of the data collected both qualitative and quantitative have been given. According to the grounded theory approach, data has been coded and sorted. The quantitative data is analyzed to see what emerges. An attempt has been made to find out the factors as per the understanding of the practitioners of what causes complexity in projects.

Section 5
Conclusion

The final chapter provides a summary of the findings. An effort has been made to verify if the results from the qualitative data conform to that of the quantitative. The chapter ends with a review of the complexity model that best fits the understanding of practitioners of complex projects.
SECTION 1: INTRODUCTION

‘I think the next century will be the century of complexity’. Stephen Hawking

‘The complexity of things – the things within things – just seems to be endless. I mean nothing is easy, nothing is simple’. Alice Munro

In today’s world, nothing is simple any longer. Both Hawking and Munro allude to what is to come in our future - complexity. The word ‘complex’ originates from the Latin words ‘cum’ meaning together or linked and ‘plexus’ meaning braided or plaited. The Oxford English Dictionary describes the term ‘complex’ as that ‘consisting of parts’ and ‘intricate – not easily analyzed or disentangled’. This is what Simon (1969) had meant when he described complex adaptive systems as something made up of large number of parts that interact in a non-simple way and the whole of which is more than the sum of its parts in a pragmatic sense.

In the last three decades, complexity theory has gained a lot of importance in several scientific disciplines like astronomy, geology, chemistry etc. It has slowly extended its usage in the field of project management. While trying to understand the managerial demands of modern day projects and the different situations faced in projects, the term ‘complexity’ is progressively becoming a benchmark term. In the recent past some of the challenging projects that have been completed are the Heathrow Terminal 5 and the construction of venues for the Beijing Olympics. But can we call these projects complex?

It is probably too simplistic to classify projects as complex or non-complex. What is particularly important is to identify the source of the complexity, the level and also the implications of the complexity. Several academicians have studied the different dimensions and established different classifications of complexity. These are put together into models of complexity.

But is this classification well-grounded in reality? This is what we aim to explore through this research. The specific questions that we wish to explore by conducting this research are:

- How does the understanding of project complexity in actuality conform to the theoretical complexity models?

In an effort to answer the primary question, our study will also throw some light on factors of complexity across different sectors. We hope that this distinction will pave way for further research within these sectors. This now brings us to our sub-question:

- How do the factors that contribute to complexity compare across different sectors?

At the outset of this research, the literature on complexity was reviewed. An attempt was made to understand what complexity means with a focus on the field of project management. It was observed that there is a new wave of thinking in this field and a camp which believes that regular project management tools and techniques cannot be used for complex projects.
This has drawn several academicians to generate models of complexity based on various factors. In this research we have focused on some important models like that of Turner and Cochrane, Ralph Stacey, Terry Williams, Kahane and Remington and Pollack. We have tried to see if any of these models fit in with how practitioners understand complexity.

To find out how practitioners comprehend complexity, we followed a grounded theory approach and also used quantitative methods to supplement the results in accordance in a mixed methodology. Semi-structured interviews were carried out with nine project managers from different sectors and different geographical locations. The interviews were analyzed and the data was broken down to different categories referred to as open coding where labelling was done. This was followed by Axial coding where we describe the properties and build relations between these categories. The final stage is selective coding where the emerged theory is integrated and refined.

Quantitative data was collected through a short questionnaire which listed out some factors which could cause or lead to complexity in projects. A total of 29 responses were obtained for the questionnaires. By analyzing this data we were able to determine the factors that project managers thought caused complexity in projects. A new dimension was also added by analyzing it sector-wise. Since we collected data from two different sources, via interviews and through questionnaires, it gave us the opportunity to triangulate the findings. We sincerely hope that this piece of work will pave way for future research on similar areas like models of complexity and perception of complexity in project management.
SECTION 2: LITERATURE REVIEW

For the purpose of clarity, we will begin with a typical definition of a project. Buchanan and Boddy (1992) define a project as a unique venture with a definitive beginning and an end, having established goals with parameters of cost, schedule and quality. This definition captures the traditional understanding of a project and also mentions the triple constraint (time, cost and quality) which is so often talked about. More recently, however, the term ‘complexity’ has increasingly become an important point of reference when we talk about projects. Practitioners frequently describe their projects as simple or complex when discussing management issues indicating a practical acceptance that conventional tools and techniques alone may not be sufficient. Simon (1969) is one of the early researchers to describe a complex system as one that is made up of a large number of parts that interact in a non-simple way. He further adds that in such systems, the whole is more than the sum of its parts. Later researchers based their definitions on this one and furthered it by adding concepts such as non-linearity (Richardson & Cilliers, 2001).

The ‘field’ of complexity science is a popular stream of thought that brings together a range of diverse disciplines within contemporary science (Richardson and Cilliers, 2001, Aritua et al, 2008). Some researchers like Rosenhead (1998) have doubted the cross-disciplinary application of complexity theory. Phelan (2001) explains that even though there are many definitions in the broad field of complexity, there are some common elements that are core to the different concepts of complexity. From a management perspective, complexity theory provides a rather different view and it is definitely picking up steam in the field of management science especially that of project management. This is aptly reflected in this statement by Frame (2002): ‘Project Management has operated in a management environment of chaos and complexity for decades’. Janice & Mengel, (2008) agree that the role of complexity, chaos and uncertainty within our projects and project environment is gaining recognition both in research and practice.

Complexity in projects is the main theme of this paper. The heart of the paper explores different models of complexity with an objective to find out if the understanding of real world project managers resonates with the theoretical models of complexity.

This now brings us to our Research Question:

How does the understanding of project complexity in actuality conform to the theoretical complexity models?

In addition to the main research question, we also attempt to answer the sub question:

- How do the factors that contribute to complexity compare across different sectors?
In order to answer the research question it is imperative to have a clear understanding of what constitutes a complex project and also to have a sound theoretical framework of selected complexity models.

It is important to understand that there is no clear distinction between complex, large, or complicated projects. There is a general acceptance that it is something more than simply a ‘big’ project (Williams, 1999). Dombkins’ (2008) viewpoint is that complicated projects are relatively common and are usually delivered by decomposing the projects into subprojects. Perhaps the main point of distinction is that complicated projects may be large but they might be manageable if their scope can be well defined right from the inception stage. On the contrary, it may be impossible to undertake accurate long term planning in complex projects. Girmscheid and Brockman (2008) add another outlook by suggesting that complicacy involves only the number of elements in a system while complexity includes their possible relationships as well. Richardson (2008) examines the difference using the aspect of linearity. He considers complicated projects to have linear thinking which is often ‘superficial and simplistic’, while complex projects follow non-linearity which is more sophisticated, implying that the output from one part is not necessarily proportional to its input. Snowden and Boone (2007) provide a clearer distinction between a complex and a complicated problem in the models section discussed later in the paper.

To put things in perspective, Laufer, et al (1996) tracked the evolution of styles that have dominated project management attitudes. The findings are summarised in the table below:

<table>
<thead>
<tr>
<th>Central Concept</th>
<th>Era of Model</th>
<th>Dominant Project Characteristics</th>
<th>Main Thrust</th>
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<td>Scheduling (Control)</td>
<td>1960s</td>
<td>Simple, Certain</td>
<td>Coordinating</td>
</tr>
<tr>
<td>Teamwork (Integration)</td>
<td>1970s</td>
<td>Complex, Uncertain</td>
<td>Cooperation between participants</td>
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<td>Reducing Uncertainty (flexibility)</td>
<td>1980s</td>
<td>Complex, Uncertain</td>
<td>Making stable decisions</td>
</tr>
<tr>
<td>Simultaneity (dynamism)</td>
<td>1990s</td>
<td>Complex, Uncertain, quick</td>
<td>Orchestrating contending demands</td>
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Table 1: Evolution of Models of Project Management (Laufer, Gordon, & Shenhar, 1996)

Laufer, Gordon, & Shenhar, (1996) explained how the 1960s was characterised by simple, certain projects; the 1970s by teamwork and the 1980s by projects for reducing uncertainty. In the 1990s we had to deal with dynamism for complex, uncertain and quick projects – these are the same aspects which Williams (1997) have used to define complexity.

As Baccarini (1996, p.201) puts it, “certain project characteristics provide a basis for determining the appropriate managerial actions required to complete a project successfully. Complexity is one such critical project dimension.” The approach taken to manage a project may depend on project characteristics like its strategic importance, length of the project, etc among other things.

The concept of complexity is still being used as an umbrella term associated with difficulty and interconnectedness (Geraldi, 2008). Complex systems primarily consist of two
parameters, interconnection and interdependence of distinct parts (Baccarini, 1996). Typically, the characteristics of a complex project would include difficulty, uncertainty (Williams, 2002), uniqueness (Crawford, 2005) indirect communication among elements (Luhman & Boje, 2001), dynamism (Kallinikos, 1998) and lack of clarity on the goals of the project (Turner & Cochrane, 1993). These characteristics unfold when we deal with different complexity models. It has to be kept in mind though, as pointed out by Stephen and Maylor (2008, p.3) that ‘simply having uncertain events during the course of the project does not constitute complexity; some amount of uncertainty is inevitable in all projects’.

In addition to the above mentioned characteristics, Dombkins (2008) added that complex projects have a high degree of disorder and instability. They are sensitive to small changes and are typically dynamic in nature. He further asserts that complex projects are not just complex adaptive systems but rather complex evolving systems. It is interesting to note that characteristics such as phase transition, adaptiveness, sensitivity, emergence and non-linearity to initial conditions are typical complex adaptive systems (Remington & Pollack, 2007). In fact, it could be argued that non-linearity underlies all of the other characteristics. These are well understood by referring to the complexity theory. In addition to these, Aritua et al (2008) have identified some more characteristics of complex adaptive systems, namely inter-relationships, self-organisation, emergence, feedback and non-linearity and have discussed their effects in multi-project situations. Payne (1995) in his study of multiple projects correlates complexity to those aspects concerned with the multiple interfaces between the projects, the projects and the organisation, the parties concerned etc. PMBOK (2004) primarily refers to complexity within the project management processes. A large and complex project may have some processes that will have to be iterated several times to define and meet stakeholder requirements (PMBOK, 2004). PMBOK’s definition is very limited and is more likely confusing complication with complexity.

Based on a typology of complexity proposed by Williams (2002), Geraldi (2008) talks about complexity of faith, complexity of fact and complexity of interaction.

- **Complexity of Faith** refers to complexity involved in creating something unique or solving new problems (Geraldi J., 2008). This type of complexity arises due to uncertainty. It is unsure whether the project outcome will work or not.

- **Complexity of Fact** is when we have to deal with large amount of interdependent information. However, there is no time to fully analyse and understand the information but a decision has to be taken. The challenge is to keep a holistic view of the problem and not get lost in the details (Geraldi J., 2008)

- **Complexity of Interaction** is present in interfaces such as neutrality, ambiguity etc and it intensifies the two types of complexities discussed above.

In an earlier paper, Geraldi and Adlbrecht (2007) concluded that these complexities vary over the life cycle of a project and that complexity of interaction is perceived to have the greater intensity during all phases of the project followed by complexity of fact and faith, in that order.
As mentioned above, Baccarini (1996, p. 201) defined project complexity as ‘consisting of many varied interrelated parts’ and can be operationalized in terms of *differentiation* and *interdependency*. A third element, which is uncertainty, is introduced by (Williams, 2002) and will be discussed in detail in the models section.

- **In terms of Organizational complexity**, differentiation would mean the number of hierarchical levels, number of units, division of tasks, etc. ‘Interdependency’ would be the degree of operational interdependencies between organizational elements (Baccarini, 1996). This differentiation has two dimensions:
  - Vertical Differentiation – referring to the depth of the organizational hierarchical structure (number of levels)
  - Horizontal Differentiation – which refers to the number of formal organization units and the division of tasks

- From a **Technological complexity** viewpoint, there seems to be a lack of consensus on the conceptual definition of technology. Technology can be divided into three areas: operations, characteristics of materials and characteristics of knowledge (Baccarini, 1996).
  - Technological complexity by differentiation refers to number and diversity of inputs and outputs and the number of different tasks to produce the end product.
  - Technological complexity by interdependency refers to the interdependent tasks and this could be classified into pooled, Sequential and reciprocal which is discussed in detail under Remington and Pollack model.

Apart from the parameters given by Baccarini, Jones and Deckro (1993) add another aspect to technical complexity, that of instability of the assumptions upon which the tasks are based. This is similar to the third element that of uncertainty introduced by Williams as discussed earlier.

The importance of complexity in project management is widely acknowledged (Baccarini, 1996; This was re-affirmed by authors like Bennett (1991), Bubshait (1992) and Gidado (1993) as cited by Baccarini (1996). The following are some examples:

- Helps determine planning, coordination and control requirements
- Hinders the clear identification of goals and objectives
- It is an important criteria for project selection
- Assists in selecting the suitable procurement arrangement
- Complexity affects the project objectives of time, cost and quality

### 2.1. An Industry Perspective

Projects undertaken in the area of defence, aerospace, information and communication technology, change management, research & development and strategic outsourcing are typically characterized by complexity.
We will analyse complexity from an industry perspective and see how it might be approached differently. To start with, we will look at the construction industry. Baccarini (1996, p.201) asserts “construction projects are invariably complex and since World War II have become progressively more so.” Santana (1990) classifies them into three categories: Normal, Complex and Singular.

- **Singular** projects are unique in that they require long periods of planning and execution. Projects undertaken by governments and MNCs requiring major investments and complicated systems of management fall under this category (Santana, 1990). The Seikan tunnel in Japan and the Channel Tunnels are typical examples of such complexity.

- **Industrial projects** are classified as **Complex**. They are not as unique as singular and the problems are better known. Projects involving public works and town development come under this category.

- **Normal** construction includes other projects like buildings, roads and earthworks. Complete planning can be done before the work is undertaken.

An interesting study was done by Kumar et al, (2005) on a Power Project development where the complexity was analysed based on Williams (1999) model. The project was a complex undertaking encompassing both structural complexity and uncertainty.

The structural complexity stems from the fact that there were multiple stakeholders: regulatory agencies, local and international financial institutions, equipment suppliers, subcontractors, fuel suppliers and other stakeholders. From an uncertainty perspective, it was not clear whether the objective of the project was to establish a market presence or to maximize returns on a project-to-project basis. (Kumar et al, 2005)

Another key area where complexity becomes a challenge is the field of Product Development. The deliverable may be complex in its function, form, integration or technology (Danilovic & Browning, 2007). There is fair level of interdependency between functions and this adds to the complexity. It should be noticed that Baccarini (1996) discusses this type of complexity at the outset. Uncertainty usually stems from assumptions about dependencies and the need for information exchange between people to solve problems and define/design and manufacture the final product (Danilovic & Browning, 2007).

In Plant Engineering projects, the main source of complexity appears to be from interaction, viz. Internationality and multi-disciplinary (Muller & Geraldi, 2007). The other sources include size, interdependency and number of sources. The complexity implies that the problems in such projects could be solved logically. Girmscheid and Brockman (2008) have identified five types of complexity in engineering projects, namely task complexity, social complexity, cultural complexity, operative complexity and cognitive complexity.

**IT projects** on the other hand have intangibles as deliverables. The key sources of complexity entails frequency and severances of scope changes, immaturity and multi-disciplinary. Trust in organizations’ capabilities and frequent changes are the main issues for complexity in IT related projects (Muller & Geraldi, 2007).
2.2. What is a model?
Before we analyze complexity models, it is important to understand what a model is. Going by the dictionary term, a model is “a simplified description of a system or complex entity, especially one designed to facilitate calculations and predictions”. Williams, (2002, p.32) breaks it down into the following key attributes of a model:

- A model represents or describes something real. This implies that a model must be formal, theoretically based definitions of reality that can be manipulated. It also defines the relationships between the concepts.
- A model simplifies that real entity. The real world is complex and hence one of the key advantages of modelling is that it helps to simplify the key elements of reality and provide us with the information we need.
- The production of a model has a purpose, generally to make some sort of calculation or predict how the entity will behave.

The most fundamental use of the model is to ensure that it helps in decision making.

2.3. Analysis of key complexity models
Having gained a fair understanding of what complex projects are and how complexity has evolved over time, we now turn our focus to complexity models. For the purpose of our research, we will analyse a select few models and draw inferences from them. We have selected these models because they seemed to be most relevant to project management context. Three of these models are directly formulated for project management and others have focused on problem solving in a change management context. Projects cause change in organisations and although the approaches used in change management are often different from those used in traditional engineering type projects they start to overlap when projects are carried out within an organisational context. In addition, to have a clearer picture we will look at them in a chronological order.

2.3.1. Goals and Methods Matrix by Turner & Cochrane
One way of assessing the potential complexity of a project has been suggested by Turner and Cochrane who have developed a 'Goals and Methods Matrix'. Turner and Cochrane (1993) classify projects using two parameters:

- How well defined the goals are, and
- How well defined are the methods of achieving those goals

Looking at ill defined methods to achieve goals, Turner and Cochrane (1993) suggest that if methods are uncertain, the fundamental building blocks of Project Management will not be known. For instance, the WBS, tasks required to complete the job, the OBS, etc.
Type 1 projects are well defined and understood. The role of the project manager is that of a conductor. Type 2 projects have well defined goals but poorly defined activities. In this case, planning has to be done on a rolling wave technique as information becomes available. The role of the project manager is that of a coach. It should be recalled that Danilovic and Browning (2007) mentioned that deliverable may be complex in its function, form, integration or technology in relation to product development. They assert that product development is a consequence of elements and their relationships, and dynamic variations in both. The Type 3 projects have poorly defined goals but well defined methods. They are planned in life-cycle stages and the role of a project manager is that of a craftsman. Type 4 projects don’t score either on goals or methods. Typically, R&D projects have this quality. In our earlier discussion, we had talked about complexity from an industry perspective and we can see that areas like product development and Construction are typically type 2 and type 1 project respectively.

However, it must be borne in mind that this model could only act as a supplement or a support to a more robust model. The focus here is entirely on goals and methods and the author is silent on other critical aspects of complexity. This model addresses the ‘Uncertainty’ aspect of complexity but fails to address the interdependence of the elements in a model.

2.3.2. Stacey’s Agreement & Certainty Matrix
A useful map for navigating your way into the concepts and field of complexity is "The Stacey Matrix". Stacey (1996) analyzes the complexity on two dimensions: The degree of certainty and the level of agreement.
A close look at the matrix shows that there are different zones. Let’s analyze the implications of these zones.

- **Close to Agreement, Close to Certainty**
  
  This zone forms the part of “Simple” projects where there is rational decision making. People involved in the project agree on what needs to be done. The traditional management approach works best and most of the management literature and theory address this region. The goal is to identify the right process where efficiency and effectiveness is maximised (Stacey, 1996).

- **Far from Agreement, Close to Certainty**
  
  While there may be agreement on how outcomes are created, there could be disagreement as to which outcomes are desirable. This leads to political game play in an organization. Typically, coalition building, negotiation and compromise are used to solve the situation.

  It is interesting to note that this complexity could be defined as ‘directionally complex’ which is dealt in the Remington and Pollack model later in the paper. The progress towards superficially agreed goals is hampered by political motivations and hidden agendas. (Remington & Pollack, 2007)

- **Close to Agreement, Far from Certainty**
  
  The ultimate goal is agreed upon, but it is unsure as to how to get there. Traditional management approaches may not work and you cannot have a predetermined plan. There has to be strong leadership with a sense of shared mission. Williams, (2002) points out that uncertainty in goals often causes changes and this leads to increase in structural complexity.
Anarchy: Far from Agreement, Far from certainty

On the other extreme, we have total anarchy where no one agrees on the plans and there is a high level of uncertainty. The traditional methods of project management will not work and perhaps the only solution is avoidance. Organizations should stay away from such situations as much as possible.

Stacey’s matrix is primarily focussed on change. This model is useful for choosing between leadership approaches for a specific issue. However, it is just one aspect of tackling a complex project. It may facilitate as an aid to approach projects based on where you are placed on the matrix but does not go beyond to demonstrate the interdependencies.

2.3.3. Complexity Model suggested by Terry Williams

A prominent author in the field of complexity is Terry Williams who shares the view of Baccarini (1996) on complexity but extends it by one additional dimension. In addition to the two components of complexity, viz. number of elements and the interdependency of these elements, he introduces the third element which is Uncertainty. Since uncertainty adds to the complexity of a project, therefore it can be viewed as a constituent dimension of project complexity (Williams, 2002).

Figure 3: Dimensions of Project Complexity (Williams, 2002)

To summarize, the author suggests that overall project complexity can be characterized by two dimensions, each having two sub-dimensions. These two sub-dimensions lead to a complex system in which the whole is more than the sum of the parts (Williams, 2002).
Williams (2002) points out that ‘complexity’ in projects is steadily increasing and this increasing complexity is part of the cause of projects going wrong. He attributes this to two compounding causes:

1. Relationship between product complexity and project complexity. As new products are developed they become more structurally complex and there is a greater degree of inter-element connectivity.
2. Second cause is the length of the projects. Projects have become more time constrained as there is an increasing desire to reduce time to market. (Williams, 2002)

2.3.4. Adam Kahane’s approach to complexity

Kahane (2004) puts a lot of emphasis on talking and listening to each other when solving tough problems. His approach to complexity is deeply rooted in a social environment. He distinguishes complexity in three ways:

- **Dynamic Complexity**
  This means that the cause and effect are far apart and it is hard to grasp from first-hand experience. They usually unfold in unpredictable and unfamiliar ways. In addition, people involved in the problem see things very differently.

- **Generative Complexity**
  This type of complexity is characterized by a situation where you cannot calculate the solution in advance based on what has worked in the past. The future is unfamiliar and undetermined.

- **Social Complexity**
  When dealing with social complexity, the people involved must participate in creating and implementing the solution. The people involved have diverse perspectives and interests.

(Kahane, 2004) introduced the U-process as a methodology for addressing complex challenges. In using the U-process, an individual or team undertakes three activities:

- Sensing the current reality of the system of which they are part
- Presencing and reflecting to allow their “inner knowledge” to emerge, about what is going on and what they have to do
- Realizing, and acting swiftly to bring forth a new reality. (Kahane, 2004)
As we move from Sensing to Realizing, we shift from uncovering current reality to creating new reality.

Similar to Stacey’s matrix, Kahane’s primary focus is on change but with emphasis on international conflict resolution. Kahane (2004) himself admits that his approach does not always work, though he has rare successes and frequent insights. His strong focus on the soft aspects of listening and collaborative learning leaves some questions unanswered on the structural complexity and technological complexity aspect.

2.3.5. **Cynefin Decision Making Framework**

Another interesting framework was developed by Snowden and Boone (2007) called the Cynefin framework which allows executives to see new things from new viewpoints, assimilate complex concepts, and address real world problems and opportunities. The framework sorts it into five contexts based on cause and effect.

The first four are simple, complicated, complex and chaotic. The last one is disorder which is applied when it is unclear which of the four is dominant. The following table clearly depicts the characteristics of each context and ways to tackle them.
To sum up, each domain in the framework requires different actions. The simple and complicated domain is characterized by cause and effect relationships and right answers can be determined based on facts. On the other hand, the complex and chaotic domains do not have a clear cause and effect relationship. You will be forced to make a decision based on incomplete data. The last domain, which is anarchy, can be tackled by breaking it down into small components and then assigning them to the other four domains. (Snowden & Boone, 2007)

It is important to note that Snowden and Boone (2007) have identified the complex system by its behaviour rather than characteristics. The cause and effect relationship and the unpredictable nature of complex systems are typical examples of it. It is more descriptive in nature and not prescriptive. The classification is oversimplified and the model is essentially focussed on the leadership perspective.
2.3.6. Remington & Pollack Model

Among the latest contributors are Remington and Pollack (2007) who provide a good starting point for categorizing complex projects. They emphasize that a clear distinction on the type of complexity helps in selecting the appropriate tool to manage the project. Based on the source of complexity and informed by the work of others Remington and Pollack (2007) suggest four types of project complexity:

- Structural complexity
- Technical complexity
- Directional complexity
- Temporal complexity

**Structural complexity** stems from large scale projects which are typically broken down to small tasks and separate contracts. Projects in the engineering, construction, IT and defence sectors are likely to have this kind of complexity. Structurally complex projects are often classified as complicated projects and this may be a debatable issue. However, the complexity stems from the difficulty in managing and keeping track of huge number of interconnected tasks and activities (Remington & Pollack, 2007).

While on the subject of Structural complexity, Williams, (2002) suggests that uncertainty in goals usually adds to structural complexity. Perhaps a good example would be software development projects where the goals are uncertain, since user requirements are difficult to specify and are subject to change. This action of making changes increases the project (structural) complexity.

In addition to that, Williams, (2002) suggests that there are two other aspects of structural complexity that needs to be taken into account:

1. The Objectives of our project – virtually all projects have multiple objectives with conflicting goals. This adds an element of structural complexity to the project
2. Virtually all projects have complexity within the stakeholders. Perhaps a good example of this kind of complexity is the Euro Tunnel project where the Eurotunnel concessionaire, the French and the British governments and the Inter Governmental Commission were involved. (Williams, 2002)

“**Technical complexity** is found in projects which have design characteristics or technical aspects that are unknown or untried” (Remington & Pollack, 2007). Complexity arises because of uncertainty regarding the outcome for many interdependent design solutions. Typically, architectural, industrial design and R&D projects are faced with this type of complexity.

It is interesting to note that (Baccarini, 1996) categorizes technological complexity in terms of differentiation and interdependencies. This view is shared by Remington & Pollock (2007) and Thompson (1967) further elaborates the interdependencies by categorizing into three types given in ascending order of complexity:

- **Pooled**, in which each element gives a discrete contribution to the project
Complexity in Projects

- **Sequential**, where one element’s output becomes another’s input
- **Reciprocal**, where each element’s output becomes inputs for other elements (Thompson, 1967).

**Directional complexity** is characterized by projects where the direction for the project is not understood or agreed upon. “Directional complexity is often found in change projects, when it is clear that something must be done to improve a problematic situation, but it is unclear what this ‘something’ should be.” (Remington & Pollack, 2007, p.51)

**Temporal complexity** results in projects where there is a high level of uncertainty regarding future constraints and could destabilise the project completely. Unexpected legislative changes, rapid change in technology making the project redundant are some typical situations where temporal complexity kicks in.

Being a fairly recent work, Remington and Pollack (2007) have been able to synthesise relevant models in the field of complex project management. Their approach is a big departure from traditional project management techniques. Their model sets the baseline upon which all the other models interact in different ways.

Dombkins (2008) was willing to go so far as to claim that complex project management is a specialist profession that requires a specific set of competencies. While the need for development of the means to manage complex projects is acknowledged, a critical evaluation of Dombkin’s definition of complex projects showed significant flaws (Stephen & Maylor, 2008). A deep understanding of context, the ability to embrace complexity, and a willingness to change leadership style will be required for leaders who want to make things happen in a time of increasing uncertainty (Snowden & Boone, 2007).

After reviewing some of these complexity models, it is clear that every model looks at complexity from a different perspective. While some of the key factors like structural complexity, uncertainty, technical complexity and clarity of goals seem to resonate in different models, there is no “one model fits all” solution out there. In the following sections, we will try to bring the experience of the practitioners and see how they fit with the complexity models. We will also attempt to look from different industry perspectives and see the kind of theory that emerges from grounded theory.
SECTION 3: METHODOLOGY

The purpose of the methodology section of a research project is to describe and analyze the methods used in the research and also to cover the limitations and resources of the study (Kaplan, 1973).

In this section we will first outline the research philosophy and the stance taken for this research project. This is followed by the research approach and the strategy used along with the methods for data collection, in order to answer the research question. Finally the ethical considerations have been addressed as well as the techniques used to assure the anonymity of the respondents.

3.1. Research Philosophy

The primary purpose of conducting research is to develop knowledge in a particular field. As Saunders et al. (2006) put it, the research philosophy is concerned with the development of knowledge and the nature of that knowledge. When trying to understand how the practitioners view complexity in projects we make certain assumptions about the way we view the world and this helps us in defining our research strategy.

The research onion suggested by Saunders (2006) is good way to depict the philosophy and approach of our research.
In order to understand which philosophy suits best for our research, it is important to understand epistemology. This concerns what should be regarded as acceptable knowledge in a discipline (Bryman & Bell, 2003). Within this consideration, we have two extremes of positivism and phenomenology. As a positivist, you take the stance of a natural scientist and focus is on facts. Typically, an hypothesis is formulated which can be later tested and this type of research is objective in nature. However, as Saunders (2006, p.106) rightly points out, ‘the rich insights into the complex world is lost if such complexity is reduced to mere law-like generalisations’. Interpretivism is closely related to and influenced by phenomenology. Interpretivists, believe that all knowledge is a matter of interpretation and share the view that the social sciences – people and their institutions, are fundamentally different from that of natural sciences (Bryman & Bell, 2003). Therefore, a phenomenologist takes a subjective view of the world and develops social scientific accounts of life by drawing on the concepts and meanings used by actors which might be overlooked from a purely positivist framework.

The critical challenge for an interpretivist is to enter the social world of our research subjects and understand it from their point of view (Saunders et al, 2006). The positivist approach is often underpinned by deductive reasoning and the interpretivist approach leans towards inductive research. Trochim and Donnelley (2006) point out that research based on inductive reasoning, by its very nature, is more open ended and exploratory, especially at the beginning. Deductive research is narrower in nature and is concerned with testing or confirming hypotheses. Another major difference between these two approaches is that deductive research is primarily based on scientific principles while inductive research aims to gain an understanding of the meanings humans attach to events.

In between these two extremes lies realism which is a branch of philosophy assuming a scientific approach similar to positivism (Saunders et al, 2006). The first type of realism, often known as direct realism, says that what you see is what you get. Whatever our senses experience is how the world is portrayed. The other type of realism is critical realism. Critical realism argues that our first experiences could be deceptive and there is a need for mental processing after the sensation meets our senses. (Saunders et al, 2006).

It is important to therefore to our particular research question at this point. We are trying to understand project complexity in practice compared to the theoretical models suggested by the academic world. Hence it is apparent that a purely positivist or interpretivist approach may not work. Therefore, our research philosophy is informed by realism, inclined towards an inductive approach. Saunders (2006) argues that the critical realism approach is highly relevant to business and management research.

3.2. Research Strategy

The research strategy is a general plan of how to go about answering the research question (Saunders et al., 2000). According to these authors, this strategy should have a clear objective which is derived from the research question, indicate the sources from which data may be collected and list out the constraints faced by the researcher. Most importantly the strategy should be appropriate for answering the research question on hand. Remenyi et al. (1998) agree with having a clear research question and go on to list the benefits of this. According to
them a clear research question facilitates communication and allows the sharing of common experiences among researchers; ensures the use of an acceptable logical structure; and institutionalizes conceptual frameworks for communication, rules of reasoning, procedures and methods for observation and verification.

Bryman and Bell (2003) divide research strategy into two different clusters: quantitative and qualitative research. They go on to explain that quantitative research focuses on quantification in data collection and analysis. It involves a deductive approach with an emphasis on theory testing, incorporates the practices of natural scientific model, in particular positivism, and embodies a view of social reality as an external objective reality. On the other hand, they point out that the focus in qualitative research is on words in collection and analysis of data. According to them, qualitative research has an inductive approach emphasizing the generation of theories, the ways that individuals interpret their social world and it embodies a view of social reality as a constantly shifting emergent property of individuals’ creation.

After developing an understanding of the different methodologies, in order to answer our research question we realized that it would be most appropriate to use an inductive approach using grounded theory as our research methodology. Grounded theory will be explained later in this section. The unit of analysis in this research is the individual respondent i.e. the project manager. The idea of triangulation (Bryman and Bell, 2003; Trochim, 2006) was adopted whereby both qualitative and quantitative data was collected, so as to increase the validity of our findings and reduce error and bias. The limitations of our research method will be discussed later.

The reason for choosing a qualitative method in this research was the nature of the field. On reviewing the literature it was observed that although there were plenty of models of project complexity suggested by various authors, not much work had been done on understanding of complexity in projects by practitioners. The need to have a reflective approach in the research strengthened the argument for the use of qualitative methods. Through this research we are making an attempt to understand the nature of experience of our respondents, as regards to handling complex projects. As we are trying to discover intricate details about phenomena such as perceptions, feelings and thought processes, qualitative research is ideally suited for this research; as such understanding is difficult to extract through conventional research methods. We supplement this method by collecting some quantitative data in order to test the theory that is generated from the qualitative method. A quantitative approach also helps in understanding the trend or popularity of the factors which lead to project complexity in the world of project management. However any conclusions reached are severely limited by our sample size.

Grounded theory is a methodology which was originally developed by two sociologists, Barney Glaser and Anselm Strauss who through this methodology focused on the generation rather than the verification of theory (Glaser and Strauss, 1967). Goulding (2002) traces the roots of grounded theory to a movement known as symbolic interactionism, the origins of which, according to her, lie in the works of Charles Cooley (1864 – 1929) and George
Herbert Mead (1863 – 1931). She explains that in this methodology, the researcher has to enter the worlds of the subjects being studied so as to understand the subject’s environment and the interactions and interpretations that occur. Grounded on this interpretation of behaviour, words and action, the researcher is required to develop a theory. Grounded theory as a methodology fits into an interpretivist framework. Hence, this paper takes a more realist stance as opposed to the positivist or the interpretivist view.

We had discussed earlier in this section the distinction between the inductive and deductive approaches. Though grounded theory is considered to be an appropriate use of the inductive approach, several authors have considered it to be a combination of induction and deduction as there is constant reference to the data, to develop and test the theory (Saunders et al., 2003; Hussey and Hussey, 1997). Grounded theory has been defined as ‘theory that was derived from data, systematically gathered and analyzed through the research process; in this method, data collection, analysis and eventual theory stand in close relationship to one another’ (Strauss and Corbin, 1998, pp 12).

According to the precepts of grounded theory a researcher starts the research with no pre-conceived notions and generates a theory where there is little already known or provides a slant on a pre-established theory. As per the original guidelines laid down by Glaser and Strauss (as cited in Goulding, 2002, p.43), the developed theory should:

- Enable prediction and explanation of behaviour
- Be useful in theoretical advances in sociology
- Be applicable in practice
- Provide a perspective on behaviour
- Guide and provide a style for research on particular areas of behaviour
- Provide clear enough categories and hypotheses so that crucial ones can be verified in present and future research

In grounded theory the data collection and analysis proceed concurrently. According to Strauss and Corbin (1998), the different stages of this methodology include open coding which involves the disaggregation of data into units, axial coding which is the process of recognizing relationships between categories and selective coding which is the integration of categories to produce a theory. As Turner (1983) puts it, the uniqueness of grounded theory is not in the investigation associated with it but in the manner in which the data collected is analyzed. In this research, we strived to perceive general themes in the data collected and process these general themes at different levels of abstraction. An attempt was made to use what Turner (1983) calls ‘creative theoretical imagination’. This was done by using the open coding followed by selective coding which helped the theory to emerge.

Over a period of time, the methodology itself has undergone a lot of change. Subsequent to the development of the theory, there was a split between the two original authors which
resulted in two versions of the methodology – the Glasserian and the Straussian. Glaser felt that the approach promoted by Strauss was ‘too prescriptive and emphasized too much the development of concepts rather than of theories’ (Glaser, 1992 as cited in Bryman and Bell, 2003, pp 541). This charge was rejected by Strauss and Corbin (whom Strauss had partnered with for his further research on grounded theory) claiming the differences to be purely based on the different writing styles and interpretation (Goulding, 2002).

As pointed out by Kirk and Van Staden (2001, pp 181), ‘Glaser’s approach produces theory, but leaves testing to other researchers that are interested in the area, whereas Strauss & Corbin call for constant verification and testing in the course of the research. In practice, time, cost and availability can constrain data collection and theory building. Although Glaser emphasizes the need to allow theory to emerge from the data, rather than forcing it as per Strauss & Corbin, the above three constraints may restrict the width and depth of the research as well as its potential for building good theory’.

Grounded theory can be used in a scenario ‘where there is comparatively little known about a phenomenon and reality is multi-faceted’ (Glaser and Strauss, 1967: Strauss and Corbin, 1990). Thus in this research we have chosen to use this methodology as it aptly fits the environment of the research and is suited for an exploratory study of the impact of a new phenomena such as complexity in projects. In the next section, we will discuss about the types of coding used in the grounded theory.

3.3. The Coding Process

Codes are tags or labels which are assigned to units of text. Coding serves as an analytical tool for handling masses of raw data (Corbin & Strauss, 1990). It helps analysts to consider different meanings of the phenomena. The main purpose of coding is to identify, develop and relate the concepts which eventually helps in building a theory (Corbin & Strauss, 1990). There are several steps of coding and each type is discussed below.

3.3.1. Open Coding

The first step of analysis after the interviews started was open coding. Open coding is the process of selecting and naming categories from the analysis of the data. To fully understand the data collected, we must open up the text and expose the thoughts, ideas and meanings contained therein. During open coding, data are broken down into discrete parts, closely examined, and compared for similarities and differences (Strauss & Corbin, 1998).

Identification of the individual participant is not paramount, because the concepts generated by the participants- not the individual participants- are at the centre of study (Glaser, 1998).

3.3.2. Axial Coding

Axial Coding is the process of relating categories to their subcategories, termed “axial” because coding occurs around the axis of a category, linking categories at the level of properties and dimensions (Strauss & Corbin, 1998). As Goulding (2002) puts it, axial coding moves to a higher level of abstraction. By using axial coding, the researcher develops a category by specifying the conditions that gave rise to it. Axial coding usually forms the basis for the construction of the theory (Goulding, 2002).
3.3.3. Selective Coding
This is the final stage of analysis which builds upon the foundation of open coding and axial coding. Selective coding is “the process of selecting the central or core category, systematically relating it to other categories, validating those relationships and filling in categories that need further refinement” (Strauss & Corbin, 1998). The idea is to give an overall picture that explains the phenomena as to what are the core categories that adds to complexity in a project.

The data is related not only on a broad conceptual level but also at the property and dimensional levels for each major category (Strauss & Corbin, 1998). This helps in mapping the theory.

3.4. Data Collection
As Remenyi et al. (1998, pp 141) explain ‘researchers have the option of different approaches for collection of evidence and the choice of approach depends on the research strategy being followed and the research question itself’. Data for grounded theory may come from various sources. The data collection process may include interviews, observations, government documents, video tapes, letters, books, etc – anything that can shed some light on the questions under study. Each of these types of data can be coded in the same way as interviews (Glaser and Strauss, 1967; Corbin and Strauss, 1990).

In this research both primary and secondary data have been used. The primary data was collected mainly through semi-structured interviews and questionnaires, while the secondary data was compiled from the academic literature, largely from books and journal articles. We relied on the secondary data to provide a foundation for answering our research question as it enabled a comparison of the understanding of project complexity amongst practitioners vis-à-vis the complexity models suggested by academics.

3.4.1. Choosing an Interviewee
While choosing the respondents for the interviews we were limited by two constraints:

- The respondent should have been involved in complex projects, so as to ensure that the respondents have relevant experience and will be able to effectively contribute to the research topic. We defined a complex project based on number of elements and their interdependencies, uncertainty, technical aspects etc., found in the literature and the different models of complexity reviewed. For the purpose of choosing a respondent, a project in any sector which exhibited one or more of the types of complexities as discussed in the complexity models, was termed as a complex project.

- The different respondents should have a background from different industries, so as to get an idea about complexity in projects across the spectrum.

Through the semi-structured interviews we hoped to get an insight into the thoughts and experiences of the respondents with respect to the broader research area.
Once the criteria were generated, we developed a list of probable respondents who were likely to have been involved in complex projects (according to our definition). This was based on our personal and official contacts. We understand that this selection method introduced a bias into the data as the population was neither randomised nor comprehensive. However, a random sample would have introduced another source of bias based on individual definitions of what constitutes a complex project. We were also constrained by limitations of time and availability of respondents. Emails were sent to respondents giving a brief outline of our research and requesting them to participate. We had a good response rate, based on which dates and times were set up for each interviewee. While scheduling the interviews, we ensured that there was sufficient time in between each interview in order to analyze each one before proceeding to the next – this being a pre-requisite of the grounded theory approach.

3.4.2. The Respondents
As is seen in the table below we managed to complete interviews with 9 respondents who were not only from different sectors but also from different geographical locations. This would eventually help us to explore one additional aspect: whether the understanding of project complexity differed across the globe. To protect the identity of the respondents, we assigned codes for each respondent.

<table>
<thead>
<tr>
<th>Code</th>
<th>Sector</th>
<th>Base Country</th>
<th>Interview type</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT01</td>
<td>IT</td>
<td>Sweden</td>
<td>Face-to-face</td>
</tr>
<tr>
<td>IT02</td>
<td>IT &amp; Strategy</td>
<td>UK</td>
<td>Telephone</td>
</tr>
<tr>
<td>S01</td>
<td>Services</td>
<td>India</td>
<td>Telephone</td>
</tr>
<tr>
<td>E01</td>
<td>Engineering</td>
<td>Australia</td>
<td>Telephone</td>
</tr>
<tr>
<td>E001</td>
<td>Education</td>
<td>UK</td>
<td>Telephone</td>
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<td>S02</td>
<td>Services</td>
<td>India</td>
<td>Telephone</td>
</tr>
<tr>
<td>E02</td>
<td>Engineering</td>
<td>India</td>
<td>Telephone</td>
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<tr>
<td>S03</td>
<td>Services</td>
<td>Australia</td>
<td>Telephone</td>
</tr>
<tr>
<td>E03</td>
<td>Engineering</td>
<td>Australia</td>
<td>Telephone</td>
</tr>
</tbody>
</table>

Table 3: Interview Codes and Sectors

3.4.3. Interview
The questions in the interview were open-ended and designed to encourage free discussion (See Appendix B for list of common questions). The focus was mainly to get the respondents to talk about their experiences in handling different types of projects. Each interview was handled with a framework of some common questions which were relevant and therefore formed part of all the interviews. During the course of the interview, further clarifying questions were asked based on the responses received. Moreover, any relevant issues brought up by one respondent were incorporated for the next interview as is the practice in grounded theory approach. Hence, as recommended for grounded theory, by many authors, the analysis began as soon as the first bit of data was collected (Glaser and Strauss, 1967; Corbin and Strauss, 1990; Goulding, 2002; Bryman and Bell, 2003; Saunders et al., 2003; Strauss and Corbin, 1998; Glaser, 2001). We started our analysis by starting the coding and labelling
process after the first interview. This helped us to be more aware of the various possibilities and observe the patterns in the interviews that followed.

Each interview lasted for duration of thirty to forty five minutes. As is seen in the table most of the interviews had to be made by phone largely due to the location of the respondent. Though there are certain elements of difficulty in conducting telephonic interviews due to inability to interpret body language, we sought to overcome these difficulties by using a web camera when possible and at other times these could be recognized through voice and language.

3.4.4. Questionnaire
A self-completing questionnaire was also prepared with a list of factors which could lead to or cause complexity in projects. The respondents were asked to evaluate the factors and rank them on a 5 point Likert scale based on their experience and understanding. This questionnaire was completed by all the respondents. This questionnaire was sent to the respondents after the conduct of the interview, so as not to influence the data collected during the interviews. Apart from them, the questionnaires were also sent directly to people across various industries having project management experience. To facilitate a higher rate of response, an online version of the questionnaire was prepared and posted on project management forums. An online survey method was chosen due to the relative low cost to the researchers and also as such a survey has a high reach which would counter the limitations of low response rate.

3.5. Ethical Considerations
While conducting research an important aspect to remember is the issue related to confidentiality and ethics. As pointed out by Ackroyd and Hughes (1981, pp 77), “the task of the interviewer is to obtain information, often of a highly personal and private nature, from a respondent who is a stranger and has a little time and effort answering questions”. Project Managers being very busy people, the least we could do to express our gratitude was to assure them of anonymity as regards identity and the nature of data collected. Ackroyd and Hughes (1981, pp 78), also stress on the importance of building a sound relationship between the researcher and the interviewee, “the interviewer must communicate trust, reassurance, and likeableness to the respondent in order to maintain his or her interest and motivation in the continuance of the interview.

The “interviewer should never threaten respondents or destroy their confidence in the relationship”. This can be nurtured by adopting an ethical behaviour. This view is shared by Fritzche (1997, p. 22) who confirms that a correct ethical behaviour develops trust among people. Permission was sought at the start of the interview for recording the conversation so as to develop an environment of trust and also to avoid errors in reproducing the data for analysis, at a later stage, based purely on memory. This allowed us to take part in the interview ‘in a natural way’ as we avoided taking notes (Burns, 2000, pp 429). Confidence for participants was also ensured. It was explained that all original data would be coded, stored carefully and destroyed after a specified period to ensure confidentiality.
SECTION 4: DATA ANALYSIS AND FINDINGS

In this section, we will look at a step by step analysis of the coding process of grounded theory and see how some of the key concepts emerged. We will then turn our focus on looking at some of the key data that was collected during the interview process. To facilitate easy understanding, this analysis will be done on a sectoral basis. We will then look at a simple descriptive quantitative analysis of the data collected through questionnaires. Finally, we will examine the key findings of the research by attempting to triangulate the data collected from the interviews and the questionnaires. We will link our findings to the complexity models to see which elements have significant relevance to the factors mentioned in the complexity models.

4.1 The Interviews

It was very important at this stage to ensure that the researcher’s opinions were not interfering or influencing the thoughts of the interviewee. Our aim was to let the concepts ‘emerge’ instead of trying to force them into pre-defined categories.

Since the respondents were from varied backgrounds with tremendous experience, the data collected through the interviews were rich and provided some useful insights in understanding what they perceived as being complex in a project situation.

While our analysis covered many sectors, a common thread that drew them together was the nature of the projects. Hence, for ease of analysis we would look at what the practitioner experts believe contributes to the complexity. However, it should be noted that since our data comes from just few interviews, it may not be possible to generalize these findings for the entire sector or across sectors. They may be representative of specific projects but not necessarily others.

4.2 Open Coding

The analytical process started with the writing of notes during the interview after which a memo was written to capture the central themes of the interview. The next step was to transcribe the interviews and that paved way for the open coding. Many categories were identified in the first interview and the number of new categories started to progressively decrease as there was repetition. The result of this effort was a list of categories identified.

Open categories of different sources of complexity

- Number of people involved in the project
- High number of deliverables
- Issues that affect the milestones
- Dependence of one deliverable on the other
- No prior experience in this type of project
• Unsuitable contract for the project type
• Methods of achieving the project goals
• Operational pressures
• Resourcing problems
• Different parties vying for attention
• No proactive planning - absence of forward thinking
• Too much interference from the client
• Challenges in dealing with the client
• Changes in Government policies
• Unstable government in international projects
• Managing different agendas of the people involved
• Level of entanglement
• Communication between different parts of the organization
• High levels of interaction between people involved in the project
• Cultural Differences
• Managing people
• Managing internal clients
• Managing a remote location
• Decision making
• Office Politics
• Lack of common understanding
• No clear definition of the scope of the project
• Attitude towards technical complexity
• Personal threshold and capabilities

These categories summarise the key concepts found in the interviews. The next step is to proceed with Axial coding which involves refining the list by deleting or combining some of the categories.

4.3 Axial Coding
We had identified many categories in the open coding stage. We then tried to relate the categories and identify different levels of importance. For example, changes in government policies and unstable government typically refer to changes in external environment. So these factors could be put under one category.

The table below depicts how concepts emerge based on their categorisation.
Figure 6: Results of Axial Coding

Structural Complexity
- Number of people involved in the project
- High number of deliverables
- Level of entanglement
- Issues that affect the milestones
- Dependence of one deliverable on the other

Planning Issues
- No proactive planning - absence of forward thinking
- No prior experience in this type of project
- Unsuitable contract for the project type
- No clear definition of the scope of the project
- Methods of achieving the project goals

Operational Challenges
- Operational pressures
- Resourcing problems
- Managing a remote location
- Decision making

Stakeholder Management
- Different parties vying for attention
- Too much interference from the client
- Managing internal clients
- Managing different agendas of the people involved
- Challenges in dealing with the client

External Environment
- Changes in Government policies
- Unstable government in international projects

Effective Communication
- Communication between different parts of the organization
- High levels of interaction between people involved in the project
- Lack of common understanding

People Management
- Cultural Differences
- Managing people
- Office Politics

Personal Traits
- Attitude towards technical complexity
- Personal threshold and capabilities
4.4 Selective Coding

The key theory that emerges from the coding is as follows:

**Structural issues** seem to be at the heart of the project. By structural, we mean the number of elements in the project and the interdependence of each of these elements. It should be noted that this points straight to Baccarini’s (1996) model of complexity which was adapted by Williams (2002) and Remington & Pollack (2007) as one of the main sources of complexity. Every respondent in all the interviews talked about complexity arising from the sheer number of people in the project or the interplay between various elements in the project.

**Managing people issues** cuts across all the sectors completely overshadowing operational and technical challenges faced by the project. Handling people seems to be the most tricky and elusive. As one of the PM, E02 quipped during the interview, “We are dealing with people and not machines, and that makes it most challenging.”

**Stakeholder Management** is also prominent, which includes all internal and external stakeholders. At a macro level, the issues seem to stem from the challenges of managing the clients and also the internal stakeholders. This aspect seems to have a direct correlation with Structural complexity. A high degree of structural complexity leads to a more challenging stakeholder management.

**Communication channels** appear to overarch every issue playing a vital role in determining the complexity levels of a project. It starts right from the initiation stage where the objectives of the project has to be clearly defined and communicated and extends during the life cycle of the project when there is a high level of interaction between and within the project team. More emphasis was made on the importance of communication in organizational change projects where the deliverables are not so clear.
4.5 Sector-wise analysis

Five out of nine interviewees had extensive experience in handling Organizational change and transformational projects although they have handled engineering projects as well. Hence, in order to better understand the context in which the respondents viewed complexity we will analyze the data from two angles:

- Complexity in organizational change and transformational projects
- Complexity in IT and Engineering projects

![Figure 7: Key Findings across sectors](image)
A snapshot of the findings is summarised in the above table. We will now look at each of these sectors in detail.

### 4.5.1 Complexity in Organizational Change and Transformational projects

For those who were involved with organisational change projects (5 out of 9 in the sample interviewed) we found that across different sectors, one of the first things that everyone agreed upon was the fact that organizational change projects and people projects are usually more complex since the final deliverable is unclear.

As one of the Project Managers pointed out, the number of parties involved and the sheer number of deliverables added to the complexity. The number of interfaces with other areas, both internal and external made the project challenging. Milestones are critical in any project and it is imperative that the PM meets these milestones. In a university project, the PM stressed on the fact that if a particular milestone is threatened and if that results in having an adverse effect on the other milestones then such projects are deemed as complex.

It should be noted at this point that Turner and Cochrane (1993) developed the model of complexity (at the stage it was developed they did not envisage it as a model for complexity – we have just placed it in that category) based on how well defined the goals are and how well defined are the methods of achieving those goals. The respondent ED01 strongly felt that clarity of goals is really not an issue that adds to complexity. As she says, “It is an absolute essential for the success of any project. If there is no clarity in goals then the project is bound to fail.” She added that the complexity may lie in the way of achieving these goals rather than the goal itself.

Another key point that came up while discussing organizational change projects was that of Resourcing. Every project has constraints in terms of the resources available at its disposal. Three respondents from Education and Services sector term this problem as “operational pressures”. While it can be argued that every project has such constraints, organizational change projects are particularly affected by acute resource availability problems thereby adding to the complexity of the project.

Another key challenge in such projects has been in the area of Stakeholder Management. How to effectively deal with the clients has been a sensitive area for the PMs. In some cases, respondents E01, E03 and S01 felt that managing projects would be lot simpler if the client took a step back and give the freedom to the project team in handling issues. Politics is closely associated with stakeholder management and the respondents felt they play an important role in change projects. As one of the respondent, ED01 put it, “It is essential to know political fancy footwork if you want to manage your stakeholders effectively.”

A great deal of literature talks about the importance of communication in project management. However, when talking about complexity, the importance of communication seems to be underplayed by all the complexity models. The respondents stressed repeatedly (7 out of 9 respondents) how a lot of complexity comes into the project from different people
interacting with each other. A well defined communication channel would go a long way in smoothing such issues. Respondents E03, S03 and IT02 reiterated many times that effective communication is vital within the organization and also in terms of managing the clients. Complications arise when issues are not brought to the notice of the client at an early stage. This eventually leads to trust issues which usually stems from poor communication.

Most of the issues that came up so far have been centred on people issues. When we touched upon the technological complexity there were no major concerns in that area. The respondents reiterated that the presence of technical problems alone did not add to the complexity. However, if it’s a fairly new technology and the staff had to be trained afresh it might add to the complexity. There was a consensus that the engineers or the IT department would usually address these issues and it was not a major concern at the PM or the Sponsor level.

The factors discussed above will be taken up during the coding process to try and analyze a pattern that might emerge which will help us better understand the reasons behind it.

4.5.2 Complexity in IT and Engineering Projects

In standard project management theory it is often assumed that engineering and IT projects are often characterized by clearly defined goals and non ambiguous deliverables. However, that does not prevent various sources of complexity from creeping in. Six of the respondents had experience in excess of 20 years in handling large infrastructure, engineering and IT projects.

To give a sense of the projects in context, one project included a telephone expansion worth $5 billion in Saudi Arabia, another was a pipe laying project for a vessel in the Oil and Gas industry and another involved the implementation of IT systems for a bank. The first impressions of why the respondents felt that these projects were complex led to some interesting findings. One respondent felt that the sheer amount of people involved in the project made it complex. Since it was an international project, there were major cultural differences in the way the work was conducted thereby adding complexity to the project.

Respondents E02, IT01, S01 and S02 added that managing a remote location was extremely challenging as there was no direct control over the extended team. One of the IT project managers, IT02, indicated that in IT process improvement projects it is very difficult to understand how the improvement will show itself. The nature of the project and the scope becomes unclear thereby adding to its complexity. Because process improvement will bring about change, the respondent suggested that it helps to clarify expectations so that the project team knows what is expected out of the project from a user perspective. This has to be followed by putting clear performance metrics in place, one that is measurable and understood by everyone. According to respondent IT02, this will go a long way in reducing the complexity.

A new dimension which came up was that of decision making in engineering projects. People vested with decision making powers do not act on time and may delay the process. This delayed decision making could be due to political reasons. Another aspect within decision
making was that of prioritisation. Decisions are not properly prioritised at various levels of the organization. From this perspective, respondents E01 and E02 felt that highly visible projects which are critical to the success of the organization do not suffer from delayed decision making as the decision making happens right at the top of the organization. All the PMs reiterated the fact that people aspects of the project always constitute the biggest challenge in a project. The PM for telephone expansion project traced back most of the problems to cultural differences which are essentially people issues.

As one of the senior project managers (E02) commented, “Having a common language that is understood by everybody in the definition process of the project is the key. It is critical to define the objective and manage the changes to the objective along the life cycle of the project. The real difficulty is that you are managing people and not machines.”

The IT project manager viewed complexity from the triple constraint perspective. Complexities could arise from scope which was discussed earlier, and also from time and cost constraints. However, issues due to time delays and cost overruns can be managed and predicted if rigorous project management methodologies are put into practice.

A key aspect was technical challenges in the IT and Engineering sector. Surprisingly, the project managers did not view this as a major hurdle. One of the project managers (IT02) made an interesting comment about technical complexity. He pointed out that it boils down to how much a PM needs to understand technology to deliver leading edge projects. It is not critical to fully understand the technology but the ability to ask the right questions as to what will work and what will not. It is sufficient to be just technologically aware and not immerse yourself in it. Respondents E01, E02, IT01 and IT02 commented that although some of the technical problems look daunting, the engineers were equipped to do the job.

An interesting observation was made by respondent IT01 about overall complexity. “Complexity is a mental state of mind. If you are comfortable with a situation, you don’t feel it is complex. There are varying thresholds for different people. Some feel overwhelmed when they have to manage three or four interdependencies. Others are able to handle far more complex situations.” This suggests that the capabilities of different individuals and their experience might affect the view of complexity and how it is. In addition to the insights through the interviews, we also managed to get responses through questionnaires which were mailed to people we knew in the industry. The following section will discuss the findings in detail.
### 4.6 Quantitative Data Analysis

In addition to the interviews, we wanted to test the data to see if our findings find similar patterns on a slightly larger scale. The objective was to triangulate the data for better coherence. Hence, a short questionnaire was prepared based on work by Remington (2008) and sent to various Project Managers across different sectors to understand their reasons as to what adds to complexity in a project. This questionnaire contained a list of factors which may lead to or cause complexity in projects. The respondents were asked to evaluate each factor on a 5-point Likert scale expressing their level of agreement whether the factor causes complexity in a project or not. This was done to supplement the data gathered through interviews and to see if there is consistency between the data collected using the two methods.

A total of 29 project managers responded to the questionnaire. The small sample size did produce quick results but may not be representative of the whole population and therefore the results cannot be considered to be reliable or precise. Due to the time and resource constraints in this research, we have interpreted the data based on this small sample size.

We understand that there are two approaches as far as analyzing data on Likert scale is concerned. For the purpose of this research we will assume that the scale used has equally spaced intervals and the data collected is not ordinal in nature. Therefore the mean, standard deviation etc for this data is valid.

The data was tabulated in Microsoft Excel for each factor vs each respondent. The values given for each point of the Likert scale were as given below:

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree</td>
<td>2</td>
</tr>
<tr>
<td>Neither Agree nor Disagree</td>
<td>3</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>5</td>
</tr>
</tbody>
</table>

*Table 4: Value Chart*
<table>
<thead>
<tr>
<th>Complexity in Projects</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Issue</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of elements</td>
<td>0%</td>
<td>3%</td>
<td>14%</td>
<td>52%</td>
<td>31%</td>
</tr>
<tr>
<td>Interdependence of elements</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>48%</td>
<td>45%</td>
</tr>
<tr>
<td>Bottlenecks</td>
<td>0%</td>
<td>7%</td>
<td>52%</td>
<td>28%</td>
<td>14%</td>
</tr>
<tr>
<td>Technical challenges</td>
<td>0%</td>
<td>17%</td>
<td>45%</td>
<td>38%</td>
<td>14%</td>
</tr>
<tr>
<td>Unclear Goals</td>
<td>0%</td>
<td>10%</td>
<td>24%</td>
<td>34%</td>
<td>31%</td>
</tr>
<tr>
<td>Disagreement on goals</td>
<td>3%</td>
<td>7%</td>
<td>21%</td>
<td>48%</td>
<td>21%</td>
</tr>
<tr>
<td>Objectives changed over time</td>
<td>0%</td>
<td>7%</td>
<td>17%</td>
<td>45%</td>
<td>31%</td>
</tr>
<tr>
<td>Key resources were unavailable</td>
<td>7%</td>
<td>24%</td>
<td>34%</td>
<td>52%</td>
<td>31%</td>
</tr>
<tr>
<td>Unanticipated changes in external environment forced changes</td>
<td>0%</td>
<td>24%</td>
<td>10%</td>
<td>59%</td>
<td>7%</td>
</tr>
<tr>
<td>Unanticipated changes in the internal organisation forced changes</td>
<td>0%</td>
<td>10%</td>
<td>34%</td>
<td>59%</td>
<td>7%</td>
</tr>
<tr>
<td>Roles and responsibilities unclear</td>
<td>0%</td>
<td>10%</td>
<td>24%</td>
<td>59%</td>
<td>7%</td>
</tr>
<tr>
<td>Top management support lacking</td>
<td>10%</td>
<td>28%</td>
<td>31%</td>
<td>14%</td>
<td>17%</td>
</tr>
<tr>
<td>Leadership style of PM</td>
<td>7%</td>
<td>34%</td>
<td>28%</td>
<td>21%</td>
<td>10%</td>
</tr>
<tr>
<td>Leadership style of Project Sponsor</td>
<td>14%</td>
<td>31%</td>
<td>24%</td>
<td>31%</td>
<td>0%</td>
</tr>
<tr>
<td>Processes unclear</td>
<td>7%</td>
<td>14%</td>
<td>21%</td>
<td>52%</td>
<td>7%</td>
</tr>
<tr>
<td>Inefficient communication</td>
<td>3%</td>
<td>0%</td>
<td>24%</td>
<td>52%</td>
<td>21%</td>
</tr>
<tr>
<td>Decision-making processes ineffective</td>
<td>3%</td>
<td>3%</td>
<td>21%</td>
<td>48%</td>
<td>24%</td>
</tr>
<tr>
<td>Unrealistic time frames</td>
<td>0%</td>
<td>21%</td>
<td>45%</td>
<td>28%</td>
<td>7%</td>
</tr>
<tr>
<td>Key risks not identified early</td>
<td>0%</td>
<td>24%</td>
<td>41%</td>
<td>28%</td>
<td>7%</td>
</tr>
<tr>
<td>Risks not managed productively</td>
<td>7%</td>
<td>24%</td>
<td>34%</td>
<td>31%</td>
<td>3%</td>
</tr>
<tr>
<td>Procurement systems did not assist in managing the scope</td>
<td>7%</td>
<td>7%</td>
<td>45%</td>
<td>38%</td>
<td>3%</td>
</tr>
<tr>
<td>Stakeholders with competing agendas</td>
<td>0%</td>
<td>7%</td>
<td>21%</td>
<td>55%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Table 5: Frequency Table
From this analysis of the whole sample, there are some interesting implications that can be drawn from this chart:

- Most respondents (59%) agreed that the factor ‘Unanticipated changes in external environment forced changes in the project’ could add to complexity in a project.
- This is closely followed by the factor ‘Stakeholders with competing agendas’ (55%).
- Factors such as ‘Number of elements’, ‘unclear processes’ and ‘Inefficient communication’ are the other factors which could lead to complexity in projects according to the respondents of this survey (52%).
- A very high percentage of respondents are not sure if ‘Bottlenecks’ in a project could cause complexity (52%)
- A similar response to factors like ‘Technical challenges’, ‘Unrealistic time-frames’ and ‘Procurement systems’ implies that these factors might have a perception of making a project difficult and not complex (45%).

As is observed in the frequency chart there may be a lot of variance in the responses. This can be further checked by finding the mean and the standard deviation for each factor. The standard deviation for a factor denotes the variation in the scale of responses i.e. a factor with a high standard deviation would mean that amongst the respondents, several of them feel differently about the factor.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of elements</td>
<td>4.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Interdependence of elements</td>
<td>4.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Bottlenecks</td>
<td>3.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Technical challenges</td>
<td>3.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Unclear Goals</td>
<td>3.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Disagreement on goals</td>
<td>3.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Objectives changed over time</td>
<td>4.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Key resources were unavailable</td>
<td>3.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Unanticipated changes in external environment forced changes</td>
<td>3.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Unanticipated changes in the internal organisation forced changes</td>
<td>3.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Roles and responsibilities unclear</td>
<td>3.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Top management support lacking</td>
<td>3.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Leadership style of PM</td>
<td>2.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Leadership style of Project Sponsor</td>
<td>2.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Processes unclear</td>
<td>3.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Inefficient communication</td>
<td>3.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Decision-making processes ineffective</td>
<td>3.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Unrealistic time frames</td>
<td>3.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Key risks not identified early</td>
<td>3.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Risks not managed productively</td>
<td>3.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Complexity in Projects

| Procurement systems did not assist in managing the scope | 3.2 | 0.9 |
| Stakeholders with competing agendas | 3.8 | 0.8 |

Table 6: Mean and Standard Deviation for each Factor

The mean for each factor (see appendix C – average scores for each factor graph) depicts the tendency for the level of agreement for all the respondents put together. Even though a factor such as ‘Interdependence of elements’ did not have a high value in the frequency chart, having a high mean value shows that most of the respondents tend to agree that this factor leads to complexity in projects. This is supplemented by the fact that the standard deviation for this factor is one of the lowest at 0.7, which indicates that the variation in the responses is very limited.

On the other hand, a factor like ‘Top management support’ has a mean value of 3, which indicates that most of the respondents neither agree nor disagree to this factor leading to complexity in projects. But when this is viewed along with the information about the standard deviation of the factor, which is the highest at 1.3, it is evident that the variation in response is spread out and therefore the mean value alone does not portray the right picture.

4.6.1 Sector-wise Analysis

The respondents for our questionnaire were from different sectors like IT, Engineering and Construction, Services etc. An attempt was made to categorize the responses sector-wise and analyze it, in order to see if the understanding for each factor varied across the sectors. The percentage of respondents from each sector is represented in the figure below.

![Sector-wise break up of Respondents](image)

Figure 8: Sector-wise break up
For each sector, the mean value of the responses for each factor was calculated. This was plotted sector wise for all the factors (see Appendix D – Education sector/Engineering/IT etc). The interpretations from this analysis can be summarized in the following table:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Top 3 rated factors</th>
<th>Lowest 3 rated factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Education Sector</td>
<td>1. Interdependence of elements</td>
<td>1. Leadership style of project sponsor</td>
</tr>
<tr>
<td></td>
<td>2. Number of elements</td>
<td>2. Lack of top management support</td>
</tr>
<tr>
<td></td>
<td>3. Stakeholders with competing agendas</td>
<td>3. Technical challenges</td>
</tr>
<tr>
<td>2. Engineering / Construction Sector</td>
<td>1. Objectives changed over time</td>
<td>1. Key resources were unavailable</td>
</tr>
<tr>
<td></td>
<td>1. Roles and responsibilities were clear</td>
<td>2. Unanticipated changes in external environment forced changes</td>
</tr>
<tr>
<td></td>
<td>2. Interdependence of elements</td>
<td>3. Leadership style of project sponsor</td>
</tr>
<tr>
<td></td>
<td>2. Disagreement on goals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Decision making processes ineffective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Stakeholders with competing agendas</td>
<td></td>
</tr>
<tr>
<td>3. IT</td>
<td>1. Interdependence of elements</td>
<td>1. Lack of top management support</td>
</tr>
<tr>
<td></td>
<td>2. Inefficient communication</td>
<td>2. Procurement systems did not assist in scope management</td>
</tr>
<tr>
<td></td>
<td>3. Number of elements</td>
<td>3. Risks not managed productively</td>
</tr>
<tr>
<td>4. Manufacturing</td>
<td>1. Number of elements</td>
<td>1. Processes unclear</td>
</tr>
<tr>
<td></td>
<td>1. Interdependence of elements</td>
<td>2. Leadership style of project manager</td>
</tr>
<tr>
<td></td>
<td>1. Objectives changed over time</td>
<td>3. Risks not managed productively</td>
</tr>
<tr>
<td></td>
<td>1. Decision making processes ineffective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Stakeholders with competing agendas</td>
<td></td>
</tr>
<tr>
<td>5. Services</td>
<td>1. Interdependence of elements</td>
<td>1. Leadership style of project manager</td>
</tr>
<tr>
<td></td>
<td>2. Disagreement on goals</td>
<td>2. Leadership style of project sponsor</td>
</tr>
<tr>
<td></td>
<td>2. Objectives changed over time</td>
<td>3. Key risks not identified early</td>
</tr>
<tr>
<td></td>
<td>2. Stakeholders with competing agendas</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Summary of top and lowest rated factors – Sector-wise

The table above shows us how the ‘interdependence of elements’ is considered to be a factor which causes complexity in projects right across all the sectors considered. Surprisingly the factor ‘Number of elements’ shows up in several sectors except the Engineering / Construction sector where one would naturally feel that this factor would have an important role to play in the complexity of a project. However in this particular sector project managers are very well trained in traditional but high level PM control techniques. That is they are very good at managing myriads of interdependecies. This is less likely to be the case in other professional sectors. Other factors that are rated highly in several sectors are ‘Stakeholders with competing agendas’ and ‘Objectives changed over time’. It is again surprising to note
how the factor ‘Disagreement of goals’ shows up as one of the top rated factors in the Engineering / Construction sector where we would assume that the goals are of more tangible nature and therefore there is not much possibility of a disagreement. It is possible though that that in this sector, there is an illusion of well-defined goals produced by the tangible nature of the outcomes. However clients change their minds and therefore goals change or there is poor initial communication which means that goals are not really shared at all but there is a perception that they are. By applying the same logic it is more understandable why it would be rated high in the Services sector.

The factors which were not perceived to have an effect on complexity in a project seem to be a bit varied across the sectors. ‘Leadership style of project manager’, ‘Leadership style of project sponsor’ and ‘Lack of top management support’ are some of the factors that were not perceived to affect complexity in a project according to our respondents. However, it is important to bear in mind that project managers may not criticise their own leadership style which could have contributed to our above finding.

4.6.2 Complexity factors according to the Models reviewed
The list of factors for this questionnaire was prepared based on those that contribute to the different types of complexities as outlined in the models reviewed in the literature and also some others. For ease of understanding and being able to correlate to the models in the literature review, after the data was collected, we have grouped the respective factors under the major types of complexities found in the models.

Thereafter the mean values of the factors were put together for each type of complexity and average scores were ascertained. This is represented in the graph below.
The graph above shows that the general perception amongst the respondents is that the complexity of a project increases due to the factors contributing to the structural complexity and those arising from uncertainty. From this data it can also be concluded that according to this sample of respondents, the technical factors do not increase the complexity of a project. This complements what we discussed earlier wherein a high percentage of the respondents were not sure if technical challenges increase the complexity or not.

The same information, this time also considering the different sectors, has been depicted on a radar chart as given below.
Figure 9: Radar chart showing the factors under each type of complexity for each sector

Based on our data the chart shows that the factors contributing to temporal complexity show a higher tendency in manufacturing projects while they appear to be lowest in the educational projects. We must bear in mind that the duration of the projects have not been considered here, as there is less likelihood of temporal complexity showing up in projects of shorter duration. As is seen the factors for structural complexity show a higher trend for manufacturing projects as against IT projects. Technical factors and issues about level of agreement are highest for the engineering projects while uncertainty factors rate the highest for services as well as engineering projects. Also see Appendix E (the complexity type histograms – sector wise) to see how each type of complexity differs across the sectors.
4.7 Mapping the key findings with the models

The key findings that emerged from grounded theory and the results from quantitative data analysis can now be compared with the complexity models which were discussed in the literature review. The following table summarises the key findings with the models.

Table 9: Summary of Key Findings with models

<table>
<thead>
<tr>
<th>Complexity Models</th>
<th>Goals &amp; Methods Matrix</th>
<th>Agreement &amp; certainty matrix</th>
<th>Terry Williams Model</th>
<th>Adam Kahane Model</th>
<th>Cynefin decision making framework</th>
<th>Remington &amp; Pollack Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of people involved in the project</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interdependence of the elements</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing stakeholders</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disagreement on goals</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objectives changed over time</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication between different parts of the organization</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>People Management</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision-making process ineffective</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Based on the results from our sample it is apparent that no one model accounts for all attributes identified by those in our sample as being associated with increasing levels of complexity in projects. For instance, the number of people involved in the project is a key factor in determining the complexity of a project. This bears resemblance to structural complexity indicated in Terry Williams’s model and the Remington & Pollack model.

**4.8 Limitations**

One of the major limitations of this research is the sample size which was small both for the questionnaires and as well as for the interviews. This research is exploratory and therefore can only provide useful insights to the situation but cannot be used for decision making. Even though the cross-section of respondents, both for interviews and questionnaires represent several sectors, the sample does not cover all the possible sectors which could have complex projects. This leads to the limitation of generalization of the findings.

In this research, we were also constrained by limitations of time and availability of respondents. The interviewees were selected based on criteria developed by the researchers, as described in the methodology section. The limitation with this kind of selection is that of non-probability sampling, which means that the selection was not random and therefore might not be representative of the whole population. We were also restricted by limitations of the self-completing questionnaire, that of low response rates.

The methodology chosen for this research also had its own set of limitations. The problems associated with the restricted use of the existing knowledge of the researcher till a later stage of analysis in grounded theory proves to be a limitation. Another limitation of this methodology is the possibility of losing the context while coding the data of what has been said during the interviews. In this research this led to some fragmentation of data.

**4.9 Reliability and Validity**

The concepts of reliability and validity have been used very frequently for quantitative research and have now been extended with a slightly different meaning to qualitative research as well.

For quantitative research, reliability can be defined as ‘the extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable’ (Joppe, 2000 as cited in Golafshani, 2003, pp 597). This makes reliability more of a criterion for quality in quantitative research. However for qualitative research, reliability is more in terms of credibility, consistency and applicability as criteria for quality (Lincoln & Guba, 1985 as cited in Golafshani, 2003).

In this research, the idea of repeatability of results obtained through questionnaires was checked through the test – retest method, wherein some respondents were asked to answer the questionnaire at another time and the answers were checked to see if they remained the same over time. For the interviews, the aspect of trustworthiness was maintained, which is important to measure reliability. External reliability is difficult to maintain in qualitative
Complexity in Projects

research (Bryman & Bell, 2003) and this is true for this research as well as it will not be possible to recreate the same settings in order to replicate the study. On the contrary, internal reliability was maintained due to the presence of two members in the team for this research.

‘Validity of a research determines whether the research truly measures what it intended to measure or how truthful the research results are’ (Joppe, 2000 as cited in Golafshani, 2003, pp 597). Construct validity which is the initial concept of which data is to be gathered and how (Wainer & Braun, 1998 as cited in Golafshani, 2003) was maintained through a detailed and careful assimilation of the kind of data required to answer the research question. Triangulation of data collection, as described earlier in the research, also helped in ameliorating the reliability and validity of this research.
SECTION 5: CONCLUSION

Complexity in Project Management is not as straightforward as just classifying certain projects complex or not complex. It is imperative to understand the various sources of complexity and how they impact the project. In this paper, we have tried to analyse some key complexity models and made an attempt to understand if the practitioners viewpoint of complexity matches with that of those present in the models. A mixed approach of generating Grounded theory through interviews and quantitative analysis through the questionnaire responses was undertaken. We now summarize the key findings of this study.

An overwhelming majority of respondents cited the number of elements in a project and its interdependence as a key factor influencing complexity. This would support those models that argue that complexity stems, at least in some part from the number of elements and the level of interconnectivity. Our analysis using grounded theory revealed that the sheer size and entanglement in a project greatly influenced the complexity levels. This was one of the themes that emerged from the study. In addition, more than 50% of the respondents to the questionnaire agreed and around 30% strongly agreed on this aspect. It should be noted that Structural complexity is a key feature of complexity models by Baccarini (1996), Williams (2002) and Remington & Pollack (2007). From an industry perspective, all the sectors rate this factor on their top three list of complexity. To that extent, there seems to be a fair agreement between the academicians and the practitioners’ viewpoint.

Another interesting finding is that of Stakeholder management. Great emphasis is laid on the importance of managing both internal and external stakeholders. Stakeholder management could be linked to Structural complexity as suggested by Williams (2002). Virtually all projects have complexity within the stakeholders, citing the example of Euro tunnel project (Williams, 2002). However, when analysed separately it is seen that managing conflicting agendas of various stakeholders seems to amplify the complexity of a project. The results from questionnaires revealed stakeholders with competing agendas are rated high. When trying to draw a parallel with the models there is no clear fit or explanation. Perhaps the only link we could establish was that with Kahane (2004) in social complexity where he talks about people with diverse perspectives and interests coming together to create and implement a solution. Stakeholder management is central to directional and temporal complexity in Remington and Pollack’s (2007) model.

When a large scale engineering or construction project is undertaken, the technical challenges involved in the project seem to overwhelm us at the initial stage. However, our results seem to say otherwise. Technical challenges especially in IT and Engineering projects were viewed as manageable task by the technical team or the engineers as the case may be. This opinion was resonated by the responses from the questionnaires as well as it did not feature in the top rated factors causing complexity. From a literature perspective, technical complexity is a key feature of many models. Baccarini (1996) categorizes technological complexity in terms of
differentiation and interdependencies. Remington and Pollack (2007) talk in detail about technically complex projects and its relation to uncertainty. However, the practitioner community are of the opinion that although technical issues are challenging, they are manageable. However, it must be borne in mind that our respondents were not from high technology industries where technical complexity is a far greater challenge.

The importance of communication was stressed repeatedly during the interviews and also reflected in our findings from the questionnaires. Regardless of the type of project, practitioners feel that communicating clearly with both internal and external clients is of prime importance. Kahane (2004) puts heavy emphasis on the importance on talking and listening to each other when dealing with a tough problem. At the core of the U-process proposed by Kahane (2004) is clear communication. Similarly, the Cynefin decision making framework suggested by Snowden and Boone (2007) outlines the approaches to be taken to handle simple, complicated, complex and chaotic situations. As the complexity increases at every level, the approach on communication moves to an increased level of interaction and clear direct communication. A quick look at directional complexity within the Remington and Pollack (2007) model suggests that clear communication would go a long way in reducing the level of complexity.

While some of the findings like the number of elements and the interdependence of these elements have a direct bearing on the complexity models, issues like people management and communication seems to have received little attention from the models. However, given the sample size, it is hard to generalize these findings. There seems to be a slightly different pattern emerging when the complexity factors are looked from different industries perspective. Perhaps there is a good research potential for analysing complexity factors specific to certain industries. Very little work has been done in this area and we sincerely hope that our research will serve as a starting point for it.

Based on the results from our sample it is apparent that no one model accounts for all attributes identified by those in our sample as being associated with increasing levels of complexity in projects. The project management models might benefit from inclusion of the some of the concepts found in the change management models, such as those by Stacey and Kahane. This will help to create more comprehensive models for Project Management.

One of the respondents (E02) made an interesting observation in the end. He mentioned that the simplest models of complexity are the ones which are most useful for practitioners. As Baccarini (1996) puts it, projects will continue to become more and more complex and there is an increasing concern about the concept of complexity and its influence on project management process.
BIBLIOGRAPHY


Complexity in Projects


### APPENDICES

**Appendix A: Questionnaire on factors of complexity**

**QUESTIONNAIRE ON FACTORS OF COMPLEXITY**

Listed below are various factors that may increase complexity in a project. Based on your experience, kindly evaluate each of the factors on the scale.

<table>
<thead>
<tr>
<th>S No</th>
<th>Factors of Complexity</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of elements in the project was high</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2</td>
<td>Interdependence of elements in the project was high</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3</td>
<td>Bottlenecks held up key processes</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4</td>
<td>Technical challenges unable to be resolved easily</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5</td>
<td>Unclear Goals</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6</td>
<td>Disagreement on goals of the project</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7</td>
<td>Objectives or requirements changed over time</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8</td>
<td>Resources planned were inadequate to complete the tasks</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Complexity in Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 There were unanticipated changes in external environment (e.g. govt. regulations or competition) forced changes during the project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 There were unanticipated changes in the internal organisation that forced changes during the project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Roles and responsibilities were unclear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Support from top management was lacking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Leadership style of the Project Manager was inappropriate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Leadership style of the Project Sponsor or senior executive was inappropriate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Processes or methods to achieve the goals were unclear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 There was ineffective or inefficient communication between parties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Decision-making processes were ineffective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 Time frames were unrealistic / too tight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Key risks were not identified early enough</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Risks, when triggered, were not managed productively</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 Procurement systems (contract management processes) did not assist in managing the scope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Stakeholders had competing agendas which were not revealed at the start of the project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Others (Please Describe)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B: General Questions for Semi-structured interviews

The following are the list of questions that were asked during the semi-structured interviews. The objective was to keep the questions open ended in order to facilitate the interviewees to elaborate and provide insights into the understanding of their view of complexity. Further questions were asked based on the situation. It was a deliberate move on our part to avoid the term complex as it is part of the colloquial language and has associations and meaning that might influence the responses.

i. Years of Project Management experience

ii. What kind of projects were handled and primarily in which sector?

iii. Can u recall any project which you call as complicated?

iv. Can you describe the project for us?

v. What was the experience like for you?

vi. Why did you categorize the project as complicated?

vii. According to you, on a general basis, what does complexity on projects depend on?
### Appendix C: Average Scores for each complexity factor

<table>
<thead>
<tr>
<th>Complexity Factor</th>
<th>Score Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholders with competing agendas</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>Procurement systems did not assist in managing the scope</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Risks not managed productively</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>Key risks not identified early</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Unrealistic time frames</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Decision-making processes ineffective</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Inefficient communication</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Processes unclear</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Leadership style of Project Sponsor</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Leadership style of PM</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Top management support lacking</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Roles and responsibilities unclear</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Unanticipated changes in the internal organisation forced changes</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Unanticipated changes in external environment forced changes</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Key resources were unavailable</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Objectives changed over time</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Disagreement on goals</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Unclear Goals</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Technical challenges</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Bottlenecks</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>Interdependence of elements</td>
<td>Neither agree nor disagree</td>
</tr>
<tr>
<td>No. of elements</td>
<td>Neither agree nor disagree</td>
</tr>
</tbody>
</table>
Appendix D: Mean value of the responses for each factor – Sector wise

Mean Value of responses - Education sector

1. Stakeholders with competing agendas
2. Procurement systems did not assist in managing the scope
3. Risks not managed productively
4. Key risks not identified early
5. Unrealistic time frames
6. Decision-making processes ineffective
7. Inefficient communication
8. Processes unclear
9. Leadership style of Project Sponsor
10. Leadership style of PM
11. Top management support lacking
12. Roles and responsibilities unclear
13. Unanticipated changes in the internal organisation forced changes
14. Unanticipated changes in external environment forced changes
15. Key resources were unavailable
16. Objectives changed over time
17. Disagreement on goals
18. Unclear Goals
19. Technical challenges
20. Bottlenecks
21. Interdependence of elements
22. No. of elements

1 1.5 2 2.5 3 3.5 4 4.5 5
Mean Value of responses - Engineering / Construction Sector

- Stakeholders with competing agendas
- Procurement systems did not assist in managing the scope
- Risks not managed productively
- Key risks not identified early
- Unrealistic time frames
- Decision-making processes ineffective
- Inefficient communication
- Processes unclear
- Leadership style of Project Sponsor
- Leadership style of PM
- Top management support lacking
- Roles and responsibilities unclear
- Unanticipated changes in the internal organisation forced changes
- Unanticipated changes in external environment forced changes
- Key resources were unavailable
- Objectives changed over time
- Disagreement on goals
- Unclear Goals
- Technical challenges
- Bottlenecks
- Interdependence of elements
- No. of elements
Mean Value of responses - IT Sector

- Stakeholders with competing agendas
- Procurement systems did not assist in managing the scope
- Risks not managed productively
- Key risks not identified early
- Unrealistic time frames
- Decision-making processes ineffective
- Inefficient communication
- Processes unclear
- Leadership style of Project Sponsor
- Leadership style of PM
- Top management support lacking
- Roles and responsibilities unclear
- Unanticipated changes in the internal organisation forced changes
- Unanticipated changes in external environment forced changes
- Key resources were unavailable
- Objectives changed over time
- Disagreement on goals
- Unclear Goals
- Technical challenges
- Bottlenecks
- Interdependence of elements
- No. of elements
Mean Value of responses - Manufacturing Sector

- Stakeholders with competing agendas
- Procurement systems did not assist in managing the scope
- Risks not managed productively
- Key risks not identified early
- Unrealistic time frames
- Decision-making processes ineffective
- Inefficient communication
- Processes unclear
- Leadership style of Project Sponsor
- Leadership style of PM
- Top management support lacking
- Roles and responsibilities unclear
- Unanticipated changes in the internal organisation forced changes
- Unanticipated changes in external environment forced changes
- Key resources were unavailable
- Objectives changed over time
- Disagreement on goals
- Unclear Goals
- Technical challenges
- Bottlenecks
- Interdependence of elements
- No. of elements
Mean Value of responses - Services

- Stakeholders with competing agendas
- Procurement systems did not assist in managing the scope
- Risks not managed productively
- Key risks not identified early
- Unrealistic time frames
- Decision-making processes ineffective
- Inefficient communication
- Processes nuclear
- Leadership style of Project Sponsor
- Leadership style of PM
- Top management support lacking
- Roles and responsibilities unclear
- Unanticipated changes in the internal organisation forced changes
- Unanticipated changes in external environment forced changes
- Key resources were unavailable
- Objectives changed over time
- Disagreement on goals
- Unclear Goals
- Technical challenges
- Bottlenecks
- Interdependence of elements
- No. of elements
Appendix E: complexity type histograms – sector wise

**Complexity in Projects**

### Structural complexity

<table>
<thead>
<tr>
<th>Sector</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>4.6</td>
</tr>
<tr>
<td>Engineering/Construction</td>
<td>4.3</td>
</tr>
<tr>
<td>IT</td>
<td>4.1</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>4.5</td>
</tr>
<tr>
<td>Services</td>
<td>4.3</td>
</tr>
<tr>
<td>Others</td>
<td>3.5</td>
</tr>
</tbody>
</table>

### Uncertainty

<table>
<thead>
<tr>
<th>Sector</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>3.0</td>
</tr>
<tr>
<td>Engineering/Construction</td>
<td>3.5</td>
</tr>
<tr>
<td>IT</td>
<td>3.0</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>4.0</td>
</tr>
<tr>
<td>Services</td>
<td>3.0</td>
</tr>
<tr>
<td>Others</td>
<td>3.0</td>
</tr>
</tbody>
</table>
Complexity in Projects

### Dynamically/Generative complex

<table>
<thead>
<tr>
<th>Category</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>3.2</td>
</tr>
<tr>
<td>Engineering/Construction</td>
<td>3.1</td>
</tr>
<tr>
<td>IT</td>
<td>3.5</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>3.8</td>
</tr>
<tr>
<td>Services</td>
<td>3.3</td>
</tr>
<tr>
<td>Others</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Temporal complexity

<table>
<thead>
<tr>
<th>Category</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>3.0</td>
</tr>
<tr>
<td>Engineering/Construction</td>
<td>3.4</td>
</tr>
<tr>
<td>IT</td>
<td>3.3</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>4.3</td>
</tr>
<tr>
<td>Services</td>
<td>3.7</td>
</tr>
<tr>
<td>Others</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Complexity in Projects

Social complexity

- Education
- Engineering/Construction
- IT
- Manufacturing
- Services
- Others

Social complexity bar chart.